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SUBJECT: Forwards comments to preliminary accident sequence precursor analysis & util calculation.

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SUSQUEHANNA STEAM ELECTRIC STATION
REVIEW OF HPCI THERMAL OVERPRESSURE
PRECURSOR ANALYSIS — **Docket Nos. 50-387 and 50-388**
PLA-4497 FILE R41-2

Pennsylvania Power & Light (PP&L) Company has reviewed the Preliminary Accident Sequence Precursor Analysis prepared by the NRC for the Susquehanna SES HPCI Thermal Overpressure event. Comments on the Precursor Analysis are provided in the attachment to this letter. In addition, please find the enclosed PP&L Calculation which provides detailed information on the condition of the HPCI valve and an assessment of the safety significance of the overpressure event. We hope this information is helpful to you in your efforts to finalize the Precursor Analysis.

In reviewing the NRC analysis, apparent differences in equipment performance and operating assumptions between the NRC and PP&L were identified. The attached comments highlight these differences and provide operating experience and operator performance information which is directly applicable to Susquehanna SES. We encourage you to incorporate this plant specific information into the analysis of this event.

If you have any questions on these comments, or require additional information, please contact Mr. James M. Kenny at (610) 774-7535.

Very truly yours,

R. G. Byram

Attachment

1/1
A001

copy: NRC Region I
Mr. K. Jenison — NRC Sr. Resident Inspector
Mr. C. Poslusny, Jr. — NRC Sr. Project Manager

REVIEW OF PRELIMINARY ACCIDENT SEQUENCE PRECURSOR ANALYSIS OF THE HPCI THERMAL OVERPRESSURIZATION EVENT

PP&L COMMENTS

The following comments are provided on the NRC's Review of Preliminary Accident Sequence Precursor Analysis for the Susquehanna Steam Electric Station, dated July 17, 1996. The comments are broken into two parts. Part I provides general comments on the analysis methodology, and assumptions within the methodology that could impact the results attained by the Precursor Analysis. Part II provides specific comments related to the HPCI valve thermal overpressurization event and the findings from the root cause analysis of the event.

PART I: GENERAL COMMENTS

1. This comment addresses modeling of the depressurization function and applies to all Susquehanna SES Precursor Events. It appears that the modeling of depressurization consists of three inputs: srv.ads, ads.inhibit and man.ads. Each of these inputs consist of three parameters: system, non-recover and operator error. A review of these parameters generated the following observations.

   It appears that the operator inhibits the ADS 99% of the time when responding to transients. Such an action is inconsistent with the operation of Susquehanna SES. PP&L has deviated from the generic BWROG EPG in this aspect of the guideline and allows the automatic system to operate as designed; there is no ADS Inhibit step in the Susquehanna SES RPV control procedure. The operator confirms the operation of ADS and would manually initiate ADS per written procedure if automatic initiation fails. This deviation is based in part upon the human reliability analysis performed to support risk evaluations for Susquehanna SES. Therefore the probability of ADS inhibit should be 0 instead of 99%. The probability of ADS initiation failure should consist of an automatic action backed up by an operator action. The automatic circuit is the standard General Electric 1 out of 2 taken twice logic.

   ADS Inhibit is performed but not required when responding to a ATWS event at Susquehanna SES. Again, PP&L deviated from the generic BWROG EPG in that the operator only allows the water level that corresponds to the level achieved from full HPCI operation. This is referred to as the TAF+5 feet strategy in the NRC Safety Evaluation Report on modifications to the BWR EPG to address core instability. Therefore during ATWS, RPV level control only requires the operator to ensure HPCI initiation and operation. This deviation is based in part upon the human reliability analysis performed to support risk evaluations for Susquehanna SES. Therefore, the probability of ADS inhibit for ATWS with success of either Feedwater or HPCI does not provide additional insight.

The Susquehanna SES ADS system also consists of Safety Relief Valves (SRVs). A failure probability of 3.7×10^{-3} is used for the Precursor Analysis. This value appears to be applicable to only one train of the ADS system at Susquehanna SES. The Susquehanna SES design consists of two banks of three valves. The valves are manufactured by Crosby and rely on pressurized nitrogen to open in the emergency depressurization mode. These valves are not susceptible to the same failure to open failure modes as the Target Rock designed valves. Each valve is equipped with three solenoids, each with an independent nitrogen supply. Two of the three headers are equipped with accumulators which have the capacity for 5 ADS actuations and an independent bank of pressurized nitrogen bottles. The bottles are capable of providing nitrogen for at least 3 days and can be replaced during an accident.

