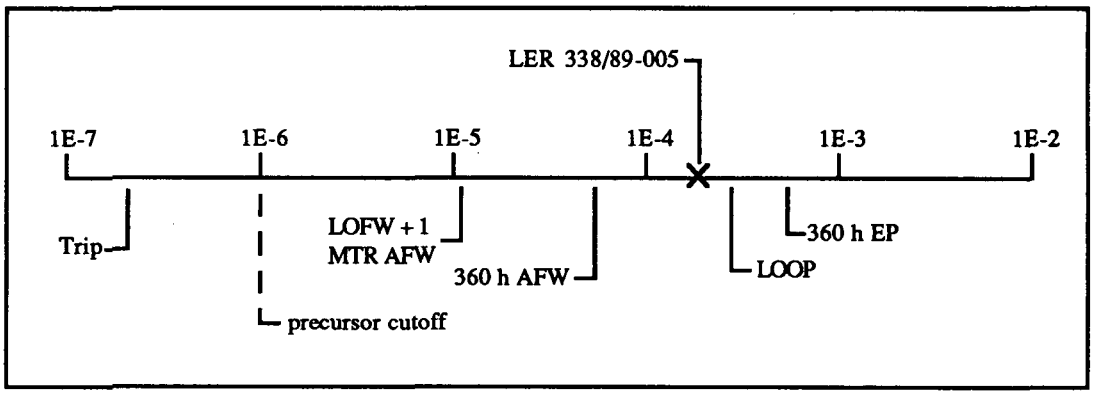
ACCIDENT SEQUENCE PRECURSOR PROGRAM EVENT ANALYSIS

LER No: 338/89-005
Event Description: Reactor trip due to MFW regulator valve closure, steam generator tube leak, and RHR suction valve failure
Date of Event: February 25, 1989
Plant: North Anna 1

Summary

A reactor trip occurred due to a steam-flow-to-feedwater-flow mismatch caused by a main feedwater valve failing closed. During the recovery from the trip, a 60- to 70-gpm steam generator (SG) tube leak was detected that was the result of a failed hot leg tube plug. Following cooldown for the leaking SG tube, the residual heat removal (RHR) system could not be placed in service because the suction isolation valve failed to remain open. The conditional probability of core damage associated with this event is estimated to be 1.9×10^{-4}. The relative significance of this event compared with other potential transients at North Anna is shown below.



Event Description

At 1407 h on February 25, 1989, Unit 1 automatically tripped from 76% power. The initiating signal for the reactor trip was "C" SG steam-flow-greater-than-feedwater-flow mismatch coincident with a low SG level. The steam-flow-greater-than-feedwater-flow mismatch was caused by the closure of the "C" main feedwater regulating valve on the loss of control air. The valve lost control air because of the fatigue failure of the instrument air supply line around the fitting on the valve positioner.

Following the trip, indications of primary to secondary leakage were detected (later determined to be 74 gpm). SG "C" was identified as the source of the leak. Emergency boration, isolation of SG "C" AFW tubine-driven pump steam lines, and RCS cooldown and depressurization were initiated.

During the recovery from the tube leak, the residual heat removal system failed because the RHR suction isolation valve (1-RH-MOV-1701) failed to remain open. Once full open indication was received, the valve immediately stroked closed. The RHR system could not be placed in service for approximately 3 h and 10 min. The cause for the RHR suction isolation valve failing to remain open during cooldown was due to the failure of the high-pressure autoclosure relay. This failure generated a close signal when the valve reached the full open position.

