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NUCLEAR REGULATORY COMMISSION

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Before the Atomic Safety and Licensing Board

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In the Matter of)
)
LONG ISLAND LIGHTING COMPANY) Docket No. 50-322-OL-4
) (Low Power)
Shoreham Nuclear Power Station,)
Unit 1))

TESTIMONY OF ROBERT WEATHERWAX, MOHAMED EL-GASSEIR AND GREGORY MINOR ON BEHALF OF SUFFOLK COUNTY

Q. Please state your names and professional affiliations.

A. My name is Robert K. Weatherwax, Jr. I am the president of Sierra Energy and Risk Assessment, Inc., of Sacramento, California. I have had 15 years experience in matters relating to nuclear safety analysis of commercial power generation, including work related to developing elements of fault tree, sequence tree, and event tree analyses. A statement of my qualifications and educational background is set forth in Attachment A.

My name is Mohamed M. El-Gasseir. I am a senior staff scientist with Sierra Energy and Risk Assessment, Inc. I hold a B.S. degree in chemical engineering from the University of California, Berkeley and a M.S. degree

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in the same field from the University of Rochester. I am a doctoral candidate of Berkeley in the field of energy and resources. My recent work at Sierra has focused on probabilistic assessments. A statement of my qualifications is set forth in Attachment B.

My name is Gregory Minor. I am founder and vice president of MHB Technical Associates. I have 24 years of experience in the nuclear industry, including 16 years with the General Electric Nuclear Energy Division and 8 years as a consultant with MHB. A copy of my qualifications has been submitted with other testimony.

My educational background is in electrical engineering in which I received a B.S. degree at the University of California, Berkeley and a M.S. degree from Stanford.

My work with General Electric included the design, testing, qualification and pre-operational testing of safety equipment and control rooms for use in nuclear power plants.

As a consultant for MHB Technical Associates I have participated in numerous technical reviews and analyses of nuclear plant safety for government, public interest, and private organizations. My work has included project coordination for a PRA study on the Barseback Nuclear Plant in Sweden, and involvement in the performance or analysis of several probabilistic consequence models related to emergency planning for nuclear plants in the United States. In addition, I have participated through review, analyses, and testifying in many licensing hearings for nuclear power plants in the United States and abroad.

Q. What is the purpose of this testimony?

A. The purpose of this testimony is to address the question whether operation of the Shoreham plant at up to 5 percent power, under the AC power system proposed by LILCO in its Supplemental Motion for Low Power Operating License (the "alternate" system), would be as safe as operation at up to 5 percent power with three fully qualified on-site emergency diesel generators, as described in the Shoreham FSAR (a "normal" system). In our opinion, operation with LILCO's alternate proposed system would not be as safe as operation with a normal system.

Q. Generally, on what do you base your opinion?

A. We have assembled and reviewed documentation that enabled us to compare the proposed LILCO alternate AC power system and its components, with the qualified on-site AC power system described in the Shoreham FSAR and its components, in particular, those systems which affect their capability to deliver, and sustain the delivery of, AC power to essential emergency loads. A description of the two systems is contained in Attachment C hereto. We then performed a quantitative comparison of the probability of Shoreham reaching a state of core vulnerability (as defined by LILCO's contractor Science Applications, Inc. in Probabilistic Risk Assessments for the Shoreham plant) due to loss of offsite power, during operation at five percent power, assuming operation with the alternate system and assuming operation with the originally proposed qualified on-site power system.

Q. How does the quantitative comparison you just described relate to the relative safety of the two systems?

A. The comparison of calculated frequencies of the Shoreham plant reaching a state of core vulnerability due to a loss of offsite power, given each of the two AC power systems, provides a quantitative measure of the two systems' relative safety in terms of the overall operation of the plant at up to five percent power. The fact that the calculated probability of core vulnerability given operation with the alternate system is substantially greater than the corresponding probability given the normal system demonstrates that operation with the alternate system is quantifiably less safe than operation with the normal system.

Q. Please describe briefly the two AC power systems you compared.

A. The proposed alternate system's major components include four General Motors EMD, mobile outdoor-type diesel repowered generators ("EMDs"), and a 20-MW refurbished Pratt and Whitney gas turbine. The EMDs as well as the gas turbine were used (prior to their relocation to Shoreham) as peaking units for several years. Technical details of this generation equipment and of the supporting electric devices can be found in Table C1 of Attachment C. The proposed configuration is depicted by the line diagram in Figure C2 of Attachment C. The geographical layout of the major equipment is shown in Figure C1. The procedures for restoring power via the gas turbine and the EMDs are described in Section 2.1.1.2. of Attachment C.

The normal system consists of a set of three self-contained and operationally independent diesel generators manufactured by Transamerica DeLaval Inc. ("TDIs"). Technical details of the TDIs can be found in Section 2.1.2.1 of Attachment C and in Testimony of G. Dennis Eley et al. on behalf of Suffolk County regarding EMD diesel generators and the 20 MW gas turbine. Specifications for other components related to operation of the TDIs are also listed in Table C1. The configuration of the normal system is shown in Figure C4 of Attachment C. The operation of the TDIs is automatic.

Q. Please describe the process you used in analyzing the probability of Shoreham reaching a state of core vulnerability during operation at five percent power under each system.

A. Recently,, at LILCO's request, Science Applications, Incorporated ("SAI") and Delian Corporation performed a Probabilistic Risk Assessment for Shoreham operation at 5 percent power. "Probabilistic Risk Assessment, Shoreham Nuclear Power Station, Low Power Operation up to 5% of Full Power," by Delian Corporation and Science Applications, Incorporated, Draft, May 1984 (hereinafter, "SAI

Low Power PRA"). Our basic approach in performing our quantitative analysis of core vulnerability probabilities was to use the structure and methodology used by SAI in performing its assessment for LILCO. We used that methodology to produce two estimates of the probability of reaching core vulnerability due to a loss of offsite power transient at Shoreham for operation at 5 percent power. One estimate assumed that the TDIs, as described in the FSAR, were fully operational; and the other assumed that the EMDs and the gas turbine were operational in place of the TDIs. We decided to produce these two estimates for purposes of comparison, because the potential for reaching a state of core vulnerability is a key measure of whether operation of the Shoreham plant at 5 percent power with the alternate AC power configuration proposed by LILCO would be as safe as 5 percent power operation with fully qualified onsite diesel generators.

Our principal data sources in deriving these two estimates of core vulnerable probability were the SAI Low Power PRA and information from the Probabilistic Risk Assessment dated June 24, 1983, also performed by SAI for LILCO. "Final Report, Probabilistic Risk Assessment, Shoreham Nuclear Power Station," Science Application

Incorporated, June 24, 1984 (hereinafter, "SAI 1983 PRA"). The latter source was used primarily to derive reliability figures relating to the operation of the TDIs.

We used the SAI data in performing our analysis for several reasons. First, we did not have sufficient time to derive all the necessary data independently. Second, the approach and methodology used by SAI in its PRAs seemed generally reasonable, and in our professional judgment, the SAI analyses were competently performed and its results, in general, were reasonable and accurate. Third, we believe that since SAI acquired much of the data it used in its analysis from LILCO, it is reasonable to assume that the underlying factual data are likely acceptable to LILCO, thus reducing the chance of controversy regarding such underlying data. We used the SAI data, however, recognizing that in our opinion, not all the assumptions incorporated into the SAI analyses were as conservative or as appropriate as they should have been. Attachment E sets forth certain adjustments that we believe would make SAI's estimates of core vulnerability probabilities at Shoreham more realistic.

Core vulnerability can be produced by a number of initiating events. We limited our analysis to core vulnerability following loss of offsite power because, in the SAI analysis, that was the only source of core vulnerability affected by the differing AC power configurations now at issue.

In its Low Power PRA, SAI assumed that the EMDs and the gas turbine comprised the onsite emergency AC power system, and then investigated five types of accident sequences, each involving a unique time within which core vulnerability was reached after a loss of offsite power. The probabilities of core vulnerability derived by SAI are contained in Table 3.1.3 of the SAI Low Power PRA. We performed a comparable analysis, using the same methodology as SAI, but assuming that the emergency onsite AC power system was comprised solely of operational TDIs. We obtained the necessary data to perform the TDI event tree analysis from the SAI 1983 PRA. The result of SAI's calculations assuming the EMDs and the gas turbine provided emergency power, and of our calculations assuming the TDIs provided emergency power, are set forth in Table 1.[1/] The

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[1/] We believe, based on our review of the SAI Low Power PRA, that SAI did not consider the possibility of repairing the

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TABLE 1

COMPARISON OF CORE VULNERABILITY FREQUENCY FOR LOSS OF OFFSITE POWER TRANSIENT FOR NORMAL AND ALTERNATE AC POWER SOURCES

Loss of Off-site Power Sequence Type	Time to Core Vulnerable	Frequency (per Rx Yr); using EMD diesels and gas turbine	Frequency (per RX Yr.); using TDI diesels
Type 1	2 days	1.0E-7	5.1E-9
Type 2	30 hours	3.2E-7	2.8E-8
Type 3	3 hours	8.1E-7	1.3E-7
Type 4	10 hours	5.9E-7	7.0E-8
Type 5	7.5 hours	1.5E-6	2.1E-7
	TOTAL	3.3E-6	0.44E-6

Note: Column totals may not exactly equal the sum of the figures in each column due to rounding.

event trees which form the bases for the frequencies in Table 1 are Attachment D.

Q. What were your conclusions?

A. As shown on Table 1, the calculated probability of core vulnerability due to loss of offsite power, assuming LILCO's alternate AC power configuration is in place (EMDs and gas turbine) is 3.3 E-6; assuming the normal configuration (TDIs) is in place, it is 0.44 E-6. This means that assuming there is a loss of offsite power during operation of the Shoreham plant at 5 percent power, it is more than seven times as likely that such an event would lead to core vulnerability under the alternate system than under the normal system. It also means that the likelihood of the Shoreham plant reaching a core vulnerable condition due to loss of offsite power is over seven times greater under the alternate configuration than under the

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EMDs or gas turbine if they failed. Accordingly, in deriving the frequencies in Table 1, we used values for the TDIs that also assumed no repairs if they failed. Because there is a possibility, however, that either the TDIs or the EMDs and gas turbine could be repaired following a failure, we also performed a sensitivity study and compared calculated core vulnerable frequencies assuming such repairs. See Attachment E.

normal configuration. Furthermore, assuming the accuracy of SAI's estimate of 1.6 E-6 for the annual frequency of core vulnerability from all other initiating events during 5 percent operation (SAI Low Power PRA at Table 4-4-1), the likelihood that the Shoreham plant would experience an event leading to core vulnerability during 5 percent operation is approximately 2-1/2 times greater under the alternate configuration than it is under the normal configuration.

We recognize that uncertainties exist in each of the core vulnerability estimates set forth in Table 1. However, we believe that the uncertainties are comparable in the two estimates and that the existence of the uncertainties does not invalidate either the comparison or our conclusions. In our opinion the comparison set forth in Table 1 demonstrates that operation of the Shoreham plant with the alternate AC power configuration is not as safe as operation with a fully qualified source of emergency power.

Q. Did you perform any additional analyses or sensitivity studies?

A. Yes. We performed a sensitivity study to assess the reduction in core vulnerability attributable to the possibility of repairing the TDI diesels and the EMDs and gas turbine following their failure. We also analyzed the effect of certain adjustments to the SAI probabilities of offsite power restoration and the frequency of loss of offsite power events at Shoreham, which we believe make those probabilities more realistic. These analyses are described in Attachment E.

Q. Do the results of your sensitivity studies cause you to modify your conclusions regarding the relative probability of core vulnerability due to loss of offsite power given the alternate as compared to the normal Shoreham emergency power system?

A. No. Our sensitivity studies confirm our conclusion that the probability of core vulnerability due to loss of offsite power transient, assuming use of the alternate system, is higher than with the use of the normal configuration. The precise difference in probability, though uncertain, is sufficiently large to conclude that low power operation with the alternate configuration would not be as safe as with the normal configuration.

ATTACHMENT A

SERA
Sierra Energy and Risk Assessment, Inc.

ROBERT K. WEATHERWAX, JR.

EXPERIENCE:

Jan. 1981 - Present	President, Sierra Energy and Risk Assessment, Inc. Sacramento, California
July 1980 - June 1981	Visiting Scientist, Energy and Resources Group, University of California, Berkeley
July 1977 - December 1980	Chief Energy Forecaster, California Energy Commission, Sacamento, California
Jan. 1977 - June 1977	Staff Scientist, Science Applications, Inc. Palo Alto, California
May 1974 - Jan. 1977	Staff Scientist, School of Engineering Princeton University, Princeton, New Jersey
Jan. 1969 - April 1974	System Safety Supervisor, McDonnell Douglas Aeronautics Company, Huntington Beach, California

As the founder and Chief Executive Officer of Sierra Energy & Risk Assessment, Inc. (SERA), Mr. Weatherwax is presently involved in the twin topics of (1) risk assessment and comparison, and associated cost benefit analysis, and (2) energy demand and supply assessment, and policy evaluation.

He has had fifteen years of experience in nuclear safety analysis of commercial power generation and isotope power systems for space application. He has worked broadly in the area of nuclear fuel cycle risk assessment, and in reliability and failure mode assessment of complex systems. He has contributed to the original development of elements of fault tree, sequence tree (i.e., FAST), and event tree analyses; and has applied these methods to light-water nuclear power plants, nuclear fuel cycles, radioiosotope thermal generators, strategic weapons systems and launch vehicles. In an American Physical Society meeting, Mr. Weatherwax debated Dr. Norman Rassmussin on the merits of the <u>Reactor Safety Study</u>, WASH-1400 (to which he was the major contributor). He is an engineer by formal education with a minor in economics and has applied these disciplines in numerous systems engineering and evaluation efforts, particularly related to energy demand forecasting and policy assessment during the last several years.

As a McDonnell Douglas Astronautics Company (MDAC) employee, Mr. Weatherwax was principal author of a PSAR for the NASA 50 kWe space station power system. He later was manager for Environmental Impact and Risk Assessment on the MDAC team selected by the Air Force Weapons Laboratory (AFWL) to perform safety analyses of LES 8/9 and Viking missions. After leaving MDAC he continued as a consultant to MDAC, and subsequently became a consultant to Teledyne Energy Systems in their support of the AFWL's space nuclear safety responsibilities.

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rwax has performed energy and risk analysis of fusion systems and nuclear
esigns. At Princeton University, he modeled performance and cost proper-
OKAMAK fusion reactor concepts and associated power conversion technologies
)0. Mr. Weatherwax managed the risk analysis of the Hanford (nuclear)
ion Purex plant. He also managed the initiation of the risk analysis of a
PWR under Swedish Government sponsorship. More recently, he has reviewed
luated the probabilistic risk assessments of the Indian Point and proposed
k light-water reactor power plants for the Union of Concerned Scientists and
nerick Ecology Action Committee, respectively. In 1983, Mr. Weatherwax
ied before the Indian Point Atomic Safety and Licensing Board regarding the
ilistic risk assessment of the Indian Point power plant.

eatherwax's current research and development interests in the area of probabi-
c risk assessment focus on the adequacy of existing fault-tree and event-tree
odologies for estimating low-probability events and representation of uncer-
ties in risk/benefit analysis. He is now involved in an AFWL project reviewing
probabilistic risk assessment of the space shuttle/Galileo - International Solar
ar missions. A list of risk assessment studies authored or contributed to by
Weatherwax is appended to this resume.

. Weatherwax's experience in energy forecasting includes work done at Princeton
iversity, UC Berkeley and as Chief Energy Forecaster for the CEC. During this
ime, he performed research involving end-use, microeconomic energy demand forecast-
ng models and implementation of data bases to various end-use forecasting models.
He developed the first utility service area version of a residential end-use energy
demand forecasting model and associated load shape forecasting model. As the Chief
Energy Forecaster, he was responsible for forecasting electricity and natural gas
requirements and peak loads for utility service areas for use in determining the
need for power plants within California. Duties included technical direction of
others in performing development and implementation of state-of-the-art microeconomic
end-use models of energy consumption by fuel type and electric peak load by economic
sector by utility service area. Other duties involved evaluation of cost effective-
ness of conservation and alternative energy options and their potential energy impact,
and management of twenty-five post-graduate level professionals.

SERA
Sierra Energy and Risk Assessment, Inc.

ROBERT K. WEATHERWAX

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Selected reports and analyses authored or coauthored by Mr. Weatherwax in the field of risk assessment include:

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ATTACHMENT B

ATTACHMENT B

SERA
Sierra Energy and Risk Assessment, Inc.

MOHAMED M. EL-GASSEIR

EXPERIENCE

Jan 1983 - Present	Senior Staff Scientist/Engineer, Sierra Energy & Risk Assessment, Inc., Sacramento, California
Oct 1980 - Oct 1981	Research Associate, Lawrence Berkeley Laboratory's Energy Analysis Program, Berkeley, California
Oct 1978 - 1980	Research Assistant, Lawrence Berkeley Laboratory's Energy Analysis Program, Berkeley, California
July 1977 - Oct 1977	Research Assistant on Project funded by the United States Council on Environmental Quality
July 1976 - Oct 1976	Consultant, National Research Council Committee on Nuclear and Alternative Energy Systems
Dec 1974 - July 1975	Assistant Lecturer, Department of Chemical Engineering, University of Tripoli, Libya
Oct 1972 - July 1975	Consultant to Libyan Government on the use of nuclear power for the generation of electricity
Oct 1972 - Nov 1972	Committee member investigating the feasibility of joint Egyptian-Libyan power projects
June 1972 - July 1973	Teaching Assistant, Department of Chemical Engineering, University of Tripoli, Libya
Additional Experience:	Design of hybrid cooling cycle for power plants capable of conserving both energy and water (Ph.D dissertation project, current)
	Constructed computer programs for the layout of heliostat fields of a solar central-receiver power plant
	Modeling of the inter- and intragenerational transfer of resources with the objective of evaluating the effects of the discount rates on equity

MOHAMED M. EL-GASSEIR

Resume (continued)

At Sierra Energy and Risk Assessment, Inc. (SERA), Mr. El-Gasseir is currently engaged in an analysis of probabilistic failure studies conducted for NASA's Galileo and International Solar Polar missions. He is specifically evaluating the validity of the approach and methodologies pursued in these studies and in the accuracy of the data and computations performed. Mr. El-Gasseir is the principal author of a recent SERA report critiquing probabilistic simulation techniques presently used by the utility inudstry in system planning.