2. This comment addresses the decay heat removal function at Susquehanna SES. The event tree presented in the Precursor Analysis package does not include use of the Reactor Water Cleanup (RWCU) system in the blowdown mode for decay heat removal. These trees should be revised to reflect RWCU. This is important because operation of RWCU in the blowdown mode for decay heat removal was developed specifically to address transient initiators with loss of decay heat removal, that is the TW sequences. PP&L calculations demonstrate that operation of RWCU in the blowdown mode (feed and bleed for the BWR) is a fully capable mode of decay heat removal, with or without offsite power. When operating RWCU in this mode, all equipment, both RWCU and support equipment, is operated within design parameters. The operators are also provided with written procedures for their use (ES-1/261-001). Additionally, calculations demonstrate that the suppression pool will remain below the design temperature if RWCU is initiated within 9 hours. Use of RWCU was presented to the NRC as a viable mode of decay heat removal, and a review was performed by Argonne National Laboratory for the NRC. The ANL review supported use of RWCU in this mode for decay heat removal.

3. Based upon comments 1 & 2, it is important to update the precursor models as the plant designs and procedures change. This will ensure that accurate precursors are identified.

4. Are the independent failure rates derived from precursor data, or from models, or generic data sources? The failure rates used for much of the equipment seem very severe. As an example, it appears that the failure rate of a train of RHR (1 of 4) is set at 0.01. Using this failure rate and the number of demands on RHR (3100 starts since initial critical), about 31 failures should have been observed. This is about a factor of 6 greater than what has been observed at Susquehanna SES. The failure rate data should be reviewed in light of this equipment operating performance.

5. Are the dependent failure factors derived from precursor failure data, or are they based upon the dependent failure model? As an example, the dependent failure rates used for the

RHR system also seem very severe. Using these rates, Susquehanna SES should have experienced 31 single train failures, 3.1 double failures, 0.93 triple failures and .47 quadruple failures. Using these dependent failure rates there is a reasonable chance that a quadruple failure should have been experienced. Yet there have only been a small number of single RHR train (1 of 4) failures at Susquehanna SES. To the extent possible, the failure rates should be derivable from the operational data. If sufficient data does not exist, then estimates should be made using models. The models should then be tested against the data to see if they provide a reasonable representation of the failure history.

6. Calculations performed using the ORNL BWRSAR code demonstrate that a single SRV stuck open is sufficient to drop the RPV pressure to the condensate shutoff head prior to the RPV water level falling to the top of active fuel. Furthermore, with one stuck open SRV, the RPV pressure falls to the low pressure ECCS shut head prior to core damage. The attached figures provide relevant information on the pressure and water level effects of a single stuck open SRV. The transient event trees should be modified to reflect these results.

7. The precursors B.58, B.59 & B.60 are associated with RCIC failures. Based upon review of the precursor event analysis, these events may be inappropriately classified as precursors. This conclusion is derived from the analysis provided with each precursor as described below.

   The CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS sheets were reviewed for these events. These sheets include the sequences that result in core damage. None of the sequences reported for events B.58 and B.60 include RCIC failure. Event B.59 includes one additional sequence, 119, beyond those identified in events B.58 and B.60. This sequence includes RCIC failure. Events B.58 and B.60 are classified as precursors independent of sequence 119. If sequence 119 is removed from event B.59, the analysis of event B.59 is the same as events B.58 and B.60. Sequence 119 then is not necessary for establishing event B.59 as a precursor. Since the RCIC failure is not necessary for classifying these events as precursors, its failure appears superfluous to the classification of an event as a precursor. Therefore, events B.58, B.59 and B.60 should be reviewed to determine if they are legitimate precursors to severe core damage events based upon failure of RCIC.

   These events appear to be classified as precursors because the conditional probability of core damage given the event is greater than 1×10^{-6}. Based upon the data provided with the events, they appear to become precursors based solely on the occurrence of an MSIV closure event. If the ASP program intends to classify all MSIV closure events as Precursors, then this statement should be added to the screening criteria in Figure 2.1. Transients, loss of feedwater, and events bounded by these events are specifically excluded as precursors. However the probability of core damage given a transient is greater than the cutoff frequency. This would imply that the cutoff frequency is set too low.

