Mr. H. B. Barron
Vice President, McGuire Site
Duke Energy Corporation
12700 Hagers Ferry Road
Huntersville, North Carolina 28078

December 8, 1997

SUBJECT: REVIEW OF PRELIMINARY ACCIDENT SEQUENCE PRECURSOR ANALYSIS OF CONDITION AT MCGUIRE NUCLEAR STATION, UNIT 2

Dear Mr. Barron:

Enclosed for your information is a copy of the final Accident Sequence Precursor analysis of the operational condition at McGuire Nuclear Station, Unit 2, reported in Licensee Event Report (LER) No.370/96-002. This final analysis (Enclosure 1) was prepared by our contractor at the Oak Ridge National Laboratory, based on review and evaluation of your comments on the preliminary analysis and comments received from the NRC staff and from our independent contractor, Sandia National Laboratories. Enclosure 2 contains our responses to your specific comments. Our review of your comments employed the criteria contained in the material which accompanied the preliminary analysis. The results of the final analysis indicate that this event is a precursor for 1996.

Please contact me at 301-415-1447 if you have any questions regarding the enclosure. We recognize and appreciate the effort expended by you and your staff in reviewing and providing comments on the preliminary analysis.

Sincerely,

ORIGINAL SIGNED BY:

Frank Rinaldi, Project Manager
Project Directorate II-2
Division of Reactor Projects - I/II
Office of Nuclear Reactor Regulation

Docket No. 50-370

Enclosures: As stated (2)

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NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

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LER No. 370/96-002

Event Description: 2B emergency diesel generator inoperable due to slow instrumentation response

Date of Event: March 6, 1996

Plant: McGuire Unit 2

Event Summary

McGuire Unit 2 was at 100% power when the 2B Emergency Diesel Generator (EDG), which was undergoing a scheduled operating test, tripped on a false low lube oil pressure signal shortly after starting (Ref. 1). The test failure was the result of air entrainment into the instrument line for the lube oil piping combined with low room temperature. Personnel determined that these conditions (air ingress and cold room temperature), which were deemed sufficient to cause the 2B EDG to trip, existed for a combined total of 540 h. (The 540-h total was distributed over four separate occasions where the 72-h single EDG outage allowed by Technical Specifications was exceeded.) This long-term unavailability of the 2B EDG could have affected the units' response to a loss of offsite power (LOOP). The estimated increase in the core damage probability (CDP) over the 540-h period for this event (i.e., the importance) is 1.8×10^{-6}. The base probability of core damage (the CDP) for the same period is 1.2×10^{-6}.

Event Description

Unit 2 was at 100% power on February 6, 1996. The 2B EDG was scheduled for a non-prelubricated start test. The 2B EDG reached 95% of rated speed in 9 s (Ref. 2). The 2B EDG tripped on a low lube oil pressure signal 30 s later (39 s after starting the EDG). Indicated pressure was 15–20 psig and decreasing; normal operating pressure is 40 psig. However, personnel determined that the low lube oil pressure indication was false. The low pressure indication resulted from a slow instrument response due to air entrainment into the instrument line for the lube oil piping, coupled with the low EDG room temperature. (An inadequate design of the instrument lines allowed for air to be introduced into the system. The lube oil pressure switch impulse line for the 2B EDG is ~70 ft long. The licensee indicated in the LER that this length is excessive.) The cool EDG room temperature added to the slow instrument response by increasing the viscosity of the oil in the instrument line. Since the low lube oil pressure trip signal is not bypassed on an emergency start of the EDGs, the failure was classified as a valid test failure.

The lowest recorded EDG room temperature in the 7 d preceding the EDG failure to start was 62°F. EDG room temperature was 68°F just before the test. On March 6, 1996, the licensee determined that the 2B EDG should be considered inoperable with the current instrument line configuration when the EDG room temperature is < 71°F and the before and after (B&A) lube oil pump is not running. Based on these criteria, all other station EDGs were determined to be operable at the time the 2B EDG failed its operating test. Based on a review of the log books containing the EDG room temperature readings, the licensee calculated that the 2B EDG was susceptible to this type of failure for a total of 666 h. Because the B&A lube oil pump runs for

15 min during each hour, the licensee estimated that the 2B EDG was susceptible to this type of failure only 75% of the time–a total of 499.5 h. Nuclear Regulatory Commission (NRC) inspectors, in NRC Inspection Report 50-370/96-02 (Ref. 2), noted that previous EDG trips occurred while the B&A lube oil pump was running. Therefore, the NRC inspectors discounted the assumption that running a B&A lube oil pump at the time of a start demand with the EDG room temperature below 71°F would have prevented this type of failure of the EDG to start. The 2B EDG was susceptible to these failure conditions on numerous separate occasions through the winter (for a total of 666 h), however, there were only four occurrences of the potential failure conditions that exceeded the EDG Technical Specification Action Statement limit of 72 h. The NRC inspection report (Ref. 2) tallied the total amount of time for the four occurrences that the room temperature dropped below 71°F and determined that the four susceptibility periods totaled 540 h.

Additional Event-Related Information

McGuire Nuclear Station maintains a Safe Shutdown Facility (SSF) designed to provide an alternate and independent means to achieve and maintain hot standby conditions (Ref. 3). The facility includes an EDG that can be used to operate a positive displacement pump to supply seal injection water to the reactor coolant pump (RCP) seals, preventing an RCP seal loss-of-coolant accident (LOCA). Credit for the SSF is included in the ASP models via a separate top event in the LOOP event tree.

