B.9 LER No. 272/83-011 and -012

Event Description: Transient with Automatic Reactor Trip Capability Failed

Date of Event: February 22, 1983

Plant: Salem 1

B.9.1 Summary

On February 22, 1983, during routine startup of Salem 1 at 20% power, both reactor trip breakers failed to open automatically on receipt of a low-low steam generator level reactor trip signal. A manual trip was initiated approximately 3 seconds after the automatic trip breaker failed to open, and was successful. Investigation focused on the reasons for the manual trip and the fact that both reactor trip breakers had failed was not revealed. A similar event occurred on February 25th, at 12% power. Both reactor trip breakers failed to open automatically on receipt of a valid low-low steam generator level reactor trip signal. A manual trip was initiated 25 seconds later, and was successful. Following the trip, the plant was placed in a stable shutdown condition. Investigation revealed that mechanical binding of the latch mechanism in the breaker undervoltage trip attachment failed both breakers in both events. These attachments were replaced with new devices and tested extensively. The combined conditional core damage probability estimate for these events is 4.6×10^{-3}.

B.9.2 Event Description

On February 22, 1983, during routine startup of Salem 1 at 20% power, a manual trip was initiated due to rapidly decreasing steam generator levels. Both reactor trip breakers failed to open 3 seconds earlier upon receipt of a valid low-low steam generator reactor trip signal. The event occurred due to a transient which was initiated by the loss of No. 1F 4-kV Group bus during the transfer to the auxiliary power transformer. An automatic safety injection occurred and No. 11 reactor coolant pump tripped for no apparent reason. Loss of pressurizer spray increased the pressurizer pressure to the power-operated relief valve (PORV) setpoint and two PORVs actuated. The PORVs mitigated the transient and no damage to the reactor coolant system occurred. The plant was then placed in safe shutdown. Investigations focused on the manual trip and the other related event, and the failure of the trip breakers was missed.

On February 25, 1983, during startup at 12% power, a low-low steam generator level signal was generated by the reactor trip system. Both reactor trip breakers failed to open and remained closed until operators manually tripped the plant 25 seconds later. During reviews of this event and the February 22nd event, it was determined that the breakers had also failed during the February 22nd event. Investigation of the reactor trip system revealed that the breakers had failed to open automatically due to mechanical binding of the latch mechanism in the undervoltage trip attachment. Since the manual trip operated the shunt trip device as well as the undervoltage trip attachment, the manual trip succeeded. Following the manual trip, the plant was placed in a safe shutdown condition.

B.9.3 Additional Event-Related Information

The Salem 1 reactor protection system (RPS) uses two independent channels and trains which consist of sensors, transmitters, relays and trip breakers to detect and protect against unsafe plant conditions. When an unsafe plant condition occurs, the RPS signals the trip breakers to open and de-energize the rod drive mechanisms, resulting in a shutdown, and also transfers the information to the safeguards equipment cabinet which in turn determines the type of accident and loads and starts the safety systems needed to mitigate the effect of the initiating event. The reactor trip breakers are ac circuit breakers positioned in series. When either trip breaker is tripped open, holding power to the control rods is lost and the rods drop into the core. Two mechanisms could open the trip breaker at the time of the event. The first mechanism is the undervoltage trip coil which, upon de-energization, would trip open the breaker. When the RPS signals the trip breakers, de-energization of the undervoltage trip coils occurs and the breakers open. The second mechanism for tripping open the breakers is through energizing the shunt trip coil. The shunt trip coils, once energized, will open the breakers. A manual scram would energize the shunt trip coils and open the breakers. Following the Salem failure-to-trip, the RPS was reconfigured to automatically actuate the shunt trip coils as well.

B.9.4 Modeling Assumptions

Because the initial failure to trip was not discovered until after the second failure, the impact of both transients was addressed in a single analysis. Both events were modeled as transients with a portion of the reactor trip system failed. The reactor trip system is modeled as a double-train system with a nonrecovery probability. Both trains represent the automatic portion of the reactor trip system. Each train is assumed to be dominated by the failure of a reactor trip breaker. One of two trip breakers must open in order for the reactor to automatically scram. The nonrecovery probability is the likelihood that operators will not manually scram the reactor. In this event, both trip breakers failed to operate correctly, thus both reactor trip system trains were set to failed. The operators successfully manually scrammed the reactor, so the nonrecovery probability was left at its default value.

The February 25, 1983, transient occurred at relatively low power. This low power level may have required reduced AFW flow and fewer relief valves for primary pressure protection than assumed in the ATWS model (see appendix A) used in this analysis. However, since development of such specialized success criteria is beyond the scope of this effort, both transients were assessed using the same model.

