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SUBJECT: Forwards "ECCS Electrical Component Single Failure Analysis."

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Iowa Electric Light and Power Company

June 26, 1989

NG-89-1856

Dr. Thomas E. Murley, Director
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Mail Station P1-137
Washington, DC 20555

Subject: Duane Arnold Energy Center
Docket No: 50-331
Op. License No: DPR-49
Consideration of Postulated Electrical Failure
in 10CFR50.46 ECCS Analysis

Reference: Letter from J. R. Hall (NRC) to L. Liu (Iowa Electric)
dated September 20, 1988

File: A-107a, A-225

Dear Dr. Murley:

In the course of the NRC staff review of the electrical swing bus design issue (Reference), a concern was raised regarding the validity of the assumptions and methodology used in analyzing the performance of the Duane Arnold Energy Center (DAEC) Emergency Core Cooling Systems (ECCSs) following a Loss of Coolant Accident (LOCA) as required by 10 CFR 50.46. We were requested to verify that failure of the 125 VDC battery is, in fact, the most limiting single failure of an electrical component that can be postulated with respect to impact on ECCS performance. The purpose of this letter is to verify that the previously-analyzed battery failure is the most limiting single failure for the DAEC.

The verification was done by performing a new single failure analysis for ECCS electrical components. Electrical components in the ECCSs and supporting systems were analyzed to determine the effect of a single failure coincident with the loss of offsite power. The results indicate that the failure of a station battery (a single division of 125 VDC power) is the most limiting failure because the battery failure results in a failure to start the associated diesel generator, which in turn results in the loss of one division of ECCS as well as all instrumentation powered from that division. A summary description of the methodology and analysis results are presented in the attachment to this letter.

A001

A copy of the complete analysis and the supporting documentation is on file and is available for review. This analysis completes all items required in the referenced letter from the NRC. If you have any further questions regarding this submittal, please contact this office.

Very truly yours,

Daniel L. Mineck
Manager, Nuclear Division

DLM/NKP/pjv+

Attachment: Emergency Core Cooling System (ECCS) Electrical Component Single Failure Analysis

cc: N. Peterson
L. Liu
L. Root
R. McGaughy
J. R. Hall (NRC-NRR)
A. Bert Davis (Region III)
NRC Resident Office
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EMERGENCY CORE COOLING SYSTEM (ECCS) ELECTRICAL COMPONENT SINGLE FAILURE ANALYSIS

This analysis evaluated the Automatic Depressurization System (ADS), High Pressure Coolant Injection (HPCI), Core Spray, Residual Heat Removal (when operating in the Low Pressure Coolant Injection (LPCI) and Torus Cooling modes) systems as well as their support systems. The Reactor Core Isolation Cooling (RCIC) system was also evaluated since RCIC is the preferred backup to HPCI (over ADS) for some accident scenarios. The results confirm that the previously analyzed loss of a single division of 125 VDC power (i.e., station battery) is the most limiting single failure for the Duane Arnold Energy Center (DAEC).

This study used a six-step approach in the performance of the analysis:

1. Determine ECCSs and necessary support systems.
2. Identify the electrical components in these systems that need to be reviewed.
3. Analyze those electrical components for the effect of a single failure.
4. Evaluate the impact of such failures on ECCS availability.
5. Determine the most limiting single failure.
6. Compare results to previously-analyzed limiting single failure.

The DAEC piping and instrument diagrams (P&IDs), single-line diagrams, and electrical schematic diagrams were used to identify the electrical components in each of the ECCS and support systems listed in Table 1. It should be noted that cables, hand switches, and control relays for each system were considered.

Table 1

Systems Analyzed

ECCS Systems
HPCI
Core Spray
Residual Heat Removal (RHR) - LPCI mode
ADS
RHR - Torus Cooling mode
RCIC *

*Not an ECCS but considered in this analysis.

Support Systems
Essential AC Power
Emergency Diesel Generators (EDGs)
250 VDC Power
125 VDC Power
Emergency Service Water (ESW)
RHR Service Water (RHRSW)
River Water Supply (RWS)
Condensate Storage Tank Water Supply
Torus Water Supply
Nitrogen Accumulators

ANALYSIS OF SINGLE FAILURE EFFECTS

Each electrical component identified was analyzed to determine the effect of its failure using the assumptions listed below. Only the effect of component failure on ECCS and RCIC performance and availability was considered.

Assumptions:

a. The analysis was limited to single failures of electrical components in ECCS and support systems. No common-mode failures or external event system interactions (other than the initiating LOCA) were considered.

b. Components were assumed to fail in the worst-case position (e.g., if a valve's safety function is to close, the analysis assumed that the valve failed in the open position).

c. Indication and alarm functions were not considered to be essential to system operation. A human factors performance evaluation to determine the effect of operator actions in response to a loss of indication or false indication or alarms was not within the scope of this study.

d. Selective breaker coordination was assumed, with the exception of the LPCI Swing Bus maintenance isolation breakers (52-3402 and 52-4402).

e. Effects of cable failures were assumed to be identical to the failure of the component to which the cable is attached.

f. Effects of hand switch failures were assumed to be identical to failure of the controlled component.

g. Failure of individual relays within a logic train were assumed to result in the failure of that logic train. Failure of interlocks between divisions of logic for a single ECCS system or interlocks between different systems, as well as instruments that provide signals to a logic train, were analyzed separately.

h. Failure of a support system or component results in an immediate loss of all supported systems. No attempt was made to evaluate time to failure due to loss of support systems.

RESULTS OF SINGLE-FAILURE ANALYSIS

HPCI

We identified several failures of HPCI electrical components that could result in the loss of the HPCI system. No failures were identified that would incapacitate equipment in any other ECCS, RCIC, or support system.