Mr. El-Gasseir is a chemical/engineer power generation specialist by education. His background and experience encompass areas as diverse as the dynamics of multiphase flow systems, simulation of complex systems, numerical and analytic quantitative techniques and institutional analysis of utility related issues. Mr. El-Gasseir's current research interests in the field of probabilistic simulation and risk assessment include the development of efficient Monte Carlo techniques for power generation applications and of effective representation of interdependent time series and the search for a universal (non-monetary) yardstick for evaluating costs and comparing risks.

Mr. El-Gasseir has recently completed the design of a novel cooling cycle for a nuclear turbine/generator. The device combines two natural-draft dry towers with a spray pond. The design offers operating flexibility so that both energy and water can be conserved. It is particularly suitable for water-scarce regions.

At the Lawrence Berkeley Laboratory (LBL) Mohamed M. El-Gasseir was in charge of investigating the water quantity and quality issues of energy development in the Southwest. He developed the algorithms for computing the cooling water requirements associated with the various fuel cycles for generating electric power in California and Nevada. He was a member of a team designated by the Department of Energy (DOE) for its Regional Issues Identification and Analysis Program. Mr. El-Gasseir represented LBL on a DOE National Laboratories committee which was responsible for planning and funding water related energy research. He also conducted a study of the prospects for industrial water conservation.

As a consultant to the National Academy of Sciences Mr. El-Gasseir was a resource group member of the National Research Council Committee on Nuclear and Alternative Energy Systems. He carried out the study of the availability of water for synthetic fuel development in the U.S. and the impacts of this future industry on the nation's water resources. The results published in Science magazine heightened government and industry interest in the environmental problems of intensive development of synthetic fuels.

EDUCATION:

B. Sc., Chemical Engineering, University of California, Berkeley
M. Sc., Chemical Engineering, University of Rochester, New York
Ph. D. candidate, Energy and Resources, University of California, Berkeley, expected June 84.

SERA
Sierra Energy and Risk Assessment, Inc.

MOHAMED M. EL-GASSEIR

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MOHAMED M. EL-GASSEIR
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ATTACHMENT C

Attachment C

DESCRIPTION OF ALTERNATE EMERGENCY AC POWER SYSTEM PROPOSED FOR LOW POWER OPERATION AND THE NORMAL QUALIFIED ONSITE EMERGENCY AC POWER SYSTEM

1. Introduction

As requested on behalf of Suffolk County, New York, Sierra Energy and Risk Assessment (SERA), Inc. of Sacramento, California has conducted an analysis of whether operation of the Shoreham Nuclear Power Station (SNPS) at up to a power level of 5 percent, would be as safe, under conditions proposed by LILCO in its Supplemental Motion for Low Power Operating License, as a fully qualified onsite AC power source. The alternate AC power system proposed by LILCO, and the normal system as set forth in the Shoreham FSAR, are described in this Attachment.

2. System Descriptions

Section 2.1 provides a description of the systems to be compared. The LILCO proposed alternate system is specified first, emphasizing its unique elements. The description of the normal system builds upon the information developed in the specification of the alternate system. A system is viewed as consisting of:

- the hardware necessary for the generation and transmission of AC power to meet safety-related loads during emergency conditions accompanied by loss of offsite power,

- the particular configuration in which the hardware components are integrated, and
- the operating procedures which must be implemented for the purpose of securing power supplies for safety-related loads during emergency conditions.

2.1 AC POWER SYSTEM DESCRIPTION

The AC power systems of concern consist of a particular configuration of hardware to be used during emergency operation accompanied by loss of offsite power and the operating procedures to be implemented under such conditions. Detailed specifications and data for the LILCO-proposed system configuration can be found in Tables C1, C2 and C3, and Figures C1, C2 and C3. The normal system configuration is depicted by the line diagram of Figure C4. The proposed alternate system is discussed first. The normal system is then described.

2.1.1 The LILCO-Proposed Alternate System

In its Supplemental Motion for Low Power Operating License, LILCO proposed to augment offsite power sources to support emergency loads by a combination of a gas turbine and a set of four mobile diesel generator units, in place of a fully qualified NRC approved onsite source of AC power as described in the FSAR. Thus, the proposed configuration consists of newly introduced elements and pre-existing components.

The geographical layout of some of the key elements in the proposed configuration is depicted in Figure C1. Figure C2 provides a line diagram of the Shoreham plant, showing how the new components, the mobile diesels and the gas turbine, fit within the pre-existing configuration. Technical and function specifications of the elements relevant to the operation of the proposed configuration are listed in Table C1. In Table C1, components which did not exist in the SNPS FSAR line diagrams but which became associated with LILCO's alternate AC power system are classified as "proposed." This is to distinguish such components from the circuit and generation elements installed prior to LILCO's proposal of the alternate AC power configuration.

Procedures for restoring AC power after the onset of a LOCA condition and loss of offsite power are presented after the discussion characterizing the alternate configuration. The procedures apply to the 20 MW gas turbine (GT or GT-002) and the 4 General Motors EMD mobile diesel generators (EMDs) procured by LILCO. The comparison is based on the latest information made available by the utility in response to discovery requests.

The designations of the components in Figure C2 and the information compiled in Table C1 are used to characterize the hardware and circuitry of the proposed configuration. Therefore, the discussion to follow has been confined to the major elements of the alternate arrangement. Additional technical details can be found in Table C1.

2.1.1.1.1 The Mobile Diesel Generators

LILCO has installed a set of four General Motors EMD diesel generator (DG) units (see Tables C1 and C2 for technical details). Prior to being purchased by LILCO, the EMDs were in service for 15 years as Units 5, 6, 7 and 8 of the Lynnway Diesel Plant of New England Power (NEP). While owned by NEP, the 4 units underwent an unusually high number of major repairs. (See Table C3 for specifics).

LILCO staff estimates that the output of a single unit (approximately, 2.5 MW) is capable of meeting the minimum emergency load required during low-power operation. The apparent redundancy is counteracted by the following features of the EMDs:

- The output of all four diesels is conveyed to the load center (Bus 11) by way of a single power conduit.

- The EMD diesel system is of the master unit type. Accordingly, all four units share:
    - one starting battery and battery charger (housed with the master unit),
    - a common fuel system, including one long-term fuel source, one main supply pipe, and a single fuel transfer system (housed within the master unit).

The EMDs have a deadline start capability. Units start sequentially. Each generator is allowed 3 starting attempts. The battery can support 12 starting attempts. In the absence of AC power, the charger cannot power the battery. Thus, if the diesels fail to start after 12 attempts, another source of AC power would have to be found.

Units are synchronized automatically but connection to the safety load on Bus 11 is achieved manually. A single circuit breaker (No. 11.1B) can disconnect all four EMDs from Bus 11 loads. Power generated by the EMDs has to be routed through two more circuit breakers before it can reach emergency bus 101, 102 or 103. The EMDs are located outside the reactor building within the fenced security area. The enclosures and the foundation they rest on are not seismically designed. The switchgear for the four EMDs is housed within a single outdoor-type control cubicle located adjacent to the EMDs.

2.1.1.1.2 The Gas Turbine

The unit, or GT-002, is a 20 MW Pratt & Whitney gas turbine (GT) with deadline black start capability. GT-002 has served as LILCO's West Babylon Unit 1, providing peaking service for 15 years before relocation to Shoreham early in 1984. Even though the unit is located within the 69 KV switchyard of Shoreham and is connected with the SNPS 69 KV circuit, it is controlled by the System Operator in Hicksville, New York, rather than by the Control Room Operator at Shoreham.

The gas turbine shares a common bus and a 13.8 KV/69 KV step-up transformer with a 55 MW gas turbine (Unit GT-001; a Shoreham peaking power facility) which does not have black start capability and cannot operate in an isolated mode. To prevent load hunting if and when off-site AC power is restored, GT-001 must be securely disconnected from the grid. LILCO plans call for the 20 MW gas turbine to be a source of AC power to serve safety-related loads in the event that off-site power and other on-site power become unavailable. However, LILCO officials have indicated that GT-002 could be used as a peaking unit. (See Testimony of William G. Schiffmacher, filed April 20, 1984). In addition to providing safety power and peaking service, the black-start 20 MW gas turbine could be the primary source of start-up power for the Shoreham nuclear facility.

2.1.1.2 Proposed Operating Procedures

Final procedures for operating the alternate AC power system proposed by LILCO for the Shoreham facility have not been issued as of the end of the writing of this report. The interim procedures described herein are for restoring AC power with the proposed alternate configuration, first, using the 20 MW gas turbine (GT-002) and then using the EMDs, assuming failure of Unit GT-002. In both cases, the following conditions apply:

1. Reactor operations at 5% power level,
2. Loss of off-site power (leading to loss of both Normal and Reserve Station power),
3. System operator informs plant personnel that the loss of off-site power will be for an extended time period, and
5. These losses of AC power occur in conjunction with a LOCA.

2.1.1.2.1 Restoration of AC power with the 20-MW Gas Turbine[1]

The gas turbine can be started by one of the following methods:

1. Local switchroom - Automatic or Manual.

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[1] Extracted from Attachment 8 of the Testimony of W. G. Schiffmacher, Docket No. 50-322-OL-4 (Low Power) and from "Additional Responses to Staff Questions", (ibid), SNRC-1036, April 11, 1984.

2. EFB main Control Room - Automatic or Manual.

3. EFB dead-line start - manual only - local or remote.

4. Hicksville supervisory - Automatic only.

Manual operation requires initiation and manual closing of Field Breaker, voltage and speed adjustment, manual synchronization by closure of the main breaker, and manual loading by the operator. Automatic operation requires only initiation by the operator, local or remote. Sequential control causes the unit to be brought up to speed, phased in and loaded to a predetermined value.

(i) Pre-Start Checks

1. Local Operation:

   a. Check all personnel clear of enclosures and all doors shut.

   b. Check all switches in proper position as follows:

      1. 43-1 (Engine lockout - local - remote)
      2. 43-2 (Engine idle - manual - automatic)
      3. 43-2A (Base - minimum)
      4. 43-3 (Parallel - isolated)
      5. GSS (Peak - Emerg. Peak)
      6. 43-GL (Gas - Liquid)
      7. FRS (Normal - Loss of Aux. Power)

8. 1L51 (Start - Stop)

Operation of Switch 1L51 will initiate the starting sequence. The following will occur.

2. Electric generator lube oil pump will start.

3. At 6 PSIG lube oil pressure (electric generator) air starter valve will open to accelerate N2 rotor. Failure to attain 1500 N2 within 30 seconds will initiate "incomplete sequence".

4. At approximately 1500 N2 ignition will be actuated and combustion should start.

5. At 3400 N2 starter valve will close. N2 will accelerate to high idle.

6. At above 5400 Nw, N3 should be above 900 RPM at which time Field Breaker switch may be closed.

7. N2 will accelerate to high idel of approximately 6200 RPM.

8. Operate Speed Control (Manual Governor) to increase N2 speed, until N3 attains approximately 3600 RPM.

9. Activate Synchroscope and adjust voltage as necessary.

10. Close main ACB to "phase in" when scope is proper. Increase load immediately.

2. Automatic Operation - Local

Set switch 43-2 in automatic. Other switches will be set as above. Operate start switch to "Start" position. Unit will start as above. However at 900 N3, Field Breaker will close automatically. Following "crossover" (from N2 to

N3 control, observed as a slight hesitation in N2 and N3 speeds) automatic sequencing will energize speed matching and synchronizing relays to permit automatic synchronization and automatic loading to predetermined setting.

3. Remote Operation - Automatic

Set switch 43-1 (Engine lockout - local - remote) to <u>remote</u> position. Set switch 43 2 (Engine idle - manual - automatic) to <u>automatic</u> position.

All sequencing will be performed automatically, including breaker closure and loading to predetermined setting. Remote base or peak operations will cause unit to increase load as required.

(ii) Automatic pick-up of Shoreham of RSS Bank 4 by GT-002: As the 69-KV PT8 de-energizes, a 30-second timer is initiated, picking up auxiliary MG-6 relays 62X and 62X1, and resulting in:

1. Tripping of Oil Circuit Breaker (OCB) 640, Air Circuit Breakers (ACB) 8Z-110 and 8Z-120, and opening of motor operated disconnect switches MABS (Mechanical Air Break Switch) 616 and MABS 617.

2. The GT-002 "Mode Selector" Switch 43-3 will change to "Isolate" mode and prevent closing of ACB 8Z-110.

3. The GT-002 receives a start signal.

4. The GT-002 shifts to isolated precise mode and starts through its DC fuel pump.

5. When GT-002 reaches 3550 RPM ACB 8Z-120 (its main breaker) will close to allow picking up of RSS Bank 4 load. When the unit reaches 3600 RPM, it begins powering the RSST through ABS 623.

6. After the unit breaker closes, the AC fuel pump starts. The DC fuel pump trips

automatically as the pressure builds up on the discharge side of the AC fuel pumps.

(iii) Normal positions of the GT-002 controls:

1.	Voltage Regulator Transfer Switch	Auto
2.	Engine Mode Selector 43-2	Auto
3.	Engine Mode Selector 43-2A	Base/Peak
4.	Mode Selector 43-3	Parallel
5.	Governor Selector	Base
6.	Synch Scope Switch	Off
7.	86 CX Breaker Failure lockout	Reset
8.	Field Ground Relay Test Switch	Normal
9.	Lockout Relay 86 G 1	Reset
10.	Lockout Relay 86 G 2	Reset
11.	Control Switches A/W:	
	a. Gen Oil Cooler Fan	Auto
	b. Gen Oil Exhaust Fan	Auto
	c. GG Lube Oil Cooler Fan	Auto
	d. FT Lube Oil Cooler Fan	Auto
	e. AC Fuel Delivery Pump	Auto
	f. DC Lube Pump	Auto
	g. Inverter	Auto
	h. DC Fuel Forward Pump	Auto
12.	ACB 9 a/w Air - PAC	Closed

2.1.1.2.2 Restoration of AC Power With the Four 2.5 MW Mobile Diesel Units[2]

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[2] Extracted from "Restoration of AC Power With On-Site Mobile Generators, Interim Emergency Procedure", SP No. TP29.015.03.

In addition to the five conditions listed earlier, it is assumed that the 20-MW gas turbine has failed to auto-start and power the RSST.

(i) Automatic actions upon loss of all AC power:

1. EMDs' supply breaker No. 1R22-ACB-11-1.B to Bus 11 trips.
2. EMDs undergo automatic start.
3. EMDs' local Generator Breakers ACB-1, 2, 3 and 4 close.

(ii) Immediate actions:

1. The 4-KV Normal Bus supply breakers No. 1R23ACB-1A-3, 11-11, 1b-2 and 12-1 are placed to pull-to-lock (PTL).
2. Verify the 3 NSST supply breakers 1R22ACB-101-1, 102-1 and 103-1 are open and that Bus Program 27/86 devices are tripped
3. Verify that main generator breakers OCB 1310 and 1330 are open.
4. Check with System Operator to determine status of off-site power restoration.

(iii) Subsequent actions:

(Note, the RSST may be restored at any time.)

1. Change the 4-KV Emergency Bus supply breakers No. 1R22*ACB-101-1, 101-2, 101-8, 102-2, 102-8, 103-1 and 103-8 to PTL. (Caution, no auto sequencing of 4-KV loads from the bus sequencing program will occur. Note, Control Room personnel can monitor power restoration to the NSST or RSST by system operations by closing Breakers 1A-3 or 1B-2 (NSST) or Breakers 1A-4 or 1B-1 (RSST) and monitoring bus indicating lights on MCB-0.)

2. An operator is dispatched to perform the following:

   a. Removal of undervoltage bus program (UBP) fuses FU-71A located in Reactor Building Service Water Pump B, Cubicle3 1R22ACB- 102.

   b. Removal of UPB fuses FU-101A located in Reactor Building Service Water Pump C, Cubicle #3 1R22ACB-103.

   c. Removal of UBP fuses (FU-42) located in Reactor Building Service Water Pump A, Cubicle #3 1R22ACB-101.

   d. Verifying that EMDs' feeder breaker 1R22-ACB-11-1B is open (located in 1R23-SWG-11).

   e. Opening the GT-002 feeder breaker 1R23-ACB- 11-1A with the Local Control Switch (located in normal switchgear 1R22-SWG-11).

   f. Opening Screen Wash pumps feeder breaker 1R22-ACB-11-2 with the local Control Switch (in normal switchgear 1R22-SWG-11).

   g. Opening the 480-V Substation feeder breaker 1R23-ACB-11-10 with the local Control Switch (in normal switchgear 1R22-SWG-11).

   h. Checking the number of closed EMD breakers by returning to the normal switchgear room and observing (indicated by red-light cubicle) (1R22-ACB-11-1B).

   i. Notifying Control Room of the status of the DGs from normal switchgear room.

    j. Notifying Control Room of the removal of the UBP fuses from the emergency switchgear cubicles.

3. All 4-KV Emergencv load breakers are placed to PTL from the Main Control Room (including RHR,

4. Inform System Operator of intention to line up the DGs to meet emergency loads.

5. Request from System Operator to open OCB 1350 and 1360.

6. If Actions 4 and 5 not accomplished proceed to Step 8.

7. If there is a fault in the NSST, as experienced by annunciators 0218 "NSS X XFMR PRI PROT TRIP" or 0219 "NSS XFRM BACKUP PROT TRIP" on panels 209H, A-1 and A-2, proceed to Step 8.

8. Notify field operator to open R11-HDS (LTR) at x-winding on low side of the NSST.

9. Directed by the Control Room, the operator in the Normal Switchgear Room puts the control switch in the closed position at 11-1B until the breakers closes (as indicated by illumination of white light on Main Control Board of Bus 11).

10. Close the NSST Supply Breaker 11-11. (After re-energizing the Emergency Buses refer to SP 29.015.01 "Loss of Offsite Power" for more instructions on equipment restoration.)

