LILCO
LONG ISLAND LIGHTING

LONG ISLAND LIGHTING COMPANY
SHOREHAM NUCLEAR POWER STATION
P.O. BOX 618, NORTH COUNTRY ROAD • WADING RIVER, N.Y. 11792

50-322

April 26, 1982

Mr. David Fisher
Advisory Committee on Reactor Safeguards
1717 H Street, NW
Washington, D.C. 20555

DC Reliability Study
Shoreham Nuclear Power Station - Unit 1

Reference: Letter SNRC-642 dated 12/8/81 to Mr. Harold Denton

Dear Dave:

Per your request in a telephone call with Mr. R. Grunseich, enclosed are details of a reliability study which was performed regarding the Shoreham Nuclear Power Station 125V DC System. These details are being forwarded in the form of informal calculations done by the Architect Engineer, and provide a basis for the information on DC system reliability contained in "Loss of AC/Loss of DC Power", which was forwarded as an attachment to the Reference 1 letter. A copy of the Reference 1 letter had also been forwarded to Mr. J. McKinley of ACRS.

Very truly yours,

J. L. Smith

J. L. Smith
Manager, Special Projects
Shoreham Nuclear Power Station

RWG:mp

Bool
S.1/1 Per L. Hylton

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A 5010.10 STONE & WEBSTER ENGINEERING CORPORATION

CALCULATION SHEET

Preliminary

Item

INFORMAL

Client Long Island Lighting Co. Location Boston Est. No. J.O. No. 11600.02

Subject Reliability of the Shoreham Nuclear Power Station Unit 1 125V DC System Date 9/11/81 By DWLamb

Based on Checked By

Revised By

CONTENTS

PURPOSE: TO CALCULATE THE RELIABILITY OF THE SHOREHAM NUCLEAR POWER STATION 125V DC SYSTEM TO PROVIDE SUFFICIENT POWER TO ITS CRITICAL LOADS DURING THE SAFE SHUTDOWN OF THE REACTOR

DEFINITIONS AND ASSUMPTIONS:

Success of Dc System - The sufficient supply of Dc power to its critical loads by at least 2 out of 3 DC sources for the shutdown period.

Failure of a DC source - insufficient dc power supplied to its critical loads by the failure of a battery, rectifier, switchgear, cables, or any single circuit breaker or contactor.

Shutdown Period - 24 hours

Repairs - No repairs or replacements of electrical equipment are assumed. Exceptions are the diesel generators AND OFFSITE POWER WHICH CAN BE REPAIRED AT ALL TIMES.

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Subject Reliability of 125-V DC system Date By OWBlank
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Common Mode Failures - NO DC OR AC common mode FAILURES ARE ASSUMED BECAUSE OF THE REDUNDANCY, ISOLATION, AND PROTECTION OF THE EQUIPMENT.

LOCA - Loss of Coolant Accident ASSUMED to be the accident FOR THIS ANALYSIS.

INITIAL CONDITIONS - THE probability that the DC system is AVAILABLE AT THE INCEPTION OF THE LOCA is EVALUATED.

BATTERY - IT IS ASSUMED THAT THE BATTERIES CAN PROVIDE DC POWER FOR 2 HOURS WITHOUT DISCHARGING BELOW A CRITICAL LEVEL.

RETURN of P.C after loss - The probability that some AC power is returned by 2 hours after All AC is lost, is evaluated.

OTHER CONDITIONS AND ASSUMPTIONS APPEAR IN THE TEXT.

NOTE: The detailed calculations used the red DC source as a model and ASSUMES the blue AND orange systems are identical TO THE RED. This is a conservative assumption to simplify calculation.