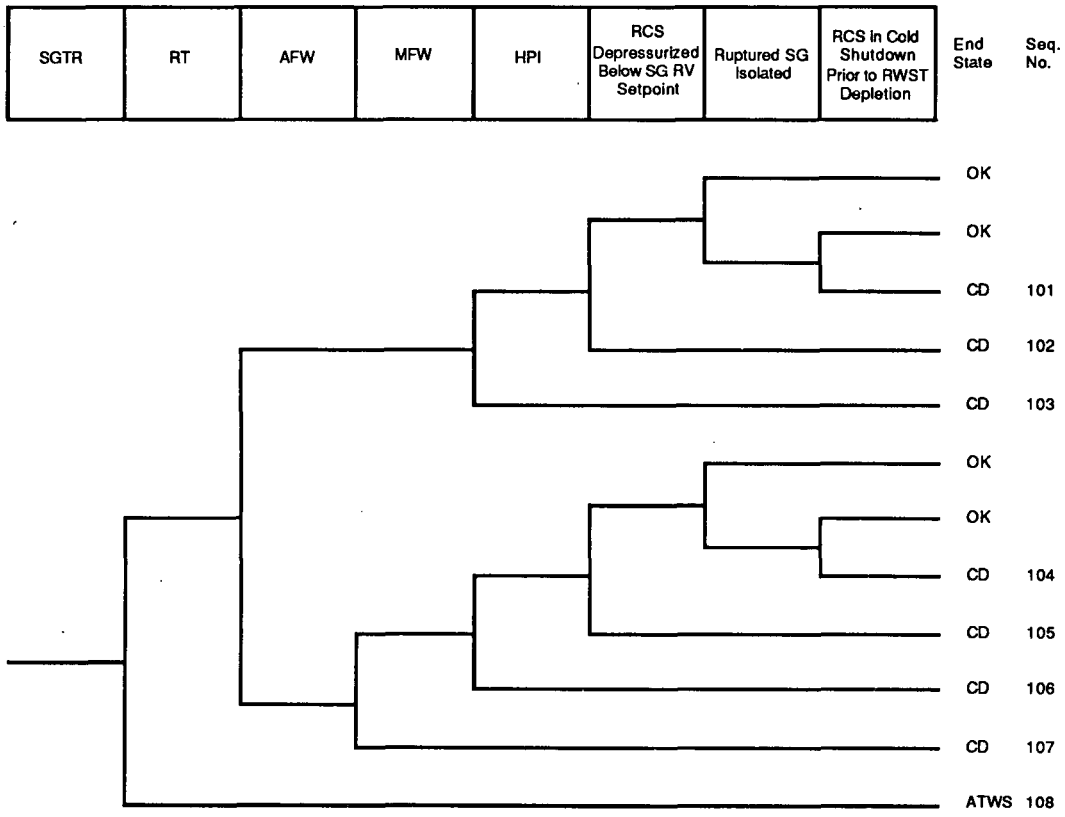
ASP Modeling Assumptions and Approach

This event was modeled as a steam generator tube leak with failure of the residual heat removal system. The probability of failing to locally recover RHR was assumed to be 0.12. This value is smaller than is usually assumed for local recovery in the ASP Program; however, the time period for recovery is long. The probability of a large tube rupture (300-500 gpm), given the observed 60- to 70-gpm leak, was assumed to be 0.1.

Potential core damage sequences associated with a tube rupture were modeled using the following event tree.

In these sequences, auxiliary feedwater (AFW) or main feedwater (MFW) is assumed required for initial core cooling, and high-pressure injection (HPI) is required for makeup of inventory lost through the break. Unavailability of HPI or AFW and MFW is assumed to result in core damage (sequences 103, 106, and 107). Because of RCS flow out of the break, bleed and feed cooling is not considered a viable core cooling method. If secondary-side cooling and HPI are successful, then isolation of the affected SG and reduction of RCS pressure below the SG relief valve setpoint are assumed to mitigate the event. In this case, flow out of the break is stopped, and secondary-side cooling using the remaining SGs provides for core cooling. Failure to reduce RCS pressure below the SG relief setpoint results in continued loss of RCS inventory. Since this inventory is not collected in the containment sump, no capability exists for high-pressure recirculation once RWST is depleted, and core damage results (sequences 102 and 105). In the event of successful reduction of RCS pressure below the SG relief valve setpoint, flow from the break is terminated. In this case, if the ruptured SG cannot be isolated, the event tree

recognizes the possibility that core cooling can still be maintained provided that the plant is placed in cold shutdown prior to depletion of RWST inventory. Failure to isolate the impacted SG and place the reactor in cold shutdown prior to RWST depletion is assumed to lead to core damage (sequences 101 and 104). Failure to trip (sequence 108) results in an ATWS sequence and is not developed further.



