B.12 LER Number 269/92-008

Event Description: Both Keowee Emergency Power Hydro Units Unavailable

Date of Event: July 16, 1992

Plant: Oconee 1, 2, and 3

B.12.1 Summary

With all three Oconee units at 100% power and emergency power source Keowee 1 unavailable because of maintenance, a failed fuse was discovered in the control power circuit for an auxiliary power breaker on Keowee 2. This rendered Keowee 2 also unavailable. Both emergency power sources were unavailable for 34 h. The conditional core damage probability estimated for this event is 2.8×10^{-6}. The relative significance of this event compared to other postulated events at Oconee is shown in Fig. B.18.

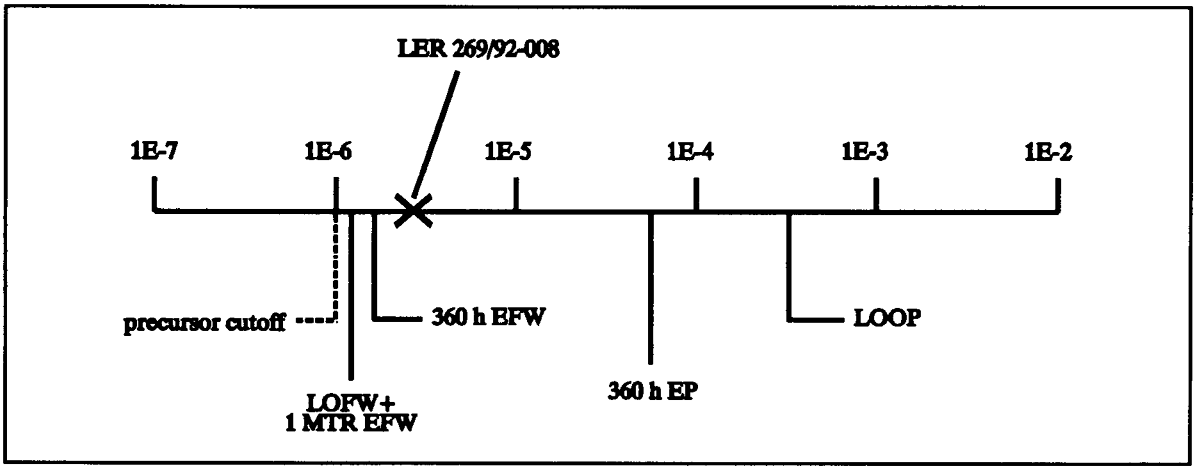

Fig. B.18. Relative event significance of LER 269/92-008 compared with other potential events at Oconee.

B.12.2 Event Description

On July 16, 1992, with all three Oconee units at 100% power, Keowee 1 was removed from service for maintenance at 1515 hours. Consistent with the Oconee Technical Specifications, Keowee 2 was aligned to the underground path.

At 1200 hours, the hydro operations specialist (HOS) at Keowee found the green (trip) control power indicator light for breaker ACB-8 (the alternate power source for Keowee 2 auxiliary loads) glowing less

brightly than expected. At 1430 hours, the red (close) control power indicator light for ACB-8 was also found to be glowing, but not as brightly as the "trip" light. The HOS concluded that the problem with the lights was caused by dirty contacts and was not an operability concern, and therefore decided to wait to investigate the problem until Keowee 2 was taken out of service for maintenance (scheduled for the next day).

Due to modification delays, Keowee 1 remained out of service. On July 17, 1992, at 1200 hours, the HOS and other personnel began to investigate the cause of the lighted control power indicator lights. At about 1330 hours, it was determined that the fuse feeding the positive circuit in ACB-8 had blown. With the positive fuse blown, a bypass series circuit path illuminated both indicator lights. In addition, the negative fuse was found to be rated at 15 amperes, instead of the required 10 amperes. The HOS realized that an operability/limiting condition for operation concern existed and began to search for replacement fuses. Unsuccessful attempts were made to contact the Oconee Operations support manager and switchyard coordinator for assistance in resolving the operability issues related to the Keowee units.

At 1415 h, the HOS notified the Oconee 2 Unit supervisor that a blown fuse had been found in the positive circuit for ACB-8. The unit supervisor realized that this rendered Keowee 2 inoperable (with Keowee 2 aligned to the underground path, closure of ACB-8 is required to power Keowee 2 auxiliary loads). Since Keowee 1 was also out of service, the Oconee Technical Specifications required the standby buses to be energized from the Lee combustion turbines. At 1436 hours, Lee was notified that backup power was required.

