# DIABLO CANYON POWER PLANT

# DIESEL GENERATOR

# ALLOWED OUTAGE TIME STUDY

May 1989

PACIFIC GAS AND ELECTRIC COMPANY

# EXECUTIVE SUMMARY

Pacific Gas and Electric Company (PG&E) has been implementing activities to enhance diesel generator (DG) reliability at Diablo Canyon. These activities include developing preventive maintenance procedures, providing personnel training, and using industry, NRC, and vendor DG reliability improvement recommendations. Further, PG&E is planning to install a sixth DG by the fourth refueling outage of Unit 2, scheduled for the fall of 1991, and has committed significant resources to this effort. As part of this overall effort, PG&E also determined an acceptable allowed outage time (AOT) for the DG system. An AOT determination study was performed based upon reliability, risk considerations, and the time necessary to perform required maintenance and testing. This report documents this study and is submitted in support of PG&E's application to amend its operating licenses to change the AOT for the DGs to seven days.

This report describes the DG system and the methods used to assess the benefits and impact of the proposed change in AOT. Two different risk calculation methods were used to perform these quantitative evaluations. The first method makes extensive use of the risk assessment models developed for the Diablo Canyon probabilistic risk assessment. The second method uses a reliability analysis, similar in approach to a recent NRC-approved license amendment for a DG AOT extension to seven days. This reliability method was also used to assess the relative and annual risk associated with the proposed AOT change at Diablo Canyon.

The results of these risk and reliability evaluations show that risk and reliability criteria are satisfied for a 7-day AOT for both the five and six DG configurations. These studies confirm that the risk levels during the 7-day AOT remain significantly less than the risk when not in the AOT period; that is, when all DGs are in their normal standby condition, and that the 7-day AOT results in an insignificant change in the risk frequencies. Finally, it was found that overall risk will be reduced over the plant life with a six DG configuration with the 7-day AOT.

DIABLO CANYON POWER PLANT
DIESEL GENERATOR ALLOWED OUTAGE TIME STUDY

# TABLE OF CONTENTS

## TABLE OF CONTENTS (Cont.)

# LIST OF FIGURES AND TABLES

# DIABLO CANYON POWER PLANT
# DIESEL GENERATOR
# ALLOWED OUTAGE TIME STUDY

## 1.0 SUMMARY

PG&E has previously implemented activities to improve Diesel Generator (DG) reliability at Diablo Canyon Power Plant (DCPP). These activities involve preventive maintenance procedures, personnel training, and use of industry, NRC, and vendor DG reliability improvement recommendations. As part of this effort, PG&E has performed this study in support of the DGs' allowed outage time (AOT) revision. This report documents this study and provides the technical basis for License Amendment Request (LAR) 89-05, requesting a revision to the DCPP Technical Specifications (Ref. 1) for the emergency onsite power system DGs.

There are currently five DGs at DCPP Units 1 and 2. However, PG&E is planning to install a sixth DG by the fourth refueling outage of Unit 2 (scheduled for October 1991) as part of this DG reliability improvement effort and has committed significant resources to this effort. This study demonstrates that a 7-day AOT is both acceptable and practical for DCPP. This study focuses on the assessment of two issues: (1) the appropriateness of a 7-day AOT for the purposes of unplanned maintenance for the current five DG and future six DG configurations and (2) the impact of a 7-day AOT for preplanned Technical Specification required maintenance activities.

Two probabilistic evaluation methods were used to assess the benefits and impacts of the proposed AOT revision. Since PG&E had recently completed development of its plant specific PRA, it was used to assess absolute and relative risk values for these two issues. However, since the PRA calculates time-average risk values, a second method, a reliability analysis, was used to assess time dependent risk involved in an AOT for unplanned maintenance, which requires testing of the remaining DGs. Such time-dependent effects are important in the evaluation of the effect of testing on the availability and reliability of remaining DGs. Such a time-dependent methodology has been recently reviewed and approved by the NRC for Brunswick (Ref. 2).

Both of these methods were used to evaluate a relative risk criterion which was developed by Brookhaven National Laboratory, NUREG/CR-3082, "Probabilistic Approaches to LCO's and Surveillance Requirements for Standby Safety Systems," dated November, 1982 (Ref. 3), and which was previously reviewed and accepted by the NRC (Ref. 2). This criterion defines a relative risk ratio that should be less than one; that is, the risk level during the AOT is less than the risk level during the non-AOT period when all DGs are in their normal standby condition while the plant is in Modes 1 through 4.

The first method, referred to in this study as the probabilistic risk analysis, makes extensive use of the Diablo Canyon Probabilistic Risk Assessment (DCPRA) models developed for the DCPP Long Term Seismic Program (Ref. 4). The DCPRA is a full scope Level 1 risk assessment which includes both internal and external initiating events. For this study, use is made of the dominant accident sequence model to compute the impact of DG AOT changes on plant risk; risk is presented in terms of core damage frequency, and also relative risk. The probabilistic risk analysis provides a method to assess the relative risk and absolute risk (core damage frequency) associated with a 72-hour AOT and a 7-day AOT while accounting for both planned and unplanned maintenance. Acceptability is demonstrated by small changes in absolute risk and maintaining a relative risk ratio less than unity. Additionally, the results trend consistently with the reliability analysis results.

The second method is referred to as the reliability analysis. This reliability analysis is compatible with the probabilistic risk analysis by basing the reliability analysis on the DCPRA DG fault tree models and plant specific data. The DG fault trees in the reliability analysis have been extended beyond what is typically modeled in PRA DG system fault trees to include diesel subsystems as well as support systems. Thus this reliability model with its DG fault trees is designed to be a stand-alone model. In addition, the mission times are representative of current regulatory requirements for the Station Blackout Rule. The reliability analysis is similar to the Carolina Power & Light Company's (CP&L's) Brunswick time dependent, approach (Ref. 5). This approach has been previously approved by the NRC for Brunswick (Ref. 2).

In this study both the risk and reliability methods evaluate three cases for their impact on plant risk and reliability. The three cases consider the current plant configuration and the future plant configuration with six DGs and the effect of different AOTs for planned and unplanned maintenance activities. The risk analysis approach addresses both planned and unplanned maintenance, whereas the reliability approach addresses unplanned maintenance.

The base case considers the existing plant configuration with a 72-hour AOT on all DGs to perform unplanned maintenance. Once every 18 months, during the refueling outage of one unit, planned maintenance on the swing DG occurs with the other unit at power. Accomplishing this maintenance with a 72-hour AOT requires multiple outages. Operational experience indicates that four outages of approximately 72 hours each have been required for a planned maintenance activity that required approximately 10 days total to complete. Thus, the baseline duration for this maintenance is 10 days.

The second case is similar to the first except that the DGs are subject to a 7-day AOT for unplanned maintenance. Planned maintenance on the swing DG is also performed; however, with the longer AOT, swing DG maintenance can be performed within the 7-day AOT and multiple outages are not required.

The third case considers the planned plant configuration with six DGs and a 7-day AOT. Technical Specification required maintenance during power operation is no longer applicable since this maintenance can now be performed without affecting the other unit.

Using the relative risk criterion, both of the analyses methods confirm the appropriateness of a 7-day AOT for the purposes of performing unplanned maintenance for both the five and six DG configurations. In particular, the relative risk ratios for all cases were determined to be significantly less than one, that is, the risk level during the DG AOT was found to be significantly less than the risk level during the non-AOT period where all DGs are in a normal standby condition.

Further, the risk-based PRA evaluation also demonstrated that there is negligible change in risk associated with a 7-day AOT over a 72-hour AOT and there are quantitative benefits in performing Technical Specification required maintenance with a 7-day AOT. The PRA and the reliability evaluations both determined that addition of the sixth DG will have a positive impact on risk over the life of the plant. In total, quantitative and qualitative analyses confirm that the 7-day AOT along with addition of the sixth DG will improve overall DG system reliability, and will provide both short term and long term benefits to the safe operation of the plant.

## 2.0 INTRODUCTION

This report provides the information required to support a revision to the DCPP Technical Specifications for the emergency onsite power system DGs. The proposed revision is to change Technical Specification 3.8.1.1's AOT to seven days. The DCPP Technical Specification revision is supported by conclusions developed from the probabilistic risk analysis and the reliability analysis. System descriptions are provided for completeness. Additionally, the background and rationale for this revision are provided below. PG&E was assisted in the preparation of this report by Westinghouse Electric Corporation and Pickard, Lowe & Garrick, Inc.

## 2.1 BACKGROUND

The purpose of the preventive maintenance program is to minimize the likelihood of DG failures by maintaining the DGs in the best possible condition and thereby increasing DG reliability. The preventive maintenance procedures were developed using ALCO's guidelines "Engine Maintenance Schedule for Standby Engines (MI-11272)." Also, the development of the procedures considered DCPP operating experience. When a DG failure occurs, an investigation is conducted to determine the cause of the failure. When it is determined that additional maintenance would help prevent recurrence of the failure, the maintenance is incorporated into the procedures. Additionally, vendor information on preventive maintenance, surveillance programs and procedures is reviewed for application at DCPP.

Another aspect of the DG reliability improvement effort is personnel training. As part of the purchase of the sixth DG, a training program will be provided for PG&E maintenance personnel and engineers. Training has been provided by the DG supplier for PG&E maintenance personnel and engineers. Also, personnel have been involved in industry DG reliability improvement meetings, such as the EPRI Seminar in August 1987 on Diesel Generator Operations, Maintenance and Testing.

The program also uses industry, NRC, and vendor DG reliability improvement recommendations. For example, after reviewing NUREG/CR-0660 "Enhancement of Onsite Emergency Diesel Generator Reliability," PG&E found many of the recommendations included in this report were already implemented at DCPP, such as prelubing of the DG and personnel training.

PG&E has also implemented the recommendations of Generic Letter 84-15 (Ref. 6). Two of the concerns raised in Generic Letter 84-15 were cold fast starting of the DG and excessive testing. The DCPP Technical Specifications were revised to allow gradual acceleration and/or gradual loading of the DGs. Further, the Technical Specifications were revised to minimize the number of DG starts per LAR 85-12 (Ref. 7).

PG&E has also modified the DGs to improve reliability. Two examples of these modifications are the fuel oil priming system and the compressed air filtration and dehumidification system. The fuel oil priming system was added to enhance the starting reliability of the DGs. The compressed air filtration and dehumidification system was added to improve reliability of the solenoid valves and air motors by reducing corrosion. The air system modifications also improve DG starting reliability.

In addition, PG&E plans to install a sixth DG to the existing emergency DG system at DCPP. The sixth DG will also be an ALCO DG like the five existing DGs. With the sixth DG installed and operable, DCPP will have three dedicated DG for each unit rather than the current five DG configuration, with a swing DG, as discussed below. This arrangement will simplify the operation of the system. The net benefit of this arrangement will be an increase of maintenance scheduling efficiency and greater flexibility of plant operation.

As part of this effort to enhance the onsite power system, PG&E has also performed detailed risk and reliability analyses to determine an appropriate AOT for the DGs. These studies demonstrated that a 7-day AOT is appropriate for the DG Technical Specification. Accordingly, LAR 89-05 will request that a 7-day AOT be specified for Technical Specification 3.8.1.1 Action Statement b.

The current DCPP Technical Specifications provide a 72-hour AOT when a DG in a unit is inoperable with the unit in Modes 1 through 4. If a DG is taken out of service (becomes inoperable), the operability of the AC offsite sources must be demonstrated by performing surveillance requirement tests within one hour and at least once per eight hours thereafter. If the DG became inoperable due to a cause other than preventive maintenance or testing, the operability of the remaining DGs must be demonstrated within 24 hours (regardless of when the inoperable DG is

restored to operable status). Currently, the inoperable DG must be restored to operable status within the 72-hour AOT or action must be initiated to place the unit in Mode 5, where the subject Limiting Condition for Operation (LCO) no longer applies.

The proposed change to the Technical Specifications is to obtain a 7-day AOT so that corrective and preventive maintenance and inspection and post maintenance operability testing can be performed. PG&E has determined that in some instances, if a DG became inoperable, the maintenance, inspection, and operability testing can not be completed within the current 72-hour AOT.

Some examples of the maintenance, inspection, and acceptance testing of the DGs are as follows: inspection of the air inlet and exhaust manifolds; replacing the fuel pump drive belt; draining and inspecting the fuel oil day tank; inspecting the turbocharger; reconditioning the air-start motor; and disassembling the generator for cleaning and inspection. Most of this work could be performed during the existing 72-hour AOT. However, generator disassembly for cleaning and inspection, and subsequent reassembly, can require up to seven days to complete. Previously, rotational 72-hour maintenance periods had been utilized to perform this work requiring DG 1-3 to be re-assembled and tested several times to meet the 72-hour AOT. For example, during the Unit 1 first refueling outage, PG&E obtained a one-time license amendment, LAR 85-15 (Ref. 8) to perform maintenance on DG 1-3 for a period of 10 days. However, during the Unit 1 second refueling outage it was necessary to take DG 1-3 out of service for approximately 10 days, using four 72-hour AOT periods. Based on this experience and additional work scope for future outages, a 7-day AOT is required.

The 7-day AOT will improve DG reliability since technicians who perform the repair, maintenance, inspection and acceptance testing can perform such tasks under a less restrictive AOT. For activities that take more than 72 hours to complete, such as disassembly-inspection-reassembly of a DG, technicians will be able to perform the work within a 7-day AOT period without having to resort to a rotational 72-hour AOT. Therefore, the potential for personnel errors will be minimized by using a single AOT as approsed to several, rotational AOTs requiring disassembly and reassembly. As such, the 7-day AOT should improve the overall quality of repair,

maintenance and post-maintenance testing. This also allows the most experience maintenance personnel to perform the work. Additionally, DG failures, which could not be repaired within the 72-hour AOT but could be repaired within a 7-day AOT, will not cause unnecessary plant transients.

## 2.2 SCOPE OF ANALYSIS

The scope of both the probabilistic risk analysis and the reliability analysis is presented in the following paragraphs. Both of these analyses evaluate annual and relative risks. The relative risk is defined by the criterion in NUREG/CR-3082 (Ref. 3), "Probabilistic Approaches to LCOs and Surveillance Requirements for Standby Safety Systems," as follows:

> "If the risk due to a DG AOT during an LCO is less than the risk during a baseline (non-LCO) period, then the risk due to the AOT is considered acceptable."

This criterion explicitly constrains the DG AOT duration by requiring that the risk during the AOT be less than the risk when not in the AOT period.

### A. PRA Work Scope

Figure 2-1 shows a general flow chart for the PRA analysis approach. In particular, the analysis involves the following tasks:

1. Define impact of changing DG AOT on the DCPRA model (for both seismic and non-seismic events) and the impact of adding a sixth DG.
2. Utilize existing DCPRA DG model (with modifications as necessary) to re-evaluate DG failure probabilities for various sensitivity cases.
3. Evaluate impact on DCPRA model due to performing scheduled maintenance on DG 1-3 during power operation.
4. Collect and analyze maintenance data for plants with 7-day AOTs.

5. Quantify system and plant models to evaluate changes in core damage frequency.

6. Evaluate the absolute risk and relative risk based on core damage results.

B. Reliability Work Scope

Figure 2-2 shows a general flow chart for the reliability analysis approach. The specific reliability analysis tasks are defined below:

1. Qualitatively analyze the benefits of an AOT extension.

2. Define boundary conditions and acceptance criteria. This includes setting the success criteria and the mission times.

3. Collect and evaluate plant specific DG data. DCPP data are included for the 72-hour AOT cases. Additionally, data from a 7-day AOT plant (Palisades) which has the same DG manufacturer as DCPP are included for the DG failure rates associated with the 7-day AOT cases.

4. Develop DG fault tree models for a single diesel. The models are quantified to determine the unavailability of a DG. The results are utilized below.

5. The reliability analysis develops fault tree models for the following cases:

   a. Loss of Offsite Power (LOOP), and
   b. Loss of Coolant Accident (LOCA) in one unit with a LOOP.

   The DG unavailability is incorporated into the fault tree case models. The models are logically reduced to generate minimal cutsets representing DG unavailability at either unit. These cutsets are loaded into the FRANTIC-ABC computer code (Ref. 9). The FRANTIC-ABC code uses time-dependent models to calculate an average and a maximum unavailability for each case.

6. Calculate risk levels for the current 72-hour AOT and the proposed 7-day AOT. Risk is measured using two approaches for the licensing design basis; relative risk and average annual risk.

Both of the approaches were used to evaluate the following cases:

- 72-hour AOT for the five DG configuration, with the risk analysis addressing a total of 10 days for the outage (i.e., several 72-hour AOT periods),
- 7-day AOT for the five DG configuration, and
- 7-day AOT for the planned six DG configuration.

The detailed modeling and analyses, along with the results, are documented in Chapters 4 through 6 of this report. The conclusions of these evaluations are provided in Chapter 7.

PG&E is planning to install a sixth DG by the fourth refueling outage of Unit 2 and has committed significant resources to this effort. The analyses documented in this report include consideration of both the current five diesel configuration as well as the planned six diesel configuration. The 7-day AOT will be applicable to all DGs of both the current five and planned six DG configurations once LAR 89-05 is approved.

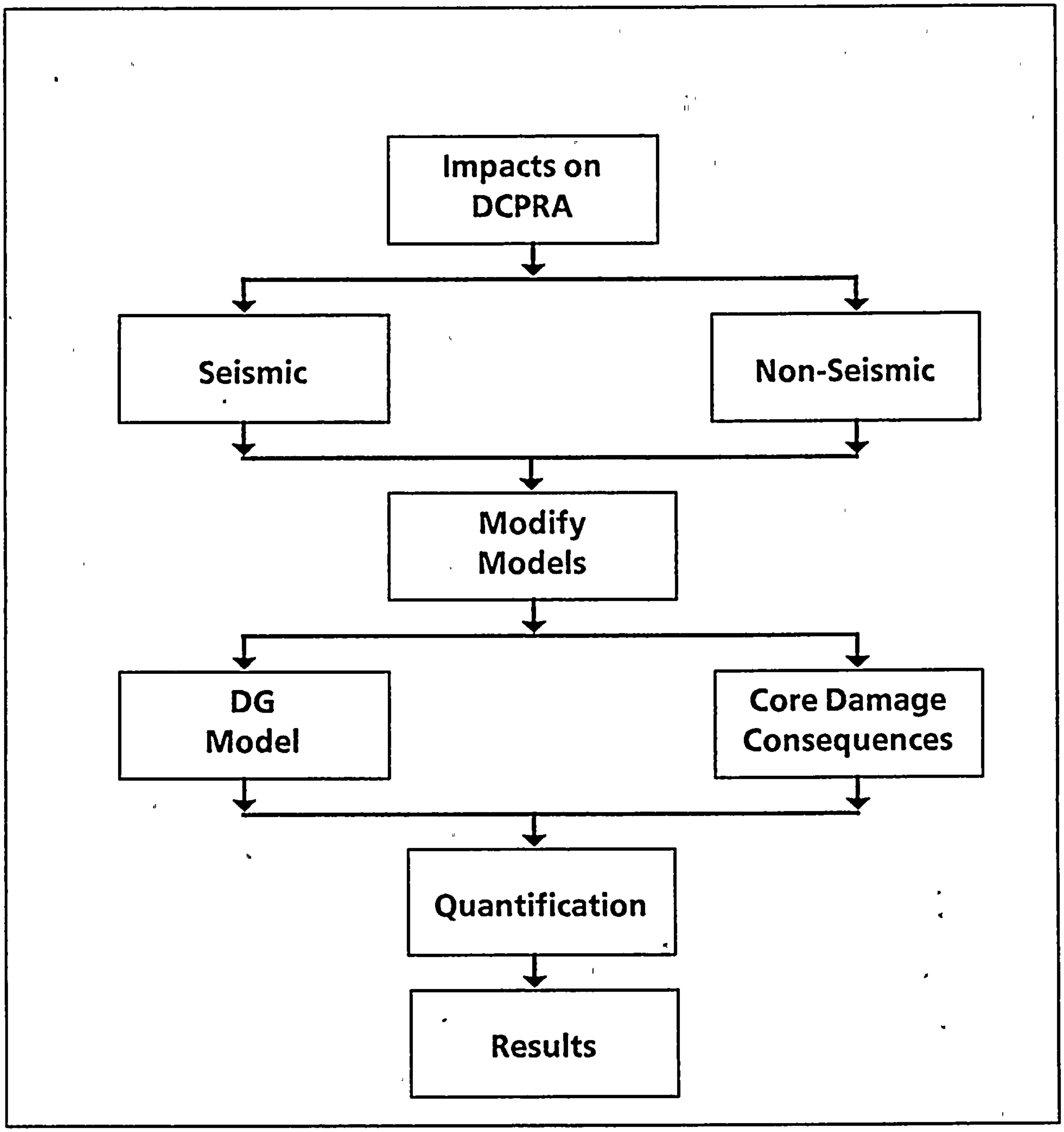


FIGURE 2-1
PROBABILISTIC RISK ASSESSMENT APPROACH

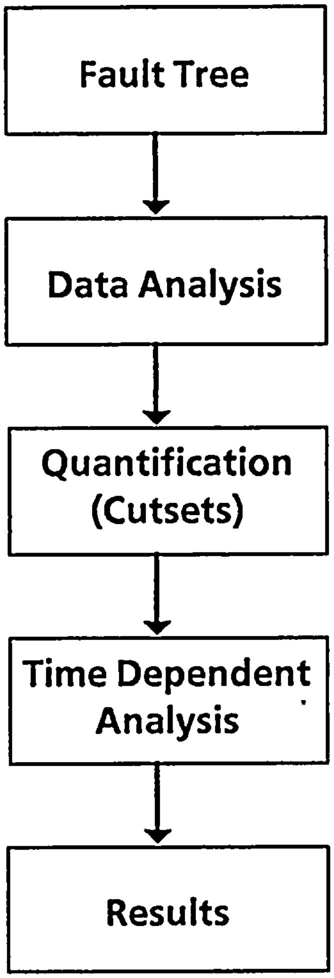


FIGURE 2-2
RELIABILITY ANALYSIS APPROACH

## 3.0 ELECTRIC POWER SYSTEM

This section describes the AC power system for DCPP and the design function, system operation, configuration, and support systems required for the operation of the DGs.

## 3.1 ELECTRIC POWER SYSTEM FUNCTION

The electrical power system at DCPP is designed to provide electric power to the necessary plant electrical equipment under all combinations of plant operation and electric power source availability. The various subsystems provide protection for electrical equipment during faulted conditions while maintaining maximum system flexibility and reliability.

The 4.16 kV distribution system supplies power to three vital buses supporting two trains of Engineered Safety Features (ESF) equipment. Any two of the three buses are adequate to serve the minimum required ESF for accident mitigation. The vital buses can also be cross-connected by operators so that the DGs can serve the loads normally connected to other buses; procedures already exist for such actions. Any two of the DGs and their associated vital buses per unit can supply sufficient power for operation of the required safeguards equipment for a design basis LOCA event coincident with a LOOP. It should be noted that fewer loads are required for mitigation of a LOOP than those required for a LOCA/LOOP, and that there is a substantially smaller likelihood of the LOCA/LOOP combination. In addition, the swing DG is designed to automatically align to the unit which first receives a safety injection signal (SIS).

The safety systems requiring electric power are:

1. Emergency core cooling system (ECCS) including centrifugal charging pumps, residual heat removal pumps, safety injection pumps, and motor driven auxiliary feedwater pumps,

2. Containment spray pumps,

3. Containment ventilation system including five fan cooler units,

4. Auxiliary saltwater system (ASWS),
5. Component cooling water system (CCWS), and
6. Chemical and volume control system (CVCS).

## 3.2 ELECTRIC POWER SYSTEM DESCRIPTION

DCPP has two offsite power sources, a 230 kV transmission system and a 500 kV transmission system. The plant is connected to the 230 kV transmission system for startup and standby power (which has two incoming transmission lines, one from the Morro Bay Power Plant and the other from the Mesa Substation), and to the 500 kV system for transmission of the plant's power output. The 500 kV connection also provides a backup offsite power source to the plant when the main generator and 230 kV power supplies are not available (Ref. 10 & 11). The offsite power system is shown in Figure 3-1.

The onsite power systems consist of all sources of electric power and their associated distribution systems. Included are the main generators, emergency DGs, and the vital and non-vital station batteries.

The system of interest in this study is the vital 4.16 kV system. The 4.16 kV loads are divided into five groups; two of these groups are not vital to the ESF buses and are connected to non-vital 4.16 kV Buses D and E. Each of the non-vital buses has two sources: one from the main generator and one from the 230 kV transmission system. The other three load groups are Class 1E and are connected to 4.16 kV vital buses F, G, and H. Each of these buses has three sources: two being the same as the non-vital buses and the third a diesel-driven generator. The loads on the vital buses are listed in Table 3-1.

The DCPP onsite power system consists of five DGs. Two DGs are dedicated to each unit. An additional DG is shared between units. This DG (DG 1-3) is referred to as the swing DG. The individual DGs are physically isolated from each other and from other equipment. DGs 1-1, 1-2 and 1-3 are physically located in Unit 1, while DGs 2-1 and 2-2 are located in Unit 2. Each DG supplies power only to its associated bus.

When the sixth DG is installed, it will be dedicated to Unit 2, and DG 1-3 will be dedicated to Unit 1 only.

## 3.3 ELECTRIC POWER SYSTEM OPERATION

Auxiliary power for normal plant operation is supplied by each unit's main generators through the unit auxiliary transformers, except during startups and shutdowns. Auxiliary power for startups and shutdowns is supplied by offsite power sources. If offsite power is unavailable, auxiliary shutdown power is furnished by the emergency DGs.

In the event of a loss of electrical power from the main generator, due to a unit trip, a safeguard signal, or a loss of voltage on the bus, the vital 4.16 kV buses are automatically disconnected from the main generator as a source. If power is available from the offsite standby source, the vital 4.16 kV buses are transferred to this source automatically after a short delay to allow for voltage decay on the motors that were running.

If bus voltage is not restored within 1 second following a loss of startup power, all of the DGs for the affected unit are started automatically and brought to a condition ready for loading. If only one bus is affected, then only the DG associated with that bus is started automatically.

The DGs are started automatically by the following signals:

1. A SIS, or
2. A 4.16 kV bus undervoltage (on respective bus) due to:
   a. Less than 3600 V for greater than 9 seconds, or
   b. Loss of startup feeder voltage for greater than 1 second, or
   c. Loss of 4.16 kV bus voltage for 0.8 seconds.

Should there be a complete LOOP, when the DGs have reached breaker close-in voltage, all circuit breakers from the normal and offsite sources to these vital 4.16 kV buses are given a trip signal independently to make sure they are open (the

expected condition at this point). The 4.16 kV circuit breaker for each DG then closes automatically to restore power to the vital 4.16 kV bus, and consequently the 480 V and 120 V buses. Following the loading of the DGs onto the vital buses, additional individual loads are put into operation in a staggered sequence to reduce the effects of momentary loads and motor starting on the DGs.

## 3.4 DIESEL GENERATORS

The DG units are 2750 kW, 18 cylinder DGs supplied by ALCO Engine Division of White Industrial Power, Inc. Each DG supplies a vital bus, with the swing DG supplying either Unit 1 or Unit 2 vital bus F.

Each DG unit consists of a self-contained diesel engine directly connected to an alternating current generator. Each DG has its own fuel oil day tank along with its own lube oil, radiator cooled and self-contained jacket cooling water system, ventilation, dual-train starting air system and associated instrumentation and controls.

The DG is started by the engine start relay which energizes two solenoids that allow the starting air system to crank the diesel engine. When the DG start has been verified by jacket water pressure, the solenoids are deenergized, and the generator field is flashed. When proper speed and voltage have been reached, the DG feeder breaker closes onto the 4.16 kV vital bus, energizing the 480 V bus, if an undervoltage condition exists. Some permanently connected loads are energized immediately as the 480 V bus is energized. The remaining vital loads are connected at time intervals determined by individual load timers.

### Fuel Oil System

The fuel oil system stores and supplies the DGs with fuel oil. Two 40,000-gallon fuel oil storage tanks with associated transfer pumps are shared by the diesels of both units. Each fuel oil transfer pump can be powered from a Unit 1 or Unit 2 vital 480 V AC power. Air-operated level control valves (LCVs) on the tanks regulate the level of fuel in the day tanks. Each diesel has its own day tank that supplies its respective engine-driven fuel oil booster pump. This booster pump maintains oil pressure in a

common header, which supplies fuel to the individual fuel oil injection pumps. There is one fuel oil injection pump and fuel injector per cylinder. These 18 injection pumps and injectors are the final delivery portion of the fuel oil system.

## Lube Oil System

The lube oil system for each engine is entirely contained on that engine's baseplate. During engine operation, all required lubricating oil is drawn from the engine crankcase through a shaft-mounted oil pump to a lubricating oil filter with a built-in pressure relief device to bypass lubricating oil in the event that the filter becomes excessively dirty. The oil is then cooled in the jacket water-cooled heat exchanger and returned to the engine bearings through a duplex strainer. If the oil pressure drops below 60 psig a low oil pressure alarm is generated. If the oil pressure drops below 40 psig, the diesel will automatically shut down, and the generator breaker will trip open.

There is a motor-driven, precirculating lube oil pump that also takes suction from the crankcase reservoir. This pump is normally in continuous operation when the diesel is shut down to coat the critical parts of the engine with oil, thus reducing wear during the engine start period. When the diesel is started, the pump automatically stops when the engine jacket water pressure exceeds 10 psig. This pump is not necessary for successful DG operation.

The prelube pump does not function as an automatic back-up for the engine-driven lube oil pump, since the prelube pump will not automatically start on decreasing oil pressure.

Electric lube oil heaters, located in the recirculating pump's discharge path, maintain lube oil temperature at 90°-110°F to eliminate engine wear during startup.

From the heat exchanger, lube oil passes through a duplex lube oil strainer before reentering the engine and turbocharger. A pressure-regulating valve, located between the strainer and the heat exchanger, maintains engine header pressure

below 85 psig by bypassing a portion of the oil flow to the engine sump. Once the lube oil has completed its path through the engine, it is collected in the lube oil sump to be picked up by the pump again.

## Jacket Cooling Water System

A closed loop jacket cooling water system is provided for each of the five DG engines. The jacket cooling water system controls the operating temperature of the diesel engine by removing diesel engine heat. The jacket water pump takes water from the lube oil cooler and the turbocharger aftercooler. Flow control orifices are used to ensure proper amounts of water flow through each heat exchanger. To compensate for any losses in the system and to account for thermal expansion, there is a 1-inch line connected from a 50-gallon expansion tank to the suction of the jacket water pump. The pump discharges water through the engine block and turbocharger to a common return line. The pump discharge line goes to a three-way, thermostatically controlled valve set to maintain engine water temperature at 170°F. If the engine discharge water temperature reaches the setpoint, the valve automatically directs the system water through the jacket water radiator where it is cooled by forced air. The jacket water pump is driven by the same crankshaft drive gear used to drive the lube oil pump. There are four pressure switches located on the discharge of the jacket water pump. Two of the switches supply signals to the starting circuitry. The other two provide a permissive indicating the engine is shutdown and as such input into the starting circuitry for the precirculating lube oil pumps and crankcase exhausters.

Cooling air is ambient air drawn by the fan from outside the building into the radiator-fan portion of the engine generator compartment. This closed system allows the DG unit to function in a self-contained manner, independent of outside cooling water systems and electric motor-driven fans.

Two sets of electric block heaters maintain the jacket water temperature between 90° and 110°F when the engine is in the standby condition.

### Starting Air System

Each diesel engine is provided with two separate air-start systems. Each of the two air-start systems together with the turbo-assist air system is capable of starting the generator in less than 10-seconds. The starting air system supplies compressed air to the starting air motors. Starting air is supplied by two motor-driven reciprocating air compressors, pumped through individual air drying systems and stored in two starting air receiver tanks. Each air drying system consists of an aftercooler, a moisture separator, a prefilter, an oil filter, and an air dryer unit. It is important that moisture and oil be removed from the air so that they do not accumulate in the receiver tanks. This could cause the diesel to become inoperable.

Each receiver has the capability to perform several consecutive starts without recharging for a total of 45 seconds of cranking.

Each DG is equipped with four starting air motors. Each starting air receiver supplies two starting air motors. Air from receivers is fed through regulator valves and up to the starting air system solenoid valves. At the initiation of a start, the solenoid operated valves open, supplying air to the motors. The air supply is shut off after initiation has been sensed by pressure switches located on the discharge of the jacket water pump.

The starting air system also supplies air to the LCVs of the diesel fuel oil day tanks.

### Turbo-Assist Air System

Each diesel engine is equipped with an engine turbocharger boost system. The turbocharger boost system serves two functions: it aids in acceleration of the large rotating mass of the turbocharger and it provides extra air to the engine to improve combustion during acceleration. The system consists of one turbo-air compressor, one starting air receiver tank, and an air dryer. Air is supplied from the receivers to the turbocharger unit on the diesel through two solenoid-operated shutoff valves, one in each line.

The diesel engine turbo-assist air controller is a solid-state device that controls the turbo-assist air supply in order to prevent a critical loss of speed when a sudden, large load increase occurs.

### Crankcase Exhauster

Each diesel engine is equipped with two small, motor-driven crankcase exhauster fans. The fans are automatically started when jacket water pressure exceeds 10 psig. Their purpose is to prevent an overpressure condition in the crankcase by removing any vapors that may be present.

### Engine Governor/Speed Control

The diesel uses a Woodward EG governor which controls the fuel delivery and therefore the engine's speed and generator output frequency to a predetermined value. The governor has electrical and mechanical controls both of which act through a hydraulic actuator to control the fuel supply.

The electrical section of the governor senses the generator speed & load and converts this information to a proportional change which acts upon the electrical portion of the hydraulic governor.

The mechanical section of the hydraulic actuator consists of centrifugal flyweights, linkage, and valves. The position of the flyweights changes with engine speed. This in turn moves linkages which, through the internal control oil system, convert the mechanical movement to a change in the fuel delivery rate. The mechanical control is generally set higher than the electrical control so that it becomes a back-up if the electrical control fails. When the electrical control fails, it goes to the full fuel position. As engine speed increases, the flyweight will take over before an overspeed condition occurs.

If both the mechanical and electrical sections were to fail, the engine is equipped with an automatic overspeed tripping device, consisting of a spring-loaded plunger that, during normal operation, is held within the carrier. When centrifugal force is great enough to overcome spring pressure (overspeed condition of 1085 to 1130 rpm), the plunger is forced outward and strikes a trip lever, releasing the spring-

loaded reset shaft. This shaft is directly coupled to the fuel pump control shaft. As the reset shaft spring unwinds, it causes rotation of the fuel pump control shaft, which moves the fuel pump racks to a shutoff position. An overtravel mechanism at the governor end allows the overspeed device to return the racks to OFF, even though the governor may remain at the full fuel demand position. There is no way for the operator to bypass this overspeed trip.

### Controls and Instrumentation

Controls for engine generator functions are both local at the engine generator compartment and remote in the main control room. Each of the units may be manually started or stopped from either location to facilitate periodic testing. Each DG is normally controlled from the control room. A two-position local-remote switch is located at each DG to allow control from either the control room or the DG compartment. Each DG is provided with two independent start control circuits powered from three vital batteries in each Unit for redundancy.

The DGs are instrumented to monitor the important parameters and alarm abnormal conditions, both locally at the DG compartment and remotely in the control room. A listing of all alarms is provided in Table 3-2.

If the engine generator unit is started automatically on loss of standby power, safety injection, or both, the engine trip or shutdown functions are limited to engine overspeed, engine low lube oil pressure and generator current differential. The autostart signal initiates alarms in both the control room and the DG room.

The engine overspeed trip is a mechanical device relying on centrifugal force to release a spring that, by mechanical action alone, stops the flow of fuel and shuts down the engine.

### Diesel Generator Output Breaker

The DG output breaker is the interface component between the DGs and the 4.16 kV vital AC bus distribution system. The DG output breakers (Figure 3-1) are listed as follows:

| | | | |
|---|---|---|---|
| DG 1-1 | Breaker 52-HH-7 | DG 2-1 | Breaker 52-HG-5 |
| DG 1-2 | Breaker 52-HG-5 | DG 2-2 | Breaker 52-HH-7 |
| DG 1-3 | Breaker 52-HF-7(U-1) | DG 1-3 | Breaker 52-HF-7(U-2) |

These breakers are controlled automatically or manually based on control board switch positions. The DG output breaker will shut automatically regardless of switch positions if all the following conditions are met:

1. The auxiliary feeder breaker is open,
2. The startup feeder breaker is open,
3. The auto interlock relay is energized,
4. The 4.16 kV undervoltage timer is timed out, and
5. The DG is at speed and voltage.

The operation of the output breaker for the swing DG requires special mention. Since this DG can feed both units, special precautions are taken to ensure that it preferentially feeds the first unit to receive a SIS or bus F undervoltage. Should a SIS on Unit 1 be received, the Unit 2 generator output breaker is prohibited from shutting on a 4.16 kV bus F undervoltage with no SIS present. However, if there is an undervoltage on Unit 2 bus F concurrently with a Unit 2 SIS, the Unit 2 output breaker will shut and the Unit 1 output breaker is prohibited from shutting regardless of the condition of bus F.

If the Unit 2 DG output breaker is already shut on a non-SI condition and a Unit 1 SIS is received, the Unit 2 DG output breaker will be tripped open. Should SIS be present on both units, the output breaker on the first unit to receive a 4.16 kV bus F undervoltage signal will automatically shut and stay shut regardless of subsequent conditions on the other unit's 4.16 kV bus F. When the sixth DG is added, the swing DG (1-3) will be dedicated to Unit 1 only, and the sixth DG will be dedicated to Unit 2.

Diesel Generator Support Systems

The DGs require 125 V DC power to start and control the operation of the diesels. The following are the normal and emergency power supplies for each DG's controls:

| | |
|---|---|
| DG 1-1 (normal) | 72-1313 Panel 13 |
| DG 1-1 (alternate) | 72-1219 Panel 12 |
| DG 1-2 (normal) | 72-1214 Panel 12 |
| DG 1-2 (alternate) | 72-1115 Panel 11 |
| DG 2-1 (normal) | 72-2214 Panel 22 |
| DG 2-1 (alternate) | 72-2115 Panel 21 |
| DG 2-2 (normal) | 72-2313 Panel 23 |
| DG 2-2 (alternate) | 72-2219 Panel 22 |
| DG 1-3 (normal) | 72-1116 Panel 11 |
| DG 1-3 (alternate) | 72-1318 Panel 13 |
| Unit 1 4.16 kV bus F | 72-1113 Panel 11 |
| Unit 1 4.16 kV bus G | 72-1213 Panel 12 |
| Unit 1 4.16 kV bus H | 72-1314 Panel 13 |
| Unit 2 4.16 kV bus F | 72-2113 Panel 21 |
| Unit 2 4.16 kV bus G | 72-2213 Panel 22 |
| Unit 2 4.16 kV bus H | 72-2314 Panel 23 |

The following is a list of 125 V DC loads for the DGs:

1. Diesel engine control panel
2. Generator regulator and exciter
3. Generator protection relays
4. Diesel engine protection relays
5. Output breaker controls and protection
6. Auto transfer and start circuits

480 V AC is required to supply power to the air compressors for the DG air start systems. There are two independent systems per diesel (trains A and B) with separate power supplies:

| | | |
|---|---|---|
| DG 1-1 compressor | train A | 480 V 1H |
| | train B | 480 V 1G |
| DG 1-2 compressor | train A | 480 V 1G |
| | train B | 480 V 1F |

| | | |
|---|---|---|
| DG 1-3 compressor | train A | 480 V 1F with backup 2F |
| | train B | 480 V 1H with backup 2H |
| DG 2-1 compressor | train A | 480 V 2G |
| | train B | 480 V 2F |
| DG 2-2 compressor | train A | 480 V 2H |
| | train B | 480 V 2G |

## 3.5 SUMMARY OF STATION BLACKOUT

A station blackout (SBO) evaluation was performed for DCPP (Ref. 12) which assessed the ability of the plant to cope with a station blackout event as required by 10 CFR 50.63 (Ref. 13). The assessment was conducted following the guidelines and technical bases contained in NUMARC 87-00, "Guidelines and Technical Bases for NUMARC Initiatives Addressing Station Blackout at Light Water Reactors."

Since DCPP is a multi-unit site with normally dedicated emergency AC power sources, where the combination of AC sources exceeds the minimum redundancy requirements for normal safe shutdown for all units, it is assumed that only one unit experiences a SBO while the other experiences a single active failure in its process of coming to safe shutdown conditions.

DCPP has never experienced a grid-related LOOP. The results of the SBO evaluation determined that the current five diesel configuration DCPP is required for a coping duration of four hours. The capacity of each of the six existing Class 1E station batteries at DCPP was determined to be adequate to supply the required loads during a four hour SBO event assuming no load stripping. For the planned six diesel configuration, preliminary analyses indicated that the coping duration is two hours.

## TABLE 3-1

## 4.16 kV VITAL BUS AND ESF LOADS

| BUS | DG | VITAL SAFETY-RELATED LOADS |
|---|---|---|
| F | 1-3<br>(swing) | Centrifugal Charging Pump No. 1<br>Safety Injection Pump No. 1<br>Containment Fan Cooler Unit No. 2<br>Containment Fan Cooler Unit No. 1<br>Component Cooling Water Pump No. 1<br>Auxiliary Saltwater Pump No. 1<br>Auxiliary Feedwater Pump No. 3 |
| G | 1-2<br>(2-1) | Centrifugal Charging Pump No. 2<br>Residual Heat Removal Pump No. 1<br>Containment Fan Cooler Unit No. 3<br>Containment Fan Cooler Unit No. 5<br>Component Cooling Water Pump No. 2<br>Auxiliary Saltwater Pump No. 2<br>Containment Spray Pump No. 1 |
| H | 1-1<br>(2-2) | Safety Injection Pump No. 2<br>Residual Heat Removal Pump No. 2<br>Containment Fan Cooler Unit No. 4<br>Component Cooling Water Pump No. 3<br>Auxiliary Feedwater Pump No. 2<br>Containment Spray Pump No. 2 |

## TABLE 3-2
## DIESEL GENERATOR ALARMS

**Annunciator**

1. Engine generator on local control
2. Generator circuit breaker on local control
3. DC control undervoltage
    a. Engine generator control
    b. Circuit breaker control
4. Engine starting air pressure - low
5. Engine fails to start (overcrank)
6. Engine lube oil system trouble
    a. Low lube oil pressure
    b. Low lube oil level
    c. High lube oil filter differential pressure
    d. High lube oil temperature
    e. Low lube oil temperature
    f. Precirculating lube oil pump failure
7. Engine cooling system trouble
    a. High jacket water temperature

## TABLE 3-2 (Cont)
## DIESEL GENERATOR ALARMS

<u>Annunciator</u>

- b. Low jacket water level
- c. High compartment air temperature
- d. High radiator discharge air temperature.

Annunciator

8. Engine fuel oil system trouble

    a. High/low engine fuel oil tank level
    b. High/low storage fuel oil tank level
    c. Fuel oil transfer pump overcurrent
    d. Low engine fuel oil priming tank level

9. Engine crankcase vacuum trouble

10. Generator stator temperature - high

11. Ground overcurrent

12. Generator negative sequence

13. Engine trip (shutdown relay tripped)

14. Engine generator circuit breaker trip

## TABLE 3-2 (Cont)
## DIESEL GENERATOR ALARMS

15. Auxiliaries undervoltage

16. Reverse power, loss of field, and overcurrent protection cut-in

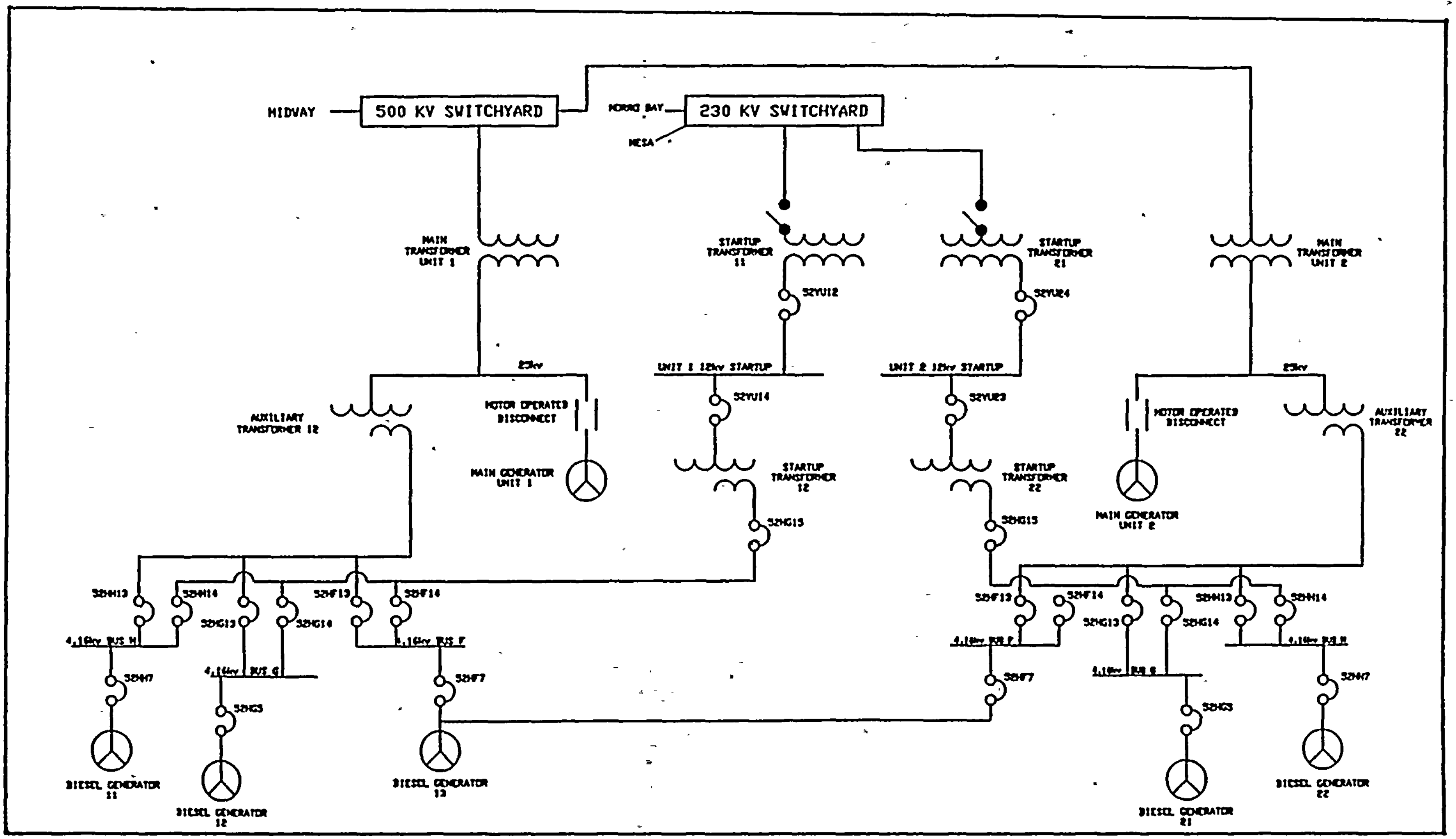


FIGURE 3-1

DIABLO CANYON ELECTRIC POWER SYSTEM

## 4.0 PROBABILISTIC RISK ANALYSIS

This chapter describes the risk assessment of alternative AOTs for different DG configurations at DCPP. The risk assessment is performed at each of three impact levels; i.e, the data level, the systems level, and the combined sequence frequency or core damage frequency level. For the purposes of this assessment, the risk results are provided in terms of the total (seismic and non-seismic) core damage frequency for Diablo Canyon Unit 1. Both absolute and relative risk measures are computed and presented. The absolute risk is the annual core damage frequency. The relative risk is the ratio of the risk of core damage during the AOT to the risk of core damage between DG outages. This ratio provides a measure of the change in the core damage frequency during the time a DG is inoperable compared to the time when all plant DGs are operable. Both the absolute and relative risk measures are described in NUREG/CR-3082 (Ref. 3). Relative risk ratios are assumed to be acceptable if they are less than unity; that is, the risk incurred during the AOT is less than the risk when not in the AOT (when all the DGs are operable) while the plant is in Modes 1 through 4. The absolute change in the mean core damage frequency is assumed to be acceptable if the change is small compared to the overall uncertainty in the core damage frequency.

The analysis makes extensive use of the DCPRA models developed previously in the Diablo Canyon Long Term Seismic Program (Ref. 14). Both seismic and non-seismic initiating events are analyzed. Chapter 6 of Reference 14 provides a summary of the DCPRA models and results. The current effort also makes use of the substantial DCPRA supporting documentation that had been previously submitted to the NRC.

The DCPRA is a full scope level 1 risk assessment. It includes an assessment of both internal and external initiating events; including an assessment of fires, floods and especially, seismic events. As a level 1 study, the DCPRA presents results in terms of the total core damage frequency. For the purposes of this study, use is made of the dominant sequence model from the DCPRA to compute the impact of changes to the AOT on plant risk. For the systems and data unaffected by such changes, results from the DCPRA are used as documented in Reference 14.

The DCPRA and the current study both present the risk for Unit 1 only. Unit 2 is sufficiently similar so that the Unit 1 risk is deemed to be applicable for Unit 2. For

systems shared between units (i.e., emergency AC power, control room ventilation, and auxiliary saltwater) both the DCPRA and the current study account for such interdependencies. For example, where appropriate, the swing DG is assumed aligned to Unit 1 only 50 percent of the time.

## 4.1 PRA CALCULATIONS

Several calculations are made to determine the impact on plant risk. The calculations are summarized in Table 4-1 and explained in more detail below. The calculations evaluate the current five DG configuration and the planned configuration with six DGs.

Two different AOTs are considered, the current 72-hour period for which a single diesel may be inoperable while the plant is at power, and a 7-day AOT. The five DG configuration is evaluated for both the 72-hour and 7-day AOTs. The six DG configuration is evaluated for the 7-day AOT only. An additional situation is considered for the current configuration in which no maintenance (scheduled or unscheduled) is performed on the DGs. This situation is used to compute the core damage frequency for the time period between DG outage events and is only used in the relative risk calculations. It is emphasized that this is not intended to represent an achievable risk level.

The scheduled 18 month maintenance interval (as prescribed by the DG manufacturer and required by the Technical Specifications) on the dedicated DGs are performed with the associated unit shutdown for both the five and six DG configurations. This also applies to the calculation for the six DG configuration. Contrary to what was previously assumed in the initial DCPRA model, recent operating experience has shown that scheduled maintenance on the swing DG occurs during Unit 1 refueling outages and with Unit 2 at power.

## 4.2 DATA ANALYSIS

In order to evaluate the impact of changing the AOT from 72-hours to 7-days, information is needed regarding maintenance practices under 7-day AOTs. The major source of information is industry data from plants which currently have 7-day

AOTs. This information is somewhat difficult to incorporate into the analysis because the maintenance philosophy at each plant can vary significantly.

Based upon maintenance practices at DCPP, the mean DG maintenance duration at DCPP is 10 hours, which is well below the current AOT of 72 hours. The fact that such a low maintenance duration has been achieved is indicative of PG&E's commitment to minimize DG unavailability.

In order to estimate how DG maintenance practices at DCPP might change under a 7-day AOT, the plant staff was consulted. It was the staff's consensus that very little change in the maintenance and operations practices and, consequently, the mean maintenance duration, is expected with a 7-day AOT. The following key observations support this conclusion:

- With a DG unavailable, the ability to perform maintenance on other systems is essentially precluded by Technical Specifications (discussed below). This restriction can have a significant impact on plant maintenance scheduling and planning. In general, other maintenance activities may be postponed until the DG is operable. Hence, there is significant motivation to return the DG to operable status as soon as possible.

- Technical Specification 3.8.1.1 Action Statement d, part 1 requires that if one DG is inoperable then verify that "All required systems, subsystems, trains, components and devices that depend on the remaining operable DG as a source of emergency power are also operable." If these conditions are not met, then action must be initiated within two hours to place the unit in Hot Standby. The plant maintenance staff must assure that this 2-hour Action Statement is met in order to avoid plant shutdown. Thus, unforeseen equipment failures provide incentive to complete any repair work on the inoperable DG.

- As part of its corporate goals and activities, PG&E has implemented the INPO performance indicator program. In this regard, PG&E management is committed to minimizing DG unavailability and monitors DG unavailability data to assure this commitment is implemented.

DG unavailability is a performance indicator parameter reported by PG&E to INPO on a quarterly basis and is reviewed by PG&E senior corporate and plant management. The data reported includes demand, start, load-run, out-of-service durations, and hour-of-operations data. This management commitment provides a further incentive to minimize DG unavailability time.

Based on these considerations, changing to a 7-day AOT is not expected to cause a significant increase in the mean DG maintenance duration. However, to use a conservative value, an increase of six hours is assumed. Thus, the mean maintenance duration would increase from 10 to 16 hours. Therefore, in the evaluation of the 7-day AOT, a mean DG maintenance duration of 16 hours is used.

Several other utilities in the nuclear industry have ALCO DGs and a 7-day AOT. The mean DG maintenance duration for these utilities is in the range of nine to 12 hours, based on a total of almost 50 DG years of experience. Thus actual maintenance experience demonstrates that the value of 16 hours used in this analysis is conservative.

## 4.3 DCPRA ELECTRIC POWER SYSTEM MODEL

The electric power systems modeled in the DCPRA include:

the standby offsite power source,
the three Unit 1 125 V vital DC power trains,
the two Unit 1 non-vital 12 kV buses,
the three Unit 1 4.16 kV vital buses,
the three Unit 2 125 V vital DC and 4.16 kV AC power trains,
the five diesel generators,
the diesel fuel oil transfer system, and
the Unit 1 vital instrument AC.

Of these systems, the one of interest for this analysis is the DG system model. Information on the electric power system models may be found in Reference 14. The following sections describe how the existing DCPRA DG model was utilized and modified to evaluate the effects of changing the DG AOT from 72-hours to 7-days.

### 4.3.1 CALCULATION MODIFICATIONS

In order to evaluate effects of scheduled maintenance, changes in AOTs, and the relative risk, the DG failure probabilities are re-evaluated. Two sets of quantifications are required for each calculation: one for non-seismic events and one for seismic events. All non-seismic results are mean values based on Monte Carlo quantification while the seismic results are point estimates. An additional difference between the two is the mission time. For non-seismic events, the DCPRA mission time has been assumed to be six hours and for seismic events it is 24 hours. The six hour mission time is conservative because within six hours it is very likely that offsite power will be recovered. The larger 24 hour mission time is assumed for seismic events because of the increased degree of difficulty believed to be associated with recovering offsite power following a seismic event. However, it should be noted that in the reliability analyses, documented in Chapter 5, a DG mission time of four hours is used based on the DCPP station blackout (SBO) evaluation with a five DG configuration. The reliability analysis uses the mission time of two hours for six DGs as determined by preliminary SBO analysis, but does not address seismic initiators.

Appendix A presents the DG system equations used in the DCPRA. This section describes the modifications of the DCPRA equations for each of the calculations listed in Table 4-1. Reference 4 provides a detailed discussion of the development of these equations. Calculations were performed to provide intermediate results and to support the assessment of the three cases of interest. These three cases are: (1) the base case (Case 1), the existing plant configuration with a 72-hour AOT; (2) Case 2, the existing plant configuration with a 7-day AOT; and (3) Case 3, the planned six DG configuration with a 7-day AOT. These calculations are described below.

Calculation 1A

This calculation corresponds to the model from the DCPRA and no re-quantification is necessary. The non-seismic and seismic results from the PRA are reproduced here and presented in the first two columns of Table 4-3. The results are presented mainly for reference and for use in the relative risk calculation. It is important to

note that the DCPRA model does not include scheduled maintenance on the swing DG during power operation of either unit.

Calculation 1B

This calculation is similar to Calculation 1A and no changes other than data are required to evaluate this situation. The same equations are used; however, the unscheduled maintenance duration of the DG is revised to reflect a change in the AOT from 72 hours to seven days. The equations are requantified using the updated mean maintenance duration of 16 hours. These results are also used in Calculations 3 and 4 and in relative risk calculations. The DG failure probabilities for this calculation are shown in the third and fourth columns of Table 4-3.

Calculations 2 and 3

Calculation 2 considers the existing five DG plant configuration with a 72-hour AOT on all DGs. However, the analysis also addresses that once every 18 months, during the refueling outage of one unit, scheduled maintenance on the swing DG occurs with the other unit at power. The duration of the scheduled maintenance is 10 days, which corresponds to recent operational experience in which four outages of approximately three days each were used to perform scheduled maintenance on the swing DG. This calculation is representative of DCPP's current operating practices and is used as the base case or Case 1 for comparison purposes.

Calculation 3 is similar to Calculation 2 except that the DGs are subject to a 7-day AOT instead of 72-hours. Calculation 3 is used as Case 2 in the comparison with the base case. Scheduled maintenance on the swing DG is also performed; however, since the AOT is longer, all the maintenance can now be performed within the 7-day AOT instead of four 72-hour AOTs. The fact that the scheduled maintenance is performed in one outage results in greater maintenance efficiency and a shorter overall outage duration.

Both Calculations 2 and 3 require modifications, as discussed below, to the DG equations to evaluate the effects of performing scheduled maintenance on the swing DG once every 18 months while a unit is at power. In addition, for

Calculations 2 and 3, the results from Calculations 1A and 1B are also utilized in evaluating the plant risk.

The calculation of core damage for the period of time that the swing DG is unavailable as a result of scheduled maintenance is described in Section 4.4. Part of this core damage calculation requires the requantification of core damage sequences involving failure of the swing DG (i.e., Top Event GF). For these sequences, the failure probability for Top Event GF is set equal to 1.0. Subsequent DG failures (Top Events GG, GH, 2G and 2H) in these sequences are dependent on the failure of Top Event GF. The failure probabilities representing these failures must be replaced with the split fractions based on the swing DG being unavailable due to the maintenance event.