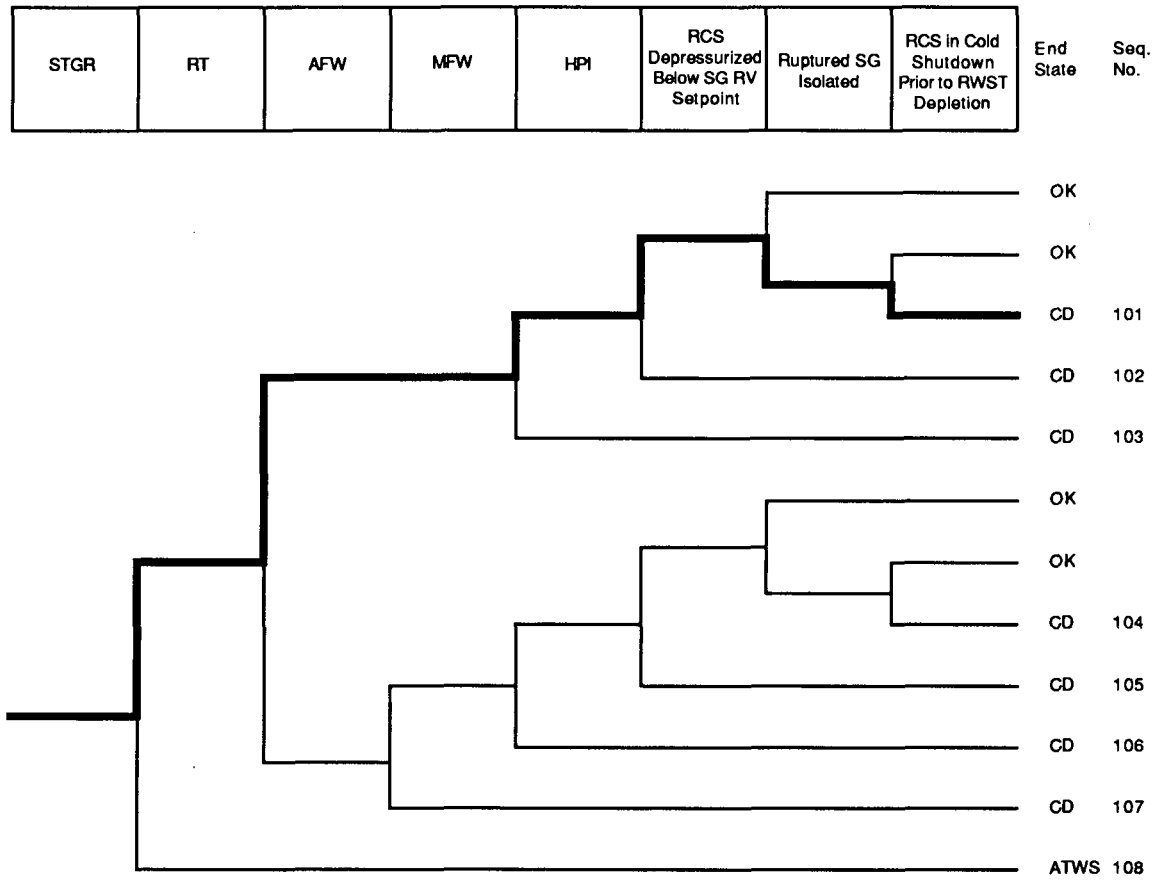
The following conditional branch probabilities were used in the analysis:

Branch	System	Nonrecovery	Operator Failure
STGR	1.0		
RT	2.8×10^{-4}*	0.12*	
AFW	3.8×10^{-4}*	0.26*	
MFW	0.2*	0.34*	
HPI	3.0×10^{-4}*	0.84*	
Ruptured SG Isolated	1.0×10^{-2}	1.0	
RCS Depressurized Below SG RV Setpoint	1.0×10^{-2}	1.0	4.0×10^{-4}
RCS in Cold Shutdown Prior to RWST Depletion	1.0×10^{-2}	1.0	4.0×10^{-4}

* Values are consistent with probability values used in other ASP calculations.