The most important recovery action with respect to this condition assessment is the possibility of restoring ac power to Unit 2 from Unit 1 via a cross-tie, given a station blackout at Unit 2. Because procedures exist detailing this operation, it is considered a viable option. Recovery via the cross-tie is included as a basic event imbedded in several LOOP event fault trees.

There was a brief period (5.3 h) when both EDGs were technically out of service due to maintenance activities on Motor Control Center 1EMXH-1, which affected ventilation. The 2A EDG was functionally available and would have performed its design function. Technical Specifications allow both EDGs to be out of service for up to 8 h.

Modeling Assumptions

Similar to the licensee's analysis of this event (Ref. 1), the failure probability of the 2B EDG was set to 1.0 (TRUE) for this condition assessment. The duration was set to 540 h per the NRC inspection report. However, sensitivity studies were examined for the total time (666 h) the 2B EDG was determined to meet the low temperature criteria and the discounted time (499.5 h) the 2B EDG was determined to be unavailable based on the hourly B&A pump operation (value assumed by the licensee).

The licensee suggested that if an actual failure to start occurred under circumstances similar to the conditions that existed since February 6, then a second start attempt would likely be successful (Ref. 1). Therefore, the emergency power nonrecovery probability (EPS-XHE-NOREC) was adjusted from 1.0 to 0.34, as shown in Table 1, to reflect the fact that the equipment appeared recoverable and was accessible (Recovery Class 2).

The 2B EDG failure appears to be a failure mode unique to the physical setup of the lube oil pressure instrumentation lines on the 2B EDG. A similar failure of the 2A EDG was documented by special report

25 months earlier (Ref. 4). The length of time between events and, consequently, the number of successful surveillance tests between events indicates that the two failures were random rather than having any common-cause effects. Consequently, the common-cause failure probability for the EDGs was not adjusted from the nominal value of 1.1×10^{-3} shown in Table 1.

During the 5-h period that both EDGs were declared unavailable, the 2A EDG was functionally available and would have performed its design function. This 5-h period was not considered separately when calculating the increase in the CDP over the entire 540-h period because the importance (i.e., the increase in the CDP) is less than the ASP cut-off value of 1.0×10^{-6}.

Credit for the SSF at McGuire was accounted for by adding a fault tree at the SSF branch point in the LOOP event tree shown in Fig. 1. The nominal probability of SSF failure is 0.36 based on information in the plant's *Individual Plant Examination* (Ref. 5). The nominal SSF failure probability is derived from the failure probabilities, listed in Table 1, for the basic events *SSF EDG Fails* (SSF-DGN-FC-1), *Operator Fails to Start SSF EDG Within 10 Minutes* (SSF-XHE-XM-DGN), and *SSF Unavailable Due to Maintenance* (SSF-XHE-MAINT).

Additionally, ac power to the emergency buses was recoverable by implementing a cross-tie to Unit 1. Based on a telephone conversation with the licensee (Ref. 6), it was assumed that personnel could cross-tie the power buses at Unit 1 with the buses at Unit 2 in less than 1 h 50% of the time, and within 2 h 95% of the time. The recovery of power by implementing a cross-tie to Unit 1 was modeled by adding the basic event *Failure to Cross-Tie Emergency Power Within 90 Min* (OEP-XHE-XTIE) to the McGuire fault trees for failure to recover power before the core uncovering given an RCP seal LOCA (OP-SL) and before battery depletion given no seal LOCA (OP-BD). Failure to cross-tie to Unit 1 was modeled as a time-reliability correlation (TRC) as described in Ref. 7. The probability distribution for this TRC is lognormal, with an error factor of 2.0 based on the licensee time estimates (Ref. 6). The median response time of 60 min was assumed to include any delays in initiating the cross-tie procedure. Without power, a seal LOCA was assumed to occur after 60 min, and the core would begin to uncover in an additional 30 min. The probability of crew failure at 90 min, estimated using this TRC and response time, is 0.17.

The actions to man the SSF and to cross-tie emergency power were assumed to be independent for this analysis. This assumption would have to be confirmed for an event occurring outside the day shift because it is unknown if sufficient personnel would be available during the period between 5:00 p.m. and 8:00 a.m. to perform all the necessary actions in parallel.

Analysis Results

The increase in the CDP (i.e., the importance) over a 540-h period for this event is 1.8×10^{-6}. This is an increase over the nominal CDP of 1.2×10^{-7}. The dominant core damage sequence for this event (sequence 41 on Fig. 1) involves

- a postulated LOOP,
- a successful reactor trip,
- failure of emergency power, and
- failure of the auxiliary feedwater (AFW) system.

This sequence accounts for 38% of the total contribution to the increase in the CDP. Sequences 29 and 39 are similar, but LOOP sequence 39 involves a power-operated relief valve (PORV) lift and successful reclosure. Combined, these two sequences account for an additional 36% of the total contribution to the increase in the CDP (Table 2). Core damage in these two sequences (29 and 39) is the result of a failure of the SSF and a resulting seal LOCA. Core damage results from battery depletion in two additional sequences (16% of the increase in the CDP) and results from a failure of a PORV to reclose in one other sequence (8% of the increase in the CDP).