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Client Long Island Lighting Co. Location Est. No J.O. No 11600.02

Subject Reliability of 125V DC system Date By DW Bartz

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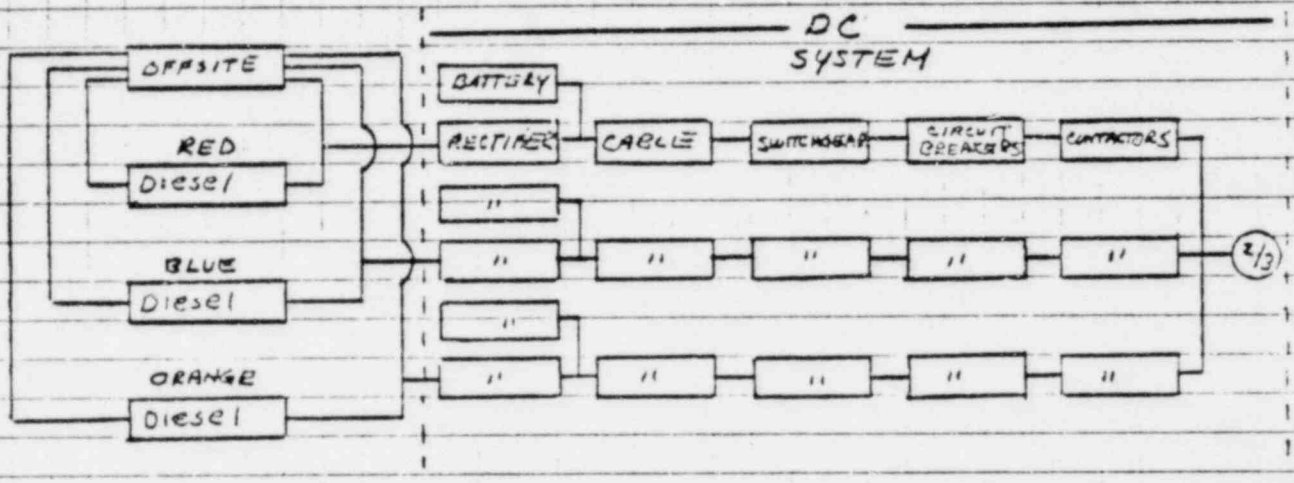
PROCEDURE

THE DC SYSTEM CAN BE MODELED THE FOLLOWING WAY:

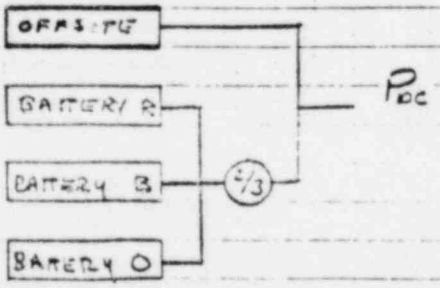


WE WILL CONSIDER THE PROBABILITY THAT THE DC SYSTEM PRODUCES SUFFICIENT POWER TO ITS CRITICAL LOADS (2 OUT OF 3 DC SOURCES OPERABLE) FOR TWO DISCRETE CASES:

1. AT THE INCEPTION OF LOCA, AND
2. SUBSEQUENT TO A LOCA

1. AT INCEPTION OF LOCA

The DC system is required to connect the diesel generators to their buses at a LOCA AND the Diesels are therefore ineffective in determining the AVAILABILITY OF the DC system FOR THIS CASE. THE probability of success is therefore the probability that either offsite power is AVAILABLE OR THAT 2 out of 3 batteries are available.



$P_{AC\ offsite} = .999$

$P_{battery}^{2/3} = .999999998$

$P_{DC} \simeq 1$

THUS THE Probability that SUFFICIENT DC power IS AVAILABLE AT THE INCEPTION OF A LOCA is essentially 1.

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Subject Reliability of 125V DC System Date By Dunham
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2. SEQUENT TO A LOCA

WE CONSIDER THE PROBABILITY THAT AT LEAST 2 OUT OF 3 OF THE DC sources is operable for 24 hours after a LOCA.