8. Comments on Precursor LER No. 387/95-013

All of the above comments apply to this event tree, especially those concerning operation of ADS (comment 1) and the RPV depressurization rate as a function of the number of SRVs open (comment 6). If these comments are incorporated into the event tree, the dominant sequence will no longer apply.

9. Reviewing the data in Table 1 it appears that equipment failure is insignificant when compared to operator error. Failure to execute EOPs steps accounts for about 6%. Such a high assumed operator failure rate will mask important equipment failure combinations.

PART II: SPECIFIC COMMENTS ON HPCI EVENT

1. Event Summary

The 2nd para. states: "...this analysis assumes the HPCI valve would have failed to operate if required following a scram while at power once the bonnet over-pressurization occurred and estimates a conditional core damage probability (CCDP) over a one-year period of 2.2 x 10^{-5}."

The assumption that the HPCI injection valve was inoperable for a one year period is very conservative, and is not consistent with the thermally induced pressurization phenomenon, nor the material condition of the valve following the pressurization event.

Details are provided in the attached calculation EC-052-1029, "HPCI HV-155F006 - Assessment of depressurization time following CR 95-0682 Thermal Overpressurization Event," Rev. 0. Conclusion (E) of the referenced calculation states:

> "A qualitative conclusion regarding the HPCI 1F006 overpressurization in 1992, accounting for the fact that the pressure seal was physically damaged, pressurization was limited to well below theoretical values, and only 2.60 lbm must leak out to fully depressurize to operating temperatures, it is conservative to conclude that the valve would have been fully depressurized within two to three days of termination of a significant bonnet temperature rise, as occurs during unit startup.
>
> Therefore, based on the operating profile for Susquehanna SES-1 restart following the sixth refueling and inspection outage in Spring 1992, (Attachment 3) it is reasonably concluded that the Unit 1 HPCI system was inoperable for not more than eight consecutive days during unit restart. Note that the incidence of overpressurization leading up to pressure seal damage would have been the longest duration of inoperability."

Please refer to the calculation for additional detail which supports our belief that the period of inoperability was of limited duration, and occurred on the first unit startup following the valve refurbishment in the Spring of 1992, which left the valve exceptionally leak-tight. That first occurrence of overpressurization resulted in deformation of pressure seal components which indicated the pressurization event was alleviated through the pressure seal.

The HPCI injection valve experienced large feedwater thermal transients during subsequent unit startups prior to the November 1995 disassembly which discovered the damage. However, repeat instances of thermal overpressurization of the magnitude of the first occurrence were unlikely because of the pressure seal damage. Whether or not the valve was inoperable during any interim unit startup periods is indeterminate.

2. Event Description

Based on LER 95-013-00, the Event Description 3rd para. states: "The valve was considered inoperable for an indeterminate amount of time between April 1992...and November 1995."

Please note that the LER was submitted prior to detailed analysis of the period of inoperability, which is documented under EC-052-1029, as detailed under Comment 1, above. The maximum known period of inoperability is calculated to be the first 8 calendar days of SSES-1 Cycle 7. Any additional window of inoperability would be in conjunction with a significant feedwater thermal transient, particularly unit startup sequences.

Additional intervals of inoperability are questionable on the basis that permanent deformations in the pressure seal region indicate that self-alleviation during the first thermal overpressurization event had left the valve less capable of retaining high pressures (although subsequent 10CFR50 Appendix J leakage rate testing during the two intervening refueling and inspection outages yielded acceptable results at the relatively low test pressures).

3. Modeling Assumptions

The 1st para. of Modeling Assumptions states:

> "This analysis assumes that the HPCI system injection valve was unavailable due to pressure locking or valve damage once the overpressurization condition occurred. Since the date when the valve damage occurred is unknown, the best estimate is one-half of the time since the valve was previously disassembled, or 22 months. This period is longer than the longest unavailability period used in an Accident Sequence Precursor (ASP) analysis, one year. For the purpose of this analysis, the valve was assumed to be unavailable for 6134 h. This period corresponds to one year of operation with the unit critical 70% of the time."