Only those DG split fractions that appear in the core damage sequences involving the failure of Top Event GF needed to be requantified. A list of these core damage sequences can be found in Appendix B. The DG split fractions in these sequences are replaced with split fractions that model the scheduled maintenance of the swing DG. These replacement split fractions are requantified to account for changes in the test and maintenance contributions to system unavailability. Specifically, the modeling of unscheduled maintenance, and DG operability tests given one diesel is out for maintenance were modified for the replacement split fractions. Table 4-2 lists the DG split fractions that appear in the core damage sequences involving the failure of the swing DG (Top Event GF). The new split fraction name is also listed along with the name of the DCPRA split fraction that was used as the basis for the new split fraction. For example, GG4 was quantified using the equations for GG3 with modifications to the test and maintenance contributions.

The modified equations for both non-seismic and seismic events are presented in Appendix A. More specifically, the unscheduled maintenance duration for a dedicated DG given the swing DG is inoperable is set equal to 8 hours. This is based on Technical Specification 3.8.1.1 Action Statement f, which requires operators to restore one of the two disabled DGs to an operable status within two hours or place the unit in Hot Standby within the next 6 hours. This eight hour duration replaces the distribution for DG maintenance duration.

The equation representing DG unavailability due to testing given one diesel is unavailable due to preventive maintenance has also been modified. It is set equal to zero since Technical Specifications do not require the other DGs to be tested if the cause of the DG outage is preventive maintenance.

The equations for variables TOT1, TOT2, TOT3 and TOT4, representing the total unavailability of 1, 2, 3, and 4 DGs, respectively, were modified as well. With one DG out for maintenance, the number of combinations of DG failures with other DGs in maintenance or testing are reduced. With the swing DG guaranteed unavailable due to maintenance, TOT1, TOT2, TOT3, and TOT4 now quantify the unavailability of 2, 3, 4, and 5 diesels, respectively. The variable TOT5 is not used for these calculations.

The DG split fraction results for quantifications of scheduled maintenance on the swing DG are summarized in Table 4-3, columns five and six. Again, the only difference between the non-seismic and seismic quantifications is the mission time which changes from 6 hours for non-seismic events to 24 hours for seismic events.

### Calculation 4

Calculation 4 considers the planned plant configuration with six DGs and a 7-day AOT, and utilizes the results of Calculation 1B. Calculation 4 is used as Case 3 in the comparison with the base case (Case 1). Scheduled maintenance required by Technical Specifications during power operation is no longer applicable since this maintenance can now be performed on all of a unit's DGs while that unit is shut down. The only changes required to evaluate this situation occur in the dominant sequence model, which is discussed in Section 4.4.

For the six DG configuration, no redistribution of loads between buses is modeled. This is appropriate because each unit currently has three 4.16 kV buses. Adding the sixth DG simply permits both Unit's 4.16 kV vital F buses (i.e., one for each unit) to be powered by their respective DGs during a LOOP event. For the present five DG configuration, during a LOOP event, only the F bus that is aligned to the swing DG is powered by onsite emergency power.

Calculation 5

Calculation 5 analyzes the situation in which no maintenance (scheduled or unscheduled) is allowed on any of the DGs. This corresponds to the standby period in which none of the DGs is out for maintenance. These results are used in the relative risk calculation.

To support the relative risk calculations (see Section 4.5.2), the DG system equations were quantified under the condition that no DG maintenance is allowed. The system equations used to quantify this case are the same as the DCPRA system equations with the following exceptions. The term representing system unavailability due to unscheduled maintenance has been set to zero and the contribution to unavailability due to diesel tests performed while one diesel is in maintenance is also set to zero. A summary of these split fraction results are provided in the last two columns of Table 4-3.

Calculation 6

Calculation 6 evaluates the risk if the swing DG were unavailable for the entire year. This is not a realistic situation; however, the value is required for the relative risk calculation.

The calculation is similar to Calculations 2 and 3, where the effects on system unavailability during scheduled maintenance are evaluated. The same equations are used for this calculation as a conservative simplification. This calculation is performed assuming a 7-day AOT. This results in an overstatement of the relative risk for the 72-hour AOT. This overstatement, however, is not significant.

## 4.4 CORE DAMAGE SEQUENCE MODELS

The DCPRA quantified 50 initiating event categories, including six seismic levels. The key contributors to the core damage frequency at DCPP are described in Chapter 6 of Reference 4. The same dominant sequence models are used here to evaluate the risk impacts of the various sensitivity cases.

### 4.4.1 DOMINANT SEQUENCE PRA MODEL

The dominant core damage sequences, other than those initiated by seismic events, have been summarized in Appendix B. Each key sequence is represented as the algebraic product of a single initiating event and the failure frequencies of failed systems under specific boundary conditions, or split fractions. These split fractions are defined and their numerical values are presented in Appendix B. Where appropriate, sequence specific recovery actions are also accounted for in this list of key sequences. Only the failed systems are included in the sequence representation. Normally the system success frequencies are very close to unity and can be conservatively omitted from the sequence frequency calculation. For sequences in which this is not the case, the system success frequencies have been included to avoid over-conservatism. For example, DG success frequencies are included. To account for the remaining, low frequency sequences that are not explicitly represented in the reduced sequence model, and to account for the system success terms which were omitted, a ratio has been applied to the total core damage frequency so that the reduced sequence model results match the detailed event tree quantification results of the DCPRA, which did account for each of these effects.

The dominant sequence model presented in Appendix B is used to evaluate the changes in the DCPP core damage frequency for each of the cases. Since the changes do not alter the intersystem dependencies reflected in the DCPRA event tree quantification, the reduced event sequence model presented in Appendix B is applicable to all of these cases. Therefore, it is not necessary to re-determine the key list of sequences from the complete DCPRA plant event tree models for each case.

Model for Scheduled Overhaul

Only the scheduled overhaul on the swing DG (performed once every 18 months) is considered to be performed with a reactor at power. The scheduled overhauls on the other two Unit 1 dedicated DGs are performed with Unit 1 shutdown. This situation introduces an asymmetry into the DG system model; whereas the DCPRA DG system model, which models the DGs of both units, assumed symmetry between the five DG trains.

Rather than revise the DCPRA DG system model to account for this asymmetry, an alternative approach is described as follows. The dominant sequence core damage model is divided into two parts, corresponding to periods of time in which the swing DG is or is not undergoing the scheduled 18 month overhaul.

For the period of time in which the swing DG is not undergoing the overhaul, the DCPRA system models apply without modification. For the period of time in which the swing DG is undergoing the scheduled overhaul, the DCPRA DG system model can be modified and then quantified separately. The modifications to the DG system models to reflect these changes were presented in Section 4.3.1. The changes made to the dominant sequence core damage model which reflect the two time periods are described below.

The modified dominant sequence model is constructed as the sum of two groups of sequences. The first group of sequences is the original dominant sequence model as presented in Appendix B, and is weighted by one minus the fraction of time that there is scheduled maintenance performed on the swing DG.

The second group of sequences are, conceptually, the same sequences as in the first group but with the DG system failure frequencies adjusted to reflect the swing DG being out for maintenance (i.e., maintenance on the other diesels is limited to eight hours pursuant to DCPP Technical Specification 3.8.1.1 Action Statement f). This second term is then weighted by the fraction of time the swing DG is in scheduled maintenance.

This conceptual sum of the core damage frequency results is simplified for computational convenience. This simplification is done because it is easier to compute the increase in core damage frequency (i.e., CDF2), for the time spent while in the swing DG 18 month overhaul and to add this frequency, weighted by the fraction of time spent performing the overhaul, to the core damage frequency when not in the 18 month overhaul (i.e., CDF1). The increase in the core damage frequency, while in the overhaul, is conservatively approximated by the frequency of the core damage sequences which increase due to the scheduled maintenance. The frequency of these sequences when not in the scheduled overhaul is not subtracted off and is, therefore, conservatively double counted. The approach followed in the current study is represented by the equation below:

$$T = (1-F)*CDF1 + F*CDF2 \simeq 1*CDF1 + F*CDF2$$

where:

T = the total core damage frequency which includes the impact of swing DG schedule maintenance every 18 months.

CDF1 = the core damage frequency computed from the dominant sequence model developed in the DCPRA, including the results from seismic and other external initiating events.

CDF2 = the increase in core damage frequency while in the swing DG 18 month scheduled overhaul but computed as the total frequency of all sequences which increase in frequency during the overhaul alignment, and

F = the fraction of time spent while at power in the swing DG 18 month overhaul.

The calculational approach to determining the core damage frequency of those sequences which change as a result of the scheduled 18 month overhaul of the swing DG is described in the next two sections.

### 4.4.2 NON-SEISMIC SEQUENCES

The dominant non-seismic initiating event sequences listed in Appendix B are reviewed to identify those which involve failure of the swing DG (i.e., Top event GF fails). For the period of time while in the scheduled outage, the failure fraction for Top Event GF is set to 1.0, since the swing DG is not available to either Unit during this time.

The failure fractions for the other two Unit 1 dedicated diesels in these same sequences are then reset (see Section 4.3.1) to account for the different boundary conditions imposed on them by the swing DG being unavailable. For example, instead of the failure fraction for top event GG with the boundary condition of top event GF failing independently, the failure fraction for top event GG with the

boundary condition of top event GF being guaranteed failed due to the overhaul is used.

The resulting non-seismic initiated sequences that are affected by the swing DG being out for the overhaul are indicated in Appendix B.

### 4.4.3 SEISMIC SEQUENCES

The seismic initiated sequences which contribute significantly to the total core damage frequency are not included in the list of important sequences found in the reduced sequence model in Appendix B. Seismic initiated sequences are treated separately because the frequency of individual sequences can not be represented without a complete specification of which systems succeed as well as which fail; i.e., the degree of conservatism introduced by assuming the systems which succeed have a success frequency of unity becomes excessive. However, the list of important seismic initiated sequences, even without the representation of which systems succeed, is an important tool for determining which sequences should be considered further in an integrated model of seismic and non-seismic caused system failures.

The top 200 point estimate core damage sequences initiated by seismic events are listed in Appendix C. The top 150 of these sequences were examined individually to determine which sequences should be modeled separately for this study. The remaining 50 were checked to insure that they were represented by the first 150 sequences. As part of the original DCPRA, a similar process was undertaken to determine which sequences needed to be modeled in the seismic uncertainty analysis.

For this study, the sequences are again reviewed to determine which sequence frequencies would change for the cases being considered. The sequences involving failure of one or more DGs are the only ones whose frequency may change appreciably; i.e., those involving failure of top events GF, GG, GH, 2G and 2H. The sequences identified as possibly changing are numbered sequences 3, 29, 39, 78, and 99 in Appendix C. These sequences are of interest because, although they are initiated by seismic events, they involve only non-seismic failures of the DGs. The DCPRA models seismic failures of the DGs as failing all five DGs. Consequently, the

scheduled overhaul on the swing DG has no impact on sequences involving seismic failure of the diesels. The scheduled overhaul only affects those sequences involving non-seismic failures of the diesels.

For seismic initiated core damage sequences, in which the system success fractions differ significantly from unity, care must be taken to not over-estimate the true contribution of each sequence to the total seismic core damage frequency.

The SEIS4 program (Ref. 15) is used to compute the increase in seismic core damage frequency while in the 18 month scheduled overhaul configuration for the swing DG. The list of affected sequences can be further grouped into two categories. Category 1 includes sequences in which the seismic event causes a LOOP, and then core damage results due to non-seismic failure of at least two Unit 1 diesels combined with other non-seismic failures. Category 2 involves sequences in which the seismic event results in a LOOP, and a failure of either the component cooling water or the auxiliary saltwater system. Loss of component cooling water or auxiliary saltwater may lead to a reactor coolant pump seal LOCA with failure of all high head injection pumps. The sequences in this category also involve non-seismic failures of the swing DG and the dedicated DG-12. The 4.16 kV buses supplied by these two diesels supply power to all three charging pumps. Therefore, these sequences involve an RCP seal LOCA with no power available to the charging pumps for their continued operation even if the operators supplied alternative cooling to the charging pumps via the fire service water system.

The SEIS4 model is used to compute the seismic failure frequency portion of each of these two sequence categories. SEIS4 combines the DCPRA hazard curves and fragilities for all seismic levels to compute the seismic frequency portion of each of these sequence categories; i.e., two quantities are computed. These terms (hereafter known as TERM1 for sequences 3, 29, 39, 78 and 99; and TERM2 for sequence 86) are then explicitly combined with the non-seismic system split fractions to arrive at the increase in core damage frequency caused by the scheduled 18 month overhaul. Appendix C lists these sequences.

The original SEIS4 input file is modified to compute the two terms described above for the time when the swing DG is in maintenance. To recompute the total seismic core damage frequency for the case which evaluates the 7-day AOT and the case

with no DG maintenance allowed, minor changes are made to reflect the particulars of each case. First, the computation of the total seismic core damage frequency is discussed.

To recompute the total seismic core damage frequency for each case, the frequencies of the systems which fail independently due to non-seismic or random failure causes following the seismic initiating event, must first be adjusted for the particular case in question. The failure causes are input as constants to the SEIS4 model since they are not dependent on the seismic level. These constants were computed for the original DCPRA assuming that the DGs are subject to an AOT of 72-hours. For the cases of interest here, these constants are recomputed using the DG system split fractions quantified for seismic events presented in Table 4-3. To represent the planned six diesel configuration, the swing DG is conservatively modeled as always being aligned to Unit 1. This is accomplished by setting the swing DG alignment event, SW, always to 0. This is conservative because no credit for emergency power on Unit 2's F bus is taken. Thus, with the system split fractions redefined to reflect each case, the constants representing the non-seismic failures are then computed for input to the SEIS4 program. SEIS4 then computes the total seismic core damage frequency for the cases when the swing DG is not in scheduled maintenance.

For the time when the swing DG is in maintenance, the same SEIS4 constants which account for non-seismic system failures must be adjusted for the particular case in order to compute TERM1 and TERM2. Since during the period of time in which the swing DG is in maintenance, no other DG outages are permitted, the system split fraction values from the scheduled maintenance seismic quantification are used, in combination with TERM1 and TERM2, to calculate the increase in the seismic core damage frequency.

In addition to modifying the input constants for SEIS4, the SEIS4 input is further modified to compute TERM1 and TERM2, (i.e., to compute the increase in seismic core damage frequency rather than the total seismic core damage frequency). These modifications simply assure that TERM1 and TERM2 represent only the increase in the seismic core damage frequency caused by being in the swing DG overhaul alignment. This is accomplished by computing the intersection of each of the two terms with the complement of all the other seismic initiated sequences

included in the original SEIS4 core damage frequency model. Use of the computed values for TERM1 and TERM2 then assures that there is no double counting of the seismic sequences.

## 4.5 QUANTIFICATION OF CORE DAMAGE FREQUENCY

The quantification of the impact on core damage frequency due to changes of the DG AOT is presented in this section. The results are presented first for the absolute risk which is based on the average annual core damage frequency and then for the relative risk ratio. For a definition of the calculations, refer to Table 4-1.

### 4.5.1 ABSOLUTE RISK RESULTS

The core damage frequency for each of the cases was evaluated using the results of the system split fraction quantification for both seismic and non-seismic events. For calculations in which there is no scheduled maintenance performed on the swing DG while the plant is at power (i.e., Calculations 1A and 1B), the DCPRA seismic model and non-seismic dominant sequence model were used. For the calculations where maintenance on the swing DG is considered (Calculations 2 and 3) the quantification process is slightly different; the revised split fractions for seismic and non-seismic events were used to calculate the increase in core damage frequency which was then added to the total core damage frequency evaluated with no scheduled maintenance allowed.

For Calculation 4, which represents a six DG configuration, the full DCPRA model was requantified with the change that the swing DG is always aligned to Unit 1 (this is representative of the addition of a sixth DG). This is a conservative modeling approach since no credit is given for Unit 2 having three DGs instead of two; this mostly affects the system analysis of the auxiliary salt water system. The revised non-seismic and seismic DG system quantifications were used.

Calculation 5 was also evaluated for use in the relative risk calculations. Calculation 5 represents the core damage frequency if no maintenance were performed on any of the DGs. This calculation is not an achievable level of plant risk as it is not possible to eliminate all DG outages. Again, the revised system quantifications for this case were used in the DCPRA core damage models.

Calculation 6 is also needed for the relative risk calculation. Calculation 6 represents the risk during the period the swing DG (or any other DG) is unavailable. The value is calculated in a similar manner as was done for Calculations 2 and 3 except that the value of F, the fraction of time in the maintenance alignment, is set equal to 1.0. Setting F to 1.0 is equivalent to a DG being unavailable for an entire year.

The results for each calculation are summarized in Table 4-4.

### 4.5.2 RELATIVE RISK RESULTS

The impact of changes to the DG AOT may also be presented in terms of a relative risk ratio. The relative risk ratio is defined differently for unscheduled and scheduled maintenance activities.

The relative risk ratio for unscheduled maintenance is computed by comparing the core damage frequency during the period when a DG is unavailable due to unscheduled maintenance, to the core damage frequency during the period when no DG is in maintenance. The period when no DG is in maintenance is termed the baseline period. This baseline period is determined from the DG maintenance frequency. On a per unit basis, the frequency of one of three DGs being out for maintenance is three times the individual DG maintenance frequency. The interval between DG maintenance outages is then the inverse of this value or, approximately 19 days.

The relative risk ratio for scheduled maintenance, which only applies to DG 1-3, is computed by comparing the core damage frequency during the period when DG 1-3 is in maintenance, to the core damage frequency during the interval (baseline period) between maintenance activities. For scheduled maintenance this interval is 18 months.

The relative risk for the cases of 72-hour and 7-day AOTs with five DG and 7-day AOTs with six DG configurations were each evaluated. The risk during a DG outage is the same for all four of these cases; it is calculated assuming that DG 1-3 is the DG which is unavailable (see discussion in Section 4.5.3). The core damage frequency under this criterion (Calculation 6) is 4.650E-4 per year. The core damage frequency

with no maintenance on any DG was evaluated as Calculation 5 and has the value of 2.042E-4 per year. This is based on a five DG configuration. A six DG configuration would actually yield a slightly lower value; however, the difference is very small and for simplicity, the six DG configuration is treated the same as the five DG case. For the 72-hour AOT the mean outage duration was found to be approximately 10 hours. For a 7-day AOT a mean outage duration of 16 hours is used. The relative risk for unscheduled maintenance is calculated as follows:

The risk during unscheduled DG maintenance is:

MOD * CDF13/8760

where :

MOD - Mean outage duration (10 hours for the 3-day AOT and 16 hours for the 7-day AOT),

CDF13 - Core damage frequency when DG 1-3 is in maintenance (4.650E-4 per year), and

8760 - The number of hours in a year.

The risk during the baseline period (i.e., period of 19 days with no DG maintenance) is:

BLN * CDFOM/8760

where :

BLN - Baseline period (average interval between DG outages) 19 days = 456 hours, and

CDFOM - Core damage frequency when there is no maintenance on any of the DGs (2.042E-4 per year).

The risk ratio is the ratio of the risk during unscheduled DG maintenance to the risk during the baseline period. The results of these calculations are presented in the first half of Table 4-5.

The risk ratio for scheduled maintenance is calculated in a similar manner; however, some of the parameters are changed. The numerator of the ratio (the risk during the scheduled maintenance) is calculated as follows:

SCHD * CDF13/8760

where :

SCHD - is the scheduled maintenance duration (10 days for 72-hour AOT, and 7 days for 7-day AOT), and

CDF13 - is the core damage frequency while the swing DG is in maintenance (4.650E-4 per year).

The denominator is the risk associated with the period between scheduled maintenance events, which is every 18 months:

BNL * CDF/8760

where :

BNL - is the period between scheduled maintenance events (18 months), and

CDF - is the core damage frequency; for cases with a 3-day AOT the value of 2.078E-4 is used (Calculation 1A) and for a 7-day AOT the value of 2.120E-4 is used (Calculation 1B).

The results of these calculations are presented in the second half of Table 4-5. The relative risk for scheduled maintenance for a six DG configuration is zero. This is because the addition of a sixth DG eliminates scheduled maintenance during operation; by definition then, the relative risk is zero.

### 4.5.3 SENSITIVITY TO SWING DIESEL IN MAINTENANCE

One assumption which was utilized in evaluating the relative risk was that the risk associated with maintenance of the swing DG is approximately the same as the risk associated with maintenance of the other two Unit 1 DGs. A study was performed to identify the contribution of each of the DGs to core damage frequency. The results indicated a 9 percent contribution for DG 1-3, 11% contribution for DG 1-2, and 12 percent contribution for DG 1-1.

From these results, it can be seen that within a few percentage points, each DG contributes approximately the same amount to plant risk. In relative risk calculations, it was assumed that DG 1-3 was the DG in maintenance. In actuality, there is a 33 percent chance that it is any one of the three diesels. By approximating the risk during the maintenance period as the risk associated with maintenance on DG 1-3, a minor non-conservatism was introduced. This non-conservatism, however, is not significant in light of the low values of the risk ratios.

## 4.6 INTERPRETATION OF RESULTS

Three of these calculations are representative of how DCPP is currently operated or planned to operate in the future. These are Calculations 2, 3, and 4, corresponding to Cases 1, 2, and 3, respectively. The other calculations were performed to support the relative risk measure analysis.

Case 1 addresses the current design and operational practices at DCPP, and is the base case against which comparisons are made. Case 1 represents a five DG configuration with a 72-hour AOT, and scheduled maintenance performed once every 18 months on the swing DG for a total duration of 10 days. The base case plant risk is 2.12E-4 per year.

Case 2 is representative of the current plant configuration as it would exist under a 7-day AOT. Under the 7-day AOT, greater maintenance efficiency is realized in performing the 18 month swing DG scheduled maintenance. Instead of a total maintenance duration of 10 days (as is necessary under the 72-hour AOT), the maintenance can be completed in one 7-day period. As a partial tradeoff, an

extension of the mean maintenance duration for unscheduled maintenance is expected. The plant risk under this configuration is 2.15E-4 per year.

The final case is Case 3, which is the six DG plant configuration under a 7-day DG AOT. Scheduled maintenance is no longer necessary while at power since each unit has three dedicated DG. The plant risk for this case is 2.02E-4 per year.

The absolute risk results presented above indicate that for the five DG configuration, changing from a 72-hour AOT to a 7-day AOT results in an insignificant change of approximately 1.4 percent increase in plant risk. In contrast, the addition of a sixth DG with a 7-day AOT shows a net reduction in plant risk of approximately 4.7 percent.

It is further emphasized that these results are conservative estimates since it is believed that in changing from a 72-hour AOT to a 7-day AOT, the mean DG maintenance duration will not change significantly due to PG&E's commitments to minimize DG unavailability. Had a less conservative value of the mean maintenance duration been used, the increase in risk for Case 2 would be less than 1.4 percent as calculated and the reduction in risk for Case 3 would be greater than the 4.7 percent calculated.

## TABLE 4-1
## DEFINITION OF CALCULATIONS

| Calculation | No. of DGs | Allowed Outage Time | Period of Scheduled Overhaul on Swing DG (with Unit 1 at power) |
|---|---|---|---|
| 1A | 5 | 3 Days | 0 Days |
| 1B | 5 | 7 Days | 0 Days |
| 2 | 5 | 3 Days | 10 Days |
| 3 | 5 | 7 Days | 7 Days |
| 4 | 6 | 7 Days | 0 Days |
| 5 | 5 | No Maintenance | 0 Days |
| 6* | 5 | 7 Days | 1 year |

* This calculation evaluates the risk if the swing DG were unavailable for the entire year under a 7-day AOT.

## TABLE 4-2
## DIESEL GENERATOR SPLIT FRACTION TRANSLATION TABLE FOR THE SCHEDULED MAINTENANCE QUANTIFICATION

| Split Fraction to be Replaced in the Core Damage Scenarios | New Split Fraction Name |  | Split Fraction Used as a Base for the New Split Fraction |
|---|---|---|---|
|  | Nonseismic | Seismic |  |
| GF1 | GFF | GFF | GFF |
| GG2 | GG4 | GG5 | GG3 |
| GH2 | GH7 | GHA | GH4 |
| GH3 | GH8 | GHB | GH5 |
| GH5 | GH9 | (NN) | GH6 |
| 2G3 | 2GC | 2GI | 2G6 |
| 2G6 | 2GE | (NN) | 2G8 |
| 2H3 | 2HI | (NN) | 2H7 |
| 2H4 | 2HJ | (NN) | 2H8 |

Note: NN = Not Needed

# TABLE 4-3
# DIESEL GENERATOR SPLIT FRACTION VALUES

| Split Fraction | Calc. 1A & 2 (DCPRA) 3 Day AOT for all Diesels | | Calcs. 1B & 3 & 4 7 Day AOT for all Diesels | | Calcs. 2, 3 & 6 Scheduled Maintenance on Diesel 13 | | Calc. 5 Zero Diesel Maintenance | |
|---|---|---|---|---|---|---|---|---|
| | Nonseismic | Seismic | Nonseismic | Seismic | S.F. Nonseismic | S.F. Seismic | Nonseismic | Seismic |
| GF1 | 4.523E-02 | 8.510E-02 | 4.946E-02 | 8.721E-02 | (1) | | 3.711E-02 | 7.561E-02 |
| GG1 | 4.477E-02 | 8.417E-02 | 4.909E-02 | 8.654E-02 | | | 3.687E-02 | 7.507E-02 |
| GG2 | 5.561E-02 | 9.502E-02 | 5.682E-02 | 9.428E-02 | GG4 4.344E-02 | GG5 8.114E-02 | 4.395E-02 | 8.226E-02 |
| GG3 | 4.523E-02 | 8.510E-02 | 4.946E-02 | 8.721E-02 | | | 3.711E-02 | 7.561E-02 |
| GH1 | 4.436E-02 | 8.334E-02 | 4.878E-02 | 8.595E-02 | | | 3.668E-02 | 7.462E-02 |
| GH2 | 5.408E-02 | 9.329E-02 | 5.545E-02 | 9.275E-02 | GH7 4.324E-02 | GHA 8.064E-02 | 4.202E-02 | 8.060E-02 |
| GH3 | 8.265E-02 | 1.115E-01 | 8.063E-02 | 1.090E-01 | GH8 4.784E-02 | GHB 8.685E-02 | 8.933E-02 | 1.008E-01 |
| GH4 | 4.477E-02 | 8.417E-02 | 4.909E-02 | 8.654E-02 | | | 3.687E-02 | 7.507E-02 |
| GH5 | 5.561E-02 | 9.502E-02 | 5.682E-02 | 9.428E-02 | GH9 4.344E-02 | | 4.395E-02 | 8.226E-02 |
| GH6 | 4.523E-02 | 8.510E-02 | 4.946E-02 | 8.721E-02 | | | 3.711E-02 | 7.561E-02 |
| 2G1 | 4.396E-02 | 8.251E-02 | 4.847E-02 | 8.537E-02 | | | 3.651E-02 | 7.419E-02 |
| 2G2 | 5.364E-02 | 9.244E-02 | 5.507E-02 | 9.205E-02 | | | 4.145E-02 | 7.990E-02 |
| 2G3 | 6.250E-02 | 1.016E-01 | 6.254E-02 | 9.964E-02 | 2GC 4.631E-02 | 2GI 8.531E-02 | 5.629E-02 | 8.852E-02 |
| 2G4 | 2.898E-01 | 1.903E-01 | 2.726E-01 | 1.851E-01 | | | 3.834E-01 | 2.100E-01 |
| 2G5 | 4.436E-02 | 8.334E-02 | 4.878E-02 | 8.595E-02 | | | 3.668E-02 | 7.462E-02 |
| 2G6 | 5.408E-02 | 9.329E-02 | 5.545E-02 | 9.275E-02 | 2GE 4.324E-02 | | 4.202E-02 | 8.060E-02 |
| 2G7 | 8.265E-02 | 1.115E-01 | 8.063E-02 | 1.090E-01 | | | 8.933E-02 | 1.008E-01 |
| 2G8 | 4.477E-02 | 8.417E-02 | 4.909E-02 | 8.654E-02 | | | 3.687E-02 | 7.507E-02 |
| 2G9 | 5.561E-02 | 9.502E-02 | 5.682E-02 | 9.428E-02 | | | 4.395E-02 | 8.226E-02 |
| 2GA | 4.523E-02 | 8.510E-02 | 4.946E-02 | 8.721E-02 | | | 3.711E-02 | 7.561E-02 |
| 2H1 | 4.356E-02 | 8.169E-02 | 4.817E-02 | 8.481E-02 | | | 3.636E-02 | 7.379E-02 |
| 2H2 | 5.320E-02 | 9.162E-02 | 5.470E-02 | 9.138E-02 | | | 4.090E-02 | 7.925E-02 |
| 2H3 | 6.206E-02 | 1.005E-01 | 6.205E-02 | 9.863E-02 | 2HI 4.585E-02 | | 5.589E-02 | 8.739E-02 |
| 2H4 | 6.922E-02 | 1.112E-01 | 6.996E-02 | 1.087E-01 | 2HJ 5.573E-02 | | 6.415E-02 | 1.002E-01 |
| 2H5 | 7.729E-01 | 5.269E-01 | 7.521E-01 | 5.214E-01 | | | 8.494E-01 | 6.230E-01 |
| 2H6 | 4.396E-02 | 8.251E-02 | 4.847E-02 | 8.537E-02 | | | 3.651E-02 | 7.419E-02 |
| 2H7 | 5.364E-02 | 9.244E-02 | 5.507E-02 | 9.205E-02 | | | 4.145E-02 | 7.990E-02 |
| 2H8 | 6.250E-02 | 1.016E-01 | 6.254E-02 | 9.964E-02 | | | 5.629E-02 | 8.852E-02 |
| 2H9 | 2.898E-01 | 1.903E-01 | 2.726E-01 | 1.851E-01 | | | 3.834E-01 | 2.100E-01 |
| 2HA | 4.436E-02 | 8.334E-02 | 4.878E-02 | 8.595E-02 | | | 3.668E-02 | 7.462E-02 |
| 2HB | 5.408E-02 | 9.329E-02 | 5.545E-02 | 9.275E-02 | | | 4.202E-02 | 8.060E-02 |
| 2HC | 8.265E-02 | 1.115E-01 | 8.063E-02 | 1.090E-01 | | | 8.933E-02 | 1.008E-01 |
| 2HD | 4.477E-02 | 8.417E-02 | 4.909E-02 | 8.654E-02 | | | 3.687E-02 | 7.507E-02 |
| 2HE | 5.561E-02 | 9.502E-02 | 5.682E-02 | 9.428E-02 | | | 4.395E-02 | 8.226E-02 |
| 2HG | 4.523E-02 | 8.510E-02 | 4.946E-02 | 8.721E-02 | | | 3.711E-02 | 7.561E-02 |

Note: (1) This quantification was used to evaluate core damage sequences that involved failure of the swing DG. The DG split fractions not listed for this case were not needed to quantify these sequences.

# TABLE 4-4
# ABSOLUTE FREQUENCY RESULTS

| Calculation | No. of DGs | Allowed Outage Time | Period of Scheduled Overhaul on Swing DG (with Unit 1 at power) | Frequency (per year) |
|---|---|---|---|---|
| 1A | 5 | 3 Day | 0 Days* | 2.078E-04 |
| 1B | 5 | 7 Day | 0 Days | 2.120E-04 |
| 2 | 5 | 3 Day | 10 Days | 2.124E-04 |
| 3 | 5 | 7 Day | 7 Days | 2.152E-04 |
| 4 | 6 | 7 Day | 0 Days | 2.017E-04 |
| 5 | 5 | No Maintenance | 0 Days | 2.042E-04 |
| 6 | 5 | 7 Day | 1 Yr. | 4.650E-04 |

* DCPRA Assumption; see Ref. 4 and 14

## TABLE 4-5

## RELATIVE RISK RESULTS

| Description | Risk Ratio | Comments |
|---|---|---|
| Impact of Allowed Outage Time | | |
| 3 Day AOT: | | |
| -5 DG configuration | 0.05* | Risk during AOT/risk during base period with no maintenance |
| 7-day AOT: | | |
| -5 DG configuration | 0.08* | Risk during AOT/risk during base period with no maintenance |
| -6 DG configuration | 0.08* | Risk during AOT/risk during base period with no maintenance |

---

| Description | Risk Ratio | Comments |
|---|---|---|
| Impact of Scheduled Outages | | |
| -5 DG configuration<br>(3 Day AOT)<br>+ 10 Days | 0.04 | Risk for scheduled outage/ risk for 18 months(72-hour AOT) |
| -5 DG configuration<br>(7 Day AOT)<br>+ 7 Days | 0.03 | Risk for scheduled outage/ risk for 18 months(7-day AOT) |
| -6 DG configuration<br>(7 Day AOT)<br>+ 7 Days | 0.00 | No scheduled outage/ risk for 18 months(7 Day AOT) |

* Based on mean maintenance duration.

## 5.0 RELIABILITY ANALYSIS

This section describes the reliability analysis, associated data, methodology, and results. The approach of this analysis follows that used by the NRC approved Brunswick AOT analysis, which is based on NUREG/CR-3082 (Ref. 3). For this reliability analysis, DCPP DG outage time data was collected and evaluated for the 72-hour AOT risk calculations. Palisades data was evaluated and utilized for the 7-day AOT risk calculations. The Palisades' plant data was chosen because the Palisades Technical Specifications provide a 7-day AOT. Additionally, the Palisades DGs were provided by the same manufacturer (ALCO) of the DCPP DGs.

The reliability analysis consists of three segments. The first segment calculates a DG hardware unavailability. This is accomplished by modeling the DG and its support systems in a fault tree and then quantifying the models. Section 5.1 discusses the details of the DG fault tree model.

The second segment of the reliability analysis generates fault trees to model DG system unavailability for the licensing design basis cases which are being evaluated, namely, the LOOP event and the LOCA in one unit with a LOOP event. These case models are quantified to generate cutsets which are then loaded into the FRANTIC-ABC computer code (Ref. 9), a PC version of FRANTIC-III. This code calculates an average and a maximum unavailability for each case model by employing time-dependent unavailability analysis. Section 5.2 discusses the case models in more detail. Section 5.3 discusses the FRANTIC-ABC analysis.

In the third segment, the relationship of risk associated with the AOT for both units is evaluated. The risk levels for the current 72-hour AOT and the proposed 7-day AOT are calculated using the relative risk and the average annual risk methods as described in NUREG/CR-3082. The risk methods are described in detail in Section 5.4.

### 5.1 DIESEL GENERATOR FAULT TREE

This section discusses the success criteria, mission time, and boundary conditions used to generate a "stand alone" fault tree model representative of a DG, its subsystems, and support systems. The fault tree models are presented as well as the quantification results.

### 5.1.1 SUCCESS CRITERIA

DG availability is challenged when a LOOP event occurs. During this event, the DGs must start and run to supply power to the vital 4.16 kV AC buses for a period of four hours. The mission time of four hours is based on the DCPP station blackout (SBO) evaluation (Ref. 13). In the case of the planned six DG configuration at the DCPP, preliminary analyses show the SBO mission time is reduced to two hours.

### 5.1.2 ASSUMPTIONS AND BOUNDARY CONDITIONS

The equipment boundaries for each DG includes the following:

- Diesel generator,
- DG output feeder breaker,
- Fuel oil day tank,
- Day tank LCVs,
- Undervoltage and transfer control relays,
- Initiation signal,
- Subsystems which support the diesel operation, and
- Support systems.

The subsystems which support DG operation include the lube oil system, the starting air system, the jacket water cooling system, the engine fuel oil system, the turbo-assist air system, and the crankcase exhauster fans. The DCPRA DG fault tree models have been expanded to include each of these subsystems. These systems are modeled in detail in order to fully understand the workings and possible ways to fail a DG.

There are two major support systems for the DGs: DC power and the diesel fuel oil transfer system. Support power for the controls of the DG is provided by vital 125 V DC trains. Each diesel is provided with a normal supply of DC power and a manually available standby source of DC power. The loss of both sources of DC power will result in the loss of the associated diesel.

The fuel oil transfer system maintains a supply of diesel fuel oil to each DG day tank. If the fuel transfer system is unavailable, it results in failure of all the DGs since the fuel transfer system is common to all DGs.

As previously stated, the DG fault tree presented in this reliability analysis is an expansion of the DCPRA fault tree model. As such, only the modeling criteria of the additional subsystems included in the fault tree model are discussed. The criteria, which are based on the system description in Chapter 3, are presented below together with any points which contrast with the DCPRA models.

1. Starting Air System: There are two independent and redundant starting air systems per diesel. These systems are referred to as Train A and Train B. The starting air system supplies air to the diesel engine as well as to the diesel day tank LCVs. The success criteria of the air supplies is as follows:

    a. Air Supply to the Diesel Engine: There are two air start motors per train. For DG operability, any one of the four motors must be operable.

    b. Air Supply to the Day Tank LCVs: There is one air supply line per LCV. For day tank operability, one of the supply lines must be operable, including the supply to the air-operated LCV located along the line.

2. Lube Oil System: If the lube oil filter plugs and its internal bypass mechanism fails, the lube oil system becomes inoperable. Excessive leakage of the lube oil heat exchanger will fail the DG. Additionally, due to the pressure differential between the lube oil and jacket water systems, if a leak occurs, the oil will leak into the jacket water system and fail that subsystem.

3. Jacket Water Cooling System:

    a. As there are no isolation valves in the heat exchanger lines, excessive leakage of either the lube oil heat exchanger or the aftercooler heat exchanger will fail the system.

    b. Excessive leakage of either radiator will fail the diesel due to high jacket water temperature. It is assumed that with excessive leakage of a

radiator, the expansion tank supply water would not be sufficient to replace the water lost through leakage.

c. Failures of the expansion tank were not modeled nor was orifice plugging.

4. Engine Fuel Oil System: If the oil filters plug, this system becomes inoperable, resulting in the loss of fuel oil to the diesel engine injectors. Additionally, there is a solenoid valve on the line from the priming tank. DG failure may result if this valve is not aligned properly, i.e., open for DG start, closed for DG run. These failure modes are considered in the modeling and are conservative because no credit is taken for a recirculation line back to the head tank.

5. There are two crankcase exhauster fans per diesel. If both fans are inoperable, the DG is considered to be inoperable. There are relief ports on the crank case that may relieve pressure buildup; however, these ports are not modeled.

6. Failure of the turbo-charger air assist system will result in the DG failing to meet the required 10 second start time, and is modeled as DG failure. While the turbo-charger is specified by Technical Specifications for DG operability, this failure is conservatively modeled since operational testing shows that the DGs will start without the turbo-charger.

7. Both the normal and the standby 125 V DC power supplies to the DG must fail in order for the respective DG to fail due to loss of starting power. This contrasts with the DCPRA which only takes credit for the normal power supply.

8. Test and maintenance activities for the diesels subsystems are not modeled in the fault trees; they are tested separately as part of the diesel test and maintenance activities, and are included as part of the FRANTIC-ABC analysis.

The assumptions used in this fault tree analysis include the following:

1. Swing DG 1-3 may be aligned to either Unit 1 or to Unit 2 in a LOOP situation, but not simultaneously. For ease in modeling it has been assumed that the swing DG will automatically align to Unit 2. If the swing DG is needed on Unit

1 and the dedicated Unit 2 DG(s) are capable of supplying the necessary power for Unit 2, the operator must take action to realign the swing DG to Unit 1. This modeling assumption is made in order to model automatic alignment to one unit while making sure it is not aligned to both units. This assumption is conservative as it introduces human errors.

2. The mission time for the DGs to run is four hours (two hours when the six DG configuration is considered). This time is based on the DCPP SBO evaluation and is consistent with performing a design basis analysis. Note that only non-seismic initiating events are being considered in the reliability analysis.

### 5.1.3 FAULT TREE DEVELOPMENT

The unavailability of a DG was calculated using fault tree techniques. A detailed "stand alone" model was developed to represent the DG configuration by including diesel subsystems and support systems. The DG fault trees were quantified twice, once for the mission time of four hours (current five diesel configuration), and once for the two hour mission time (planned six diesel configuration).

The three major contributors to DG hardware unavailability are listed below:

1. Unavailability of components due to random failures,
2. Unavailability of components due to human error, and
3. Common cause failures.

Component unavailability due to test or maintenance is not considered in the fault trees. Rather, it is accounted for in the time-dependent FRANTIC-ABC analysis. The major contributors are further discussed below.

1. Unavailability of Components due to Random Failures

   Hourly failure rates for the components modeled in the fault tree were obtained using plant specific data. These failure rates were then converted to failure probabilities using the following formula:

   $P_r$ = Failure Rate (hourly) * $T_M$,

where: $P_r$ = Random failure probability, and
$T_M$ = Total defined mission time (hours).

The demand failure probability is given directly by the data base such that:

$P_r$ = Failure Rate (demand) x 1 demand.

2. Unavailability of Components due to Human Error

There are four possible human errors considered in the DG fault trees. Each is described below.

a. It is assumed that if the swing DG is aligned to Unit 2 but is required for Unit 1 operation, an operator will switch the DG to supply power to Unit 1. If the operator fails to switch the DG, it is modeled as a procedural error and the action is assigned a nominal failure probability of 1.0E-03.

b. Following a DG test in which the operator changes the control switch from AUTO to MANUAL, there is a possibility the operators fail to reposition the switch back to AUTO. However, this event is considered to be highly unlikely because there are checklists in which the personnel must signoff that the switch was returned to AUTO. In addition, before the DG can be declared "operable" following the test, a tag which was placed on the switch at the beginning of the test, must be removed. Thus the personnel removing the tag must also acknowledge the switch is in AUTO. Note that of the 905 diesel tests considered in this reliability analysis, there were no occurrences of this error. Therefore, a low probability of 1.0E-04 is assigned for these human errors.

c. If an initiation signal should fail, the operator may manually try to start the diesel. The probability that the operator fails to manually actuate is considered to be small, thus a value of 1.0E-03 is assigned for this error.

d. There is a probability that during the monthly stroke test of the LCVs on the lines to the day tank, the operator fails to return the LCVs control

switch to AUTO. This is modeled as a procedural error and the probability of this event occurring is estimated to be 1.0E-03.

3. Common Cause Failures

Common cause failures are simultaneous failures of like components with identical functional requirements. Possible independent and dependent component failures were identified and accounted for in the common cause failure calculations. The Beta factor method was employed, which assumes that the total failure rate for each component can be expanded into independent and dependent failure contributions. The Beta factors were defined pursuant to EPRI NP-3967, "Classification and Analysis of Reactor Operating Experience Involving Dependent Failures" (Ref. 16), and were used in calculating the conditional probability of a common cause initiated failure of a component given that a similar component has failed. The total common cause failure contributions were calculated and accounted for in each fault tree.

The failure rate estimates used in calculating the component unavailabilities are based on DCPP plant specific data. The DG "Fail to Start" and "Fail to Run" failure rates are based on plant specific data from August 1985 through March 1989. Palisades PRA diesel failure data (Ref. 17) from January 1977 to December 1982 is considered for the 7-day AOT cases. The failure rate of the DG turbo-charger was calculated using data from NSAC-108, "The Reliability of Emergency Diesel Generators at U.S. Nuclear Power Plants" (Ref. 18). For component data not included in the DCPRA, the failure rates are taken from the IEEE Standard Reliability Data (Ref. 19). The data base developed for the reliability analysis is presented in Table 5-1.

Two fault trees were developed to model DG unavailability. The first tree models the ways a dedicated unit diesel may become unavailable during the mission time. DG 1-1 was chosen to represent the dedicated diesels. The second fault tree models the swing DG failures except those components which are unit specific (i.e., feeder breakers to AC buses and actuation signals).

The unit specific components mentioned above are modeled in two additional fault trees. The first one represents the unavailability of the swing DG to supply power to its Unit 2 bus. This encompasses the output feeder breaker to the Unit 2 4.16 kV AC bus, the Unit 2 relays (transfer control and undervoltage), and the DG initiation signal.

The other fault tree considers the case when the swing DG is aligned to Unit 2 but is needed to supply power for Unit 1. If the appropriate number of dedicated diesels are available for Unit 2 operation, then the operator must switch the swing DG to Unit 1.

The fault trees discussed above are presented in Appendix D as follows:

| Figure | Tree Name | Fault Tree Representation |
|---|---|---|
| D-1 | DG11 | DG 1-1 unavailable |
| D-2 | DG13 | Swing DG 1-3 unavailable |
| D-3 | DG13POW2 | Power from swing DG for a given unit unavailable or no initiation signal received |
| D-4 | SWITCH1 | Swing DG aligned to Unit 2, one DG in Unit 2 available, operator error to realign swing DG to Unit 1 |

### 5.1.4 QUANTIFICATION

Following initial quantification of the DG11 and DG13 trees, the resultant cutsets are screened to identify dependent failures (common cause). The fault trees are then requantified to include the common cause failure probability, resulting in DG hardware unavailability. The common cause contribution from DG13POW2 is included with the swing DG common cause contribution which is modeled in the DG13 fault tree model. There are no common cause failures associated with the SWITCH1 fault tree.

Table 5-2 lists the hardware unavailability for each of the fault tree models discussed. The dominant contributors to the dedicated DG unavailability are listed in Table 5-3.

Once these fault trees have been quantified, the calculations regarding the initiating events may be performed. The calculations are discussed in the next section.

## 5.2 CALCULATION MODELS

Once the DG unavailabilities have been calculated, the unavailability of the DG system may be evaluated. Of interest in this analysis is the availability of the system, with one of two conditions:

1. LOOP, and
2. LOOP coincident with a LOCA in one Unit.

Several fault tree models are developed to represent the above conditions during the AOT (when one DG is out of service) as well as for the condition in which all DGs are in standby (none out for maintenance or repair). The fault trees are quantified to generate cutsets and are then used as input into the FRANTIC-ABC computer code.

### 5.2.1 SUCCESS CRITERIA

Each DG supplies power to one 4.16 kV bus, which in turn supplies power to ESF equipment. In the event of a LOOP, one DG per unit must successfully start, load, and run.

In the second condition to be evaluated, a LOOP occurs along with a LOCA in one unit, which is assumed to be in Unit 1. This is the FSAR design basis for DCPP. Any two of the three DG buses are adequate to serve at least the minimum required ESF loads of the unit in which the LOCA occurred. Therefore, two of three DGs must successfully start, load, and run for the unit in which the LOCA has occurred.

### 5.2.2 CALCULATION MODEL CRITERIA

The top-level fault trees were developed with the following conditions:

1. For a LOOP event, one DG per unit is needed. For the unit in which a LOCA occurs, two DGs are required.

2. The fuel oil transfer system is required for DG operability.

3. The top-level fault tree models must consider in which unit the LOCA occurs. If the LOCA occurs in Unit 1, two of the three DGs which supply power to Unit 1 must be operable. These three diesels include the two dedicated Unit 1 DGs as well as the swing DG. This analysis assumes that the required number of dedicated diesels needed for Unit 2 are operable.

### 5.2.3 CALCULATIONS

A total of 8 top-level fault trees were developed to model the DG system unavailability given any of three situations. The current DCPP five DG configuration and the planned six DG configuration were analyzed. The calculations and the associated fault trees are listed in Table 5-4. The fault trees are presented in Appendix D.

There is a symmetry between the units with the addition of a sixth DG such that each unit now has three dedicated DGs. At this point there is no swing DG considered in the models.

The fault tree models are presented in Appendix D as follows.

Current five DG configuration:

| Figure | Tree Name | Fault Tree Representation |
|---|---|---|
| D-5 | CASE1-LP | LOOP in both units, all DGs in standby |
| D-6 | CASE1-1 | LOCA in Unit 1 with LOOP, all DGs in standby |
| D-7 | CASE2 | LOOP, swing DG out of service (limiting case) |
| D-8 | CASE3 | LOCA in Unit 1 with LOOP, one DG out of service |

Planned six DG configuration:

| Figure | Tree Name | Fault Tree Representation |
|---|---|---|
| D-9 | CASE4-LP | LOOP in both units, all DGs in standby |
| D-10 | CASE4-1 | LOCA in Unit 1 with LOOP, all DGs in standby |
| D-11 | CASE5 | LOOP, Unit 1 dedicated DG out of service |
| D-12 | CASE6 | LOCA in Unit 1 with LOOP, Unit 1 dedicated DG out of service |

## 5.3 ALLOWED OUTAGE TIME ANALYSIS

A time dependent unavailability analysis was performed on the fault tree models using the FRANTIC-ABC computer code (Ref. 9). FRANTIC-ABC (FRANTIC) is the PC version of the FRANTIC-III code which is discussed in References 20, 21, and 22. This code calculates the maximum and average time dependent unavailability of a system.

FRANTIC assumes the unavailability of a system is based on a Weibull probability density function. A brief discussion of the most relevant code inputs for this reliability analysis is provided in Table 5-5.

The LAMBDA (Weibull scale) parameter input to the FRANTIC code can be derived in several ways. NUREG-2989, "Reliability of Emergency AC Power Systems at Nuclear Power Plants," (Ref. 23) and "FRANTIC-III - A Computer Code for Time-Dependent Reliability Analysis (User's Manual)," (Ref. 21) discuss the method of estimating this parameter. For the reliability analysis, the failures of the DGs were assumed to be dominated by a time dependency. An estimate of LAMBDA was calculated to be equal to the number of DG failures ("Fail to Start" and "Fail to Run") divided by the time of observation over which the failures occurred.

The cutsets from the top level fault tree case models discussed in Section 5.2.3 were used as input to FRANTIC. Each element of the cutsets is defined as a component in the FRANTIC code. The DGs are represented individually in these cutsets as periodically tested components. Other "components" in the model represent the fuel oil transfer system (a support system) and common cause failures of the DGs. These have a constant unavailability.

Table 5-4 describes the various case models used with the FRANTIC code. Cases 1 and 4 assume all the DGs are in a standby mode and are capable of performing their intended function. These standby cases used a test interval (TEST2 parameter) of 31 days as required by Surveillance Requirement 4.8.1.1.2. The testing occurs on a staggered test basis (TEST1 parameter) pursuant to Reference 1. The start test requires one-half hour to complete (TAU parameter) representing the current situation at DCPP. This test duration is used for the 72-hour AOT as well as the 7-day AOT.

The other cases represent situations where one DG is out of service, placing the unit in the subject Action Statement. The unit(s) affected by the Action Statement are required to test the remaining DGs within 24 hours. It was assumed the first remaining DG is tested six hours after entry into the Action Statement. The other DGs are then tested in a sequential manner.

The 7-day AOT cases for the loss of one DG situation also assume the remaining DGs are tested sequentially starting six hours after entry into the Action Statement condition. Consistent with the current practice at DCPP, the operable DGs will be tested once within the first 24 hours during the 7-day AOT cases.

The unavailability values calculated with the FRANTIC code are presented in Table 5-6.

## 5.4 RELIABILITY ANALYSIS RESULTS

Generally, when a component is removed from service for repair or test for a period of time, there is a period of increased vulnerability concerning the fact that the affected system will not be available to mitigate an accident. This period of increased vulnerability exists until the component is restored to service (operable status). Of interest in this study is the relationship of risk to the AOT. Only by explicitly relating risk to AOT can outage times be constrained by placing limits on risk. The relative risk method and the average annual risk comparison method both relate the AOT to the risk, as discussed in NUREG/CR-3082 and presented in this section.

### 5.4.1 RELATIVE RISK METHOD

The relative risk method limits component (DG) outage time by constraining the risk during the DG outage to be no larger than the risk during a period in which no DG outage occurs. This method is consistent with that used in Chapter 4. The exposure time during the AOT outage is determined by the fraction of time a DG is inoperable while the plant is in Modes 1 through 4. This fraction is assigned a parameter value, $f_o$, in the analysis. Two sets of values were derived for this $f_o$ parameter: one for the 72-hour AOT, based on DCPP DG outage time records, and one for the 7-day AOT, based on Palisades data.

The DCPP DG outage time records were reviewed to determine when the DGs were declared inoperable due to testing, maintenance/repairs, and failures with either unit in Modes 1 through 4. The outage records were screened to remove biases for 1) any unusual situations which may considerably skew the data, such as the swing DG preplanned maintenance which was performed under a 10-day AOT exemption from Technical Specification 3.8.1.1 (Ref. 8); and 2) the additional time that had been required for maintenance work on the swing DG due to its more complex tag-out and maintenance processes compared to that of dedicated DGs.

A list of the outage times and dates was collected from the Palisades PRA (Ref. 17) and updated with additional Palisades data from EPRI report NSAC-108 (Ref. 18).

Based on the data, $f_o$ was determined for DCPP to be 0.0303 for the 72-hour AOT. The value of $f_o$ for the Palisades 7-day AOT was determined to be 0.0308. Table 5-7 summarizes the DG outage time data for both DCPP and Palisades.

The relative risk criterion, as defined in NUREG/CR-3082, is:

$$R_o \leq R_t$$

where:

$R_o$ = risk during DG outage duration, and
$R_t$ = risk during standby period, assuming no DG outage.

NUREG/CR-3082 states:

> If the risk due to a DG AOT during an LCO is less than the risk during a baseline (non-LCO) period, then the risk due to the AOT is considered acceptable."

Consistent with NUREG/CR-3082, the standby period of the relative risk criterion is defined to be that period during which all DGs are available in the normal standby condition; i.e., the standby period is defined by the fraction of time that the DGs are not inoperable and, therefore, is determined as $f_t = 1 - f_o$.

These risks are calculated for each condition analyzed but are distinguished from each other by initiating event. The analyses for two initiating event conditions (LOOP event, LOCA in one unit with a LOOP event) are described below.

LOOP Event:

The risk during the DG outage is the probability of the LOOP event occurring during the DG outage, multiplied by the probability the remaining DG systems fail during that time. The equation used to calculate risk during the DG outage is:

$$R_o = \lambda_1 f_o Q_o$$

where:

$\lambda_1$ = initiating event frequency for a LOOP event,
$f_o$ = fraction of time the DG was inoperable as defined above, and
$Q_o$ = system average unavailability with one DG out of service.

The risk during the standby period, or the time the DG is not in an outage, is calculated using the following formula:

$$R_t = \lambda_1 f_t Q_t$$

where:

$f_t$ = fraction of time the DG was operable ($1 - f_o$), i.e., the DG standby time fraction as defined above, and

$Q_t$ = system average unavailability over the period when all five DGs are in normal standby configuration.

The system average and maximum unavailabilities (Q) calculated using FRANTIC are provided in Table 5-6.

LOCA in One Unit with a LOOP Event:

For this event, the risk during the DG outage is the probability that the LOOP event occurs within 24 hours following a large break LOCA in one unit multiplied by the probability the DG system failed during the outage. The equation used to calculate this risk is:

$$R_o = \lambda_2 f_o Q_o$$

where:

$\lambda_2$ = frequency of a large break LOCA and LOOP event.

The risk during the standby period with a LOOP event and a large break LOCA is calculated as follows:

$$R_t = \lambda_2 f_t Q_t.$$

The initiating event frequencies (λ) used in the reliability analysis risk calculations are based on the DCPRA initiating event frequencies. The LOOP initiating event frequency is taken directly from the DCPRA, which is 9.10E-02/year. The LOCA with a LOOP event is calculated to be the frequency of a large break LOCA occurring (2.02E-04/year) multiplied by the frequency of a LOOP event and is calculated to be 5.04E-08/year.

### 5.4.2 AVERAGE ANNUAL RISK METHOD

The average annual risk considers the status of the DG system. Over a period of time, the status alternates between the periods of an AOT and the normal standby condition of the DG. Thus the average system unavailability is determined over a

cycle. The equations used to calculate the average annual risk for the two conditions analyzed are presented below.

For a LOOP event, the annual risk is calculated by

$$R_a = \lambda_1 (f_o Q_o + f_t Q_t).$$

For a large break LOCA in one unit with a LOOP event, the risk is calculated using

$$R_a = \lambda_2 (f_o Q_o + f_t Q_t).$$

The results of the relative and annual risk quantifications are presented below.

### 5.4.3 RISK RESULTS

As previously discussed, the reliability analysis considered two methods of calculating risk, the relative risk method and the annual risk method, for the impact of unplanned maintenance activities upon plant risk. These methods will now assist in the comparison of results for the AOT study. Table 5-8 presents the results of the relative risk analysis for three cases:

1. 72-hour AOT with the current five DG configuration,
2. 7-day AOT with the current five DG configuration, and
3. 7-day AOT with the planned six DG configuration.

The average and maximum risks for these cases are listed with the relative risk ratios in Table 5-8. The average annual risk results for the three cases are listed in Table 5-9.

The acceptance criterion, as defined in NUREG/CR-3082, for the relative risk ratio is required to be less than unity. In all cases of the reliability analysis, the results show the relative risk ratios more than satisfy the acceptance criteria, thus indicating the risk while in an LCO Action Statement (DG inoperable) is always much less than the risk while the DGs are all in the standby mode.

Comparing the relative risk values between the 72-hour AOT and the 7-day AOT cases, it can be seen that the risk during the 72-hour LCO Action Statement is much smaller than the risk during the standby period. As shown in Table 5-8, when the AOT is increased to seven days, the resulting ratio of risk during the AOT to the risk during the standby period remains much less than one. In fact, the relative risk ratios for the five DG configuration indicates the risk during the AOT is never more than 10 percent of the risk during the standby period. With the planned six DG configuration, the risk during a 7-day AOT is only 13 percent of the risk during the standby period. These values clearly show the risk associated with a 7-day AOT is acceptable.

Similar results are shown in Table 5-9 for the average annual risk values. Furthermore, with the addition of the sixth DG, the annual risk decreases by approximately 15 percent from the current risk levels. Such a decrease indicates that when the sixth DG is installed with a 7-day AOT, the risk levels during an AOT will be less than that for the five DG configuration with either a 72-hour AOT or a 7-day AOT

## 5.5 SENSITIVITY STUDY

A sensitivity study was performed to determine the effects of testing the remaining operable DGs every 72 hours during a 7-day AOT rather than just once within the first 24 hours while in the LCO Action Statement. A discussion of the effects of this additional testing is provided below.

The testing procedures at DCPP currently require each remaining operable DG to be start tested within 24 hours of the initiation of the AOT (when the inoperable DG is out for other than preventive maintenance or testing). As a sensitivity study, consideration was given to additional testing of the operable DGs during the 7-day AOT. Specifically, this sensitivity study modeled the operable DGs such that they were tested every 72 hours during the AOT. This additional testing was shown to slightly reduce the risk. However, the need to perform a fast start test on the remaining operable DGs every 72 hours during the 7-day AOT not only imposes additional work on the operating staff, but also contributes to further wear and stress of the DGs. Therefore, the additional testing is not considered beneficial.