The probability that offsite power will NOT BE AVAILABLE some time during the 24 hours is:

$\overline{P_{offsite}} = 1 - e^{-\lambda T}$ $\lambda = 2 \times 10^{-5}$ pt. estimate of offsite failure rate

$\overline{P_{offsite}} = 4.7988 \times 10^{-4}$ $T = 24$ hours

BUT BECAUSE OFFSITE POWER IS COMMON TO ALL THREE DC Sources the effective probability of losing offsite power for each DC source can be estimated as: $\sqrt[3]{4.7988 \times 10^{-4}} = 7.829 \times 10^{-2}$

THIS IS A CONSERVATIVE ESTIMATE

FOR EACH DC SOURCE the probability that some AC POWER IS AVAILABLE FOR THE 24 hr period is:

effective offsite	(1/2)	=	.922	(1/2) = .9977
Diesel			.970	

IF ALL AC POWER IS LOST FOR SOME TIME DURING THIS PERIOD THE BATTERIES will TAKE OVER FOR UP TO TWO HOURS BEFORE DISCHARGING COMPLETELY.

THE PROBABILITY THAT SOME AC POWER IS AVAILABLE WITHIN 2 hours after ALL AC POWER IS LOST IS

.8647	(1/2)	= .8769
.0908		

where .8647 is the probability OFFSI IS RETURNED AND .0908 TH THE DIESEL IS

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Item

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Subject Reliability of 125V DC System Date By OW Lamb

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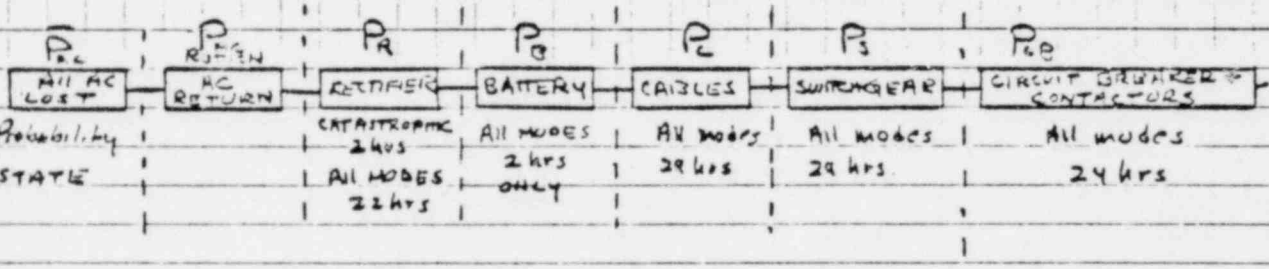
WE CONSIDER TWO BROAD PROBABILITY STATES THAT THE DC SYSTEM CAN BE IN DEPENDING UPON THE AVAILABILITY OF AC POWER DURING THE 24 HOUR PERIOD

STATE I

Consider the probability that A DC source is successful FOR 24 hours, if All AC power is lost for some time during that period. WE ASSUME THAT THE BATTERY MUST WORK FOR THE FULL 2 HOURS (a CONSERVATIVE ASSUMPTION) AND we consider the probability that some AC power is returned at that time. DURING THE 2 hours that the battery works the rectifier can only fail catastrophically. DURING THE balance of 22 hours the rectifier can fail All modes AND THE BATTERY IS REMOVED

FOR A DC SOURCE TO BE SUCCESSFUL IN STATE 1 P_{1DC}



$$P_{1DC} = (0.0023)(.8769)\left(e^{-.557\times10^{-6}(2)}\right)\left(e^{-1.487\times10^{-6}(22)}\right)\left(e^{-.0204\times10^{-6}(2)}\right)\times$$
$$\left(e^{-1.92\times10^{-6}(24)}\right)\left(e^{-.878\times10^{-6}(24)}\right)\left(e^{-7.18\times10^{-6}(24)}\right)$$

$$P_{1DC} = (.0023)(.8769)(.999999)(.99997)(999999)(.99995)(.99998)(.99983)$$

$$P_{1DC} = .00201633$$

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Subject Reliability of 125-V DC System Date By