The replacement fuses needed for ACB-8 were determined to be safety-related. When none could be located on-site, fuses from a spare breaker cabinet were used. These fuses appeared to be original equipment and were determined to be in good condition. After the fuses for ACB-8 were replaced, the breaker was tested and determined to be operable at 1509 hours.

At 1513 hours, Oconee Operations personnel were notified that Keowee 2 was operable. At 1528 hours, Lee notified Oconee that a gas turbine was in operation and that transformer CT-5 was energized. This was almost 2 h after Keowee 2 had been declared inoperable. The Lee operators had experienced trouble with the first gas turbine they had started, and a second turbine had to be started. The standby buses were never energized from the Lee gas turbine because Keowee 2 had been returned to service before Oconee received power from Lee.

B.12.3 Additional Event-Related Information

The Keowee Hydro Station, located approximately three-fourths of a mile east-northeast of the Oconee Nuclear Station, consists of two hydroelectric generators that generate at 13.8 kV. The two Keowee hydro units serve the dual functions of generating commercial power to the Duke Power system grid through the Oconee 230-kV switchyard and providing emergency power to the Oconee Station. When a Keowee unit is generating to the grid and an emergency start at Oconee occurs, it is separated from the 230-kV switchyard and continues to run in standby until needed. Upon loss of power from an Oconee generating unit and 230-kV switchyard, power is supplied from both Keowee units through two separate and independent paths. One path is a 4000-ft underground 13.8-kV cable feeder to transformer CT-4,

which supplies power to the 4160-V standby buses. The underground power path is connected at all times to one hydro unit on a predetermined basis through locked-closed breakers. The underground power path and the associated transformer are sized to carry full engineered safeguards auxiliaries of one Oconee unit plus auxiliaries for safe shutdown of the other two units. If a Keowee unit is to provide power to an Oconee unit through the underground power path (required by Technical Specifications if one of the Keowee units is out of service), then due to the limited capacity of CT-4, loadshed of non-essential loads occurs. The second path from Keowee is a 230-kV transmission line through breakers ACB-1 or ACB-2, via the yellow bus, to the startup transformer of each Oconee unit.

Keowee auxiliary power is required for the ac hydraulic oil pumps, which are used to pressurize the air pre-loaded accumulators that provide hydraulic oil pressure to the governor which controls the position (depending on load) of the wicket gates on the Keowee water turbine. The length of time that the Keowee units can run without ac auxiliaries is limited by the changing load to which the governor must respond. The utility has indicated in several LERs that one hour is the expected maximum time period of Keowee operation without ac auxiliaries.

A standby shutdown facility (SSF) is located in a separate building on the Oconee site. This facility, which is not normally manned, is capable of providing limited high-pressure injection for reactor coolant system (RCS) makeup and reactor coolant pump (RCP) seal cooling [provided an RCP seal loss-of-coolant accident (LOCA) does not occur]. It can also supply limited steam generator makeup. The facility includes a separate diesel generator which can power SSF loads in the event of a station blackout. SSF systems consist of single trains and are therefore not single-failure-proof.

A more detailed description of the Oconee emergency power system is included in the precursor analysis for LER 270/92-004, *Loss of offsite power with failed emergency power.*

B.12.4 Modeling Assumptions

The event was modeled as a postulated LOOP during the 34 h that both Keowee units were unavailable. Potential sequences associated with the event are described in Appendix A, Sect. A.3.1, PWR Loss of Offsite Power. These sequences were modified to address the Oconee-specific SSF, as described later in this section, and shown on the event tree included with this analysis documentation. The plant response observed during the event impacted the following branch on the event tree:

Emergency Power. Consistent with the analysis for LER 270/92-004, *Loss of Offsite Power with Failed Emergency Power*, October 19, 1992, the Keowee hydro units were assumed to fail after approximately 37 min without auxiliary power; once the supply of hydraulic oil in the accumulator tanks, used for wicket gate positioning, was consumed. When the Keowee on-call technician arrived during the October 19, 1992 event, he was able to quickly reset the locked-out and tripped breakers and restore auxiliary power. However, hydraulic oil was almost depleted by the time he arrived.