## TABLE 5-1
## DIABLO CANYON DIESEL GENERATOR RELIABILITY DATA BASE

| # | COMP | FAILURE MODE | FAILRATE | UNIT | SOURCE |
|---|---|---|---|---|---|
| 1 | BU | BUS FAILS DURING OPERATION | 4.48E-07 | HR | PG&E |
| 2 | GN | GENERATOR FAILURE | 1.28E-08 | HR | IEEE |
| 3 | CB | DC CIRCUIT BREAKER TRANSFERS OPEN | 2.68E-07 | HR | PG&E |
| 4 | DG | DIESEL GENERATOR FAILS TO START (72-HOUR AOT) | 3.32E-03 | D | DCPP |
| 5 | DG | DIESEL GENERATOR FAILS TO RUN (72-HOUR AOT) | 2.29E-03 | HR | DCPP |
| 6 | HE | OPERATOR FAILS TO SWITCH DG TO AUTO AFTER TEST | 1.00E-04 | D | CALC |
| 7 | RE | RELAY FAILS TO OPERATE | 2.41E-04 | D | PG&E |
| 8 | SW | LEVEL SWITCH FAILS TO OPERATE | 2.69E-04 | D | PG&E |
| 9 | TK | TANK RUPTURES DURING OPERATION | 2.66E-08 | HR | PG&E |
| 10 | AV | AIR OPERATED VALVE FAILS TO OPERATE | 6.22E-04 | D | PG&E |
| 11 | AV | AIR OPERATED VALVE TRANSFERS OPEN/CLOSED | 2.29E-07 | HR | PG&E |
| 12 | CV | CHECK VALVE FAILS TO OPERATE | 1.70E-04 | D | PG&E |
| 13 | PV | PRESSURE CONTROL VALVE FAILS DURING OPERATION | 3.90E-06 | HR | PG&E |
| 14 | SV | SOLENOID VALVE FAILURE TO OPERATE | 2.43E-03 | D | PG&E |
| 15 | SV | SOLENOID VALVE TRANSFERS OPEN/CLOSED | 1.27E-06 | HR | PG&E |
| 16 | CB | CIRCUIT BREAKER (>480 V AC) FAILS TO CLOSE | 1.61E-03 | D | PG&E |
| 17 | CB | CIRCUIT BREAKER (>480 V AC) TRANSFERS OPEN | 8.28E-07 | HR | PG&E |
| 19 | CC | COMMON CAUSE FAILURE OF DIESEL GENERATOR | 7.40E-04 | D | CALC |
| 20 | DG | DIESEL GENERATOR AVAILABILITY (5 DGs) | 9.84E-01 | D | CALC |
| 21 | HE | OPERATOR ERROR | 1.00E-03 | D | CALC |
| 23 | HX | HEAT EXCHANGER PLUGGING/EXCESSIVE LEAKAGE | 1.54E-06 | HR | PG&E |
| 24 | SR | STRAINER PLUGS DURING OPERATION | 6.22E-06 | HR | PG&E |
| 25 | FL | FUEL OIL FILTER PLUGGED | 1.06E-06 | HR | PG&E |
| 26 | SW | PRESSURE SWITCH FAILS TO OPERATE | 2.69E-04 | D | PG&E |

## TABLE 5-1 (Continued)
## DIABLO CANYON DIESEL GENERATOR RELIABILITY DATA BASE

| # | COMP | FAILURE MODE | FAILRATE | UNIT | SOURCE |
|---|---|---|---|---|---|
| 27 | TB | TURBO-CHARGER FAILS TO OPERATE | 2.73E-04 | D | CALC |
| 29 | PM | JACKET WATER/LUBE OIL PUMPS FAIL | 1.81E-06 | HR | IEEE |
| 30 | MR | AIR START MOTORS FAIL | 3.20E-06 | HR | IEEE |
| 31 | FN | EXHAUST FANS FAIL TO OPERATE | 2.50E-06 | HR | IEEE |
| 32 | SI | INITIATION SIGNAL FAILS | 1.10E-03 | D | CALC |
| 33 | DG | DIESEL GENERATOR FAILS TO START (7 DAY AOT) | 6.37E-03 | D | PALS |
| 34 | DG | DIESEL GENERATOR FAILS TO RUN (7 DAY AOT) | 1.63E-03 | HR | PALS |
| 35 | DG | COMMON CAUSE FAILURE OF DG (6 DGs) | 7.37E-04 | D | CALC |

NOTES:

| | |
|---|---|
| CALC: | CALCULATED VALUE |
| DCPP: | DIABLO CANYON PLANT SPECIFIC DATA |
| IEEE: | IEEE-500 EQUIPMENT RELIABILITY DATA |
| PALS: | PALISADES DATA |
| PG&E: | DIABLO CANYON PRA DATA |

## TABLE 5-2
## FAULT TREE QUANTIFICATION RESULTS

### Unavailability for Current Diesel Configuration

| Tree Name | 72-Hour AOT | 7 Day AOT |
|---|---|---|
| DG11 | 1.98E-02 | 2.02E-02 |
| DG13 | 1.77E-02 | 1.81E-02 |
| DG13POW2 | 2.09E-03 | 2.09E-03 |
| SWITCH1 | 1.95E-03 | 1.95E-03 |

### Unavailability for Planned Six Diesel Configuration

| Tree Name | 7 Day AOT |
|---|---|
| DG11 | 1.62E-02 |
| DG13 | 1.62E-02* |
| DG13POW2 | N/A |
| SWITCH1 | N/A |

* The unavailability of DG 1-3 for the six DG configuration is the same as the unavailability of dedicated DG 1-1.

## TABLE 5-3
## DOMINANT CONTRIBUTORS TO DG 1-1 UNAVAILABILITY

| | | |
|---|---|---|
| 1. | 9.16E-03 | DG 11 FAILS TO RUN FOR 4 HOURS |
| 2. | 3.32E-03 | DG 11 FAILS TO START |
| 3. | 2.43E-03 | FUEL OIL SDV SV-713 FAILS TO CLOSE WHEN DG STARTS |
| 4. | 1.61E-03 | BREAKER CB 52-HH-7 FAILS TO CLOSE |
| 5. | 1.49E-03 | DG 11 COMMON CAUSE FAILURES |
| 6. | 4.72E-04 | FUEL OIL SDV SV-713 TRANSFERS CLOSED PRIOR TO DG START/TRANSFERS OPEN AFTER START |
| 7. | 2.73E-04 | TURBO-CHARGER FAILS |
| 8. | 2.41E-04 | UV RELAY 27-HH-B2 FAILS TO ACTUATE |
| 9. | 2.41E-04 | TRANSFER CONTROL RELAY 4HH FAILS TO ACTUATE |
| 10. | 1.70E-04 | FUEL OIL CHECK VALVE 1-999 FAILS TO OPERATE |
| 11. | 1.70E-04 | FUEL OIL CHECK VALVE 1-134 FAILS TO OPERATE |
| 12. | 1.00E-04 | OPERATOR FAILS TO RETURN DG SWITCH TO AUTO AFTER TEST |

DG1-1 UNAVAILABILITY = 1.98E-02

# TABLE 5-4
# RELIABILITY CASES ANALYZED

## CURRENT FIVE DIESEL CONFIGURATION

| | |
|---|---|
| Calculation 1: | All DGs in Standby |
| Calculation 1-LP | LOOP event in both units |
| Calculation 1-1 | LOCA in Unit 1 with a LOOP event |
| Calculation 2: | LOOP Event, AOT Condition (One DG Out of Service) |
| Calculation 3: | LOCA in Unit 1 with a LOOP event<br>AOT Condition (One DG Out of Service) |

## PLANNED SIX DIESEL CONFIGURATION

| | |
|---|---|
| Calculation 4: | All DGs in Standby |
| Calculation 4-LP | LOOP event in both units |
| Calculation 4-1 | LOCA in Unit 1 with a LOOP event |
| Calculation 5: | LOOP Event, AOT Condition (One DG Out of Service) |
| Calculation 6: | LOCA in Unit 1 with a LOOP event<br>AOT Condition (One DG Out of Service) |

# TABLE 5-5
# FRANTIC COMPONENT INPUTS

The inputs discussed here are all relevant for periodically tested components in the DG system model. The components other than the DGs are modeled such that only one input, QRESID, is required by FRANTIC.

| Input Name | Discussion |
|---|---|
| LAMBDA | The Weibull distribution scale parameter, estimated to be the number of DG failures per hours of observation (1.60E-04). |
| TEST2 | The periodic testing interval for each component (31 days). |
| TEST1 | The time when the first periodic test occurs. This parameter allows the model to include Staggered Test Basis testing of components as well as sequential and simultaneous testing sequences (Day 1, 2, 11, 12, 21, 22). |
| TAU | The average duration of the test period (0.5 hours for a DG start test). |
| QOVRD | The probability that the component cannot transfer from the testing state to the operating state (4.2E-05). |
| QRESID | A constant unavailability of the component equal to the fault tree calculated unavailabilities. |
| ITYPE | This parameter is used to model the state of the component after the test. For this study, all periodically tested components, i.e., the DGs, were assumed to be "as good as new" after a test. From the perspective of the FRANTIC code, the components were modeled such that their age is set to zero after the test. |

## TABLE 5-6
## FRANTIC DG SYSTEM UNAVAILABILITY RESULTS

### 72-HOUR CALCULATIONS:

| Calculation | Average Unavailability | Max Unavailability |
|---|---|---|
| 1-1 | 2.10E-02 | 3.80E-02 |
| 1-LP | 2.45E-03 | 3.27E-03 |
| 2 | 4.83E-03 | 5.37E-03 |
| 3 | 5.07E-02 | 6.17E-02 |

### 7 DAY CALCULATIONS:

| Calculation | Average Unavailability | Max Unavailability |
|---|---|---|
| 1-1 | 2.03E-02 | 3.83E-02 |
| 1-LP | 2.48E-03 | 3.31E-03 |
| 2 | 5.99E-03 | 7.68E-03 |
| 3 | 6.61E-02 | 9.18E-02 |
| 4-1 | 1.34E-02 | 2.49E-02 |
| 4-LP | 2.16E-03 | 2.87E-03 |
| 5 | 3.24E-03 | 4.06E-03 |
| 6 | 5.66E-02 | 8.18E-02 |

## TABLE 5-7
## DIESEL GENERATOR OUTAGE TIMES

### DCPP

| | DG 1-1 | DG 1-2 | DG 1-3 | DG 2-1 | DG 2-2 | For Both Units |
|---|---|---|---|---|---|---|
| Total outage hours | 259 | 157 | 388 | 358 | 269 | 1431 |
| Outage hours/ hours plant at power | 0.0108 | 0.0066 | 0.0164 | 0.0154 | 0.0116 | 0.0303 |

Total number of DG outages 123

| | Unit 1 | Unit 2 | Total |
|---|---|---|---|
| Total hours plant at power | 23978 | 23309 | 47287 |

### PALISADES

| | DG 1-1 | DG 1-2 | For both DGs |
|---|---|---|---|
| Total outage hours | 557 | 460 | 1017 |
| Outage hours/ hours plant at power | 0.0169 | 0.0139 | 0.0308 |

Total number of DG outages: 88

Total hours plant at power: 32991

## TABLE 5-8
## RELATIVE RISK ANALYSIS RESULTS

| | Average/ Maximum Risk | Ratio | Standby Risk |
|---|---|---|---|
| **72-Hour AOT - 5 DGs** | | | |
| LOOP | 1.33E-05/<br>1.48E-05 | 0.06 | 2.16E-04 |
| LOOP/LOCA | 7.74E-11/<br>9.41E-11 | 0.08 | 1.03E-09 |
| **7-Day AOT - 5 DGs** | | | |
| LOOP | 1.68E-05/<br>2.15E-05 | 0.08 | 2.19E-04 |
| LOOP/LOCA | 1.03E-10/<br>1.42E-10 | 0.10 | 9.93E-10 |
| **7-Day AOT - 6 DGs** | | | |
| LOOP | 9.09E-06/<br>1.14E-05 | 0.05 | 1.91E-04 |
| LOOP/LOCA | 8.78E-11/<br>1.27E-10 | 0.13 | 6.55E-10 |

## TABLE 5-9
## AVERAGE ANNUAL RISK RESULTS

| | Annual Risk |
|---|---|
| 72-Hour AOT - 5 DGs | |
| LOOP | 2.29E-04 |
| LOOP/LOCA | 1.10E-09 |
| 7-Day AOT - 5 DGs | |
| LOOP | 2.35E-04 |
| LOOP/LOCA | 1.10E-09 |
| 7-Day AOT - 6 DGs | |
| LOOP | 2.00E-04 |
| LOOP/LOCA | 7.43E-10 |

## 6.0 SUMMARY OF RESULTS

This section discusses the overall results of the AOT determination studies, based on the two approaches of probabilistic risk analysis and the reliability analysis.

Table 6-1 presents the numerical values of the results for the cases analyzed, for both the PRA approach and the reliability analysis approach. The table presents the results for each of the three cases. The PRA analysis provides the risk frequencies for the combined effect of unplanned and planned maintenance activities. The duration to perform technical specification required preventive maintenance is shown for the five DG configuration. These results combine the benefits and impacts of the change from a 3-day to a 7-day AOT period and the elimination of planned maintenance when a unit is at power. The reliability analysis provides results expressed as frequencies of DG unavailability in combination with LOOP or LOOP/LOCA initiators. For both the PRA and reliability analysis, the risk frequencies and relative ratios are shown for the unplanned maintenance activities; the unplanned maintenance results do not account for the benefits of eliminating DG maintenance while at power.

Several observations can be made from these results.

1. The frequencies for all cases are acceptably low (in the E-4 range).
2. The relative risk ratio criterion is satisfied for all cases by both methods of analysis.
3. The effect of changing from a 72-hour to a 7-day AOT is insignificant, on the order of 1 percent to 3 percent.
4. The effect of adding the sixth DG is greater than the effect of changing to a 7-day AOT, with a decrease on the order of 5 percent to 15 percent.
5. The two analyses provide results which are consistent. The trends of the results for the three cases are comparable between the PRA and reliability analyses. Further, the magnitude of the frequency results are comparable between the two different quantitative approaches.

Overall, the risk and reliability analyses show low levels of risk with the multiple 72-hour AOTs for the five DG configuration, and the risk levels do not change significantly when the AOT is changed to seven days. The slight increase in risk in changing to a 7-day AOT may be generally attributed to the longer period of time the DGs are unavailable in the AOT condition due to an assumed longer maintenance duration (see Section 4.2). However, the increase is insignificant when compared to the overall uncertainty in plant risk, as determined in the DCPRA. Furthermore, it is no longer necessary to use multiple DG outages as in the 72-hour AOT situation, and the risk levels remained low with the 7-day AOT because effective maintenance practices will continue to minimize the time needed to perform DG maintenance regardless of the AOT period.

More specifically, without a 7-day AOT, Technical Specification Surveillance Requirement 4.8.1.1.2b for the Unit 1 third and fourth refueling outages would have to be scheduled to be performed in several 72-hour periods in accordance with the present Technical Specification 3.8.1.1 AOT. However, it would be more efficient to perform the surveillances in one 7-day period. Performing the surveillances in one 7-day period would result in DG 1-3 total out-of-service time being less than if they were performed in several 72-hour periods. Likewise, performing the maintenance in several 72-hour periods requires more DG testing than if the maintenance were performed in one 7-day period. This additional testing is necessary because the DG must be tested and subsequently declared operable at the end of each 72-hour period. In addition, performing all maintenance activities in a single 7-day AOT should minimize the possibility for turnover and other related operator errors. Further, with an increase in the AOT, maintenance personnel would be given more flexibility to perform their repairs and would in turn increase the thoroughness and quality of the maintenance process.

Moreover, the risk and reliability analyses show that the risk levels during the AOTs are significantly less than the plant risk during the time the plant is normally operating with the DGs in a standby condition for the five DG configuration. Risks in the AOT are small because effective maintenance practices minimize the time the DG is actually unavailable, thus making the period of DG unavailability short compared to the DG standby period.

Finally, the analyses show that the risk levels decrease when the sixth DG is installed. This decrease in risk is attributable to the elimination of the swing DG configuration, along with the inclusion of a third dedicated DG to each unit; thus assuring that each unit has a full complement of emergency onsite supply. Further, scheduled maintenance activities do not have to be performed with a unit at power.

In summary, the reliability analysis approach focuses on the situation where a DG is out of service due to reasons other than scheduled or preventive maintenance. The analysis demonstrated that the risk levels are essentially unchanged when the AOT is changed from 72 hours to seven days, and remain much less than the risk levels from normal plant operation when the DGs are in the standby condition. This result is due to increased availability of the remaining DGs, which are demonstrated by the testing of these remaining DGs in the first 24 hours after a DG is declared inoperable.

These risk variations are confirmed by the PRA analysis; the risk values resulting from the PRA for the 7-day AOT show a small change from that of the 72-hour AOT. The PRA approach, however, includes consideration of both scheduled/preventive maintenance as well as unplanned maintenance. In particular, the PRA demonstrated that a planned DG outage, utilizing several 72-hour AOT periods for a maintenance activity, and a planned or unplanned DG outage with a 7-day AOT result in a decrease in the risk level for the 7-day AOT. Furthermore, the risk levels following installation of the sixth DG are less than those for the five DG configuration, as shown by both the reliability analyses and the PRA, for both the unplanned maintenance situation and for scheduled/preventive maintenance.

# TABLE 6-1

## ANALYTICAL RESULTS(1) FOR UNPLANNED AND PLANNED MAINTENANCE ACTIVITIES

| | PRA Analysis | | | Reliability Analysis (Unplanned) | |
|---|---|---|---|---|---|
| | Unplanned & Planned(2) | Unplanned | | | |
| | Frequency | Frequency | Relative Ratio(3) | Frequency | Relative Ratio(3) |
| **BASE CASE** | | | | | |
| 3-Day AOT/5 DGs (10 day Outage)(2) | 2.12E-04 | 2.08E-04 | 0.05 | LOOP 2.29E-04<br>LOCA/ LOOP 1.10E-09 | 0.06<br>0.08 |
| **CASE 2** | | | | | |
| 7-Day AOT/5 DGs (7 day Outage)(2) | 2.15E-04 | 2.12E-04 | 0.08 | LOOP 2.35E-04<br>LOCA/ LOOP 1.10E-09 | 0.08<br>0.10 |
| **CASE 3** | | | | | |
| 7-Day AOT/6 DGs (0 day)(2) | 2.02E-04 | 2.02E-04 | 0.08 | LOOP 2.00E-04<br>LOCA/ LOOP 7.43E-10 | 0.05<br>0.13 |

(1) PRA reflects frequency for Unit 1 only, whereas reliability considers frequency for both units
(2) Duration of outage for planned maintenance.
(3) AOT Risk Level/Non-AOT Risk Level

## 7.0 CONCLUSIONS

PG&E has previously implemented activities to improve DG reliability at DCPP. As part of these activities, PG&E is planning to install a sixth DG and has committed significant resources to this effort. Further, PG&E has performed this study to determine an appropriate AOT for DCPP. This study focused on the assessment of two issues: (1) the appropriateness of a 7-day AOT for the purposes of unplanned maintenance for the current five DG and future six DG configurations and (2) the impact of a 7-day AOT for preplanned Technical Specification required maintenance activities.

Two different probabilistic calculation methods were used, both of which have been previously reviewed and accepted by the NRC. PG&E's plant specific DCPRA, which is currently under review by the NRC Staff, was used to find time-averaged risks involved with both planned and unplanned maintenance. A DCPP specific reliability analysis was also performed to assess the time-dependent risk involved in an AOT for unplanned maintenance, which require testing of the remaining DGs. PG&E believes that conservatisms are present in both these analyses which provide margins to further support the validity of the qualitative conclusions.

Both methodologies were used to analyze three different cases: the base case addresses the current situation of five DGs with a 72-hour AOT; the second case addresses a similar situation but with a 7-day AOT; and the third case addresses six DGs with a 7-day AOT.

Using a relative risk criterion developed by Brookhaven National Laboratory (Ref. 3) that was previously reviewed and accepted by the NRC (Ref. 2), both of these methods confirm the acceptability of a 7-day AOT for the purposes of performing unplanned maintenance for both the five and six DG configurations. In particular, the relative risk ratios for all cases were determined to be significantly less than one; that is, the risk level during the DG AOT was found to be significantly less than the risk level during the non-AOT period when all DGs are in a normal standby condition while the plant is in Modes 1 through 4.

Furthermore, the risk-based PRA evaluation also demonstrated that there is an insignificant change in risk associated with a 7-day AOT over a 72-hour AOT and that there are slight qualitative and quantitative benefits in performing Technical Specification required maintenance with a 7-day AOT. The risk-based PRA and the reliability analyses also determined that addition of the sixth diesel will have a positive benefit by reducing risk over the life of the plant. In summary, quantitative and qualitative analyses confirm that the 7-day AOT, along with addition of the sixth diesel in the fourth refueling outage of Unit 2, will improve overall DG system reliability and will provide both short term and long term benefits to the safe operation of the plant.

## 8.0 REFERENCES

1. Diablo Canyon Power Plant Technical Specifications, Appendix A to Facility Operating Licenses Numbers DPR-80 and DPR-02.

2. Sylvester, E.D., Issuance of Amendments Nos. 104 and 134 to Facility Operating Nos. DPR-71 and DPR-62 for the Brunswick Steam Electric Plants, Units 1 and 2, March 27, 1989.

3. Lofgren, E.V. and F. Varcolik, "Probabilistic Approaches to LCO's and Surveillance Requirements For Standby Safety Systems", November,1982, NUREG/CR-3082,(BNL-NUREG-51628).

4. Pacific Gas and Electric Company, "Documentation of Long-term Seismic Program Probabilistic Risk Assessment," DCL-88-260, October 28, 1988.

5. Carolina Power and Light Company, "Brunswick Steam Electric Plant, Unit Nos. 1 and 2, Docket Nos. 50-325 & 50-324/License Nos. DPR-71 and DPR-62, Request for License Amendment, Diesel Generator Operability, Enclosure to NLS-85-516, Proposed Technical Specification Pages," 85TSB01, June 28, 1985.

6. "Proposed Staff Actions to Improve and Maintain Diesel Generator Reliability," Generic Letter 84-15, and Regulatory Guide 1.108, Rev. 1, August, 1977.

7. PG&E License Amendment Request 85-12, DCL-85-329, October 25, 1985.

8. PG&E License Amendment Request 85-15, DCL-85-375, December 26, 1985.

9. Ginzburg, T., Jacquez, G. M. and Vesely, W. E., "FRANTIC ABC User's Manual - Time Dependent Reliability Analysis," Applied Biomathematics, Inc., 100 North Country Road, Setauket, N.Y., 11733, December 1988.

10. DCPP System Description - Electrical Systems, Revision 1, 1987.

11. PG&E, "Units 1 and 2 Diablo Canyon Power Plant Final Safety Analysis Report Update," Docket No. 50-275 and 50-323.

12. PG&E, Diablo Canyon Units 1 and 2, "Station Blackout," April 17, 1989.

13. Memorandum from Nuclear Engineering and Construction Services to Nuclear Regulatory Affairs, Dated March 27, 1989, re: 10 CFR 50.63, Station Blackout Engineering Evaluation.

14. PG&E, "Final Report of the Diablo Canyon Longterm Seismic Program", Jully,1988; Docket Nos 50-275 And 50-323.

15. Lin, J.C. and Stan Kaplan, "SEIS4 (Seismic Risk Assessment) Computer Code User's Manual", December, 1985, PLG-0287.

16. EPRI NP-3967, "Classification and Analysis of Reactor Operating Experience Involving Dependent Failures," Pickard, Lowe and Garrick, Fleming, K.N, et al., Sponsored by Electric Power Research Institute, June 1985.

17. Consumers Power Company, "Palisades Plant - Evaluation of Palisades - MSLB Single-Failure Backfits," Appendix 4, Docket No. 50-255, August 21, 1984.

18. "The Reliability of Emergency Diesel Generators at U.S. Nuclear Power Plants," EPRI Report NSAC 108, September, 1986.

19. "I.E.E.E. Guide to the Collection and Presentation of Electrical, Electronic, Sensing Component, and Mechanical Equipment Reliability Data for Nuclear-Power Generating Stations," IEEE Std 500-1984, Institute of Electrical and Electronics Engineers, Inc., 1983.

20. Ginzburg, T. and Powers, J. T., "FRANTIC III - A Computer Code for Time-Dependent Reliability Analysis (Methodology Manual)," Brookhaven National Laboratory, Upton, Long Island, New York, 11973, April 1, 1984.

21. Ginzburg, T. and Powers, J. T., "FRANTIC III - A computer code for Time-Dependent Reliability Analysis (User's Manual)," Brookhaven National Laboratory, Upton, Long Island, New York, 11973, August 20, 1986.

22. FRANTIC, "A Computer Code for Time Dependent Unavailability Analysis," NUREG-0193, March, 1977.

23. NUREG-2989, "Reliability of Emergency AC Power Systems at Nuclear Power Plants".

**APPENDIX A:** DIESEL GENERATOR EQUATIONS
**Figure A-1:** Base System Equations From the DCPRA
**Reference:** PGE.1123.2 RISKMAN3.PHASE3 SEISPH3B EPDGS.EQS

| | | | |
|---|---|---|---|
| GF1 | 1 GF1 | = P[1] | CSF for GF given: All support available. |
| GF1 | 2 TOTAL | = HW + TS + MN | Total for P[1]. |
| GF1 | 3 HW | = HWI + HWD | |
| GF1 | 4 HWI | = HWI1 | |
| GF1 | 5 HWD | = HWD1 | |
| GF1 | 6 TS | = TS1 + TS5 | |
| GF1 | 7 MN | = MN1 | |
| GF1 | 8 SEIS | = SEIST | |
| GG1 | 1 GG1 | = (P[1]-P[2])/(1-P[1]) | CSF for GG given: GF-S |
| GG1 | 2 TOTAL | = HWI1 + HWD1 + TS1 + MN1 + TS5 | Total for P[1]. See GF1 for breakdown of P[1]. |
| GG2 | 1 GG2 | = P[2]/P[1] | CSF for GG given: GF-F |
| GG2 | 2 TOTAL | = HW + TS + MN | Total for P[2]. |
| GG2 | 3 HW | = HWI + HWD | |
| GG2 | 4 HWI | = HWI2 | |
| GG2 | 5 HWD | = HWD2 | |
| GG2 | 6 TS | = 2*TS1*HW1 + TS5 | |
| GG2 | 7 MN | = 2*MN1*HW1 + 2*TIM | |
| GG2 | 8 SEIS | = SEIST | |
| GG3 | 1 GG3 | = P[1] | CSF for GG given: GF-B |
| GG3 | 2 TOTAL | = HWI1 + HWD1 + TS1 + MN1 + TS5 | Total for P[1]. See GF1 for breakdown of P[1]. |
| GH1 | 1 GH1 | = (P[1]-2*P[2]+P[3])/(1-2*P[1]+P[2]) | CSF for GH given: GF-S, GG-S |
| GH1 | 2 TOTAL | = HWI1 + HWD1 + TS1 + MN1 +TS5 | Total for P[1]. See GF1 for breakdown of P[1]. |
| GH2 | 1 GH2 | = (P[2]-P[3])/(P[1]-P[2]) | CSF for GH given: GF-S/F, GG-F/S |
| GH2 | 2 TOTAL | = HWI2 + HWD2 + 2*TS1*HW1 + 2*MN1*HW1 + 2*TIM + TS5 | Total for P[2]. See GG2 for breakdown of P[2]. |
| GH3 | 1 GH3 | = P[3]/P[2] | CSF for GH given: GF-F, GG-F |
| GH3 | 2 TOTAL | = HW + TS + MN | Total for P[3]. |
| GH3 | 3 HW | = HWI + HWD | |
| GH3 | 4 HWI | = HWI3 | |
| GH3 | 5 HWD | = HWD3 | |
| GH3 | 6 TS | = 3*TS1*HW2 + TS5 | |
| GH3 | 7 MN | = 3*MN1*HW2 + 6*TIM*HW1 | |
| GH3 | 8 SEIS | = SEIST | |
| GH4 | 1 GH4 | = (P[1]-P[2])/(1-P[1]) | CSF for GH given: GF-S/B, GG-B/S |
| GH4 | 2 TOTAL | = HWI1 + HWD1 + TS1 + MN1 + TS5 | Total for P[1]. See GF1 for breakdown of P[1]. |
| GH5 | 1 GH5 | = P[2]/P[1] | CSF for GH given: GF-F/B, GG-B/F |

| | | | |
|---|---|---|---|
| GH5 | 2 TOTAL | = HWI2 + HWD2 + 2*TS1*HW1 + 2*MN1*HW1 + 2*TIM + TS5 | Total for P[2]. See GG2 for breakdown of P[2]. |
| GH6 | 1 GH6 | = P[1] | CSF for GH given: GF-B, GG-B |
| GH6 | 2 TOTAL | = HWI1 + HWD1 + TS1 + MN1 + TS5 | Total for P[1]. See GF1 for breakdown of P[1]. |
| 2G1 | 1 2G1 | = (P[1]-3*P[2] + 3*P[3]-P[4])/(1-3*P[1] + 3*P[2]-P[3]) | CSF for 2G given: GF-S; GG-S, GH-S |
| 2G1 | 2 TOTAL | = HWI1 + HWD1 + TS1 + MN1 + TS5 | Total for P[1]. See GF1 for breakdown of P[1]. |
| 2G2 | 1 2G2 | = (P[2]-2*P[3] + P[4])/(P[1]-2*P[2] + P[3]) | CSF for 2G given: GF-S/S/F,GG-S/F/S,GH-F/S/S |
| 2G2 | 2 TOTAL | = HWI2 + HWD2 + 2*TS1*HW1 + 2*MN1*HW1 + 2*TIM + TS5 | Total for P[2]. See GG2 for breakdown of P[2]. |
| 2G3 | 1 2G3 | = (P[3]-P[4])/(P[2]-P[3]) | CSF for 2G given: GF-S/F/F,GG-F/F/S,GH-F/S/F |
| 2G3 | 2 TOTAL | = HWI3 + X2G32 | Total for P[3]. See GH3 for breakdown of P[3]. |
| 2G3 | 2 X2G32 | = HWD3 + 3*TS1*HW2 + 3*MN1*HW2 + 6*TIM*HW1 + TS5 | |
| 2G4 | 1 2G4 | = P[4]/P[3] | CSF for 2G given: GF-F,GG-F,GH-F |
| 2G4 | 2 TOTAL | = HW + TS + MN | Total for P[4]. |
| 2G4 | 3 HW | = HWI + HWD | |
| 2G4 | 4 HWI | = HWI4 | |
| 2G4 | 5 HWD | = HWD4 | |
| 2G4 | 6 TS | = 4*TS1*HW3 + TS5 | |
| 2G4 | 7 MN | = 4*MN1*HW3 + 12*TIM*HW2 | |
| 2G4 | 8 SEIS | = SEIST | |
| 2G5 | 1 2G5 | = (P[1]-2*P[2] + P[3])/(1-2*P[1] + P[2]) | CSF for 2G given: GF-S/S/B,GG-S/B/S,GH-B/S/S |
| 2G5 | 2 TOTAL | = HWI1 + HWD1 + TS1 + MN1 + TS5 | Total for P[1]. See GF1 for breakdown of P[1]. |
| 2G6 | 1 2G6 | = (P[2]-P[3])/(P[1]-P[2]) | CSF for 2G given: GF&GG-GH:S&FB/BF,F&BS/SB,B&FS/SF |
| 2G6 | 2 TOTAL | = HWI2 + HWD2 + 2*TS1*HW1 + 2*MN1*HW1 + 2*TIM + TS5 | Total for P[2]. See GG2 for breakdown of P[2]. |
| 2G7 | 1 2G7 | = P[3]/P[2] | CSF for 2G given: GF-F/F/B,GG-F/B/F,GH-B/F/F |
| 2G7 | 2 TOTAL | = HWI3 + X2G72 | Total for P[3]. See GH3 for breakdown of P[3]. |
| 2G7 | 2 X2G72 | = HWD3 + 3*TS1*HW2 + 3*MN1*HW2 + 6*TIM*HW1 + TS5 | |
| 2G8 | 1 2G8 | = (P[1]-P[2])/(1-P[1]) | CSF for 2G given: GF-S/B/B,GG-B/S/B,GH-B/B/S |
| 2G8 | 2 TOTAL | = HWI1 + HWD1 + TS1 + MN1 + TS5 | Total for P[1]. See GF1 for breakdown of P[1]. |
| 2G9 | 1 2G9 | = P[2]/P[1] | CSF for 2G given: GF-F/B/B,GG-B/F/B,GH-B/B/F |
| 2G9 | 2 TOTAL | = HWI2 + HWD2 + 2*TS1*HW1 + 2*MN1*HW1 + 2*TIM + TS5 | Total for P[2]. See GG2 for breakdown of P[2]. |
| 2GA | 1 2GA | = P[1] | CSF for 2G given: GF-B,GG-B,GH-B |
| 2GA | 2 TOTAL | = HWI1 + HWD1 + TS1 + MN1 + TS5 | Total for P[1]. See GF1 for breakdown of P[1]. |
| 2H1 | 1 2H1 | = (P[1]-4*P[2] + 6*P[3]-4*P[4] + P[5])/X2H11 | CSF for 2H given: GF-GG&GH-2G: SS&SS |
| 2H1 | 1 X2H11 | = (1-4*P[1] + 6*P[2]-4*P[3] + P[4]) | Total for P[1]. See GF1 for breakdown of P[1]. |
| 2H1 | 2 TOTAL | = HWI1 + HWD1 + TS1 + MN1 + TS5 | |
| 2H2 | 1 2H2 | = (P[2]-3*P[3] + 3*P[4]-P[5])/(P[1]-3*P[2] + 3*P[3]-P[4]) | CSF for 2H given: GF-GG&GH-2G: SS&SF/FS, SF/FS&SS |
| 2H2 | 2 TOTAL | = HWI2 + HWD2 + 2*TS1*HW1 + 2*MN1*HW1 + 2*TIM + TS5 | Total for P[2]. See GG2 for breakdown of P[2]. |
| 2H3 | 1 2H3 | = (P[3]-2*P[4] + P[5])/(P[2]-2*P[3] + P[4]) | CSF-2H: GF-GG&GH-2G: FS/SF&SF/FS, SS&FF, FF&SS |
| 2H3 | 2 TOTAL | = HWI3 + X2H32 | Total for P[3]. See GH3 for breakdown of P[3]. |

| | | | |
|---|---|---|---|
| 2H3 | 2 X2H32 | = HWD3 + 3*TS1*HW2 + 3*MN1*HW2 + 6*TIM*HW1 + TS5 | |
| 2H4 | 1 2H4 | = (P[4]-P[5])/(P[3]-P[4]) | CSF for 2H given: GF-GG&GH-2G: SF/FS&FF, FF&SF/FS |
| 2H4 | 2 TOTAL | = HWI4 + X2H42 | Total for P[4]. See 2G4 for breakdown of P[4]. |
| 2H4 | 2 X2H42 | = HWD4 + 4*TS1*HW3 + 4*MN1*HW3 + 12*TIM*HW2 + TS5 | |
| 2H5 | 1 2H5 | = P[5]/P[4] | CSF for 2H given: GF-GG&GH-2G: FF&FF |
| 2H5 | 2 TOTAL | = HW + TS + MN | Total for P[5]. |
| 2H5 | 3 HW | = HWI + HWD | |
| 2H5 | 4 HWI | = HWI5 | |
| 2H5 | 5 HWD | = HWD5 | |
| 2H5 | 6 TS | = 5*TS1*HW4 + TS5 | |
| 2H5 | 7 MN | = 5*MN1*HW4 + 20*TIM*HW3 | |
| 2H5 | 8 SEIS | = SEIST | |
| 2H6 | 1 2H6 | = (P[1]-3*P[2]+3*P[3]-P[4])/(1-3*P[1]+3*P[2]-P[3]) | CSF for 2H given: GF-GG&GH-2G: SS&SB/BS, SB/BS&SS |
| 2H6 | 2 TOTAL | = HWI1 + HWD1 + TS1 + MN1 + TS5 | Total for P[1]. See GF1 for breakdown of P[1]. |
| 2H7 | 1 2H7 | = (P[2]-2*P[3]+P[4])/(P[1]-2*P[2]+P[3]) | CSF-2H: Two DGs succeed, one fails, one bypassed. |
| 2H7 | 2 TOTAL | = HWI2+HWD2+2*TS1*HW1+2*MN1*HW1+2*TIM+TS5 | Total for P[2]. See GG2 for breakdown of P[2]. |
| 2H8 | 1 2H8 | = (P[3]-P[4])/(P[2]-P[3]) | CSF-2H: Two DGs fail, one succeeds, one bypassed. |
| 2H8 | 2 TOTAL | = HWI3 + X2H82 | Total for P[3]. See GH3 for breakdown of P[3]. |
| 2H8 | 2 X2H82 | = HWD3 + 3*TS1*HW2 + 3*MN1*HW2 + 6*TIM*HW1 + TS5 | |
| 2H9 | 1 2H9 | = P[4]/P[3] | CSF for 2H given: GF-GG&GH-2G: FF&FB/BF, FB/BF&FF |
| 2H9 | 2 TOTAL | = HWI4 + X2H92 | Total for P[4]. See 2G4 for breakdown of P[4]. |
| 2H9 | 2 X2H92 | = HWD4 + 4*TS1*HW3 + 4*MN1*HW3 + 12*TIM*HW2 + TS5 | |
| 2HA | 1 2HA | = (P[1]-2*P[2]+P[3])/(1-2*P[1]+P[2]) | CSF-2H: GF-GG&GH-2G: SB/BS&BS/SB, SS&BB, BB&SS |
| 2HA | 2 TOTAL | = HWI1 + HWD1 + TS1 + MN1 + TS5 | Total for P[1]. See GF1 for breakdown of P[1]. |
| 2HB | 1 2HB | = (P[2]-P[3])/(P[1]-P[2]) | CSF-2H: Two DGs bypassed, one fails, one succeeded. |
| 2HB | 2 TOTAL | = HWI2+HWD2+2*TS1*HW1+2*MN1*HW1+2*TIM+TS5 | Total for P[2]. See GG2 for breakdown of P[2]. |
| 2HC | 1 2HC | = P[3]/P[2] | CSF-2H: GF-GG&GH-2G: FB/BF&BF/FB, FF&BB, BB&FF |
| 2HC | 2 TOTAL | = HWI3 + X2HC2 | Total for P[3]. See GH3 for breakdown of P[3]. |
| 2HC | 2 X2HC2 | = HWD3 + 3*TS1*HW2 + 3*MN1*HW2 + 6*TIM*HW1 + TS5 | |
| 2HD | 1 2HD | = (P[1]-P[2])/(1-P[1]) | CSF for 2H given: GF-GG&GH-2G: SB/BS&BB, BB&SB/BS |
| 2HD | 2 TOTAL | = HWI1 + HWD1 + TS1 + MN1 + TS5 | Total for P[1]. See GF1 for breakdown of P[1]. |
| 2HE | 1 2HE | = P[2]/P[1] | CSF for 2H given: GF-GG&GH-2G: FB/BF&BB, BB&FB/BF |
| 2HE | 2 TOTAL | = HWI2+HWD2+2*TS1*HW1+2*MN1*HW1+2*TIM+TS5 | Total for P[2]. See GG2 for breakdown of P[2]. |
| 2HG | 1 2HG | = P[1] | CSF for 2H given: GF-GG&GH-2H: BB&BB |
| 2HG | 2 TOTAL | = HWI1 + HWD1 + TS1 + MN1 + TS5 | Total for P[1]. See GF1 for breakdown of P[1]. |
| SW0 | 1 SW0 | = 0.0 | All branch points for LOCA initiating event. |
| SW1 | 1 SW1 | = 0.5 | LOSP with equal number of DG operating on each unit. |
| SW2 | 1 SW2 | = 0.5*ZHESW1 | LOSP with more DGs aligned to unit 2 than unit 1. |
| SW3 | 1 SW3 | = 0.5 + 0.5*(1-ZHESW1) | LOSP with more DGs aligned to unit 1 than unit 2. |

| | | |
|---|---|---|
| P[1] | = TOT1 + SEIST - SEIST*TOT1 | Total single train unavailability. |
| TOT1 | = HW1*F1 + MN1 + TS1 + TS5 | |
| P[2] | = TOT2 + SEIST - SEIST*TOT2 | Total two train unavailability. |
| TOT2 | = HW2*F2 + (2*MN1-2*TIM)*HW1 + 2*TS1*HW1 + 2*TIM + TS5 | |
| P[3] | = TOT3 + SEIST - SEIST*TOT3 | Total three train unavailability. |
| TOT3 | = HW3*F3 + (3*MN1-6*TIM)*HW2 + 3*TS1*HW2 + 6*TIM*HW1 + TS5 | |
| P[4] | = TOT4 + SEIST - SEIST*TOT4 | Total four train unavailability. |
| TOT4 | = HW4*F4 + (4*MN1-12*TIM)*HW3 + 4*TS1*HW3 + 12*TIM*HW2 + TS5 | |
| P[5] | = TOT5 + SEIST - SEIST*TOT5 | Total five train unavailability. |
| TOT5 | = HW5*F5 + (5*MN1-20*TIM)*HW4 + 5*TS1*HW4 + 20*TIM*HW3 + TS5 | |
| F1 | = (1 - MN1 - TS1 - TS5) | Fraction of the time the system is in normal alignment. |
| F2 | = (1 - 2*MN1 - 2*TS1 - TS5) | Fraction of the time the system is in normal alignment. |
| F3 | = (1 - 3*MN1 - 3*TS1 - TS5) | Fraction of the time the system is in normal alignment. |
| F4 | = (1 - 4*MN1 - 4*TS1 - TS5) | Fraction of the time the system is in normal alignment. |
| F5 | = (1 - 5*MN1 - 5*TS1 - TS5) | Fraction of the time the system is in normal alignment. |
| HW1 | = HWI1 + HWD1 | Single train total hardware failures. |
| HW2 | = HWI2 + HWD2 | Two train total hardware failures. |
| HW3 | = HWI3 + HWD3 | Three train total hardware failures. |
| HW4 | = HWI4 + HWD4 | Four train total hardware failures. |
| HW5 | = HWI5 + HWD5 | Five train total hardware failures. |
| HWI1 | = 1*HEV*IV + 1*ID | Single train independent hardware failure. |
| HWI2 | = 2*HEV*ID*IV + 1*HEV*IV*IV + 1*ID*ID | Two train independent hardware failure. |
| HWI3 | = 3*HEV*ID*ID*IV + 3*HEV*ID*IV*IV + 1*HEV*IV*IV*IV + 1*ID*ID*ID | Three train independent hardware failure. |
| HWI4 | = 4*HEV*ID*ID*ID*IV + 6*HEV*ID*ID*IV*IV + ZI401 | Four train independent hardware failure. |
| ZI401 | = 4*HEV*ID*IV*IV*IV + 1*HEV*IV*IV*IV*IV + 1*ID*ID*ID*ID | |
| HWI5 | = 5*HEV*ID*ID*ID*ID*IV + 10*HEV*ID*ID*ID*IV*IV + ZI501 | Five train independent hardware failure. |
| ZI501 | = 10*HEV*ID*ID*IV*IV*IV + 5*HEV*ID*IV*IV*IV*IV + ZI502 | |
| ZI502 | = 1*HEV*IV*IV*IV*IV*IV + 1*ID*ID*ID*ID*ID | |
| HWD1 | = 4*DV*HEV + 1*GD + 1*GV*HEV + 6*HEV*TV + 6*TD | Single train dependent hardware failures. |
| HWD2 | = 1*DD + 9*DD*DD + 18*DD*DV*HEV + 6*DD*HEV*IV + ZD201 | Two train dependent hardware failures. |
| ZD201 | = 18*DD*HEV*TV + 6*DD*ID + 18*DD*TD + 9*DV*DV*HEV + ZD202 | |
| ZD202 | = 1*DV*HEV + 6*DV*HEV*ID + 6*DV*HEV*IV + 18*DV*HEV*TD + ZD203 | |
| ZD203 | = 18*DV*HEV*TV + 1*GD + 1*GV*HEV + 6*HEV*ID*TV + ZD204 | |
| ZD204 | = 6*HEV*IV*TD + 6*HEV*IV*TV + 18*HEV*TD*TV + 3*HEV*TV + ZD205 | |
| ZD205 | = 9*HEV*TV*TV + 6*ID*TD + 3*TD + 9*TD*TD | |
| HWD3 | = 8*DD*DD*DD + 24*DD*DD*DV*HEV + 12*DD*DD*HEV*IV + ZD301 | Three train dependent hardware failures. |
| ZD301 | = 12*DD*DD*HEV*TV + 12*DD*DD*ID + 12*DD*DD*TD + ZD302 | |
| ZD302 | = 24*DD*DV*DV*HEV + 18*DD*DV*HEV + 24*DD*DV*HEV*ID + ZD303 | |
| ZD303 | = 24*DD*DV*HEV*IV + 24*DD*DV*HEV*TD + ZD304 | |

ZD304 = 24*DD*DV*HEV*TV + 12*DD*HEV*ID*IV + ZD305
ZD305 = 12*DD*HEV*ID*TV + 3*DD*HEV*IV + 6*DD*HEV*IV*IV + ZD306
ZD306 = 12*DD*HEV*IV*TD + 12*DD*HEV*IV*TV + ZD307
ZD307 = 12*DD*HEV*TD*TV + 27*DD*HEV*TV + 6*DD*HEV*TV*TV + ZD308
ZD308 = 3*DD*ID + 6*DD*ID*ID + 12*DD*ID*TD + 27*DD*TD + ZD309
ZD309 = 6*DD*TD*TD + 8*DV*DV*DV*HEV + 9*DV*DV*HEV + ZD310
ZD310 = 12*DV*DV*HEV*ID + 12*DV*DV*HEV*IV + ZD311
ZD311 = 12*DV*DV*HEV*TD + 12*DV*DV*HEV*TV + 3*DV*HEV*ID + ZD312
ZD312 = 6*DV*HEV*ID*ID + 12*DV*HEV*ID*IV + 12*DV*HEV*ID*TD + ZD313
ZD313 = 12*DV*HEV*ID*TV + 3*DV*HEV*IV + 6*DV*HEV*IV*IV + ZD314
ZD314 = 12*DV*HEV*IV*TD + 12*DV*HEV*IV*TV + 27*DV*HEV*TD + ZD315
ZD315 = 6*DV*HEV*TD*TD + 12*DV*HEV*TD*TV + 27*DV*HEV*TV + ZD316
ZD316 = 6*DV*HEV*TV*TV + 1*GD + 1*GV*HEV + 3*HEV*ID*ID*TV + ZD317
ZD317 = 6*HEV*ID*IV*TD + 12*HEV*ID*IV*TV + 6*HEV*ID*TV + ZD318
ZD318 = 3*HEV*ID*TV*TV + 3*HEV*IV*IV*TD + 3*HEV*IV*IV*TV + ZD319
ZD319 = 6*HEV*IV*TD + 3*HEV*IV*TD*TD + 6*HEV*IV*TD*TV + ZD320
ZD320 = 6*HEV*IV*TV + 6*HEV*IV*TV*TV + 36*HEV*TD*TV + ZD321
ZD321 = 3*HEV*TD*TV*TV + 1*HEV*TV + 18*HEV*TV*TV + ZD322
ZD322 = 1*HEV*TV*TV*TV + 3*ID*ID*TD + 6*ID*TD + 3*ID*TD*TD + ZD323
ZD323 = 1*TD + 18*TD*TD + 1*TD*TD*TD
HWD4 = 3*DD*DD + 22*DD*DD*DD + 1*DD*DD*DD*DD + ZD401 Four train dependent hardware failures.
ZD401 = 4*DD*DD*DD*DV*HEV + 4*DD*DD*DD*HEV*IV + ZD402
ZD402 = 4*DD*DD*DD*ID + 6*DD*DD*DV*DV*HEV + ZD403
ZD403 = 66*DD*DD*DV*HEV + 12*DD*DD*DV*HEV*ID + ZD404
ZD404 = 12*DD*DD*DV*HEV*IV + 12*DD*DD*HEV*ID*IV + ZD405
ZD405 = 24*DD*DD*HEV*IV + 6*DD*DD*HEV*IV*IV + ZD406
ZD406 = 42*DD*DD*HEV*TV + 24*DD*DD*ID + 6*DD*DD*ID*ID + ZD407
ZD407 = 42*DD*DD*TD + 4*DD*DV*DV*DV*HEV + 66*DD*DV*DV*HEV + ZD408
ZD408 = 24*DD*DV*DV*HEV*ID + 6*DD*DV*HEV + 48*DD*DV*HEV*ID + ZD409
ZD409 = 12*DD*DV*HEV*ID*ID + 24*DD*DV*HEV*ID*IV + ZD410
ZD410 = 48*DD*DV*HEV*IV + 12*DD*DV*HEV*IV*IV + ZD411
ZD411 = 84*DD*DV*HEV*TD + 84*DD*DV*HEV*TV + ZD412
ZD412 = 12*DD*HEV*ID*ID*IV + 12*DD*HEV*ID*IV + ZD413
ZD413 = 12*DD*HEV*ID*IV*IV + 36*DD*HEV*ID*TV + ZD414
ZD414 = 6*DD*HEV*IV*IV + 4*DD*HEV*IV*IV*IV + ZD415
ZD415 = 36*DD*HEV*IV*TD + 84*DD*HEV*IV*TV + 22*DD*HEV*TV + ZD416
ZD416 = 24*DD*HEV*TV*TV + 6*DD*ID*ID + 4*DD*ID*ID*ID + ZD417
ZD417 = 36*DD*ID*TD + 22*DD*TD + 24*DD*TD*TD + ZD418
ZD418 = 1*DV*DV*DV*DV*HEV + 22*DV*DV*DV*HEV + ZD419

ZD419 = 4*DV*DV*DV*HEV*ID + 4*DV*DV*DV*HEV*IV + ZD420
ZD420 = 3*DV*DV*HEV + 24*DV*DV*HEV*ID + 6*DV*DV*HEV*ID*ID + ZD421
ZD421 = 12*DV*DV*HEV*ID*IV + 24*DV*DV*HEV*IV + ZD422
ZD422 = 6*DV*DV*HEV*IV*IV + 42*DV*DV*HEV*TD + ZD423
ZD423 = 42*DV*DV*HEV*TV + 6*DV*HEV*ID*ID + ZD424
ZD424 = 4*DV*HEV*ID*ID*ID + 12*DV*HEV*ID*ID*IV + ZD425
ZD425 = 12*DV*HEV*ID*IV + 12*DV*HEV*ID*IV*IV + ZD426
ZD426 = 12*DV*HEV*ID*TD + 36*DV*HEV*ID*TV + 6*DV*HEV*IV*IV + ZD427
ZD427 = 4*DV*HEV*IV*IV*IV + 36*DV*HEV*IV*TD + ZD428
ZD428 = 36*DV*HEV*IV*TV + 22*DV*HEV*TD + 24*DV*HEV*TD*TD + ZD429
ZD429 = 48*DV*HEV*TD*TV + 22*DV*HEV*TV + 24*DV*HEV*TV*TV + ZD430
ZD430 = 1*GD + 1*GV*HEV + 6*HEV*ID*ID*TV + ZD431
ZD431 = 48*HEV*ID*IV*TD + 4*HEV*ID*TV + 12*HEV*ID*TV*TV + ZD432
ZD432 = 6*HEV*IV*IV*TD + 6*HEV*IV*IV*TV + 4*HEV*IV*TD + ZD433
ZD433 = 36*HEV*IV*TD*TD + 4*HEV*IV*TV + 24*HEV*IV*TV*TV + ZD434
ZD434 = 42*HEV*TD*TV + 12*HEV*TD*TV*TV + 21*HEV*TV*TV + ZD435
ZD435 = 4*HEV*TV*TV*TV + 6*ID*ID*TD + 4*ID*TD + 12*ID*TD*TD + ZD436
ZD436 = 21*TD*TD + 4*TD*TD*TD
HWD5 = 30*DD*DD*DD + 5*DD*DD*DD*DD + 20*DD*DD*DD*DV*HEV + ZD501 Five train dependent hardware failures.
ZD501 = 20*DD*DD*DD*HEV*IV + 20*DD*DD*DD*ID + ZD502
ZD502 = 30*DD*DD*DV*DV*HEV + 90*DD*DD*DV*HEV + ZD503
ZD503 = 60*DD*DD*DV*HEV*ID + 60*DD*DD*DV*HEV*IV + ZD504
ZD504 = 60*DD*DD*HEV*ID*IV + 15*DD*DD*HEV*IV + ZD505
ZD505 = 30*DD*DD*HEV*IV*IV + 90*DD*DD*HEV*TV + 15*DD*DD*ID + ZD506
ZD506 = 30*DD*DD*ID*ID + 90*DD*DD*TD + 20*DD*DV*DV*DV*HEV + ZD507
ZD507 = 90*DD*DV*DV*HEV + 60*DD*DV*DV*HEV*ID + ZD508
ZD508 = 60*DD*DV*DV*HEV*IV + 30*DD*DV*HEV*ID + ZD509
ZD509 = 60*DD*DV*HEV*ID*ID + 120*DD*DV*HEV*ID*IV + ZD510
ZD510 = 30*DD*DV*HEV*IV + 60*DD*DV*HEV*IV*IV + ZD511
ZD511 = 180*DD*DV*HEV*TD + 180*DD*DV*HEV*TV + ZD512
ZD512 = 30*DD*HEV*ID*ID*IV + 30*DD*HEV*ID*IV*IV + ZD513
ZD513 = 60*DD*HEV*ID*TV + 10*DD*HEV*IV*IV*IV + ZD514
ZD514 = 120*DD*HEV*IV*TD + 120*DD*HEV*TD*TV + 10*DD*HEV*TV + ZD515
ZD515 = 60*DD*HEV*TV*TV + 10*DD*ID*ID*ID + 60*DD*ID*TD + ZD516
ZD516 = 10*DD*TD + 60*DD*TD*TD + 5*DV*DV*DV*DV*HEV + ZD517
ZD517 = 30*DV*DV*DV*HEV + 20*DV*DV*DV*HEV*ID + ZD518
ZD518 = 20*DV*DV*DV*HEV*IV + 15*DV*DV*HEV*ID + ZD519
ZD519 = 30*DV*DV*HEV*ID*ID + 60*DV*DV*HEV*ID*IV + ZD520
ZD520 = 15*DV*DV*HEV*IV + 30*DV*DV*HEV*IV*IV + ZD521

| | | |
|---|---|---|
| ZD521 | = 90*DV*DV*HEV*TD + 90*DV*DV*HEV*TV + ZD522 | |
| ZD522 | = 10*DV*HEV*ID*ID*ID + 30*DV*HEV*ID*ID*IV + ZD523 | |
| ZD523 | = 30*DV*HEV*ID*IV*IV + 60*DV*HEV*ID*TD + ZD524 | |
| ZD524 | = 60*DV*HEV*ID*TV + 10*DV*HEV*IV*IV*IV + ZD525 | |
| ZD525 | = 60*DV*HEV*IV*TD + 60*DV*HEV*IV*TV + 10*DV*HEV*TD + ZD526 | |
| ZD526 | = 60*DV*HEV*TD*TD + 120*DV*HEV*TD*TV + 10*DV*HEV*TV + ZD527 | |
| ZD527 | = 60*DV*HEV*TV*TV + 1*GD + 1*GV*HEV + ZD528 | |
| ZD528 | = 10*HEV*ID*ID*TV + 20*HEV*ID*IV*TD + ZD529 | |
| ZD529 | = 20*HEV*ID*IV*TV + 60*HEV*ID*TD*TV + ZD530 | |
| ZD530 | = 30*HEV*ID*TV*TV + 10*HEV*IV*IV*TD + ZD531 | |
| ZD531 | = 10*HEV*IV*IV*TV + 30*HEV*IV*TD*TD + ZD532 | |
| ZD532 | = 60*HEV*IV*TD*TV + 30*HEV*IV*TV*TV + ZD533 | |
| ZD533 | = 30*HEV*TD*TD*TV + 30*HEV*TD*TV + 30*HEV*TD*TV*TV + ZD534 | |
| ZD534 | = 15*HEV*TV*TV + 10*HEV*TV*TV*TV + 10*ID*ID*TD + ZD535 | |
| ZD535 | = 30*ID*TD*TD + 15*TD*TD + 10*TD*TD*TD | |
| DD | = D5DGSS + D5DGS1 + D5DGS2*(TM-1) + D5CB1C + D5RL1D + D5RL1D | All DG double event failures. |
| TD | = T5DGSS + T5DGS1 + T5DGS2*(TM-1) + T5CB1C + T5RL1D + T5RL1D | All DG triple event failures. |
| GD | = G5DGSS + G5DGS1 + G5DGS2*(TM-1) + G5CB1C + G5RL1D + G5RL1D | All DG global event failures. |
| ID | = S5DGSS + S5DGS1 + S5DGS2*(TM-1) + S5CB1C + S5RL1D + S5RL1D + IDA | Total DG independent failures. |
| IDA | = DAYTNK + ZTCB1T*TM | |
| DAYTNK | = ZTTK1B*TM | DG day tank ruptures during operation. |
| IV | = ND*(ZTVAOD + ZTSWLD + ZTVCOD) + (VCHK + VLCV)*TR + IVA | Total LCV train independent failures. |
| IVA | = (AIRRCV + VMAN + VPCV + FLINK)*TM | |
| DV | = ND*(DDVAOD + DDSWLD + DDVCOD) + 5.0*TV | LCV train double event failures. |
| TV | = ND*(TDVAOD + TDSWLD + TDVCOD) | LCV train triple event failures. |
| GV | = ND*(GDVAOD + GDSWLD + GDVCOD) | LCV train global event failures. |
| VCHK | = ZTVCOP | |
| VLCV | = ZTVAOT | |
| AIRRCV | = ZTTK1B | |
| VMAN | = ZTVHOT | |
| VPCV | = ZTVPCT | |
| FLINK | = ZTSPRI | |
| TR | = ND*(PSTOP - PSTART)/(FDR - FCR) | Run time for LCVs. |
| PSTOP | = 509 | Valve close level. |
| PSTART | = 252 | Valve open level. |
| FDR | = 55*60 | Pump fuel delivery rate. |
| FCR | = 3.2*60 | DG fuel consumption rate. |
| ND | = (5/6)*TM | No. of valve demands in time TM. |
| MN1 | = MD + MV - MV*MD | Total maintenance unavailability. |

| | | |
|---|---|---|
| MD | = ZMDGSF*ZMDGSD | DG maintenance unavailability. |
| MV | = ZMGNDF*ZMGN3D | LCV maintenance unavailability. |
| TS1 | = TS1HE + TS2HE | Total DG unavailability due to surveillance test. |
| TS5 | = TS3HE | Unavailability of 5 DGs due to test error. |
| TS1HE | = TSD*TSF*HE1A + DT1*TSF*HE1B | Diesel unavailability due to auto control missalignment. |
| TS2HE | = DT2*TSF*HE2 | Diesel unavailability due to LCV missalignment. |
| TS3HE | = ZHDFO2*TS3F*ZHEFO2 | STP-V303: Misalignment of all LCV in stop position. |
| ZHEFO2 | = ZHEO1B | Human error of omission. |
| TS3F | = 1/2160 | STP-V303 testing frequency. |
| TIM | = ZMDGSF*N*TSD*HE1A + ZMDGSF*N*(HE1B*DT1 + HE2*DT2) | DG test unavailability resulting from DG maintenance. |
| N | = 1.0 | Number of tests for DGs while one is in maintenance. |
| TM | = 6*ZDGSMT + 24*(1-ZDGSMT) | Mission time. |
| TSD | = 70/60 | DG test duration. |
| TSF | = 1/720.0 | DG test frequency. |
| DT1 | = ZHDDG1 | Discovery time for failure to restore auto control. |
| DT2 | = ZHDDG3 | D.T. for LCVs not in auto control. |
| HE1A | = ZHEDG1 | Human error to restore DG to auto control during test. |
| HE1B | = ZHEDG2 | Human error to restore DG to auto control after test. |
| HE2 | = ZHEDG3 | Human error to restore LCVs to auto control. |
| ZHEDG1 | = ZHED01 | Dynamic human error. |
| ZHEDG2 | = ZHEO1B | Human error of omission. |
| ZHEDG3 | = ZHEO1B | |
| SEIST | = ZDGCPN + SEIS1 - ZDGCPN*SEIS1 | DG control panel. |
| SEIS1 | = ZDGEXC + SEIS2 - ZDGEXC*SEIS2 | DG excitation cubicle. |
| SEIS2 | = ZDGRWP + SEIS3 - ZDGRWP*SEIS3 | DG radiator/water pump. |
| SEIS3 | = ZDSLGN | Diesel Generator. |
| HEV | = ZHEFO6 | Operator action to manually operate LCVs. |