11. Reset bus program lockout Emergency Bus 101.

12. Close Emergency Bus/NSST Supply Breaker 101-1.

13. Verify that the 4-KV Emergency Bus 101 is energized.

14. Verify that the 480-V Emergency Bus 111 is energized.

15. Reset bus program lockout Emergency Bus 103.

16. Close Emergency Bus/NSST Supply Breaker 103-1.

17. Verify that the 4-KV Emergency Bus 103 is energized.

18. Verify that the 480-V Emergency Bus 113 is energized.

19. Reset bus program lockout Emergency Bus 102.

20. Close Emergency Bus/NSST Supply Breaker 102-1.

21. Verify that the 4-KV Emergency Bus 102 is energized.

22. Verify that the 480-V Emergency Bus 112 is energized.

    (Ensure that maximum current rating does not exceed 434 amps per DG unit and 1200 amps at Breaker 11-1B.)

23. For a LOCA, refer to SP 29.023.01 for level control.

24. Power the ECCS pumps to recover to required level, using only the emergency buses.

2.1.2 The Normal System

Figure C4 contains a line diagram of the Shoreham station, showing the onsite (auxiliary) AC power system configuration. With the exception of the three diesel generators marked G-101, 102, and 103, all components which bear upon the comparative assessment of the safety the two AC power systems are described in Table C1. The following discussion will, therefore, focus on the three emergency diesel generators, which are the most important element in the auxiliary power system for providing AC power to safety functions.

Before we proceed further, two observations must be made. First, the description to be given and (for that matter) Figure 4 have been extracted from the SNPS FSAR, dated 1979. Second, in spite of the technical difficulties LILCO has encountered with the diesels identified in the FSAR, we have assumed that the requirements of GDC 17 and of other pertinent regulations will have to be eventually satisfied if the plant is to operate. Hence, we have considered the FSAR information to be generically applicable where safety requirements are concerned.

2.1.2.1 Onsite Emergency Diesel Generators

The onsite emergency diesel generators are described in the Shoreham FSAR as follows:

The Shoreham plant is provided with three independent standby diesel generators with buses arranged so that any two generators, operating independently, can provide power to all the loads that are deemed essential for the design basis accident. The emergency diesel generators are not used for the purpose of supplying additional power to the utility power system (peaking). It is assumed that the onsite power system satisfies GDC 17 and 18, IEEE 308-1971, and Regulatory Guide 1.9. The rating of each diesel generator set is as follows:

Continuous (8,760 hr)	3,500 KW
2 hr per 24 hr period	3,900 KW

The criteria used to size the emergency diesel generators are:

1. The capacity of any two diesels is adequate to meet the safety features demand caused by a loss of coolant accident. The established demand is shown in FSAR Table 8.3.1-1.

2. The maximum continuous load imposed on the diesel is less than the continuous rating of the machine, defined as the output the unit is expected to maintain for a minimum of 8,700 hours. The maximum intermittent load in the first 60 seconds (approximately) during the operation of the motor-operated

valves is less than the 2-hour rating of the machine. These loads are given in FSAR Table 8.3.1-1.

3. Each generator is capable of starting and accelerating to rated speed, and then in the required sequence, meeting all of its emergency shutdown loads, as shown in FSAR Table 8.3.1-2.

Sizing of the emergency diesel generators is consistent with Regulatory Guide 1.9.

The emergency diesel generators are automatically started on:

1. Loss of voltage to the respective 4,160 V bus to which each generator is connected.

2. High drywell pressure.

3. Low reactor coolant level signal.

If the preferred (offsite) power source is not available, the emergency diesel generators are automatically connected to the 4,160 V emergency buses and sequentially loaded. The capacity of any two emergency diesel generators is sufficient to meet the safety related load required by a loss of coolant accident during a loss of offsite AC power. The required loads and maximum coincident demand is shown in FSAR Table 8.3.1-1. Only one emergency diesel generator is needed for low power operation. The emergency diesel generator loading sequence for the above shutdown conditions is shown in FSAR Table 8.3.1-2. The loading sequence prevents system instability during motor starting. A fast responding exciter and a voltage regulator ensure quick voltage buildup during the starting sequence. Each diesel generator has independent start control circuits. The emergency diesel generator units are housed in separate rooms designed to Seismic Category I.

Each diesel generator is equipped with protective relays which shut the unit down automatically in the event of unit faults. During operation under emergency conditions, trip conditions are limited to those, which if allowed to continue, would rapidly result in the loss of the emergency diesel generator. Surveillance instrumentation is provided to monitor the status of the diesel generator. Conditions which can adversely affect performance of the emergency diesel generators are annunciated locally and in the main control room. The following list shows the important functions that are annunciated:

Function	Alarm	
	Local	Control Room
1. Low Pressure Lube Oil	X	X

2. Overspeed Shutdown	X	X
3. Main Board Control Disabled	X	X

Except for the control rod drive pumps, all nonsafety-related loads are connected to the diesel generator bus through two series connected breakers (for those 480 V loads that are disconnected on LOCA, one of these breakers is the molded case shunt-trip or switchgear breaker). The magnetic breakers have been installed to limit detrimental effects on the emergency buses due to faults and overloads on nonsafety related equipment. The power and control circuits for the control rod drive pumps are treated as Class IE circuits, and the power circuits to 480 V nonsafety loads fed through two series connected breakers are treated as Class IE circuits up to the second breaker.

The three diesel engines operate on No. 2 fuel oil. Each engine is supplied by a separate diesel generator fuel oil storage and transfer system design to allow for 7 days continuous operation of the diesel engine at rated load. All safety-related portions of the diesel generator fuel oil storage and transfer systems are designed to ASME III, Code Class 3, and Seismic Category I requirements. The system design incorporates sufficient redundancy to prevent a malfunction or failure of any single active or passive component from impairing the capability of the system to supply fuel oil to at least two of the diesel engines. The diesel generator fuel oil storage and transfer systems are designed so that makeup fuel oil may be transferred from the auxiliary boiler fuel oil storage tanks to the fill piping for the diesel generator fuel oil storage tanks. Auxiliary boiler fuel will be compatible with diesel generator fuel requirements. Missile protection is provided for the fuel oil storage and transfer systems in accordance with General Design Criterion 4 of 10 CFR 50, Appendix A.

The diesel generator fuel oil storage and transfer system located in the area adjacent to the diesel generator rooms consists of:

1. Three buried diesel fuel oil storage tanks - one for each diesel engine. Each storage tank has a capacity of 42,000 gallons, providing sufficient fuel oil for continuous operation of the associated diesel at rated load for 7 days. Each tank is vented to the atmosphere.

2. Six 10 gpm full-capacity, electric motor driven rotary positive displacement fuel oil transfer pumps (two

pumps for each diesel generator fuel oil storage tank) are provided. Each pump is provided with a relief valve discharging back to its associated suction line. Each diesel generator fuel oil transfer pump is mounted directly above its associated fuel oil storage tank.

3. A diesel generator fuel oil day tank for each diesel engine is situated in the associated diesel generator room. Each diesel generator fuel oil day tank is sized to store 550 gallons of fuel oil. Each diesel generator fuel oil day tank is supplied with a flame arrestor on the vent.

4. Two 13 gpm, full capacity, positive displacement fuel oil booster pumps per diesel engine. The shaft driven and d-c motor driven booster pumps are piped in parallel and mounted on the diesel engine skid. Each pump discharge is equipped with a relief valve back to the pump suction. A large mesh Y type fuel oil strainer is located upstream of each booster pump.

As a result of the redundancy incorporated in the system design, the diesel generator fuel oil system provides its minimum required safety function under any of the following conditions:

1. Loss of offsite power coincident with failure of one diesel generator.

2. Loss of offsite power coincident with maintenance outage or failure of one diesel generator fuel oil transfer pump or one diesel generator fuel oil booster pump associated with each diesel generator.

The fuel oil storage tanks are buried 2 1/2 feet below grade, with a 4 foot separation between the sides of each tank. The tanks rest on, and are covered by compacted sand. Six inches above the top of the tanks, supported by the compacted soil, is a 2 foot thick concrete slab, designed to Seismic Category I requirements. The fuel oil transfer pumps are mounted above this slab, and take suction through the top of the tanks. A Seismic Category I concrete block house is provided above each tank to enclose the two fuel oil transfer pumps, associated discharge piping, instrumentation, and manhole into the tank. The blockhouse and slab together provide the fuel oil storage and transfer system with adequate protection against potential missiles due to tornadoes or hurricanes. This arrangement meets the intent of General Design Criterion 4.

Each of the diesel generator fuel oil day tanks is sized to store a maximum 550 gallons of diesel fuel oil, as allowed by National Fire Protection Association (NFPA) standards, Vol. 1, 1971-1972. This storage capacity provides for 2 hours of continuous operation of the diesel generator at rated load.

Each of the diesel generator fuel oil storage tanks is provided with a connection for manual determination of the diesel fuel oil level. A level transmitter is also provided to give a continuous computer monitored reading of the tank level in the main control room. On low fuel level, a low level alarm, initiated by a level switch independent from the level transmitter, is annunciated in the diesel generator room, and a diesel trouble alarm is annunciated in the main control room. Each diesel generator fuel oil day tank is provided with local indication of the day tank level. A level switch is provided to alarm high and low diesel generator fuel oil day tank level on the standby diesel generator panel, and to indicate diesel trouble in the main control room. The level of the fuel oil day tanks is controlled by the automatic starting and stopping of the corresponding preferred diesel generator fuel oil transfer pump. Should the preferred pump fail to start, a redundant level switch will automatically start the second fuel oil transfer pump. Manual pump control is also provided on the standby diesel generator panel for starting or stopping either the preferred or secondary fuel oil transfer pumps. In the event that the pumps fail to stop, a gravity drain overflow is provided from the day tank back to the diesel fuel oil storage tank. An interlock is provided to automatically shut off the fuel oil transfer pumps when the carbon dioxide fire protection system is actuated in the associated diesel generator room. A high differential pressure alarm across each of the booster pump Y strainers is provided on the diesel generator panel and annunciated as a diesel trouble alarm in the main control room.

Each diesel generator set has a separate air starting system designed to be capable of starting the diesel engine without external power and also to meet the single failure criterion. The air storage tanks and piping between tanks and the air start distributors are designed to ASME Boiler and Pressure Vessel Code Section III, Class 3. All other portions of this system are designed to manufacturer's standards and Seismic Category I requirements. Each diesel generator is provided with two independent, redundant starting systems (Figure 9.5.6-1). Each independent starting system includes the following:

1. One ac motor driven air compressor with intake filter

2. One air compressor after cooler

3. One refrigerant air drier with moisture trap

4. Two check valves

5. Two air storage tanks with relief valves and drain valves

6. One manual shutoff valve

7. One strainer

8. Instrumentation and control systems

9. Air stater distributor system

Each independent redundant air starting system is of sufficient volume to be capable of cranking the engine for a minimum of five starts, without recharging the tanks. Each motor driven air compressor has the capacity to recharge the air storage system in 30 minutes to provide for a minimum of five starts. Its motor is furnished with automatic start and stop control on pressure signals from the air storage tanks.

Because of the independence and redundancy incorporated in the system design, the diesel generator starting system provides its minimum required safety function under the following conditions:

1. Design basis accident with loss of offsite power, by putting into operation the standby diesel generator.

2. Maintenance outage or failure of one of the two air starting systems associated with the diesel engine.

Procurement of components is governed by the requirements of 10 CFR 50 Appendix B.

Each diesel generator has its own lubrication system. Each lubrication system includes the following equipment:

1. One direct engine driven lubricating oil pump.

2. One a-c motor driven lubricating oil circulating pump to supply warm lubricating oil to the engine sump and other necessary components when the engine is not running, as well as supply pressurized oil to the engine block until the shaft driven pump reaches effective speed.

The lubricating oil cooler is designed to ASME Boiler and Pressure Vessels Code, Section III, Class 3. The lubricating oil cooler itself is serviced with the engine jacket water. All the other equipment is designed to manufacturer's standards, and Seismic Category I requirements. Each diesel generator lubrication system is an independent system, thereby satisfying the single failure criterion by assuring operation of at least two of the three diesel generators.

Each of the three diesel generators has its own jacket cooling water system. The engine jacket cooling water heat exchanger is designed to ASME Section III code Class 3. The engine jacket cooling water pumps and piping are designed according to manufacturer's standards. All components of the diesel generator cooling water system are designed and qualified to Seismic Category I requirements. The diesel cooling water system is furnished as a part of the diesel generator package, pre-piped by the manufacturer. Procurement of components is governed by the requirements of 10 CFR 30, Appendix B.

Each of the emergency diesel generator units is located in its own separate room within the control building. The control building is a Seismic Category I structure and is capable of withstanding tornado missiles.

Each emergency diesel generator room is provided with fixed CO2 total flooding system. These systems are provided with temperature detection for automatic actuation. A smoke detection system is provided in these areas for actuation of alarms. Manual operation is provided at a local station near the protected area. There is a time delay between system actuation and system CO_2 release, with signals provided to warn personnel. The fuel transfer area consists of a concrete pit with individual cubicles to house the fuel tanks and transfer pumps. Due to their remote location and segregation from each other, only yard fire hydrant protection is provided with fire detection devices from the fire detection and plant security system. Fire detection systems using smoke detectors of the ionization combustion products type are monitored on an annunciator panel in the main control room to alert personnel of a possible fire situation in the DG rooms. The plant design isolates each emergency generator room from the adjacent diesel generator room by a 3 hour fire wall. The day tank is located in the room with the engine it supplies. Fuel oil storage tanks are buried. Provisions are made to confine the spread of oil to the immediate fire area. Fire detection systems are provided for early warning. A detection and fire protection system as described previously is provided. Fuel oil tanks for the auxiliary boilers and the emergency diesel generators are buried. In addition, the emergency diesel generator fuel oil tanks are covered with a two-foot concrete slab with their associated fuel oil pumps located in individual concrete cubicles. Adequate fire protection is supplied from yard fire hose houses in close proximity of all oil tanks. The gas turbine oil tank is an above ground tank, located approximately 450 feet from the nearest safety related structure, surrounded by a steel dyke sized to hold 110 percent of the volume of the gas turbine oil tank. Therefore, the tank presents no fire hazard to safety related structures. On flash oil fires around diesel generators, the time between detection and the opening of the CO_2 valve could be almost simultaneous.

2.1.3 Common Elements

There are several components common to both the alternative and the normal systems which have not been described in detail here. They include the 480 volt systems fed from the safety buses (e.g., from Bus 11) and the loads used for specific safety functions. Because they are common to both systems, these components do not impact a comparative evaluation of the alternative and normal systems.

TABLE C-1

COMPONENT SPECIFICATION OF SNPS PROPOSED LOCAL AC POWER SYSTEM AND RELATED ELEMENTS

Item	No.	Proposed	Specification
Standby Diesel Generators:			
Mobile Diesel Generator	EMD-DG-401 thru 404	Yes	4 General Motors EMD units, previously Units 5, 6, 7 and 8 at Lynnway Diesel Plant of New England Power; each 2.5 MW, 4.16 kV, 20 cylinder EMD series 645 turbo-charged engine, deadline start capability (automatic start on loss of offsite power on the 4.16 kV bus from the NSS transformer), independent weather-resistant enclosure, two 125-V dc motors for starting, 15 seconds per starting cycle, 3 attempts at starter motor engagement before lockout; units start sequentially, share one single battery, automatically synchronize after reaching rated speed and voltage, connected to load as one unit in parallel operation, connection done manually; EMDs are mounted outdoors near the reactor building within fence-protected area, not in a seismic structure nor on a foundation designed to withstand a DBE; have no defined quality specifications for design, fabrication, and installation; are not classified as safety-related; are not seismically qualified, nor is their installation and foundation seismic Category 1; no fire protection or design basis fire has been defined; are not independent and will not meet the single failure criterion due to common reliance on one starting battery, one long term fuel supply, and a single bus feeding power to the 4.16 kV switchgear room; are not classified as a vital area but are inside the main security area of the plant, thus are assured of only nominal protection per Part 73 requirements; associated components (such as the cable carrying power to safety loads) also are not qualified, thus do not meet GDC 2 or 4 or Part 100 of Appendix A; power from EMDs is directed to the 4.16 kV switchgear room via a single nonsafety-related above-ground conduit; cable from EMDs is in exposed cable tray, minimal Part 73 Protection.

TABLE C-1

COMPONENT SPECIFICATION OF SNPS PROPOSED LOCAL AC POWER SYSTEM AND RELATED ELEMENTS (Continued)

Item	No.	Proposed	Specification
Starting Motors	XSMD	Yes	Dual independent, battery-powered starting motors for cranking an engine; when starting circuit is energized a stepping switch moves from one DG to another at 1/4 second intervals in search of a ready-to-start unit; if such unit is found a relay energizes its starting motors for a 15-seconds attempt (maximum) and if it fails it locks out: if starter pinions do not engage the ring gear in 2 seconds, stepping switch moves to the next ready-to-start unit; switch bypasses running units until all units have started; a unit failing to start after 3 attempts will be locked out; after an engine has started a speed-sensing device deenergizes its starting circuit; starting motors are not to operate more than 20 seconds at a time; allow a 2-minute cooling period before repeating starting procedure.
Starting Battery	XSBD	Yes	420-amp hour, 125-volt dc, lead acid battery, provides starting power sequentially to all 4 mobile DGs; housed with DG #2; charged by charger powered from auxiliary transformer that is powered from the 4-KV system during standby, and from the DGs otherwise; battery rated for 12 starting attempts, potential source of single failure that could prevent operation of DGs.
Battery Charger	XBCD	Yes	Located in the master unit (DG #2), within the generator compartment; automatic, solid state, constant voltage device, capable of AC-voltage compensation, DC-voltage regulation and current limiting; has relay device for disconnecting automati charging control from the battery (to prevent drainage) in case of AC power loss; automatic resumption of charging with return of AC power; fused AC input-line; fused DC output-line.