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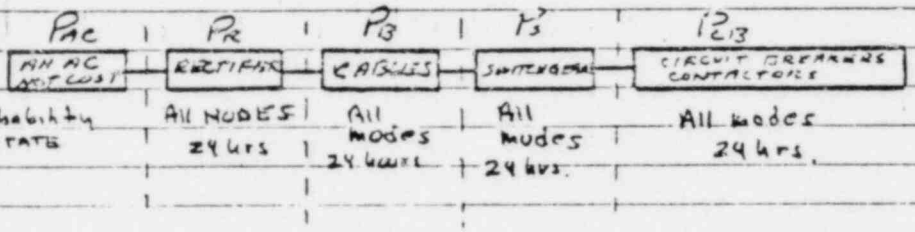
STATE II

Consider the probability that a DC source is successful for 24 hours, if all AC power is not lost during this period. The rectifier can fail all modes for 24 hrs and the battery is removed

For a DC source to be successful in state II P_{IIDC}



$$P_{IIDC} = (.9977)(e^{-1.48 \times 10^{-6}(24)})(e^{-1.921 \times 10^{-6}(24)})(e^{-.878 \times 10^{-6}(24)})(e^{-7.18 \times 10^{-6}(24)})$$

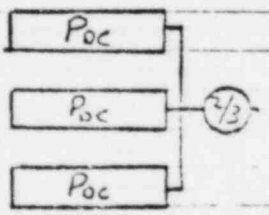
$$= (.9977)(.999964)(.999954)(.99998)(.99983)$$

$$= .9974287$$

COMBINING Probability States I & II GIVES THE TOTAL PROBABILITY OF SUCCESS FOR A DC SOURCE TO OPERATE FOR 24 HOURS.

$P_{DC} = P_{IDC} + P_{IIDC} = .999445$

THE PROBABILITY THAT THE DC SYSTEM WILL BE SUCCESSFUL FOR 24 hours SUBSEQUENT TO A LOCA IS (2 OUT OF 3):



$$P_{DC}^3 + 3P_{DC}^2(1-P_{DC})$$

$$= (.999445)^3 + 3(.999445)^2(.000554)$$

$$= .999999$$

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Subject Reliability of 125V DC System Date By DW Lambe

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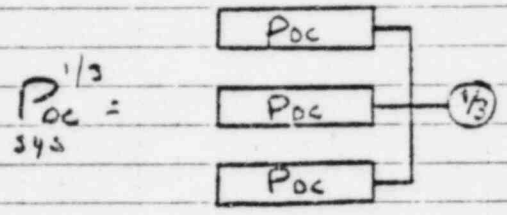
THE PROBABILITY THAT THE DC SYSTEM IS AVAILABLE FOR AT LEAST 1 OUT OF 3 DC SOURCES IS:



$P_{DC\ SYS}^{1/3} =$

$$P_{DC}^3 + 3P_{DC}^2(1-P_{DC}) + 3P_{DC}(1-P_{DC})^2$$

$$= (.999445)^3 + 3(.999445)^2(.0005545) + 3(.999445)(.0005545)^2$$

$$= .999999998$$

THE PROBABILITY THAT NO DC SOURCES ARE SUCCESSFUL IN THE 24 HRS IS:

$$1 - P_{DC}^{1/3} = 2 \times 10^{-10}$$

THE PROBABILITY OF A LEAST 1 OUT OF 2 DC SOURCES IS

$$= 2 \times P_{DC} - P_{DC}^2$$

$$= 0.999999692$$

or 3.08×10^{-7} chance of failure

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Client Long Island Lighting Co. Location Est. No. J.O. No. 116005

Subject Reliability of 125-V DC System Date By D'Victoria L.