**Figure A-2:** Basic Component Failure Rates Used in the Diesel Generator Split Fraction Quantification

**Reference:** PGE.1123 EVENT.TREES BNL DATA.TITLES

DCPP PLANT SPECIFIC DATA BASE AS OF 7/9/88

| SEQUENCE NO. | | NAME OF DISTRIBUTION | MEAN | VARIANCE | 5TH %ILE | MEDIAN | 95TH %ILE |
|---|---|---|---|---|---|---|---|
| 6. S5CB1C | CCA | 1 OF 5 CIRCUIT BREAKER (480VAC AND ABOVE) FAIL TO CLOSE | 1.50E-03 | 3.53E-06 | 2.60E-04 | 1.09E-03 | 2.99E-03 |
| 7. D5CB1C | CCA | 2 OF 5 CIRCUIT BREAKER (480VAC AND ABOVE) FAIL TO CLOSE | 3.19E-05 | 3.01E-09 | 3.30E-07 | 1.52E-05 | 8.02E-05 |
| 8. T5CB1C | CCA | 3 OF 5 CIRCUIT BREAKER (480VAC AND ABOVE) FAIL TO CLOSE | 4.33E-06 | 5.99E-11 | 4.89E-08 | 1.82E-06 | 1.20E-05 |
| 9. G5CB1C | CCA | 4/5 OR 5/5 C.B.BREAKER (480VAC AND ABOVE) FAIL TO CLOSE | 2.86E-06 | 4.46E-11 | 2.00E-08 | 9.00E-07 | 8.22E-06 |
| 29. S5DGSS | CCA | 1 OF 5 DIESEL GENERATORS FAIL TO START | 1.58E-02 | 3.81E-05 | 7.48E-03 | 1.45E-02 | 2.70E-02 |
| 30. D5DGSS | CCA | 2 OF 5 DIESEL GENERATORS FAIL TO START | 8.27E-06 | 4.64E-11 | 9.46E-07 | 5.59E-06 | 1.95E-05 |
| 31. T5DGSS | CCA | 3 OF 5 DIESEL GENERATORS FAIL TO START | 5.23E-07 | 5.16E-13 | 8.71E-09 | 2.22E-07 | 1.59E-06 |
| 32. G5DGSS | CCA | 4 OR MORE OF 5 DIESEL GENERATORS FAIL TO START | 6.17E-07 | 1.01E-12 | 7.57E-09 | 2.30E-07 | 1.85E-06 |
| 33. S5DGS1 | CCA | 1 OF 5 DIESEL GENERATORS FAIL TO RUN DURING 1ST HR. | 8.63E-03 | 1.34E-05 | 3.66E-03 | 7.62E-03 | 1.41E-02 |
| 34. D5DGS1 | CCA | 2 OF 5 DIESEL GENERATORS FAIL TO RUN DURING 1ST HR. | 3.48E-05 | 5.62E-10 | 7.78E-06 | 2.66E-05 | 7.28E-05 |
| 35. T5DGS1 | CCA | 3 OF 5 DIESEL GENERATORS FAIL TO RUN DURING 1ST HR. | 4.65E-06 | 2.67E-11 | 3.75E-07 | 2.61E-06 | 1.22E-05 |
| 36. G5DGS1 | CCA | 4 OR 5 OF 5 DIESEL GENERATORS FAIL TO RUN DURING 1ST HR. | 6.15E-06 | 6.16E-11 | 3.65E-07 | 3.08E-06 | 1.68E-05 |
| 37. S5DGS2 | CCA | 1 OF 5 DIESEL GENERATORS FAIL TO RUN AFTER 1ST HR. | 2.07E-03 | 4.05E-06 | 2.11E-04 | 1.41E-03 | 4.37E-03 |
| 38. D5DGS2 | CCA | 2 OF 5 DIESEL GENERATORS FAIL TO RUN AFTER 1ST HR. | 5.06E-06 | 5.44E-11 | 2.38E-07 | 2.37E-06 | 1.44E-05 |
| 39. T5DGS2 | CCA | 3 OF 5 DIESEL GENERATORS FAIL TO RUN AFTER 1ST HR. | 1.27E-06 | 4.11E-12 | 4.63E-08 | 5.27E-07 | 3.74E-06 |
| 40. G5DGS2 | CCA | 4 OR 5 OF 5 DIESEL GENERATORS FAIL TO RUN AFTER 1ST HR. | 1.48E-06 | 6.47E-12 | 4.79E-08 | 5.99E-07 | 4.31E-06 |
| 112. S5RL1D | CCC | 1 OF 5 RELAYS FAIL ON DEMAND | 2.28E-04 | 1.29E-07 | 1.54E-05 | 1.23E-04 | 6.19E-04 |
| 113. D5RL1D | CCC | 2 OF 5 RELAYS FAIL ON DEMAND | 5.23E-06 | 1.15E-10 | 4.35E-08 | 1.74E-06 | 1.52E-05 |
| 114. T5RL1D | CCC | 3 OF 5 RELAYS FAIL ON DEMAND | 2.82E-07 | 6.10E-13 | 7.50E-10 | 6.35E-08 | 7.83E-07 |
| 115. G5RL1D | CCC | 4 OR 5 OF 5 RELAYS FAIL ON DEMAND | 3.38E-07 | 9.22E-13 | 8.20E-10 | 7.08E-08 | 9.70E-07 |
| 142. DDSWLD | CCC | 2 OF 10 LEVEL SWITCHES FAIL TO OPERATE ON DEMAND | 5.81E-06 | 1.47E-10 | 6.98E-08 | 1.61E-06 | 1.78E-05 |
| 143. TDSWLD | CCC | 3 OF 10 LEVEL SWITCHES FAIL TO OPERATE ON DEMAND | 3.08E-07 | 6.28E-13 | 6.57E-10 | 5.99E-08 | 9.60E-07 |
| 144. GDSWLD | CCC | 4 OR MORE OF 10 LEVEL SWITCHES FAIL TO OPERATE ON DEMAND | 3.72E-07 | 9.41E-13 | 7.59E-10 | 6.95E-08 | 1.13E-06 |
| 161. DDVAOD | CCC | 2 OF 10 AIR OPERATED VALVES FAIL ON DEMAND | 1.25E-05 | 1.64E-10 | 2.54E-07 | 7.43E-06 | 3.23E-05 |
| 162. TDVAOD | CCC | 3 OF 10 AIR OPERATED VALVES FAIL ON DEMAND | 1.70E-06 | 4.57E-12 | 2.38E-08 | 8.49E-07 | 4.68E-06 |
| 163. GDVAOD | CCC | 4 OR MORE OF 10 AIR OPERATED VALVES FAIL ON DEMAND | 1.16E-06 | 3.97E-12 | 1.45E-08 | 4.35E-07 | 3.36E-06 |
| 178. DDVCOD | CCD | 2 OF 10 CHECK VALVES FAIL ON DEMAND | 4.61E-07 | 2.08E-13 | 3.99E-08 | 2.79E-07 | 1.19E-06 |
| 179. TDVCOD | CCD | 3 OF 10 CHECK VALVES FAIL ON DEMAND | 5.54E-08 | 4.49E-15 | 3.51E-09 | 2.79E-08 | 1.52E-07 |
| 180. GDVCOD | CCD | 4 OR MORE OF 10 CHECK VALVES FAIL ON DEMAND | 6.78E-08 | 7.90E-15 | 3.30E-09 | 3.21E-08 | 1.87E-07 |
| 226. ZTCB1T | | CIRCUIT BREAKER (480VAC AND ABOVE)-TRANSFER OPEN DURING OPER. | 8.28E-07 | 1.57E-12 | 5.08E-08 | 3.99E-07 | 2.36E-06 |
| 295. ZTSPRI | | FIRE SPRINKLER HEAD INADVERTANT ACTUATION | 9.99E-07 | 1.47E-12 | 1.18E-07 | 6.06E-07 | 3.01E-06 |

|  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|
| 299. ZTSWLD | LEVEL SWITCH - FAIL TO OPERATE ON DEMAND | 2.69E-04 | 2.09E-07 | 1.41E-05 | 1.25E-04 | 7.69E-04 |
| 301. ZTTK1B | STORAGE TANK -- RUPTURE DURING OPERATION | 2.66E-08 | 3.17E-15 | 7.59E-10 | 1.04E-08 | 7.63E-08 |
| 307. ZTVAOD | AIR OPERATED VALVE - FAIL TO OPERATE ON DEMAND | 6.22E-04 | 1.41E-07 | 1.58E-04 | 5.09E-04 | 1.23E-03 |
| 309. ZTVAOT | AIR OPERATED VALVES TRANSFER OPEN/CLOSED | 2.29E-07 | 1.53E-13 | 1.74E-08 | 1.14E-07 | 5.91E-07 |
| 310. ZTVCOD | OTHER CHECK VALVE - FAIL TO OPERATE ON DEMAND | 1.70E-04 | 8.55E-09 | 4.05E-05 | 1.41E-04 | 2.84E-04 |
| 313. ZTVCOP | CHECK VALVES (OTHER STOP) TRANSFER CLOSED/PLUGGED | 1.04E-08 | 5.60E-17 | 2.43E-09 | 7.80E-09 | 2.18E-08 |
| 322. ZTVHOT | MANUAL VALVE TRANSFERS CLOSED/OPEN | 3.32E-08 | 3.45E-15 | 1.65E-09 | 1.39E-08 | 1.04E-07 |
| 327. ZTVPCT | PRESSURE CONTROL VALVE, SELF CONTAINED FAILURE DURING OPERATION | 3.90E-06 | 2.35E-10 | 2.49E-08 | 6.05E-07 | 1.41E-05 |
| 347. ZHDDG1 | DISCOVERY TIME FOR FAIL TO RETURN DG TO AUTO AFTER SURV TEST | 1.72E+00 | 1.66E+00 | 8.33E-02 | 1.00E+00 | 3.50E+00 |
| 349. ZHDDG3 | DISCOV TIME FOR FAIL TO RTN FTP AND LCV CTRLS TO AUTO AFTER TEST | 1.38E+01 | 4.60E+01 | 2.30E+00 | 1.33E+01 | 2.25E+01 |
| 351. ZHDFO2 | DISCOV TIME FOR FAIL TO RTN FTP AND LCV CTRLS TO AUTO AFTER TEST | 1.38E+01 | 4.60E+01 | 2.30E+00 | 1.33E+01 | 2.25E+01 |
| 354. ZDGSMT | SWITCH TO DETERMINE WHICH MISSION TIME TO USE | 1.00E+00 | 0.00E-01 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| 364. ZMDGSF | DIESEL GENERATOR - MAINTENANCE FREQUENCY | 7.74E-04 | 2.33E-08 | 5.25E-04 | 7.52E-04 | 9.66E-04 |
| 371. ZMGNDF | MAINTENANCE FREQUENCY FOR VALVES | 2.03E-05 | 3.52E-11 | 1.14E-05 | 1.91E-05 | 2.97E-05 |
| 393. ZMDGSD | DIESEL GENERATOR - MAINT. DURATION | 1.01E+01 | 3.99E+00 | 6.65E+00 | 9.74E+00 | 1.33E+01 |
| 398. ZMGN3D | MAINT. DURATION FOR VALVES WITH TECH SPEC LIMITS OF 72 HRS. | 1.89E+01 | 5.97E+02 | 1.54E+00 | 1.01E+01 | 5.13E+01 |
| 469. ZHESW1 | H.E. FAIL TO REALIGN SWING DG TO OPPOSITE UNIT | 3.54E-03 | 3.68E-05 | 2.09E-04 | 1.63E-03 | 1.21E-02 |
| 477. ZHEO1B | HUMAN ERROR RATE OF OMISSION - TYPE 1B | 4.70E-03 | 2.76E-05 | 5.40E-04 | 2.85E-03 | 1.18E-02 |
| 478. ZHED01 | H.E. DYNAMIC HUMAN ERROR RATE (KNOWLEDGE BASED) | 1.00E-01 | 1.10E-02 | 1.02E-02 | 6.98E-02 | 2.49E-01 |
| 488. ZHEFO6 | H.E. FAIL TO ALIGN A DEDICATED, PORTABLE FUEL OIL TRANSFER PUMP | 4.00E-02 | 2.36E-03 | 4.72E-03 | 2.43E-02 | 1.21E-01 |
| 519. ZDSLGN | DIESEL GENERATORS | 0.00E-01 | 0.00E-01 | 0.00E-01 | 0.00E-01 | 0.00E-01 |
| 520. ZDGRWP | DG RADIATOR/WATER PUMP | 0.00E-01 | 0.00E-01 | 0.00E-01 | 0.00E-01 | 0.00E-01 |
| 521. ZDGEXC | DG EXCITATION CUBICAL | 0.00E-01 | 0.00E-01 | 0.00E-01 | 0.00E-01 | 0.00E-01 |
| 522. ZDGCPN | DG CONTROL PANEL | 0.00E-01 | 0.00E-01 | 0.00E-01 | 0.00E-01 | 0.00E-01 |

**Figure A-3: Equations Modified for One DG in Scheduled Maintenance (Non-Seismic)**
**Reference: PGE.1123.2 RISKMAN3.PHASE3 SEISPH3B DGAOT.SYS SCHD.EQS**

```
GG4    1 GG3     = P[1]                                               CSF for GG given: GF-B
GG4    2 TOTAL   = HWI1 + HWD1 + TS1 + MN1 + TS5 + TIM                Total for P[1].   See GF1 for breakdown of P[1].
GH7    1 GH4     = (P[1]-P[2])/(1-P[1])                               CSF for GH given: GF-S/B, GG-B/S
GH7    2 TOTAL   = HWI1 + HWD1 + TS1 + MN1 + TS5 + TIM                Total for P[1].   See GF1 for breakdown of P[1].
GH8    1 GH5     = P[2]/P[1]                                          CSF for GH given: GF-F/B, GG-B/F
GH8    2 TOTAL   = HWI2+HWD2+2*TS1*HW1+2*MN1*HW1+TS5+2*TIM*HW1        Total for P[2].
GH9    1 GH6     = P[1]                                               $ CSF for GH given: GF-B, GG-B
GH9    2 TOTAL   = HWI1 + HWD1 + TS1 + MN1 + TS5                      Total for P[1].   See GF1 for breakdown of P[1].
2GC    1 2G6     = (P[2]-P[3])/(P[1]-P[2])                            CSF for 2G given: GF&GG-GH:S&FB/BF,F&BS/SB,B&FS/SF
2GC    2 TOTAL   = HWI2+HWD2+2*TS1*HW1+2*MN1*HW1+TS5+2*TIM*HW1        Total for P[2].   See GG2 for breakdown of P[2].
2GE    1 2G8     = (P[1]-P[2])/(1-P[1])                               CSF for 2G given: GF-S/B/B,GG-B/S/B,GH-B/B/S
2GE    2 TOTAL   = HWI1 + HWD1 + TS1 + MN1 + TS5 + TIM                Total for P[1].   See GF1 for breakdown of P[1].
2HI    1 2H7     = (P[2]-2*P[3]+P[4])/(P[1]-2*P[2]+P[3])              CSF-2H: Two DGs succeed, one fails, one bypassed.
2HI    2 TOTAL   = HWI2+HWD2+2*TS1*HW1+2*MN1*HW1+TS5+2*TIM*HW1        Total for P[2].   See GG2 for breakdown of P[2].
2HJ    1 2H8     = (P[3]-P[4])/(P[2]-P[3])                            CSF-2H: Two DGs fail, one succeeds, one bypassed.
2HJ    2 TOTAL   = HWI3 + X2H82 - HWI3 * X2H82                        Total for P[3].   See GH3 for breakdown of P[3].
2HJ      X2H82   = HWD3 + 3*TS1*HW2 + 3*MN1*HW2 + TS5 + 3*T>M*HW2
                    P[1]   = TOT1 + SEIST - SEIST*TOT1                Total single train unavailability.
                    TOT1   = HW1*F1 + MN1 + TS1 + TS5 + TIM
                    P[2]   = TOT2 + SEIST - SEIST*TOT2                Total two train unavailability.
                    TOT2   = HW2*F2+2*MN1*HW1+2*TS1*HW1+TS5+2*T>M*HW1
                    P[3]   = TOT3 + SEIST - SEIST*TOT3                Total three train unavailability.
                    TOT3   = HW3*F3+3*MN1*HW2+3*TS1*HW2+TS5+3*TIM*HW2
                    P[4]   = TOT4 + SEIST - SEIST*TOT4                Total four train unavailability.
                    TOT4   = HW4*F4+4*MN1*HW3+4*TS1*HW3+TS5+4*TIM*HW3
                    P[5]   = TOT5 + SEIST - SEIST*TOT5                Total five train unavailability.
                    TOT5   = HW5*F5+(5*MN1-20*TIM)*HW4+5*TS1*HW4+TS5+20*TIM*HW3     (Not used for these split fractions)
         F1      = (1 - MN1 - TS1 - TS5 + TIM)                        Fraction of the time the system is in normal alignment.
         F2      = (1 - 2*MN1 - 2*TS1 - TS5 + 2*TIM*HW1)              Fraction of the time the system is in normal alignment.
         F3      = (1 - 3*MN1 - 3*TS1 - TS5 + 3*TIM*HW2)              Fraction of the time the system is in normal alignment.
         F4      = (1 - 4*MN1 - 4*TS1 - TS5 + 4*TIM*HW3)              Fraction of the time the system is in normal alignment.
         F5      = (1 - 5*MN1 - 5*TS1 - TS5)
         HW1     = HWI1 + HWD1                                        Single train total hardware failures.
         HW2     = HWI2 + HWD2                                        Two train total hardware failures.
         HW3     = HWI3 + HWD3                                        Three train total hardware failures.
         HW4     = HWI4 + HWD4                                        Four train total hardware failures.
```

HW5 = HWI5 + HWD5 Five train total hardware failures.
HWI1 = 1*HEV*IV + 1*ID Single train independent hardware failure.
HWI2 = 2*HEV*ID*IV + 1*HEV*IV*IV + 1*ID*ID Two train independent hardware failure.
HWI3 = 3*HEV*ID*ID*IV + 3*HEV*ID*IV*IV + 1*HEV*IV*IV*IV + 1*ID*ID*ID Three train independent hardware failure.
HWI4 = 4*HEV*ID*ID*ID*IV + 6*HEV*ID*ID*IV*IV + ZI401 Four train independent hardware failure.
ZI401 = 4*HEV*ID*IV*IV*IV + 1*HEV*IV*IV*IV*IV + 1*ID*ID*ID*ID
HWI5 = 5*HEV*ID*ID*ID*ID*IV + 10*HEV*ID*ID*ID*IV*IV + ZI501 Five train independent hardware failure.
ZI501 = 10*HEV*ID*ID*IV*IV*IV + 5*HEV*ID*IV*IV*IV*IV + ZI502
ZI502 = 1*HEV*IV*IV*IV*IV*IV + 1*ID*ID*ID*ID*ID
HWD1 = 4*DV*HEV + 1*GD + 1*GV*HEV + 6*HEV*TV + 6*TD Single train dependent hardware failures.
HWD2 = 1*DD + 9*DD*DD + 18*DD*DV*HEV + 6*DD*HEV*IV + ZD201 Two train dependent hardware failures.
ZD201 = 18*DD*HEV*TV + 6*DD*ID + 18*DD*TD + 9*DV*DV*HEV + ZD202
ZD202 = 1*DV*HEV + 6*DV*HEV*ID + 6*DV*HEV*IV + 18*DV*HEV*TD + ZD203
ZD203 = 18*DV*HEV*TV + 1*GD + 1*GV*HEV + 6*HEV*ID*TV + ZD204
ZD204 = 6*HEV*IV*TD + 6*HEV*IV*TV + 18*HEV*TD*TV + 3*HEV*TV + ZD205
ZD205 = 9*HEV*TV*TV + 6*ID*TD + 3*TD + 9*TD*TD
HWD3 = 8*DD*DD*DD + 24*DD*DD*DV*HEV + 12*DD*DD*HEV*IV + ZD301 Three train dependent hardware failures.
ZD301 = 12*DD*DD*HEV*TV + 12*DD*DD*ID + 12*DD*DD*TD + ZD302
ZD302 = 24*DD*DV*DV*HEV + 18*DD*DV*HEV + 24*DD*DV*HEV*ID + ZD303
ZD303 = 24*DD*DV*HEV*IV + 24*DD*DV*HEV*TD + ZD304
ZD304 = 24*DD*DV*HEV*TV + 12*DD*HEV*ID*IV + ZD305
ZD305 = 12*DD*HEV*ID*TV + 3*DD*HEV*IV + 6*DD*HEV*IV*IV + ZD306
ZD306 = 12*DD*HEV*IV*TD + 12*DD*HEV*IV*TV + ZD307
ZD307 = 12*DD*HEV*TD*TV + 27*DD*HEV*TV + 6*DD*HEV*TV*TV + ZD308
ZD308 = 3*DD*ID + 6*DD*ID*ID + 12*DD*ID*TD + 27*DD*TD + ZD309
ZD309 = 6*DD*TD*TD + 8*DV*DV*DV*HEV + 9*DV*DV*HEV + ZD310
ZD310 = 12*DV*DV*HEV*ID + 12*DV*DV*HEV*IV + ZD311
ZD311 = 12*DV*DV*HEV*TD + 12*DV*DV*HEV*TV + 3*DV*HEV*ID + ZD312
ZD312 = 6*DV*HEV*ID*ID + 12*DV*HEV*ID*IV + 12*DV*HEV*ID*TD + ZD313
ZD313 = 12*DV*HEV*ID*TV + 3*DV*HEV*IV + 6*DV*HEV*IV*IV + ZD314
ZD314 = 12*DV*HEV*IV*TD + 12*DV*HEV*IV*TV + 27*DV*HEV*TD + ZD315
ZD315 = 6*DV*HEV*TD*TD + 12*DV*HEV*TD*TV + 27*DV*HEV*TV + ZD316
ZD316 = 6*DV*HEV*TV*TV + 1*GD + 1*GV*HEV + 3*HEV*ID*ID*TV + ZD317
ZD317 = 6*HEV*ID*IV*TD + 12*HEV*ID*IV*TV + 6*HEV*ID*TV + ZD318
ZD318 = 3*HEV*ID*TV*TV + 3*HEV*IV*IV*TD + 3*HEV*IV*IV*TV + ZD319
ZD319 = 6*HEV*IV*TD + 3*HEV*IV*TD*TD + 6*HEV*IV*TD*TV + ZD320
ZD320 = 6*HEV*IV*TV + 6*HEV*IV*TV*TV + 36*HEV*TD*TV + ZD321
ZD321 = 3*HEV*TD*TV*TV + 1*HEV*TV + 18*HEV*TV*TV + ZD322
ZD322 = 1*HEV*TV*TV*TV + 3*ID*ID*TD + 6*ID*TD + 3*ID*TD*TD + ZD323

ZD323 = 1*TD + 18*TD*TD + 1*TD*TD*TD
HWD4 = 3*DD*DD + 22*DD*DD*DD + 1*DD*DD*DD*DD + ZD401 Four train dependent hardware failures.
ZD401 = 4*DD*DD*DD*DV*HEV + 4*DD*DD*DD*HEV*IV + ZD402
ZD402 = 4*DD*DD*DD*ID + 6*DD*DD*DV*DV*HEV + ZD403
ZD403 = 66*DD*DD*DV*HEV + 12*DD*DD*DV*HEV*ID + ZD404
ZD404 = 12*DD*DD*DV*HEV*IV + 12*DD*DD*HEV*ID*IV + ZD405
ZD405 = 24*DD*DD*HEV*IV + 6*DD*DD*HEV*IV*IV + ZD406
ZD406 = 42*DD*DD*HEV*TV + 24*DD*DD*ID + 6*DD*DD*ID*ID + ZD407
ZD407 = 42*DD*DD*TD + 4*DD*DV*DV*DV*HEV + 66*DD*DV*DV*HEV + ZD408
ZD408 = 24*DD*DV*DV*HEV*ID + 6*DD*DV*HEV + 48*DD*DV*HEV*ID + ZD409
ZD409 = 12*DD*DV*HEV*ID*ID + 24*DD*DV*HEV*ID*IV + ZD410
ZD410 = 48*DD*DV*HEV*IV + 12*DD*DV*HEV*IV*IV + ZD411
ZD411 = 84*DD*DV*HEV*TD + 84*DD*DV*HEV*TV + ZD412
ZD412 = 12*DD*HEV*ID*ID*IV + 12*DD*HEV*ID*IV + ZD413
ZD413 = 12*DD*HEV*ID*IV*IV + 36*DD*HEV*ID*TV + ZD414
ZD414 = 6*DD*HEV*IV*IV + 4*DD*HEV*IV*IV*IV + ZD415
ZD415 = 36*DD*HEV*IV*TD + 84*DD*HEV*IV*TV + 22*DD*HEV*TV + ZD416
ZD416 = 24*DD*HEV*TV*TV + 6*DD*ID*ID + 4*DD*ID*ID*ID + ZD417
ZD417 = 36*DD*ID*TD + 22*DD*TD + 24*DD*TD*TD + ZD418
ZD418 = 1*DV*DV*DV*DV*HEV + 22*DV*DV*DV*HEV + ZD419
ZD419 = 4*DV*DV*DV*HEV*ID + 4*DV*DV*DV*HEV*IV + ZD420
ZD420 = 3*DV*DV*HEV + 24*DV*DV*HEV*ID + 6*DV*DV*HEV*ID*ID + ZD421
ZD421 = 12*DV*DV*HEV*ID*IV + 24*DV*DV*HEV*IV + ZD422
ZD422 = 6*DV*DV*HEV*IV*IV + 42*DV*DV*HEV*TD + ZD423
ZD423 = 42*DV*DV*HEV*TV + 6*DV*HEV*ID*ID + ZD424
ZD424 = 4*DV*HEV*ID*ID*ID + 12*DV*HEV*ID*ID*IV + ZD425
ZD425 = 12*DV*HEV*ID*IV + 12*DV*HEV*ID*IV*IV + ZD426
ZD426 = 12*DV*HEV*ID*TD + 36*DV*HEV*ID*TV + 6*DV*HEV*IV*IV + ZD427
ZD427 = 4*DV*HEV*IV*IV*IV + 36*DV*HEV*IV*TD + ZD428
ZD428 = 36*DV*HEV*IV*TV + 22*DV*HEV*TD + 24*DV*HEV*TD*TD + ZD429
ZD429 = 48*DV*HEV*TD*TV + 22*DV*HEV*TV + 24*DV*HEV*TV*TV + ZD430
ZD430 = 1*GD + 1*GV*HEV + 6*HEV*ID*ID*TV + ZD431
ZD431 = 48*HEV*ID*IV*TD + 4*HEV*ID*TV + 12*HEV*ID*TV*TV + ZD432
ZD432 = 6*HEV*IV*IV*TD + 6*HEV*IV*IV*TV + 4*HEV*IV*TD + ZD433
ZD433 = 36*HEV*IV*TD*TD + 4*HEV*IV*TV + 24*HEV*IV*TV*TV + ZD434
ZD434 = 42*HEV*TD*TV + 12*HEV*TD*TV*TV + 21*HEV*TV*TV + ZD435
ZD435 = 4*HEV*TV*TV*TV + 6*ID*ID*TD + 4*ID*TD + 12*ID*TD*TD + ZD436
ZD436 = 21*TD*TD + 4*TD*TD*TD
HWD5 = 30*DD*DD*DD + 5*DD*DD*DD*DD + 20*DD*DD*DD*DV*HEV + ZD501 Five train dependent hardware failures.

ZD501 = 20*DD*DD*DD*HEV*IV + 20*DD*DD*DD*ID + ZD502
ZD502 = 30*DD*DD*DV*DV*HEV + 90*DD*DD*DV*HEV + ZD503
ZD503 = 60*DD*DD*DV*HEV*ID + 60*DD*DD*DV*HEV*IV + ZD504
ZD504 = 60*DD*DD*HEV*ID*IV + 15*DD*DD*HEV*IV + ZD505
ZD505 = 30*DD*DD*HEV*IV*IV + 90*DD*DD*HEV*TV + 15*DD*DD*ID + ZD506
ZD506 = 30*DD*DD*ID*ID + 90*DD*DD*TD + 20*DD*DV*DV*DV*HEV + ZD507
ZD507 = 90*DD*DV*DV*HEV + 60*DD*DV*DV*HEV*ID + ZD508
ZD508 = 60*DD*DV*DV*HEV*IV + 30*DD*DV*HEV*ID + ZD509
ZD509 = 60*DD*DV*HEV*ID*ID + 120*DD*DV*HEV*ID*IV + ZD510
ZD510 = 30*DD*DV*HEV*IV + 60*DD*DV*HEV*IV*IV + ZD511
ZD511 = 180*DD*DV*HEV*TD + 180*DD*DV*HEV*TV + ZD512
ZD512 = 30*DD*HEV*ID*ID*IV + 30*DD*HEV*ID*IV*IV + ZD513
ZD513 = 60*DD*HEV*ID*TV + 10*DD*HEV*IV*IV*IV + ZD514
ZD514 = 120*DD*HEV*IV*TD + 120*DD*HEV*TD*TV + 10*DD*HEV*TV + ZD515
ZD515 = 60*DD*HEV*TV*TV + 10*DD*ID*ID*ID + 60*DD*ID*TD + ZD516
ZD516 = 10*DD*TD + 60*DD*TD*TD + 5*DV*DV*DV*DV*HEV + ZD517
ZD517 = 30*DV*DV*DV*HEV + 20*DV*DV*DV*HEV*ID + ZD518
ZD518 = 20*DV*DV*DV*HEV*IV + 15*DV*DV*HEV*ID + ZD519
ZD519 = 30*DV*DV*HEV*ID*ID + 60*DV*DV*HEV*ID*IV + ZD520
ZD520 = 15*DV*DV*HEV*IV + 30*DV*DV*HEV*IV*IV + ZD521
ZD521 = 90*DV*DV*HEV*TD + 90*DV*DV*HEV*TV + ZD522
ZD522 = 10*DV*HEV*ID*ID*ID + 30*DV*HEV*ID*ID*IV + ZD523
ZD523 = 30*DV*HEV*ID*IV*IV + 60*DV*HEV*ID*TD + ZD524
ZD524 = 60*DV*HEV*ID*TV + 10*DV*HEV*IV*IV*IV + ZD525
ZD525 = 60*DV*HEV*IV*TD + 60*DV*HEV*IV*TV + 10*DV*HEV*TD + ZD526
ZD526 = 60*DV*HEV*TD*TD + 120*DV*HEV*TD*TV + 10*DV*HEV*TV + ZD527
ZD527 = 60*DV*HEV*TV*TV + 1*GD + 1*GV*HEV + ZD528
ZD528 = 10*HEV*ID*ID*TV + 20*HEV*ID*IV*TD + ZD529
ZD529 = 20*HEV*ID*IV*TV + 60*HEV*ID*TD*TV + ZD530
ZD530 = 30*HEV*ID*TV*TV + 10*HEV*IV*IV*TD + ZD531
ZD531 = 10*HEV*IV*IV*TV + 30*HEV*IV*TD*TD + ZD532
ZD532 = 60*HEV*IV*TD*TV + 30*HEV*IV*TV*TV + ZD533
ZD533 = 30*HEV*TD*TD*TV + 30*HEV*TD*TV + 30*HEV*TD*TV*TV + ZD534
ZD534 = 15*HEV*TV*TV + 10*HEV*TV*TV*TV + 10*ID*ID*TD + ZD535
ZD535 = 30*ID*TD*TD + 15*TD*TD + 10*TD*TD*TD
DD = D5DGSS + D5DGS1 + D5DGS2*(TM-1) + D5CB1C + D5RL1D + D5RL1D    All DG double event failures.
TD = T5DGSS + T5DGS1 + T5DGS2*(TM-1) + T5CB1C + T5RL1D + T5RL1D    All DG triple event failures.
GD = G5DGSS + G5DGS1 + G5DGS2*(TM-1) + G5CB1C + G5RL1D + G5RL1D    All DG global event failures.
ID = S5DGSS + S5DGS1 + S5DGS2*(TM-1) + S5CB1C + S5RL1D + S5RL1D + IDA    Total DG independent failures.

| | | |
|---|---|---|
| IDA | = DAYTNK + ZTCB1T*TM | |
| DAYTNK | = ZTTK1B*TM | DG day tank ruptures during operation. |
| IV | = ND*(ZTVAOD + ZTSWLD + ZTVCOD) + (VCHK + VLCV)*TR + IVA | Total LCV train independent failures. |
| IVA | = (AIRRCV + VMAN + VPCV + FLINK)*TM | |
| DV | = ND*(DDVAOD + DDSWLD + DDVCOD) + 5.0*TV | LCV train double event failures. |
| TV | = ND*(TDVAOD + TDSWLD + TDVCOD) | LCV train triple event failures. |
| GV | = ND*(GDVAOD + GDSWLD + GDVCOD) | LCV train global event failures. |
| VCHK | = ZTVCOP | |
| VLCV | = ZTVAOT | |
| AIRRCV | = ZTTK1B | |
| VMAN | = ZTVHOT | |
| VPCV | = ZTVPCT | |
| FLINK | = ZTSPRI | |
| TR | = ND*(PSTOP - PSTART)/(FDR - FCR) | Run time for LCVs. |
| PSTOP | = 509 | Valve close level. |
| PSTART | = 252 | Valve open level. |
| FDR | = 55*60 | Pump fuel delivery rate. |
| FCR | = 3.2*60 | DG fuel consumption rate. |
| ND | = (5/6)*TM | No. of valve demands in time TM. |
| MN1 | = MD + MV - MV*MD | Total maintenance unavailability. |
| MD | = ZMDGSF*ZM2DGD | DG maintenance unavailability. |
| MV | = ZMGNDF*ZM2DGD | LCV maintenance unavailability. |
| ZM2DGD | = 8.0 | 8 hour tech. spec. given 2 DGs in maint. |
| TS1 | = TS1HE + TS2HE | Total DG unavailability due to surveillance test. |
| TS5 | = TS3HE | Unavailability of 5 DGs due to test error. |
| TS1HE | = TSD*TSF*HE1A + DT1*TSF*HE1B | Diesel unavailability due to auto control missalignment. |
| TS2HE | = DT2*TSF*HE2 | Diesel unavailability due to LCV missalignment. |
| TS3HE | = ZHDFO2*TS3F*ZHEFO2 | STP-V303: Misalignment of all LCV in stop position. |
| ZHEFO2 | = ZHEO1B | Human error of omission. |
| TS3F | = 1/2160 | STP-V303 testing frequency. |
| TIM | = 0.0 | DG test unavailability resulting from DG maintenance. |
| TM | = 6*ZDGSMT + 24*(1-ZDGSMT) | Mission time. |
| TSD | = 70/60 | DG test duration. |
| TSF | = 1/720.0 | DG test frequency. |
| DT1 | = ZHDDG1 | Discovery time for failure to restore auto control. |
| DT2 | = ZHDDG3 | D.T. for LCVs not in auto control. |
| HE1A | = ZHEDG1 | Human error to restore DG to auto control during test. |
| HE1B | = ZHEDG2 | Human error to restore DG to auto control after test. |
| HE2 | = ZHEDG3 | Human error to restore LCVs to auto control. |

|  |  |  |
|---|---|---|
| ZHEDG1 | = ZHED01 | Dynamic human error. |
| ZHEDG2 | = ZHEO1B | Human error of omission. |
| ZHEDG3 | = ZHEO1B |  |
| SEIST | = ZDGCPN + SEIS1 - ZDGCPN*SEIS1 | DG control panel. |
| SEIS1 | = ZDGEXC + SEIS2 - ZDGEXC*SEIS2 | DG excitation cubicle. |
| SEIS2 | = ZDGRWP + SEIS3 - ZDGRWP*SEIS3 | DG radiator/water pump. |
| SEIS3 | = ZDSLGN | Diesel Generator. |
| HEV | = ZHEFO6 | Operator action to manually operate LCVs. |
| ZDGFPM | = 0.0 |  |
| ZDGRWP | = 0.0 |  |
| ZDGEXC | = 0.0 |  |
| ZDGCPN | = 0.0 |  |
| ZDSLGN | = 0.0 |  |

**Figure A-4:** Equations Modified for One DG in Scheduled Maintenance (Seismic)
**Reference:** PGE.1123.2 RISKMAN3.PHASE3 SEISPH3B DGAOT.SYS SCHD/S.EQS

| | | | |
|---|---|---|---|
| GG5 | 1 GG3 | = P[1] | CSF for GG given: GF-B |
| GG5 | 2 TOTAL | = HWI1 + HWD1 + TS1 + MN1 + TS5 + TIM | Total for P[1]. See GF1 for breakdown of P[1]. |
| GHA | 1 GH4 | = (P[1]-P[2])/(1-P[1]) | CSF for GH given: GF-S/B, GG-B/S |
| GHA | 2 TOTAL | = HWI1 + HWD1 + TS1 + MN1 + TS5 + TIM | Total for P[1]. See GF1 for breakdown of P[1]. |
| GHB | 1 GH5 | = P[2]/P[1] | CSF for GH given: GF-F/B, GG-B/F |
| GHB | 2 TOTAL | = HWI2 + HWD2 + 2*TS1*HW1 + 2*MN1*HW1 + TS5 + 2*TIM*HW1 | Total for P[2]. |
| 2GI | 1 2G6 | = (P[2]-P[3])/(P[1]-P[2]) | CSF for 2G given: GF&GG-GH:S&FB/BF,F&BS/SB,B&FS/SF |
| 2GI | 2 TOTAL | = HWI2 + HWD2 + 2*TS1*HW1 + 2*MN1*HW1 + TS5 + 2*TIM*HW1 | Total for P[2]. See GG2 for breakdown of P[2]. |
| | P[1] | = TOT1 + SEIST - SEIST*TOT1 | Total single train unavailability. |
| | TOT1 | = HW1*F1 + MN1 + TS1 + TS5 + TIM | |
| | P[2] | = TOT2 + SEIST - SEIST*TOT2 | Total two train unavailability. |
| | TOT2 | = HW2*F2 + 2*MN1*HW1 + 2*TS1*HW1 + TS5 + 2*TIM*HW1 | |
| | P[3] | = TOT3 + SEIST - SEIST*TOT3 | Total three train unavailability. |
| | TOT3 | = HW3*F3 + 3*MN1*HW2 + 3*TS1*HW2 + TS5 + 3*TIM*HW2 | |
| | P[4] | = TOT4 + SEIST - SEIST*TOT4 | Total four train unavailability. |
| | TOT4 | = HW4*F4 + 4*MN1*HW3 + 4*TS1*HW3 + TS5 + 4*TIM*HW3 | |
| | P[5] | = TOT5 + SEIST - SEIST*TOT5 | Total five train unavailability. |
| | TOT5 | = HW5*F5 + (5*MN1-20*TIM)*HW4 + 5*TS1*HW4 + TS5 + 20*TIM*HW3 | (Not used for these split fractions) |
| | F1 | = (1 - MN1 - TS1 - TS5 + TIM) | Fraction of the time the system is in normal alignment. |
| | F2 | = (1 - 2*MN1 - 2*TS1 - TS5 + 2*TIM*HW1) | Fraction of the time the system is in normal alignment. |
| | F3 | = (1 - 3*MN1 - 3*TS1 - TS5 + 3*TIM*HW2) | Fraction of the time the system is in normal alignment. |
| | F4 | = (1 - 4*MN1 - 4*TS1 - TS5 + 4*TIM*HW3) | Fraction of the time the system is in normal alignment. |
| | F5 | = (1 - 5*MN1 - 5*TS1 - TS5) | Fraction of the time the system is in normal alignment. |
| | HW1 | = HWI1 + HWD1 | Single train total hardware failures. |
| | HW2 | = HWI2 + HWD2 | Two train total hardware failures. |
| | HW3 | = HWI3 + HWD3 | Three train total hardware failures. |
| | HW4 | = HWI4 + HWD4 | Four train total hardware failures. |
| | HW5 | = HWI5 + HWD5 | Five train total hardware failures. |
| | HWI1 | = 1*HEV*IV + 1*ID | Single train independent hardware failure. |
| | HWI2 | = 2*HEV*ID*IV + 1*HEV*IV*IV + 1*ID*ID | Two train independent hardware failure. |
| | HWI3 | = 3*HEV*ID*ID*IV + 3*HEV*ID*IV*IV + 1*HEV*IV*IV*IV + 1*ID*ID*ID$ | Three train independent hardware failure. |
| | HWI4 | = 4*HEV*ID*ID*ID*IV + 6*HEV*ID*ID*IV*IV + ZI401 | Four train independent hardware failure. |
| | ZI401 | = 4*HEV*ID*IV*IV*IV + 1*HEV*IV*IV*IV*IV + 1*ID*ID*ID*ID | |
| | HWI5 | = 5*HEV*ID*ID*ID*ID*IV + 10*HEV*ID*ID*ID*IV*IV + ZI501 | Five train independent hardware failure. |
| | ZI501 | = 10*HEV*ID*ID*IV*IV*IV + 5*HEV*ID*IV*IV*IV*IV + ZI502 | |
| | ZI502 | = 1*HEV*IV*IV*IV*IV*IV + 1*ID*ID*ID*ID*ID | |

HWD1 = 4*DV*HEV + 1*GD + 1*GV*HEV + 6*HEV*TV + 6*TD   Single train dependent hardware failures.

HWD2 = 1*DD + 9*DD*DD + 18*DD*DV*HEV + 6*DD*HEV*IV + ZD201   Two train dependent hardware failures.

ZD201 = 18*DD*HEV*TV + 6*DD*ID + 18*DD*TD + 9*DV*DV*HEV + ZD202

ZD202 = 1*DV*HEV + 6*DV*HEV*ID + 6*DV*HEV*IV + 18*DV*HEV*TD + ZD203

ZD203 = 18*DV*HEV*TV + 1*GD + 1*GV*HEV + 6*HEV*ID*TV + ZD204

ZD204 = 6*HEV*IV*TD + 6*HEV*IV*TV + 18*HEV*TD*TV + 3*HEV*TV + ZD205

ZD205 = 9*HEV*TV*TV + 6*ID*TD + 3*TD + 9*TD*TD

HWD3 = 8*DD*DD*DD + 24*DD*DD*DV*HEV + 12*DD*DD*HEV*IV + ZD301   Three train dependent hardware failures.

ZD301 = 12*DD*DD*HEV*TV + 12*DD*DD*ID + 12*DD*DD*TD + ZD302

ZD302 = 24*DD*DV*DV*HEV + 18*DD*DV*HEV + 24*DD*DV*HEV*ID + ZD303

ZD303 = 24*DD*DV*HEV*IV + 24*DD*DV*HEV*TD + ZD304

ZD304 = 24*DD*DV*HEV*TV + 12*DD*HEV*ID*IV + ZD305

ZD305 = 12*DD*HEV*ID*TV + 3*DD*HEV*IV + 6*DD*HEV*IV*IV + ZD306

ZD306 = 12*DD*HEV*IV*TD + 12*DD*HEV*IV*TV + ZD307

ZD307 = 12*DD*HEV*TD*TV + 27*DD*HEV*TV + 6*DD*HEV*TV*TV + ZD308

ZD308 = 3*DD*ID + 6*DD*ID*ID + 12*DD*ID*TD + 27*DD*TD + ZD309

ZD309 = 6*DD*TD*TD + 8*DV*DV*DV*HEV + 9*DV*DV*HEV + ZD310

ZD310 = 12*DV*DV*HEV*ID + 12*DV*DV*HEV*IV + ZD311

ZD311 = 12*DV*DV*HEV*TD + 12*DV*DV*HEV*TV + 3*DV*HEV*ID + ZD312

ZD312 = 6*DV*HEV*ID*ID + 12*DV*HEV*ID*IV + 12*DV*HEV*ID*TD + ZD313

ZD313 = 12*DV*HEV*ID*TV + 3*DV*HEV*IV + 6*DV*HEV*IV*IV + ZD314

ZD314 = 12*DV*HEV*IV*TD + 12*DV*HEV*IV*TV + 27*DV*HEV*TD + ZD315

ZD315 = 6*DV*HEV*TD*TD + 12*DV*HEV*TD*TV + 27*DV*HEV*TV + ZD316

ZD316 = 6*DV*HEV*TV*TV + 1*GD + 1*GV*HEV + 3*HEV*ID*ID*TV + ZD317

ZD317 = 6*HEV*ID*IV*TD + 12*HEV*ID*IV*TV + 6*HEV*ID*TV + ZD318

ZD318 = 3*HEV*ID*TV*TV + 3*HEV*IV*IV*TD + 3*HEV*IV*IV*TV + ZD319

ZD319 = 6*HEV*IV*TD + 3*HEV*IV*TD*TD + 6*HEV*IV*TD*TV + ZD320

ZD320 = 6*HEV*IV*TV + 6*HEV*IV*TV*TV + 36*HEV*TD*TV + ZD321

ZD321 = 3*HEV*TD*TV*TV + 1*HEV*TV + 18*HEV*TV*TV + ZD322

ZD322 = 1*HEV*TV*TV*TV + 3*ID*ID*TD + 6*ID*TD + 3*ID*TD*TD + ZD323

ZD323 = 1*TD + 18*TD*TD + 1*TD*TD*TD

HWD4 = 3*DD*DD + 22*DD*DD*DD + 1*DD*DD*DD*DD + ZD401   Four train dependent hardware failures.

ZD401 = 4*DD*DD*DD*DV*HEV + 4*DD*DD*DD*HEV*IV + ZD402

ZD402 = 4*DD*DD*DD*ID + 6*DD*DD*DV*DV*HEV + ZD403

ZD403 = 66*DD*DD*DV*HEV + 12*DD*DD*DV*HEV*ID + ZD404

ZD404 = 12*DD*DD*DV*HEV*IV + 12*DD*DD*HEV*ID*IV + ZD405

ZD405 = 24*DD*DD*HEV*IV + 6*DD*DD*HEV*IV*IV + ZD406

ZD406 = 42*DD*DD*HEV*TV + 24*DD*DD*ID + 6*DD*DD*ID*ID + ZD407

ZD407 = 42*DD*DD*TD + 4*DD*DV*DV*DV*HEV + 66*DD*DV*DV*HEV + ZD408

ZD408 = 24*DD*DV*DV*HEV*ID + 6*DD*DV*HEV + 48*DD*DV*HEV*ID + ZD409
ZD409 = 12*DD*DV*HEV*ID*ID + 24*DD*DV*HEV*ID*IV + ZD410
ZD410 = 48*DD*DV*HEV*IV + 12*DD*DV*HEV*IV*IV + ZD411
ZD411 = 84*DD*DV*HEV*TD + 84*DD*DV*HEV*TV + ZD412
ZD412 = 12*DD*HEV*ID*ID*IV + 12*DD*HEV*ID*IV + ZD413
ZD413 = 12*DD*HEV*ID*IV*IV + 36*DD*HEV*ID*TV + ZD414
ZD414 = 6*DD*HEV*IV*IV + 4*DD*HEV*IV*IV*IV + ZD415
ZD415 = 36*DD*HEV*IV*TD + 84*DD*HEV*IV*TV + 22*DD*HEV*TV + ZD416
ZD416 = 24*DD*HEV*TV*TV + 6*DD*ID*ID + 4*DD*ID*ID*ID + ZD417
ZD417 = 36*DD*ID*TD + 22*DD*TD + 24*DD*TD*TD + ZD418
ZD418 = 1*DV*DV*DV*DV*HEV + 22*DV*DV*DV*HEV + ZD419
ZD419 = 4*DV*DV*DV*HEV*ID + 4*DV*DV*DV*HEV*IV + ZD420
ZD420 = 3*DV*DV*HEV + 24*DV*DV*HEV*ID + 6*DV*DV*HEV*ID*ID + ZD421
ZD421 = 12*DV*DV*HEV*ID*IV + 24*DV*DV*HEV*IV + ZD422
ZD422 = 6*DV*DV*HEV*IV*IV + 42*DV*DV*HEV*TD + ZD423
ZD423 = 42*DV*DV*HEV*TV + 6*DV*HEV*ID*ID + ZD424
ZD424 = 4*DV*HEV*ID*ID*ID + 12*DV*HEV*ID*ID*IV + ZD425
ZD425 = 12*DV*HEV*ID*IV + 12*DV*HEV*ID*IV*IV + ZD426
ZD426 = 12*DV*HEV*ID*TD + 36*DV*HEV*ID*TV + 6*DV*HEV*IV*IV + ZD427
ZD427 = 4*DV*HEV*IV*IV*IV + 36*DV*HEV*IV*TD + ZD428
ZD428 = 36*DV*HEV*IV*TV + 22*DV*HEV*TD + 24*DV*HEV*TD*TD + ZD429
ZD429 = 48*DV*HEV*TD*TV + 22*DV*HEV*TV + 24*DV*HEV*TV*TV + ZD430
ZD430 = 1*GD + 1*GV*HEV + 6*HEV*ID*ID*TV + ZD431
ZD431 = 48*HEV*ID*IV*TD + 4*HEV*ID*TV + 12*HEV*ID*TV*TV + ZD432
ZD432 = 6*HEV*IV*IV*TD + 6*HEV*IV*IV*TV + 4*HEV*IV*TD + ZD433
ZD433 = 36*HEV*IV*TD*TD + 4*HEV*IV*TV + 24*HEV*IV*TV*TV + ZD434
ZD434 = 42*HEV*TD*TV + 12*HEV*TD*TV*TV + 21*HEV*TV*TV + ZD435
ZD435 = 4*HEV*TV*TV*TV + 6*ID*ID*TD + 4*ID*TD + 12*ID*TD*TD + ZD436
ZD436 = 21*TD*TD + 4*TD*TD*TD
HWD5 = 30*DD*DD*DD + 5*DD*DD*DD*DD + 20*DD*DD*DD*DV*HEV + ZD501 Five train dependent hardware failures.
ZD501 = 20*DD*DD*DD*HEV*IV + 20*DD*DD*DD*ID + ZD502
ZD502 = 30*DD*DD*DV*DV*HEV + 90*DD*DD*DV*HEV + ZD503
ZD503 = 60*DD*DD*DV*HEV*ID + 60*DD*DD*DV*HEV*IV + ZD504
ZD504 = 60*DD*DD*HEV*ID*IV + 15*DD*DD*HEV*IV + ZD505
ZD505 = 30*DD*DD*HEV*IV*IV + 90*DD*DD*HEV*TV + 15*DD*DD*ID + ZD506
ZD506 = 30*DD*DD*ID*ID + 90*DD*DD*TD + 20*DD*DV*DV*DV*HEV + ZD507
ZD507 = 90*DD*DV*DV*HEV + 60*DD*DV*DV*HEV*ID + ZD508
ZD508 = 60*DD*DV*DV*HEV*IV + 30*DD*DV*HEV*ID + ZD509
ZD509 = 60*DD*DV*HEV*ID*ID + 120*DD*DV*HEV*ID*IV + ZD510

ZD510 = 30*DD*DV*HEV*IV + 60*DD*DV*HEV*IV*IV + ZD511
ZD511 = 180*DD*DV*HEV*TD + 180*DD*DV*HEV*TV + ZD512
ZD512 = 30*DD*HEV*ID*ID*IV + 30*DD*HEV*ID*IV*IV + ZD513
ZD513 = 60*DD*HEV*ID*TV + 10*DD*HEV*IV*IV*IV + ZD514
ZD514 = 120*DD*HEV*IV*TD + 120*DD*HEV*TD*TV + 10*DD*HEV*TV + ZD515
ZD515 = 60*DD*HEV*TV*TV + 10*DD*ID*ID*ID + 60*DD*ID*TD + ZD516
ZD516 = 10*DD*TD + 60*DD*TD*TD + 5*DV*DV*DV*DV*HEV + ZD517
ZD517 = 30*DV*DV*DV*HEV + 20*DV*DV*DV*HEV*ID + ZD518
ZD518 = 20*DV*DV*DV*HEV*IV + 15*DV*DV*HEV*ID + ZD519
ZD519 = 30*DV*DV*HEV*ID*ID + 60*DV*DV*HEV*ID*IV + ZD520
ZD520 = 15*DV*DV*HEV*IV + 30*DV*DV*HEV*IV*IV + ZD521
ZD521 = 90*DV*DV*HEV*TD + 90*DV*DV*HEV*TV + ZD522
ZD522 = 10*DV*HEV*ID*ID*ID + 30*DV*HEV*ID*ID*IV + ZD523
ZD523 = 30*DV*HEV*ID*IV*IV + 60*DV*HEV*ID*TD + ZD524
ZD524 = 60*DV*HEV*ID*TV + 10*DV*HEV*IV*IV*IV + ZD525
ZD525 = 60*DV*HEV*IV*TD + 60*DV*HEV*IV*TV + 10*DV*HEV*TD + ZD526
ZD526 = 60*DV*HEV*TD*TD + 120*DV*HEV*TD*TV + 10*DV*HEV*TV + ZD527
ZD527 = 60*DV*HEV*TV*TV + 1*GD + 1*GV*HEV + ZD528
ZD528 = 10*HEV*ID*ID*TV + 20*HEV*ID*IV*TD + ZD529
ZD529 = 20*HEV*ID*IV*TV + 60*HEV*ID*TD*TV + ZD530
ZD530 = 30*HEV*ID*TV*TV + 10*HEV*IV*IV*TD + ZD531
ZD531 = 10*HEV*IV*IV*TV + 30*HEV*IV*TD*TD + ZD532
ZD532 = 60*HEV*IV*TD*TV + 30*HEV*IV*TV*TV + ZD533
ZD533 = 30*HEV*TD*TD*TV + 30*HEV*TD*TV + 30*HEV*TD*TV*TV + ZD534
ZD534 = 15*HEV*TV*TV + 10*HEV*TV*TV*TV + 10*ID*ID*TD + ZD535
ZD535 = 30*ID*TD*TD + 15*TD*TD + 10*TD*TD*TD
DD = D5DGSS + D5DGS1 + D5DGS2*(TM-1) + D5CB1C + D5RL1D + D5RL1D    All DG double event failures.
TD = T5DGSS + T5DGS1 + T5DGS2*(TM-1) + T5CB1C + T5RL1D + T5RL1D    All DG triple event failures.
GD = G5DGSS + G5DGS1 + G5DGS2*(TM-1) + G5CB1C + G5RL1D + G5RL1D    All DG global event failures.
ID = S5DGSS + S5DGS1 + S5DGS2*(TM-1) + S5CB1C + S5RL1D + S5RL1D + IDA    Total DG independent failures.
IDA = DAYTNK + ZTCB1T*TM
DAYTNK = ZTTK1B*TM    DG day tank ruptures during operation.
IV = ND*(ZTVAOD + ZTSWLD + ZTVCOD) + (VCHK + VLCV)*TR + IVA    Total LCV train independent failures.
IVA = (AIRRCV + VMAN + VPCV + FLINK)*TM
DV = ND*(DDVAOD + DDSWLD + DDVCOD) + 5.0*TV    LCV train double event failures.
TV = ND*(TDVAOD + TDSWLD + TDVCOD)    LCV train triple event failures.
GV = ND*(GDVAOD + GDSWLD + GDVCOD)    LCV train global event failures.
VCHK = ZTVCOP
VLCV = ZTVAOT

| | | |
|---|---|---|
| AIRRCV | = ZTTK1B | |
| VMAN | = ZTVHOT | |
| VPCV | = ZTVPCT | |
| FLINK | = ZTSPRI | |
| TR | = ND*(PSTOP - PSTART)/(FDR - FCR) | Run time for LCVs. |
| PSTOP | = 509 | Valve close level. |
| PSTART | = 252 | Valve open level. |
| FDR | = 55*60 | Pump fuel delivery rate. |
| FCR | = 3.2*60 | DG fuel consumption rate. |
| ND | = (5/6)*TM | No. of valve demands in time TM. |
| MN1 | = MD + MV - MV*MD | Total maintenance unavailability. |
| MD | = ZMDGSF*ZM2DGD | DG maintenance unavailability. |
| MV | = ZMGNDF*ZM2DGD | LCV maintenance unavailability. |
| ZM2DGD | = 8.0 | 8 hour tech. spec. given 2 DGs in maint. |
| TS1 | = 0.0 | Included in TIM term for the AOT split fractions. |
| TS1 | = TS1HE + TS2HE | Total DG unavailability due to surveillance test. |
| TS5 | = TS3HE | Unavailability of 5 DGs due to test error. |
| TS1HE | = TSD*TSF*HE1A + DT1*TSF*HE1B | Diesel unavailability due to auto control missalignment. |
| TS2HE | = DT2*TSF*HE2 | Diesel unavailability due to LCV missalignment. |
| TS3HE | = ZHDFO2*TS3F*ZHEFO2 | STP-V303: Misalignment of all LCV in stop position. |
| ZHEFO2 | = ZHEO1B | Human error of omission. |
| TS3F | = 1/2160 | STP-V303 testing frequency. |
| TIM | = 0.0 | DG test unavailability resulting from DG maintenance. |
| TM | = 24 | Mission time (for ATWS events). |
| TSD | = 70/60 | DG test duration. |
| TSF | = 1/720.0 | DG test frequency. |
| DT1 | = ZHDDG1 | Discovery time for failure to restore auto control. |
| DT2 | = ZHDDG3 | D.T. for LCVs not in auto control. |
| HE1A | = ZHEDG1 | Human error to restore DG to auto control during test. |
| HE1B | = ZHEDG2 | Human error to restore DG to auto control after test. |
| HE2 | = ZHEDG3 | Human error to restore LCVs to auto control. |
| ZHEDG1 | = ZHED01 | Dynamic human error. |
| ZHEDG2 | = ZHEO1B | Human error of omission. |
| ZHEDG3 | = ZHEO1B | |
| SEIST | = ZDGCPN + SEIS1 - ZDGCPN*SEIS1 | DG control panel. |

|  |  |  |
|---|---|---|
| SEIS1 | = ZDGEXC + SEIS2 - ZDGEXC*SEIS2 | DG excitation cubicle. |
| SEIS2 | = ZDGRWP + SEIS3 - ZDGRWP*SEIS3 | DG radiator/water pump. |
| SEIS3 | = ZDSLGN | Diesel Generator. |
| HEV | = ZHEFO6 | Operator action to manually operate LCVs. |
| ZDGFPM | = 0.0 |  |
| ZDGRWP | = 0.0 |  |
| ZDGEXC | = 0.0 |  |
| ZDGCPN | = 0.0 |  |
| ZDSLGN | = 0.0 |  |