The increase in the CDP over a 666-h period for this event is 2.2×10^{-6} if the 2B EDG is assumed to be inoperable for the collective total time the 2B EDG room temperature was below 71°F as reported by the licensee. This is an increase over the nominal CDP for 666 h of 1.5×10^{-6}. The dominant core damage sequence for this sensitivity case study is the same as it is for the 540-h analysis. Similarly, if a 499.5-h period is assumed (as the licensee contends is the most appropriate period when the operation of the B&A pump is considered), the increase in the CDP is 1.6×10^{-6} over the nominal CDP for 499.5 h of 1.1×10^{-6}. These sensitivity studies show that there is not much difference with respect to the CDP among unavailabilities of 499.5, 540, and 666 h.

Definitions and probabilities for selected basic events are shown in Table 1. The conditional probabilities associated with the highest probability sequences are shown in Table 2. Table 3 lists the sequence logic associated with the sequences listed in Table 2. Table 4 describes the system names associated with the dominant sequences. Minimal cut sets associated with the dominant sequences are shown in Table 5.

Acronyms

AFW	auxiliary feedwater system
B&A	before and after lube oil pump
CCDP	conditional core damage probability
CDP	core damage probability
EDG	emergency diesel generator
LOCA	loss-of-coolant accident
LOOP	loss of offsite power
NRC	Nuclear Regulatory Commission
PORV	power-operated relief valve
PWR	pressurized water reactor
RCP	reactor coolant pump
SGTR	steam generator tube rupture
SLOCA	small-break LOCA
SSF	safe shutdown facility
TRANS	transient

References

1. LER 370/96-002, Rev. 0, "Past Inoperability of Emergency Diesel Generator 2B Due to Low Lube Oil Pressure Caused by Unanticipated Interaction of Systems and Components," March 29, 1996.

2. NRC Inspection Report No. 50-370/96-02, Inspection Conducted: March 11 – April 1, 1996.

3. *Final Safety Analysis Report*, McGuire Nuclear Station.

4. Duke Power Company, *Diesel Generator Special Report*, McGuire Nuclear Station, Special Report 94-01 (PIP 2-M94-0242), March 15, 1994.