The probability of the on-call technician failing to arrive on-site and recover auxiliary power to Keowee Hydro prior to the loss of hydraulic oil was estimated to be 0.64, as described under Modeling Assumptions for the precursor analysis for LER 270/92-004. Use of an on-call technician was assumed

to be required except for the day shift, when adequate support was assumed available on-site to quickly correct the breaker problem and restore auxiliary power, if needed. This assumption results in a revised estimate for failing to recover Keowee of (16h/24h) $\times$ 0.64 = 0.43.

The Central Switchyard was also assumed available as an alternate source of power to the Standby Buses for plant-centered LOOPs. A probability of 0.12 (ASP nonrecovery class R3, see Appendix A, Sect. A.1) was assumed for failing to recover power from the Central Switchyard via transformer CT-5. This value was chosen because recovery appeared possible in the required time period from the control room. However, during a postulated LOOP with problems at Keowee, this recovery would be considered to be non-routine and burdened. During a postulated grid- or severe weather-related LOOP, the Central Switchyard was assumed to be unavailable. However, during a postulated grid-related LOOP, ac power was assumed to be recoverable in approximately 1 h using the Lee combustion turbines. A non-recovery probability of 0.12 was also assumed for this action, for the same reasons.

The frequency of LOOP and the probability of not recovering offsite power with a loss of emergency power at 37 min was estimated as described in Modeling Assumptions for LER 270/92-004, *Loss of Offsite Power with Failed Emergency Power*, October 19, 1992. The frequencies and probability values used in the calculations follow:

	LOOP Type		
	Plant-Centered	Grid-Related	Severe Weather-Related
LOOP frequency	1.3×10^{-5}/hr	1.6×10^{-6}/hr	1.1×10^{-6}/hr
P_{nrec} (LOOP)	0.15	0.48	0.93
P_{nrec} (emergency power)	0.43×0.12	0.43	0.43
P_{nrec} (ac power prior to battery depletion)	0.056	0.20×0.12	0.86

The use of the SSF as an alternate source of reactor coolant system (RCS) and steam generator (SG) makeup was also addressed in the analysis. This was done by identifying core damage sequences that could be recovered through the use of the SSF (sequences with failed SG makeup or RCP seal cooling and without loss of inventory), and modifying the event tree model described in Appendix A to include its consideration. The revised event tree for Oconee is included with this analysis. A combined operator and equipment failure probability of 0.2 was used for the SSF. This probability is consistent with values developed in the Oconee PRA (NSAC-60) and in licensee analyses of this event.

B.12.5 Analysis Results

The conditional core damage probability estimated for the event is 2.8×10^{-6}. This conditional probability is applicable to each of the three Oconee units. The dominant core damage sequence, highlighted on the event tree in Fig. B.19, involves a postulated severe weather-related LOOP with failed emergency power and failure to recover ac power before battery depletion.

The conditional probability estimate is strongly influenced by assumptions concerning the failure of Keowee upon loss of hydraulic oil and the likelihood of Keowee recovery.