**APPENDIX B:** REDUCED CORE DAMAGE SEQUENCE MODEL
**Figure B-1:** Reduced Sequence Model (Internals and Externals, No Seismic)
**Reference:** PGE.1123 EVENT.TREES INTERNALS RMODEL DGAOT BASE.MODEL CDFREQ.EQS

CDF 1 TOTAL = TOTAL1*(0.000607/0.0006229)
CDF 1 TOTAL1 = SEQ001 + SEQ002 + SEQ003 + SEQ004 + SEQ005 + SEQ006 + SEQ007 + X1
CDF 1 X1 = SEQ008 + SEQ009 + SEQ010 + SEQ011 + SEQ012 + SEQ013 + SEQ014 + X2
CDF 1 X2 = SEQ015 + SEQ016 + SEQ017 + SEQ018 + SEQ019 + SEQ020 + SEQ021 + X3
CDF 1 X3 = SEQ022 + SEQ023 + SEQ024 + SEQ025 + SEQ026 + SEQ027 + SEQ028 + X4
CDF 1 X4 = SEQ029 + SEQ030 + SEQ031 + SEQ032 + SEQ033 + SEQ034 + SEQ035 + X5
CDF 1 X5 = SEQ036 + SEQ037 + SEQ038 + SEQ039 + SEQ040 + SEQ041 + SEQ042 + X6
CDF 1 X6 = SEQ043 + SEQ044 + SEQ045 + SEQ046 + SEQ047 + SEQ048 + SEQ049 + X7
CDF 1 X7 = SEQ050 + SEQ051 + SEQ052 + SEQ053 + SEQ054 + SEQ055 + SEQ056 + X8
CDF 1 X8 = SEQ057 + SEQ058 + SEQ059 + SEQ060 + SEQ061 + SEQ062 + SEQ063 + X9
CDF 1 X9 = SEQ064 + SEQ065 +SEQ066 + SEQ067 + SEQ068 + SEQ069 + SEQ070 + X10
CDF 1 X10 = SEQ071 + SEQ072 + SEQ073 + SEQ074 + SEQ075 + SEQ076 + SEQ077 + X11
CDF 1 X11 = SEQ078 + SEQ079 + SEQ080 + SEQ081 + SEQ082 + SEQ083 + SEQ084 + X12
CDF 1 X12 = SEQ085 + SEQ086 + SEQ087 + SEQ088 + SEQ089 + SEQ090 + SEQ091 + X13
CDF 1 X13 = SEQ092 + SEQ093 + SEQ094 + SEQ095 + SEQ096 + SEQ097 + SEQ098 + X14
CDF 1 X14 = SEQ099 + SEQ100 + SEQ101 + SEQ102 + SEQ103 + SEQ104 + SEQ105 + X15
CDF 1 X15 = SEQ106 + SEQ107 + SEQ108 + SEQ109 + SEQ110 + SEQ111 + SEQ112 + X16
CDF 1 X16 = SEQ113 + SEQ114 + SEQ115 + SEQ116 + SEQ117 + SEQ118 + SEQ119 + X17
CDF 1 X17 = SEQ120 + SEQ121 + SEQ122 + SEQ123 + SEQ124 + SEQ125 + SEQ126 + X18
CDF 1 X18 = SEQ127 + SEQ128 + SEQ129 + SEQ130 + SEQ131 + SEQ132 + SEQ133 + X19
CDF 1 X19 = SEQ134 + SEQ135 + SEQ136 + SEQ137 + SEQ138 + SEQ139 + SEQ140 + X20
CDF 1 X20 = SEQ141 + SEQ142 + SEQ143 + SEQ144 + SEQ145 + SEQ146 + SEQ147 + X21
CDF 1 X21 = SEQ148 + SEQ149 + SEQ150 + SEQ151 + SEQ152 + SEQ153 + SEQ154 + X22
CDF 1 X22 = SEQ155 + SEQ156 + SEQ157 + SEQ158 + SEQ159 + SEQ160 + SEQ161 + X23
CDF 1 X23 = SEQ162 + SEQ163 + SEQ164 + SEQ165 + SEQ166 + SEQ167 + SEQ168 + X24
CDF 1 X24 = SEQ169 + SEQ170 + SEQ171 + SEQ172 + SEQ173 + SEQ174 + SEQ175 + X25
CDF 1 X25 = SEQ176 + SEQ177 + SEQ178 + SEQ179 + SEQ180 + SEQ181 + SEQ182 + X26
CDF 1 X26 = SEQ183 + SEQ184 + SEQ185 + SEQ186 + SEQ187 + SEQ188 + SEQ189 + X27
CDF 1 X27 = SEQ190 + SEQ191 + SEQ192 + SEQ193 + SEQ194 + SEQ195 + SEQ196 + X28
CDF 1 X28 = SEQ197 + SEQ198 + SEQ199 + SEQ200 + SEQ201 + SEQ202 + SEQ203 + X29
CDF 1 X29 = SEQ204 + SEQ205 + SEQ206 + SEQ207 + SEQ208 + SEQ209 + SEQ210 + X30
CDF 1 X30 = SEQ211 + SEQ212 + SEQ213 + SEQ214 + SEQ215 + SEQ216 + SEQ217 + X31
CDF 1 X31 = SEQ218 + SEQ219 + SEQ220 + SEQ221 + SEQ222 + SEQ223 + SEQ224 + X32

```
CDF        1 X32      =SEQ225+SEQ226+SEQ227+SEQ228+SEQ229+SEQ230+SEQ231+X33
CDF        1 X33      =SEQ232+SEQ233+SEQ234+SEQ235+SEQ236+SEQ237+SEQ238+X34
CDF        1 X34      =SEQ239+SEQ240+SEQ241+SEQ242+SEQ243+SEQ244+SEQ245+X35
CDF        1 X35      =SEQ246+SEQ247+SEQ248+SEQ249+SEQ250+SEQ251+SEQ252+X36
CDF        1 X36      =SEQ253+SEQ254+SEQ255+SEQ256+SEQ257+SEQ258+SEQ259+X37
CDF        1 X37      =SEQ260+SEQ261+SEQ262+SEQ263+SEQ264+SEQ265+SEQ266+X38
CDF        1 X38      =SEQ267+SEQ268+SEQ269+SEQ270+SEQ271+SEQ272+SEQ273+X39
CDF        1 X39      =SEQ274+SEQ275+SEQ276+SEQ277+SEQ278+SEQ279+SEQ280+X40
CDF        1 X40      =SEQ281+SEQ282+SEQ283+SEQ284+SEQ285+SEQ286+SEQ287+X41
CDF        1 X41      =SEQ288+SEQ289+SEQ290+SEQ291+SEQ292+SEQ293+SEQ294+X42
CDF        1 X42      =SEQ295+SEQ296+SEQ297+SEQ298+SEQ299+SEQ300+SEQ301+X43
CDF        1 X43      =SEQ302+SEQ303+SEQ304+SEQ305+SEQ306+SEQ307+SEQ308+X44
CDF        1 X44      =SEQ309+SEQ310+SEQ311+SEQ312+SEQ313+SEQ314+SEQ315+X45
CDF        1 X45      =SEQ316+SEQ317+SEQ318+SEQ319+SEQ320+SEQ321+SEQ322+X46
CDF        1 X46      =SEQ323+SEQ324+SEQ325+SEQ326+SEQ327+SEQ328+SEQ329+X47
CDF        1 X47      =SEQ330+SEQ331+SEQ332+SEQ333+SEQ334+SEQ335+SEQ336+X48
CDF        1 X48      =SEQ337+SEQ338+SEQ339+SEQ340+SEQ341+SEQ342+SEQ343+X49
CDF        1 X49      =SEQ344+SEQ345+SEQ346+SEQ347+SEQ348+SEQ349+SEQ350+X50
CDF        1 X50      =SEQ351+SEQ352+SEQ353+SEQ354+SEQ355+SEQ356+SEQ357+X51
CDF        1 X51      =SEQ358+SEQ359+SEQ360+SEQ361+SEQ362+SEQ363+SEQ364+X52
CDF        1 X52      =SEQ365+SEQ366+SEQ367+SEQ368+SEQ369+SEQ370+SEQ371+X53
CDF        1 X53      =SEQ372+SEQ373+SEQ374+SEQ375+SEQ376+SEQ377+SEQ378+X54
CDF        1 X54      =SEQ379+SEQ380+SEQ381+SEQ382+SEQ383+SEQ384+SEQ385+X55
CDF        1 X55      =SEQ386+SEQ387+SEQ388+SEQ389+SEQ390+SEQ391+SEQ392+X56
CDF        1 X56      =SEQ393+SEQ394+SEQ395+SEQ396+SEQ397+SEQ398+SEQ399+X57
CDF        1 X57      =SEQ400+SEQ401+SEQ402+SEQ403+SEQ404+SEQ405+SEQ406+X58
CDF        1 X58      =SEQ407+SEQ408+SEQ409+SEQ410+SEQ411+SEQ412+SEQ413+X59
CDF        1 X59      =SEQ414+SEQ415+SEQ416+SEQ417+SEQ418+SEQ419+SEQ420+OTHER
CDF        2 SEQ001   =LOSWV *IAF*SVF*(RF4S*CI1S*SI1S*OG1S*SA1S*SB1S)*ZHESV3
CDF        3 SEQ002   =L1DC *DGF*I2F*AW7*OB3*(RF4S*CI1S)*ZHEAW3
CDF        4 SEQ003   =LOOP *OGF*GF1*GG2*GH3*CVF*ASF*RESLC2
CDF        5 SEQ004   =SLOCN *IAF*LA1*LB2*(CI1S)*MU2
CDF        6 SEQ005   =LOOP *OGF*GF1*GH2*IAF*AW4*(GG2S*TG3S*TH3S)*RESLC1*REOB1
CDF        7 SEQ006   =L1DC *DGF*I2F*CC3*(RF4S)*ZHERP2
CDF        8 SEQ007   =LOOP *OGF*GF1*GG2*TG3*IAF*ASF*(GH3S*TH4S)*RESLC2
CDF        9 SEQ008   =LOOP *OGF*FO1*CVF*ASF*(GF1S*GG1S*GH1S*TG1S*TH1S)*RSEQ8
CDF        10 SEQ009  =LOOP *OGF*GG1*GH2*IAF*PRD*(GF1S)*ZHERE2*REAC06
```

```
CDF          11 SEQ010 = LOOP *OGF*GH1*TG2*SW1*IAF*AW4*(GF1S*GG1S*TH2S)*RSEQ10
CDF          12 SEQ011 = LOOP *OGF*GH1*TH2*SW1*IAF*AW4*(GF1S*GG1S*TG2S)*RSEQ10
CDF          13 SEQ012 = FS1  *IAF*AW4*OB1*(RF4S)
CDF          14 SEQ013 = LOOP *OGF*SW1*IAF*SV2*(GF1S*GG1S*GH1S*TG1S*TH1S)*ZHESV3
CDF          15 SEQ014 = SLBO *IAF*MS2*AW8*OB1*(RF4S)*(AW3 + ZHEAW4)
CDF          16 SEQ015 = LOOP *OGF*GF1*GG2*IAF*CC5*(GH3S*TG3S*TH3S)*ZHERE2*RESLC3
CDF          17 SEQ016 = RT   *DH1*I3F*AW8*(RF4S*CI1S)
CDF          18 SEQ017 = LOOP *OGF*GF1*GG2*IAF*ASB*(GH3S*TG3S*TH3S)*RESLC2
CDF          19 SEQ018 = TT   *DH1*I3F*AW8*(RF4S*CI1S)
CDF          20 SEQ019 = FS8  *AFF*AGF*AHF*IAF*CCF
CDF          21 SEQ020 = RT   *DG1*I2F*AW7*(RF4S)*ZHEOB2
CDF          22 SEQ021 = RT   *IAF*HS1*(RF4S*CI1S)
CDF          23 SEQ022 = TT   *DG1*I2F*AW7*(RF4S)*ZHEOB2
CDF          24 SEQ023 = TT   *IAF*HS1*(RF4S*CI1S)
CDF          25 SEQ024 = LOOP *OGF*GH1*IAF*AW3*(GF1S*GG1S*TG2S*TH2S)*RSEQ24
CDF          26 SEQ025 = LOOP *OGF*GG1*TH2*FO4*CVF*ASF*(GF1S*GH2S*TG2S)*RSEQ25
CDF          27 SEQ026 = LOSWV *IAF*SVF*RF4*(CI1S*SI1S)*ZHESV3
CDF          28 SEQ027 = L1DC *DGF*I2F*AW7*OB3*RF4*(CI1S)*ZHEAW3
CDF          29 SEQ028 = PLMFW *DH1*I3F*AW8*(RF4S*CI1S)
CDF          30 SEQ029 = LOOP *OGF*GH1*IAF*PRD*LA1*REAC06
CDF          31 SEQ030 = LOOP *OGF*GG1*IAF*PRD*LB3*(GF1S*GH2S*TG2S*TH2S)*REAC06
CDF          32 SEQ031 = SLBO *DG1*I2F*MS2*(RF4S*CI1S)*(ZHEAW4 + AW7)
CDF          33 SEQ032 = SLBO *DH1*I3F*MS2*(RF4S*CI1S)*(ZHEAW4 + AW8)
CDF          34 SEQ033 = SLBO *AH1*IAF*MS2*(RF4S*CI1S)*(ZHEAW4 + AW3)
CDF          35 SEQ034 = LOOP*OGF*GG1*TG2*SW1*IAF*CC5*GF1S*GH2S*TH3S*RSEQ34
CDF          36 SEQ035 = RT   *IAF*AW1*OB1*(RF4S*CI1S)
CDF          37 SEQ036 = PLMFW *DG1*I2F*AW7*(RF4S)*ZHEOB2
CDF          38 SEQ037 = PLMFW *IAF*HS1*(RF4S*CI1S)
CDF          39 SEQ038 = FS11 *IAF*ASF*RP2*SE1
CDF          40 SEQ039 = LOOP*OGF*GG1*TG2*SW1*IAF*ASB*GF1S*GH2S*TH3S*RSEQ34
CDF          41 SEQ040 = TT   *IAF*AW1*OB1
CDF          42 SEQ041 = RT   *IAF*SV1*(RF4S*CI1S*SI1S)*ZHESV3
CDF          43 SEQ042 = L1DC *DGF*I2F*AS3*(RF4S)*ZHERP2
CDF          44 SEQ043 = LOOP *OGF*SW1*IAF*AW3*OB1*AW1/AW3*(ZHESW1 + AW3)
CDF          45 SEQ044 = FS1  *IAF*AW4*VI2
CDF          46 SEQ045 = TT   *IAF*SV1*(RF4S*CI1S*SI1S)*ZHESV3
CDF          47 SEQ046 = LPCC *IAF*ASF*RP2*SE1
```

```
CDF        48 SEQ047 =LOOP *OGF*GF1*GG2*GH3*CVF*ASF*AW4*RESLC1
CDF        49 SEQ048 =PLMFW *IAF*AW1*OB1
CDF        50 SEQ049 =SLBO *IAF*MS2*AW8*VI2*(AW3 + ZHEAW4)
CDF        51 SEQ050 =L1DC *DGF*I2F*AW7*VI2
CDF        52 SEQ051 =L1DC *DGF*I2F*AW7*LB3*MU2
CDF        53 SEQ052 =PLMFW *IAF*SV1*(RF4S*CI1S*SI1S)*ZHESV3
CDF        54 SEQ053 =MLOCA *IAF*RF3
CDF        55 SEQ054 =LOOP *OGF*GF1*GH2*IAF*SV5*ZHESV3
CDF        56 SEQ055 =MLOCA *IAF*LA3*LB2
CDF        57 SEQ056 =LOOP *OGF*GH1*TH2*FO2*CVF*ASF*RSEQ25
CDF        58 SEQ057 =LOOP *OGF*GG1*TG2*FO2*CVF*ASF*RSEQ25
CDF        59 SEQ058 =LOOP *OGF*GF1*GH2*TG3*IAF*AW4*REOB1*RESLC1
CDF        60 SEQ059 =LOOP *OGF*GF1*GH2*TH3*IAF*AW4*REOB1*RESLC1
CDF        61 SEQ060 =LOOP *OGF*GH1*TG2*TH3*SW3*IAF*AW4*REOB1*RESLC1
CDF        62 SEQ061 =FS9  *IAF*OB1
CDF        63 SEQ062 =LOOP *OGF*GG1*GH2*TG3*TH4*CVF*ASF*RESLC2
CDF        64 SEQ063 =MLOCA *IAF*SI1*2*CH2
CDF        65 SEQ064 =LOOP *OGF*GF1*GG2*TG3*TH4*IAF*ASF*RESLC2
CDF        66 SEQ065 =EXFW *DH1*I3F*AW8
CDF        67 SEQ066 =LOOP *OGF*FO1*CVF*ASF*AW4*ZHEFO6*RESLC1
CDF        68 SEQ067 =LOOP *OGF*GF1*GG2*GH3*CVF*ASF*PRD
CDF        69 SEQ068 =LOOP *OGF*IAF*SV4*(SW1S*RF4S*CI1S*SI1S)*ZHESV3
CDF        70 SEQ069 =LOSW *IAF*ASF*RP2*SE1
CDF        71 SEQ070 =LOOP *OGF*GG1*FO3*CVF*ASF*RSEQ25
CDF        72 SEQ071 =LOOP *OGF*TH1*FO3*CVF*ASF*RSEQ25
CDF        73 SEQ072 =LLOCA *IAF*AC1
CDF        74 SEQ073 =EXFW *DG1*I2F*AW7*ZHEOB2
CDF        75 SEQ074 =EXFW *IAF*HS1
CDF        76 SEQ075 =SGTR *IAF*SL1*MU1
CDF        77 SEQ076 =LOOP *OGF*GF1*GH2*IAF*AW4*PRD
CDF        78 SEQ077 =FS1  *DG1*I2F
CDF        79 SEQ078 =LOOP *OGF*GH1*IAF*SV2*ZHESV3*REAC12
CDF        80 SEQ079 =LOOP *OGF*TG1*SW3*IAF*SV2*ZHESV3*REAC12
CDF        81 SEQ080 =LOOP *OGF*TH1*SW3*IAF*SV2*ZHESV3*REAC12
CDF        82 SEQ081 =LOOP *OGF*GF1*IAF*SV2*ZHESV3*REAC12
CDF        83 SEQ082 =LOOP *OGF*GF1*GG2*TG3*CV3*ASF*RESLC2
CDF        84 SEQ083 =L1DC *DGF*I2F*AW7*OB3*LB1*(RF4S)*ZHEAW3
```

```
CDF      85 SEQ084  =RT    *AH1*IAF*AW3*REOB1
CDF      86 SEQ085  =LOOP  *OGF*GF1*GG2*TG3*IAF*ASF*PRD
CDF      87 SEQ086  =RT    *IAF*AW1*VI2
CDF      88 SEQ087  =MLOCA *IAF*VI3
CDF      89 SEQ088  =LOOP  *OGF*GH1*TG2*SW1*IAF*SV5*ZHESV3
CDF      90 SEQ089  =L1DC  *DGF*I2F*AW7*OB3*CS2*(RF4S)*ZHEAW3
CDF      91 SEQ090  =FS11  *IAF*ASF*(RP2S)
CDF      92 SEQ091  =LOOP  *OGF*GG1*GH2*TH3*CVF*PRD
CDF      93 SEQ092  =L1DC  *DGF*I2F*AW7*CH2*OB3*ZHEAW3
CDF      94 SEQ093  =LOOP  *OGF*GH1*IAF*PRD*HRD*REAC06
CDF      95 SEQ094  =TT    *AH1*IAF*AW3*REOB1
CDF      96 SEQ095  =LOOP  *OGF*GG1*GH2*TG3*IAF*PRD*REAC06
CDF      97 SEQ096  =L1DC  *DGF*DH2*I2F*I3F*I4F*AWA
CDF      98 SEQ097  =LOOP  *OGF*GH1*TH2*SW1*IAF*SV5*ZHESV3*REAC12
CDF      99 SEQ098  =TT    *IAF*AW1*VI2
CDF         SEQ099  =L1DC  *DGF*AH4*I2F*I4F*AWA
CDF         SEQ100  =LOOP  *OGF*GH1*IAF*PRD*VA1*REAC06
CDF         SEQ101  =SGTR  *IAF*SL1*LA1*LB2
CDF         SEQ102  =LOOP  *OGF*SW1*IAF*AW3*VI2
CDF         SEQ103  =LLOCA *IAF*RF3
CDF         SEQ104  =EXFW  *IAF*AW1*OB1
CDF         SEQ105  =LOOP  *OGF*GG1*IAF*PRD*VB1
CDF         SEQ106  =LOOP  *OGF*GH1*FO1*CVF*ASF
CDF         SEQ107  =LOOP  *OGF*TG1*FO1*CVF*ASF
CDF         SEQ108  =LOOP  *OGF*GF1*FO1*CVF*ASF
CDF         SEQ109  =LPCC  *IAF*ASF*(RP2S)
CDF         SEQ110  =LOOP  *OGF*GG1*GH2*TH3*FO5*CVF*ASF
CDF         SEQ111  =LOOP  *OGF*GG1*TG2*TH3*FO5*CVF*ASF
CDF         SEQ112  =LOOP  *OGF*GG1*IAF*PRD*HRB
CDF         SEQ113  =EXFW  *IAF*SV1
CDF         SEQ114  =LOOP  *OGF*FO1*CVF*ASF*PRD
CDF         SEQ115  =LOPF  *DH1*I3F*AW8
CDF         SEQ116  =LOOP  *OGF*GG1*GH2*CV3*PRD
CDF         SEQ117  =PLMFW *AH1*IAF*AW3
CDF         SEQ118  =FS1   *IAF*AW4*OB1*RF4
CDF         SEQ119  =RT    *DG1*I2F*CC3
CDF         SEQ120  =PLMFW *IAF*AW1*VI2
```

```
CDF     SEQ121   =LOOP *OGF*GH1*SW2*IAF*AW4
CDF     SEQ122   =LOOP *OGF*GF1*GH2*IAF*CC5*AW4
CDF     SEQ123   =SLBI *IAF*AWB*RP2*OB1
CDF     SEQ124   =RT   *DH1*I3F*CC2
CDF     SEQ125   =FS1  *IAF*AW4*LA1*LB2
CDF     SEQ126   =LOOP *OGF*GH1*TG2*SW1*IAF*AW4*PRD
CDF     SEQ127   =L1DC *DGF*DH2*I2F*I3F*I4F*AWA*OB3
CDF     SEQ128   =TT   *DG1*I2F*CC3
CDF     SEQ129   =IMSIV *DH1*I3F*AW8
CDF     SEQ130   =L1DC *DGF*AH4*I2F*I4F*AWA*OB3
CDF     SEQ131   =LOOP *OGF*SW1*IAF*SV2*RF4
CDF     SEQ132   =LOOP *OGF*GH1*TH2*SW1*IAF*AW4*PRD
CDF     SEQ133   =L1DC *DF1*DGF*I1F*I2F*MS2*AWA*OB3
CDF     SEQ134   =TT   *DH1*I3F*CC2
CDF     SEQ135   =L1DC *DGF*I2F*AW7*OB3*SR2
CDF     SEQ136   =L1DC *DGF*AF1*I2F*AWA*OB3
CDF     SEQ137   =TLMFW *DH1*I3F*AW8
CDF     SEQ138   =VSI  *IAF*IT1*ME1
CDF     SEQ139   =LOPF *DG1*I2F*AW7
CDF     SEQ140   =LOPF *IAF*HS1
CDF     SEQ141   =LOSWV *SA1*SVF
CDF     SEQ142   =LOSWV *SB1*SVF
CDF     SEQ143   =L1DC *DF1*DGF*I1F*I2F*CC5*MS2
CDF     SEQ144   =SLBO *IAF*MS2*AWB*OB1*RF4
CDF     SEQ145   =SLOCI *IAF*PRN*LA1*LB2
CDF     SEQ146   =LOOP *OGF*GF1*GG2*TH3*IAF*CC5
CDF     SEQ147   =LCV  *DH1*I3F*AW8
CDF     SEQ148   =L1DC *DGF*I2F*SB1*AW7*OB3
CDF     SEQ149   =IMSIV *IAF*HS1
CDF     SEQ150   =L1DC *DGF*AF1*I2F*CC5
CDF     SEQ151   =IMSIV *DG1*I2F*AW7
CDF     SEQ152   =FS9  *IAF*VI2
CDF     SEQ153   =SLBI *SA5*SBE*OSF*MS2
CDF     SEQ154   =SLBO *I31*MS2*OB1
CDF     SEQ155   =L1DC *DGF*DH2*I2F*I3F*I4F*CC4
CDF     SEQ156   =SLBO *I11*MS2*OB1
CDF     SEQ157   =LOOP *OGF*DH1*GF1*I3F*AW9
```

```
CDF        SEQ158    =SLBO  *IAF*MS2*AWB*LA1*LB2
CDF        SEQ159    =LOOP  *OGF*GH1*TH2*SW1*CV6*AW4
CDF        SEQ160    =L1DC  *DGF*AH4*I2F*I4F*CC4
CDF        SEQ161    =LOOP  *OGF*GG1*TH2*FO4*CVF*ASF*AW4
CDF        SEQ162    =RT    *DF1*I1F*AW8*OB1
CDF        SEQ163    =TLMFW *DG1*I2F*AW7
CDF        SEQ164    =LOOP  *OGF*GF1*GG2*TH3*IAF*ASB
CDF        SEQ165    =TLMFW *IAF*HS1
CDF        SEQ166    =LOOP  *OGF*DF1*GH1*I1F*AW9
CDF        SEQ167    =MLOCA *SA2*SB6*OSF
CDF        SEQ168    =LOOP  *OGF*GH1*IAF*PRD*RF1
CDF        SEQ169    =LOOP  *OGF*GG1*GH2*SW2*IAF*CCF
CDF        SEQ170    =SGTR  *IAF*OP1*VI5
CDF        SEQ171    =SLBI  *SBC*OSF*RP2*OB1
CDF        SEQ172    =SLBI  *SA5*OSF*RP2*OB1
CDF        SEQ173    =L1DC  *DGF*I2F*AW7*VB1
CDF        SEQ174    =LOOP  *OGF*GG1*IAF*PRD*RF1
CDF        SEQ175    =PLMFW *DG1*I2F*CC3
CDF        SEQ176    =TT    *DF1*I1F*AW8*OB1
CDF        SEQ177    =LOCV  *DH1*I3F*CVF*AW8
CDF        SEQ178    =RT    *I31*AW5*OB1
CDF        SEQ179    =LOCV  *CVF*RT1*OSF
CDF        SEQ180    =RT    *DH1*I3F*AW8*RF4
CDF        SEQ181    =RT    *I11*AW5*OB1
CDF        SEQ182    =ISI   *DH1*I3F*AW8
CDF        SEQ183    =L1DC  *DGF*I2F*AW7*HRB
CDF        SEQ184    =PLMFW *DH1*I3F*CC2
CDF        SEQ185    =LOOP  *OGF*BG1*GF1*GG2*IAF*ASF
CDF        SEQ186    =FS6   *AFF*AGF*IAF*CC5*RP2
CDF        SEQ187    =RT    *SA1*SB2*RT7*OSF
CDF        SEQ188    =LCV   *DG1*I2F*AW7
CDF        SEQ189    =LOSW  *IAF*ASF*(RP2S)
CDF        SEQ190    =LCV   *IAF*HS1
CDF        SEQ191    =LOOP  *OGF*SW1*IAF*CC7*SE1
CDF        SEQ192    =TT    *I31*AW5*OB1
CDF        SEQ193    =TT    *I11*AW5*OB1
CDF        SEQ194    =TT    *DH1*I3F*AW8*RF4
```

CDF SEQ195 =LOOP *OGF*DH1*I3F*AW8
CDF SEQ196 =L1DC *DGF*I2F*AW7*OB3*CI2
CDF SEQ197 =RT *SA1*SB2*OS1*MS2
CDF SEQ198 =LOPF *IAF*AW1*OB1
CDF SEQ199 =TT *SA1*SB2*RT7*OSF
CDF SEQ200 =LOOP *OGF*GF1*GH2*CV2*AW4
CDF SEQ201 =LOOP *OGF*GF1*GG2*CV3*CC5
CDF SEQ202 =SLOCI *IAF*CC1
CDF SEQ203 =LOOP *OGF*GG1*I32*PRD
CDF SEQ204 =LOOP *OGF*GG1*GH2*IAF*CC5*PRD
CDF SEQ205 =LOOP *OGF*TH1*SW3*IAF*AW3*OB1
CDF SEQ206 =LOOP *OGF*TG1*SW3*IAF*AW3*OB1
CDF SEQ207 =LOOP *OGF*GF1*GG2*TH3*FO4*CVF*ASF
CDF SEQ208 =LOOP *OGF*GF1*GH2*IAF*SV5*AW9
CDF SEQ209 =LOOP *OGF*GF1*IAF*AW3*OB1
CDF SEQ210 =RT *IAF*HS1*RF4
CDF SEQ211 =LOCV *DG1*I2F*CVF*AW7
CDF SEQ212 =TT *SA1*SB2*OS1*MS2
CDF SEQ213 =LOCV *CVF*HS1
CDF SEQ214 =LOOP *OGF*GF1*GG2*IAF*CC5*PRD
CDF SEQ215 =RT *DG1*I2F*AW7*RF4
CDF SEQ216 =LOOP *OGF*GF1*GH2*IAF*AW4*CH2
CDF SEQ217 =ISI *IAF*HS1
CDF SEQ218 =ISI *DG1*I2F*AW7
CDF SEQ219 =LOOP *OGF*GF1*GG2*CV3*ASB
CDF SEQ220 =SGTR *IAF*OP1*MU1
CDF SEQ221 =LOOP *OGF*GF1*GH2*IAF*CC5*PRD
CDF SEQ222 =SLBI *DG1*I2F
CDF SEQ223 =LOPF *IAF*SV1
CDF SEQ224 =LOOP *OGF*GH1*TG2*SW1*IAF*CC5*AW4
CDF SEQ225 =SLBI *DH1*I3F
CDF SEQ226 =IMSIV *IAF*AW1*OB1
CDF SEQ227 =SLBI *AH1*IAF*RP2
CDF SEQ228 =RT *IAF*CC1*RP2*SE1
CDF SEQ229 =TT *IAF*HS1*RF4
CDF SEQ230 =LOOP *OGF*GF1*GG2*IAF*ASB*PRD
CDF SEQ231 =LOOP *OGF*GH1*TH2*SW1*IAF*CC5*AW4

CDF SEQ232 =TT *DG1*I2F*AW7*RF4
CDF SEQ233 =ELOCA *IAF
CDF SEQ234 =LOOP *OGF*GH1*IAF*AW3*RF4
CDF SEQ235 =TLMFW *IAF*AW1*OB1
CDF SEQ236 =MLOCA *CV1*OSF
CDF SEQ237 =PLMFW *DF1*I1F*AW8*OB1
CDF SEQ238 =LOOP *OGF*DG1*I2F*AW7
CDF SEQ239 =L1DC *DGF*I2F*AW7*OB3*VB3
CDF SEQ240 =TT *IAF*CC1*RP2*SE1
CDF SEQ241 =LOOP *OGF*GG1*GH2*IAF*AW3
CDF SEQ242 =SGTR *I31*SL2
CDF SEQ243 =SGTR *I11*SL2
CDF SEQ244 =IMSIV *IAF*SV1
CDF SEQ245 =LOOP *OGF*BG1*GH1*SW1*IAF*AW4
CDF SEQ246 =SLBO *DF1*I1F*MS2*OB1
CDF SEQ247 =FS8 *AFF*AGF*AHF*IAF*CCF*PRD
CDF SEQ248 =PLMFW *I31*AW5*OB1
CDF SEQ249 =SLBO *AF1*IAF*MS2*OB1
CDF SEQ250 =LOOP *OGF*GF1*GG2*IAF*AW3
CDF SEQ251 =PLMFW *DH1*I3F*AW8*RF4
CDF SEQ252 =LOSWV *IAF*SVF*CI1*(RF4S)
CDF SEQ253 =PLMFW *I11*AW5*OB1
CDF SEQ254 =LOOP *OGF*BH1*GH1*SW1*IAF*AW4
CDF SEQ255 =LOOP *OGF*AH1*GF1*IAF*AW4
CDF SEQ256 =TLMFW *IAF*SV1
CDF SEQ257 =LOOP *OGF*DG1*GF1*GH5*I2F*I4F*CVF*ASF*MS2
CDF SEQ258 =LCV *IAF*AW1*OB1
CDF SEQ259 =RT *OG1*GF1*GG2*GH3*CVF*ASF*RP2
CDF SEQ260 =PLMFW *SA1*SB2*RT7*OSF
CDF SEQ261 =L1DC *DF1*DGF*I1F*I2F*AS4*MS2
CDF SEQ262 =SLBO *DG1*I2F*MS2*RF4
CDF SEQ263 =SLBO *DH1*I3F*MS2*RF4
CDF SEQ264 =LOOP *OGF*AF1*GH1*IAF*AW4
CDF SEQ265 =SLOCI *DG1*I2F*LB3
CDF SEQ266 =SLBO *AH1*IAF*MS2*RF4
CDF SEQ267 =LOOP *OGF*GG1*TH2*IAF*PRD*LB3
CDF SEQ268 =SLOCI *DH1*I3F*LA1

```
CDF       SEQ269    =SLOCI *AG1*IAF*LB3
CDF       SEQ270    =L1DC *DGF*AF1*I2F*AS4
CDF       SEQ271    =SLOCI *AH1*IAF*LA1
CDF       SEQ272    =MLOCA *IAF*LV1
CDF       SEQ273    =EXFW *AH1*IAF*AW3
CDF       SEQ274    =PLMFW *SA1*SB2*OS1*MS2
CDF       SEQ275    =LOOP *OGF*GF1*GG2*IAF*PRD*LB3
CDF       SEQ276    =SLOCN *IAF*RW1
CDF       SEQ277    =EXFW *IAF*AW1*VI2
CDF       SEQ278    =TT   *OG1*GF1*GG2*GH3*CVF*ASF*RP2
CDF       SEQ279    =LOOP *OGF*DH1*TG5*SW1*I3F*AW9
CDF       SEQ280    =SLBO *I21*MS2*OB1
CDF       SEQ281    =LCV  *IAF*SV1
CDF       SEQ282    =LOOP *OGF*GH1*IAF*AW3*PRD
CDF       SEQ283    =RT   *OG1*GF1*GH2*IAF*AW4*RP2
CDF       SEQ284    =LOOP *OGF*GG1*TH2*FO4*CVF*ASF*PRD
CDF       SEQ285    =LOOP *OGF*GF1*GH2*IAF*PRD*LA1
CDF       SEQ286    =SLBO *I41*MS2*OB1
CDF       SEQ287    =SGTR *IAF*OP1*LA1*LB2
CDF       SEQ288    =L1DC *DGF*I2F*AW7*SI1*OB3
CDF       SEQ289    =LOSWV *IAF*SVF*SI1*(RF4S*CI1S)
CDF       SEQ290    =LOOP *OGF*DG1*GH4*I2F*I4F*AWA
CDF       SEQ291    =RT   *IAF*AW1*OB1*RF4
CDF       SEQ292    =LOOP *OGF*DH1*TH6*SW1*I3F*AW9
CDF       SEQ293    =LOCV *CVF*AW1*OB1
CDF       SEQ294    =RT   *DF1*I1F*SV2
CDF       SEQ295    =PLMFW *IAF*HS1*RF4
CDF       SEQ296    =LOOP *OGF*AH1*GF1*GG2*CVF*ASF
CDF       SEQ297    =LOOP *OGF*AG1*GF1*GH5*CVF*ASF
CDF       SEQ298    =ISI  *IAF*AW1*OB1
CDF       SEQ299    =L1DC *DGF*I2F*AW7*RF1
CDF       SEQ300    =LOOP *OGF*DH1*GF1*GG2*I3F*CVF*ASF
CDF       SEQ301    =PLMFW *DG1*I2F*AW7*RF4
CDF       SEQ302    =RT   *AF1*IAF*SV2
CDF       SEQ303    =TT   *OG1*GF1*GH2*IAF*AW4*RP2
CDF       SEQ304    =RT   *IAF*AW1*LA1*LB2
CDF       SEQ305    =LOOP *OGF*GG1*CV3*PRD*LB3
```

```
CDF     SEQ306   =RT   *I21*AW5*OB1
CDF     SEQ307   =TT   *IAF*AW1*OB1*RF4
CDF     SEQ308   =PLMFW *IAF*CC1*RP2*SE1
CDF     SEQ309   =TT   *DF1*I1F*SV2
CDF     SEQ310   =RT   *I41*AW5*OB1
CDF     SEQ311   =LOOP *OGF*DG1*GF1*I2F*AWA
CDF     SEQ312   =FS6  *AFF*AGF*IAF*AS4*RP2
CDF     SEQ313   =LOOP *OGF*AF1*GG1*GH2*CVF*ASF
CDF     SEQ314   =LOOP *OGF*GF1*GG2*GH3*SB1*CVF*ASF
CDF     SEQ315   =LOOP *OGF*GG1*GH2*IAF*PRD*SI2
CDF     SEQ316   =LOOP *OGF*GF1*GG2*IAF*PRD*SI2
CDF     SEQ317   =LOCV *CVF*SV1
CDF     SEQ318   =TT   *AF1*IAF*SV2
CDF     SEQ319   =LOOP *OGF*SW1*IAF*AW3*OB1*RF4
CDF     SEQ320   =ISI  *IAF*SV1
CDF     SEQ321   =TT   *IAF*AW1*LA1*LB2
CDF     SEQ322   =LOOP *OGF*DF1*GG1*GH2*I1F*CVF*ASF
CDF     SEQ323   =LOOP *OGF*AG1*GF1*TG6*IAF*ASF
CDF     SEQ324   =RT   *IAF*SV1*RF4
CDF     SEQ325   =TT   *I21*AW5*OB1
CDF     SEQ326   =LOOP *OGF*DG1*GF1*TG6*I2F*ASF
CDF     SEQ327   =LLOCA *SA2*SB6*OSF
CDF     SEQ328   =LOOP *OGF*GG1*SW2*IAF*CC5
CDF     SEQ329   =TT   *I41*AW5*OB1
CDF     SEQ330   =SLOCN *IAF*RF1*MU2
CDF     SEQ331   =LOOP *OGF*SW1*IAF*AW3*LA1*LB2
CDF     SEQ332   =FS1  *IAF*AW4*VI2*RF4
CDF     SEQ333   =LOOP *OGF*DF1*GG1*TG2*I1F*ASF
CDF     SEQ334   =FS5  *IAF*ASF*RP2*SE1
CDF     SEQ335   =RT   *OG1*GF1*GG2*TG3*IAF*ASF*RP2
CDF     SEQ336   =L1DC *DGF*I2F*I32*AW7
CDF     SEQ337   =LOOP *OGF*AF1*GG1*TG2*IAF*ASF
CDF     SEQ338   =FS11 *DG1*I2F*ASF
CDF     SEQ339   =FS10 *IAF*AW4*OB1
CDF     SEQ340   =FS11 *DH1*I3F*ASF
CDF     SEQ341   =LOOP *OGF*GG1*GH2*IAF*PRD*CH2
CDF     SEQ342   =TT   *IAF*SV1*RF4
```

```
CDF        SEQ343    =SLBI *IAF*AWB*RP2*VI2
CDF        SEQ344    =LOOP *OGF*GH1*TH2*FO2*CVF*ASF*AW4
CDF        SEQ345    =LOOP *OGF*GG1*TG2*FO2*CVF*ASF*AW4
CDF        SEQ346    =LOOP *OGF*GG1*TG2*SW1*IAF*CC5*PRD
CDF        SEQ347    =LOOP *OGF*GF1*GH2*SB1*AW4
CDF        SEQ348    =LOOP *OGF*GH1*TG2*SW1*IAF*SV5*AW9
CDF        SEQ349    =SGTR *DF1*I1F*SL2
CDF        SEQ350    =PLMFW *OG1*GF1*GG2*GH3*CVF*ASF*RP2
CDF        SEQ351    =LOOP *OGF*GH1*TG2*SW1*IAF*AW4*CH2
CDF        SEQ352    =TT   *OG1*GF1*GG2*TG3*IAF*ASF*RP2
CDF        SEQ353    =L1DC *DGF*I2F*CC3*PRA
CDF        SEQ354    =SGTR *DH1*I3F*SL2
CDF        SEQ355    =RT   *DH1*I3F*SV3
CDF        SEQ356    =SGTR *DG1*I2F*SL2
CDF        SEQ357    =LOOP *OGF*GH1*TH2*SW1*IAF*SV5*AW9
CDF        SEQ358    =LOOP *OGF*GH1*IAF*CC7*PRD
CDF        SEQ359    =FS1  *DH1*I3F*AW9
CDF        SEQ360    =LOOP *OGF*GH1*TG2*SW1*IAF*CC5*PRD
CDF        SEQ361    =RT   *AH1*IAF*SV3
CDF        SEQ362    =LOOP *OGF*GH1*TH2*SW1*IAF*AW4*CH2
CDF        SEQ363    =LOOP *OGF*GG1*GH2*TG3*TH4*CVF*ASF*AW4
CDF        SEQ364    =LOOP *OGF*GG1*TG2*SW1*IAF*ASB*PRD
CDF        SEQ365    =LOOP *OGF*SW1*IAF*AS5*SE1
CDF        SEQ366    =LOOP *OGF*SW1*IAF*SV2*SI2
CDF        SEQ367    =LOOP *OGF*GG1*IAF*CC7*PRD
CDF        SEQ368    =LOOP *OGF*GH1*TH2*SW1*IAF*CC5*PRD
CDF        SEQ369    =EXFW *DG1*I2F*CC3
CDF        SEQ370    =FS1  *IAF*AW4*OB1*LA1
CDF        SEQ371    =FS1  *IAF*AW4*OB1*LB1
CDF        SEQ372    =TT   *DH1*I3F*SV3
CDF        SEQ373    =PLMFW *OG1*GF1*GH2*IAF*AW4*RP2
CDF        SEQ374    =LPCC *DG1*I2F*ASF
CDF        SEQ375    =LOOP *OGF*IAF*HS1
CDF        SEQ376    =LPCC *DH1*I3F*ASF
CDF        SEQ377    =TT   *AH1*IAF*SV3
CDF        SEQ378    =EXFW *DH1*I3F*CC2
CDF        SEQ379    =LOOP *OGF*SW1*IAF*HS1
```

```
CDF        SEQ380   =L1DC *DGF*I2F*SA1*CC3
CDF        SEQ381   =L1DC *DGF*I2F*SB1*CC3
CDF        SEQ382   =LOOP *OGF*GH1*TG2*IAF*AW3
CDF        SEQ383   =PLMFW *IAF*AW1*OB1*RF4
CDF        SEQ384   =LOOP *OGF*GG1*IAF*SV4
CDF        SEQ385   =PLMFW *DF1*I1F*SV2
CDF        SEQ386   =LOOP *OGF*DH1*GG1*I3F*PRD
CDF        SEQ387   =LOOP *OGF*GG1*IAF*AW1
CDF        SEQ388   =LOOP *OGF*GF1*GH2*TG3*TH4*IAF*AW4
CDF        SEQ389   =LOOP *OGF*GH1*TH2*IAF*AW3
CDF        SEQ390   =SGTR *I21*SL2
CDF        SEQ391   =LOOP *OGF*AH1*GG1*IAF*PRD
CDF        SEQ392   =LOOP *OGF*GF1*GG2*TG3*SB1*ASF
CDF        SEQ393   =LOOP *OGF*AG1*GH4*IAF*PRD
CDF        SEQ394   =PLMFW *AF1*IAF*SV2
CDF        SEQ395   =LOOP *OGF*GG1*TG2*SW1*IAF*AW3
CDF        SEQ396   =SGTR *I41*SL2
CDF        SEQ397   =SLBO *IAF*MS2*AWB*VI2*RF4
CDF        SEQ398   =LOOP *OGF*GF1*GH2*TG3*IAF*SV5
CDF        SEQ399   =PLMFW *IAF*AW1*LA1*LB2
CDF        SEQ400   =L1DC *DGF*I2F*AW7*VI2*RF4
CDF        SEQ401   =PLMFW *I21*AW5*OB1
CDF        SEQ402   =LOOP *OGF*GF1*GH2*TH3*IAF*SV5
CDF        SEQ403   =LOOP *OGF*AH1*TG5*SW1*IAF*AW4
CDF        SEQ404   =LOOP *OGF*GH1*TG2*TH3*SW3*IAF*SV5
CDF        SEQ405   =PLMFW *I41*AW5*OB1
CDF        SEQ406   =RT   *OG1*FO1*CVF*ASF*RP2
CDF        SEQ407   =LOOP *OGF*GF1*GH2*IAF*AW4*CI2
CDF        SEQ408   =LOOP *OGF*TH1*FO3*CVF*ASF*AW4
CDF        SEQ409   =LOOP *OGF*GG1*FO3*CVF*ASF*AW4
CDF        SEQ410   =SLOCN *I31*LA1
CDF        SEQ411   =SLBO *I31*MS2*VI2
CDF        SEQ412   =SLBO *I11*MS2*VI2
CDF        SEQ413   =LOOP *OGF*GH1*TG2*IAF*PRD*LA1
CDF        SEQ414   =LOOP *OGF*GG1*GH2*TG3*FO2*CVF*ASF
CDF        SEQ415   =LOOP *OGF*GF1*GH2*TH3*FO2*CVF*ASF
CDF        SEQ416   =LOOP *OGF*GH1*TG2*TH3*FO2*CVF*ASF
```

```
CDF      SEQ417    =LOOP *OGF*GF1*GG2*TG3*FO2*CVF*ASF
CDF      SEQ418    =LOOP *OGF*SW1*IAF*SV2*CH2
CDF      SEQ419    =LLOCA *IAF*LA3*LB8
CDF      SEQ420    =LOOP *OGF*AH1*TH6*SW1*IAF*AW4
CDF      OTHER     = HAZCHM*ZHEHS5 *0.1 + CRFIRE
CDF      RP2S      = 1.-RP2
CDF      RF4S      = 1.-RF4
CDF      CI1S      = 1.-CI1
CDF      SI1S      = 1.-SI1
CDF      SW1S      = 1.-SW1
CDF      OG1S      = 1.-OG1
CDF      SA1S      = 1.-SA1
CDF      SB1S      = 1.-SB1
CDF      GF1S      = 1.-GF1
CDF      GG1S      = 1.-GG1
CDF      GH1S      = 1.-GH1
CDF      TG1S      = 1.-TG1
CDF      TH1S      = 1.-TH1
CDF      GG2S      = 1.-GG2
CDF      TG3S      = 1.-TG3
CDF      TH3S      = 1.-TH3
CDF      GH3S      = 1.-GH3
CDF      TH4S      = 1.-TH4
CDF      TH2S      = 1.-TH2
CDF      TG2S      = 1.-TG2
CDF      GH2S      = 1.-GH2
CDF      REOB1     = (OB1 + RF1 + LA1 + CH2)
CDF      RSEQ8     = ZHEFO6*RESLC3
CDF      RSEQ10    = (ZHESW1 + AW4)*RESLC1
CDF      RSEQ24    = (OB1 + LA1 + RF1 + CH1 + VA1)
CDF      RSEQ25    = ZHEFO6*RESLC3
CDF      RSEQ34    = ZHERE2*RESLC3
```

**Figure B-2:** Sequences for Swing DG Maintenance Configuration
**Reference:** PGE.1123 EVENT.TREES INTERNALS RMODEL DGAOT DG57AOT CDFSCH.EQS

Calculation 1A:

| | | |
|---|---|---|
| C3A | 1 TOTAL = CDF3 + NEWSEQ | TOTAL CORE MELT NO SCHEDULED MAINT ON SWING |
| C3A | 5 NEWSEQ = SEIS1 + SEIS2 + GF1SEQ | CORE MELT CONTRIBUTION DUE TO DG F PREVENTIVE MAINTENANCE |
| C3A | 6 SEIS1 = SEIS1C*0.0 | CORE MELT - SEISMIC - NONSEISMIC DG FAILURES |
| C3A | 7 SEIS2 = SEIS2C*0.0 | CORE MELT - SEISMIC CCW FAILURES |
| C3A | 8 GF1SEQ = GF1CND*0.0 | CORE MELT - DG F FAILS - NONSEISMIC |
| C3A | 9 SEIS1C = SEIS1T * (GF1*GG5*(GHB + TGI + GHA*AW4 + ASB) + GF1*GHA*AW4) | CONDITIONAL CORE MELT - SEISMIC - NONSEISMIC DG FAILURES |
| C3A | 10 SEIS2C = SEIS2T * GF1 * GG5 | CONDITIONAL CORE MELT - SEISMIC CCW FAILURES |
| C3A | 11 GF1CND = SEQ003 + SEQ005 + SEQ007 + SEQ015 + SEQ017 + SEQ047 + SEQ054 + X1 | CONDITIONAL CORE MELT - DG F FAILS - NONSEISMIC |

Calculation 2:

| | | |
|---|---|---|
| C3D | 1 TOTAL = CDF3 + NEWSEQ | TOTAL CORE MELT, 10 DAY SCHEDULED MAINT ON SWING |
| C3D | 5 NEWSEQ = SEIS1 + SEIS2 + GF1SEQ | CORE MELT CONTRIBUTION DUE TO DG F PREVENTIVE MAINTENANCE |
| C3D | 6 SEIS1 = SEIS1C* (10/(365*1.5)) | CORE MELT - SEISMIC - NONSEISMIC DG FAILURES |
| C3D | 7 SEIS2 = SEIS2* (10/(365*1.5)) | CORE MELT - SEISMIC CCW FAILURES |
| C3D | 8 GF1SEQ = GF1CND* (10/(365*1.5)) | CORE MELT - DG F FAILS - NONSEISMIC |
| C3D | 9 SEIS1C = SEIS1T * (GF1*GG5*(GHB + TGI + GHA*AW4 + ASB) + GF1*GHA*AW4) | CONDITIONAL CORE MELT - SEISMIC - NONSEISMIC DG FAILURES |
| C3D | 10 SEIS2C = SEIS2T * GF1 * GG5 | CONDITIONAL CORE MELT - SEISMIC CCW FAILURES |
| C3D | 11 GF1CND = SEQ003 + SEQ005 + SEQ007 + SEQ015 + SEQ017 + SEQ047 + SEQ054 + X1 | CONDITIONAL CORE MELT - DG F FAILS - NONSEISMIC |

Calculation 1B:

| | | |
|---|---|---|
| C7A | 1 TOTAL = CDF7 + NEWSEQ | TOTAL CORE MELT NO SCHEDULED MAINT ON SWING |
| C7A | 5 NEWSEQ = SEIS1 + SEIS2 + GF1SEQ | CORE MELT CONTRIBUTION DUE TO DG F PREVENTIVE MAINTENANCE |
| C7A | 6 SEIS1 = SEIS1C*0.0 | CORE MELT - SEISMIC - NONSEISMIC DG FAILURES |
| C7A | 7 SEIS2 = SEIS2C*0.0 | CORE MELT - SEISMIC CCW FAILURES |
| C7A | 8 GF1SEQ = GF1CND*0.0 | CORE MELT - DG F FAILS - NONSEISMIC |
| C7A | 9 SEIS1C = SEIS1T * (GF1*GG5*(GHB + TGI + GHA*AW4 + ASB) + GF1*GHA*AW4) | CONDITIONAL CORE MELT - SEISMIC - NONSEISMIC DG FAILURES |
| C7A | 10 SEIS2C = SEIS2T * GF1 * GG5 | CONDITIONAL CORE MELT - SEISMIC CCW FAILURES |
| C7A | 11 GF1CND = SEQ003 + SEQ005 + SEQ007 + SEQ015 + SEQ017 + SEQ047 + SEQ054 + X1 | CONDITIONAL CORE MELT - DG F FAILS - NONSEISMIC |

Calculation 3:

| | | |
|---|---|---|
| C7C | 1 TOTAL = CDF7 + NEWSEQ | TOTAL CORE MELT, 7 DAY SCHEDULED MAINT ON SWING |
| C7C | 5 NEWSEQ = SEIS1 + SEIS2 + GF1SEQ | CORE MELT CONTRIBUTION DUE TO DG F PREVENTIVE MAINTENANCE |
| C7C | 6 SEIS1 = SEIS1C* (7/(365*1.5)) | CORE MELT - SEISMIC - NONSEISMIC DG FAILURES |
| C7C | 7 SEIS2 = SEIS2C* (7/(365*1.5)) | CORE MELT - SEISMIC CCW FAILURES |
| C7C | 8 GF1SEQ = GF1CND* (7/(365*1.5)) | CORE MELT - DG F FAILS - NONSEISMIC |
| C7C | 9 SEIS1C = SEIS1T * (GF1*GG5*(GHB + TGI + GHA*AW4 + ASB) + GF1*GHA*AW4) | CONDITIONAL CORE MELT - SEISMIC - NONSEISMIC DG FAILURES |
| C7C | 10 SEIS2C = SEIS2T * GF1 * GG5 | CONDITIONAL CORE MELT - SEISMIC CCW FAILURES |
| C7C | 11 GF1CND = SEQ003 + SEQ005 + SEQ007 + SEQ015 + SEQ017 + SEQ047 + SEQ054 + X1 | CONDITIONAL CORE MELT - DG F FAILS - NONSEISMIC |

Calculation 6:

| | | |
|---|---|---|
| C7Y | 1 TOTAL = CDF7 + SEIS1C + SEIS2C + GF1CND | |
| C7Y | 2 SEIS1C = SEIS1T *(GF1*GG5(GHB + TGI + GHA*AW4 + ASB) + GF1*GHA*AW4) | CONDITIONAL CORE MELT - SEISMIC - NONSEISMIC DG FAILURES |
| C7Y | 3 SEIS2C = SEIS2T * GF1 * GG5 | CONDITIONAL CORE MELT - SEISMIC CCW FAILURES |
| C7Y | 4 GF1CND = SEQ003 + SEQ005 + SEQ007 + SEQ015 + SEQ017 + SEQ047 + SEQ054 + X1 | CONDITIONAL CORE MELT - DG F FAILS - NONSEISMIC |

Common Equations:

X1 = SEQ058 + SEQ059 + SEQ064 + SEQ067 + SEQ076 + SEQ081 + SEQ082 + X2
X2 = SEQ085 + SEQ108 + SEQ122 + SEQ146 + SEQ157 + SEQ164 + SEQ185 + X3
X3 = SEQ200 + SEQ201 + SEQ207 + SEQ208 + SEQ209 + SEQ214 + SEQ216 + X4
X4 = SEQ219 + SEQ221 + SEQ230 + SEQ250 + SEQ255 + SEQ257 + SEQ259 + X5
X5 = SEQ275 + SEQ278 + SEQ283 + SEQ285 + SEQ296 + SEQ297 + SEQ300 + X6
X6 = SEQ303 + SEQ311 + SEQ314 + SEQ316 + SEQ323 + SEQ326 + SEQ335 + X7
X7 = SEQ347 + SEQ350 + SEQ352 + SEQ373 + SEQ388 + SEQ392 + SEQ398 + X8
X8 = SEQ402 + SEQ407 + SEQ415 + SEQ417
SEQ003 = LOOP *OGF*GF1*GG2*GH3*CVF*ASF*RESLC2
SEQ005 = LOOP *OGF*GF1*GH2*IAF*AW4*(GG2S*TG3S*TH3S)*RESLC1*REOB1
SEQ007 = LOOP *OGF*GF1*GG2*TG3*IAF*ASF*(GH3S*TH4S)*RESLC2
SEQ015 = LOOP *OGF*GF1*GG2*IAF*CC5*(GH3S*TG3S*TH3S)*ZHERE2*RESLC3
SEQ017 = LOOP *OGF*GF1*GG2*IAF*ASB*(GH3S*TG3S*TH3S)*RESLC2
SEQ047 = LOOP *OGF*GF1*GG2*GH3*CVF*ASF*AW4*RESLC1
SEQ054 = LOOP *OGF*GF1*GH2*IAF*SV5*ZHESV3
SEQ058 = LOOP *OGF*GF1*GH2*TG3*IAF*AW4*REOB1*RESLC1
SEQ059 = LOOP *OGF*GF1*GH2*TH3*IAF*AW4*REOB1*RESLC1

```
SEQ064   =LOOP *OGF*GF1*GG2*TG3*TH4*IAF*ASF*RESLC2
SEQ067   =LOOP *OGF*GF1*GG2*GH3*CVF*ASF*PRD
SEQ076   =LOOP *OGF*GF1*GH2*IAF*AW4*PRD
SEQ081   =LOOP *OGF*GF1*IAF*SV2*ZHESV3*REAC12
SEQ082   =LOOP *OGF*GF1*GG2*TG3*CV3*ASF*RESLC2
SEQ085   =LOOP *OGF*GF1*GG2*TG3*IAF*ASF*PRD
SEQ108   =LOOP *OGF*GF1*FO1*CVF*ASF
SEQ122   =LOOP *OGF*GF1*GH2*IAF*CC5*AW4
SEQ146   =LOOP *OGF*GF1*GG2*TH3*IAF*CC5
SEQ157   =LOOP *OGF*DH1*GF1*I3F*AW9
SEQ164   =LOOP *OGF*GF1*GG2*TH3*IAF*ASB
SEQ185   =LOOP *OGF*BG1*GF1*GG2*IAF*ASF
SEQ200   =LOOP *OGF*GF1*GH2*CV2*AW4
SEQ201   =LOOP *OGF*GF1*GG2*CV3*CC5
SEQ207   =LOOP *OGF*GF1*GG2*TH3*FO4*CVF*ASF
SEQ208   =LOOP *OGF*GF1*GH2*IAF*SV5*AW9
SEQ209   =LOOP *OGF*GF1*IAF*AW3*OB1
SEQ214   =LOOP *OGF*GF1*GG2*IAF*CC5*PRD
SEQ216   =LOOP *OGF*GF1*GH2*IAF*AW4*CH2
SEQ219   =LOOP *OGF*GF1*GG2*CV3*ASB
SEQ221   =LOOP *OGF*GF1*GH2*IAF*CC5*PRD
SEQ230   =LOOP *OGF*GF1*GG2*IAF*ASB*PRD
SEQ250   =LOOP *OGF*GF1*GG2*IAF*AW3
SEQ255   =LOOP *OGF*AH1*GF1*IAF*AW4
SEQ257   =LOOP *OGF*DG1*GF1*GH5*I2F*I4F*CVF*ASF*MS2
SEQ259   =RT *OG1*GF1*GG2*GH3*CVF*ASF*RP2
SEQ275   =LOOP *OGF*GF1*GG2*IAF*PRD*LB3
SEQ278   =TT *OG1*GF1*GG2*GH3*CVF*ASF*RP2
SEQ283   =RT *OG1*GF1*GH2*IAF*AW4*RP2
SEQ285   =LOOP *OGF*GF1*GH2*IAF*PRD*LA1
SEQ296   =LOOP *OGF*AH1*GF1*GG2*CVF*ASF
SEQ297   =LOOP *OGF*AG1*GF1*GH5*CVF*ASF
SEQ300   =LOOP *OGF*DH1*GF1*GG2*I3F*CVF*ASF
SEQ303   =TT *OG1*GF1*GH2*IAF*AW4*RP2
SEQ311   =LOOP *OGF*DG1*GF1*I2F*AWA
SEQ314   =LOOP *OGF*GF1*GG2*GH3*SB1*CVF*ASF
SEQ316   =LOOP *OGF*GF1*GG2*IAF*PRD*SI2
```

```
SEQ323   =LOOP *OGF*AG1*GF1*TG6*IAF*ASF
SEQ326   =LOOP *OGF*DG1*GF1*TG6*I2F*ASF
SEQ335   =RT *OG1*GF1*GG2*TG3*IAF*ASF*RP2
SEQ347   =LOOP *OGF*GF1*GH2*SB1*AW4
SEQ350   =PLMFW *OG1*GF1*GG2*GH3*CVF*ASF*RP2
SEQ352   =TT *OG1*GF1*GG2*TG3*IAF*ASF*RP2
SEQ373   =PLMFW *OG1*GF1*GH2*IAF*AW4*RP2
SEQ388   =LOOP *OGF*GF1*GH2*TG3*TH4*IAF*AW4
SEQ392   =LOOP *OGF*GF1*GG2*TG3*SB1*ASF
SEQ398   =LOOP *OGF*GF1*GH2*TG3*IAF*SV5
SEQ402   =LOOP *OGF*GF1*GH2*TH3*IAF*SV5
SEQ407   =LOOP *OGF*GF1*GH2*IAF*AW4*CI2
SEQ415   =LOOP *OGF*GF1*GH2*TH3*FO2*CVF*ASF
SEQ417   =LOOP *OGF*GF1*GG2*TG3*FO2*CVF*ASF
RP2S     =1.-RP2
RF4S     =1.-RF4
CI1S     =1.-CI1
SI1S     =1.-SI1
SW1S     =1.-SW1
OG1S     =1.-OG1
SA1S     =1.-SA1
SB1S     =1.-SB1
GF1S     =1.-GF1
GG1S     =1.-GG1
GH1S     =1.-GH1
TG1S     =1.-TG1
TH1S     =1.-TH1
GG2S     =1.-GG2
TG3S     =1.-TG3
TH3S     =1.-TH3
GH3S     =1.-GH3
TH4S     =1.-TH4
GH2S     =1.-GH2
REOB1    =(OB1+RF1+LA1+CH2)
RSEQ8    =ZHEFO6*RESLC3
RSEQ10   =(ZHESW1+AW4)*RESLC1
RSEQ24   =(OB1+LA1+RF1+CH1+VA1)
```

```
RSEQ25   =ZHEFO6*RESLC3
RSEQ34   =ZHERE2*RESLC3
GF1      =1.0    SPLIT FRACTION REPLACEMENT FOR TECH SPEC STUDY
GG2      =GG4    SPLIT FRACTION REPLACEMENT FOR TECH SPEC STUDY
GH2      =GH7    SPLIT FRACTION REPLACEMENT FOR TECH SPEC STUDY
GH3      =GH8    SPLIT FRACTION REPLACEMENT FOR TECH SPEC STUDY
GH5      =GH9    SPLIT FRACTION REPLACEMENT FOR TECH SPEC STUDY
TG3      =TGC    SPLIT FRACTION REPLACEMENT FOR TECH SPEC STUDY
TG6      =TGE    SPLIT FRACTION REPLACEMENT FOR TECH SPEC STUDY
TH3      =THI    SPLIT FRACTION REPLACEMENT FOR TECH SPEC STUDY
TH4      =THJ    SPLIT FRACTION REPLACEMENT FOR TECH SPEC STUDY
CDF3     =.0002078 $ 1.728E-4 (non-seismic) + 3.497E-5 (seismic) 3 day aot
CDF7     =.0002120 $ 1.770E-4 (non-seismic) + 3.500E-5 (seismic) 7 day aot
GG4      =.04339 $ Revised split fractions with DG 13 in maintenance
GH7      =.04319 $
GH8      =.04805 $
GH9      =.04339 $
TGC      =.04643 $
TGE      =.04319 $
THI      =.04595 $
THJ      =.05719 $
GG5      =.08114 $
GHA      =.08064 $
GHB      =.08685 $
TGI      =.08531 $
```

Figure B-3: DCPRA Base Split Fraction Values For Non-Seismic Initiating Events

| CSF | BOUNDARY CONDITION | MEAN | 5TH %IL | MEDIAN | 95TH %ILE |
|---|---|---|---|---|---|
| SUPPORT SYSTEMS | | | | | |
| SPLIT FRACTIONS FOR TOP EVENT OG | | | | | |
| OG1 | Given Offsite Grid success. | 7.63E-04 | 4.20E-04 | 5.78E-04 | 1.35E-03 |
| OGF | Given Offsite Grid fails (guaranteed failure OG). | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| SPLIT FRACTIONS FOR TOP EVENT NV | | | | | |
| NV1 | Given all support available. | 1.63E-04 | 2.60E-05 | 1.03E-04 | 3.76E-04 |
| NV2 | Given DC 13 or DC 12 failed and OG succeeded. | 2.46E-03 | 8.29E-04 | 1.87E-03 | 4.60E-03 |
| 3NVF | Given DC 13 and DC 12 failed or, OG failed. | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| SPLIT FRACTIONS FOR TOP EVENT DF | | | | | |
| DF1 | 480 V vital bus 1F available. | 7.05E-04 | 2.28E-04 | 5.56E-04 | 1.36E-03 |
| SPLIT FRACTIONS FOR TOP EVENT DG | | | | | |
| DG1 | 480 V vital bus 1G available, DF succeeded. | 7.05E-04 | 2.28E-04 | 5.56E-04 | 1.36E-03 |
| DG2 | 480 V vital bus 1G available, DF failed. | 7.02E-04 | 2.26E-04 | 5.53E-04 | 1.35E-03 |
| DGF | Guaranteed failure. | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| SPLIT FRACTIONS FOR TOP EVENT DH | | | | | |
| DH1 | 480 V 1H available, DF-S, DG-S | 7.00E-04 | 2.24E-04 | 5.51E-04 | 1.35E-03 |
| DH2 | 480 V 1H available, DF-S, DG-F | 6.98E-04 | 2.22E-04 | 5.49E-04 | 1.35E-03 |
| DH3 | 480 V 1H available, DF-F, DG-S | 6.98E-04 | 2.22E-04 | 5.49E-04 | 1.35E-03 |
| DH4 | 480 V 1H available, DF-F, DG-F | 6.96E-04 | 2.20E-04 | 5.47E-04 | 1.35E-03 |
| SPLIT FRACTIONS FOR TOP EVENT AF | | | | | |
| AF1 | All support available with recovery. | 6.92E-04 | 1.34E-04 | 4.43E-04 | 1.40E-03 |
| AFA | All support available no recovery. | 7.40E-04 | 1.63E-04 | 4.91E-04 | 1.45E-03 |
| AFF | Guaranteed failure. | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| SPLIT FRACTIONS FOR TOP EVENT AG | | | | | |
| AG1 | DF-S, AF-S with recovery | 6.92E-04 | 1.34E-04 | 4.43E-04 | 1.40E-03 |
| AG2 | DF-S, AF-F with recovery | 8.37E-04 | 1.94E-04 | 5.63E-04 | 1.70E-03 |
| AG3 | DF-F with recovery | 6.92E-04 | 1.34E-04 | 4.43E-04 | 1.40E-03 |
| AGA | DF-S, AF-S no recovery | 7.13E-04 | 1.47E-04 | 4.66E-04 | 1.42E-03 |
| AGB | DF-S, AF-F no recovery | 5.18E-02 | 3.92E-03 | 2.57E-02 | 1.48E-01 |
| AGC | DF-F no recovery | 7.40E-04 | 1.63E-04 | 4.91E-04 | 1.45E-03 |
| AGF | GUARANTEED FAILURE | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |

| | | | | | |
|---|---|---|---|---|---|
| SPLIT FRACTIONS FOR TOP EVENT AH | | | | | |
| AH1 | DF-S, DG-S, AF-S, AG-S with recovery | 6.92E-04 | 1.34E-04 | 4.43E-04 | 1.40E-03 |
| AH2 | DF-S, DG-S, AF-S, AG-F, or DF-S, DG-S, AF-F, AG-S w.r. | 8.01E-04 | 1.80E-04 | 5.32E-04 | 1.63E-03 |
| AH3 | DF-S, DG-S, AF-F, AG-F with recovery | 4.72E-02 | 9.06E-04 | 7.96E-03 | 1.71E-01 |
| AH4 | DF-S, DG-F, AF-S or DF-F, DG-S, AG-S with recovery | 6.92E-04 | 1.34E-04 | 4.43E-04 | 1.40E-03 |
| AH5 | DF-S, DG-F, AF-F or DF-F, DG-S, AG-F with recovery | 8.37E-04 | 1.94E-04 | 5.63E-04 | 1.70E-03 |
| AH6 | DF-F, DG-F with recovery | 6.92E-04 | 1.34E-04 | 4.43E-04 | 1.40E-03 |
| AHA | DF-S, DG-S, AF-S, AG-S no recovery | 6.92E-04 | 1.34E-04 | 4.43E-04 | 1.40E-03 |
| AHB | DF-S, DG-S, AF-S, AG-F, or DF-S, DG-S, AF-F, AG-S n.r. | 4.42E-02 | 1.16E-03 | 1.52E-02 | 1.37E-01 |
| AHC | DF-S, DG-S, AF-F, AG-F no recovery | 3.03E-01 | 6.28E-03 | 1.70E-01 | 8.17E-01 |
| AHD | DF-S, DG-F, AF-S or DF-F, DG-S, AG-S no recovery | 7.13E-04 | 1.47E-04 | 4.66E-04 | 1.42E-03 |
| AHE | DF-S, DG-F, AF-F or DF-F, DG-S, AG-F no recovery | 5.18E-02 | 3.92E-03 | 2.57E-02 | 1.48E-01 |
| AHG | DF-F, DG-F no recovery | 7.40E-04 | 1.63E-04 | 4.91E-04 | 1.45E-03 |
| AHF | GUARANTEED FAILURE | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| SPLIT FRACTIONS FOR TOP EVENT SF | | | | | |
| SF1 | All support available with recovery. | 1.60E-03 | 3.51E-04 | 1.15E-03 | 3.11E-03 |
| SFA | All support available no recovery. | 1.71E-03 | 4.34E-04 | 1.24E-03 | 3.22E-03 |
| SPLIT FRACTIONS FOR TOP EVENT SG | | | | | |
| SG1 | SF-S with recovery | 1.60E-03 | 3.51E-04 | 1.15E-03 | 3.11E-03 |
| SG2 | SF-F with recovery | 1.74E-03 | 4.70E-04 | 1.24E-03 | 3.30E-03 |
| SG3 | SF-B with recovery | 1.60E-03 | 3.51E-04 | 1.15E-03 | 3.11E-03 |
| SGA | SF-S no recovery | 1.65E-03 | 3.92E-04 | 1.19E-03 | 3.15E-03 |
| SGB | SF-F no recovery | 5.31E-02 | 6.81E-03 | 3.08E-02 | 1.36E-01 |
| SGC | SF-B no recovery | 1.71E-03 | 4.34E-04 | 1.24E-03 | 3.22E-03 |
| SPLIT FRACTIONS FOR TOP EVENT SH | | | | | |
| SH1 | SF-S, SG-S with recovery | 1.60E-03 | 3.51E-04 | 1.15E-03 | 3.11E-03 |
| SH2 | SF-S, SG-F or SF-F, SG-S with recovery | 1.70E-03 | 4.35E-04 | 1.21E-03 | 3.24E-03 |
| SH3 | SF-F, SG-F with recovery | 3.03E-02 | 1.54E-03 | 6.44E-03 | 9.56E-02 |
| SH4 | SF-S, SG-B or SF-B, SG-S with recovery | 1.60E-03 | 3.51E-04 | 1.15E-03 | 3.11E-03 |
| SH5 | SF-F, SG-B or SF-B, SG-F with recovery | 1.74E-03 | 4.70E-04 | 1.24E-03 | 3.30E-03 |
| SH6 | SF-B, SG-B with recovery | 1.60E-03 | 3.51E-04 | 1.15E-03 | 3.11E-03 |
| SHA | SF-S, SG-S no recovery | 1.60E-03 | 3.51E-04 | 1.15E-03 | 3.11E-03 |
| SHB | SF-S, SG-F or SF-F, SG-S no recovery | 4.42E-02 | 2.24E-03 | 2.07E-02 | 1.23E-01 |
| SHC | SF-F, SG-F no recovery | 2.90E-01 | 1.34E-02 | 1.83E-01 | 7.59E-01 |
| SHD | SF-S, SG-B or SF-B, SG-S no recovery | 1.65E-03 | 3.92E-04 | 1.19E-03 | 3.15E-03 |
| SHE | SF-F, SG-B or SF-B, SG-F no recovery | 5.31E-02 | 6.81E-03 | 3.08E-02 | 1.36E-01 |
| SHG | SF-B, SG-B no recovery | 1.71E-03 | 4.34E-04 | 1.24E-03 | 3.22E-03 |

| | | | | | |
|---|---|---|---|---|---|
| SPLIT FRACTIONS FOR TOP EVENT BF | | | | | |
| BF1 | OG-F | 1.44E-03 | 5.56E-04 | 1.14E-03 | 2.67E-03 |
| SPLIT FRACTIONS FOR TOP EVENT BG | | | | | |
| BG1 | OG-F, BF-S | 1.44E-03 | 5.56E-04 | 1.14E-03 | 2.67E-03 |
| BG2 | OG-F, BF-F | 1.49E-03 | 6.07E-04 | 1.18E-03 | 2.73E-03 |
| SPLIT FRACTIONS FOR TOP EVENT BH | | | | | |
| BH1 | OG-F, BF-S, BG-S | 1.44E-03 | 5.56E-04 | 1.14E-03 | 2.67E-03 |
| BH2 | OG-F, BF-S, BG-F or OG-F, BF-F, BG-S | 1.48E-03 | 5.96E-04 | 1.17E-03 | 2.71E-03 |
| BH3 | OG-F, BF-F, BG-F | 1.19E-02 | 1.13E-03 | 3.14E-03 | 3.31E-02 |
| SPLIT FRACTIONS FOR TOP EVENT GF | | | | | |
| GF1 | All support available. | 4.52E-02 | 2.90E-02 | 4.18E-02 | 6.28E-02 |
| SPLIT FRACTIONS FOR TOP EVENT GG | | | | | |
| GG1 | GF-S | 4.48E-02 | 2.85E-02 | 4.13E-02 | 6.24E-02 |
| GG2 | GF-F | 5.56E-02 | 3.91E-02 | 5.23E-02 | 7.33E-02 |
| GG3 | GF-B | 4.52E-02 | 2.90E-02 | 4.18E-02 | 6.28E-02 |
| SPLIT FRACTIONS FOR TOP EVENT GH | | | | | |
| GH1 | GF-S, GG-S | 4.44E-02 | 2.82E-02 | 4.09E-02 | 6.20E-02 |
| GH2 | GF-S/F, GG-F/S | 5.41E-02 | 3.75E-02 | 5.08E-02 | 7.17E-02 |
| GH3 | GF-F, GG-F | 8.27E-02 | 6.00E-02 | 7.72E-02 | 1.11E-01 |
| GH4 | GF-S/B, GG-B/S | 4.48E-02 | 2.85E-02 | 4.13E-02 | 6.24E-02 |
| GH5 | GF-F/B, GG-B/F | 5.56E-02 | 3.91E-02 | 5.23E-02 | 7.33E-02 |
| GH6 | GF-B, GG-B | 4.52E-02 | 2.90E-02 | 4.18E-02 | 6.28E-02 |
| SPLIT FRACTIONS FOR TOP EVENT 2G | | | | | |
| 2G1 | GF-S, GG-S, GH-S | 4.40E-02 | 2.77E-02 | 4.05E-02 | 6.16E-02 |
| 2G2 | GF-S/S/F, GG-S/F/S, GH-F/S/S | 5.36E-02 | 3.70E-02 | 5.03E-02 | 7.14E-02 |
| 2G3 | GF-S/F/F, GG-F/F/S, GH-F/S/F | 6.25E-02 | 4.62E-02 | 5.95E-02 | 7.91E-02 |
| 2G4 | GF-F, GG-F, GH-F | 2.90E-01 | 1.28E-01 | 2.48E-01 | 5.02E-01 |
| 2G5 | GF-S/S/B, GG-S/B/S, GH-B/S/S | 4.44E-02 | 2.82E-02 | 4.09E-02 | 6.20E-02 |
| 2G6 | GF-S/S/F/F/B/B, GG-F/B/B/S/S/F, GH-B/F/S/B/F/S | 5.41E-02 | 3.75E-02 | 5.08E-02 | 7.17E-02 |
| 2G7 | GF-F/F/B, GG-F/B/F, GH-B/F/F | 8.27E-02 | 6.00E-02 | 7.72E-02 | 1.11E-01 |
| 2G8 | GF-S/B/B, GG-B/S/B, GH-B/B/S | 4.48E-02 | 2.85E-02 | 4.13E-02 | 6.24E-02 |
| 2G9 | GF-F/B/B, GG-B/F/B, GH-B/B/F | 5.56E-02 | 3.91E-02 | 5.23E-02 | 7.33E-02 |
| 2GA | GF-B, GG-B, GH-B | 4.52E-02 | 2.90E-02 | 4.18E-02 | 6.28E-02 |
| SPLIT FRACTIONS FOR TOP EVENT 2H | | | | | |
| 2H1 | GF-GG&GH-2G:SS&SS | 4.36E-02 | 2.73E-02 | 4.01E-02 | 6.12E-02 |
| 2H2 | GF-GG&GH-2G:SS&SF/FS, SF/FS&SS | 5.32E-02 | 3.64E-02 | 4.99E-02 | 7.12E-02 |
| 2H3 | GF-GG&GH-2G:FS/SF&SF/FS, SS&FF, FF&SS | 6.21E-02 | 4.59E-02 | 5.90E-02 | 7.86E-02 |
| 2H4 | GF-GG&GH-2G:SF/FS&FF, FF&SF/FS | 6.92E-02 | 5.21E-02 | 6.62E-02 | 8.69E-02 |

| | | | | | |
|---|---|---|---|---|---|
| 2H5 | GF-GG&GH-2G:FF&FF | 7.73E-01 | 4.25E-01 | 7.95E-01 | 9.39E-01 |
| 2H6 | GF-GG&GH-2G:SS&SB/BS, SB/BS&SS | 4.40E-02 | 2.77E-02 | 4.05E-02 | 6.16E-02 |
| 2H7 | GF-GG&GH-2G:SF/FS&SB/BS, SB/BS&FS/SF, FB/BF&SS, SS&FB/BF | 5.36E-02 | 3.70E-02 | 5.03E-02 | 7.14E-02 |
| 2H8 | GF-GG&GH-2G:SF/FS&FB/BF, FB/BF&SF/FS, BS/SB&FF, FF&SB/BS | 6.25E-02 | 4.62E-02 | 5.95E-02 | 7.91E-02 |
| 2H9 | GF-GG&GH-2G:FF&FB/BF, FB/BF&FF | 2.90E-01 | 1.28E-01 | 2.48E-01 | 5.02E-01 |
| 2HA | GF-GG&GH-2G:SB/BS&BS/SB, SS&BB, BB&SS | 4.44E-02 | 2.82E-02 | 4.09E-02 | 6.20E-02 |
| 2HB | GF-GG&GH-2G:BF/FB&SB/BS, BS/SB&FB/BF, FS/SF&BB, BB&FS/SF | 5.41E-02 | 3.75E-02 | 5.08E-02 | 7.17E-02 |
| 2HC | GF-GG&GH-2G:FB/BF&BF/FB, FF&BB, BB&FF | 8.27E-02 | 6.00E-02 | 7.72E-02 | 1.11E-01 |
| 2HD | GF-GG&GH-2G:SB/BS&BB, BB&SB/BS | 4.48E-02 | 2.85E-02 | 4.13E-02 | 6.24E-02 |
| 2HE | GF-GG&GH-2G:FB/BF&BB, BB&FB/BF | 5.56E-02 | 3.91E-02 | 5.23E-02 | 7.33E-02 |
| 2HG | GF-GG&GH-2H:BB&BB | 4.52E-02 | 2.90E-02 | 4.18E-02 | 6.28E-02 |
| SPLIT FRACTIONS FOR TOP EVENT SW | | | | | |
| SW0 | All branch points for LOCA initiating event. | 0.00E-01 | 0.00E-01 | 0.00E-01 | 0.00E-01 |
| SW1 | LOSP with equal number of DG operating on each unit. | 5.00E-01 | 2.50E-02 | 2.50E-01 | 4.75E-01 |
| SW2 | LOSP with more DGs aligned to unit 2 than unit 1. | 1.77E-03 | 9.55E-05 | 7.30E-04 | 6.82E-03 |
| SW3 | LOSP with more DGs aligned to unit 1 than unit 2. | 9.98E-01 | 9.93E-01 | 9.98E-01 | 1.00E+00 |
| SPLIT FRACTIONS FOR TOP EVENT FO | | | | | |
| FO1 | All support available. | 2.16E-04 | 4.28E-05 | 1.40E-04 | 5.29E-04 |
| FO2 | Support available to one train only. | 7.04E-03 | 3.49E-03 | 6.33E-03 | 1.11E-02 |
| FO3 | 1/2 normal support unavailable, recover backup. | 3.51E-04 | 1.02E-04 | 2.70E-04 | 7.18E-04 |
| FO4 | 2/2 normal support unavailable, recover backups. | 2.26E-02 | 5.70E-03 | 1.67E-02 | 4.90E-02 |
| FO5 | 2/2 normal and 1/2 backup support unavail., rec. backup. | 5.08E-02 | 1.73E-02 | 3.95E-02 | 1.01E-01 |
| FOF | Guaranteed Failure | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| SPLIT FRACTIONS FOR TOP EVENT I1 | | | | | |
| I11 | Given: DF-S,AF-S,AG-S or DF-S,AF-F,AG-S. | 1.15E-03 | 4.16E-04 | 9.05E-04 | 2.11E-03 |
| I12 | Given: DF-S,AF-S,AG-F or DF-S,AF-F,AG-F. | 1.74E-03 | 7.16E-04 | 1.49E-03 | 3.01E-03 |
| I1F | Given: DF-F (guaranteed failure). | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| SPLIT FRACTIONS FOR TOP EVENT I2 | | | | | |
| I21 | Given: AG-S. | 5.76E-04 | 2.08E-04 | 4.53E-04 | 1.05E-03 |
| I22 | Given: DG-S, AG-F | 8.68E-04 | 3.58E-04 | 7.43E-04 | 1.51E-03 |
| I23 | Given: AG-S, I1-F | 5.76E-04 | 2.08E-04 | 4.53E-04 | 1.05E-03 |
| I24 | Given: DG-S, AG-F, I1-F | 8.68E-04 | 3.58E-04 | 7.43E-04 | 1.51E-03 |
| I2F | Given: DG-F (guaranteed failure). | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| SPLIT FRACTIONS FOR TOP EVENT I3 | | | | | |
| I31 | Given: DH-S,AH-S,AG-S or DH-S,AH-F,AG-S. | 1.15E-03 | 4.16E-04 | 9.05E-04 | 2.11E-03 |
| I32 | Given: DH-S,AH-S,AG-F or DH-S,AH-F,AG-F. | 1.74E-03 | 7.16E-04 | 1.49E-03 | 3.01E-03 |
| I3F | Given: DH-F (guaranteed failure). | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |

| | | | | | |
|---|---|---|---|---|---|
| SPLIT FRACTIONS FOR TOP EVENT I4 | | | | | |
| I41 | Given: DG-S,AH-S,AG-S, or DG-S,AH-F,AG-S. | 5.76E-04 | 2.08E-04 | 4.53E-04 | 1.05E-03 |
| I42 | Given: DG-F,AH-S or AG-F,DG-S,(AH-S or AH-F) | 8.68E-04 | 3.58E-04 | 7.43E-04 | 1.51E-03 |
| I4F | Given: DG-F, AH-F (guaranteed failure). | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| SPLIT FRACTIONS FOR TOP EVENT SA | | | | | |
| SA1 | General Transient | 7.58E-03 | 2.62E-03 | 5.43E-03 | 1.55E-02 |
| SA2 | Large Loss of Coolant Accident All 4 Channels Available | 1.14E-02 | 3.82E-03 | 8.02E-03 | 2.40E-02 |
| SA3 | LLOCA with loss of power to two CP H-H channels (not I) | 1.78E-02 | 6.71E-03 | 1.39E-02 | 3.49E-02 |
| SA4 | Steam Generator Tube Rupture | 1.19E-02 | 3.61E-03 | 8.11E-03 | 2.56E-02 |
| SA5 | Steam Line Break Inside Containment All 4 Channels Avlb | 1.40E-02 | 4.46E-03 | 9.72E-03 | 2.96E-02 |
| SA6 | SLBIC with loss of power to two CP H-H channels (not I) | 2.04E-02 | 7.59E-03 | 1.58E-02 | 3.96E-02 |
| SA7 | Steam Line Break Outside Containment | 1.19E-02 | 3.61E-03 | 8.11E-03 | 2.56E-02 |
| SA8 | Small Loss of Coolant Accident | 1.19E-02 | 3.61E-03 | 8.11E-03 | 2.56E-02 |
| SAF | Guaranteed Failure | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| SPLIT FRACTIONS FOR TOP EVENT SB | | | | | |
| SB1 | GT given Train A success | 7.48E-03 | 2.58E-03 | 5.32E-03 | 1.54E-02 |
| SB2 | GT given Train A failure | 2.40E-02 | 5.32E-03 | 1.58E-02 | 5.63E-02 |
| SB3 | GT given AC I unavailable (same as SA1) | 7.58E-03 | 2.62E-03 | 5.43E-03 | 1.55E-02 |
| SB4 | LLOCA given Train A success, all AC channels available | 1.08E-02 | 3.33E-03 | 7.37E-03 | 2.32E-02 |
| SB5 | LLOCA given Train A success, AC II&III unavailable | 1.09E-02 | 3.35E-03 | 7.42E-03 | 2.33E-02 |
| SB6 | LLOCA given Train A failure, all AC channels available | 8.43E-02 | 2.11E-02 | 7.39E-02 | 1.53E-01 |
| SB7 | LLOCA given Train A failure, AC II&III unavailable | 4.10E-01 | 1.22E-01 | 3.65E-01 | 7.19E-01 |
| SB8 | LLOCA given AC I and II(or III)unavailable (same as SA3) | 1.78E-02 | 6.71E-03 | 1.39E-02 | 3.49E-02 |
| SB9 | SGTR given Train A success | 1.17E-02 | 3.50E-03 | 7.86E-03 | 2.53E-02 |
| SBA | SGTR given Train A failure | 3.55E-02 | 6.54E-03 | 2.27E-02 | 8.65E-02 |
| SBB | SGTR given AC I unavailable (same as SA4) | 1.19E-02 | 3.61E-03 | 8 11E-03 | 2.56E-02 |
| SBC | SLBIC given Train A success, all AC channels available | 1.34E-02 | 3.95E-03 | 9.06E-03 | 2.89E-02 |
| SBD | SLBIC given Train A success, AC II&III unavailable | 1.35E-02 | 3.97E-03 | 9.12E-03 | 2.91E-02 |
| SBE | SLBIC given Train A failure, all AC channels available | 7.43E-02 | 1.88E-02 | 6.48E-02 | 1.36E-01 |
| SBG | SLBIC given Train A failure, AC II&III unavailable | 3.71E-01 | 1.03E-01 | 3.22E-01 | 6.79E-01 |
| SBH | SLBIC given AC I and II(or III)unavailable (same as SA6) | 2.04E-02 | 7.59E-03 | 1.58E-02 | 3.96E-02 |
| SBI | SLBOC given Train A success | 1.17E-02 | 3.50E-03 | 7.86E-03 | 2.53E-02 |
| SBJ | SLBOC given Train A failure | 3.49E-02 | 6.07E-03 | 2.20E-02 | 8.60E-02 |
| SBK | SLBOC given AC I unavailable (same as SA7) | 1.19E-02 | 3.61E-03 | 8.11E-03 | 2.56E-02 |
| SBL | SLOCA given Train A success | 1.17E-02 | 3.50E-03 | 7.86E-03 | 2.53E-02 |
| SBM | SLOCA given Train A failure | 3.49E-02 | 6.07E-03 | 2.20E-02 | 8.60E-02 |
| SBN | SLOCA given AC I unavailable (same as SA8) | 1.19E-02 | 3.61E-03 | 8.11E-03 | 2.56E-02 |
| SBF | Guaranteed Failure | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |

SPLIT FRACTIONS FOR TOP EVENT RT

| | | | | | |
|---|---|---|---|---|---|
| RT1 | 1/2 Trains (both SSPS signals generated) | 6.58E-06 | 3.57E-08 | 5.17E-07 | 1.30E-05 |
| RT2 | 1/2 Trains (DC power lost to one shunt trip) | 6.59E-06 | 3.76E-08 | 5.28E-07 | 1.30E-05 |
| RT3 | 1/2 Trains (DC power lost to both shunt trip coils) | 7.24E-06 | 8.49E-08 | 8.59E-07 | 1.44E-05 |
| RT4 | 1/1 Train (only one SSPS signal generated) | 1.60E-05 | 6.13E-07 | 4.70E-06 | 4.49E-05 |
| RT5 | 1/1 Train (one SSPS signal, LOP to shunt trip coil) | 2.10E-05 | 8.62E-07 | 6.57E-06 | 6.37E-05 |
| RT6 | Gravity Insertion (insuffìcent power to prevent insert) | 6.30E-06 | 5.60E-09 | 3.33E-07 | 1.25E-05 |
| RT7 | Operator initiated (DC power lost to both shunt coils) | 1.93E-03 | 1.16E-04 | 7.74E-04 | 5.82E-03 |
| RTF | Guaranteed failure | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |

SPLIT FRACTIONS FOR TOP EVENT CV

| | | | | | |
|---|---|---|---|---|---|
| CV1 | 1/2 subtrains: All support available (OSP,2F,1G,1H,2H) | 7.60E-04 | 2.15E-04 | 4.68E-04 | 1.36E-03 |
| CV2 | 1/2 subtrains: Normal power for subtrain F unavail. (2F) | 2.06E-02 | 6.81E-03 | 1.59E-02 | 4.24E-02 |
| CV3 | 1/1 subtrain: No support for subtrain F (2F,1G) | 5.68E-02 | 3.24E-02 | 5.11E-02 | 8.56E-02 |
| CV4 | 1/1 subtrain: No support for subtrain H (1H,2H) | 2.00E-02 | 8.56E-03 | 1.70E-02 | 3.34E-02 |
| CV5 | 1/2 subtrains:LOSP, all vital buses avail. (2F,1G,1H,2H) | 3.65E-03 | 1.63E-03 | 3.07E-03 | 5.99E-03 |
| CV6 | 1/1 subtrains:LOSP, no support for subtrain H (1H,2H) | 3.88E-02 | 2.21E-02 | 3.51E-02 | 5.60E-02 |
| CVF | Guaranteed Failure: 480V 2F,1G,1H,2H unavailable | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| LOCV | Initiating Event frequency for 1 year | 7.98E-02 | 3.56E-02 | 6.64E-02 | 1.35E-01 |

PLIT FRACTIONS FOR TOP EVENT SV

| | | | | | |
|---|---|---|---|---|---|
| SV1 | 1/2 trains; OSP, 480V 1F,1H available | 1.70E-06 | 4.70E-08 | 4.92E-07 | 5.47E-06 |
| SV2 | 1/1 train start and run; 480V Bus 1F unavailable | 1.80E-04 | 5.05E-06 | 4.99E-05 | 5.69E-04 |
| SV3 | 1/1 train continue to run; 480 V Bus 1H unavail. | 1.33E-04 | 3.02E-06 | 3.40E-05 | 4.17E-04 |
| SV4 | 1/2 trains start and run; LOSP, 480V Bus 1F,1H availab. | 2.57E-05 | 8.14E-07 | 7.84E-06 | 7.93E-05 |
| SV5 | Only recovery possible, Bus 1F,1H unavailable | 5.62E-03 | 2.38E-04 | 1.78E-03 | 2.17E-02 |
| SVF | Guaranteed failed, all inverters alrready failed | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| SVI | Initiating Event frequency for 1 year | 6.29E-05 | 4.56E-07 | 9.12E-06 | 2.02E-04 |
| SV0 | Station Blackout, guaranteed success. | 0.00E-01 | 0.00E-01 | 0.00E-01 | 0.00E-01 |

SPLIT FRACTIONS FOR TOP EVENT AS

| | | | | | |
|---|---|---|---|---|---|
| AS1 | All Pump Trains Available: 2 Running, 2 Standby (OP1) | 1.85E-06 | 3.74E-07 | 1.14E-06 | 4.17E-06 |
| AS2 | 3 Pump Trains Available: Fail Train 11 (OP2) | 3.55E-04 | 1.69E-04 | 3.10E-04 | 5.84E-04 |
| AS3 | 3 Pump Trains Available: Fail Train 12 (OP1) | 1.22E-04 | 4.38E-05 | 9.62E-05 | 2.34E-04 |
| AS4 | 2 Pump Trains Available: Fail Trains 11 and 12 (OP2) | 1.69E-02 | 6.58E-03 | 1.33E-02 | 3.16E-02 |
| AS5 | LOSP: 3 Pump Trains Available: Fail Train 11 (OP2) | 3.58E-04 | 1.71E-04 | 3.13E-04 | 5.88E-04 |
| AS6 | LOSP: 3 Pump Trains Available: Fail Train 21 (OP1) | 7.86E-06 | 3.04E-06 | 6.30E-06 | 1.47E-05 |
| AS7 | LOSP: 2 Pump Trains Available: Fail Trains 11 & 12 (OP2) | 1.69E-02 | 6.66E-03 | 1.34E-02 | 3.17E-02 |
| AS8 | LOSP: 2 Pump Trains Available: Fail 11 & 21(or 22) (OP2) | 4.71E-04 | 2.43E-04 | 4.12E-04 | 7.54E-04 |

| | | | | | |
|---|---|---|---|---|---|
| AS9 | LOSP: 2 Pump Trains Available: Fail Trains 12 & 21 (OP1) | 2.74E-04 | 1.02E-04 | 2.13E-04 | 5.30E-04 |
| ASA | LOSP: 2 Pump Trains Available: Fail Trains 21 & 22 (OPF) | 1.83E-04 | 7.00E-05 | 1.52E-04 | 3.39E-04 |
| ASB | LOSP: 1 Pump Train Available:Fail 11,12 & 21(or 22)(OP2) | 2.70E-02 | 1.54E-02 | 2.37E-02 | 4.22E-02 |
| ASC | LOSP: 1 Pump Train Available:Fail 11(or 12),21 & 22(OPF) | 1.07E-02 | 6.68E-03 | 9.68E-03 | 1.57E-02 |
| ASI | Loss of ASW Supply to Unit 1 Initiating Event Frequency | 9.73E-05 | 2.47E-05 | 6.23E-05 | 1.97E-04 |
| ASF | Guaranteed Failure | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| SPLIT FRACTIONS FOR TOP EVENT CC | | | | | |
| CC1 | All Support Available(N/3 pumps starts and/or runs) | 1.88E-05 | 5.69E-06 | 1.31E-05 | 4.33E-05 |
| CC2 | Loss of 4KV Bus H (N/2 pumps runs) | 5.69E-04 | 2.25E-04 | 4.79E-04 | 9.65E-04 |
| CC3 | Loss of 4KV Bus G (N/2 pumps starts and/or runs) | 5.85E-04 | 2.32E-04 | 4.93E-04 | 9.99E-04 |
| CC4 | Loss of 4KV Buses G and H (1/1 pump runs) | 2.67E-02 | 1.09E-02 | 2.07E-02 | 5.06E-02 |
| CC5 | Loss of 4KV Buses F and G (1/1 pump starts and runs) | 2.87E-02 | 1.24E-02 | 2.27E-02 | 5.26E-02 |
| CC6 | LOSP - All Support Available(N/3 pumps starts and runs) | 2.43E-05 | 8.65E-06 | 1.89E-05 | 4.89E-05 |
| CC7 | LOSP - Loss of one 4KV bus (N/2 pumps starts and runs) | 6.63E-04 | 2.74E-04 | 5.55E-04 | 1.14E-03 |
| CCI | Initiating Event Frequency (All pumps fail) | 1.97E-04 | 3.05E-05 | 1.23E-04 | 4.84E-04 |
| CCF | Guaranteed Failure | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| SPLIT FRACTIONS FOR TOP EVENT IA | | | | | |
| IAF | Guaranteed Failure | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| | | | | | |
| FRONTLINE SYSTEMS | | | | | |
| SPLIT FRACTIONS FOR TOP EVENT TT | | | | | |
| TT0 | Turbine Trip - TT Initiator | 0.00E-01 | 0.00E-01 | 0.00E-01 | 0.00E-01 |
| TT1 | Turbine Trip - All Support Available | 1.55E-05 | 8.85E-07 | 5.20E-06 | 3.86E-05 |
| TT2 | Turbine Trip ATWT - All Support Available | 3.27E-03 | 4.59E-04 | 1.84E-03 | 8.48E-03 |
| TT3 | Turbine Trip ATWT, Man. Rx trip - All Support | 8.92E-03 | 6.22E-04 | 3.70E-03 | 2.58E-02 |
| TT4 | Turbine Trip - 1 Train of Support Avail. | 2.98E-03 | 5.02E-04 | 1.67E-03 | 7.39E-03 |
| TT5 | *Turbine Trip ATWT - 1 Train of Support Avail.* | 6.12E-03 | 1.44E-03 | 4.07E-03 | 1.38E-02 |
| TT6 | Turbine Trip ATWT, Man. Rx trip-1 Support Train | 1.17E-02 | 1.79E-03 | 6.19E-03 | 3.16E-02 |
| TTF | Turbine Trip - Guaranteed failure | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| SPLIT FRACTIONS FOR TOP EVENT MS | | | | | |
| MS0 | Main Steam Isolation, TT failed,fire scenario 2 | 0.00E-01 | 0.00E-01 | 0.00E-01 | 0.00E-01 |
| MS1 | Main Steam Isolation ,TT succeeds- All Support Avail. | 7.51E-03 | 2.41E-03 | 6.13E-03 | 1.71E-02 |
| MS2 | MS Isolation - TT fails, All Support Avail. | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| MSF | MS Isolation - Guaranteed failure | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| SPLIT FRACTIONS FOR TOP EVENT AW | | | | | |
| AW1 | All Support Sys Available, Lo Power | 3.73E-05 | 8.78E-06 | 2.56E-05 | 8.10E-05 |
| AW2 | All Support Sys Available, Hi Power | 1.17E-01 | 7.28E-02 | 1.07E-01 | 1.71E-01 |

| | | | | | |
|---|---|---|---|---|---|
| AW3 | Support for 1 MDP Unavail, Lo Power | 1.24E-03 | 4.10E-04 | 9.65E-04 | 2.36E-03 |
| AW4 | Support for 2 MDP's Unavail, Lo Power | 7.25E-02 | 3.73E-02 | 6.27E-02 | 1.18E-01 |
| AW5 | Support for All 10% Stm Dumps Unavail, Lo Power | 3.30E-02 | 1.38E-05 | 2.10E-04 | 1.04E-01 |
| AW6 | Support for All 10% Stm Dumps Unavail, Hi Power | 2.01E-01 | 7.86E-02 | 1.27E-01 | 5.31E-01 |
| AW7 | Support for All 10% SD's and TDP Unavail, Lo Power | 3.50E-04 | 8.72E-05 | 2.23E-04 | 6.91E-04 |
| AW8 | Support for All 10% SD's and 1 MDP Unavail, Lo Power | 8.00E-03 | 3.86E-04 | 9.39E-04 | 2.37E-03 |
| AW9 | Support for All 10% SD's and 2 MDP's Unavail, Lo Power | 1.41E-01 | 4.34E-02 | 8.34E-02 | 3.70E-01 |
| AWA | Support for All 10% SD's, 1 MDP & TDP Unavail, Lo Power | 9.59E-02 | 1.66E-02 | 3.49E-02 | 3.28E-01 |
| AWB | One SG depressurizes, All Support Sys Avail., Lo Power | 2.41E-02 | 1.47E-02 | 2.21E-02 | 3.50E-02 |
| AWC | ATWS; All Support Systems Available, TT Success | 2.45E-03 | 7.98E-04 | 1.90E-03 | 4.69E-03 |
| AWF | Guaranteed failure | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| SPLIT FRACTIONS FOR TOP EVENT TD | | | | | |
| TD1 | Support for 2 MDP's Unavail., Seismic events | 7.11E-02 | 3.68E-02 | 6.16E-02 | 1.16E-01 |
| TD2 | Support for all 10% SD's & 2 MDP's unavail.,Seismic IE | 1.41E-01 | 4.34E-02 | 8.34E-02 | 3.70E-01 |
| TDF | Guaranteed failure | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| SPLIT FRACTIONS FOR TOP EVENT PR | | | | | |
| PR0 | Guaranteed Success | 0.00E-01 | 0.00E-01 | 0.00E-01 | 0.00E-01 |
| PR1 | 1/2 PORV's or (1/3 SRV's), LOSP or SGTR | 5.03E-04 | 5.26E-05 | 1.95E-04 | 9.51E-04 |
| PR2 | 1/2 PORV's and 3/3 SRV's | 1.00E-02 | 1.25E-03 | 4.86E-03 | 2.55E-02 |
| PR3 | 2/2 PORV's and 3/3 SRV's | 2.59E-02 | 6.45E-03 | 1.60E-02 | 5.75E-02 |
| PR4 | 2/2 PORV's and 2/3 SRV's or(3/3 SRV'S) | 8.86E-03 | 6.56E-04 | 3.76E-03 | 2.43E-02 |
| PR5 | 1/2 PORV's or (1/3 SRV's), HPI or SLB | 2.18E-05 | 1.24E-07 | 2.91E-06 | 4.51E-05 |
| PR6 | 1/1 PORV or (1/3 SRV's), LOSP or SGTR | 2.36E-04 | 3.49E-05 | 1.25E-04 | 5.33E-04 |
| PR7 | 1/1 PORV and 3/3 SRV's | 1.83E-02 | 3.95E-03 | 1.09E-02 | 4.15E-02 |
| PR8 | 3/3 SRV's | 9.45E-03 | 9.45E-04 | 4.42E-03 | 2.45E-02 |
| PR9 | 1/1 PORV or (1/3 SRV's), HPI or SLB | 2.92E-05 | 3.85E-07 | 6.19E-06 | 7.17E-05 |
| PRA | 1/3 SRV's | 8.23E-03 | 3.44E-04 | 3.34E-03 | 2.32E-02 |
| PRB | 3/3 SRV's | 9.31E-03 | 7.89E-04 | 4.28E-03 | 2.43E-02 |
| PRC | 1/3 SRV's | 2.84E-03 | 3.18E-05 | 6.89E-04 | 8.47E-03 |
| PRD | 1/2 PORV's or (1/3 SRV's), LOSP/SGTR,no blk vlvs | 4.88E-02 | 1.37E-02 | 3.81E-02 | 9.74E-02 |
| PRE | 1/2 PORV's and 3/3 SRV's blk vlvs not avail. | 5.90E-02 | 1.91E-02 | 4.64E-02 | 1.15E-01 |
| PRF | Guaranteed Failure | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| PRG | 2/2 PORV's and 3/3 SRV's blk vlvs not avail. | 7.47E-02 | 2.79E-02 | 5.98E-02 | 1.42E-01 |
| PRH | 2/2 PORV's and 2/3 SRV's or(3/3 SRV'S) no blk vlvs | 5.74E-02 | 1.80E-02 | 4.49E-02 | 1.13E-01 |
| PRI | 1/2 PORV's or (1/3 SRV's), HPI or SLB no blk vlvs | 2.13E-03 | 2.38E-05 | 5.03E-04 | 6.28E-03 |
| PRJ | 1/1 PORV or (1/3 SRV's), LOSP/SGTR, no blk vlvs | 2.53E-02 | 5.90E-03 | 1.87E-02 | 5.41E-02 |
| PRK | 1/1 PORV and 3/3 SRV's no blk vlvs | 4.33E-02 | 1.53E-02 | 3.35E-02 | 8.35E-02 |

|  |  |  |  |  |  |
|---|---|---|---|---|---|
| PRL | 3/3 SRV's no blk vlvs | 3.41E-02 | 1.01E-02 | 2.58E-02 | 6.97E-02 |
| PRM | 1/1 PORV or (1/3 SRV's), HPI or SLB no blk vlvs | 1.11E-03 | 1.04E-05 | 2.54E-04 | 3.19E-03 |
| PRN | 1/1 Block valve closes, All support available | 7.66E-03 | 1.98E-03 | 4.96E-03 | 1.76E-02 |
| PRP | 1/2 PORV's or (1/3 SRV's), Manual-reactor trip | 6.11E-08 | 2.07E-09 | 1.60E-08 | 1.32E-07 |
| PRQ | 1/1 PORV or (1/3 SRV's), Manual reactor trip | 2.73E-08 | 1.51E-09 | 9.91E-09 | 6.64E-08 |
| PRR | 1/3 SRV's, Manual reactor trip | 9.57E-07 | 2.05E-08 | 2.48E-07 | 2.68E-06 |
| PRS | 1/2 PORV's or (1/3 SRV's), Manual reactor trip | 5.69E-06 | 5.19E-07 | 2.97E-06 | 1.52E-05 |
| PRT | 1/1 PORV or (1/3 SRV's), Manual reactor trip | 2.85E-06 | 2.50E-07 | 1.43E-06 | 7.67E-06 |
| SPLIT FRACTIONS FOR TOP EVENT PO |  |  |  |  |  |
| PO1 | 1/2 PORVs ATWT,boration,all support,AFW avail. | 7.19E-04 | 1.44E-04 | 3.93E-04 | 1.24E-03 |
| PO2 | 2/2 PORVs ATWT,boration,no block valves,no AFW | 6.54E-02 | 2.30E-02 | 5.15E-02 | 1.25E-01 |
| PO3 | 1/2 PORVs ATWT,boration,no block valves,AFW avail. | 4.89E-02 | 1.39E-02 | 3.82E-02 | 9.72E-02 |
| POF | Guaranteed Failure | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| SPLIT FRACTIONS FOR TOP EVENT OB |  |  |  |  |  |
| OB1 | Loss of Instrument air | 2.89E-02 | 6.25E-03 | 1.71E-02 | 6.46E-02 |
| OB2 | Loss of Instrument air, charging failed | 2.89E-02 | 6.25E-03 | 1.71E-02 | 6.46E-02 |
| OB3 | Loss of 1 DC bus Initiating event | 3.75E-01 | 3.48E-01 | 3.65E-01 | 4.14E-01 |
| OBF | Guaranteed Failure | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| SPLIT FRACTIONS FOR TOP EVENT CH |  |  |  |  |  |
| CH1 | All support available. | 6.23E-04 | 3.01E-04 | 5.57E-04 | 9.65E-04 |
| CH2 | One standby pump train available only | 1.41E-02 | 9.12E-03 | 1.32E-02 | 1.97E-02 |
| CH3 | Normally running pump train available only. | 1.16E-02 | 7.46E-03 | 1.10E-02 | 1.61E-02 |
| CH4 | LOSP ; All support available | 7.95E-04 | 4.17E-04 | 7.12E-04 | 1.22E-03 |
| CHF | Guaranteed failure. | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| SPLIT FRACTIONS FOR TOP EVENT SI |  |  |  |  |  |
| SI1 | All support available (1/2) | 3.25E-03 | 6.25E-04 | 1.62E-03 | 1.04E-02 |
| SI2 | One safety injection pump train available only(1/1) | 1.60E-02 | 7.49E-03 | 1.31E-02 | 2.99E-02 |
| SI3 | Medium LOCA; All support available, CH failed. (2/2) | 2.89E-02 | 1.40E-02 | 2.44E-02 | 5.16E-02 |
| SIF | Guaranteed failure. | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| SPLIT FRACTIONS FOR TOP EVENT HR |  |  |  |  |  |
| HR1 | All support available | 2.11E-04 | 1.11E-04 | 1.94E-04 | 3.22E-04 |
| HR2 | Top event CH or SI failed | 1.91E-03 | 1.11E-03 | 1.59E-03 | 3.57E-03 |
| HR3 | Top event LA or LB failed | 4.01E-03 | 2.55E-03 | 3.68E-03 | 5.86E-03 |
| HR4 | Top event CH or SI and top events LA or LB failed | 4.33E-03 | 2.77E-03 | 3.99E-03 | 6.28E-03 |
| HR5 | 4KV Bus F failed | 2.29E-03 | 1.36E-03 | 2.11E-03 | 3.35E-03 |
| HR6 | 4KV Bus F failed, top event CH or SI failed | 3.99E-03 | 2.55E-03 | 3.65E-03 | 5.89E-03 |
| HR7 | 4KV Bus F failed, top event LA or LB failed | 6.08E-03 | 4.16E-03 | 5.74E-03 | 8.24E-03 |

| | | | | | |
|---|---|---|---|---|---|
| HR8 | 4KV Bus F failed, top event CH or SI & LA or LB failed | 6.40E-03 | 4.39E-03 | 6.04E-03 | 8.64E-03 |
| HR9 | 4KV Bus F and 4KV Bus G failed | 6.08E-03 | 4.16E-03 | 5.74E-03 | 8.24E-03 |
| HRA | 4KV Bus F and 4KV Bus H failed | 2.36E-03 | 1.39E-03 | 2.19E-03 | 3.42E-03 |
| HRB | 4KV Bus G failed | 4.01E-03 | 2.55E-03 | 3.68E-03 | 5.86E-03 |
| HRC | 4KV Bus G failed, top event CH or SI failed | 6.43E-03 | 4.03E-03 | 6.01E-03 | 9.06E-03 |
| HRD | 4KV Bus H failed | 4.56E-03 | 3.07E-03 | 4.36E-03 | 6.07E-03 |
| HRE | 4KV Bus H failed, top event CH or SI failed | 8.66E-03 | 5.87E-03 | 8.24E-03 | 1.15E-02 |
| HRF | Guaranteed failure | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| SPLIT FRACTIONS FOR TOP EVENT RC | | | | | |
| RC1 | Both RHR pump trains operable | 4.43E-05 | 5.88E-06 | 2.72E-05 | 1.10E-04 |
| RC2 | One RHR pump train operable | 1.18E-03 | 6.84E-04 | 1.07E-03 | 1.83E-03 |
| SPLIT FRACTIONS FOR TOP EVENT RF | | | | | |
| RF1 | Switchover after SLOCA or B/F with CS failed | 3.16E-03 | 4.78E-04 | 1.80E-03 | 8.26E-03 |
| RF2 | Switchover after SLOCA or B/F with CS success | 3.37E-03 | 5.07E-04 | 1.92E-03 | 8.84E-03 |
| RF3 | Switchover after LLOCA or MLOCA initiating event | 4.93E-03 | 9.22E-04 | 3.07E-03 | 1.21E-02 |
| RF4 | Switchover to recirculation after core melt | 5.47E-02 | 9.54E-03 | 3.41E-02 | 1.34E-01 |
| SPLIT FRACTIONS FOR TOP EVENT LA | | | | | |
| LA1 | All support available. (SLOCA Case) | 2.04E-02 | 1.13E-02 | 1.80E-02 | 3.22E-02 |
| LA2 | All support available. (Bleed & Feed case) | 2.04E-02 | 1.12E-02 | 1.78E-02 | 3.23E-02 |
| LA3 | All support available. (LLOCA/MLOCA Case) | 1.58E-02 | 9.03E-03 | 1.41E-02 | 2.42E-02 |
| LAF | Guaranteed failure | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| SPLIT FRACTIONS FOR TOP EVENT LB | | | | | |
| LB1 | All support available. Top event LA successful. (SLOCA) | 1.56E-02 | 8.78E-03 | 1.38E-02 | 2.39E-02 |
| LB2 | All support available. Top event LA failed. (SLOCA) | 2.32E-01 | 6.20E-02 | 1.79E-01 | 4.83E-01 |
| LB3 | Top Event LA Guaranteed Failure (SLOCA) | 2.04E-02 | 1.13E-02 | 1.80E-02 | 3.22E-02 |
| LB4 | All support available. Top event LA successful. (B & F) | 1.56E-02 | 8.78E-03 | 1.38E-02 | 2.39E-02 |
| LB5 | All support available. Top event LA failed. (B & F) | 2.30E-01 | 6.04E-02 | 1.78E-01 | 4.73E-01 |
| LB6 | Top Event LA Guaranteed Failure (B & F) | 2.04E-02 | 1.12E-02 | 1.78E-02 | 3.23E-02 |
| LB7 | All support available. Top event LA successful.(LLOCA) | 1.55E-02 | 8.74E-03 | 1.37E-02 | 2.38E-02 |
| LB8 | All support available. Top event LA failed. (LLOCA) | 3.75E-02 | 1.66E-02 | 2.81E-02 | 7.16E-02 |
| LB9 | Top Event LA Guaranteed Failure (LLOCA) | 1.58E-02 | 9.03E-03 | 1.41E-02 | 2.42E-02 |
| LBF | Guaranteed failure | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| SPLIT FRACTIONS FOR TOP EVENT LV | | | | | |
| LV1 | All conditions(No support required) | 4.59E-04 | 1.32E-04 | 3.00E-04 | 1.20E-03 |
| SPLIT FRACTIONS FOR TOP EVENT RW | | | | | |
| RW1 | All conditions(No support required) | 3.94E-05 | 3.44E-06 | 1.78E-05 | 1.09E-04 |