B.9.5 Analysis Results

The conditional core damage probability estimate for each transient is 2.3×10^{-3}, resulting in an overall estimate for the combined event of 4.6×10^{-3}. The dominant sequences are all postulated ATWS sequences, with the highest contributor involving failure to trip, a successful AFW given ATWS, and failure of the emergency boration system. The dominant sequence is highlighted on the event tree in Figure B.9.1.

LER 272/83-013 reported the occurrence of an all-rods-out positive moderator temperature coefficient (MTC) prior to the transient on February 22nd. Since the value of the MTC at the time of the trip breaker failures is not known, the high MTC was not addressed in the analysis. According to NUREG/CR 4550, Vol. 3, Rev.1, Part 1, *Analysis of Core Damage Frequency: Surry, Unit 1 Internal Events,* an MTC of -7pcm/F is the critical value above which, if the plant is at high power, RCS pressure cannot be maintained below 3200 psi; transients initiated at low power have no restrictions on MTC, since the PORVs would be able to maintain the pressure below 3200 psi, and high power is assumed to be above 25% power. In this event, power was never greater than 20%. However, had the transient been initiated at a power above 25%, when the MTC was greater than -7 pcm/F, mitigation may have been affected since RCS pressure may have exceeded 3200 psi.

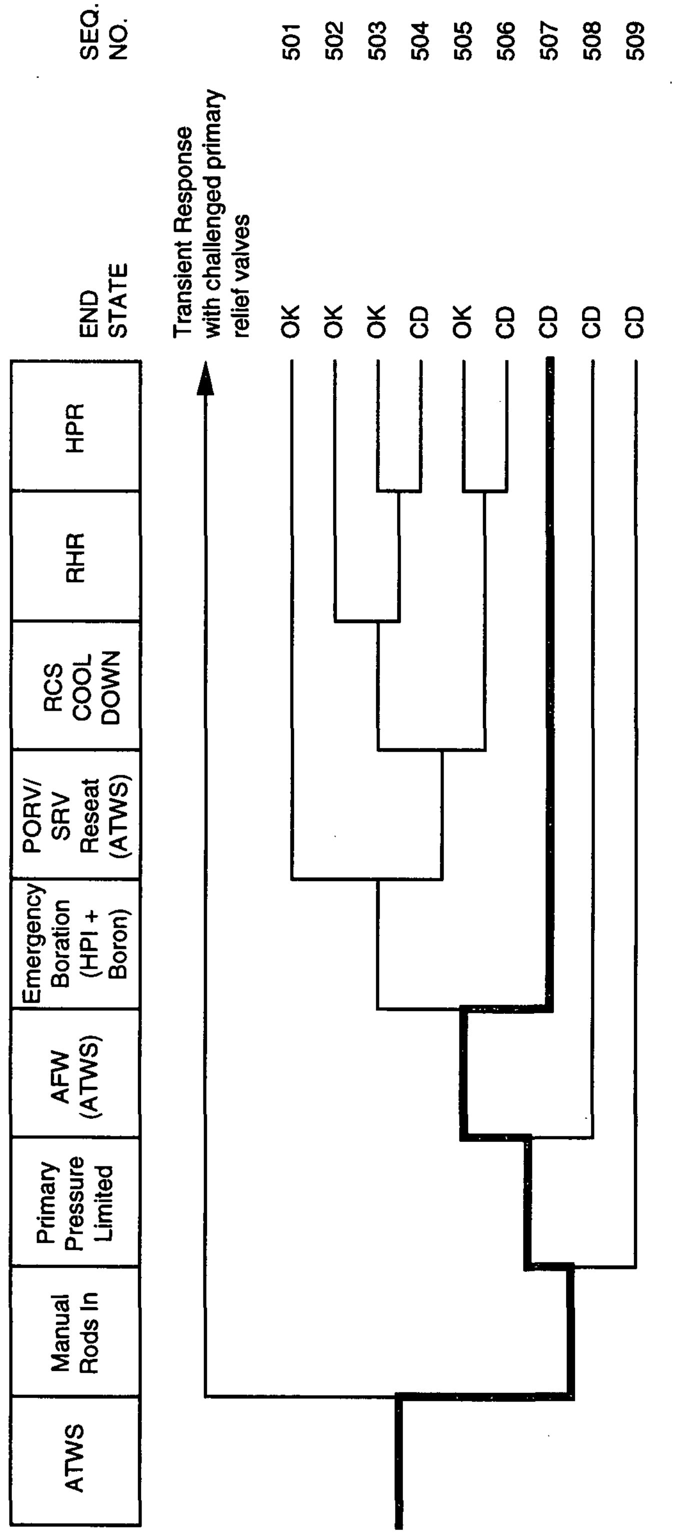

Figure B.9.1 Dominant core damage sequence for LER 272/83-011 and -012

CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS

Event Identifier: 272/83-011 and -012
Event Description: Transient with automatic trip breakers failed
Event Date: February 22, 1983
Plant: Salem 1