5. McGuire Nuclear Station, *Individual Plant Examination*.

6. Conference call with McGuire licensing and probabilistic risk assessment staff, September 11, 1997.

7. E. M. Dougherty and J. R. Fragola, *Human Reliability Analysis*, John Wiley and Sons, New York, 1988.

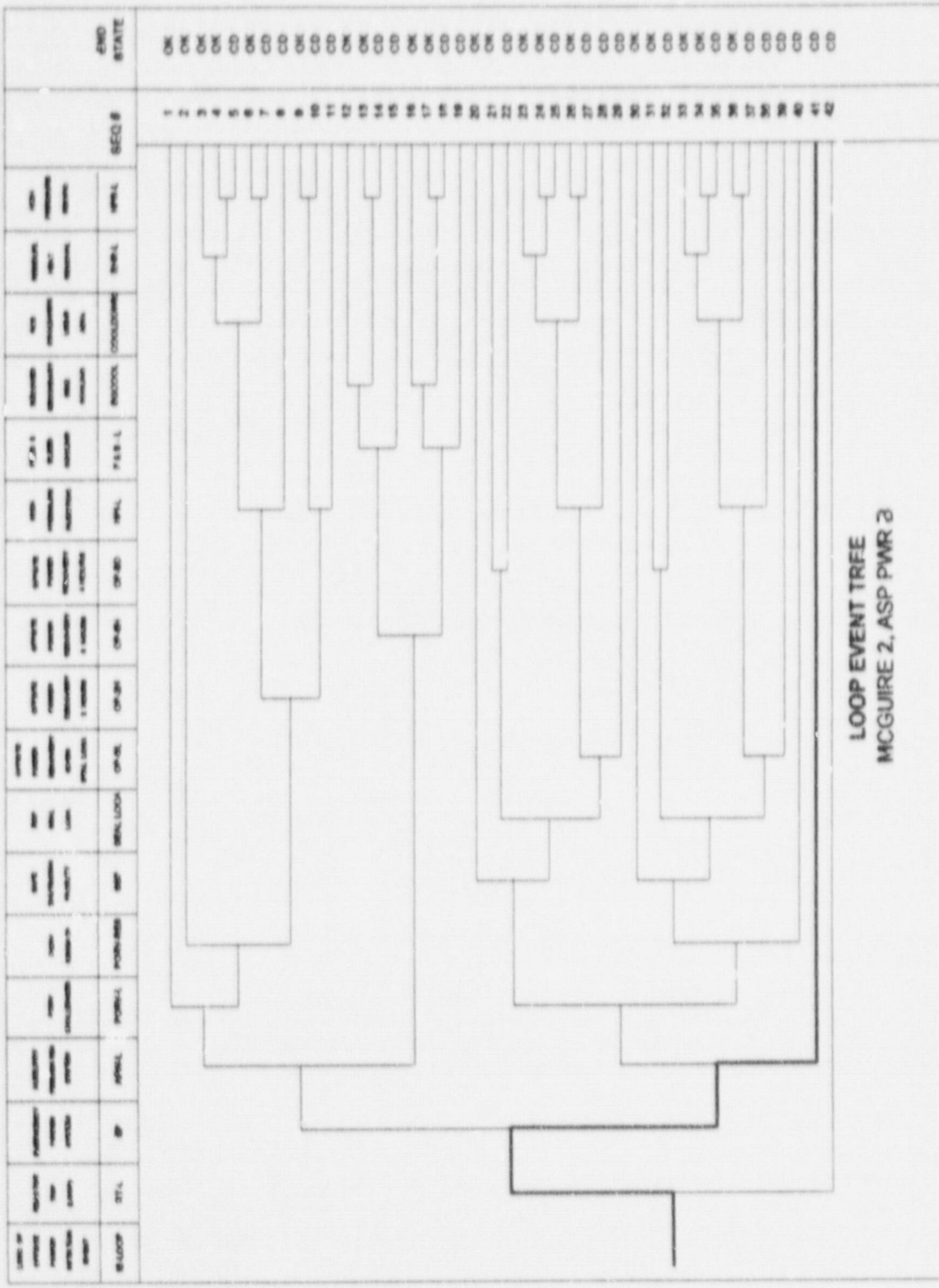

Fig. 1. Dominant core damage sequence for LER No. 370/96-002.

Table 1. Definitions and Probabilities for Selected Basic Events for LER No. 370/96-002

Event name	Description	Base probability	Current probability	Type	Modified for this event
IE-LOOP	Initiating Event–LOOP	9.3 E-006	9.3 E-006		No
IE-SGTR	Initiating Event–Steam Generator Tube Rupture	1.6 E-006	1.6 E-006		No
IE-SLOCA	Initiating Event–SLOCA	1.0 E-006	1.0 E-006		No
IE-TRANS	Initiating Event–Transient (TRANS)	5.3 E-004	5.3 E-004		No
AFW-TDP-FC-1A	Turbine-Driven AFW Pump Fails	3.2 E-002	3.2 E-002		No
AFW-XHE-NOREC-EP	Operator Fails to Recover AFW During a Station Blackout (SBO)	3.4 E-001	3.4 E-001		No
EPS-DGN-CF-ALL	Common-Cause Failure of EDGs	1.1 E-003	1.1 E-003		No
EPS-DGN-FC-1A	EDG A Fails	4.2 E-002	4.2 E-002		No
EPS-DGN-FC-1B	EDG B Fails	4.2 E-002	1.0 E+000	TRUE	Yes
EPS-XHE-NOREC	Operator Fails to Recover Emergency Power	1.0 E+000	3.4 E-001		Yes
OEP-XHE-NOREC-BD	Operator Fails to Recover Offsite Power Before Battery Depletion	9.7 E-002	9.7 E-002		No
OEP-XHE-NOREC-SL	Operator Fails to Recover Offsite Power During a Seal LOCA	7.4 E-001	7.4 E-001		No
OEP-XHE-XTIE	Failure to Cross-Tie ac Power From the Opposite Unit	1.7 E-001	1.7 E-001	NEW	No
PPR-SRV-CO-SBO	PORVs Open During an SBO	3.7 E-001	3.7 E-001		No
PPR-SRV-OO-PRV1	PORV 1 Fails to Reclose	2.0 E-003	2.0 E-003		No
PPR-SRV-OO-PRV2	PORV 2 Fails to Reclose	2.0 E-003	2.0 E-003		No
PPR-SRV-OO-PRV3	PORV 3 Fails to Reclose	2.0 E-003	2.0 E-003		No
RCS-MDP-LK-SEALS	RCP Seals Fail Without Cooling and Injection Water	2.3 E-001	2.3 E-001		No
SSF-DGN-FC-1	SSF EDG Fails	2.0 E-001	2.0 E-001	NEW	No
SSF-XHE-MAINT	SSF Unavailable Due to Maintenance	6.1 E-002	6.1 E-002	NEW	No
SSF-XHE-XM-DGN	Operator Fails to Start SSF EDG Within 10 Min	1.0 E-001	1.0 E-001	NEW	No

Table 2. Sequence Conditional Probabilities for LER No. 370/96-002

Event tree name	Sequence number	Conditional core damage probability (CCDP)	Core damage probability (CDP)	Importance (CCDP-CDP)	Percent contribution[a]
LOOP	41	8.0 E-007	1.2 E-007	6.7 E-007	38.3
LOOP	29	4.8 E-007	7.6 E-008	4.0 E-007	23.0
LOOP	39	2.8 E-007	4.4 E-008	2.3 E-007	13.4
LOOP	22	2.1 E-007	3.3 E-008	1.7 E-007	10.1
LOOP	40	1.6 E-007	2.5 E-008	1.3 E-007	7.7
LOOP	32	1.2 E-007	1.9 E-008	1.0 E-007	5.9
Total (all sequences)		**3.0 E-006**	**1.2 E-006**	**1.8 E-006**	

[a]Percent contribution to the total importance.

Table 3. Sequence Logic for Dominant Sequences for LER No. 370/96-002

Event tree name	Sequence number	Logic
LOOP	41	/RT-L, EP, AFW-L-EP
LOOP	29	/RT-L, EP, /AFW-L-EP, /PORV-SBO, SSF, SEALLOCA, OP-SL
LOOP	39	/RT-L, EP, /AFW-L-EP, PORV-SBO, /PORV-EP, SSF, SEALLOCA, OP-SL
LOOP	22	/RT-L, EP, /AFW-L-EP, /PORV-SBO, SSF, /SEALLOCA, OP-BD
LOOP	40	/RT-L, EP, /AFW-L-EP, PORV-SBO, PORV-EP
LOOP	32	/RT-L, EP, /AFW-L-EP, PORV-SBO, /PORV-EP, SSF, /SEALLOCA, OP-BD