| | | | | | |
|---|---|---|---|---|---|
| SPLIT FRACTIONS FOR TOP EVENT VA | | | | | |
| VA1 | All support available. | 4.38E-03 | 2.87E-03 | 4.17E-03 | 5.83E-03 |
| VAF | Guaranteed failure | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| SPLIT FRACTIONS FOR TOP EVENT VB | | | | | |
| VB1 | All support available. Top event VA successful. | 4.18E-03 | 2.69E-03 | 3.98E-03 | 5.64E-03 |
| VB2 | All support available. Top event VA failed. | 5.00E-02 | 2.52E-02 | 4.51E-02 | 7.85E-02 |
| VB3 | Top Event VA Guaranteed Failure | 4.38E-03 | 2.87E-03 | 4.17E-03 | 5.83E-03 |
| VBF | Guaranteed failure | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| SPLIT FRACTIONS FOR TOP EVENT AC | | | | | |
| AC1 | All conditions(No support required) | 6.27E-03 | 1.44E-03 | 3.30E-03 | 1.92E-02 |
| SPLIT FRACTIONS FOR TOP EVENT LI | | | | | |
| LI1 | All conditions except large LOCA;(No support required) | 4.03E-06 | 7.90E-07 | 1.98E-06 | 1.25E-05 |
| LI2 | LLOCA initiating event: Given failure of top event AC | 5.55E-04 | 1.99E-04 | 3.59E-04 | 9.43E-04 |
| SPLIT FRACTIONS FOR TOP EVENT MU | | | | | |
| MU1 | Power available at AC buses G and H | 7.98E-03 | 3.67E-03 | 6.51E-03 | 1.41E-02 |
| MUF | Guaranteed failure | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| MU2 | Power avail at AC buses G and H (Make-up Via RFW Pump) | 1.54E-02 | 5.48E-03 | 1.09E-02 | 3.16E-02 |
| MUV | Makeup to RWST | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| SPLIT FRACTIONS FOR TOP EVENT FC | | | | | |
| FC1 | 2 OF 5 CFCUs start rate 24 hours | 1.86E-06 | 1.72E-07 | 1.00E-06 | 4.88E-06 |
| FC2 | 2 OF 4 CFCUs start and operate 24 hours | 4.83E-06 | 9.90E-07 | 3.32E-06 | 1.09E-05 |
| FC3 | 2 OF 3 CFCUs start and operate 24 hours | 6.07E-05 | 1.84E-05 | 4.73E-05 | 1.19E-04 |
| FC4 | 2 OF 2 CFCUs start and operate 24 hours | 6.59E-03 | 2.88E-03 | 5.72E-03 | 1.11E-02 |
| FCF | Guaranteed failure | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| SPLIT FRACTIONS FOR TOP EVENT CS | | | | | |
| CS1 | 1/2 Trains Operates(All Support Available) | 5.91E-04 | 2.24E-04 | 4.59E-04 | 1.12E-03 |
| CS2 | 1/1 Train Operates(Loss of One Vital Bus or SSPS train) | 1.43E-02 | 7.29E-03 | 1.24E-02 | 2.35E-02 |
| CSF | Guaranteed failure | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| SPLIT FRACTIONS FOR TOP EVENT SR | | | | | |
| SR1 | 1/2 Trains Operates(All Support Available) | 3.80E-03 | 4.33E-04 | 1.76E-03 | 1.02E-02 |
| SR2 | 1/1 Train Operates(Loss of 1 Bus or SSPS or RHR train) | 9.47E-03 | 4.15E-03 | 7.18E-03 | 1.85E-02 |
| SRF | Guaranteed failure | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| SPLIT FRACTIONS FOR TOP EVENT CI | | | | | |
| CI1 | Either inboard or outboard isol. valve(s) must close | 4.06E-03 | 3.37E-04 | 1.93E-03 | 1.07E-02 |
| CI2 | Inboard vlves(pen 45) and 1/2 vlves(pen 50,51,52) close | 5.77E-03 | 1.61E-03 | 3.69E-03 | 1.24E-02 |
| CI3 | Inboard isolation vlaves (pen 45,50,51,52) must close | 7.31E-03 | 2.84E-03 | 5.29E-03 | 1.40E-02 |
| CI4 | Inbd. or Outbd. Isolation vlvs close - Excessive LOCA | 4.06E-03 | 3.37E-04 | 1.93E-03 | 1.07E-02 |
| CI5 | Inbd.pen.45 & 1/2 vlvs pen.50,51,52 close - ELOCA | 5.77E-03 | 1.61E-03 | 3.69E-03 | 1.24E-02 |

|  |  |  |  |  |  |
|---|---|---|---|---|---|
| CI6 | Inbd.isol.vlvs.pen.45,50,51,52 close - ELOCA | 7.31E-03 | 2.84E-03 | 5.29E-03 | 1.40E-02 |
| CIF | Guaranteed failure | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| SPLIT FRACTIONS FOR TOP EVENT CP |  |  |  |  |  |
| CP1 | Either inboard or outboard isolation valve(s) must close | 9.05E-07 | 1.51E-07 | 5.95E-07 | 2.06E-06 |
| CP2 | Outboard isolation valves must close | 1.01E-05 | 3.66E-06 | 8.29E-06 | 1.95E-05 |
| CP3 | Fraction of time penetration 61, 62, or 63 is open | 8.41E-03 | 8.41E-03 | 8.41E-03 | 8.41E-03 |
| CP4 | Same as CP1 with VI failed seismicly | 9.05E-07 | 1.51E-07 | 5.95E-07 | 2.06E-06 |
| CP5 | Same as CP2 with VI failed seismicly | 1.01E-05 | 3.66E-06 | 8.29E-06 | 1.95E-05 |
| CP6 | Same as CP3 with VI failed seismicly | 8.41E-03 | 8.41E-03 | 8.41E-03 | 8.41E-03 |
| SPLIT FRACTIONS FOR TOP EVENT WL |  |  |  |  |  |
| WL1 | Either FCV-500 (inboard) or FCV-501(outboard) must close | 4.32E-05 | 5.17E-06 | 2.60E-05 | 1.11E-04 |
| WL2 | Inboard vlv FCV-500 (or outboard vlv FCV-501) must close | 6.34E-04 | 2.19E-04 | 5.31E-04 | 1.23E-03 |
| WL3 | Fraction of time containment sump discharge line is open | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| SPLIT FRACTIONS FOR TOP EVENT SL |  |  |  |  |  |
| SL1 | All Support Available | 6.06E-03 | 1.29E-03 | 3.67E-03 | 1.56E-02 |
| SL2 | Loss of support to 10% steam dump valves | 6.52E-03 | 1.32E-03 | 3.88E-03 | 1.68E-02 |
| SPLIT FRACTIONS FOR TOP EVENT VD |  |  |  |  |  |
| VDI | Initiating event frequency (discharge side valves) | 3.86E-06 | 1.33E-08 | 2.68E-07 | 7.97E-06 |
| SPLIT FRACTIONS FOR TOP EVENT VS |  |  |  |  |  |
| VSI | Initiating event frequency (suction side valves) | 1.01E-06 | 5.03E-09 | 8.40E-08 | 2.14E-06 |
| SPLIT FRACTIONS FOR TOP EVENT VO |  |  |  |  |  |
| VO1 | Pressure relief valves open 3/3 for VSI IE | 6.99E-05 | 4.14E-06 | 2.90E-05 | 2.60E-04 |
| VO2 | Pressure relief valves open 2/2 for VDI IE | 4.66E-05 | 2.76E-06 | 1.93E-05 | 1.73E-04 |
| SPLIT FRACTIONS FOR TOP EVENT VC |  |  |  |  |  |
| VC1 | Leak rate of 1700 gpm for VSI IE | 1.48E-01 | 5.98E-04 | 1.18E-02 | 2.96E-01 |
| VC2 | Leak rate of 800 gpm for VDI IE | 6.93E-02 | 2.43E-04 | 4.83E-03 | 1.36E-01 |
| SPLIT FRACTIONS FOR TOP EVENT VR |  |  |  |  |  |
| VR1 | Pressure relief valves reclose 3/3 for VSI IE | 2.44E-01 | 1.17E-02 | 2.28E-01 | 6.39E-01 |
| VR2 | Pressure relief valves reclose 2/2 for VDI IE | 1.80E-01 | 7.82E-03 | 1.58E-01 | 4.96E-01 |
| SPLIT FRACTIONS FOR TOP EVENT IT |  |  |  |  |  |
| IT1 | RHR piping intact; VO successful | 9.90E-01 | 4.95E-02 | 4.95E-01 | 9.40E-01 |
| SPLIT FRACTIONS FOR TOP EVENT LW |  |  |  |  |  |
| LW1 | RCS flow to RWST for VSI IE | 4.14E-04 | 1.15E-05 | 1.17E-04 | 1.32E-03 |
| LW2 | Guaranteed success | 0.00E-01 | 0.00E-01 | 0.00E-01 | 0.00E-01 |
| LW3 | MOV support power not available | 4.13E-04 | 1.44E-05 | 1.17E-04 | 1.81E-03 |
| SPLIT FRACTIONS FOR TOP EVENT ME |  |  |  |  |  |
| ME1 | Medium LOCA; for VSI IE | 5.00E-01 | 2.50E-02 | 2.50E-01 | 4.75E-01 |

| | | | | | |
|---|---|---|---|---|---|
| ME2 | Medium LOCA; for VDI IE | 6.00E-03 | 3.00E-04 | 3.00E-03 | 5.70E-03 |
| SPLIT FRACTIONS FOR TOP EVENT SM | | | | | |
| SM1 | Small LOCA; for VSI IE | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| SM2 | Small LOCA; for VDI IE | 5.00E-01 | 2.50E-02 | 2.50E-01 | 4.75E-01 |
| SPLIT FRACTIONS FOR TOP EVENT OT | | | | | |
| OT1 | Failure to isolate break, stops leakage; Initiates E-1 | 9.99E-02 | 5.00E-03 | 5.00E-02 | 9.50E-02 |
| OTF | Operator fails to isolate break | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| SPLIT FRACTIONS FOR TOP EVENT OS | | | | | |
| OS1 | Manual SI Actuation | 1.89E-03 | 1.94E-04 | 1.04E-03 | 5.97E-03 |
| OSF | Guaranteed Failure | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| SPLIT FRACTIONS FOR TOP EVENT CD | | | | | |
| CDF | Guaranteed Failure | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| SPLIT FRACTIONS FOR TOP EVENT FW | | | | | |
| FWF | Guaranteed Failure | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| SPLIT FRACTIONS FOR TOP EVENT SE | | | | | |
| SE1 | RCP Seal Cooling, CCW unavailable | 9.91E-03 | 2.83E-03 | 7.42E-03 | 2.43E-02 |
| SE2 | RCP Seal Cooling, CCW available | 0.00E-01 | 0.00E-01 | 0.00E-01 | 0.00E-01 |
| SE0 | Guaranteed Success | 0.00E-01 | 0.00E-01 | 0.00E-01 | 0.00E-01 |
| SEF | Guaranteed failure | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| SPLIT FRACTIONS FOR TOP EVENT VI | | | | | |
| VI0 | Vessel Integrity Guaranteed success | 0.00E-01 | 0.00E-01 | 0.00E-01 | 0.00E-01 |
| VI1 | Vessel Integrity (TT & MS Failed) | 1.10E-04 | 5.50E-06 | 5.50E-05 | 1.04E-04 |
| VI2 | Vessel Integrity Loss of Secondary Heat Sink | 2.20E-02 | 1.10E-03 | 1.10E-02 | 2.09E-02 |
| VI3 | Vessel Integrity Medium LOCA Events | 2.00E-03 | 1.00E-04 | 1.00E-03 | 1.90E-03 |
| VI4 | SGTR; With Successful ECCS Termination | 1.80E-06 | 9.00E-08 | 9.00E-07 | 1.71E-06 |
| VI5 | SGTR; With Delayed ECCS Termination | 8.99E-03 | 4.50E-04 | 4.50E-03 | 8.55E-03 |
| SPLIT FRACTIONS FOR TOP EVENT RP | | | | | |
| RP0 | Guaranteed Success | 0.00E-01 | 0.00E-01 | 0.00E-01 | 0.00E-01 |
| RP1 | RCS pressure <1275# | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| RP2 | CCW lost,operator must trip to prevent seal loca | 9.96E-01 | 9.82E-01 | 9.98E-01 | 1.00E+00 |
| RPF | Guaranteed Failure | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| SPLIT FRACTIONS FOR TOP EVENT OI | | | | | |
| OIF | Guaranteed Failure | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| OI1 | when WL fails | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| OI2 | when CP fails | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| OI3 | when CI fails | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |

| | | | | | |
|---|---|---|---|---|---|
| SPLIT FRACTIONS FOR TOP EVENT OP | | | | | |
| OP1 | SGTR when SL S, terminate SI | 4.16E-03 | 4.29E-04 | 2.28E-03 | 1.32E-02 |
| OP2 | SGTR when SL F,B; terminate SI | 4.16E-03 | 4.29E-04 | 2.28E-03 | 1.32E-02 |
| SPLIT FRACTIONS FOR TOP EVENT OE | | | | | |
| OE1 | initiate boration in 10 minutes given ATWT | 2.32E-03 | 2.40E-04 | 1.28E-03 | 7.35E-03 |
| OE2 | initiate boration in 20 minutes given ATWT | 2.32E-03 | 2.40E-04 | 1.28E-03 | 7.35E-03 |
| OE3 | initiate boration in 30 minutes given ATWT | 2.32E-03 | 2.40E-04 | 1.28E-03 | 7.35E-03 |
| SPLIT FRACTIONS FOR TOP EVENT HS | | | | | |
| HS1 | hot standby,all available | 4.71E-06 | 2.37E-07 | 1.91E-06 | 1.73E-05 |
| HS2 | hot standby,with small LOCA | 3.09E-06 | 3.18E-07 | 1.70E-06 | 9.77E-06 |
| HS3 | hot standby,instrumentation lost | 5.06E-03 | 2.54E-04 | 2.05E-03 | 1.86E-02 |
| HS4 | hot standby,LOCA and instrumentation lost | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| HSF | guaranteed failure | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| SPLIT FRACTIONS FOR TOP EVENT RS | | | | | |
| RS1 | 43 of 53 inserted within 10 minutes | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| RSF | reactor trip failed | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| SPLIT FRACTIONS FOR TOP EVENT PL | | | | | |
| PL1 | power level greater than 80% | 0.00E-01 | 0.00E-01 | 0.00E-01 | 0.00E-01 |
| SPLIT FRACTIONS FOR TOP EVENT MC | | | | | |
| MC1 | moderator coefficient less negative than -7 | 1.00E-02 | 5.00E-04 | 5.00E-03 | 9.50E-03 |
| SPLIT FRACTIONS FOR TOP EVENT SS | | | | | |
| SSF | Guaranteed Failure | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| SPLIT FRACTIONS FOR TOP EVENT OD | | | | | |
| ODF | Guaranteed Failure | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| OV1 | Failure to diagnoses a LOCA to RHR; Initiates ECA 1.2 | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| OL1 | Operator fails to depressurizes RCS | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| CT1 | Seismic Failure of relays chattering givne /OP | 0.00E-01 | 0.00E-01 | 0.00E-01 | 0.00E-01 |
| CT2 | Seismic Failure of relays chattering given OP | 0.00E-01 | 0.00E-01 | 0.00E-01 | 0.00E-01 |
| CTF | Guaranteed Failure | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| EL1 | Excessive LOCA | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| ELF | Guaranteed Failure | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| ID1 | Identification of operator | 0.00E-01 | 0.00E-01 | 0.00E-01 | 0.00E-01 |
| IDF | Guaranteed Failure | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |

APPENDIX C: SEISMIC SEQUENCE ANALYSIS
Figure C-1: First 200 Seismic Sequences
Reference: PGE.1123 EVENT.TREES SEISMIC SQLINKSO
SEQUENCE LIMIT OF, 2000 REACHED FOR TOTAL DAMAGE AT CUMULATIVE % OF 70.49 1

SUPPORT MODEL/MAINLINE MODEL MAXIMA8 SEQUENCE LINKING FOR D.C.P.R.A.(SEISMIC) 06/07/88
DOMINANT SEQUENCE LIST FOR TOTAL DAMAGE
FREQUENCY OF TOTAL DAMAGE 3.43E-05

| | INIT. | | E.P. TREE | | A.M. TREE | | | F.L. TREE | | REC. TREE | | | SEQUENCE | | PERCENT. | CUMUL. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| NO. | EVENT (FREQ) | SUP STATE | END STATE | SEQ NUM. | RUN NUM. | END STATE | SEQ NUM. | RUN NUM. | END STATE | SEQ NUM. | RUN NUM. | END STATE | SEQ NUM. | RUN NUM. | FREQUENCY PER YEAR | OF TOTAL DAMAGE | % OF TOTAL |
| 1 | SEIS4 | SS27 | EP48 | 1240 | 4 | MS3 | 23 | 315 | LT2A4 | 25 | 420 | 3H | 13 | 455 | 2.196E-06 | 6.404 | 6.404 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| | (1.17E-04) | | STAGES 1 AND 2, OG1 AF1 AG2 AH3/CVF ASF/ | | | | | | | | | | | | | | |
| | STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF | | | | | | | | | | | | | | | | |
| 2 | SEIS5 | SS27 | EP48 | 1240 | 5 | MS3 | 23 | 417 | LT2A5 | 25 | 520 | 3H | 13 | 554 | 1.422E-06 | 4.147 | 10.551 |
| | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | | |
| + | | | | | | | | | | | | | | | | | |
| | (2.82E-05) | | | STAGES 1 AND 2, OG1 AF1 AG2 AH3/CVF ASF/ | | | | | | | | | | | | | |
| | | | STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF | | | | | | | | | | | | | | |
| 3 | SEIS4 | SS27 | EP48 | 437 | 4 | MS3 | 23 | 315 | LT2A4 | 25 | 420 | 3H | 13 | 455 | 1.270E-06 | 3.703 | 14.254 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | | | | | | | | | | | | | | | | | |
| | (1.17E-04) | | STAGES 1 AND 2, OG1 GF1 GG2 GH3/CVF ASF/ | | | | | | | | | | | | | | |
| | | | STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF | | | | | | | | | | | | | | |
| 4 | SEIS5 | SS27 | EP48 | 437 | 5 | MS3 | 23 | 417 | LT2A5 | 25 | 520 | 3H | 13 | 554 | 8.792E-07 | 2.564 | 16.818 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | | | | | | | | | | | | | | | | | |
| | (2.82E-05) | | STAGES 1 AND 2, OG1 GF1 GG2 GH3/CVF ASF/ | | | | | | | | | | | | | | |
| | | | STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF | | | | | | | | | | | | | | |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | SEIS2 | SS27 | EP12 | 101 | 2 | MS3 | 9 | 109 | LT2A2 | 25 | 216 | 3H | 13 | 252 | 8.583E-07 | 2.503 | 19.321 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | | | | | | | | | | | | | | | | | |
| | (8.00E-04) | | STAGES 1 AND 2, AF1 AG2 AH3/IAF CCF/<br>STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF | | | | | | | | | | | | | | |
| 6 | SEIS3 | SS27 | EP48 | 1240 | 3 | MS3 | 23 | 218 | LT2A3 | 25 | 319 | 3H | 13 | 353 | 7.674E-07 | 2.238 | 21.559 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | | | | | | | | | | | | | | | | | |
| | (1.47E-04) | | STAGES 1 AND 2, OG1 AF1 AG2 AH3/CVF ASF/<br>STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF | | | | | | | | | | | | | | |
| 7 | SEIS5 | SS89 | EP153 | 2178 | 5 | MS56 | 1302 | 461 | LT2A5 | 26 | 539 | 3H | 18 | 553 | 7.567E-07 | 2.207 | 23.766 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | | | | | | | | | | | | | | | | | |
| | (2.82E-05) | | STAGES 1 AND 2, OG1 DF1 DG2 DH4/I1F I2F I3F I4F RT7 OSF ASF SVF/<br>STAGES 3 AND 4, CHF SIF AWF/FCF WL3 CIF OI1 | | | | | | | | | | | | | | |
| 8 | SEIS4 | SS27 | EP12 | 101 | 4 | MS3 | 9 | 307 | LT2A4 | 25 | 420 | 3H | 13 | 455 | 5.374E-07 | 1.567 | 25.333 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | | | | | | | | | | | | | | | | | |
| | (1.17E-04) | | STAGES 1 AND 2, AF1 AG2 AH3/IAF CCF/<br>STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF | | | | | | | | | | | | | | |
| 9 | SEIS6 | SS27 | EP48 | 1240 | 6 | MS3 | 23 | 508 | LT2A6 | 25 | 616 | 3H | 13 | 654 | 5.209E-07 | 1.519 | 26.852 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | | | | | | | | | | | | | | | | | |
| | (7.43E-06) | | STAGES 1 AND 2, OG1 AF1 AG2 AH3/CVF ASF/<br>STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF | | | | | | | | | | | | | | |
| 10 | SEIS5 | SS27 | EP48 | 1240 | 5 | MS3 | 23 | 417 | LT2A5 | 81 | 520 | 3H | 13 | 554 | 4.741E-07 | 1.383 | 28.234 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | | | | | | | | | | | | | | | | | |
| | (2.82E-05) | | STAGES 1 AND 2, OG1 AF1 AG2 AH3/CVF ASF/<br>STAGES 3 AND 4, CT2 CHF SIF SEF HSF/FCF CIF OIF | | | | | | | | | | | | | | |

```
11   SEIS3  SS27   EP12     101    3      MS3     9      210    LT2A3   25     319    3H     13     353    4.378E-07   1.277       29.511
                   FAILED SPLIT FRACTIONS
 +                 ______________________
     (1.47E-04)    STAGES 1 AND 2, AF1 AG2 AH3/IAF CCF/
                   STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF

12   SEIS4  SS89   EP153 2178      4      MS56    1302   357    LT2A4   26     443    3H     18     453    4.370E-07   1.274       30.785
                   FAILED SPLIT FRACTIONS
 +                 ______________________
     (1.17E-04)    STAGES 1 AND 2, OG1 DF1 DG2 DH4/I1F I2F I3F I4F RT7 OSF ASF SVF/
                   STAGES 3 AND 4, CHF SIF AWF/FCF WL3 CIF OI1

13   SEIS4  SS88   EP153    2178   4      MS52    1290   357    LT2A4   26     443    3H     18     453    4.368E-07   1.274       32.059
                   FAILED SPLIT FRACTIONS
 +                 ______________________
     (1.17E-04)    STAGES 1 AND 2, OG1 DF1 DG2 DH4/I1F I2F I3F I4F OSF ASF SVF/
                   STAGES 3 AND 4, CHF SIF AWF/FCF WL3 CIF OI1

14   SEIS3  SS27   EP48     437    3      MS3     23     218    LT2A3   25     319    3H     13     353    4.187E-07   1.221       33.280
                   FAILED SPLIT FRACTIONS
 +                 ______________________
     (1.47E-04)    STAGES 1 AND 2, OG1 GF1 GG2 GH3/CVF ASF/
                   STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF

15   SEIS2  SS27   EP48     1240   2      MS3     23     117    LT2A2   25     216    3H     13     252    4.123E-07   1.202       34.482
                   FAILED SPLIT FRACTIONS
 +                 ______________________
     (8.00E-04)    STAGES 1 AND 2, OG1 AF1 AG2 AH3/CVF ASF/
                   STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF

16   SEIS6  SS89   EP153    2178   6      MS56    1302   535    LT2A6   26     625    3H     18     653    4.065E-07   1.185       35.668
                   FAILED SPLIT FRACTIONS
 +                 ______________________
     (7.43E-06)    STAGES 1 AND 2, OG1 DF1 DG2 DH4/I1F I2F I3F I4F RT7 OSF ASF SVF/
                   STAGES 3 AND 4, CHF SIF AWF/FCF WL3 CIF OI1
```

```
17   SEIS6   SS27    EP48   1240   6      MS3    23     508    LT2A6   81    616   3H   13   654   3.975E-07   1.159    36.827
                     FAILED SPLIT FRACTIONS
+
     (7.43E-06)      STAGES 1 AND 2, OG1 AF1 AG2 AH3/CVF ASF/
                     STAGES 3 AND 4, CT2 CHF SIF SEF HSF/FCF CIF OIF

18   SEIS2   SS27    EP48   437    2      MS3    23     117    LT2A2   25    216   3H   13   252   3.352E-07   0.977    37.804
                     FAILED SPLIT FRACTIONS
+
     (8.00E-04)      STAGES 1 AND 2, OG1 GF1 GG2 GH3/CVF ASF/
                     STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF

19   SEIS4   SS27    EP48   1240   4      MS3    23     315    LT2A4   81    420   3H   13   455   3.049E-07   0.889    38.693
                     FAILED SPLIT FRACTIONS
+
     (1.17E-04)      STAGES 1 AND 2, OG1 AF1 AG2 AH3/CVF ASF/
                     STAGES 3 AND 4, CT2 CHF SIF SEF HSF/FCF CIF OIF

20   SEIS5   SS27    EP48   437    5      MS3    23     417    LT2A5   81    520   3H   13   554   2.931E-07   0.855    39.548
                     FAILED SPLIT FRACTIONS
+
     (2.82E-05)      STAGES 1 AND 2, OG1 GF1 GG2 GH3/CVF ASF/
                     STAGES 3 AND 4, CT2 CHF SIF SEF HSF/FCF CIF OIF

21   SEIS6   SS27    EP48   437    6      MS3    23     508    LT2A6   25    616   3H   13   654   2.914E-07   0.850    40.398
                     FAILED SPLIT FRACTIONS
+
     (7.43E-06)      STAGES 1 AND 2, OG1 GF1 GG2 GH3/CVF ASF/
                     STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF

22   SEIS6   SS89    EP153 2178    6      MS56   1302   535    LT2A6   115   625   3H   18   653   2.641E-07   0.770    41.168
                     FAILED SPLIT FRACTIONS
+
     (7.43E-06)      STAGES 1 AND 2, OG1 DF1 DG2 DH4/I1F I2F I3F I4F RT7 OSF ASF SVF/
                     STAGES 3 AND 4, CT2 TDF CHF SIF AWF/FCF WL3 CIF OI1
```

```
23   SEIS2  SS88   EP46    366    2    MS52   1288   115   LT2A2   26    241   3H   18   253   2.603E-07   0.759   41,927
                   FAILED SPLIT FRACTIONS
+                  ______________________
     (8.00E-04)    STAGES 1 AND 2, DF1 DG2 DH4/I1F I2F I3F I4F OSF CCF SVF/
                   STAGES 3 AND 4, CHF SIF AWF/FCF WL3 CIF OI1

24   SEIS4  SS27   EP48    1240   4    MS3    23     315   LT2A4   26    420   3H   13   455   2.265E-07   0.661   42.588
                   FAILED SPLIT FRACTIONS
+                  ______________________
     (1.17E-04)    STAGES 1 AND 2, OG1 AF1 AG2 AH3/CVF ASF/
                   STAGES 3 AND 4, CHF SIF AW4/FCF CIF OIF

25   SEIS6  SS27   EP48    437    6    MS3    23     508   LT2A6   81    616   3H   13   654   2.224E-07   0.649   43.237
                   FAILED SPLIT FRACTIONS
+                  ______________________
     (7.43E-06)    STAGES 1 AND 2, OG1 GF1 GG2 GH3/CVF ASF/
                   STAGES 3 AND 4, CT2 CHF SIF SEF HSF/FCF CIF OIF

26   SEIS5  SS89   EP153 2178     5    MS56   1302   461   LT2A5   115   539   3H   18   553   2.147E-07   0.626   43.863
                   FAILED SPLIT FRACTIONS
+                  ______________________
     (2.82E-05)    STAGES 1 AND 2, OG1 DF1 DG2 DH4/I1F I2F I3F I4F RT7 OSF ASF SVF/
                   STAGES 3 AND 4, CT2 TDF CHF SIF AWF/FCF WL3 CIF OI1

27   SEIS4  SS27   EP48    437    4    MS3    23     315   LT2A4   81    420   3H   13   455   1.763E-07   0.514   44.377
                   FAILED SPLIT FRACTIONS
+                  ______________________
     (1.17E-04)    STAGES 1 AND 2, OG1 GF1 GG2 GH3/CVF ASF/
                   STAGES 3 AND 4, CT2 CHF SIF SEF HSF/FCF CIF OIF

28   SEIS5  SS27   EP48    1240   5    MS3    23     417   LT2A5   26    520   3H   13   554   1.576E-07   0.460   44.836
                   FAILED SPLIT FRACTIONS
+                  ______________________
     (2.82E-05)    STAGES 1 AND 2, OG1 AF1 AG2 AH3/CVF ASF/
                   STAGES 3 AND 4, CHF SIF AW4/FCF CIF OIF
```

```
29  SEIS2  SS16   EP85   433    2    MS3    11    139   LT2A2  24   210   3D   11   251   1.468E-07   0.428   45.265
                  FAILED SPLIT FRACTIONS
 +                ______________________
     (8.00E-04)   STAGES 1 AND 2, OG1 GF1 GG2 2G3/IAF ASF/
                  STAGES 3 AND 4, CHF SIF SEF/FCF

30  SEIS1  SS27   EP12   101    1    MS3    9     12    LT2A1  25   113   3H   13   152   1.312E-07   0.383   45.647
                  FAILED SPLIT FRACTIONS
 +                ______________________
     (1.41E-02)   STAGES 1 AND 2, AF1 AG2 AH3/IAF CCF/
                  STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF

31  SEIS4  SS27   EP48   437    4    MS3    23    315   LT2A4  26   420   3H   13   455   1.310E-07   0.382   46.029
                  FAILED SPLIT FRACTIONS
 +                ______________________
     (1.17E-04)   STAGES 1 AND 2, OG1 GF1 GG2 GH3/CVF ASF/
                  STAGES 3 AND 4, CHF SIF AW4/FCF CIF OIF

32  SEIS3  SS88   EP153  2178   3    MS52   1290  260   LT2A3  26   343   3H   18   354   1.300E-07   0.379   46.408
                  FAILED SPLIT FRACTIONS
 +                ______________________
     (1.47E-04)   STAGES 1 AND 2, OG1 DF1 DG2 DH4/I1F I2F I3F I4F OSF ASF SVF/
                  STAGES 3 AND 4, CHF SIF AWF/FCF WL3 CIF OI1

33  SEIS3  SS89   EP153 2178    3    MS56   1302  260   LT2A3  26   343   3H   18   354   1.296E-07   0.378   46.786
                  FAILED SPLIT FRACTIONS
 +                ______________________
     (1.47E-04)   STAGES 1 AND 2, OG1 DF1 DG2 DH4/I1F I2F I3F I4F RT7 OSF ASF SVF/
                  STAGES 3 AND 4, CHF SIF AWF/FCF WL3 CIF OI1

34  SEIS2  SS88   EP153  2178   2    MS52   1290  160   LT2A2  26   241   3H   18   253   1.250E-07   0.365   47.151
                  FAILED SPLIT FRACTIONS
 +                ______________________
     (8.00E-04)   STAGES 1 AND 2, OG1 DF1 DG2 DH4/I1F I2F I3F I4F OSF ASF SVF/
                  STAGES 3 AND 4, CHF SIF AWF/FCF WL3 CIF OI1
```

```
35  SEIS4  SS11   EP10  368   4    MS1    7     306   LT3E4  49   408   2D   106   492   1.235E-07  0.360   47.511
                  FAILED SPLIT FRACTIONS
 +                ________________________
    (1.17E-04)    STAGES 1 AND 2, OG1 SW1/IAF/
                  STAGES 3 AND 4, EL1/RF4

36  SEIS4 SS1     EP47  367   4    MS1    7     314   LT3E4  49   400   2D   106   490   1.187E-07  0.346   47.857
                  FAILED SPLIT FRACTIONS
 +                ________________________
    (1.17E-04)    STAGES 1 AND 2, OG1/IAF/
                  STAGES 3 AND 4, EL1/RF4

37  SEIS1  SS79   EP1   1     1    MS143  973   1     LT2A1  26   114   3H   18    153   1.170E-07  0.341   48.199
                  FAILED SPLIT FRACTIONS
 +                ________________________
    (1.41E-02)    STAGES 1 AND 2, I11 SB3 OSF/
                  STAGES 3 AND 4, CHF SIF AWF/FCF WL3 CIF OI1

38  SEIS5  SS14   EP10  368   5    MS3    9     406   LT2A5  24   510   3D   11    552   1.149E-07  0.335   48.534
                  FAILED SPLIT FRACTIONS
 +                ________________________
    (2.82E-05)    STAGES 1 AND 2, OG1 SW1/IAF CC7/
                  STAGES 3 AND 4, CHF SIF SE1/FCF

39  SEIS2  SS25   EP79  421   2    MS1    7     135   LT2A2  14   214   3D   11    251   1.144E-07  0.334   48.867
                  FAILED SPLIT FRACTIONS
 +                ________________________
    (8.00E-04)    STAGES 1 AND 2, OG1 GF1 GH2/IAF/
                  STAGES 3 AND 4, SIF AW4 OBF/FCF

40  SEIS2  SS1    EP1   1     2    MS1    7     101   LT3E2  49   200   2A   1     290   1.132E-07  0.330   49.197
                  FAILED SPLIT FRACTIONS
 +                ________________________
    (8.00E-04)    STAGES 1 AND 2, IAF/
                  STAGES 3 AND 4, EL1/
```

```
41   SEIS4   SS89    EP46    366     4       MS56    1300    313     LT2A4   26      443     3H      18      453     1.068E-07   0.312       49.509
                     FAILED SPLIT FRACTIONS
                     ______________________
 +
     (1.17E-04)      STAGES 1 AND 2, DF1 DG2 DH4/I1F I2F I3F I4F RT7 OSF CCF SVF/
                     STAGES 3 AND 4, CHF SIF AWF/FCF WL3 CIF OI1

42   SEIS4   SS88    EP46    366     4       MS52    1288    313     LT2A4   26      443     3H      18      453     1.068E-07   0.311       49.820
                     FAILED SPLIT FRACTIONS
                     ______________________
 +
     (1.17E-04)      STAGES 1 AND 2, DF1 DG2 DH4/I1F I2F I3F I4F OSF CCF SVF/
                     STAGES 3 AND 4, CHF SIF AWF/FCF WL3 CIF OI1

43   SEIS1   SS27    EP48    437     1       MS3     23      32      LT2A1   25      113     3H      13      152     1.023E-07   0.298       50.118
                     FAILED SPLIT FRACTIONS
                     ______________________
 +
     (1.41E-02)      STAGES 1 AND 2, OG1 GF1 GG2 GH3/CVF ASF/
                     STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF

44   SEIS5   SS27    EP48    437     5       MS3     23      417     LT2A5   26      520     3H      13      554     9.748E-08   0.284       50.403
                     FAILED SPLIT FRACTIONS
                     ______________________
 +
     (2.82E-05)      STAGES 1 AND 2, OG1 GF1 GG2 GH3/CVF ASF/
                     STAGES 3 AND 4, CHF SIF AW4/FCF CIF OIF

45   SEIS2   SS27    EP12    101     2       MS3     9       109     LT2A2   26      216     3H      13      252     8.583E-08   0.250       50.653
                     FAILED SPLIT FRACTIONS
                     ______________________
 +
     (8.00E-04)      STAGES 1 AND 2, AF1 AG2 AH3/IAF CCF/
                     STAGES 3 AND 4, CHF SIF AW4/FCF CIF OIF

46   SEIS3   SS27    EP48    1240    3       MS3     23      218     LT2A3   26      319     3H      13      353     7.747E-08   0.226       50.879
                     FAILED SPLIT FRACTIONS
                     ______________________
 +
     (1.47E-04)      STAGES 1 AND 2, OG1 AF1 AG2 AH3/CVF ASF/
                     STAGES 3 AND 4, CHF SIF AW4/FCF CIF OIF
```

```
47   SEIS3   SS1    EP1    1      3    MS1    7      201   LT3E3   49    300   2D   106   390   7.720E-08   0.225   51.104
                    FAILED SPLIT FRACTIONS
+                   ______________________
     (1.47E-04)     STAGES 1 AND 2, IAF/
                    STAGES 3 AND 4, EL1/RF4

48   SEIS5   SS27   EP12   101    5    MS3    9      407   LT2A5   25    520   3H   13    554   7.692E-08   0.224   51.328
                    FAILED SPLIT FRACTIONS
+                   ______________________
     (2.82E-05)     STAGES 1 AND 2, AF1 AG2 AH3/IAF CCF/
                    STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF

49   SEIS1   SS16   EP85   433    1    MS3    11     54    LT2A1   24    108   3D   11    151   7.578E-08   0.221   51.549
                    FAILED SPLIT FRACTIONS
+                   ______________________
     (1.41E-02)     STAGES 1 AND 2, OG1 GF1 GG2 2G3/IAF ASF/
                    STAGES 3 AND 4, CHF SIF SEF/FCF

50   SEIS4   SS27   EP12  101     4    MS3    9      307   LT2A4   81    420   3H   13    455   7.461E-08   0.218   51.767
                    FAILED SPLIT FRACTIONS
+                   ______________________
     (1.17E-04)     STAGES 1 AND 2, AF1 AG2 AH3/IAF CCF/
                    STAGES 3 AND 4, CT2 CHF SIF SEF HSF/FCF CIF OIF

51   SEIS5   SS28   EP48   1240   5    MS11   29     417   LT2A5   25    520   3H   18    553   7.401E-08   0.216   51.983
                    FAILED SPLIT FRACTIONS
+                   ______________________
     (2.82E-05)     STAGES 1 AND 2, OG1 AF1 AG2 AH3/CVF OS1 ASF/
                    STAGES 3 AND 4, CHF SIF SEF HSF/FCF WL3 CIF OI1

52   SEIS3   SS88   EP46   366    3    MS52   1288   216   LT2A3   26    343   3H   18    354   7.386E-08   0.215   52.198
                    FAILED SPLIT FRACTIONS
+                   ______________________
     (1.47E-04)     STAGES 1 AND 2, DF1 DG2 DH4/I1F I2F I3F I4F OSF CCF SVF/
                    STAGES 3 AND 4, CHF SIF AWF/FCF WL3 CIF OI1
```

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 53 | SEIS5 | SS11 | EP10 | 368 | 5 | MS1 | 7 | 406 | LT3E5 | 49 | 508 | 2D | 106 | 592 | 7.373E-08 | 0.215 | 52.413 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | | | | | | | | | | | | | | | | | |
| | (2.82E-05) | | STAGES 1 AND 2, OG1 SW1/IAF/<br>STAGES 3 AND 4, EL1/RF4 | | | | | | | | | | | | | | |
| 54 | SEIS3 | SS89 | EP46 | 366 | 3 | MS56 | 1300 | 216 | LT2A3 | 26 | 343 | 3H | 18 | 354 | 7.361E-08 | 0.215 | 52.628 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | | | | | | | | | | | | | | | | | |
| | (1.47E-04) | | STAGES 1 AND 2, DF1 DG2 DH4/I1F I2F I3F I4F RT7 OSF CCF SVF/<br>STAGES 3 AND 4, CHF SIF AWF/FCF WL3 CIF OI1 | | | | | | | | | | | | | | |
| 55 | SEIS5 | SS27 | EP48 | 1240 | 5 | MS3 | 23 | 417 | LT2A5 | 47 | 520 | 3H | 13 | 554 | 7.263E-08 | 0.212 | 52.840 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | | | | | | | | | | | | | | | | | |
| | (2.82E-05) | | STAGES 1 AND 2, OG1 AF1 AG2 AH3/CVF ASF/<br>STAGES 3 AND 4, PRA CHF SIF/FCF CIF OIF | | | | | | | | | | | | | | |
| 56 | SEIS6 | SS27 | EP48 | 1240 | 6 | MS3 | 23 | 508 | LT2A6 | 26 | 616 | 3H | 13 | 654 | 6.943E-08 | 0.202 | 53.042 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | | | | | | | | | | | | | | | | | |
| | (7.43E-06) | | STAGES 1 AND 2, OG1 AF1 AG2 AH3/CVF ASF/<br>STAGES 3 AND 4, CHF SIF AW4/FCF CIF OIF | | | | | | | | | | | | | | |
| 57 | SEIS6 | SS27 | EP48 | 1240 | 6 | MS3 | 23 | 508 | LT2A6 | 47 | 616 | 3H | 13 | 654 | 6.347E-08 | 0.185 | 53.227 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | | | | | | | | | | | | | | | | | |
| | (7.43E-06) | | STAGES 1 AND 2, OG1 AF1 AG2 AH3/CVF ASF/<br>STAGES 3 AND 4, PRA CHF SIF/FCF CIF OIF | | | | | | | | | | | | | | |
| 58 | SEIS5 | SS11 | EP10 | 368 | 5 | MS1 | 7 | 406 | LT2E5 | 88 | 508 | 3H | 13 | 571 | 6.340E-08 | 0.185 | 53.412 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | | | | | | | | | | | | | | | | | |
| | (2.82E-05) | | STAGES 1 AND 2, OG1 SW1/IAF/<br>STAGES 3 AND 4, CT2 OC1 SEF/FCF CIF OIF | | | | | | | | | | | | | | |

```
59   SEIS2  SS21   EP69  403  2   MS1   7    129   LT1A2  32   213  5E   1239  215   6.202E-08   0.181   53.593
                   FAILED SPLIT FRACTIONS
+
     (8.00E-04)    STAGES 1 AND 2, OG1 GG1 GH2/IAF/
                   STAGES 3 AND 4, PRD/LAF LBF CSF CIF OIF

60   SEIS5  SS5    EP47  367  5   MS3   9    416   LT2A5  24   504  3D   11    552   6.152E-08   0.179   53.772
                   FAILED SPLIT FRACTIONS
+
     (2.82E-05)    STAGES 1 AND 2, OG1/IAF CC6/
                   STAGES 3 AND 4, CHF SIF SE1/FCF

61   SEIS1  SS25   EP79  421  1   MS1   7    50    LT2A1  14   111  3D   11    151   5.874E-08   0.171   53.944
                   FAILED SPLIT FRACTIONS
+
(1.41E-02)         STAGES 1 AND 2, OG1 GF1 GH2/IAF/
                   STAGES 3 AND 4, SIF AW4 OBF/FCF

62   SEIS1  SS79   EP1   1    1   MS69  217  1     LT2A1  26   114  3H   18    153   5.849E-08   0.171   54.114
                   FAILED SPLIT FRACTIONS
+
     (1.41E-02)    STAGES 1 AND 2, I41 SA1 OSF/
                   STAGES 3 AND 4, CHF SIF AWF/FCF WL3 CIF OI1

63   SEIS2  SS25   EP59  386  2   MS1   7    124   LT2A2  14   214  3D   11    251   5.788E-08   0.169   54.283
                   FAILED SPLIT FRACTIONS
+
     (8.00E-04)    STAGES 1 AND 2, OG1 GH1 2G2 SW1/IAF/
                   STAGES 3 AND 4, SIF AW4 OBF/FCF

64   SEIS5  SS27   EP48  396  5   MS3   23   417   LT2A5  25   520  3H   13    554   5.694E-08   0.166   54.449
                   FAILED SPLIT FRACTIONS
+
     (2.82E-05)    STAGES 1 AND 2, OG1 GG1 2H2 FO4/CVF ASF/
                   STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF
```

```
65   SEIS4  SS27   EP12   101    4    MS3   9    307   LT2A4  26   420   3H   13    455   5.542E-08   0.162   54.611
                   FAILED SPLIT FRACTIONS
+                  ________________________
     (1.17E-04)    STAGES 1 AND 2, AF1 AG2 AH3/IAF CCF/
                   STAGES 3 AND 4, CHF SIF AW4/FCF CIF OIF

66   SEIS2  SS25   EP57   383    2    MS1   7    122   LT2A2  14   214   3D   11    251   5.539E-08   0.162   54.772
                   FAILED SPLIT FRACTIONS
+                  ________________________
     (8.00E-04)    STAGES 1 AND 2, OG1 GH1 2H2 SW1/IAF/
                   STAGES 3 AND 4, SIF AW4 OBF/FCF

67   SEIS5  SS11   EP10   368    5    MS1   7    406   LT1A5  32   508   5A   1237  513   5.527E-08   0.161   54.933
                   FAILED SPLIT FRACTIONS
+                  ________________________
     (2.82E-05)    STAGES 1 AND 2, OG1 SW1/IAF/
                   STAGES 3 AND 4, PR1/LA1 LB2 CSF

68   SEIS3  SS1    EP1    1      3    MS1   7    201   LT1A3  32   300   5A   1237  310   5.263E-08   0.153   55.087
                   FAILED SPLIT FRACTIONS
+                  ________________________
     (1.47E-04)    STAGES 1 AND 2, IAF/
                   STAGES 3 AND 4, PR1/LA1 LB2 CSF

69   SEIS3  SS16   EP85   433    3    MS3   11   240   LT2A3  24   311   3D   11    351   5.262E-08   0.153   55.240
                   FAILED SPLIT FRACTIONS
+                  ________________________
     (1.47E-04)    STAGES 1 AND 2, OG1 GF1 GG2 2G3/IAF ASF/
                   STAGES 3 AND 4, CHF SIF SEF/FCF

70   SEIS4  SS27   EP48   1240   4    MS3   23   315   LT2A4  47   420   3H   13    455   5.032E-08   0.147   55.387
                   FAILED SPLIT FRACTIONS
+                  ________________________
     (1.17E-04)    STAGES 1 AND 2, OG1 AF1 AG2 AH3/CVF ASF/
                   STAGES 3 AND 4, PRA CHF SIF/FCF CIF OIF

71   SEIS5  SS1    EP47   367    5    MS1   7    416   LT3E5  49   500   2D   106   590   4.686E-08   0.137   55.524
                   FAILED SPLIT FRACTIONS
+                  ________________________
     (2.82E-05)    STAGES 1 AND 2, OG1/IAF/
                   STAGES 3 AND 4, EL1/RF4
```

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 72 | SEIS3 | SS27 | EP48 | 1240 | 3 | MS3 | 23 | 218 | LT2A3 | 81 | 319 | 3H | 13 | 353 | 4.603E-08 | 0.134 | 55.658 |
|  |  |  | FAILED SPLIT FRACTIONS |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| + | (1.47E-04) |  | STAGES 1 AND 2, OG1 AF1 AG2 AH3/CVF ASF/<br>STAGES 3 AND 4, CT2 CHF SIF SEF HSF/FCF CIF OIF |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 73 | SEIS4 | SS16 | EP85 | 433 | 4 | MS3 | 11 | 337 | LT2A4 | 24 | 412 | 3D | 11 | 451 | 4.578E-08 | 0.133 | 55.791 |
|  |  |  | FAILED SPLIT FRACTIONS |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| + | (1.17E-04) |  | STAGES 1 AND 2, OG1 GF1 GG2 2G3/IAF ASF/<br>STAGES 3 AND 4, CHF SIF SEF/FCF |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 74 | SEIS5 | S28 | EP48 | 437 | 5 | MS11 | 29 | 417 | LT2A5 | 25 | 520 | 3H | 18 | 553 | 4.576E-08 | 0.133 | 55.925 |
|  |  |  | FAILED SPLIT FRACTIONS |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| + | (2.82E-05) |  | STAGES 1 AND 2, OG1 GF1 GG2 GH3/CVF OS1 ASF/<br>STAGES 3 AND 4, CHF SIF SEF HSF/FCF WL3 CIF OI1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 75 | SEIS5 | SS27 | EP48 | 437 | 5 | MS3 | 23 | 417 | LT2A5 | 47 | 520 | 3H | 13 | 554 | 4.491E-08 | 0.131 | 56.056 |
|  |  |  | FAILED SPLIT FRACTIONS |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| + | (2.82E-05) |  | STAGES 1 AND 2, OG1 GF1 GG2 GH3/CVF ASF/<br>STAGES 3 AND 4, PRA CHF SIF/FCF CIF OIF |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 76 | SEIS5 | SS27 | EP48 | 1240 | 5 | MS3 | 23 | 417 | LT2A5 | 115 | 520 | 3H | 13 | 554 | 4.472E-08 | 0.130 | 56.186 |
|  |  |  | FAILED SPLIT FRACTIONS |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| + | (2.82E-05) |  | STAGES 1 AND 2, OG1 AF1 AG2 AH3/CVF ASF/<br>STAGES 3 AND 4, CT2 TD1 CHF SIF AWF/FCF CIF OIF |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 77 | SEIS3 | SS27 | EP12 | 101 | 3 | MS3 | 9 | 210 | LT2A3 | 26 | 319 | 3H | 13 | 353 | 4.420E-08 | 0.129 | 56.315 |
|  |  |  | FAILED SPLIT FRACTIONS |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| + | (1.47E-04) |  | STAGES 1 AND 2, AF1 AG2 AH3/IAF CCF/<br>STAGES 3 AND 4, CHF SIF AW4/FCF CIF OIF |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 78 | SEIS3 | SS27 | EP48 | 437 | 3 | MS3 | 23 | 218 | LT2A3 | 26 | 319 | 3H | 13 | 353 | 4.227E-08 | 0.123 | 56.438 |
|  |  |  | FAILED SPLIT FRACTIONS |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| + | (1.47E-04) |  | STAGES 1 AND 2, OG1 GF1 GG2 GH3/CVF ASF/<br>STAGES 3 AND 4, CHF SIF AW4/FCF CIF OIF |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

```
79   SEIS2  SS27   EP48   1240   2    MS3    23     117   LT2A2   26    216   3H   13   252   4.123E-08   0.120   56.559
                   FAILED SPLIT FRACTIONS
 +                 ______________________
     (8.00E-04)    STAGES 1 AND 2, OG1 AF1 AG2 AH3/CVF ASF/
                   STAGES 3 AND 4, CHF SIF AW4/FCF CIF OIF

80   SEIS3  SS27   EP48   396    3    MS3    23     218   LT2A3   25    319   3H   13   353   4.099E-08   0.120   56.678
                   FAILED SPLIT FRACTIONS
 +                 ______________________
     (1.47E-04)    STAGES 1 AND 2, OG1 GG1 2H2 FO4/CVF ASF/
                   STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF

81   SEIS5 SS5     EP47   367    5    MS3    21     416   LT2A5   24    504   3D   11   552   4.077E-08   0.119   56.797
                   FAILED SPLIT FRACTIONS
 +                 ______________________
     (2.82E-05)    STAGES 1 AND 2, OG1/CV2 CC6/
                   STAGES 3 AND 4, CHF SIF SE1/FCF

82   SEIS5  SS89   EP46   366    5    MS56   1300   415   LT2A5   26    539   3H   18   553   3.957E-08   0.115   56.912
                   FAILED SPLIT FRACTIONS
 +                 ______________________
     (2.82E-05)    STAGES 1 AND 2; DF1 DG2 DH4/I1F I2F I3F I4F RT7 OSF CCF SVF/
                   STAGES 3 AND 4, CHF SIF AWF/FCF WL3 CIF OI1

83   SEIS5  SS1    EP47   367    5    MS1    7      416   LT2E5   88    500   3H   13   570   3.919E-08   0.114   57.027
                   FAILED SPLIT FRACTIONS
 +                 ______________________
     (2.82E-05)    STAGES 1 AND 2, OG1/IAF/
                   STAGES 3 AND 4, CT2 OC1 SEF/FCF CIF OIF

84   SEIS6  SS27   EP48   437    6    MS3    23     508   LT2A6   26    616   3H   13   654   3.885E-08   0.113   57.140
                   FAILED SPLIT FRACTIONS
 +                 ______________________
     (7.43E-06)    STAGES 1 AND 2, OG1 GF1 GG2 GH3/CVF ASF/
                   STAGES 3 AND 4, CHF SIF AW4/FCF CIF OIF
```

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 85 | SEIS3 | SS1 | EP47 | 367 | 3 | MS1 | 7 | 217 | LT3E3 | 49 | 300 | 2D | 106 | 390 | 3.774E-08 | 0.110 | 57.250 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | (1.47E-04) | | STAGES 1 AND 2, OG1/IAF/<br>STAGES 3 AND 4, EL1/RF4 | | | | | | | | | | | | | | |
| 86 | SEIS3 | SS16 | EP83 | 429 | 3 | MS3 | 9 | 239 | LT2A3 | 24 | 311 | 3D | 11 | 351 | 3.693E-08 | 0.108 | 57.358 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | (1.47E-04) | | STAGES 1 AND 2, OG1 GF1 GG2/IAF CC5/<br>STAGES 3 AND 4, CHF SIF SEF/FCF | | | | | | | | | | | | | | |
| 87 | SEIS4 | SS16 | EP83 | 429 | 4 | MS3 | 9 | 336 | LT2A4 | 24 | 412 | 3D | 11 | 451 | 3.674E-08 | 0.107 | 57.465 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | (1.17E-04) | | STAGES 1 AND 2, OG1 GF1 GG2/IAF CC5/<br>STAGES 3 AND 4, CHF SIF SEF/FCF | | | | | | | | | | | | | | |
| 88 | SEIS3 | SS27 | EP48 | 393 | 3 | MS3 | 23 | 218 | LT2A3 | 25 | 319 | 3H | 13 | 353 | 3.636E-08 | 0.106 | 57.571 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | (1.47E-04) | | STAGES 1 AND 2, OG1 GG1 FO3/CVF ASF/<br>STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF | | | | | | | | | | | | | | |
| 89 | SEIS3 | SS27 | EP48 | 372 | 3 | MS3 | 23 | 218 | LT2A3 | 25 | 319 | 3H | 13 | 353 | 3.636E-08 | 0.106 | 57.677 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | (1.47E-04) | | STAGES 1 AND 2, OG1 2H1 FO3/CVF ASF/<br>STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF | | | | | | | | | | | | | | |
| 90 | SEIS4 | SS27 | EP48 | 396 | 4 | MS3 | 23 | 315 | LT2A4 | 25 | 420 | 3H | 13 | 455 | 3.611E-08 | 0.105 | 57.782 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | (1.17E-04) | | STAGES 1 AND 2, OG1 GG1 2H2 FO4/CVF ASF/<br>STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF | | | | | | | | | | | | | | |
| 91 | SEIS6 | SS27 | EP48 | 437 | 6 | MS3 | 23 | 508 | LT2A6 | 47 | 616 | 3H | 13 | 654 | 3.551E-08 | 0.104 | 57.886 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | (7.43E-06) | | STAGES 1 AND 2, OG1 GF1 GG2 GH3/CVF ASF/<br>STAGES 3 AND 4, PRA CHF SIF/FCF CIF OIF | | | | | | | | | | | | | | |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 92 | SEIS2 | SS16 | EP83 | 429 | 2 | MS3 | 9 | 138 | LT2A2 | 24 | 210 | 3D | 11 | 251 | 3.536E-08 | 0.103 | 57.989 |
|  |  |  | FAILED SPLIT FRACTIONS |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| + |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | (8.00E-04) |  | STAGES 1 AND 2, OG1 GF1 GG2/IAF CC5/<br>STAGES 3 AND 4, CHF SIF SEF/FCF |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 93 | SEIS4 | SS27 | EP48 | 372 | 4 | MS3 | 23 | 315 | LT2A4 | 25 | 420 | 3H | 13 | 455 | 3.528E-08 | 0.103 | 58.092 |
|  |  |  | FAILED SPLIT FRACTIONS |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| + |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | (1.17E-04) |  | STAGES 1 AND 2, OG1 2H1 FO3/CVF ASF/<br>STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 94 | SEIS4 | SS27 | EP48 | 393 | 4 | MS3 | 23 | 315 | LT2A4 | 25 | 420 | 3H | 13 | 455 | 3.527E-08 | 0.103 | 58.195 |
|  |  |  | FAILED SPLIT FRACTIONS |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| + |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | (1.17E-04) |  | STAGES 1 AND 2, OG1 GG1 FO3/CVF ASF/<br>STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 95 | SEIS3 | SS25 | EP79 | 421 | 3 | MS1 | 7 | 236 | LT2A3 | 14 | 317 | 3D | 11 | 351 | 3.524E-08 | 0.103 | 58.297 |
|  |  |  | FAILED SPLIT FRACTIONS |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| + |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | (1.47E-04) |  | STAGES 1 AND 2, OG1 GF1 GH2/IAF/<br>STAGES 3 AND 4, SIF AW4 OBF/FCF |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 96SEIS5 |  | SS27 | EP12 | 101 | 5 | MS3 | 11 | 407 | LT2A5 | 25 | 520 | 3H | 13 | 554 | 3.412E-08 | 0.099 | 58.397 |
|  |  |  | FAILED SPLIT FRACTIONS |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| + |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | (2.82E-05) |  | STAGES 1 AND 2, AF1 AG2 AH3/IAF AS4/<br>STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| 97 | SEIS2 | SS27 | EP48 | 437 | 2 | MS3 | 23 | 117 | LT2A2 | 26 | 216 | 3H | 13 | 252 | 3.352E-08 | 0.098 | 58.495 |
|  |  |  | FAILED SPLIT FRACTIONS |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| + |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | (8.00E-04) |  | STAGES 1 AND 2, OG1 GF1 GG2 GH3/CVF ASF/<br>STAGES 3 AND 4, CHF SIF AW4/FCF CIF OIF |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 98 | SEIS2 | SS27 | EP48 | 369 | 2 | MS3 | 23 | 117 | LT2A2 | 25 | 216 | 3H | 13 | 252 | 3.304E-08 | 0.096 | 58.591 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | (8.00E-04) | | STAGES 1 AND 2, OG1 FO1/CVF ASF/<br>STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF | | | | | | | | | | | | | | |
| 99 | SEIS2 | SS16 | EP83 | 429 | 2 | MS3 | 11 | 138 | LT2A2 | 24 | 210 | 3D | 11 | 251 | 3.119E-08 | 0.091 | 58.682 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | (8.00E-04) | | STAGES 1 AND 2, OG1 GF1 GG2/IAF ASB/<br>STAGES 3 AND 4, CHF SIF SEF/FCF | | | | | | | | | | | | | | |
| 100 | SEIS4 | SS27 | EP12 | 101 | 4 | MS3 | 11 | 307 | LT2A4 | 25 | 420 | 3H | 13 | 455 | 3.113E-08 | 0.091 | 58.773 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | (1.17E-04) | | STAGES 1 AND 2, AF1 AG2 AH3/IAF AS4/<br>STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF | | | | | | | | | | | | | | |
| 101 | SEIS4 | SS25 | EP79 | 421 | 4 | MS1 | 7 | 333 | LT2A4 | 14 | 418 | 3D | 11 | 451 | 3.097E-08 | 0.090 | 58.863 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | (1.17E-04) | | STAGES 1 AND 2, OG1 GF1 GH2/IAF/<br>STAGES 3 AND 4, SIF AW4 OBF/FCF | | | | | | | | | | | | | | |
| 102 | SEIS1 | SS25 | EP59 | 386 | 1 | MS1 | 7 | 39 | LT2A1 | 14 | 111 | 3D | 11 | 151 | 2.972E-08 | 0.087 | 58.950 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | (1.41E-02) | | STAGES 1 AND 2, OG1 GH1 2G2 SW1/IAF/<br>STAGES 3 AND 4, SIF AW4 OBF/FCF | | | | | | | | | | | | | | |
| 103 | SEIS4 | SS27 | EP48 | 437 | 4 | MS3 | 23 | 315 | LT2A4 | 47 | 420 | 3H | 13 | 455 | 2.910E-08 | 0.085 | 59.034 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | (1.17E-04) | | STAGES 1 AND 2, OG1 GF1 GG2 GH3/CVF ASF/<br>STAGES 3 AND 4, PRA CHF SIF/FCF CIF OIF | | | | | | | | | | | | | | |
| 104 | SEIS5 | SS5 | EP1 | 1 | 5 | MS3 | 9 | 401 | LT2A5 | 24 | 504 | 3D | 11 | 552 | 2.896E-08 | 0.084 | 59.119 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | (2.82E-05) | | STAGES 1 AND 2, IAF CC1/<br>STAGES 3 AND 4, CHF SIF SE1/FCF | | | | | | | | | | | | | | |

```
105  SEIS1  SS25    EP57   383    1      MS1    7     37     LT2A1   14     111    3D     11    151   2.845E-08   0.083     59.202
                    FAILED SPLIT FRACTIONS
 +                  ____________________
     (1.41E-02)     STAGES 1 AND 2, OG1 GH1 2H2 SW1/IAF/
                    STAGES 3 AND 4, SIF AW4 OBF/FCF

106  SEIS3  SS16    EP83   429    3      MS3    11    239    LT2A3   24     311    3D     11    351   2.821E-08   0.082     59.284
                    FAILED SPLIT FRACTIONS
 +                  ____________________
     (1.47E-04)     STAGES 1 AND 2, OG1 GF1 GG2/IAF ASB/
                    STAGES 3 AND 4, CHF SIF SEF/FCF

107  SEIS5  SS27    EP48   437    5      MS3    23    417    LT2A5   115    520    3H     13    554   2.765E-08   0.081     59.365
                    FAILED SPLIT FRACTIONS
 +                  ____________________
     (2.82E-05)     STAGES 1 AND 2, OG1 GF1 GG2 GH3/CVF ASF/
                    STAGES 3 AND 4, CT2 TD1 CHF SIF AWF/FCF CIF OIF

108  SEIS6  SS89    EP48   1240   6      MS56   1302  508    LT2A6   26     625    3H     18    653   2.659E-08   0.078     59.442
                    FAILED SPLIT FRACTIONS
 +                  ____________________
     (7.43E-06)     STAGES 1 AND 2, OG1 AF1 AG2 AH3/I12 I24 I3F I4F RT7 OSF ASF SVF/
                    STAGES 3 AND 4, CHF SIF AWF/FCF WL3 CIF OI1

109  SEIS3  SS27    EP12   101    3      MS3    9     210    LT2A3   81     319    3H     13    353   2.626E-08   0.077     59.519
                    FAILED SPLIT FRACTIONS
 +                  ____________________
     (1.47E-04)     STAGES 1 AND 2, AF1 AG2 AH3/IAF CCF/
                    STAGES 3 AND 4, CT2 CHF SIF SEF HSF/FCF CIF OIF

110  SEIS3  SS1     EP47   367    3      MS1    7     217    LT1A3   32     300    5A     1237  310   2.573E-08   0.075     59.594
                    FAILED SPLIT FRACTIONS
 +                  ____________________
     (1.47E-04)     STAGES 1 AND 2, OG1/IAF/
                    STAGES 3 AND 4, PR1/LA1 LB2 CSF
```

```
111  SEIS5  SS27   EP12   101   5   MS3   9   407   LT2A5   81   520   3H   13   554   2.565E-08   0.075   59.669
                   FAILED SPLIT FRACTIONS
+                  ______________________
     (2.82E-05)    STAGES 1 AND 2, AF1 AG2 AH3/IAF CCF/
                   STAGES 3 AND 4, CT2 CHF SIF SEF HSF/FCF CIF OIF

112  SEIS3  SS27   EP48   437   3   MS3   23  218   LT2A3   81   319   3H   13   353   2.511E-08   0.073   59.742
                   FAILED SPLIT FRACTIONS
+                  ______________________
     (1.47E-04)    STAGES 1 AND 2, OG1 GF1 GG2 GH3/CVF ASF/
                   STAGES 3 AND 4, CT2 CHF SIF SEF HSF/FCF CIF OIF

113  SEIS3  SS27   EP12   101   3   MS3   11  210   LT2A3   25   319   3H   13   353   2.510E-08   0.073   59.815
                   FAILED SPLIT FRACTIONS
+                  ______________________
     (1.47E-04)    STAGES 1 AND 2, AF1 AG2 AH3/IAF AS4/
                   STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF

114  SEIS5  SS14   EP52   374   5   MS3   9   419   LT2A5   24   510   3D   11   552   2.478E-08   0.072   59.887
                   FAILED SPLIT FRACTIONS
+                  ______________________
     (2.82E-05)    STAGES 1 AND 2, OG1 2G1 SW3/IAF CC7/
                   STAGES 3 AND 4, CHF SIF SE1/FCF

115  SEIS4  SS16   EP83   429   4   MS3   11  336   LT2A4   24   412   3D   11   451   2.475E-08   0.072   59.959
                   FAILED SPLIT FRACTIONS
+                  ______________________
     (1.17E-04)    STAGES 1 AND 2, OG1 GF1 GG2/IAF ASB/
                   STAGES 3 AND 4, CHF SIF SEF/FCF

116  SEIS5  SS14   EP50   371   5   MS3   9   406   LT2A5   24   510   3D   11   552   2.451E-08   0.071   60.031
                   FAILED SPLIT FRACTIONS
+                  ______________________
     (2.82E-05)    STAGES 1 AND 2, OG1 2H1 SW3/IAF CC7/
                   STAGES 3 AND 4, CHF SIF SE1/FCF
```