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RESULTS

PROBABILITY THAT DC SYSTEM IS AVAILABLE AT INCEPTION OF LOCA:

$> 0.999999999 = 1$

PROBABILITY THAT DC SYSTEM IS AVAILABLE (2 OUT OF 3 SOURCES operable) FOR 24 HOURS SUBSEQUENT TO LOCA:

0.999999

PROBABILITY THAT DC SYSTEM IS AVAILABLE (1 OUT OF 3 SOURCES operable) FOR 24 HOURS SUBSEQUENT TO LOCA:

0.9999999998

PROBABILITY THAT THERE IS NO DC POWER AVAILABLE (0 out of 3 DC sources operable) FOR 24 hours after a LOCA is:

2.0×10^{-10}

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DISCUSSION

The probability that 2 out of 3 DC sources will be operable and supply power to their critical loads is very high and consistant with values reported in WASH 1400.

The probability that there is no DC power at all is extremely small and approaches zero.

The most interesting result of this calculation is that the probability of some DC power returning within two hours after it is lost is only .0877. However the probability of losing all DC power is small and the actual loss of a DC source because of a discharged battery is very small.

REFERENCES

REACTOR SAFETY STUDY, APPENDIX II (VOL. 3) BWR FAULT TREES, WASH 1400

IEEE GUIDE TO THE COLLECTION AND PRESENTATION OF ELECTRICAL ELECTRONIC AND SENSING COMPONENT RELIABILITY DAT FOR NUCLEAR POWER GENERATING STATIONS THE INSTITUTE OF ELECTRICAL AND ELECTRONI ENGINEERS.

S&W DWG. NO. 11600.02-FE-1AT-5, 1AY-4, 1AK-

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Client Long Island Lighting Co. Location Est. No J.O. No 11600.02
Subject Reliability of 125V DC Systems Date By
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TABLE 1

COMPONENT	Failure rate $\times 10^{-6}$		
	LOW	RECOMENDED	HIGH
RECTIFIER			
All Modes	0.14	1.487	30.00
Catastrophic	0.044	0.557	11.90
CABLE			
From BATTERY TO BUS 276 FT. Line to Line short	0.00265	0.2865	0.5232
BATTERY			
All Modes	0.0031	0.0704	0.1408
CABLE			
From rectifier to bus 35 FT Line to Line short	0.00034	0.0363	0.0664
CIRCUIT BREAKERS HIA			
All Modes	0.02	0.139	0.400
CABLE			
From inverter to bus 133 ft Line to Line short	0.0013	0.138	0.252
CIRCUIT BREAKERS AIB			
All MODES	0.02	0.139	0.400
CABLE			
From HIB to REAC. BLDG MCCS - 1010 FT Line to line short	0.0097	1.048	1.915

NOTES: 1) DOES NOT CONSIDER TESTING AND INCIPIENT FAILURES
CIRCUIT [illegible] DO NOT INCLUDE FAILURE TO CLOSE

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Subject Reliability of 125V DC System Date By DLB
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R. CONTACTOR			
All Modes	0.2567	1.700	8.092
NR CONTACTOR			
All modes	0.0301	0.200	0.952
CIRCUIT BREAKERS REAC BLDG			
All modes	0.040	0.276	0.504
CIRCUIT BREAKERS AIC			
All Modes	0.020	0.139	0.400
CABLE			
From AIC to PNL-A2 220 ft. Line to Line Short	0.0266	0.341	0.723
CIRCUIT Breakers PNL - A2 (21)			
All Modes	0.420	2.919	8.4
CABLE			
From AIC to PNL-A1 46 ft Line to Line Short	0.0056	0.071	0.1511
CIRCUIT BREAKERS			
PNL - A1 (12) All Modes	0.240	1.668	4.8
SWITCHGEAR			
Low-Voltage Power Circuit Breaker (2)	0.020	0.078	0.860
Switchboards (2)	0.300	0.800	5.472