Table 4. System Names for LER No. 370/96-002

System name	Logic
AFW-L-EP	No or Insufficient AFW Flow During a Station Blackout
EP	Failure of Both Trains of Emergency Power
OP-BD	Operator Fails to Recover Offsite Power Before Battery Depletion
OP-SL	Operator Fails to Recover Offsite Power During a Seal LOCA
PORV-EP	PORVs Fail to Reclose (No Electric Power)
PORV-SBO	PORVs Open During a Station Blackout
RT-L	Reactor Fails to Trip During a LOOP
SEALLOCA	RCP Seals Fail During a LOOP
SSF	Safe Shut Down Facility Failure

Table 5. Conditional Cut Sets for Higher Probability Sequences for LER No. 370/96-002

Cut set number	Percent contribution	CCDP[a]	Cut sets[b]
LOOP Sequence 41		8.0 E-007	
1	96.6	7.8 E-007	EPS-DGN-FC-1A, EPS-DGN-FC-1B, EPS-XHE-NOREC, AFW-TDP-FC-1A, AFW-XHE-NOREC-EP
2	2.6	2.0 E-008	EPS-DGN-CF-ALL, EPS-XHE-NOREC, AFW-TDP-FC-1A, AFW-XHE-NOREC-EP
LOOP Sequence 29		4.8 E-007	
1	53.9	2.6 E-007	EPS-DGN-FC-1A, EPS-DGN-FC-1B, EPS-XHE-NOREC, /PPR-SRV-CO-SBO, SSF-DGN-FC-1, RCS-MDP-LK-SEALS, OEP-XHE-NOREC-SL, OEP-XHE-XTIE
2	27.0	1.3 E-007	EPS-DGN-FC-1A, EPS-DGN-FC-1B, EPS-XHE-NOREC, /PPR-SRV-CO-SBO, SSF-XHE-XM-DGN, RCS-MDP-LK-SEALS, OEP-XHE-NOREC-SL, OEP-XHE-XTIE
3	16.5	8.0 E-008	EPS-DGN-FC-1A, EPS-DGN-FC-1B, EPS-XHE-NOREC, /PPR-SRV-CO-SBO, SSF-XHE-MAINT, RCS-MDP-LK-SEALS, OEP-XHE-NOREC-SL, OEP-XHE-XTIE
LOOP Sequence 39		2.8 E-007	
1	53.9	1.5 E-007	EPS-DGN-FC-1A, EPS-DGN-FC-1B, EPS-XHE-NOREC, PPR-SRV-CO-SBO, SSF-DGN-FC-1, RCS-MDP-LK-SEALS, OEP-XHE-NOREC-SL, OEP-XHE-XTIE
2	27.0	7.5 E-008	EPS-DGN-FC-1A, EPS-DGN-FC-1B, EPS-XHE-NOREC, PPR-SRV-CO-SBO, SSF-XHE-XM-DGN, RCS-MDP-LK-SEALS, OEP-XHE-NOREC-SL, OEP-XHE-XTIE
3	16.5	4.6 E-008	EPS-DGN-FC-1A, EPS-DGN-FC-1B, EPS-XHE-NOREC, PPR-SRV-CO-SBO, SSF-XHE-MAINT, RCS-MDP-LK-SEALS, OEP-XHE-NOREC-SL, OEP-XHE-XTIE
LOOP Sequence 22		2.1 E-007	
1	53.9	1.1 E-007	EPS-DGN-FC-1A, EPS-DGN-FC-1B, EPS-XHE-NOREC, /PPR-SRV-CO-SBO, SSF-DGN-FC-1, /RCS-MDP-LK-SEALS, OEP-XHE-NOREC-BD, OEP-XHE-XTIE
2	27.0	5.7 E-008	EPS-DGN-FC-1A, EPS-DGN-FC-1B, EPS-XHE-NOREC, /PPR-SRV-CO-SBO, SSF-XHE-XM-DGN, /RCS-MDP-LK-SEALS, OEP-XHE-NOREC-BD, OEP-XHE-XTIE

Table 5. Conditional Cut Sets for Higher Probability Sequences for LER No. 370/96-002

Cut set number	Percent contribution	CCDP[a]	Cut sets[b]
3	16.5	3.5 E-008	EPS-DGN-FC-1A, EPS-DGN-FC-1B, EPS-XHE-NOREC, /PPR-SRV-CO-SBO, SSF-XHE-MAINT, /RCS-MDP-LK-SEALS, OEP-XHE-NOREC-BD, OEP-XHE-XTIE
LOOP Sequence 40		1.6 E-007	
1	32.5	5.3 E-008	EPS-DGN-FC-1A, EPS-DGN-FC-1B, EPS-XHE-NOREC, PPR-SRV-CO-SBO, PPR-SRV-OO-PRV1
2	32.5	5.3 E-008	EPS-DGN-FC-1A, EPS-DGN-FC-1B, EPS-XHE-NOREC, PPR-SRV-CO-SBO, PPR-SRV-OO-PRV2
3	32.5	5.3 E-008	EPS-DGN-FC-1A, EPS-DGN-FC-1B, EPS-XHE-NOREC, PPR-SRV-CO-SBO, PPR-SRV-OO-PRV3
LOOP Sequence 32		1.2 E-007	
1	32.5	6.7 E-008	EPS-DGN-FC-1A, EPS-DGN-FC-1B, EPS-XHE-NOREC, PPR-SRV-CO-SBO, SSF-DGN-FC-1, /RCS-MDP-LK-SEALS, OEP-XHE-NOREC-BD, OEP-XHE-XTIE
2	32.5	3.3 E-008	EPS-DGN-FC-1A, EPS-DGN-FC-1B, EPS-XHE-NOREC, PPR-SRV-CO-SBO, SSF-XHE-XM-DGN, /RCS-MDP-LK-SEALS, OEP-XHE-NOREC-BD, OEP-XHE-XTIE
3	32.5	2.0 E-008	EPS-DGN-FC-1A, EPS-DGN-FC-1B, EPS-XHE-NOREC, PPR-SRV-CO-SBO, SSF-XHE-MAINT, RCS-MDP-LK-SEALS, OEP-XHE-NOREC-SL, OEP-XHE-XTIE
Total (all sequences)		**3.0 E-006**	