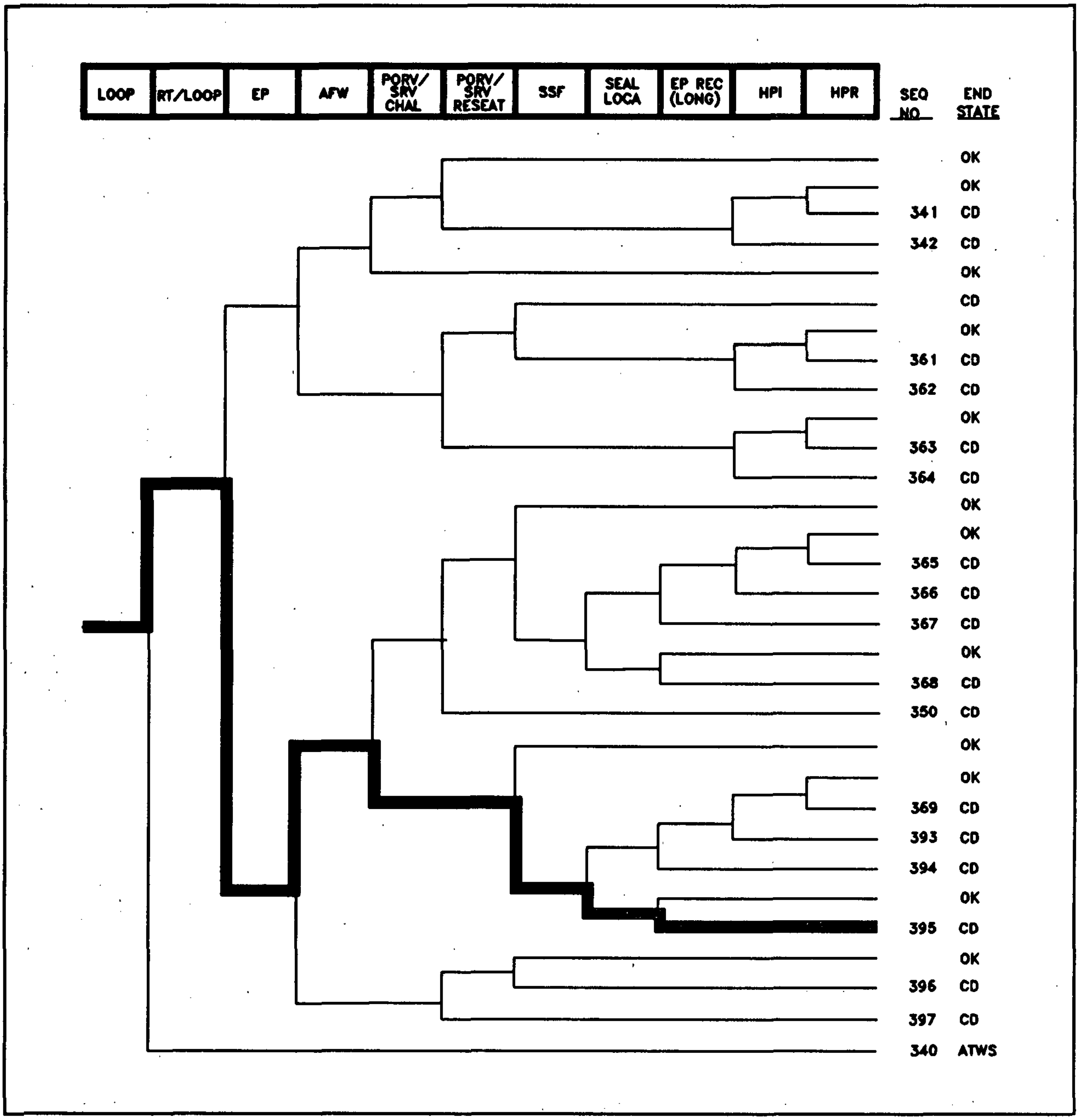

Fig. B.19. Dominant core damage sequence for LER 269/92-008.

CONDITIONAL CORE DAMAGE PROBABILITY CALCULATIONS

Event Identifier: 269/92-008
Event Description: Both Keowee hydro units unavailable
Event Date: 07/16/92
Plant: Oconee 1

UNAVAILABILITY, DURATION= 34 hours

NON-RECOVERABLE INITIATING EVENT PROBABILITIES

LOOP(PLANT_CENT)	6.6E-05
LOOP(GRID)	2.7E-05
LOOP(WEATHER)	3.6E-05

SEQUENCE CONDITIONAL PROBABILITY SUMS

End State/Initiator	Probability
CD	
LOOP(PLANT_CENT)	5.1E-08
LOOP(GRID)	1.0E-07
LOOP(WEATHER)	2.7E-06
Total	2.8E-06
ATWS	
LOOP(PLANT_CENT)	0.0E+00
LOOP(GRID)	0.0E+00
LOOP(WEATHER)	0.0E+00
Total	0.0E+00

SEQUENCE CONDITIONAL PROBABILITIES (PROBABILITY ORDER)

	Sequence	End State	Prob	N Rec**
395	loop(weather) -rt/loop EMERG.POWER(WEATHER) -afw/emerg.power -porv.or.srv.chall(loop) ssf -seal.loca(weather) ep.rec(weather)	CD	2.4E-06	4.0E-01
368	loop(weather) -rt/loop EMERG.POWER(WEATHER) -afw/emerg.power porv.or.srv.chall(loop) -porv.or.srv.reseat/emerg.power ssf -seal.loca(weather) ep.rec(weather)	CD	2.1E-07	4.0E-01

** non-recovery credit for edited case

SEQUENCE CONDITIONAL PROBABILITIES (SEQUENCE ORDER)