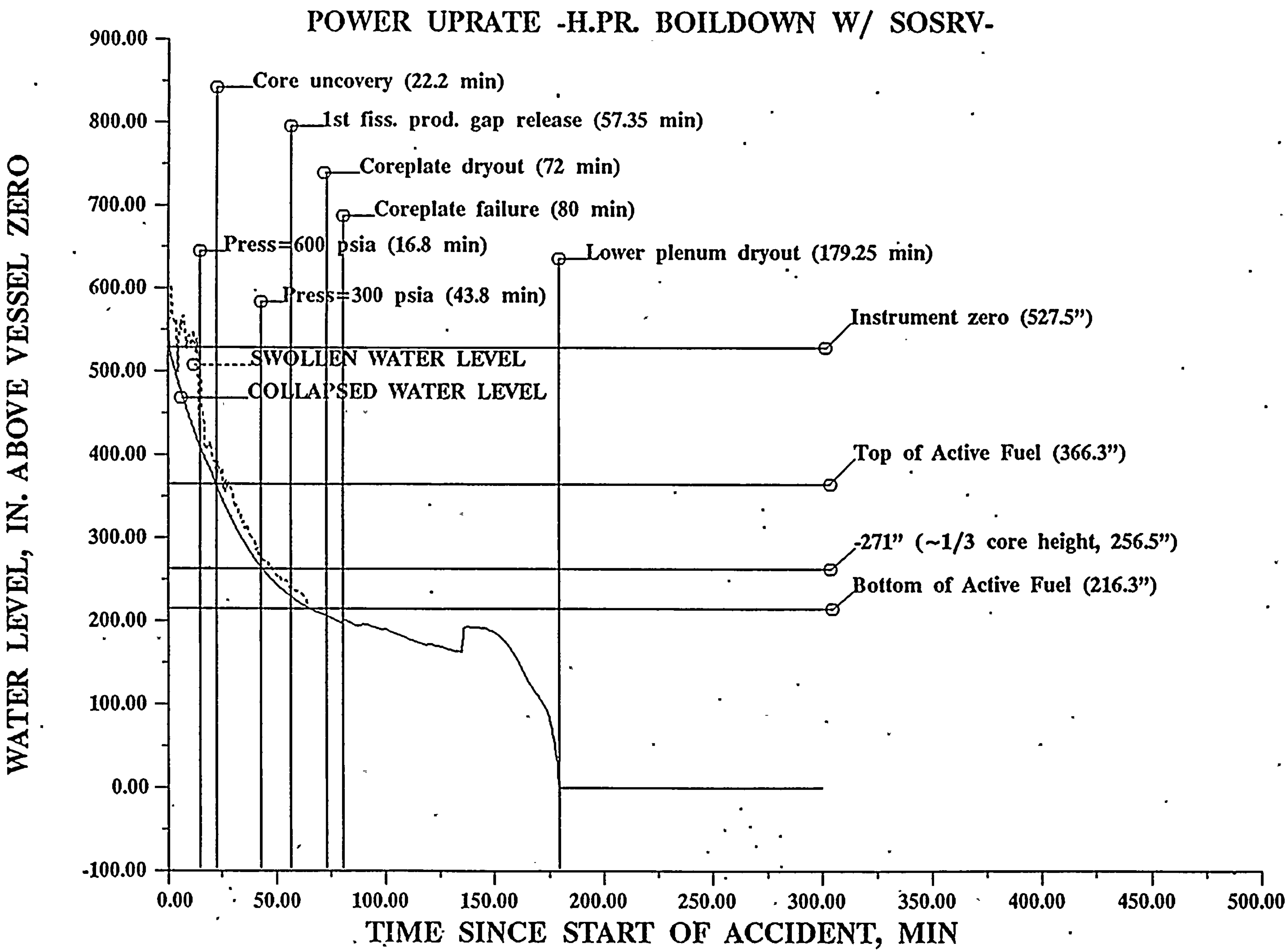
PP&L believes that 6134 hours is overly conservative, and is not consistent with the thermally induced pressurization phenomenon, nor the material condition of the valve following the pressurization event. As detailed in EC-052-1029, only 2.60 lbm of water had to leak out to fully depressurize the HPCI injection valve to normal operating pressure. PP&L does not believe it is realistic to assume that a valve with a damaged pressure seal would not equalize with line pressure once temperatures had stabilized. Per Conclusion (D) of EC-052-1029:

> "Based on a conservative, quantitative assessment of depressurization time from 7000 psig to 1140 psig, using the manufacturer's leak rate acceptance criterion for 2200 psig testing for a pristine valve, the valve would be depressurized within 42 to 56 hours following stabilization of bonnet water temperature, depending on leakage

pathway (i.e., 41.78 hours for leakage past pressure seal or stem packing; 42.60 hours for seat leakage to the HPCI system; and 55.90 hours for seat leakage to the Feedwater system)."

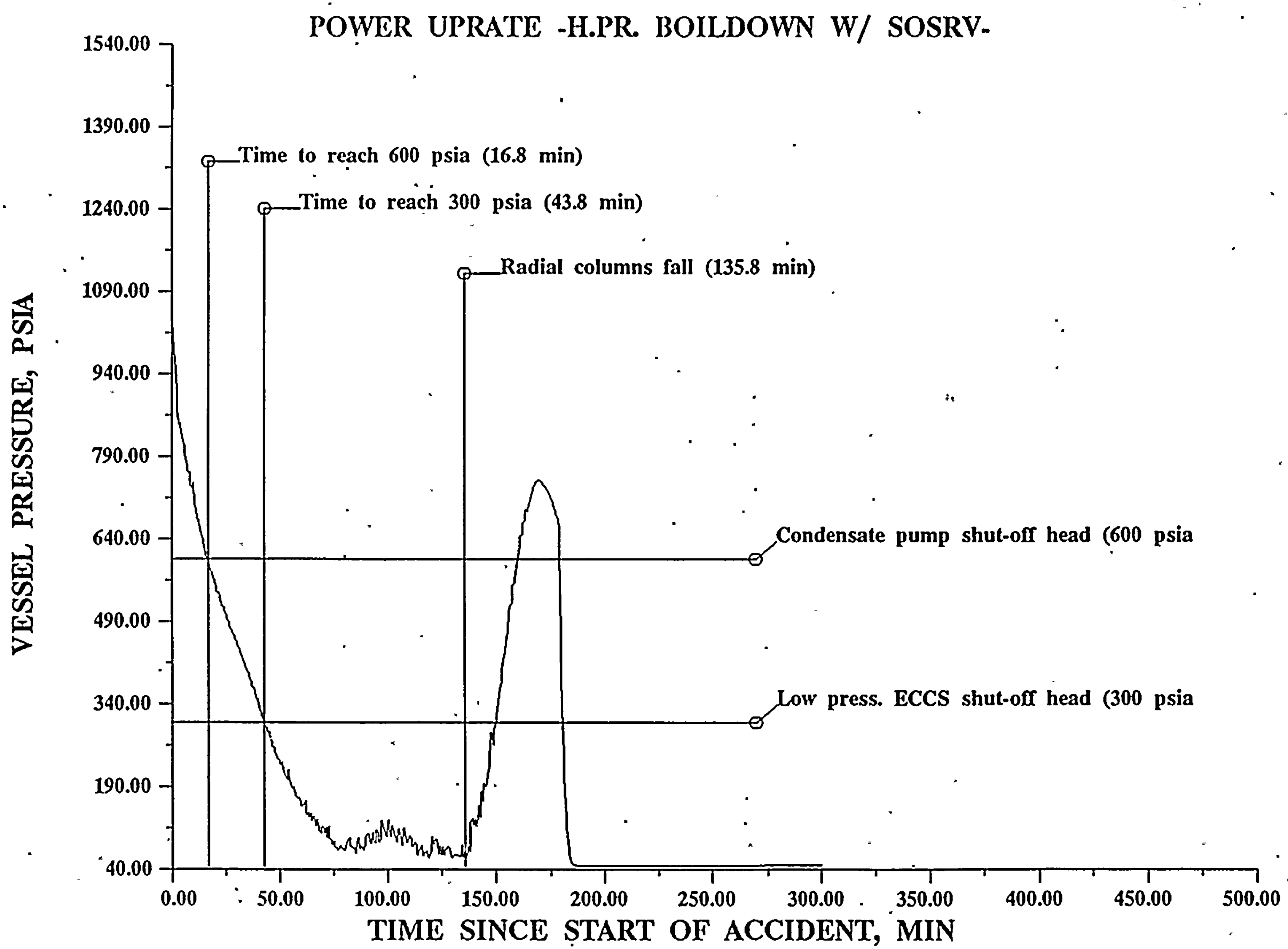
Based on the operating profile for Susquehanna SES-1 restart following the sixth refueling and inspection outage in Spring 1992, EC-052-1029 concluded that the Unit 1 HPCI system was inoperable for not more than eight consecutive days during unit restart.