TABLE C-1

COMPONENT SPECIFICATION OF SNPS PROPOSED LOCAL AC POWER SYSTEM AND RELATED ELEMENTS (Continued)

Item	No.	Proposed	Specification
Fuel Oil System	XFOD	Yes	Consists of a DG's fuel oil system, the fuel oil transfer system for all four units, and a piping network.
DG's Fuel Oil System	XDFSD	Yes	For each DG, it consists of a day tank, pump, suction straine filter, sight glasses, pressure gauge, intake manifolds, injectors, and associated plumbing (Figure 3-A).
Day Tank	XDTD	Yes	130 gallon capacity; supplies fuel and reservoir for unused fuel returned from the engine injectors.
Sight Glasses	XSGD	Yes	A fuel return sight glass (FRSG) and a fuel bypass sight glass (FBSG); provide visual indication of fuel status; FRSG contains a 10-lb. relief valve which opens if fuel pressure exceeds 10 lbs to return excess fuel to day tank; FBSG (mounted between pump and fuel filter) houses a 60-lb relief valve which opens (at pressure higher than 60 lbs) if filter becomes clogged, so that oil is diverted from engine manifolds towards day tank.
Pump	XPD	Yes	Engine-driven pump draws fuel from day tank through suction strainer, 10-lb check valve, and filter (there is a pressure gauge between the valve and filter).
Fuel Transfer System	XFTSD	Yes	System housed within master unit; consists of 2 transfer pumps, suction strainer for each pump, check valves, waste type filter(s), and float level gauges and switches; system transfers fuel from main storage source to the day tanks of the units; fuel level is controlled by float switches in the day tank of the master unit (Unit 2); fuel levels in day tanks are equalized by equalizer lines; Fuel Transfer Switch Normal activates first pump to maintain normal fuel level; Fuel Transfer Switch Low activates second pump for fuel levels below normal; Fuel Transfer Switch High de-activates the circuit to both pumps for levels above normal; deviations from normal fuel level trigger the Fuel Transfer light on the unit's annunciator (but fault indication would not cause a shutdown) (Figure 3-B).

TABLE C-1

COMPONENT SPECIFICATION OF SNPS PROPOSED LOCAL AC POWER SYSTEM AND RELATED ELEMENTS (Continued)

Item	No.	Proposed	Specification
Fuel Piping System	XFPSD	Yes	Consists of a main supply pipe extending from an existing diesel-oil fill station to the master unit (EMD-DG-402), a number of joints on the pipe, equalizer pipe-network, ard valves.
Main Supply Pipe	XMSPD	Yes	Consists of 8 sections of 2" Schedule 40 carbon steel ending with a section of flexible pipe (Flexonics #PCS-200-MMT, 2" Screwed ends), three valves, and at least 10 joints.
Equalizer Pipe Network	XEPD	Yes	A 2" steel line made up of 3 main sections and an end (held together by 4 joints), and four flexible pipes (Flexonics) each ending with a valve at each engine.
Valves	XLV1	Yes	Manually operated lever-type valve, located at the diesel oil fill station; normally open.
	XLV2	Yes	As above but located just ahead of the fuel transfer system in the master unit.
	XLV3	Yes	Manually operated lever-type valve located before the mouth of the emergency truck-fill connect next to the master unit; normally closed.
	XGV1 thru XGV4	Yes	4 gate (screwed)-type valves, each at the entry point of a generating unit fuel oil system; normally open.
Fuel Tanker Trucks	XFTD	Yes	2 tanker trucks; each, 9,000 gallons of fuel oil capacity capable of sustaining all 4 diesels for 9 hours or one diesel for 36 hours at full load; will be stationed in the vicinity of the Auxiliary Boiler fueling station which is outside the Reactor Building near the EMDs; one tanker can feed the diesels by gravity feed into the lines while the other is being replenished from off-site sources or from the onsite 972,931-gallons gas turbine storage tank by pump or gravity feed if fuel is appropriate; no fire protection or design basis fire has been defined.
Cooling System	XCSD	Yes	Includes coolant sources, any intake or discharge facilities, and pumping equipment and power sources.
Circuit Breakers	EMD-SWG-400-1 thru	Yes	Air circuit breaker between each DG and the bus shared by the DGs, 1200A; all housed in the diesels' control cubicle (EMD-SWG-400).

TABLE C-1

COMPONENT SPECIFICATION OF SNPS PROPOSED LOCAL AC POWER SYSTEM AND RELATED ELEMENTS (Continued)

Item	No.	Proposed	Specification
DG's Switchgear	EMD-SWG-400	Yes	Located in the control cubicle adjacent to the diesels, includes the DGs' circuit breakers; to load DGs to emergency buses requires manual operations which is expected to take 30 minutes.
Circuit Breaker	11.1B	Yes	Mobile diesel supply breaker between DGs' bus and Bus #11 in the normal switchgear room, air break type, 1200A.
Power Line	XPLD	Yes	Single power line from the DGs enters via nonsafety-related switchgear room, routed in an above ground covered raceway, except where near RSST where it is to be burried.

TABLE C-1

COMPONENT SPECIFICATION OF SNPS PROPOSED LOCAL AC POWER SYSTEM AND RELATED ELEMENTS (Continued)

Item	No.	Proposed	Specification
Normal Station Service Transformer:			
Normal Station Service Transformer	NSST-003	No	1 operating and 1 spare; spare stored in 138-KV switchyard requires several days to be installed and could be source of spare parts; each 24/32/40 (44.8) MVA OA/FA/FOA, 55/65C, 131.73 (Δ)-4.16 (Y)-4.16 (Y) KV; provided with split secondary windings [one winding powers normal station service (NSS) Buses 1A and 1B and the other NSS Buses 11 and 12 and the emergency Buses 101, 102 and 103]. During normal operation reactor and turbine-generator systems' loads are shared between NSST-003 and Reserve Station Service Transformer (RSST-004).
Switch	1R21-DISC-400A	Yes	Disconnecting switch between NSST-003 and Bus #11; 7.2 KV 4000 A; stk. oper.
	1R21-DISC-400B	Yes	Disconnecting grounding switch between Switch 1R21-DISC-400A and NSST-003; 15 KV, 600A, M&S Code 185095; normally open; stk. oper.
4-KV System:			
Circuit Breakers (CBs)	All CBs listed with the 4-KV system	No	Three-pole air break type, 125 V-DC powered, 250 MVA nominal 3-phase interrupting class, 78,000 amp closing and latching capability, stored energy operating mechanism.

TABLE C-1

COMPONENT SPECIFICATION OF SNPS PROPOSED LOCAL AC POWER SYSTEM AND RELATED ELEMENTS (Continued)

Item	No.	Proposed	Specification
CBs between NSST/RSST and Buses 1A, 1B, 11, and 12	400, 410, 420, 430, 440, 450, 460, 470	No	In addition to the above, can automatically and immediately transfer auxiliaries from NSST to RSST and vice versa through auto tripping, if fast transfer is completed within 10 cycles from time protective relays initiate the trip, or for system faults not cleared by high speed relays; also identified as No. 1B-1, 1A-3, 1A-4, 1B-2, 12-11, 11-11, 11-1 and 12-1, respectively; No. 400, 410, 440 and 450 are normally closed, remaining CBs are normally open.
CBs between Buses 11 and 12, and Buses 101, 102 and 103	415, 424, 435, 444, 455, 464, or 101-1, 101-2, 103-1, 103-2, 102-1, 102-2	No	In addition to properties common to all 4KV breakers, these CBs possess dual trip coils; one coil is connected to the safety related circuit while the other is connected to nonsafety related circuits; coils are separated by metal barrier and wiring is separated within the switchgear design limitations; breakers must be tripped by safety related signals special to the bus and from common nonsafety related transformer signals; CBs allow fast transfer of auxiliaries from NSST to RSST only, for auto and manual tripping of NSS CBs; with an accident CBs trip if under voltage is sensed on the emergency buses; linking of a DG to an emergency bus will not be interferred with by a nonsignificant trip on the nonsafety-related trip coil; if open circuits in nonsafety related circuits prevent tripping of CB in response to a fault undervoltage will eventually be sensed on the bus; No. 415, 435 and 455 are normally closed, the rest are normally open.
Switch Breakers	411 thru 417	No	Between the 4 KV-480 V transformers and the 4-KV emergency buses (101, 102 & 103); also identified as No. 102-3, 102-3, 103-3, 103-5, 101-3, and 101-4, respectively; 411, 413, and 416 are normally closed, the rest are normally open.
Others	11-10 12-3	No	Two circuit breakers, one between Bus 11 and one end of the 480V switchgear and the other between Bus 12 and the other end of the same switchgear; both normally closed.

TABLE C-1

COMPONENT SPECIFICATION OF SNPS PROPOSED LOCAL AC POWER SYSTEM AND RELATED ELEMENTS (Continued)

Item	No.	Proposed	Specification
Normal Large Motor Buses	1A & 1B	No	Two metal-clad indoor type buses; supply power to the condensate booster pump motors, the driver motors for the variable frequency motor generator sets for the reactor coolant recirculation pump motors, and 2 of the 4 circulating water pump motors; auxiliaries can be transferred automatically and immediately from NSST to RSST and vice versa.
Normal Small Motor Buses	11 & 12	No	Two metal-clad indoor type buses; power all 4-KV NSS motor loads not covered by Buses 1A& 1B and, through step-down transformers and voltage regulators; the 480V Bus 11 & 12 loads can be transferred quickly as in the case of 1A & 1B bus loads.
Emergency Station Service Buses	101, 102, & 103	No	Three metal-clad indoor type buses; power the 4-KV emergency core cooling system (ECCS) loads, control rod drive water pumps and, through step-down transformers, provide power to 480V emergency buses 111, 112 & 113.
Double-Ended 480-V Load Centers:			
General System	XGS480	No	Four double-ended load centers for normal 480-V station auxiliaries; each consists of a 4-KV current-limiting fused disconnect switch, a 4 KV-480 V step-down transformer and a metal-enclosed switchgear section with incoming main bus tie circuit breakers.
NSST-Side Buses	11A thru 11D	No	Normal load buses fed by NSST or the mobile diesels.
RSST-Side Buses	12A thru 12D	No	Normal load centers' buses fed by RSST.

TABLE C-1

COMPONENT SPECIFICATION OF SNPS PROPOSED LOCAL AC POWER SYSTEM AND RELATED ELEMENTS (Continued)

Item	No.	Proposed	Specification
Interrupter Switches	XS11A thru XS11D & XS12A thru XS12D	No	Four on each side of the double-ended load centers; each with current limiting fuse; 5 KV, 600 amp continuous, 61,000 amp momentary, 96,000 amp fault closing.
Transformers	T-001A thru T-011D and T-012A thru T-012D	No	For stepping down voltage; 4 KV-480 V, 1000/1333 KVa.
Voltage Regulators	IND-11A thru IND-11D & IND-12A thru IND-12D	No	Four inductrols on each side of the double-ended load centers regulate voltage to the 480-V normal load centers; 1500 KVa, 480 V± 20%.
Circuit Breakers	XCBTA thru XCBTD	No	Bus ties between Buses 11A and 12A through 11D and 12D; 1600 amp continuous, 50,000 amp symmetrical interrupting capacity; air-magnetic drawout type; normally open.
	XCB11A thru XCB11D & XCB12A thru XCB12D	No	Incoming main CBs between buses 11A through 11D and inductrol IND-11A through IND-11D, and between buses 12A through 12D and inductrols IND-12A through IND-12D; rated as above; air-magnetic drawout type; normally closed.
	XOCB	No	Other feeder breakers; 600 amp continuous, interrupting capacity of 30,000 amp symmetrical (with instantaneous trips) and 22,000 amp symmetrical (without instantaneous trips); air-magnetic drawout type.

TABLE C-1

COMPONENT SPECIFICATION OF SNPS PROPOSED LOCAL AC POWER SYSTEM AND RELATED ELEMENTS (Continued)

Item	No.	Proposed	Specification
Single-Ended 480-V (Emergency) Load Centers:			
Transformers	T-101, 102, 103	No	Between each of the 4-KV emergency buses and each of the 480 V emergency buses; 1000/1333 KVa, 4160-480 V (step-down); grounded.
Emergency Buses	111, 112 and 113	No	480-V physically isolated and electrically independent buses; metal-enclocsed switchgear; power safety-related loads; feed motor control centers supporting 100 hp and smaller power requirements; support essential nonsafety related 480-V loads; some nonsafety loads are tripped off of these buses during a LOCA.
Circuit Breakers	XCB111, XCB112, XCB113	No	Between each of the 4 KV-480 V transformers (T-101,102 & 103) and each of the 480 V emergency buses (111, 112 & 113); 1500 A continuous, 50,000 A symmetrical interrupting capacity, air-magnetic draw-out type; all normally closed.
Reserve Station Service Transformer:			
Reserve Station Service Transformer	RSST-004	No	1 operating and 1 spare; spare stored in 138-KV switchyard, requires several days to be installed and could be source of spare parts; each 24/32/40 (44.8) MVA OA/FA/FOA, 55-65C, 65.86 (Y)-4.16 (Y)-4.16 KV provided with split secondary windings (one winding powers normal station service (NSS) Buses 1A and 1B and the other supplies NSS Buses 11 and 12 and emergency Buses 101, 102 and 103). During normal operation reactor and turbine-generator systems' loads are shared between RSST-004 and NSST-003.
69-KV/4-KV System			
Circuit Breakers	640	No	Oil circuit breaker; 69 KV 600A, Westinghouse GO-48; can disconnect the Shoreham gas turbines from the RSST-004 (and safety - and nonsafety-related 4-KV and 480-V plant loads) and from the Wildwood substation (offsite loads) if Switch 623 is open.

TABLE C-1

COMPONENT SPECIFICATION OF SNPS PROPOSED LOCAL AC POWER SYSTEM AND RELATED ELEMENTS (Continued)

Item	No.	Proposed	Specification
	44F thru 47F	No	Fused switches for disconnecting various nonsafety loads (including construction) from 4-KV bus fed by transformer Banks No. 6 and 7.
	63F, 66F, 67F	No	Fused switches capable of isolating the 69-KV system from miscellaneous nonsafety loads(in addition to switches 616 & 617.
	404, 407, 455	Yes	Manually operated switches for disconnecting various 4-KV loads from transformer banks No. 6 and 7.
	613	No	Motor operated air-break switch; 69KV, 600A, Joslyn, by ITE; can isolate gas turbines GT-001 and GT-002 from the 69-KV system.
	616, 617	No	Motor operated air-break switches 69KV, 600A, Joslyn; function similar to switches 63F, 66F and 67F.
	623	No	Motor operated air-break switch; 69KV, 600A; can isolate RSST-004 from the 69-KV system; manually operated; should be open when 69-KV by-pass bus is used to dispatch gas turbine power.
	633	No	69KV, 600A, Joslyn switch isolates gas turbine starting transformer (66.4-4.33 KV) and construction power and gas turbine auxiliary power from 69-KV system; manually operated.
	643	No	Motor operated 69KV, 600A, Joslyn RF-2 switch for isolating the 69-KV system from outside AC power sources (backs up CB 640) (provided the 69-KV by-pass is not in use or switch 623 is open).
Potential Transformers	XPT1	Yes	Branches off 69-KV line between CB 640 and Wildwood; lead to XPT1 is to be disconnected when 69-KV by-pass is used.
	XPT2	--	Three potential transformers (PTs) off 69-KV bus.
Transformers	Bank 3	No	Gas turbine starting transformer; supplies 2.4 KV power for construction and starting gas turbine; 66.4-4.33 KV.

TABLE C-1

COMPONENT SPECIFICATION OF SNPS PROPOSED LOCAL AC POWER SYSTEM AND RELATED ELEMENTS (Continued)

Item	No.	Proposed	Specification
	Bank 5	No	For stepping up gas turbines (GT-001 & GT-002) output voltage; 33/44/55 MVA OA/FA/FOA, 66-13 KV; G.E., N.P. #525.
	Banks 6 & 7	No	Two 66-4 KV transformers provide 4-KV voltage power to miscellaneous nonsafety loads; #6 is 516.25 FMVA, Westinghouse N.P. 272; #7 is 515.6 FMVA, G.E. N.P. 414.
Lightning Arresters	XLA1	New	Three lightning arresters (LAs) off line between 69-KV switchyard and RSST-004; each with arrester and 60-KV G.E. Allugard II.
	XLA2	New	Three LAs off line between CB 640 and Wildwood; each with arrester.
	XLA3	--	Three LAs off line linking Shoreham gas turbines with 69-KV system; each with arrester.
Cable Lines	XL1	Yes	Buried 69-KV line between RSST-004 and Switch 623; constitutes normal route to RSST-004.
	XL2	Yes	Buried 69-KV line between RSST-004 (prior to the normally open contact) and CB 640 (after PT1).
	XL3	Yes	Buried 69-KV line between RSST-004 and the normally open contact on the line to CB 640.
	XL4	Yes	Portable cable taps (stored on-site) for linking CB 640 with an alternate route to RSST-004 when the normal route is faulted.
	XL5	Yes	Cable leads to be disconnected when the 69-KV by-pass is used.
	XL6	Yes	69-KV by-pass bus.

TABLE C-1

COMPONENT SPECIFICATION OF SNPS PROPOSED LOCAL AC POWER SYSTEM AND RELATED ELEMENTS (Continued)

Item	No.	Proposed	Specification
	XL7	Yes	Same as for XL4; note that XL7 can link CB 640 with RSST-004 through either XL4 or through XL6.
	XL7A	Yes	Portable taps (stored on-site) for connecting the by-pass XL6 with the normal route to RSST-004.
Contacts	XNOC1	Yes	Normally open contact on the alternate 69-KV line to RSST-004
13.8-KV System:			
The 55-MW Gas Turbine	GT-001	No	55-MW, 13.8-KV, 0.8 PF, 0.5 SCR; shares a common bus with the 20-MW unit (GT-002); houses the 125 V-DC battery supplyin the control power for the 69-KV oil CB; G.E.
Switches	11F	No	3 fused switches between potential transformer XPT4 and GT-001 circuit.
	13F	No	Fused switch between potential transformer XPT3 and GT-001 circuit.
	XF1, XF2, XF3	Yes	Fused switches between GT-002 circuit and potential transformers XPT5, XPT6, and XPT7, respectively.
	112	Yes	13-KV, 1200A manually operated switch for isolating the 20-MW gas turbine (GT-002).
Circuit Breakers	8Z-110	No	CB between GT-001 and bus shared with GT-002; AM 13.8, 1000 MVA, 300A; formerly CB 52C.
	8Z-120	Yes	CB between GT-002 and bus shared with GT-001; AM 13.8, 1000 MVA, 3000 A, formerly CB 52.
Potential Transformers	XPT3	--	Several PTs off GT-001 line.
	XPT4	--	Three PTs; each G.E., JVM-5, 14400-120 V; off bus linked with GT-001 line.
	XPT5	New	PT off GT-002 line after CB 8Z-120; 112.5 KVA, 13.8 KV-230V.
	XPT6	New	Three PTs off GT-002 line before CB 8Z-120.

