APR 25 1990

Mr. H. G. Stanley
Superintendent of Plant
Susquehanna Steam Electric Station
Pennsylvania Power and Light Company
Two North Ninth Street
Allentown, PA 18101

Dear Mr. Stanley:

An analysis has been performed of the safety significance of an event which occurred at Susquehanna Unit 1 on February 3, 1990. Loss of RPS bus "B" caused loss of shutdown cooling. The event and the associated circuit breaker problem adversely impacted the ability of the plant to provide uninterrupted shutdown cooling to remove core decay heat. A copy of our report describing the analysis performed is enclosed for your information and use.

The analysis of this event was performed using techniques developed by the NRC's Accident Sequence Precursor (ASP) program. The ASP program methods allow estimating the significance of combinations of operational events and plant conditions. The technique in brief consists of coupling actual or postulated initiating events with actual or postulated plant system response to quantitatively estimate the significance of operational events. The mechanics of this technique involve mapping the degradations, failures, and pertinent plant conditions onto an event tree to show the most likely postulated scenarios and, when the tree is quantified, provide a perspective of the significance of the event.

The operating situation and modeling provided by the enclosed report may be pertinent to analyses you may do for loss of decay heat removal at shutdown for the Susquehanna Plant Units. If you would like to discuss the attached analysis, we would be happy to do so. Also, if you have new information on the equipment operability which could change some of the assumptions of the enclosed analysis, we would welcome the information. Although the risk significance of this event was moderate, the analysis indicates the need to examine these types of events which can disable or fail the shutdown cooling function. A copy of the 1988 ASP annual report is also enclosed to help put this analysis in perspective in terms of other operating events. The attached report on the Susquahanna event is provided for your information and use. No action is required or requested by this letter.

Original signed by
J. E. Rosenthal for
Thomas M. Novak, Director
Division of Safety Programs
Office for Analysis and Evaluation
of Operational Data
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

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Enclosures: As stated

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ACCIDENT SEQUENCE PRECURSOR PROGRAM EVENT ANALYSIS

Preliminary

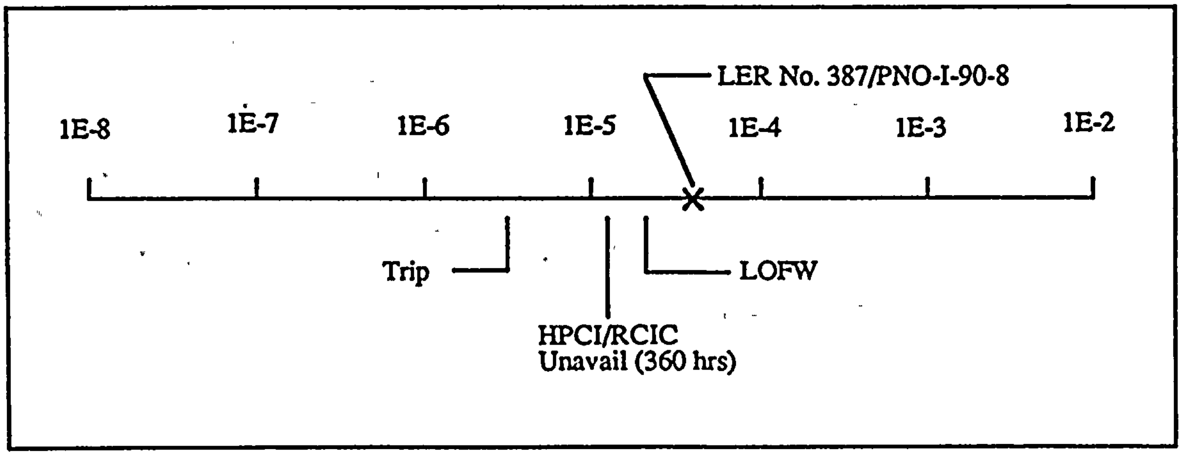
This analysis was based on information which is preliminary in nature and subject to revision.

LER No.:	387/PNO-I-90-8
Event Description:	Loss of RPS bus "B" causes loss of shutdown cooling.
Date of Event:	February 3, 1990
Plant:	Susquehanna Unit 1

Summary:

A ground fault resulted in the loss of Reactor Protection System (RPS) bus "B". The RPS buses provide power to the isolation control system and the de-energization of RPS bus "B" resulted in the isolation of a shutdown cooling suction supply valve causing a loss of shutdown cooling.