Furthermore, the degree of physical damage sustained, in and of itself did not degrade the ability of the HPCI injection valve to perform its safety functions. This is based on successful inservice testing (including static diagnostic VOTES testing) during the two intervening refueling and inspection outages between April 1993 and November 1995.



POWER UPRATE -H.PR. BOILDOWN W/ SOSRV-
WATER LEVEL, IN. ABOVE VESSEL ZERO
TIME SINCE START OF ACCIDENT, MIN
Core uncovery (22.2 min)
1st fiss. prod. gap release (57.35 min)
Coreplate dryout (72 min)
Coreplate failure (80 min)
Press=600 psia (16.8 min)
Lower plenum dryout (179.25 min)
Press=300 psia (43.8 min)
Instrument zero (527.5")
SWOLLEN WATER LEVEL
COLLAPSED WATER LEVEL
Top of Active Fuel (366.3")
-271" (~1/3 core height, 256.5")
Bottom of Active Fuel (216.3")
900.00
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
-100.00
0.00
50.00
100.00
150.00
200.00
250.00
300.00
350.00
400.00
450.00
500.00

03/20/92



POWER UPRATE -H.PR. BOILDOWN W/ SOSRV-
1540.00
1390.00
1240.00
1090.00
940.00
790.00
640.00
490.00
340.00
190.00
40.00
VESSEL PRESSURE, PSIA
Time to reach 600 psia (16.8 min)
Time to reach 300 psia (43.8 min)
Radial columns fall (135.8 min)
Condensate pump shut-off head (600 psia
Low press. ECCS shut-off head (300 psia
0.00
50.00
100.00
150.00
200.00
250.00
300.00
350.00
400.00
450.00
500.00
TIME SINCE START OF ACCIDENT, MIN

03/20/92

1summary of results bwrsar version 1.6 SSES BWRSAR-BASE INPUT D

0rv leak/break flow taken 45% downcomer, 55% bottom head
0containment sprays do not operate
0ecc system does not operate
0output is in american engineering units
0

event	time (min)	primary pressure	fraction of clad reacted
0core uncovery	22.20	531.3	
01st fp gap rel.	57.35	178.0	
0clad melt starts	69.30	126.8	0.0162
0can. melt starts	69.75	119.7	0.0168
0fuel melt starts	70.75	119.0	0.0196
0deb.reloc.starts	71.40	114.6	
0coreplate dryout	72.00	106.2	0.0247
0c.b. melt starts	78.35	72.2	0.0597
0coreplat.fails 2	79.90	75.8	0.0689
0coreplat.fails 6	80.20	102.6	0.0711
0coreplat.fails 8	80.20	102.6	0.0711
0coreplat.fails 4	80.30	95.3	0.0711
0coreplat.fails 7	87.20	74.8	0.1196
0coreplat.fails 1	89.30	106.9	0.1433
0coreplat.fails 5	89.30	106.9	0.1433
0coreplat.fails 3	94.55	125.8	0.2014
0coreplat.fails10	98.60	110.7	0.2436
0coreplat.fails 9	119.60	65.6	0.4158
0rad.col. 1 falls	135.81	51.5	0.5224
0rad.col. 2 falls	135.81	51.5	0.5224
0rad.col. 5 falls	135.81	51.5	0.5224
0rad.col. 6 falls	135.81	51.5	0.5224
0rad.col. 7 falls	135.81	51.5	0.5224
0rad.col. 8 falls	135.81	51.5	0.5224
0l.plenum dryout	179.25	664.2	0.6879
0crgts fail	235.51	45.6	0.6879
0inst.tub.fails-2	271.85	46.7	
0inst.tub.fails-2	275.85	46.7	
0inst.tub.fails-2	281.15	46.8	