TABLE C-1

COMPONENT SPECIFICATION OF SNPS PROPOSED LOCAL AC POWER SYSTEM AND RELATED ELEMENTS (Continued)

Item	No.	Proposed	Specification
	XPT7	New	PT off GT-002 line before CB 8Z-120.
	XPT8	--	PT off GT-001 line; G.E.-HT, 112.5 KVA, 13.8 KV-240/480 V.
Transformers	XT1	No	Grounded transformer for GT-001; 10 KVA, 12KV-240 V.
	XT2	Yes	Grounded transformer for GT-002; 25 KVA, 13.8 KV-120/240 V.
Lightning Arresters	XLA4	New	Three LAs off-line linking GT-002 with transformer Bank #5 (after CB 8Z-120); with arrester.
	XLA5	--	Three LAs off-line linking GT-001 with transformer Bank #5 (before CB 8Z-110); with arrester.
Capacitor	XC1	Yes	Grounded capacitor off GT-002 after CB 8Z-120.
Cable Lines	XL8	Yes	Buried 13.8-KV line between CB 8Z-120 and Switch 112.
	XL9	Yes	Buried 13.8-KV line between CB 8Z-120 and Switch 112 (bypass portion).
Bus	--	Yes	13-KV bus serving both gas turbines (GT-001 and GT-002).

TABLE C-1

COMPONENT SPECIFICATION OF SNPS PROPOSED LOCAL AC POWER SYSTEM AND RELATED ELEMENTS (Continued)

Item	No.	Proposed	Specification
The 20-MW Gas Turbine			
Gas Turbine	GT-002	Yes	A single Pratt & Whitney Model #FT 4A-8 Power Pack 20-MW gas turbine with deadline start capability; generator, gas turbine, and all electrical and mechanical controls contained in a weather-resistant enclosure which is outside security fence; GT-002 is mounted on a pad in the 69 KV switchyard, separate from the main plant without protection against missiles by a structure nor is it designed to withstand earthquakes, thus does not meet GDC 2 or 4 Part 100 of AppendixA; the unit feeds the same 69 KV line that supplies power through the RSS transformer to the 4.16 KV buses 1B and 12 but does not normally feed the emergency buses; manual operation is required to load the gas turbine to emergency buses, loading is expected to take 10 minutes; gas turbine has no defined quality specifications for design, fabrication and installation, is not seismically qualified and is not classified safety-related; no fire protection or design basis fire has been defined for the gas turbine; has not been designed to meet the single failure criterion.
Starting System	XSS2	--	Consists of an air starter, pressure regulators, air cylinder and a compressor; capable of 3 starting attempts, represents a point of single failure.
Air Starter	XAS2	--	Newly installed ACE-507 Series Air Starting System; drives the high pressure compressor rotor from standstill; driven by compressed air; below a certain minimum system pressure a starting lockout prevents starting the unit.
Air Cylinder	XACY2	--	Store air at 400-500 psig; capacity allows 3 starting attempt without recharging (275 cu. ft.).
Pressure Regulators	XPR2	--	Located downstream from high pressure air cylinder; reduce pressure of air supply to the air starter over two stages.

TABLE C-1

COMPONENT SPECIFICATION OF SNPS PROPOSED LOCAL AC POWER SYSTEM AND RELATED ELEMENTS (Continued)

Item	No.	Proposed	Specification
Air Compressor	XAC2	--	1000 PSI 3-stage Ingersoll-Rand compressor, driven by 20-HP, 230 V motor; maintains compressed air supply; automatically controlled; cycled on/off; housed within the gas turbine enclosure; powered by auxiliary transformer.
Battery	XB2	--	Provides control power for the sequencer, breakers, and the DC fuel pump; 150 amp/hour, 125-V DC.
Charger	XC2	--	New 50-amp charger; maintains distribution system battery charge; powered from same auxiliary transformer supplying compressor.
Power Line	XPL2	--	69 KV line from the gas turbine connects to the RSS transformer via a buried cable and then enters the non-safety-related switchgear room which is not protected in accordance with Appendix R.
Auxiliary Transformer	XAT2	--	Supplies power to battery charger, air compressor and AC-powered fuel pump; powered from the 69-KV system during standby and from the gas turbine (GT-002) during latter's operation.
Fuel System	XFSG	--	Consists of a main fuel oil tank, fuel booster pumps, generator-driven fuel pump, fuel-pressurizing and dump valve, throttle valve and actuator, solenoid-generated bypass, fuel manifold and nozzles.
Fuel Tank	XFTG2	--	Above ground storage tank located outside the main security fence and near the 69 KV switchyard; 972,931 gallon capacity; can sustain the gas turbine at full load for 500 hours; no fire protection or design basis fire has been defined for the fuel tank.
Fuel Booster Pumps	XFPG2	--	Two fuel pumps; take fuel from the fuel tank; supply fuel under pressure to GT-002 generator-driven pump suction through filters; one pump is powered by same 125-V DC battery supplying power to distribution system; other pump is AC powered and takes over from DC-pump after GT-002 starts; AC pump receives power from above-mentioned auxiliary transforme a bypass and check valve is provided around the AC pump; during dead-bus starting the bypass supplies fuel under tank-lead pressure to the DC-driven pump suction until the AC pump is energized.

TABLE C-1

COMPONENT SPECIFICATION OF SNPS PROPOSED LOCAL AC POWER SYSTEM AND RELATED ELEMENTS (Continued)

Item	No.	Proposed	Specification
Generator-Drive Fuel Pump	XGP2	--	Receives fuel oil from the operating booster pump at 35-50 PSI; delivers fuel to the throttle valve and actuator; a relief valve limits pressure rise to 835-845 PSI.
Throttle-Valve and Actuator	XTVA2	--	A constant-pressure, metering-type shutoff valve, controlled by the SPC2 fuel control; discharges to the fuel-pressurizing and dump valve through the fuel bypass valve.
SPC-2 Fuel Control	XSPC2	--	A newly installed Hamilton Standard SPC-2A electronic stationary servo-system fuel controller; monitors operation of the throttle valve.
Fuel Bypass Valve	XBV2	--	A solenoid-operated 3-way valve; permits fuel flow in the energized position and bypasses fuel back to the main fuel pump inlet when de-energized.

TABLE C-2

DATA SPECIFIC TO THE MOBILE EMD DIESEL GENERATOR UNITS*

	Unit 1	Unit 2	Unit 3	Unit 4
Unit # @ NEP **	5	6	7	8
Year Installed	1968	1968	1968	1968
Serial #, Engine	67-F101031	67-F1-1051	67-F101071	67-F1-1058
Serial #, Generator	67-F1-1004	67-F1-1003	67-F1-1106	67-F1-1005
Model # or Type	20-645-E4	20-645-E4	20-645-E4	20-645-E4
Rated KW	2750	2750	2750	2750
RPM	900	900	900	900
Volts	2400/4160	2400/4160	2400/4160	2400/4160
Amps/Terminal	826/477	826/477	826/477	826/477
Rated P.F.	0.80	0.80	0.80	0.80
Rated KVA	3440	3440	3440	3440
Rated HP	3600	3600	3600	3600
No. of Cylinders	20	20	20	20
Bore & Stroke	9 1/16x10	9 1/16x10	9 1/16x10	9 1/16x10
Cycle	2	2	2	2
EMD #	63610	63609	63612	63611
UTEX @ Hour	6,030	6,552	6,163	8,070
Repower @ Hour	12,932	-	13,153	-
Oper. Hours After UTEX or Repower +	345	6,281	120	4,965
Lube Oil Consumption (gal/hr.) +	0.95	0.92	1.14	1.02 ≠

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* Source: Discovery Request #3.

** New England Power.

\+ Over a time period between 1968 and 1983.

≠ This figure is based upon 1968-1983 data. However, the lube oil consumption rate of Unit 4 just before relocation to Shoreham amounted to 1.7 Gal/hr.

TABLE C-3

ENGINE MAINTENANCE SUMMARY FOR THE FOUR MOBILE DIESEL GENERATOR UNITS WHILE IN SERVICE AT NEW ENGLAND POWER LYNNWAY STATION PLANT NO. 1: 1974-1983*

Engine Number	Operating Hours	Item	Average Lube Oil Consumption
5	6,030	3/72 UTEX Engine Installed	.95 gal/hr
	11,601	New Radiator (Rear)	
	11,618	New Cylinder Head (9)	
	12,242	New Cylinder Head (8, 18)	
	12,274	New Cylinder Head (2)	
	12,498	New Clock	
	12,932	Repower	
	12,938	New Starters	
	13,019	New Cylinder (#11)	
6	6,552	UTEX Engine Installed	.92 gal/hr
	10,834	New Rear Radiator Core	
	11,279	New Batteries	
	11,727	New Cylinder Head (6)	
	12,471	New Clock	
	12,667	New Stack	
	12,697	New Stack	
7	6,163	3/72 UTEX Engine Installed	1.14 gal/hr
	11,062	New Cylinder Head (2)	
	11,306	New Cylinder Head (9)	
	11,632	New Cylinder Head (14)	
	11,695	New Cylinder Head (14)	
	11,868	New Cylinder Head (4)	
	11,910	New Cylinder Head (12)	
	12,170	New Cylinder Head (6, 3)	
	12,551	New Cylinder Head (20)	
	12,694	New Starting Motors	
	12,952	New Starting Motors	
	13,153	Repower	
	13,177	New Stack	
8	8,070	1/73 UTEX Engine Installed	1.02 gal/hr
	9,407	New Generator	
	10,962	New Turbo-Charger	
	11,617	New Starting Motors	
	11,617	New Cylinder (11, 13)	
	11,696	New Cylinder (10, 9), New Turbo-Charger	
	12,667	New Rear Radiator	
	12,781	New Governor	

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* Source: Discovery Request No. 3.

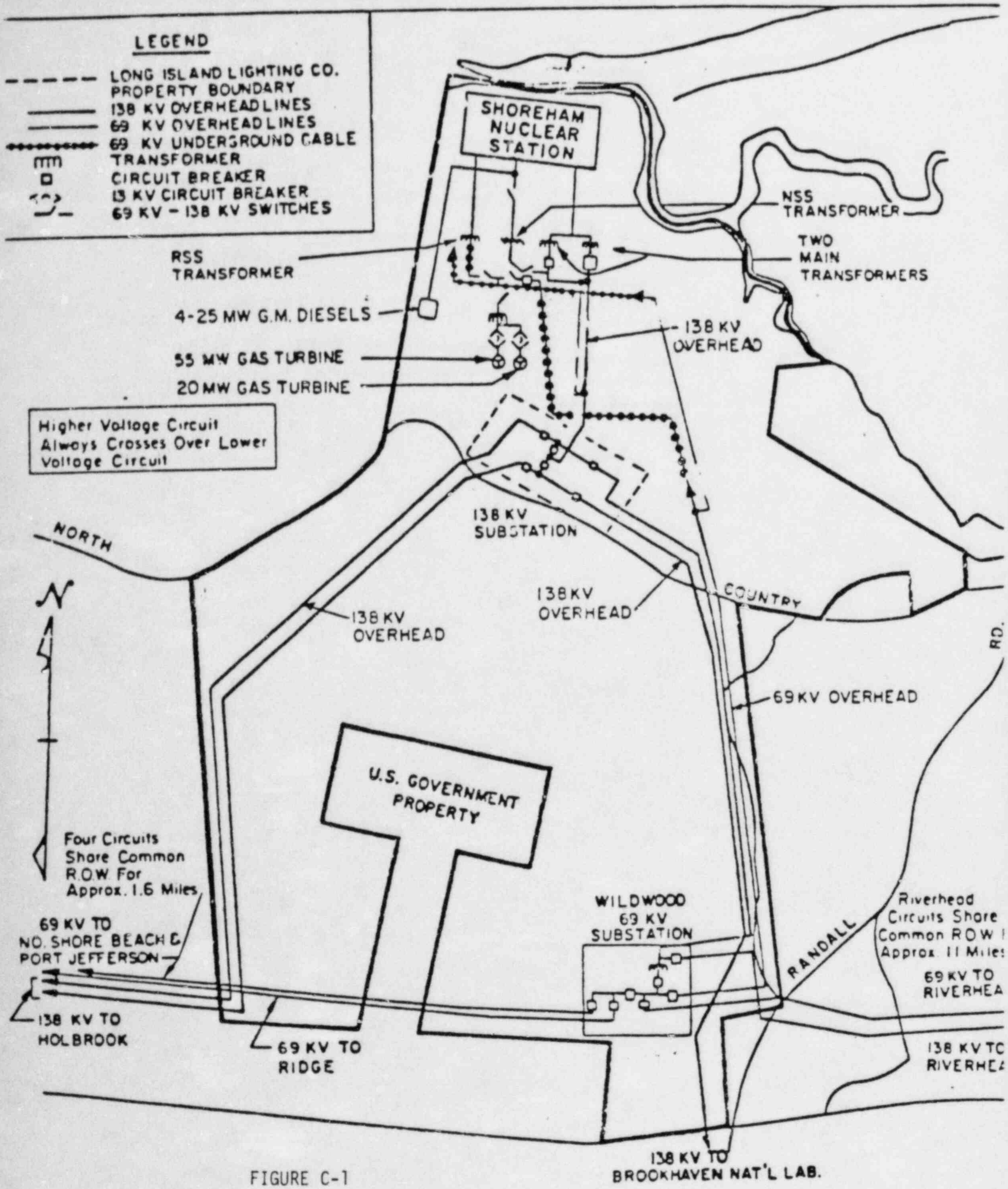


FIGURE C-1

OVERALL LILCO-PROPOSED SYSTEM GEOGRAPHICAL LAYOUT

FIGURE C-2

SHOREHAM LINE DIAGRAM SHOWING ELEMENTS OF PROPOSED AC POWER CONFIGURATION

(Use in Conjunction with Table 1)

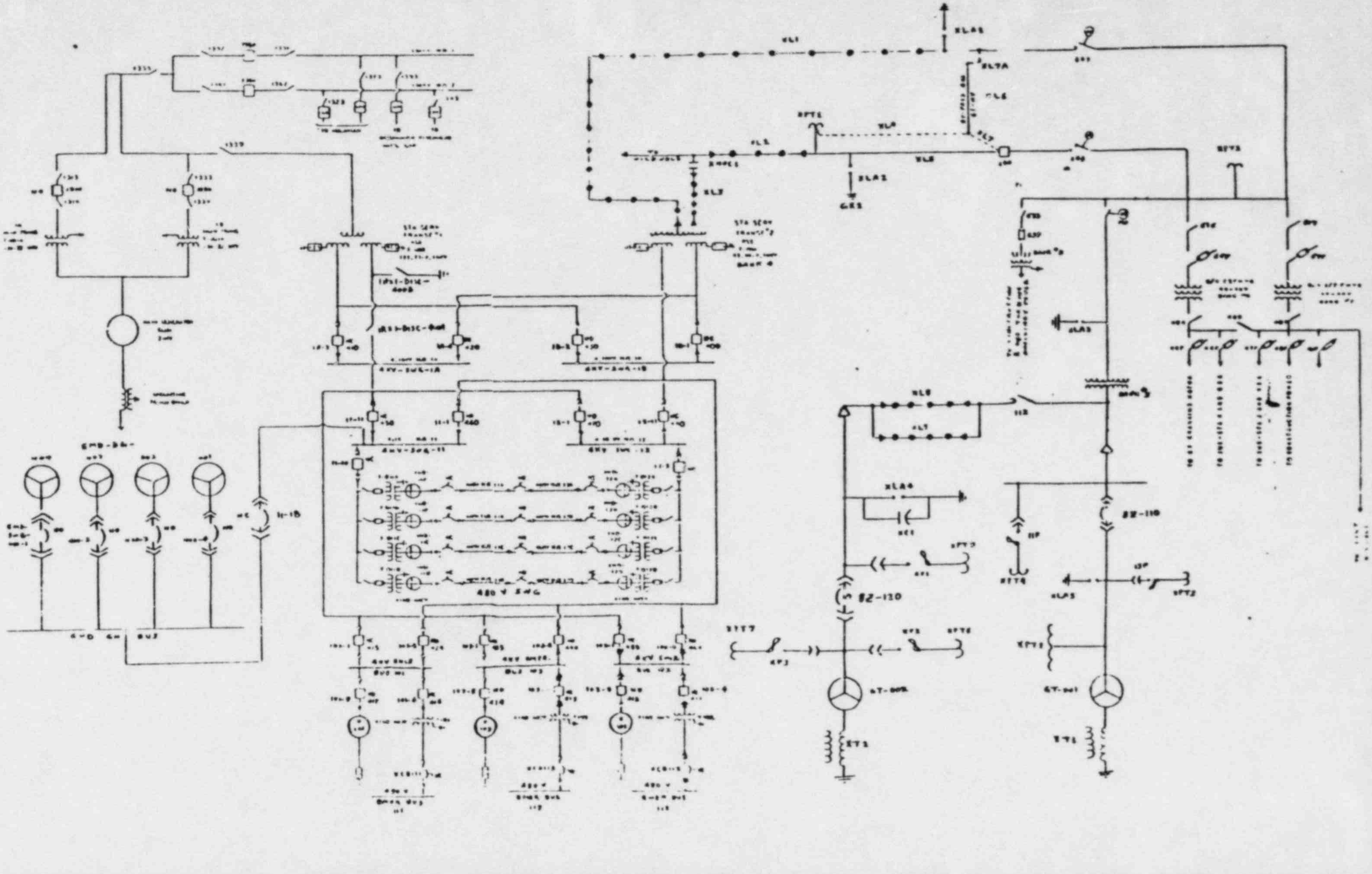
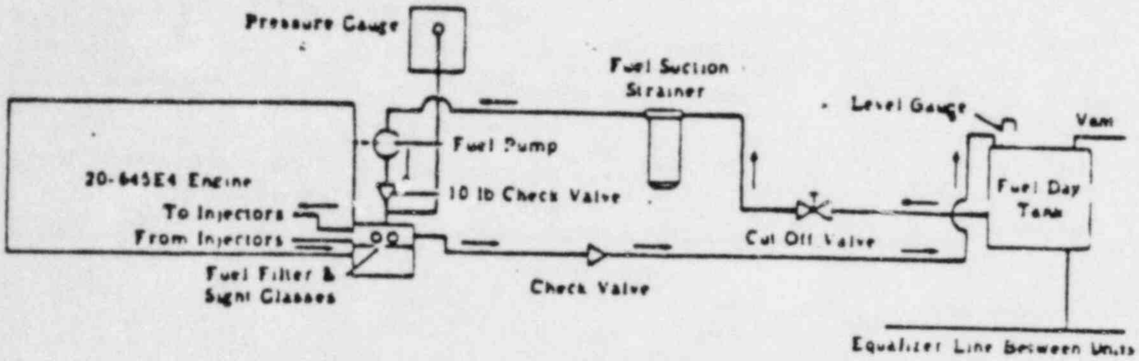