INITIATING EVENT

NON-RECOVERABLE INITIATING EVENT PROBABILITIES

TRANS	1.0E+00

SEQUENCE CONDITIONAL PROBABILITY SUMS

End State/Initiator	Probability
CD	
TRANS	2.3E-03
Total	2.3E-03

SEQUENCE CONDITIONAL PROBABILITIES (PROBABILITY ORDER)

	Sequence	End State	Prob	N Rec**
507	trans RT -prim.press.limited -afw/atws emrg.boration	CD	9.9E-04	1.0E-01
509	trans RT prim.press.limited	CD	8.8E-04	1.0E-01
508	trans RT -prim.press.limited afw/atws	CD	4.3E-04	1.0E-01

** non-recovery credit for edited case

SEQUENCE CONDITIONAL PROBABILITIES (SEQUENCE ORDER)

	Sequence	End State	Prob	N Rec**
507	trans RT -prim.press.limited -afw/atws emrg.boration	CD	9.9E-04	1.0E-01
508	trans RT -prim.press.limited afw/atws	CD	4.3E-04	1.0E-01
509	trans RT prim.press.limited	CD	8.8E-04	1.0E-01

** non-recovery credit for edited case

SEQUENCE MODEL: c:\aspcode\models\pwrb8283.cmp
BRANCH MODEL: c:\aspcode\models\saleml.82
PROBABILITY FILE: c:\aspcode\models\pwr8283.pro

No Recovery Limit

BRANCH FREQUENCIES/PROBABILITIES

Branch	System	Non-Recov	Opr Fail
trans	1.2E-03	1.0E+00	
loop	1.6E-05	5.3E-01	
loca	2.4E-06	5.4E-01	
sgtr	1.6E-06	1.0E+00	
RT	2.8E-04 > 1.0E+00	1.0E-01	
Branch Model: 1.OF.2			
Train 1 Cond Prob:	1.5E-03 > Failed		
Train 2 Cond Prob:	1.9E-01 > Failed		
rt(loop)	0.0E+00	1.0E+00	
afw	3.8E-04	4.5E-01	
afw/atws	4.3E-03	1.0E+00	
afw/ep	5.0E-02	3.4E-01	
mfw	2.0E-01	3.4E-01	1.0E-03
porv.chall	4.0E-02	1.0E+00	
porv.chall/afw	1.0E+00	1.0E+00	
porv.chall/loop	1.0E-01	1.0E+00	
porv.chall/sbo	1.0E+00	1.0E+00	
porv.reseat	2.0E-02	1.1E-02	
porv.reseat/ep	2.0E-02	1.0E+00	
srv.reseat(atws)	1.0E-01	1.0E+00	
hpi	1.0E-05	8.9E-01	
feed.bleed	2.0E-02	1.0E+00	1.0E-02
emrg.boration	0.0E+00	1.0E+00	1.0E-02
recov.sec.cool	2.0E-01	1.0E+00	
recov.sec.cool/offsite.pwr	3.4E-01	1.0E+00	
rcs.cooldown	3.0E-03	1.0E+00	1.0E-03
rhr	2.2E-02	7.0E-02	1.0E-03
rhr.and.hpr	1.0E-03	1.0E+00	1.0E-03
hpr	4.0E-03	1.0E+00	1.0E-03
ep	5.4E-04	8.9E-01	
seal.loca	2.7E-01	1.0E+00	
offsite.pwr.rec/-ep.and.-afw	2.2E-01	1.0E+00	
offsite.pwr.rec/-ep.and.afw	6.7E-02	1.0E+00	
offsite.pwr.rec/seal.loca	5.7E-01	1.0E+00	
offsite.pwr.rec/-seal.loca	7.0E-02	1.0E+00	
sg.iso.and.rcs.cooldown	1.0E-02	1.0E-01	
rcs.cool.below.rhr	3.0E-03	1.0E+00	3.0E-03
prim.press.limited	8.8E-03	1.0E+00	

* branch model file
** forced