Analysis Results

The conditional probability of severe core damage estimated for this event is 1.9×10^{-4}. The dominant sequence for this event (highlighted on the following event tree), involves successful AFW, HPI, and RCS depressurization following the tube rupture, with subsequent failure to isolate the break and place the RCS in cold shutdown prior to RWST depletion.



Dominant core damage sequence for LER 338/89-005

CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS

Event Identifier: 338/89-005
Event Description: Reactor trip, SG tube leak and failed RHR system
Event Date: 02/25/89
Plant: PWR SGTR

INITIATING EVENT

NON-RECOVERABLE INITIATING EVENT PROBABILITIES

SGTR	1.0E-01

SEQUENCE CONDITIONAL PROBABILITY SUMS

End State/Initiator	Probability
CD	
SGTR	1.9E-04
Total	1.9E-04
ATWS	
SGTR	3.4E-06
Total	3.4E-06

SEQUENCE CONDITIONAL PROBABILITIES (PROBABILITY ORDER)

	Sequence	End State	Prob	N Rec**
101	SGTR -rt -afw -hpi -rcs.depr<sg.rv.setpoint ruptured.sg.isol R CS.COLD.PRIOR.TO.RWST.DEPL	CD	1.2E-04	1.2E-02
102	SGTR -rt -afw -hpi rcs.depr<sg.rv.setpoint	CD	4.1E-05	1.0E-01
103	SGTR -rt -afw hpi	CD	2.5E-05	8.4E-02
108	SGTR rt	ATWS	3.4E-06	1.2E-02

** non-recovery credit for edited case

SEQUENCE CONDITIONAL PROBABILITIES (SEQUENCE ORDER)

	Sequence	End State	Prob	N Rec**
101	SGTR -rt -afw -hpi -rcs.depr<sg.rv.setpoint ruptured.sg.isol R CS.COLD.PRIOR.TO.RWST.DEPL	CD	1.2E-04	1.2E-02
102	SGTR -rt -afw -hpi rcs.depr<sg.rv.setpoint	CD	4.1E-05	1.0E-01
103	SGTR -rt -afw hpi	CD	2.5E-05	8.4E-02
108	SGTR rt	ATWS	3.4E-06	1.2E-02

** non-recovery credit for edited case

SEQUENCE MODEL: c:\asp\1989\PWRSGTR.CMP
BRANCH MODEL: c:\asp\1989\PWRSGTR.NEW
PROBABILITY FILE: c:\asp\1989\PWR_BSL1.PRO

No Recovery Limit

BRANCH FREQUENCIES/PROBABILITIES

Branch	System	Non-Recov	Opr Fail
SGTR	5.0E-03 > 5.0E-03	1.0E+00 > 1.0E-01	
Branch Model: INITOR			
Initiator Freq:	5.0E-03		
rt	2.8E-04	1.2E-01	
afw	3.8E-04	2.6E-01	
mfw	2.0E-01	3.4E-01	
hpi	3.0E-04	8.4E-01	

ruptured.sg.isol	1.0E-02	1.0E+00	
rcs.depr<sg.rv.setpoint	1.0E-05	1.0E+00	4.0E-04
RCS.COLD.PRIOR.TO.RWST.DEPL	1.0E-02 > 1.0E+00	1.0E+00 > 1.2E-01	4.0E-04
Branch Model: 1.OF.1+opr			
Train 1 Cond Prob:	1.0E-02 > Failed		

* branch model file
** forced

Minarick
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