FIGURE C-3

FUEL SYSTEM OF THE EMD DIESEL GENERATORS

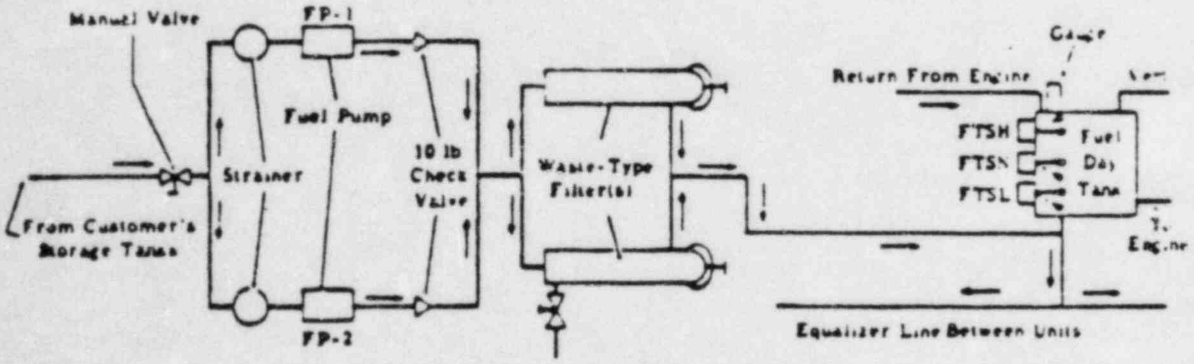
(Source: EMD Operating Manual, GM April 1958)

FIGURE C-3A



GENERATING UNIT FUEL OIL SCHEMATIC

FIGURE C-3B



FUEL TRANSFER SYSTEM SCHEMATIC
(Applies To MPA Unit Only)

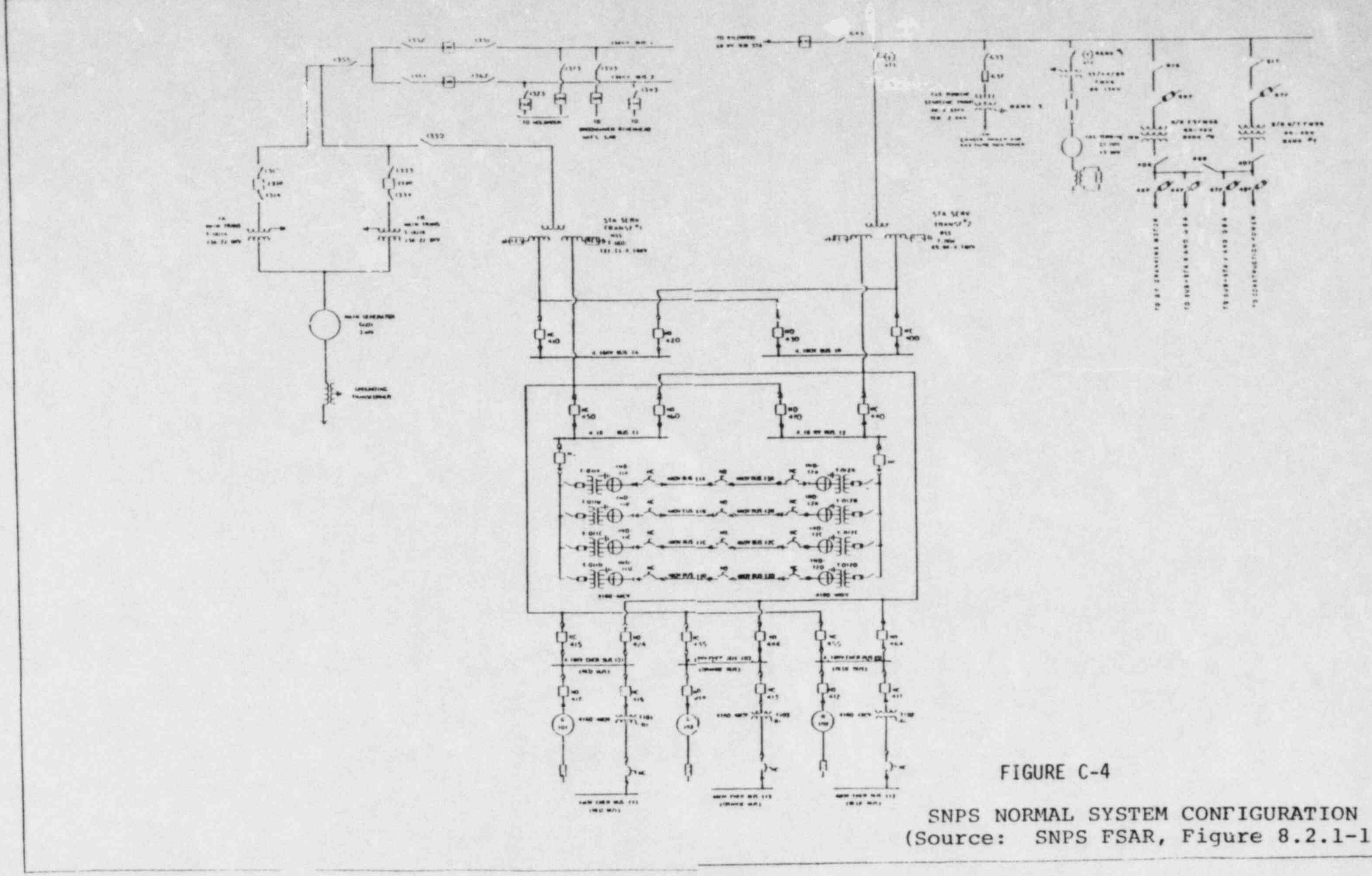
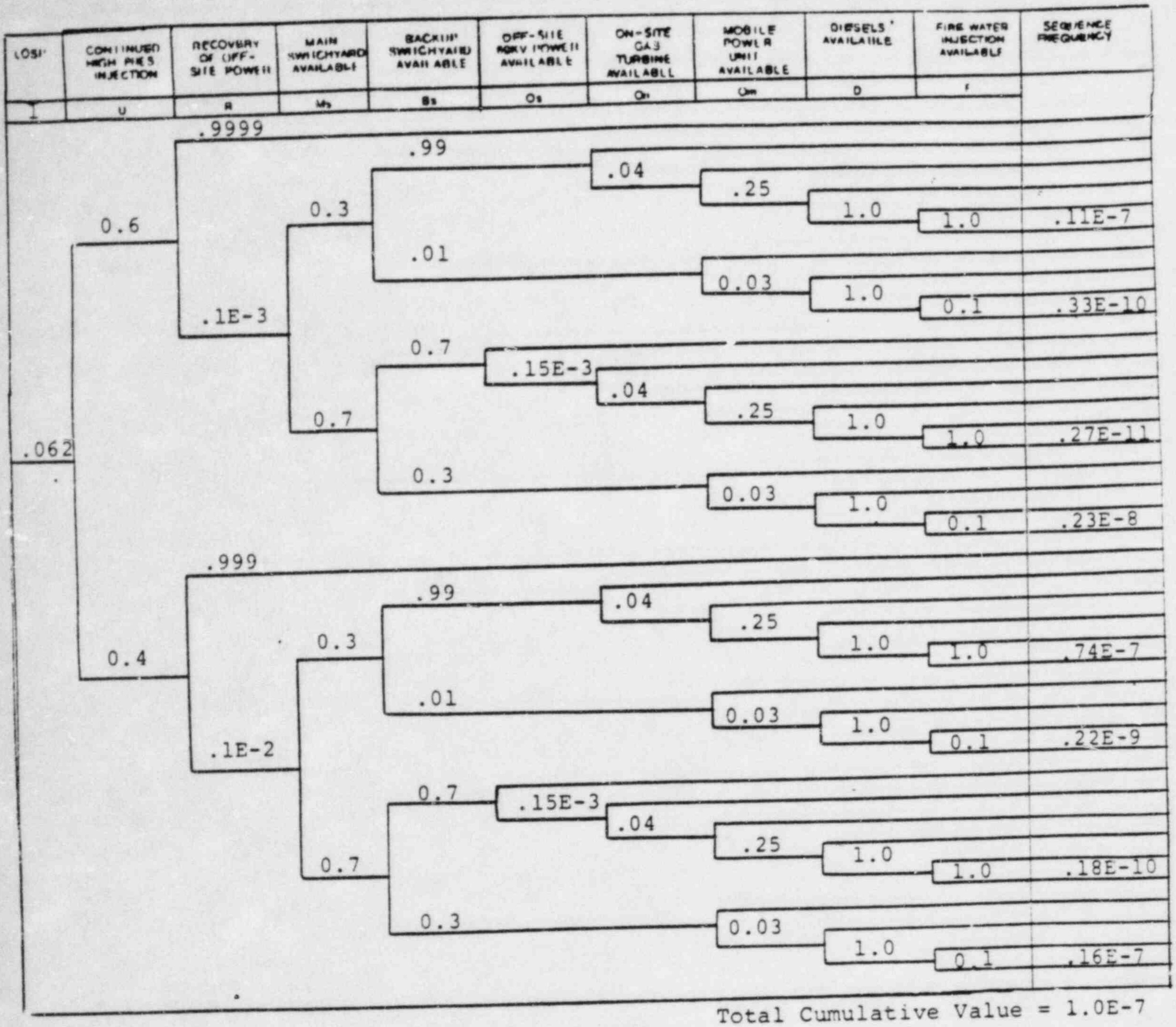


FIGURE C-4

SNPS NORMAL SYSTEM CONFIGURATION
(Source: SNPS FSAR, Figure 8.2.1-1)

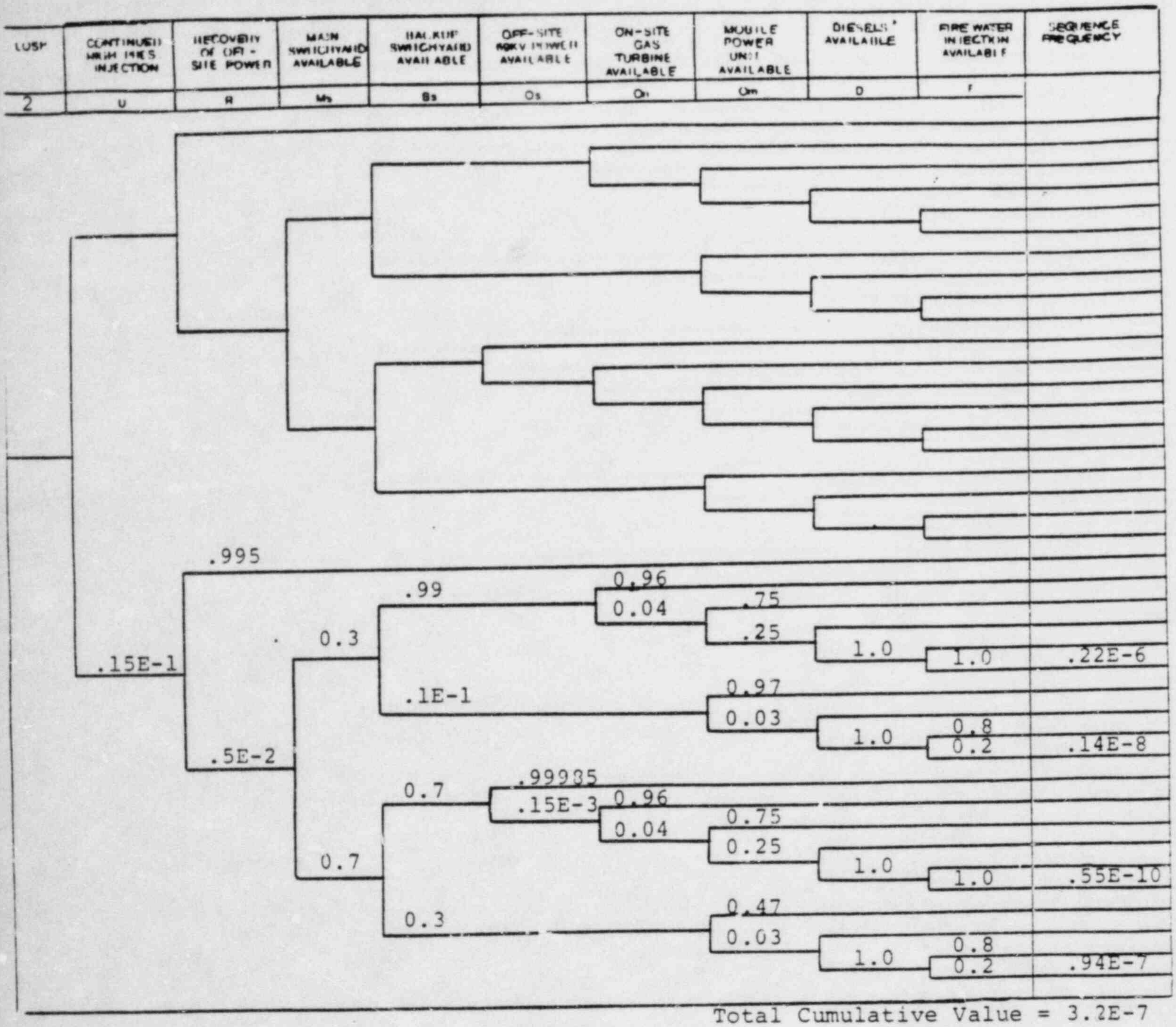
ATTACHMENT D



Total Cumulative Value = 1.0E-7

Entry Conditions Sequence Type 1: LOSP; Isolation: Reactor Scrammed: Primary System Intact; Coolant Injection Available through 10 hours via HPCI/RCIC; reactor may be depressurized to 150 psia.

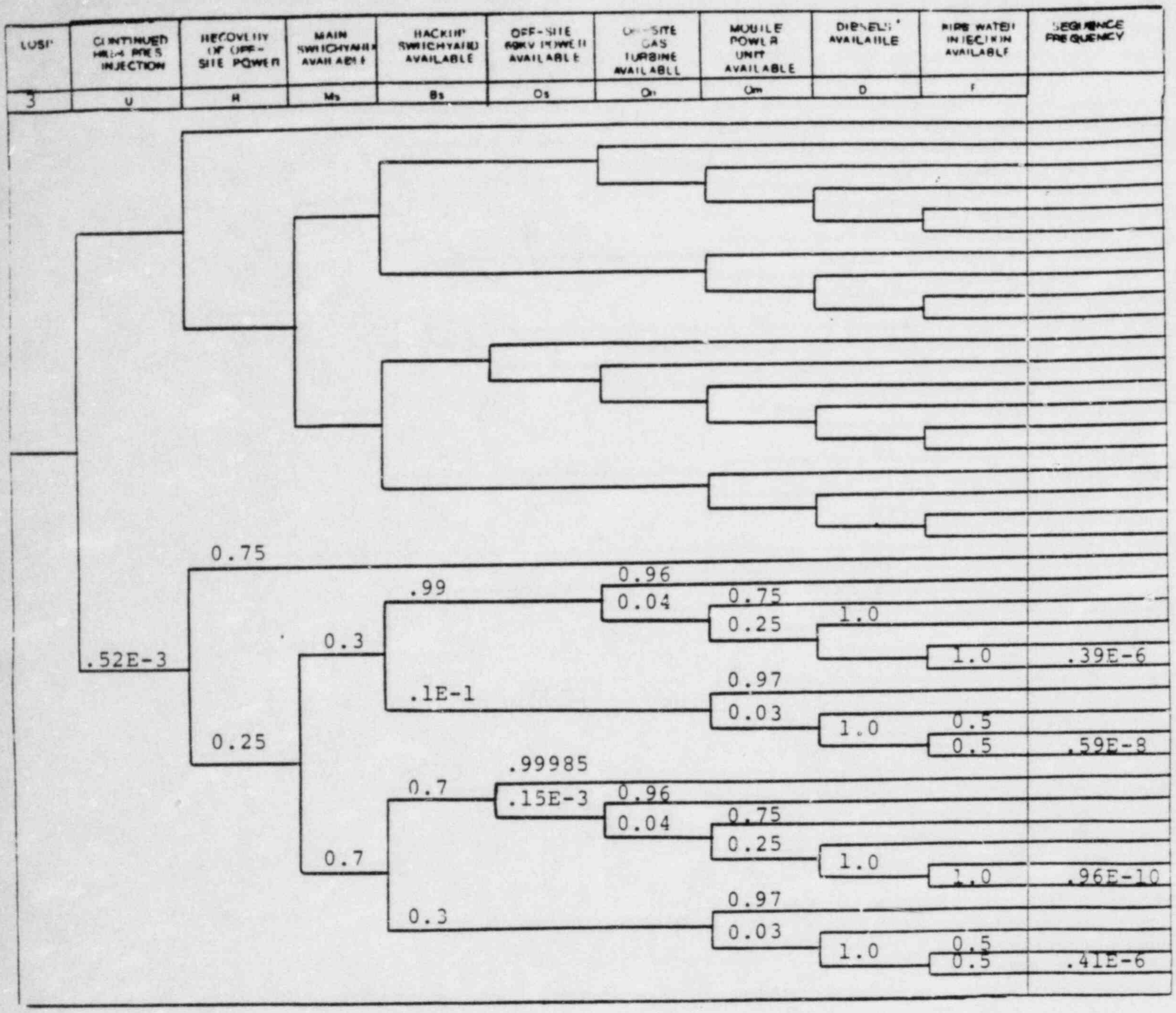
EVENT TREE D-1
(Table 1, Column 3)



Total Cumulative Value = 3.2E-7

Entry Conditions Sequence Type 2: LOSP; Isolation; Reactor Scrammed; Reactor Integrity Intact; Coolant Makeup Available 0-4 Hours: Reactor may be depressurized to 150 psia.