[a]The CCDP is determined by multiplying the probability that the portion of the sequence that makes the precursor visible (e.g., the system with a failure is demanded) will occur during the duration of the event by the probabilities of the remaining basic events in the minimal cut set. This can be approximated by $1 - e^{-p}$, where p is determined by multiplying the expected number of initiators that occur during the duration of the event by the probabilities of the basic events in that minimal cut set. The expected number of initiators is given by λt, where λ is the frequency of the initiating event (given on a per-hour basis), and t is the duration time of the event (540 h). This approximation is conservative for precursors made visible by the initiating event. The frequency of interest for this event is $\lambda_{LOOP} = 9.3 \times 10^{-6}$/h. The importance is determined by subtracting the CDP for the same period but with plant equipment assumed to be operating nominally.

[b]Basic event EPS-DGN-FC-1B is a type TRUE event. This type of event is not normally included in the output of the fault tree reduction process but has been added to aid in understanding the sequences to potential core damage associated with the event.

LER No. 370/96-002

Event Description: 2B emergency diesel generator inoperable due to slow instrumentation response

Date of Event: March 6, 1996

Plant: McGuire Unit 2

Licensee Comments

Reference: Letter from H. B. Barron, Vice President, McGuire Nuclear Station, Duke Power Company, to U. S. Nuclear Regulatory Commission, "McGuire Nuclear Station, Docket No. 370, Preliminary Accident Sequence Precursor," October 14, 1997.

Comment 1: The McGuire EDG design uses a pre-lubrication pump called the Before and After lube oil pump. This pump starts automatically and runs for 15 minutes out of each hour to lubricate the engine journal bearings and upper deck. The pump also runs for 20 minutes after engine shutdown. While operating, the lube oil header and instrumentation line is pressurized to about 11 psig. The EDG was not susceptible to the low lube oil pressure trip on startup during the periods of time that the pump was running.

Although no formal documentation of the meeting minutes from the 4/15/96 Enforcement Conference could be found, the 499.5 hours of failure susceptibility (versus 540) was agreed to by those present based on taking credit for Before and After (pre-lubrication) lube oil pump operation 15 minutes out of each hour. Based on the observations by the Operator several seconds after the event that lube oil pressure as read from the control panel gauge was 15-20 psig and decreasing rapidly, the EDG would have met its 33 psig lube oil pressure requirement had the pump been running prior to the start.

The trip referenced by the Inspectors that occurred with the Before and After lube oil pump running was during post outage startup break-in runs (with the EDG inoperable) after the lube oil system had been drained (with the header not completely vented) and is not directly comparable to this event. This trip occurred ten years ago and several modifications (e.g., adding 15 seconds to the delay before arming the low lube oil pressure trip) to improve lube oil pressure response have been made in the interim.

Therefore, the exposure time appropriate for the Accident Sequence Precursor analysis is 499.5 instead of the 540 hours used in the preliminary analysis.

Enclosure 2

Response 1: The NRC inspector methodology for calculating the 2B EDG to be unavailable for 540 h did not involve measuring the total time the 2B EDG met the low room temperature criteria and adjusting for the Before and After lube oil pump run time. The documented NRC methodology simply accounted for the four occasions when the 2B EDG was technically inoperable for longer than the 72 h allowed by the Technical Specifications, which summed to 540 h. This total was very close to the 499.5 h calculated by a methodology that accounts for the Before and After lube oil pump operation. Based on this and the results of the sensitivity study described below, assuming a total of 540 h was judged to be satisfactory.

Additionally, the probability of the operator failing to recover emergency power following a failure was adjusted from 1.0 to 0.34 (Recovery Class 2) to account for the likelihood of success on a second start attempt of the 2B EDG. This is based on the impact the initial start attempt has on the oil pressure sensed at the pressure transmitter. This adjustment to the emergency power non-recovery probability would also encompass the pressure contribution of the Before and After lube oil pump to a successful initial start without directly modeling the pump itself.

The difference in the calculated unavailability times is explored in a sensitivity study and documented in the *Analysis Results* section of the analysis. The importance (CCDP - CDP) calculated for the 540 h case (1.8×10^{-6}) is 2.0×10^{-7} greater than the importance calculated for the 499.5 h case ([illegible]6 $\times 10^{-6}$). The importance for the total 666 h unavailability time (2.2×10^{-6}) is also explored based on the adjustment to the emergency power non-recovery probability discussed previously. These sensitivity studies show that there is not much difference with respect to the importance between an unavailability of 499.5 h and one of 666 h.