Core Spray

There are several failures of Core Spray system electrical components that could result in the loss of one train (A or B) of Core Spray. No single failure could result in the loss of both trains.

The Core Spray logic provides initiation signals to the LPCI and HPCI logic trains, a permissive signal to the ADS logic and an input to the LOOP-LOCA electrical load-shed logic, as well as Primary Containment Isolation System (PCIS) Group 7 isolation logic. The Core Spray logic also provides initiation signals to the emergency diesel generators (EDGs). Each LPCI and HPCI logic train interrogates both divisions of Core Spray; therefore, a loss of a single train of Core Spray logic would not result in the loss of HPCI or LPCI. The EDG automatic start circuit interrogates only the division of Core Spray that it is associated with, i.e., Division I Core Spray provides a LOCA start signal only to the Division I EDG, and Division II Core Spray provides a LOCA start signal only to the Division II EDG.

In the event of a loss of a single train of Core Spray logic, the EDG associated with that train would not receive a LOCA start signal. The EDG would automatically start on LOOP or could be started manually. It should also be noted that the EDG would not automatically start in the event of a LOCA with offsite power available. However, the EDG is not needed in this accident scenario. This failure is bounded by the previously-analyzed failure of a single division of 125 VDC power (See Table 2).

RHR (LPCI and Torus Cooling modes)

There are several failures of RHR electrical components that could result in the loss of one train of RHR; however, only a failure of the LPCI Swing Bus could result in the loss of both LPCI injection trains. In the event of a loss of the LPCI Swing Bus, the minimum ECCS requirements are met by the use of both trains of Core Spray. Loss of a LPCI logic train would result in the loss of the same division of RHRSW. No other failure was identified that could incapacitate equipment in any other ECCS, RCIC, or support system.

RCIC

There are several failures of RCIC electrical components that could result in loss of the RCIC system. However, none of these failures could incapacitate equipment in any ECCS or support system.

ADS

There are several failures of ADS electrical components that could result in the loss of one ADS valve. However, no single failure could result in the loss of more than one ADS valve or incapacitate equipment in any other ECCS, RCIC, or support system.

ESW

There are a few failures of ESW electrical components that could result in the loss of one train (A or B) of ESW, but none could result in the loss of both trains. Loss of one train of ESW cause the associated EDG to fail due to inadequate cooling and eventually would result in the loss of one train of Essential AC power, one train of Core Spray, one train of RHRSW, and one division of RHR (LPCI and Torus Cooling). The effect of the loss of one train of ESW on Room Coolers for ECCS pumps is bounded by the EDG failure.

RHRSW

There are several failures of RHRSW electrical components that could result in the loss of one train (A or B) of RHRSW, however, none could result in the loss of both trains. Loss of one train of RHRSW would result in the loss of one train of Torus Cooling. No other ECCS, RCIC, or support systems would be affected.

RWS

There are a few failures of RWS electrical components that could result in the loss of one train (A or B) of RWS; however, none could result in the loss of both trains. The failure of one train of RWS will not result in a failure of any ECCS, RCIC, or support system.

Essential AC Power

There are several electrical failures that could result in the loss of one train of ECCS components. These failures involve the loss of an EDG, 4.16 KV switchgear, transformer, 480 VAC load center or motor control center (MCC) in one division. Certain failures lead to a loss of the LPCI Swing Bus. Failure of the LPCI Swing Bus would result in the loss of both trains of LPCI; however, the minimum ECCS availability requirements would still be met. No other failures was identified that could affect both trains of other ECCS components, RCIC, or support systems.

250 VDC Power

There are several electrical failures that could result in the loss of the HPCI system. No other ECCS, RCIC, or support systems would be affected.

125 VDC Power

There are several failures that could result in the loss of a single division of 125 VDC power. A loss of Division I 125 VDC power would result in the loss of the RCIC system and the Division I EDG. The EDG failure results in the loss of Division I of Core Spray, RHR (LPCI mode), RHRSW, ESW, and RWS. A loss of Division II 125 VDC power would result in the loss of the HPCI system initiation logic and the Division II EDG. The EDG failure results in the loss of Division II of Core Spray, RHR (LPCI mode), RHRSW, ESW, and RWS. The EDGs are assumed to fail because 125 VDC power is required in the EDG start and run logic.

No failures were identified that would result in a loss of both trains of 125 VDC power.

Table 2
MINIMUM AVAILABILITY OF SYSTEMS FOLLOWING LOOP-LOCA

Single Failure	Systems Available							
	HPCI	RCIC[1]	ADS	A Core Spray	B Core Spray	LPCI	A EDG	B EDG
125 VDC (Division I)	X		X[2]		X	X[3]		X
125 VDC (Division II)		X	X	X		X[3]	X	
A Core Spray Logic	X	X	X		X	X	X[4]	X
B Core Spray Logic	X	X	X	X		X	X	X[4]

NOTES:
Note 1 - Not an ECCS but considered in this analysis
Note 2 - Loss of 'A' Channel of ADS logic only, ADS system is operational.
Note 3 - LPCI operating with 2 RHR pumps only
Note 4 - Starts on LOOP start signals only, LOCA start signals are inoperable.

CONCLUSION

The results of these analyses indicate that the failure of a single division of 125 VDC power (i.e., station battery) is the most limiting single failure. As seen in Table 2, the loss of a single division of 125 VDC power results in the greatest loss of ECCS capability following a LOOP-LOCA. However, the minimum ECCS performance requirements of our existing 10CFR50.46 ECCS analysis are still met.