	Sequence	End State	Prob	N Rec**
368	loop(weather) -rt/loop EMERG.POWER(WEATHER) -afw/emerg.power porv.or.srv.chall(loop) -porv.or.srv.reseat/emerg.power ssf -seal.loca(weather) ep.rec(weather)	CD	2.1E-07	4.0E-01
395	loop(weather) -rt/loop EMERG.POWER(WEATHER) -afw/emerg.power -porv.or.srv.chall(loop) ssf -seal.loca(weather) ep.rec(weather)	CD	2.4E-06	4.0E-01

** non-recovery credit for edited case

Event Identifier: 269/92-008

Note: For unavailabilities, conditional probability values are differential values which reflect the added risk due to failures associated with an event. Parenthetical values indicate a reduction in risk compared to a similar period without the existing failures.

SEQUENCE MODEL: c:\asp\1989\oconseal.cmp
BRANCH MODEL: c:\asp\1989\oconee1.ssf
PROBABILITY FILE: c:\asp\1989\pwr_bsl1.pro

No Recovery Limit

BRANCH FREQUENCIES/PROBABILITIES

Branch	System	Non-Recov	Opr Fail
trans	6.4E-05	1.0E+00	
loop(plant_cent)	1.3E-05	1.5E-01	
loop(grid)	1.6E-06	4.8E-01	
loop(weather)	1.1E-06	9.3E-01	
loca	2.4E-06	4.3E-01	
rt	2.8E-04	1.2E-01	
rt/loop	0.0E+00	1.0E+00	
EMERG.POWER(PLANT_CENT)	3.0E-04 > 1.2E-01[1]	8.0E-01 > 4.3E-01[1]	
Branch Model: 1.OF.3			
Train 1 Cond Prob:	5.0E-02 > Failed[2]		
Train 2 Cond Prob:	5.0E-02 > Failed[2]		
Train 3 Cond Prob:	1.2E-01		
EMERG.POWER(GRID)	2.5E-03 > 1.0E+00[1]	8.0E-01 > 4.3E-01[1]	
Branch Model: 1.OF.2			
Train 1 Cond Prob:	5.0E-02 > Failed[2]		
Train 2 Cond Prob:	5.0E-02 > Failed[2]		
EMERG.POWER(WEATHER)	2.5E-03 > 1.0E+00[1]	8.0E-01 > 4.3E-01[1]	
Branch Model: 1.OF.2			
Train 1 Cond Prob:	5.0E-02 > Failed[2]		
Train 2 Cond Prob:	5.0E-02 > Failed[2]		
afw	3.8E-04	2.6E-01	
afw/emerg.power	5.0E-02	3.4E-01	
mfw	2.0E-01	3.4E-01	
porv.or.srv.chall	8.0E-02	1.0E+00	
porv.or.srv.chall(loop)	8.0E-02	1.0E+00	
porv.or.srv.reseat	1.0E-02	1.1E-02	
porv.or.srv.reseat/emerg.power	1.0E-02	1.0E+00	
ssf	2.0E-01	1.0E+00	
seal.loca(plant_cent)	0.0E+00	1.0E+00	
seal.loca(grid)	0.0E+00	1.0E+00	
seal.loca(weather)	0.0E+00	1.0E+00	
ep.rec(sl)(plant_cent)	0.0E+00	1.0E+00	
ep.rec(sl)(grid)	0.0E+00	1.0E+00	
ep.rec(sl)(weather)	0.0E+00	1.0E+00	

Event Identifier: 269/92-008

EP.REC(PLANT_CENT)	2.3E-01 > 5.6E-02[1]	1.0E+00	
Branch Model: 1.OF.1			
Train 1 Cond Prob:	2.3E-01 > 5.6E-02		
EP.REC(GRID)	5.3E-02 > 2.4E-02[1]	1.0E+00	
Branch Model: 1.OF.2			
Train 1 Cond Prob:	4.4E-01 > 2.0E-01		
Train 2 Cond Prob:	1.2E-01		
ep.rec(weather)	8.6E-01[1]	1.0E+00	
hpi	3.0E-04	8.4E-01	
hpi(f/b)	3.0E-04	8.4E-01	1.0E-02
hpr/-hpi	1.5E-04	1.0E+00	1.0E-03

* branch model file
** forced

Notes:

[1] See Modeling Assumptions for the development of this probability value.
[2] Both Keowee units assumed failed if auxiliary power not recovered.

Event Identifier: 269/92-008