Comment 2: The LOOP frequency in the preliminary analysis of 1.6E-05/hr translates to an annual frequency of 0.1/yr (based on 6250 hours of interest/yr). This frequency is significantly higher compared to the industry average of approximately 0.03/yr (Pg xii & 2-22, EPRI TR-106306) or the McGuire IPE LOOP frequency–0.07/yr (Table 2.1-3, MNS PRA). The current plant specific LOOP frequency for McGuire is 0.057/yr. This value is based on industry experience for 1980 to 1995 and updated for McGuire plant specific data. We request that the analysis be revised using a more realistic LOOP frequency.

Response 2: The analysis was revised using the McGuire plant specific LOOP frequency of 0.057/yr (based on 6130 h of interest/yr).

Comment 3: In looking at the preliminary analysis, it appears that the McGuire plant capabilities following a LOOP event with concurrent failure of the EDGs to be mitigated by use of the power from the other unit and the SSF has not been given appropriate consideration. There are two 7kV to 4kV shared transformers (SATA and SATB) at McGuire. Normally one transformer is powered from unit 1 and the other shared transformer is powered from unit 2. A total loss of offsite power to both units is needed to render the power from the shared transformers unavailable.

For an event involving a LOOP and a failure of both EDGs, three independent options are available to mitigate the event and avoid a core damage condition:

a) Energize the vital 4 kV switchgear from the shared transformer energized by the other unit.

b) Use the SSF to maintain secondary side heat removal (SSHR) and RCP seal cooling, and

c) Recover off-site power.

In accident sequences 28, 37, and 39 [revised analysis sequences 29, 39, and 41], it appears that credit given for the SSF and cross-tying the units is not in-line with McGuire's capabilities. For example, assuming reasonable and realistic values for LOOP, SSF, and cross-tying the unit, the core damage probability can be approximated as follows:

C[C]DP = LOOP (0.05) × EDG fails (0.04) × Recover EDG (0.34) × SSF(0.2) × Opposite Unit (0.17) × Recover Off-site Power (0.05, failure to recover power during seal LOCA) × Exposure Time (0.08, 500/6250) = 9.25E-08

C[C]DP = LOOP (0.05) × EDG fails (0.04) × Recover EDG (0.34) × SSHR(0.032) × Opposite Unit (0.17) × Recover Off-site Power (0.2, failure to recover power with loss of SSHR) × Exposure Time (0.08, 500/6250) = 5.92E-08

The equivalent sequences in the preliminary analysis are 28 and 37 for the first sequence [revised analysis sequences 29 and 39] and 39 [revised analysis sequence 41] for the second sequence. The preliminary analysis sequences have a CDP [CCDP] of 2.4E-06 (1.5E-06 + 8.8E-07) and 1.4E-06, respectively. This is a substantial difference and should not occur if more realistic values are used. We request that the models and associated inputs be reexamined so that the accident sequences are a realistic quantification.

Response 3: The preliminary analysis included the SSF capability and the cross-tie capability as part of the LOOP frequency and recovery probabilities. Apparently, this was confusing when it was desired to identify the individual SSF components and the specific cross-tie components associated with a given sequence. Therefore, the preliminary model was reexamined and modified so that the LOOP frequency and the SSF capabilities were addressed separately.

The modified ASP model factors the SSF facility into the LOOP event tree as a separate top event in the event tree model. The SSF failure probability was set to 0.36 according to the McGuire IPE based on the probability of (1) the SSF EDG failing, (2) failing to man the SSF in a timely manner, and (3) the SSF being in maintenance when demanded. The unit cross-tie capability was factored into the linked fault trees concerning off-site power restoration prior to battery depletion and core damage given a seal LOCA. The probability of failing to cross-tie to unit 1 was calculated to be 0.17, which is the same value used by McGuire in the above approximations. Substituting appropriate values (LOOP frequency, exposure time, and off-site power recovery) into the approximation presented above yields values of the same order of magnitude (10^{-7}) as those produced when running the revised model. The revised model allows easier identification of the three power alternatives at McGuire.

Comment 4: As required by the design basis, the SSF is required to be staffed and operational within 10 minutes. Plant personnel have verified that the SSF can be staffed and operational within 10 minutes. The assumption of 30 minutes (page 3 of the analysis) is too long and should be modified to indicate a time less than 10 minutes.

Response 4: In the revised analysis, the SSF is included as a top event on the revised LOOP event tree (Fig. 1 in the analysis). The associated SSF fault tree now includes an *Operator Fails to Start SSF EDG Within 10 Minutes* basic event (SSF-XHE-XM-DGN). The probability for this basic event (0.1) is taken from the McGuire IPE.

Comment 5: The probability of SSF failure assumed in the McGuire preliminary analysis is 0.36. The failure value was taken from the McGuire IPE report. This number includes both hardware failures (SSF DG fails to start or run) and operator errors (operators fail to start the SSF in time). Provided below are the top events from the SSF IPE model:

Description	Value
SSF EDG fails to run (12 hr mean failure)	1.70E-01
Operators fail to initiate SSF in time - station blackout case	1.00E-01
SSF EDG in maintenance	5.20E-02
SSF left unavailable after maintenance	1.24E-02
SSF EDG fails to start	1.30E-02
SSF RCP makeup components in maintenance	9.00E-03

For the preliminary analysis, a failure probability that includes short term failures (start failures) and excludes the long term failures (SSF DG fails to run) and maintenance is appropriate. A failure probability of 0.2 is a reasonable value considering the short term failures. If the operator error for the SSF is used elsewhere in the ASP model, the value should be 0.1. We request that the analysis be requantified using a SSF failure probability of 0.2 (0.1 if appropriate).