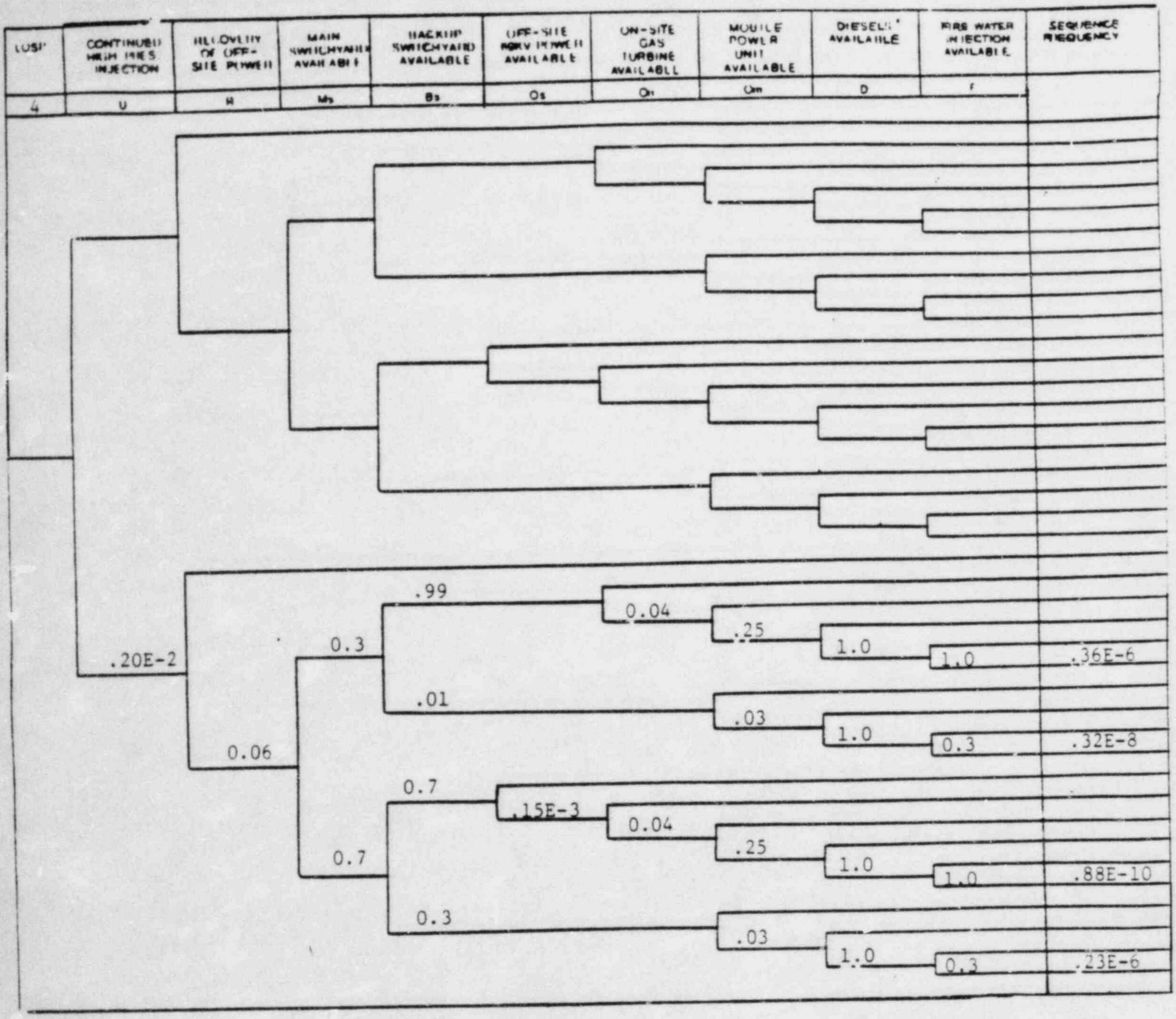
EVENT TREE D-2
(Table 1, Column 3)



Total Cumulative Value = 8.1E-7

Entry Conditions Sequence Type 3: LOSP; Isolation; Reactor Scrammed; SORV, LOCA or ADS; no Coolant Makeup Available; Reactor Depressurized to Less than 65 psia.

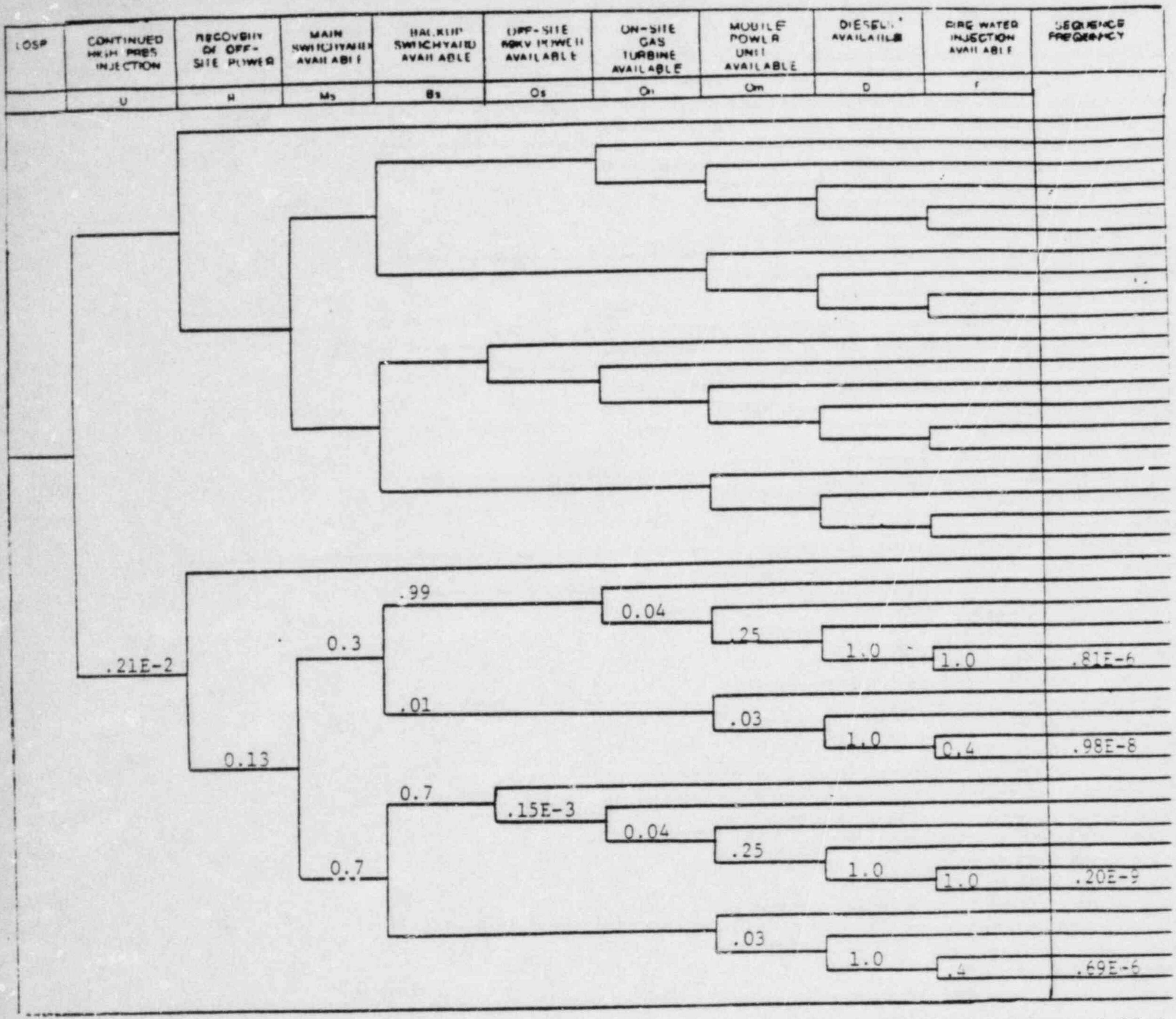
EVENT TREE D-3
(Table 1, Column 3)



Total Cumulative Value = 5.9E-7

Entry Conditions Sequence Type 4: LOSP; Isolation; SORV, Coolant Injection Available Initially.

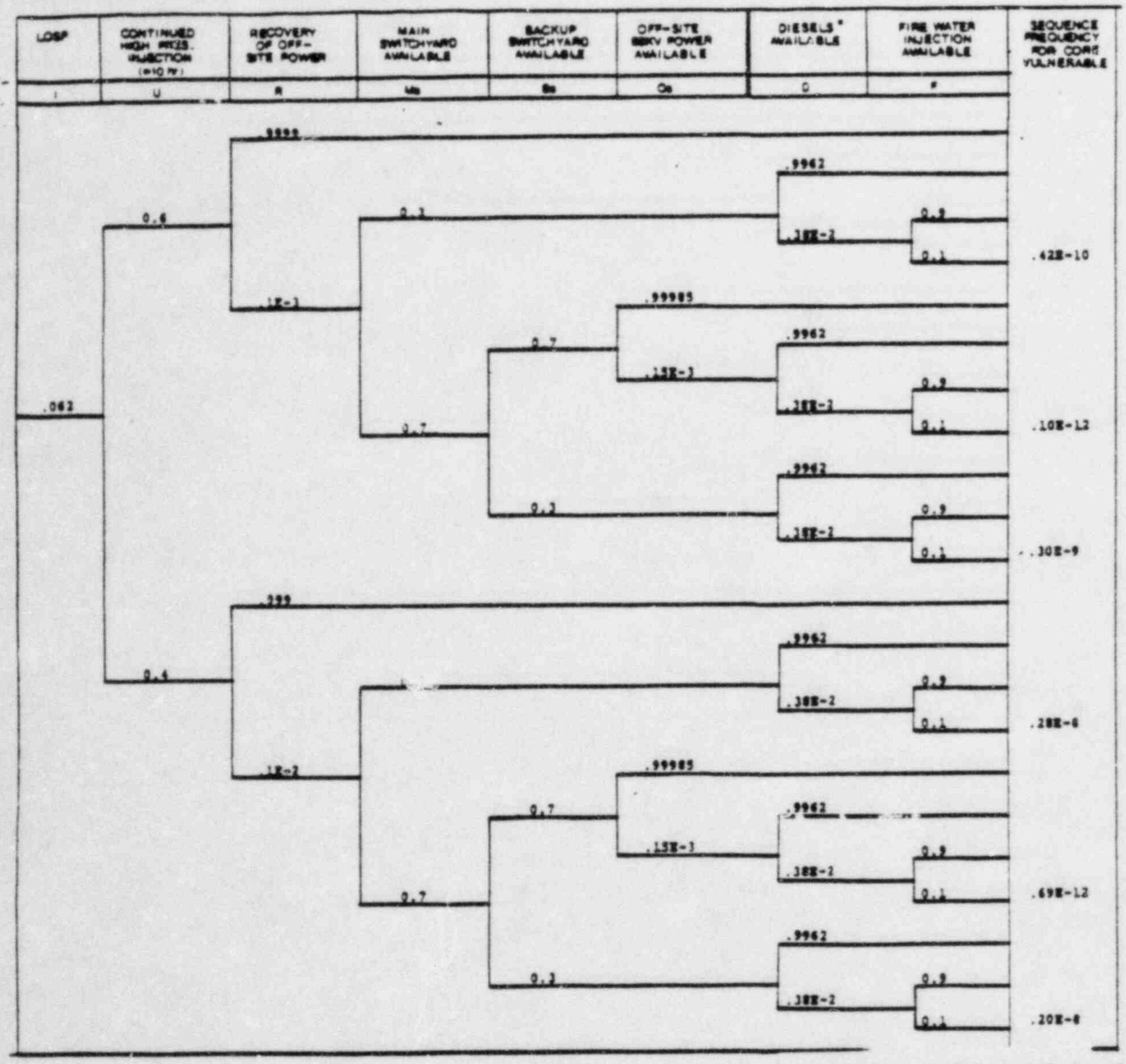
EVENT TREE D-4
(Table 1, Column 3)



Total Cumulative Value = 1.5E-6

Entry Conditions for Sequence Type 5: LOSP; Isolation; no initial
Coolant Makeup; Procedural
Depressurization

EVENT TREE D-5
(Table 1, Column 3)

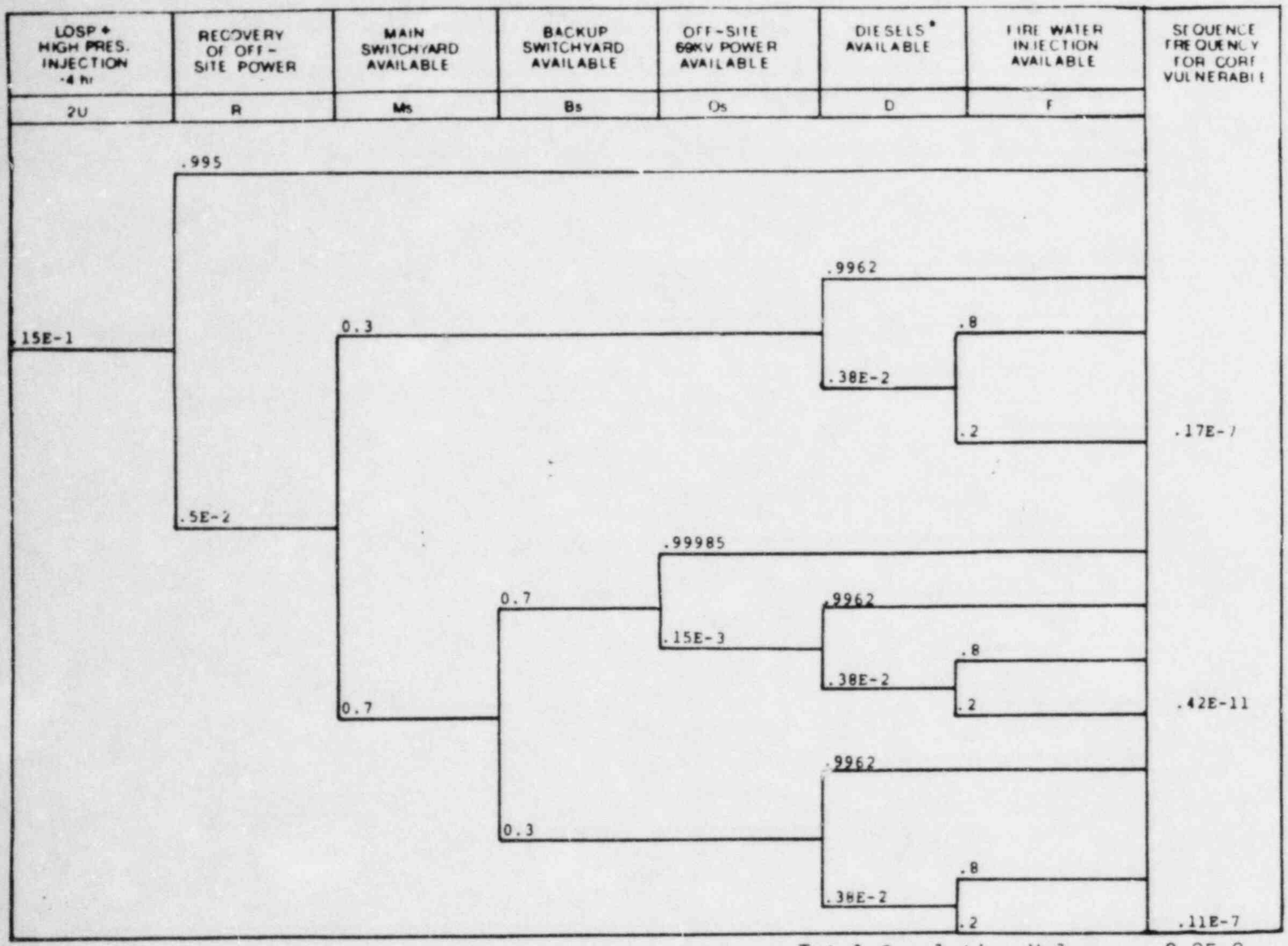


Total Cumulative Value = 5.1E-9

Entry Conditions Sequence Type 1: LOSP, Isolation; Reactor Scrammed; Primary System Intact; Coolant Injection Available through 10 hours via HPCI/RCIC; reactor may be depressurized to 150 psia.

* Does not reflect repair.