Core cooling was maintained using safety relief valves, control rod drive pumps, and the suppression pool cooling mode of RHR. The conditional probability of subsequent core damage associated with the event is conservatively estimated to be 4.1×10^{-5}. The relative significance of this event compared to other postulated events at Susquehanna is shown below:



Event Description:

Susquehanna Unit One was shut down on February 1, 1990 for maintenance. Two days later

a test of the alternate power supply to RPS bus "B" was conducted. When the normal power supply was de-energized, the alternate supply failed to close in on the bus. Manual closure of the normal and alternate supplies was attempted but they immediately tripped open. Subsequent investigation revealed that an insulator on a circuit breaker fed by RPS bus "B" had developed a crack which resulted in a ground fault on the bus.

The RPS system provides power to the isolation control system. Loss of power on RPS bus "B" resulted in isolation of certain valves controlled by this system including a Residual Heat Removal (RHR) System shutdown cooling suction supply valve. With shutdown cooling lost, reactor water temperature began to rise. Operators stemmed the coolant temperature rise at 252 F. and 31 psia by opening three Safety Relief Valves (SRVs) and providing makeup from the control rod drive system. Suppression pool cooling was used to remove the heat transferred to the suppression pool by the SRVs.

The defective circuit breaker was replaced and RPS bus "B" was re-energized. This permitted a return to shutdown cooling.

Event-Related Plant Information:

There are two RPS buses for each unit, each of which is normally fed by a high-inertia motor-generator (MG) set. The MG sets are fed from 480 volt boards and generate 120 Volts AC (VAC). There are alternate 120 VAC sources which may feed the RPS buses but these are interlocked to ensure that no more than one bus is fed from its alternate supply at any given time. Interlocks also exist to ensure that the MG sets are not paralleled with the alternate supplies.

In addition to providing power for the reactor protection system, the RPS buses provide power to the isolation control system. This system operates valves as required to isolate the reactor vessel and/or primary containment to conserve coolant inventory and prevent the release of radioactive materials. Loss of power to RPS bus "B" de-energizes all "B" train logic in the isolation control system and results in the isolation of the Reactor Water Cleanup System and the shutdown cooling supply to the RHR system.

The normal shutdown cooling flow path is from Recirculation loop B, through inboard and outboard containment isolation valves, to either of two pairs of RHR pumps and thence to either of two RHR heat exchangers which are cooled by RHR service water. The cooled water is then returned to the reactor vessel through either "A" or "B" recirculation loop. Isolation of either shutdown cooling supply valve renders the shutdown cooling system inoperable and other means of decay heat removal must be provided when the unit is shut down.

Susquehanna's "Loss of RHR Shutdown Cooling Mode" procedure required that operators provide for natural or forced reactor coolant circulation within the vessel, that they demonstrate operability of alternate methods of decay heat removal using RHR/Low Pressure Coolant Injection (LPCI) system and core spray system, and that they reestablish cooling by one of several methods. These methods involve control rod drive cooling, condensate transfer through keepful and/or shutdown cooling flush, condensate, RHR, core spray, RWCU recirculation/letdown, and SRV blowdown.

ASP Modelling Assumptions and Approach:

An event tree model of sequences to core damage given a total loss of shutdown cooling was developed considering the potential unavailability of mitigating features described in Susquehanna procedure ON-149-001, Rev. 7, "Loss of RHR Shutdown Cooling Mode." This event tree, shown in Fig. 1, addresses RPV makeup via the control rod drive, condensate, core spray, or LPCI systems. Heat removal and letdown is via the SRVs (to the suppression pool) or the RWCU system. If the SRVs are used, then suppression pooling cooling is also assumed required. If the RWCU system is utilized, then the model assumes that the condensate system is required for makeup. Both this assumption and the requirement for short-term suppression pool cooling are most likely conservative, considering the shutdown decay heat levels which exist during cold shutdown.

Additional conservatism exists in that not all makeup/letdown combinations identified in ON-149-001 are included in the model.