Response 5: The SSF is now specifically included as a top event on the revised LOOP event tree (Fig. 1 in the analysis). Both short-term and long-term failures are typically considered in event modeling; therefore, SSF EDG failure to run and maintenance components were included. Operator errors involving the SSF are not included elsewhere in the revised model. The values presented in the above table were used as the basis for the inputs for the SSF fault tree, resulting in a nominal overall SSF failure probability of approximately 0.36.

Comment 6: For cross-tying the Unit 1 and Unit 2 buses, the preliminary analysis assumes that plant personnel could cross-tie the units in 1 hr 5% of the time and within 2 hours 95% of the time. From the conference call on September 11, 1997, this assumption is based somewhat on the LOOP event at Catawba in which the operators took a long time to cross-tie the units.

The Catawba event is not an appropriate event to use to estimate the failure probability for cross-tying the units. The Catawba event did not involve the need to cross-tie since EDG power was available. For LOOPs with failure of EDG, operators will quickly get to the point in the emergency procedure that direct the operators to perform the cross-tie. The cross-tie can be performed in a half-hour.

We request that the HRA for cross-tying the units be requantified based on a time available over one hour. The time required is one half-hour. Attached for your information is a copy of the procedure for cross-tying the units' power sources.

Response 6: Based on the conference call on September 11, 1997, it was assumed that the operators could cross-tie the units in 1 h 50% of the time and within 2 h 95% of the time. The median response time of 60 min was assumed to include any delays in initiating the cross-tie procedure based on licensee information provided during the conference call. The recovery of power by implementing a cross-tie to Unit 1 was modeled by adding a basic event *Failure to cross-tie emergency power within 90 min* (OEP-XHE-XTIE) to the McGuire fault trees for failure to recover power before the core uncovering given an RCP seal LOCA (OP-SL) and before battery depletion given no seal LOCA (OP-BD). Without power, a seal LOCA was assumed to occur after 60 min and the core would begin to uncover in an additional 30 min. The probability of failure to cross-tie emergency power within 90 min, estimated using a lognormal time-reliability correlation and response time, is 0.17. This correction significantly reduced the calculated CCDP from sequences 29, 39, and 22 (sequences 28, 37, and 21 in the preliminary analysis).

Comment 7: Sequences involving OEP-XHE-NOREC-BD result in core damage after battery failure. We assume that this leads to a loss of secondary side heat removal in the preliminary analysis. However, the turbine-driven emergency feedwater pump at McGuire can continue to operate without battery power since all valves remain in their open position. Furthermore, the SSF can provide control power to the turbine-driven emergency feedwater pump and steam generator level indication. In addition, the McGuire DC system is shared and the battery chargers can be supplied by either unit. Therefore, failure to recover power before battery failure would not necessarily lead to core damage at McGuire. LOOP sequences 21 and 30 [revised analysis sequences 22 and 32] appear to be a failure of secondary side heat removal after failure of the batteries. These sequences should be removed or modified to account for McGuire capabilities.

Response 7: The SSF was included as a top event on the revised LOOP event tree (Fig. 1 in the analysis). Loss of control power to the turbine-driven emergency feedwater pump and steam generator level indication is not considered possible unless emergency power, the SSF, and battery power have all failed. Sequences 22 and 32 both involve a loss of emergency power and a failure of the SSF as shown in Table 3 in the revised analysis. Sharing battery chargers between units is not addressed in the McGuire IPE and no procedure was provided; therefore this possibility was not considered.

Comment 8: LOOP sequence 38 [revised analysis sequence 40] contains a failure of emergency power and failure of a PORV to re-close after opening. However, this sequence does not contain any events that would challenge the PORV such as failure of secondary side heat removal. For a blackout at McGuire, the PORVs are not expected to be challenged unless secondary side heat removal fails. These sequences should not be included in the analysis or additional failures should be included in the cut set.

Response 8: Two events of interest impact the reactor coolant system pressure following a loss of offsite power: (1) a loss of non-emergency power to the unit, and (2) a loss of forced flow in the reactor coolant system. The McGuire FSAR addresses both of these possibilities. The pressure response to a loss of non-emergency power depicted in Figure 15-35 of the McGuire FSAR indicates a peak pressure of approximately 2,230 psig. This pressure is below all the PORV set points, though it is possible that, with set point drift, PORV NC-34A could open based on rate compensation. However, in response to a loss of forced flow in the reactor coolant system due to a loss of ac power, a higher pressure peak of approximately 2,350 psig is shown in Figure 15-60 of the McGuire FSAR. This peak is above the set points of all three PORVs (identified on page 5-30 of the McGuire FSAR). Therefore, the possibility of a PORV lift following a station blackout exists at McGuire as identified in the accident analysis section of the McGuire FSAR.

A study of the safety analyses performed at several plants has suggested that there is a possibility of a PORV lifting at most plants. Based on this review, a probability (0.37) is assigned to the potential for the PORVs being challenged (basic event PPR-SRV-CO-SBO), possibly leading to a failure of a PORV to re-close and a subsequent LOCA. This is the premise of LOOP sequence 40 shown in Figure 1 of the analysis.