EVENT TREE D-6
(Table 1, Column 4)

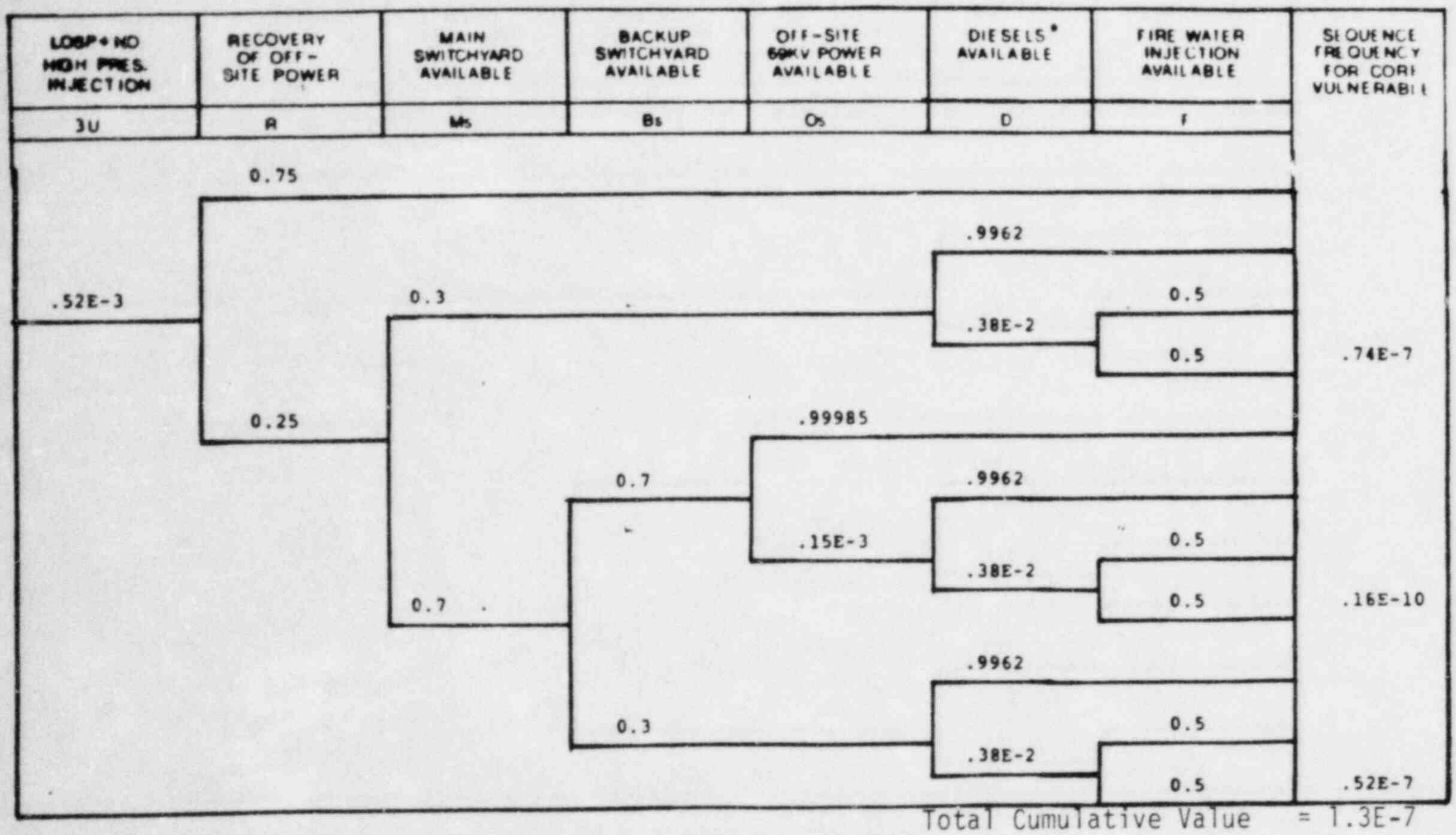


Total Cumulative Value = 2.8E-8

Entry Conditions Sequence Type 2: LOSP; Isolation; Reactor Scrammed; Reactor Integrity Intact; Coolant Makeup Available 0-4 Hours; Reactor may be depressurized to 150 psia.

* Does not reflect repair

EVENT TREE D-7
(Table 1, Column 4)

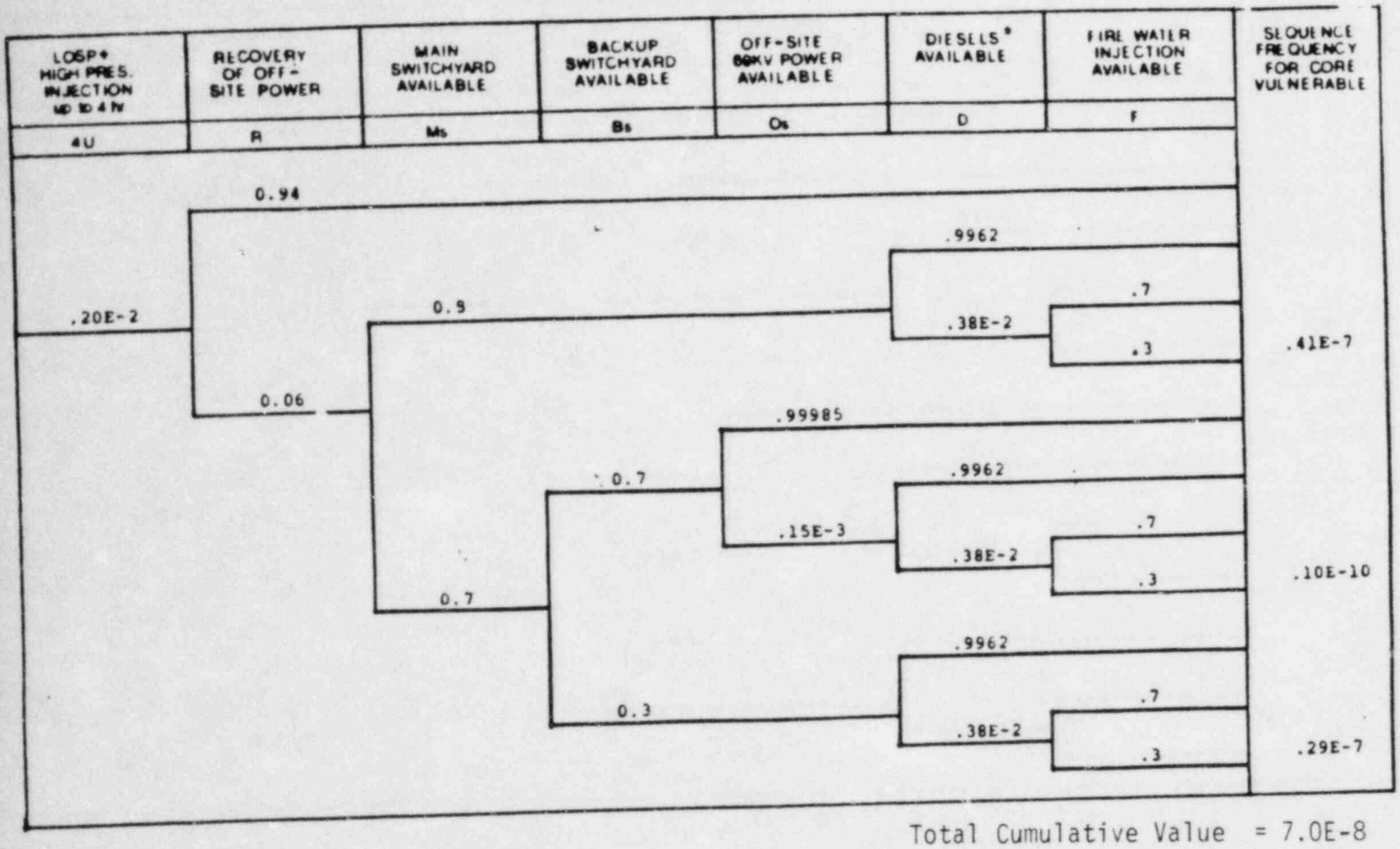


Total Cumulative Value = 1.3E-7

Entry Conditions Sequence Type 3: LOSP; Isolation; Reactor Scrammed; SORV, LOCA or ADS; no coolant Makeup Available; Reactor Depressurized to Less than 65 psia.

* Does not reflect repair

EVENT TREE D-8
(Table 1, Column 4)

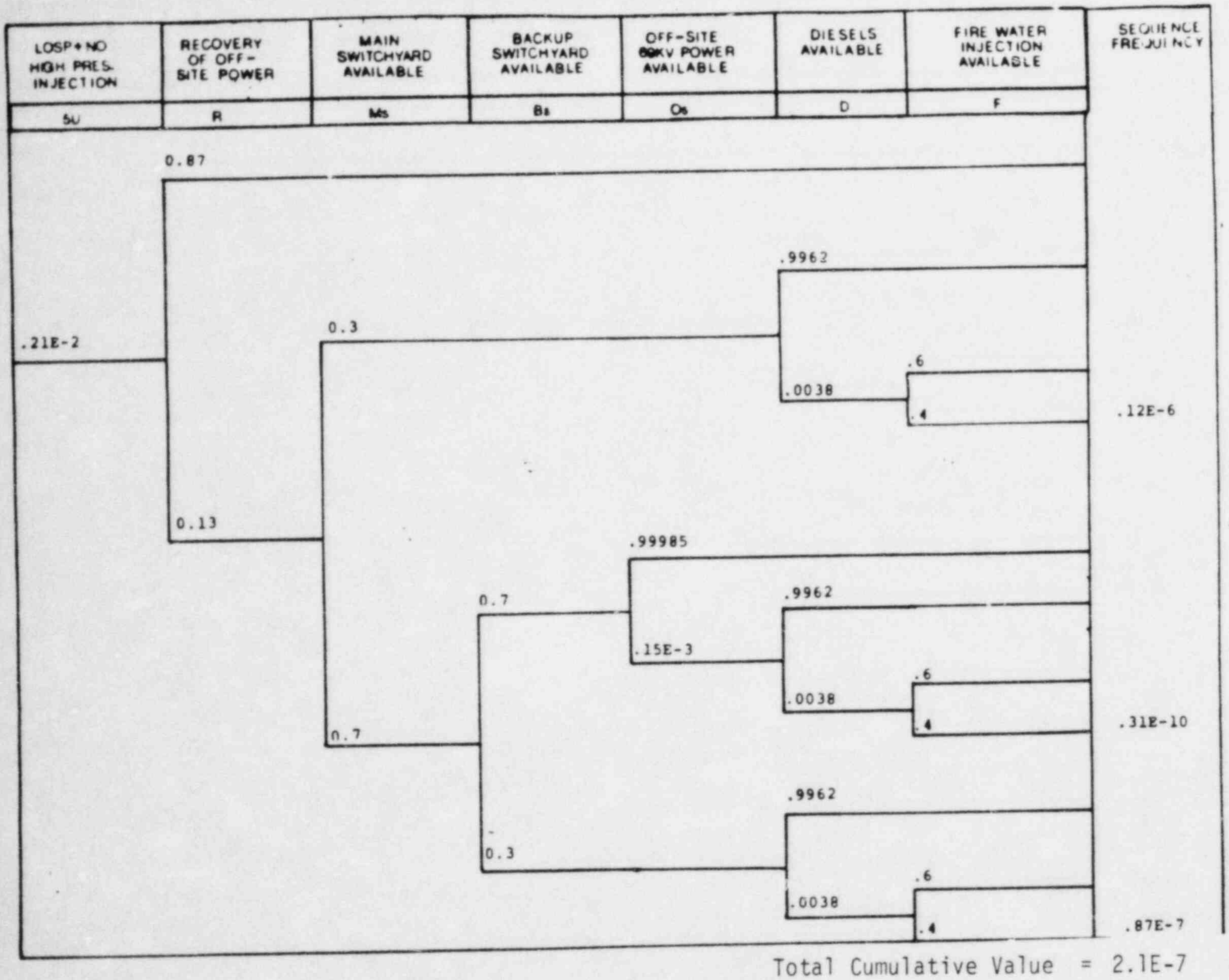


Total Cumulative Value = 7.0E-8

Entry Conditions Sequence Type 4: LOSP; Isolation; SORV; Coolant Injection Available Initially.

*Does not reflect repair

EVENT TREE D-9
(Table 1, Column 4)



Total Cumulative Value = 2.1E-7

Entry Conditions for Sequence Type 5: LOSP; Isolation; no initial Coolant Makeup; Procedural Depressurization.

* Does not reflect repair

EVENT TREE D-10

ATTACHMENT E

Attachment E

SENSITIVITY STUDIES AND ADJUSTMENTS TO SAI METHODOLOGY AND DATA

Some of the data and assumptions used by SAI in performing its Low Power PRA for LILCO could be improved or made more accurate. The two most significant items are (1) the frequency of occurrence of the loss of offsite power transient at the Shoreham facility, and (2) the assumed means of restoring offsite power via the 69 KV switchyard. It also appears that slight changes are necessary in the probability of restoring power following a loss of offsite power and in the conditional availability of the 138 KV switchyard following the occurrence of a loss of offsite power. We have recalculated the frequencies of core vulnerable conditions due to loss of offsite power, as set forth in Table 1 of our testimony, using corrected data as described below.

First, we used a loss of offsite power frequency of 0.25 events per year instead of .082 events per year as was used by SAI in both the Low Power PRA and its 1983

PRA. SAI's loss of offsite power frequency value is based on data concerning only the LILCO grid. (SAI 1983 PRA, page 3-102). Thus, its value of .082/year does not take into account the probability of failures within the Shoreham switchyard resulting in loss of offsite power. In our opinion, the failure to account for such failures makes the SAI value unrealistically low.

The .25/year frequency of loss of offsite power, which we believe is more realistic, is from a Brookhaven National Laboratory assessment of the frequency of loss of offsite power for the nuclear reactors found in the Reliability Council region to which LILCO belongs. *See* Table E-1. We consider this figure to be conservative, but more realistic than SAI's, because it takes into account the contribution to losses of offsite power from failures in the switchyards of nuclear power plants. Such failures are a major contributor to loss of offsite power events. Although we believe that a value even higher than the .25 figure might be appropriate for a plant such as Shoreham which will be operated at low power by relatively inexperienced operating staff using equipment subject to break-in type failures, we did not increase the Brookhaven frequency in performing our calculation.

Second, our recalculation also corrected what we believe to be an error in the SAI model for offsite power availability. The SAI low power event tree for the loss of offsite power transient takes into account the possibility that offsite power will be restored at different times after the transient, with varying probabilities. SAI also assumes, however, availability of offsite 69 KV power with a probability of 0.99985, after the occurrence of the loss of offsite power transient. We believe this second assumption is improper, and amounts to double counting, because the probability of restoring offsite 69 KV power is already included in the event tree in the time varying probabilities for restoring offsite power. We have eliminated this double counting in our recalculation.

The final major change we made was to consider the possibility of repairing the gas turbine and the EMDs following a failure. The SAI Low Power PRA did not discuss the possibility of repairing the EMDs and gas turbine. Thus, to the best of our knowledge, the values in Table 1 of our testimony reflect comparable assumptions of no repairs for both the EMDs and gas turbine, and the TDIs. If the SAI Low Power PRA <u>did</u> include repairs of the EMDs and gas turbine, then the difference between the core vulnerable frequencies for the TDIs and the EMDs and gas turbine is understated in Table 1 to our testimony, because adding the repairability assumption to the TDI values would further reduce the probability of reaching a core vulnerable condition.

We took values from the SAI 1983 PRA to determine the core vulnerable frequencies assuming the TDIs could be repaired. To be conservative, we used the same TDI repair values used by SAI in our EMD and gas turbine event trees to determine core vulnerable frequencies for the alternate system.

The results of our recalculations are summarized in Table E-2. Increasing the frequency of loss of offsite power increases the estimated frequency of core vulnerability due to loss of offsite power by an equal factor of about 3 for both the alternate and the normal AC power systems. Thus, the impact of this adjustment is only in the overall core vulnerable frequency, and the adjustment does not affect the frequency for one system relative to the other. The elimination of redundant consideration of offsite power restoration results in a greater increase in the probability of core vulnerability for the alternate configuration than for the normal configuration. This would reflect the greater dependency of the alternative system on the 69 KV switchyard availability.

Explicitly considering repair of the gas turbine and EMDs reduces the estimated probability of core vulnerability due to loss of offsite power for the alternate system. The TDI analysis showed a comparable reduction in core vulnerable frequency when repairability was included. This is expected because the system components might be returned to operation even though they may have initially failed to operate.

Combining the corrections in data and methodology described above, and assuming the possibility of repair for both the alternate and normal systems, the probability of core vulnerability due to loss of offsite power, is still about a factor of 4 higher for the alternate system. Furthermore, assuming the accuracy of SAI's estimate of 1.6 E-6 for the annual frequency of core vulnerability from all other initiating events during 5 percent operation (SAI 1983 PRA at Table 4-4-1), the likelihood that the Shoreham plant would experience an event leading to core vulnerability during 5 percent operation is approximately 2.8 times greater under the alternate configuration than it is under the normal configuration.

TABLE E-1

PLANT-SPECIFIC POSTERIOR PROBABILITY FOR THE FREQUENCY OF THE LOOP
(Events Per Year)

RELIABILITY COUNCIL - NPCC

PLANTS IN SITE	N	T	MEAN	5 PERC	50 PERC	95 PERC
1. Fitzpatrick	2	5.55	2.8E-01	9.6E-02	2.4E-01	5.4E-01
2. Ginna	3	10.57	2.6E-01	1.0E-01	2.2E-01	4.6E-01
3. Haddam Neck	5	13.72	3.0E-01	1.3E-01	2.7E-01	5.0E-01
4. Indian Point 2 & 3	4	7.94	3.5E-01	1.4E-01	3.0E-01	6.2E-01
5. Main Yankee	1	7.62	2.0E-01	5.3E-02	1.7E-01	3.8E-01
6. Millstone 1 & 2	1	10.47	1.7E-01	4.5E-02	1.5E-01	3.2E-01
7. Nine Mile Point	1	11.32	1.6E-01	4.3E-02	1.4E-01	3.1E-01
8. Pilgrim	4	7.96	3.5E-01	1.4E-01	3.0E-01	6.2E-01
9. Vermont Yankee	1	8.19	1.9E-01	5.1E-02	1.6E-01	3.7E-01
10. Yankee Rowe	1	20.70	1.2E-01	2.9E-02	1.0E-01	2.2E-01
AGGREGATE	23	104.04	2.5E-01	4.4E-02	1.9E-01	5.8E-01

Source: I. A. Papazoglou et al, Bayes Analysis Under Population Variability With An Application to the Frequency of Loss of Offsite Power in Nuclear Plants, BNL Report, Feb., 1983.

TABLE E-2

REQUANTIFICATION OF SAI EVENT TREE FOR CORE VULNERABILITY DUE TO LOSS OF OFFSITE POWER TRANSIENT

(Frequency Per Reactor Year)

	Gas Turbine/EMD Diesels		TDI Diesels	
Type	Non-Repairable	Repairable	Non-Repairable	Repairable
1	2.3E-5	1.0E-6	1.4E-6	6.4E-8
2	1.9E-5	1.7E-6	1.2E-5	1.1E-6
3	4.0E-6	2.0E-6	7.0E-7	3.5E-7
4	5.6E-6	1.3E-6	6.8E-7	1.6E-7
5	8.7E-6	2.6E-6	1.2E-6	3.6E-7
Sum	6.0E-5	.87E-5	1.6E-5	.21E-5

Note: Column totals may not exactly equal the sum of the figures in each column due to rounding.