Fig. 1 includes the following core damage sequences:

Sequence	Description
1	Successful use of the SRVs and SP cooling for heat removal, but failure to provided RPV makeup via the CRD, condensate, core spray and LPCI systems.
2	Failure of SP cooling following successful opening of the SRVs. RWCU is successful but makeup via the condensate system fails.
3	Failure of SP cooling following successful opening of the SRVs. RWCU fails to provide letdown/heat removal.
4	Similar to sequence 2 except the SRVs fail to open.
5	Similar to sequence 3 except the SRVs fail to open.

The following branch probability values were utilized with the event tree.

Branch	Failure Probability
Failure of at least three SRVs to open. The SRV/ADS failure probability estimated from precursor data was utilized, with a non-recovery estimate of 0.12, to take into account the long time period available for repair.	4.4×10^{-4}
Failure of SP Cooling. A failure probability of 2×10^{-3} was assumed (this value is also used in the current at-power ASP models), with a non-recovery estimate of 0.12.	2.4×10^{-4}
Unavailability of RWCU. A failure probability of 0.05 was assumed. RWCU is isolated upon loss of RPS bus "B." The containment isolation signal must be unblocked or the RWCU isolation valve manually opened. The failure probability for this was assumed to be 0.04. In addition, a failure probability of 0.01 for the RWCU system itself was also assumed.	5.0×10^{-2}
Unavailability of CRD Cooling. *	1.0×10^{-2}
Unavailability of makeup via the condensate system. A failure probability of 0.01 was assumed.	1.0×10^{-2}
Unavailability of core spray. *	1.0×10^{-3}
Unavailability of LPCI. Given SP cooling success, failure of LPCI involves failure to open the series RPV injection valves in both trains. A failure probability of 0.002 was assumed.	2.0×10^{-3}

* value currently used with current ASP models.

Failure to implement the loss of SDC procedure has not been specifically addressed in Figure 1. Based on the long estimated time to core uncovery (~16 hours based on simplified hand calculations) and the two year operator training cycle at Susquehanna, the likelihood of operator error is low, and equipment failure is assumed to dominate the core damage probability estimate.

Analysis Results:

Based on the model described above, a core damage probability of 4.1×10^{-5} is estimated. Because of the long response times associated with shutdown related events, and the potential for system unavailabilities during shutdown because of allowed maintenance, the uncertainty in the core damage probability estimate is high.

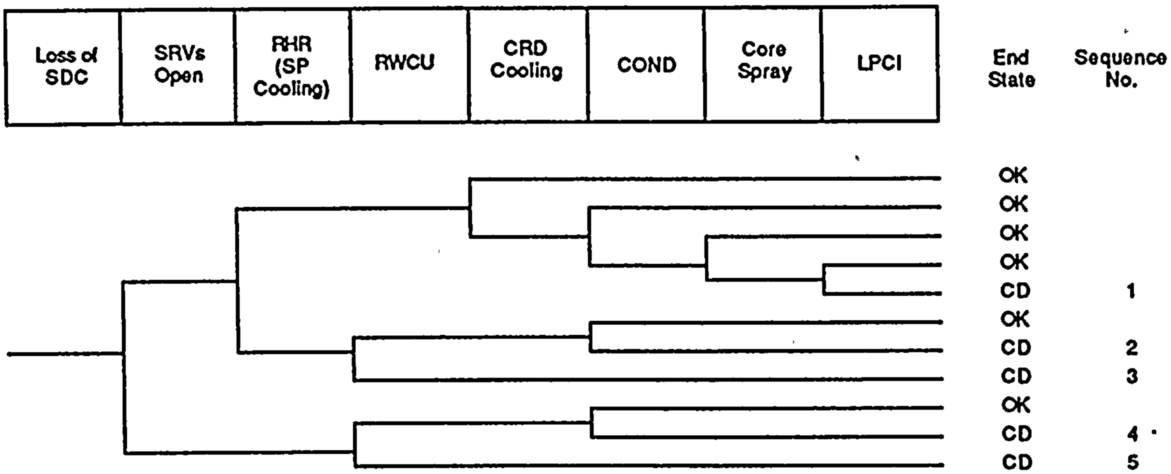


Fig. 1. Event Tree for Loss of Shutdown Cooling at Susquehanna 1