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 117 | SEIS2 | SS27 | EP48 | 396 | 2 | MS3 | 23 | 117 | LT2A2 | 25 | 216 | 3H | 13 | 252 | 2.337E-08 | 0.068 | 60.099 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | (8.00E-04) | | STAGES 1 AND 2, OG1 GG1 2H2 FO4/CVF ASF/<br>STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF | | | | | | | | | | | | | | |
| 118 | SEIS4 | SS11 | EP52 | 374 | 4 | MS1 | 7 | 317 | LT3E4 | 49 | 408 | 2D | 106 | 492 | 2.265E-08 | 0.066 | 60.165 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | (1.17E-04) | | STAGES 1 AND 2, OG1 2G1 SW3/IAF/<br>STAGES 3 AND 4, EL1/RF4 | | | | | | | | | | | | | | |
| 119 | SEIS4 | SS11 | EP50 | 371 | 4 | MS1 | 7 | 306 | LT3E4 | 49 | 408 | 2D | 106 | 492 | 2.245E-08 | 0.065 | 60.231 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | (1.17E-04) | | STAGES 1 AND 2, OG1 2H1 SW3/IAF/<br>STAGES 3 AND 4, EL1/RF4 | | | | | | | | | | | | | | |
| 120 | SEIS4 | SS11 | EP75 | 413 | 4 | MS1 | 7 | 331 | LT3E4 | 49 | 408 | 2D | 106 | 492 | 2.131E-08 | 0.062 | 60.293 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | (1.17E-04) | | STAGES 1 AND 2, OG1 GF1/IAF/<br>STAGES 3 AND 4, EL1/RF4 | | | | | | | | | | | | | | |
| 121 | SEIS3 | SS16 | EP66 | 398 | 3 | MS3 | 9 | 229 | LT2A3 | 24 | 311 | 3D | 11 | 351 | 2.057E-08 | 0.060 | 60.353 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | (1.47E-04) | | STAGES 1 AND 2, OG1 GG1 2G2 SW1/IAF CC5/<br>STAGES 3 AND 4, CHF SIF SEF/FCF | | | | | | | | | | | | | | |
| 122 | SEIS4 | SS16 | EP66 | 398 | 4 | MS3 | 9 | 326 | LT2A4 | 24 | 412 | 3D | 11 | 451 | 2.047E-08 | 0.060 | 60.412 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | (1.17E-04) | | STAGES 1 AND 2, OG1 GG1 2G2 SW1/IAF CC5/<br>STAGES 3 AND 4, CHF SIF SEF/FCF | | | | | | | | | | | | | | |
| 123 | SEIS5 | SS89 | EP48 | 1240 | 5 | MS56 | 1302 | 417 | LT2A5 | 26 | 539 | 3H | 18 | 553 | 1.972E-08 | 0.057 | 60.470 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | (2.82E-05) | | STAGES 1 AND 2, OG1 AF1 AG2 AH3/I12 I24 I3F I4F RT7 OSF ASF SVF/<br>STAGES 3 AND 4, CHF SIF AWF/FCF WL3 CIF OI1 | | | | | | | | | | | | | | |

```
124  SEIS5  SS27   EP48   396   5    MS3   23   417   LT2A5   81   520   3H   13   554   1.898E-08   0.055   60.525
                     FAILED SPLIT FRACTIONS
 +                   ______________________
       (2.82E-05)    STAGES 1 AND 2, OG1 GG1 2H2 FO4/CVF ASF/
                     STAGES 3 AND 4, CT2 CHF SIF SEF HSF/FCF CIF OIF

125  SEIS3  SS25   EP59   386   3    MS1    7   225   LT2A3   14   317   3D   11   351   1.891E-08   0.055   60.580
                     FAILED SPLIT FRACTIONS
 +                   ______________________
       (1.47E-04)    STAGES 1 AND 2, OG1 GH1 2G2 SW1/IAF/
                     STAGES 3 AND 4, SIF AW4 OBF/FCF

126  SEIS5  SS16   EP83   429   5    MS3   11   440   LT2A5   24   512   3D   11   551   1.881E-08   0.055   60.635
                     FAILED SPLIT FRACTIONS
 +                   ______________________
       (2.82E-05)    STAGES 1 AND 2, OG1 GF1 GG2/IAF ASB/
                     STAGES 3 AND 4, CHF SIF SEF/FCF

127  SEIS5  SS16   EP83   429   5    MS3    9   440   LT2A5   24   512   3D   11   551   1.863E-08   0.054   60.690
                     FAILED SPLIT FRACTIONS
 +                   ______________________
       (2.82E-05)    STAGES 1 AND 2, OG1 GF1 GG2/IAF CC5/
                     STAGES 3 AND 4, CHF SIF SEF/FCF

128  SEIS2  SS16   EP66   398   2    MS3    9   128   LT2A2   24   210   3D   11   251   1.844E-08   0.054   60.743
                     FAILED SPLIT FRACTIONS
 +                   ______________________
       (8.00E-04)    STAGES 1 AND 2, OG1 GG1 2G2 SW1/IAF CC5/
                     STAGES 3 AND 4, CHF SIF SEF/FCF

129  SEIS3  SS25   EP57   383   3    MS1    7   223   LT2A3   14   317   3D   11   351   1.811E-08   0.053   60.796
                     FAILED SPLIT FRACTIONS
 +                   ______________________
       (1.47E-04)    STAGES 1 AND 2, OG1 GH1 2H2 SW1/IAF/
                     STAGES 3 AND 4, SIF AW4 OBF/FCF
```

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 130 | SEIS2 | SS27 | EP48 | 412 | 2 | MS3 | 23 | 117 | LT2A2 | 25 | 216 | 3H | 13 | 252 | 1.792E-08 | 0.052 | 60.848 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | | | | | | | | | | | | | | | | | |
| | (8.00E-04) | | STAGES 1 AND 2, OG1 GG1 GH2 2G3 2H4/CVF ASF/ | | | | | | | | | | | | | | |
| | | | STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF | | | | | | | | | | | | | | |
| 131 | SEIS2 | SS16 | EP86 | 435 | 2 | MS3 | 11 | 139 | LT2A2 | 24 | 210 | 3D | 11 | 251 | 1.770E-08 | 0.052 | 60.900 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | | | | | | | | | | | | | | | | | |
| | (8.00E-04) | | STAGES 1 AND 2, OG1 GF1 GG2 2G3 2H4/IAF ASF/ | | | | | | | | | | | | | | |
| | | | STAGES 3 AND 4, CHF SIF SEF/FCF | | | | | | | | | | | | | | |
| 132 | SEIS5 | SS89 | EP46 | 366 | 5 | MS56 | 1302 | 415 | LT2A5 | 26 | 539 | 3H | 18 | 553 | 1.755E-08 | 0.051 | 60.951 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | | | | | | | | | | | | | | | | | |
| | (2.82E-05) | | STAGES 1 AND 2, DF1 DG2 DH4/I1F I2F I3F I4F RT7 OSF AS4 SVF/ | | | | | | | | | | | | | | |
| | | | STAGES 3 AND 4, CHF SIF AWF/FCF WL3 CIF OI1 | | | | | | | | | | | | | | |
| 133 | SEIS1 | SS16 | EP83 | 429 | 1 | MS3 | 9 | 53 | LT2A1 | 24 | 108 | 3D | 11 | 151 | 1.739E-08 | 0.051 | 61.002 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | | | | | | | | | | | | | | | | | |
| | (1.41E-02) | | STAGES 1 AND 2, OG1 GF1 GG2/IAF CC5/ | | | | | | | | | | | | | | |
| | | | STAGES 3 AND 4, CHF SIF SEF/FCF | | | | | | | | | | | | | | |
| 134 | SEIS6 | SS89 | EP48 | 1240 | 6 | MS56 | 1302 | 508 | LT2A6 | 115 | 625 | 3H | 18 | 653 | 1.728E-08 | 0.050 | 61.052 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | | | | | | | | | | | | | | | | | |
| | (7.43E-06) | | STAGES 1 AND 2, OG1 AF1 AG2 AH3/I12 I24 I3F I4F RT7 OSF ASF SVF/ | | | | | | | | | | | | | | |
| | | | STAGES 3 AND 4, CT2 TDF CHF SIF AWF/FCF WL3 CIF OI1 | | | | | | | | | | | | | | |
| 135 | SEIS2 | SS1 | EP47 | 367 | 2 | MS1 | 7 | 116 | LT3E2 | 49 | 200 | 2A | 1 | 290 | 1.711E-08 | 0.050 | 61.102 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | | | | | | | | | | | | | | | | | |
| | (8.00E-04) | | STAGES 1 AND 2, OG1/IAF/ | | | | | | | | | | | | | | |
| | | | STAGES 3 AND 4, EL1/ | | | | | | | | | | | | | | |
| 136 | SEIS1 | SS27 | EP48 | 369 | 1 | MS3 | 23 | 32 | LT2A1 | 25 | 113 | 3H | 13 | 152 | 1.678E-08 | 0.049 | 61.151 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | | | | | | | | | | | | | | | | | |
| | (1.41E-02) | | STAGES 1 AND 2, OG1 FO1/CVF ASF/ | | | | | | | | | | | | | | |
| | | | STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF | | | | | | | | | | | | | | |

```
137  SEIS4  SS25   EP59   386    4     MS1    7    322   LT2A4   14    418   3D   11   451   1.663E-08   0.048    61.200
                   FAILED SPLIT FRACTIONS
 +              ________________________
     (1.17E-04)    STAGES 1 AND 2, OG1 GH1 2G2 SW1/IAF/
                   STAGES 3 AND 4, SIF AW4 OBF/FCF

138  SEIS4  SS27   EP48   1240   4     MS3    71   315   LT2A4   25    420   3H   13   455   1.629E-08   0.048    61.247
                   FAILED SPLIT FRACTIONS
 +              ________________________
     (1.17E-04)    STAGES 1 AND 2, OG1 AF1 AG2 AH3/SB1 CVF ASF/
                   STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF

139  SEIS2  SS16   EP66   398    2     MS3    11   128   LT2A2   24    210   3D   11   251   1.625E-08   0.047    61.294
                   FAILED SPLIT FRACTIONS
 +              ________________________
     (8.00E-04)    STAGES 1 AND 2, OG1 GG1 2G2 SW1/IAF ASB/
                   STAGES 3 AND 4, CHF SIF SEF/FCF

140  SEIS5  SS16   EP66   398    5     MS3    11   429   LT2A5   24    512   3D   11   551   1.613E-08   0.047    61.341
                   FAILED SPLIT FRACTIONS
 +              ________________________
     (2.82E-05)    STAGES 1 AND 2, OG1 GG1 2G2 SW1/IAF ASB/
                   STAGES 3 AND 4, CHF SIF SEF/FCF

141  SEIS1  SS16   EP83   429    1     MS3    11   53    LT2A1   24    108   3D   11   151   1.607E-08   0.047    61.388
                   FAILED SPLIT FRACTIONS
 +              ________________________
     (1.41E-02)    STAGES 1 AND 2, OG1 GF1 GG2/IAF ASB/
                   STAGES 3 AND 4, CHF SIF SEF/FCF

142  SEIS5  SS16   EP66   398    5     MS3    9    429   LT2A5   24    512   3D   11   551   1.598E-08   0.047    61.435
                   FAILED SPLIT FRACTIONS
 +              ________________________
     (2.82E-05)    STAGES 1 AND 2, OG1 GG1 2G2 SW1/IAF CC5/
                   STAGES 3 AND 4, CHF SIF SEF/FCF
```

```
143  SEIS4  SS25   EP57   383   4     MS1    7      320   LT2A4  14   418   3D   11    451   1.591E-08   0.046       61.481
                    FAILED SPLIT FRACTIONS
 +             ________________________
     (1.17E-04)     STAGES 1 AND 2, OG1 GH1 2H2 SW1/IAF/
                    STAGES 3 AND 4, SIF AW4 OBF/FCF

144  SEIS5  SS11   EP52   374   5     MS1    7      419   LT3E5  49   508   2D   106   592   1.589E-08   0.046       61.528
                    FAILED SPLIT FRACTIONS
 +             ________________________
  (2.82E-05)        STAGES 1 AND 2, OG1 2G1 SW3/IAF/
                    STAGES 3 AND 4, EL1/RF4

145  SEIS5  SS14   EP75   413   5     MS3    9      435   LT2A5  24   510   3D   11    552   1.577E-08   0.046       61.574
                    FAILED SPLIT FRACTIONS
 +             ________________________
     (2.82E-05)     STAGES 1 AND 2, OG1 GF1/IAF CC7/
                    STAGES 3 AND 4, CHF SIF SE1/FCF

146  SEIS5  SS11   EP50   371   5     MS1    7      406   LT3E5  49   508   2D   106   592   1.573E-08   0.046       61.620
                    FAILED SPLIT FRACTIONS
 +             ________________________
     (2.82E-05)     STAGES 1 AND 2, OG1 2H1 SW3/IAF/
                    STAGES 3 AND 4, EL1/RF4

147  SEIS3  SS16   EP66   398   3     MS3    11     229   LT2A3  24   311   3D   11    351   1.571E-08   0.046       61.665
                    FAILED SPLIT FRACTIONS
 +             ________________________
     (1.47E-04)     STAGES 1 AND 2, OG1 GG1 2G2 SW1/IAF ASB/
                    STAGES 3 AND 4, CHF SIF SEF/FCF

148  SEIS6  SS89   EP48   437   6     MS56   1302   508   LT2A6  26   625   3H   18    653   1.488E-08   0.043       61.709
                    FAILED SPLIT FRACTIONS
 +             ________________________
     (7.43E-06)     STAGES 1 AND 2, OG1 GF1 GG2 GH3/I12 I24 I3F I4F RT7 OSF ASF SVF/
                    STAGES 3 AND 4, CHF SIF AWF/FCF WL3 CIF OI1

149  SEIS4  SS27   EP48   369   4     MS3    23     315   LT2A4  25   420   3H   13    455   1.450E-08   0.042       61.751
                    FAILED SPLIT FRACTIONS
 +             ________________________
     (1.17E-04)     STAGES 1 AND 2, OG1 FO1/CVF ASF/
                    STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF
```

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 150 | SEIS4 | SS16 | EP66 | 398 | 4 | MS3 | 11 | 326 | LT2A4 | 24 | 412 | 3D | 11 | 451 | 1.378E-08 | 0.040 | 61.791 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | | | | | | | | | | | | | | | | | |
| | (1.17E-04) | | STAGES 1 AND 2, OG1 GG1 2G2 SW1/IAF ASB/<br>STAGES 3 AND 4, CHF SIF SEF/FCF | | | | | | | | | | | | | | |
| 151 | SEIS5 | SS11 | EP52 | 374 | 5 | MS1 | 7 | 419 | LT2E5 | 88 | 508 | 3H | 13 | 571 | 1.366E-08 | 0.040 | 61.831 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | | | | | | | | | | | | | | | | | |
| | (2.82E-05) | | STAGES 1 AND 2, OG1 2G1 SW3/IAF/<br>STAGES 3 AND 4, CT2 OC1 SEF/FCF CIF OIF | | | | | | | | | | | | | | |
| 152 | SEIS5 | SS16 | EP83 | 429 | 5 | MS3 | 23 | 440 | LT2A5 | 24 | 512 | 3D | 11 | 551 | 1.362E-08 | 0.040 | 61.871 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | | | | | | | | | | | | | | | | | |
| | (2.82E-05) | | STAGES 1 AND 2, OG1 GF1 GG2/CV3 ASB/<br>STAGES 3 AND 4, CHF SIF SEF/FCF | | | | | | | | | | | | | | |
| 153 | SEIS5 | SS11 | EP50 | 371 | 5 | MS1 | 7 | 406 | LT2E5 | 88 | 508 | 3H | 13 | 571 | 1.352E-08 | 0.039 | 61.910 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | | | | | | | | | | | | | | | | | |
| | (2.82E-05) | | STAGES 1 AND 2, OG1 2H1 SW3/IAF/<br>STAGES 3 AND 4, CT2 OC1 SEF/FCF CIF OIF | | | | | | | | | | | | | | |
| 154 | SEIS5 | SS16 | EP83 | 429 | 5 | MS3 | 21 | 440 | LT2A5 | 24 | 512 | 3D | 11 | 551 | 1.349E-08 | 0.039 | 61.950 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | | | | | | | | | | | | | | | | | |
| | (2.82E-05) | | STAGES 1 AND 2, OG1 GF1 GG2/CV3 CC5/<br>STAGES 3 AND 4, CHF SIF SEF/FCF | | | | | | | | | | | | | | |
| 155 | EIS2 | SS25 | EP81 | 425 | 2 | MS1 | 7 | 136 | LT2A2 | 14 | 214 | 3D | 11 | 251 | 1.265E-08 | 0.037 | 61.986 |
| | | | FAILED SPLIT FRACTIONS | | | | | | | | | | | | | | |
| + | | | | | | | | | | | | | | | | | |
| | (8.00E-04) | | STAGES 1 AND 2, OG1 GF1 GH2 2G3/IAF/<br>STAGES 3 AND 4, SIF AW4 OBF/FCF | | | | | | | | | | | | | | |

```
156  SEIS5  SS16   EP15   392    5     MS3    9      409   LT2A5   24     512    3D    11    551   1.254E-08   0.037      62.023
                   FAILED SPLIT FRACTIONS
 +           ____________________
     (2.82E-05)    STAGES 1 AND 2, OG1 GG1 SW2/IAF CC5/
                   STAGES 3 AND 4, CHF SIF SEF/FCF

157  SEIS5  SS16   EP15   392    5     MS3    11     409   LT2A5   24     512    3D    11    551   1.240E-08   0.036      62.059
                   FAILED SPLIT FRACTIONS
 +           ____________________
     (2.82E-05)    STAGES 1 AND 2, OG1 GG1 SW2/IAF AS7/
                   STAGES 3 AND 4, CHF SIF SEF/FCF

158  SEIS2  SS25   EP80   423    2     MS1    7      125   LT2A2   14     214    3D    11    251   1.238E-08   0.036      62.095
                   FAILED SPLIT FRACTIONS
 +           ____________________
     (8.00E-04)    STAGES 1 AND 2, OG1 GF1 GH2 2H3/IAF/
                   STAGES 3 AND 4, SIF AW4 OBF/FCF

159  SEIS2  SS25   EP61   389    2     MS1    7      125   LT2A2   14     214    3D    11    251   1.235E-08   0.036      62.131
                   FAILED SPLIT FRACTIONS
 +           ____________________
     (8.00E-04)    STAGES 1 AND 2, OG1 GH1 2G2 2H3 SW3/IAF/
                   STAGES 3 AND 4, SIF AW4 OBF/FCF

160  SEIS4  SS27   EP12   101    4     MS3    9      307   LT2A4   47     420    3H    13    455   1.231E-08   0.036      62.167
                   FAILED SPLIT FRACTIONS
 +           ____________________
     (1.17E-04)    STAGES 1 AND 2, AF1 AG2 AH3/IAF CCF/
                   STAGES 3 AND 4, PRA CHF SIF/FCF CIF OIF

161  SEIS5  SS89   EP48   437    5     MS56   1302   417   LT2A5   26     539    3H    18    553   1.220E-08   0.036      62.203
                   FAILED SPLIT FRACTIONS
 +           ____________________
     (2.82E-05)    STAGES 1 AND 2, OG1 GF1 GG2 GH3/I12 I24 I3F I4F RT7 OSF ASF SVF/
                   STAGES 3 AND 4, CHF SIF AWF/FCF WL3 CIF OI1

162  SEIS1  SS27   EP48   396    1     MS3    23     32    LT2A1   25     113    3H    13    152   1.200E-08   0.035      62.238
                   FAILED SPLIT FRACTIONS
 +           ____________________
 (1.41E-02)        STAGES 1 AND 2, OG1 GG1 2H2 FO4/CVF ASF/
                   STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF
```

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 163 | SEIS5 | SS11 | EP52 | 374 | 5 | MS1 | 7 | 419 | LT1A5 | 32 | 508 | 5A | 1237 | 513 | 1.191E-08 | 0.035 | 62.272 |

FAILED SPLIT FRACTIONS

\+

(2.82E-05) STAGES 1 AND 2, OG1 2G1 SW3/IAF/
STAGES 3 AND 4, PR1/LA1 LB2 CSF

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 164 | SEIS5 | SS11 | EP50 | 371 | 5 | MS1 | 7 | 406 | LT1A5 | 32 | 508 | 5A | 1237 | 513 | 1.179E-08 | 0.034 | 62.307 |

FAILED SPLIT FRACTIONS

\+

(2.82E-05) STAGES 1 AND 2, OG1 2H1 SW3/IAF/
STAGES 3 AND 4, PR1/LA1 LB2 CSF

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 165 | SEIS3 | SS27 | EP48 | 369 | 3 | MS3 | 23 | 218 | LT2A3 | 25 | 319 | 3H | 13 | 353 | 1.160E-08 | 0.034 | 62.341 |

FAILED SPLIT FRACTIONS

\+

(1.47E-04) STAGES 1 AND 2, OG1 FO1/CVF ASF/
STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 166 | SEIS2 | SS27 | EP12 | 101 | 2 | MS3 | 11 | 109 | LT2A2 | 25 | 216 | 3H | 13 | 252 | 1.154E-08 | 0.034 | 62.374 |

FAILED SPLIT FRACTIONS

\+

(8.00E-04) STAGES 1 AND 2, AF1 AG2 AH3/IAF AS4/
STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 167 | SEIS5 | SS27 | EP48 | 408 | 5 | MS3 | 23 | 417 | LT2A5 | 25 | 520 | 3H | 13 | 554 | 1.138E-08 | 0.033 | 62.408 |

FAILED SPLIT FRACTIONS

\+

(2.82E-05) STAGES 1 AND 2, OG1 GG1 GH2 2H3 FO5/CVF ASF/
STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 168 | SEIS5 | SS27 | EP12 | 101 | 5 | MS3 | 11 | 407 | LT2A5 | 81 | 520 | 3H | 13 | 554 | 1.138E-08 | 0.033 | 62.441 |

FAILED SPLIT FRACTIONS

\+

(2.82E-05) STAGES 1 AND 2, AF1 AG2 AH3/IAF AS4/
STAGES 3 AND 4, CT2 CHF SIF SEF HSF/FCF CIF OIF

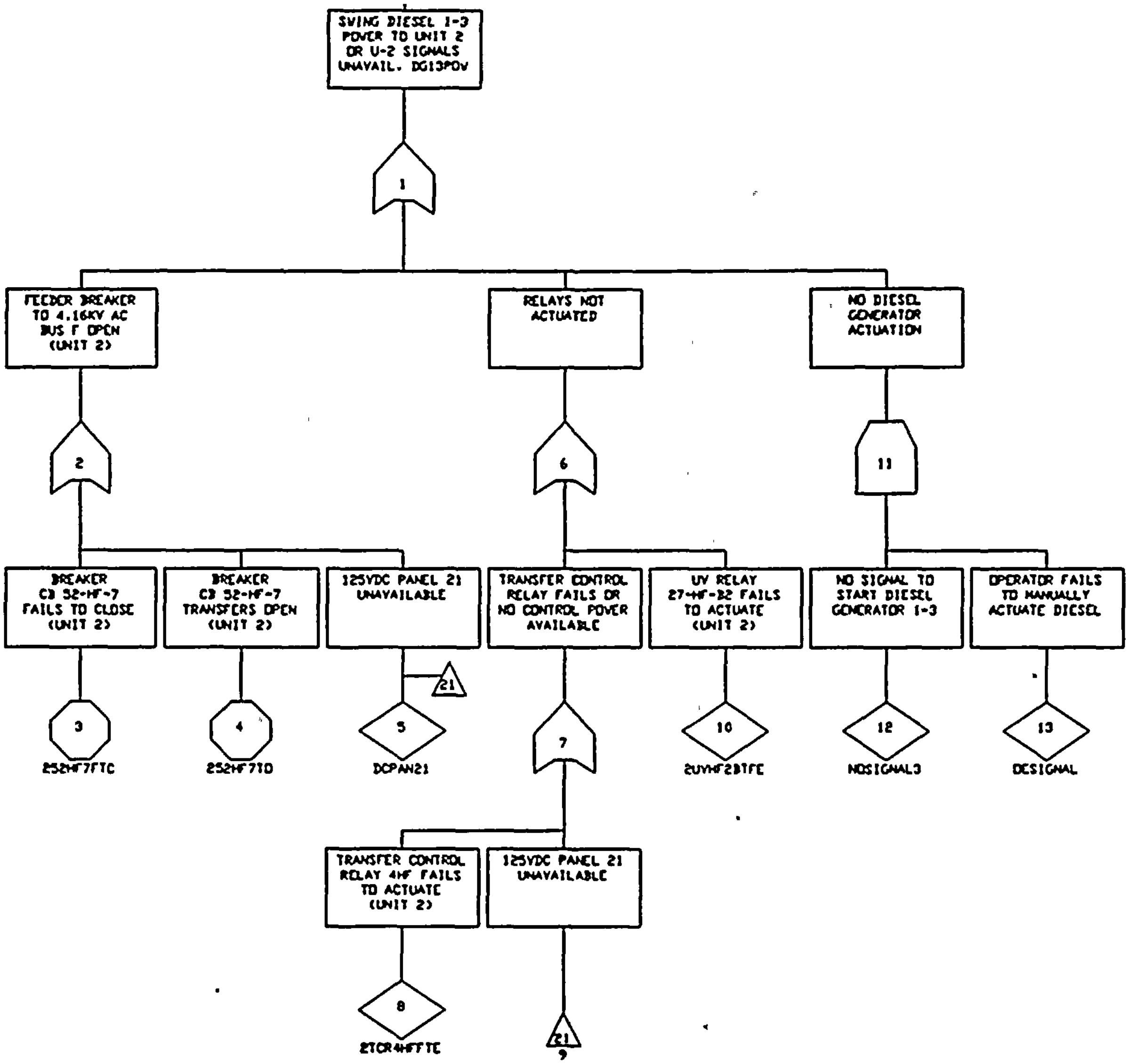
```
169  SEIS5  SS27   EP48   402    5    MS3    23     417   LT2A5   25    520   3H    13    554   1.137E-08   0.033    62.474
                   FAILED SPLIT FRACTIONS
 +                 ______________________
     (2.82E-05)    STAGES 1 AND 2, OG1 GG1 2G2 2H3 FO5/CVF ASF/
                   STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF

170  SEIS5  SS89   EP46   366    5    MS56   1300   415   LT2A5   115   539   3H    18    553   1.123E-08   0.033    62.507
                   FAILED SPLIT FRACTIONS
 +                 ______________________
     (2.82E-05)    STAGES 1 AND 2, DF1 DG2 DH4/I1F I2F I3F I4F RT7 OSF CCF SVF/
                   STAGES 3 AND 4, CT2 TDF CHF SIF AWF/FCF WL3 CIF OI1

171  SEIS5  SS27   EP48   1240   5    MS3    71     417   LT2A5   25    520   3H    13    554   1.053E-08   0.031    62.537
                   FAILED SPLIT FRACTIONS
 +                 ______________________
     (2.82E-05)    STAGES 1 AND 2, OG1 AF1 AG2 AH3/SB1 CVF ASF/
                   STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF

172  SEIS5  SS14   EP75   413    5    MS3    21     435   LT2A5   24    510   3D    11    552   1.046E-08   0.030    62.568
                   FAILED SPLIT FRACTIONS
 +                 ______________________
     (2.82E-05)    STAGES 1 AND 2, OG1 GF1/CV2 CC7/
                   STAGES 3 AND 4, CHF SIF SE1/FCF

173  SEIS2  SS27   EP48   399    2    MS3    23     117   LT2A2   25    216   3H    13    252   1.036E-08   0.030    62.598
                   FAILED SPLIT FRACTIONS
 +                 ______________________
     (8.00E-04)    STAGES 1 AND 2, OG1 GG1 2G2 FO2/CVF ASF/
                   STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF

174  SEIS2  SS27   EP48   384    2    MS3    23     117   LT2A2   25    216   3H    13    252   1.036E-08   0.030    62.628
                   FAILED SPLIT FRACTIONS
 +                 ______________________
     (8.00E-04)    STAGES 1 AND 2, OG1 GH1 2H2 FO2/CVF ASF/
                   STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF

175  SEIS5  SS11   EP75   413    5    MS1    7      435   LT3E5   49    508   2D    106   592   1.012E-08   0.030    62.658
                   FAILED SPLIT FRACTIONS
 +                 ______________________
     (2.82E-05)    STAGES 1 AND 2, OG1 GF1/IAF/
                   STAGES 3 AND 4, EL1/RF4
```

```
176  SEIS6  SS89   EP48   437   6   MS56  1302  508  LT2A6  115  625  3H  18  653  9.668E-09  0.028  62.686
                   FAILED SPLIT FRACTIONS
+
     (7.43E-06)    STAGES 1 AND 2, OG1 GF1 GG2 GH3/I12 I24 I3F I4F RT7 OSF ASF SVF/
                   STAGES 3 AND 4, CT2 TDF CHF SIF AWF/FCF WL3 CIF OI1

177  SEIS3  SS27   EP48   408   3   MS3   23    218  LT2A3  25   319  3H  13  353  9.638E-09  0.028  62.714
                   FAILED SPLIT FRACTIONS
+
     (1.47E-04)    STAGES 1 AND 2, OG1 GG1 GH2 2H3 FO5/CVF ASF/
                   STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF

178  SEIS3  SS27   EP48   402   3   MS3   23    218  LT2A3  25   319  3H  13  353  9.638E-09  0.028  62.742
                   FAILED SPLIT FRACTIONS
+
     (1.47E-04)    STAGES 1 AND 2, OG1 GG1 2G2 2H3 FO5/CVF ASF/
                   STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF

179  SEIS5  SS14   EP10   368   5   MS3   11    406  LT2A5  24   510  3D  11  552  9.446E-09  0.028  62.770
                   FAILED SPLIT FRACTIONS
+
     (2.82E-05)    STAGES 1 AND 2, OG1 SW1/IAF AS5/
                   STAGES 3 AND 4, CHF SIF SE1/FCF

180  SEIS4  SS27   EP48   437   4   MS3   71    315  LT2A4  25   420  3H  13  455  9.424E-09  0.027  62.797
                   FAILED SPLIT FRACTIONS
+
     (1.17E-04)    STAGES 1 AND 2, OG1 GF1 GG2 GH3/SB1 CVF ASF/
                   STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF

181  SEIS1  SS27   EP48   412   1   MS3   23    32   LT2A1  25   113  3H  13  152  9.206E-09  0.027  62.824
                   FAILED SPLIT FRACTIONS
+
     (1.41E-02)    STAGES 1 AND 2, OG1 GG1 GH2 2G3 2H4/CVF ASF/
                   STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF
```

```
182  SEIS1  SS16  EP86  435  1    MS3    11   54   LT2A1  24  108  3D  11  151  9.142E-09  0.027  62.851
                  FAILED SPLIT FRACTIONS
 +                ____________________
     (1.41E-02)   STAGES 1 AND 2, OG1 GF1 GG2 2G3 2H4/IAF ASF/
                  STAGES 3 AND 4, CHF SIF SEF/FCF

183  SEIS1  SS16  EP66  398  1    MS3    9    43   LT2A1  24  108  3D  11  151  9.062E-09  0.026  62.877
                  FAILED SPLIT FRACTIONS
 +                ____________________
     (1.41E-02)   STAGES 1 AND 2, OG1 GG1 2G2 SW1/IAF CC5/
                  STAGES 3 AND 4, CHF SIF SEF/FCF

184  SEIS1  SS79  EP1   1    1    MS69   997  1    LT2A1  26  114  3H  18  153  8.928E-09  0.026  62.903
                  FAILED SPLIT FRACTIONS
 +                ____________________
     (1.41E-02)   STAGES 1 AND 2, I11 I41 OSF/
                  STAGES 3 AND 4, CHF SIF AWF/FCF WL3 CIF OI1

185  SEIS5  SS27  EP48  372  5    MS3    23   417  LT2A5  25  520  3H  13  554  8.900E-09  0.026  62.929
                  FAILED SPLIT FRACTIONS
 +                ____________________
     (2.82E-05)   STAGES 1 AND 2, OG1 2H1 FO3/CVF ASF/
                  STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF

186  SEIS5  SS27  EP48  393  5    MS3    23   417  LT2A5  25  520  3H  13  554  8.900E-09  0.026  62.955
                  FAILED SPLIT FRACTIONS
 +                ____________________
     (2.82E-05)   STAGES 1 AND 2, OG1 GG1 FO3/CVF ASF/
                  STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF

187  SEIS1  SS90  EP1   1    1    MS103  397  1    LT2A1  26  138  3H  18  153  8.840E-09  0.026  62.981
                  FAILED SPLIT FRACTIONS
 +                ____________________
     (1.41E-02)   STAGES 1 AND 2, I31 I41 OSF/
                  STAGES 3 AND 4, CHF SIF AWF/FCF WL3 CIF OI1

188  SEIS1  SS90  EP1   1    1    MS127  691  1    LT2A1  26  138  3H  18  153  8.775E-09  0.026  63.006
                  FAILED SPLIT FRACTIONS
 +                ____________________
     (1.41E-02)   STAGES 1 AND 2, I21 I31/
                  STAGES 3 AND 4, CHF SIF AWF/FCF WL3 CIF OI1
```

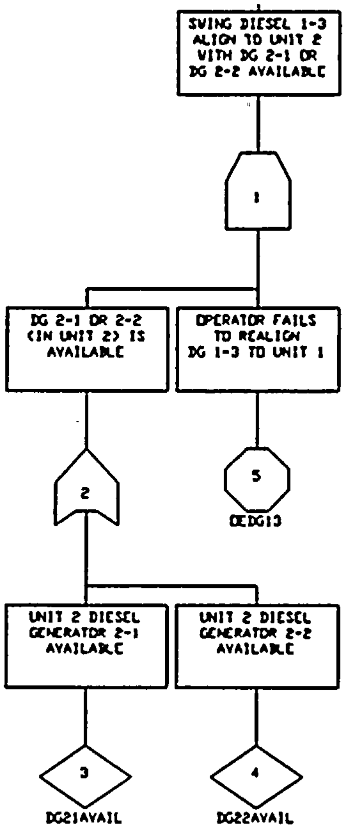
```
189  SEIS5  SS11   EP75  413  5   MS1    7    435  LT2E5  88  508  3H  13  571  8.701E-09  0.025  63.032
                   FAILED SPLIT FRACTIONS
+                  ______________________
     (2.82E-05)    STAGES 1 AND 2, OG1 GF1/IAF/
                   STAGES 3 AND 4, CT2 OC1 SEF/FCF CIF OIF

190  SEIS5  SS16   EP85  433  5   MS3    11   441  LT2A5  24  512  3D  11  551  8.589E-09  0.025  63.057
                   FAILED SPLIT FRACTIONS
+                  ______________________
     (2.82E-05)    STAGES 1 AND 2, OG1 GF1 GG2 2G3/IAF ASF/
                   STAGES 3 AND 4, CHF SIF SEF/FCF

191  SEIS5  SS27   EP12  101  5   MS3    9    407  LT2A5  26  520  3H  13  554  8.529E-09  0.025  63.082
                   FAILED SPLIT FRACTIONS
+                  ______________________
     (2.82E-05)    STAGES 1 AND 2, AF1 AG2 AH3/IAF CCF/
                   STAGES 3 AND 4, CHF SIF AW4/FCF CIF OIF

192  SEIS4  SS27   EP48  402  4   MS3    23   315  LT2A4  25  420  3H  13  455  8.514E-09  0.025  63.106
                   FAILED SPLIT FRACTIONS
+                  ______________________
     (1.17E-04)    STAGES 1 AND 2, OG1 GG1 2G2 2H3 FO5/CVF ASF/
                   STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF

193  SEIS4  S27    EP48  408  4   MS3    23   315  LT2A4  25  420  3H  13  455  8.514E-09  0.025  63.131
                   FAILED SPLIT FRACTIONS
+                  ______________________
     (1.17E-04)    STAGES 1 AND 2, OG1 GG1 GH2 2H3 FO5/CVF ASF/
                   STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF

194  SEIS1  SS90   EP23  249  1   MS124  625  19   LT2A1  26  138  3H  18  153  8.408E-09  0.025  63.156
                   FAILED SPLIT FRACTIONS
+                  ______________________
     (1.41E-02)    STAGES 1 AND 2, DG1/I2F I42 OSF/
                   STAGES 3 AND 4, CHF SIF AWF/FCF WL3 CIF OI1
```

```
195  SEIS1  SS16   EP66   398   1    MS3   11    43    LT2A1   24    108    3D    11     151   8.376E-09   0.024    63.180
                   FAILED SPLIT FRACTIONS
+                  ________________________
     (1.41E-02)    STAGES 1 AND 2, OG1 GG1 2G2 SW1/IAF ASB/
                   STAGES 3 AND 4, CHF SIF SEF/FCF

196  SEIS5  SS27   EP48   432   5    MS3   23    417   LT2A5   25    520    3H    13     554   8.117E-09   0.024    63.204
                   FAILED SPLIT FRACTIONS
+                  ________________________
     (2.82E-05)    STAGES 1 AND 2, OG1 GF1 GG2 2H3 FO4/CVF ASF/
                   STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF

197  SEIS2  SS16   EP85   433   2    MS3   23    139   LT2A2   24    210    3D    11     251   8.003E-09   0.023    63.227
                   FAILED SPLIT FRACTIONS
+                  ________________________
     (8.00E-04)    STAGES 1 AND 2, OG1 GF1 GG2 2G3/CV3 ASF/
                   STAGES 3 AND 4, CHF SIF SEF/FCF

198  SEIS5  SS11   EP75   413   5    MS1   7     435   LT1A5   32    508    5A    1237   513   7.585E-09   0.022    63.249
                   FAILED SPLIT FRACTIONS
+                  ________________________
     (2.82E-05)    STAGES 1 AND 2, OG1 GF1/IAF/
                   STAGES 3 AND 4, PR1/LA1 LB2 CSF

199  SEIS5  SS27   EP48   369   5    MS3   23    417   LT2A5   25    520    3H    13     554   7.304E-09   0.021    63.271
                   FAILED SPLIT FRACTIONS
+                  ________________________
     (2.82E-05)    STAGES 1 AND 2, OG1 FO1/CVF ASF/
                   STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF

200  SEIS6  SS27   EP12   101   6    MS3   9     503   LT2A6   25    616    3H    13     654   7.292E-09   0.021    63.292
                   FAILED SPLIT FRACTIONS
+                  ________________________
     (7.43E-06)    STAGES 1 AND 2, AF1 AG2 AH3/IAF CCF/
                   STAGES 3 AND 4, CHF SIF SEF HSF/FCF CIF OIF
```



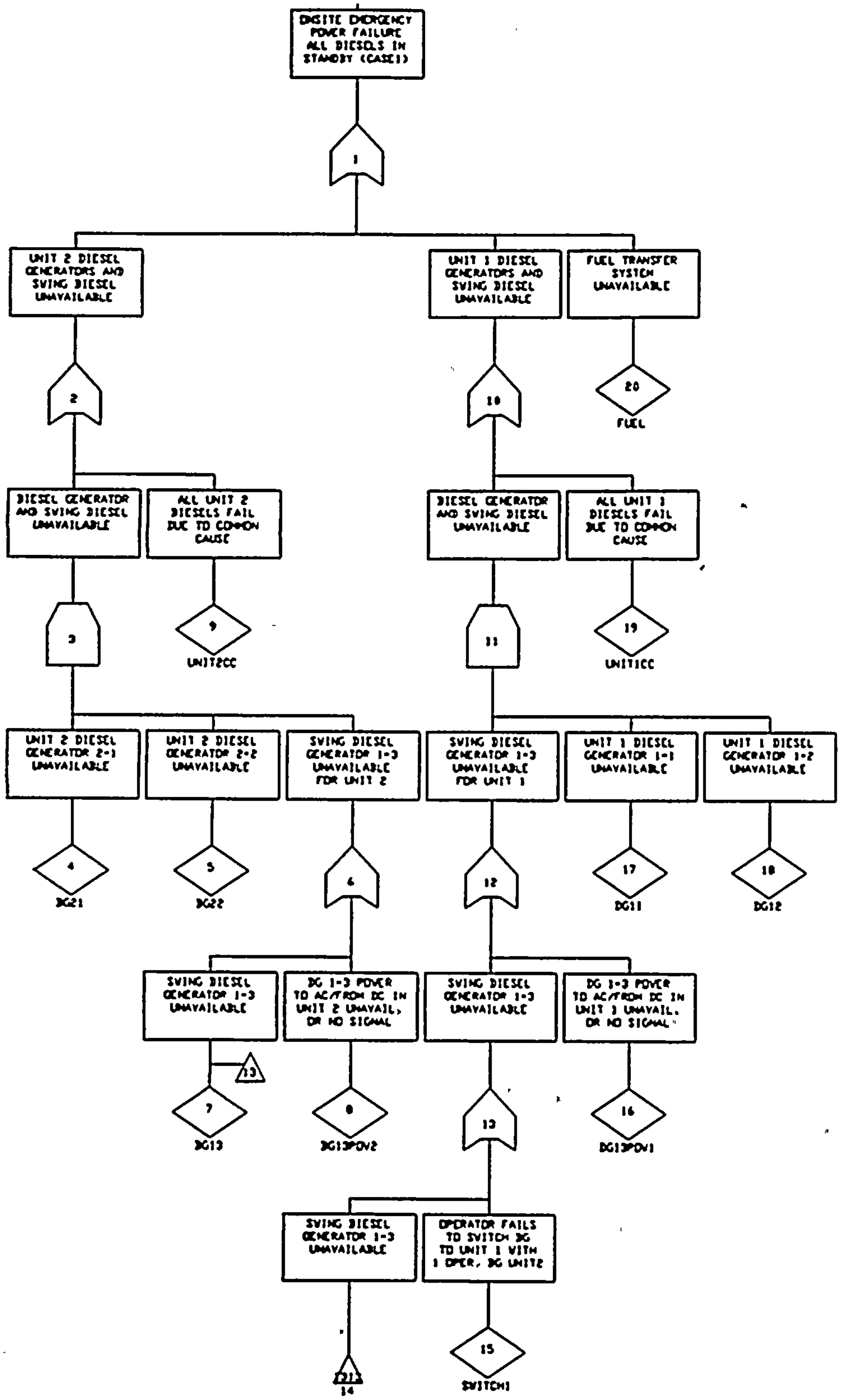
DIABLO CANYON
POWER FROM SWING DIESEL UNAVAILABLE
(DG13POW2)

FIGURE D-3



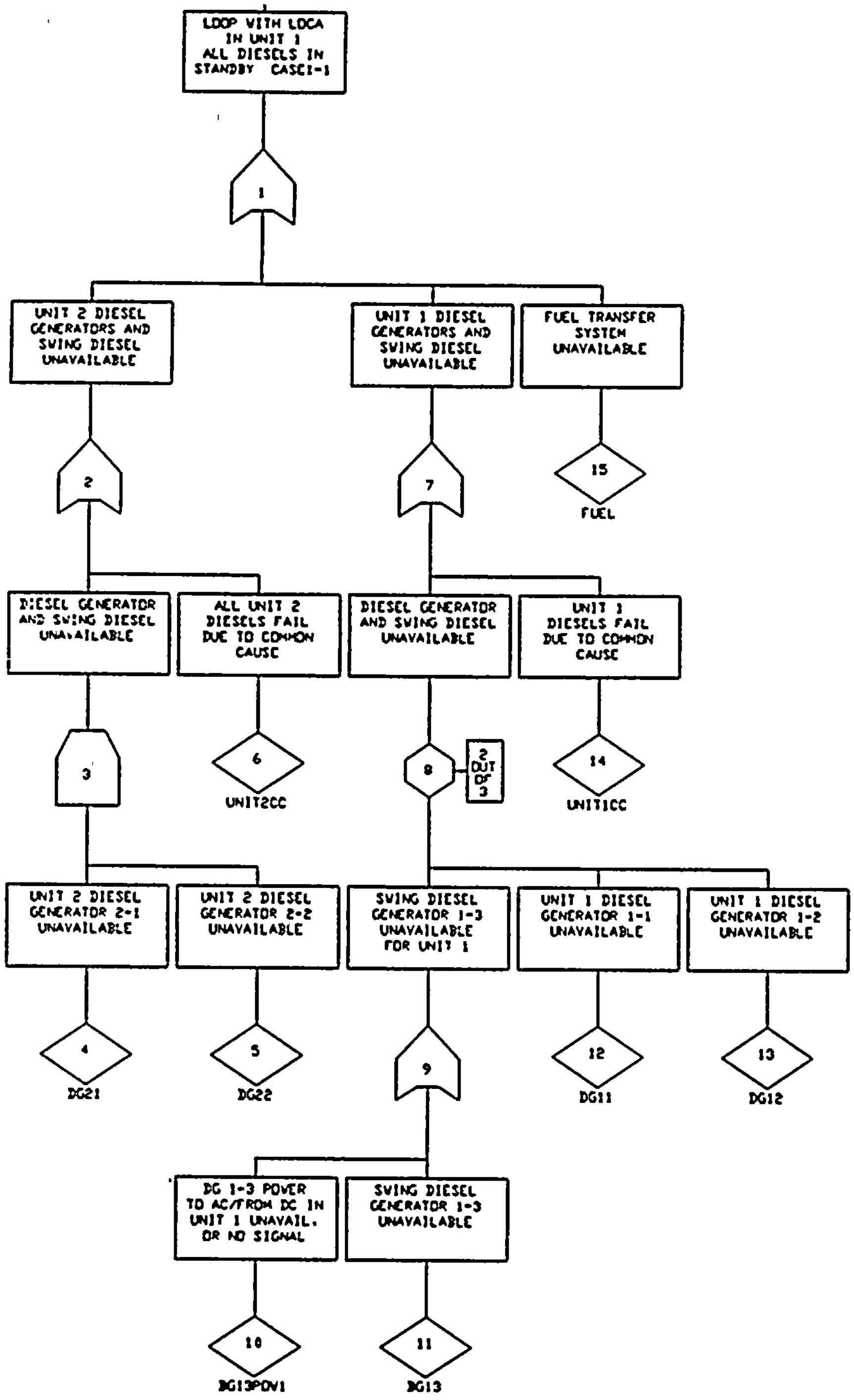
DIABLO CANYON
SWING DIESEL ALIGNED TO UNIT 2
ONE DG IN UNIT 2 AVAILABLE
(SWITCH1)

FIGURE D-4



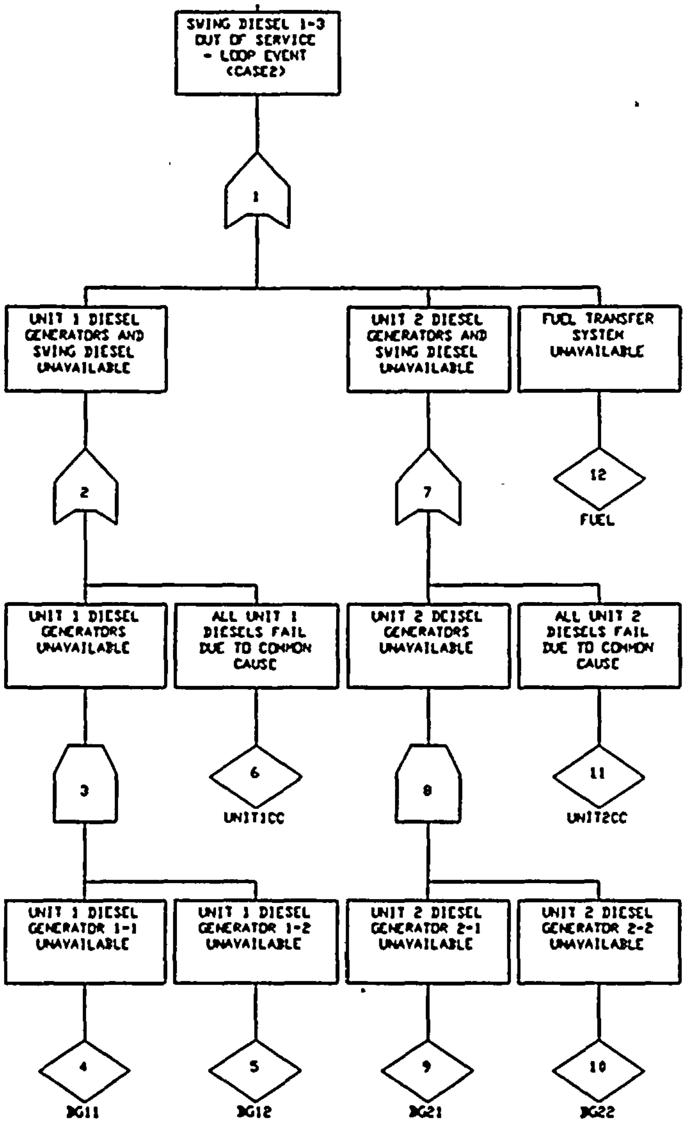
DIABLO CANYON
LOOP EVENT & ALL DG'S IN STANDBY
(CASE1-LP)

FIGURE D-5



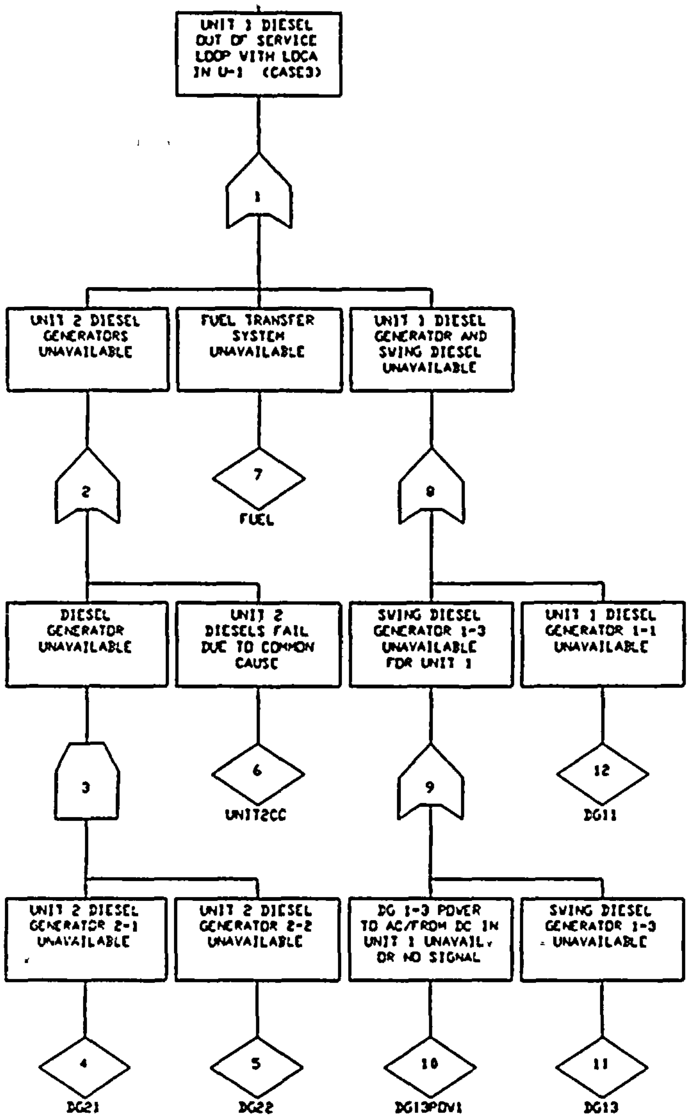
DIABLO CANYON
LOOP EVENT WITH LOCA IN UNIT 1
ALL DG'S IN STANDBY
(CASE1-1)

FIGURE D-6



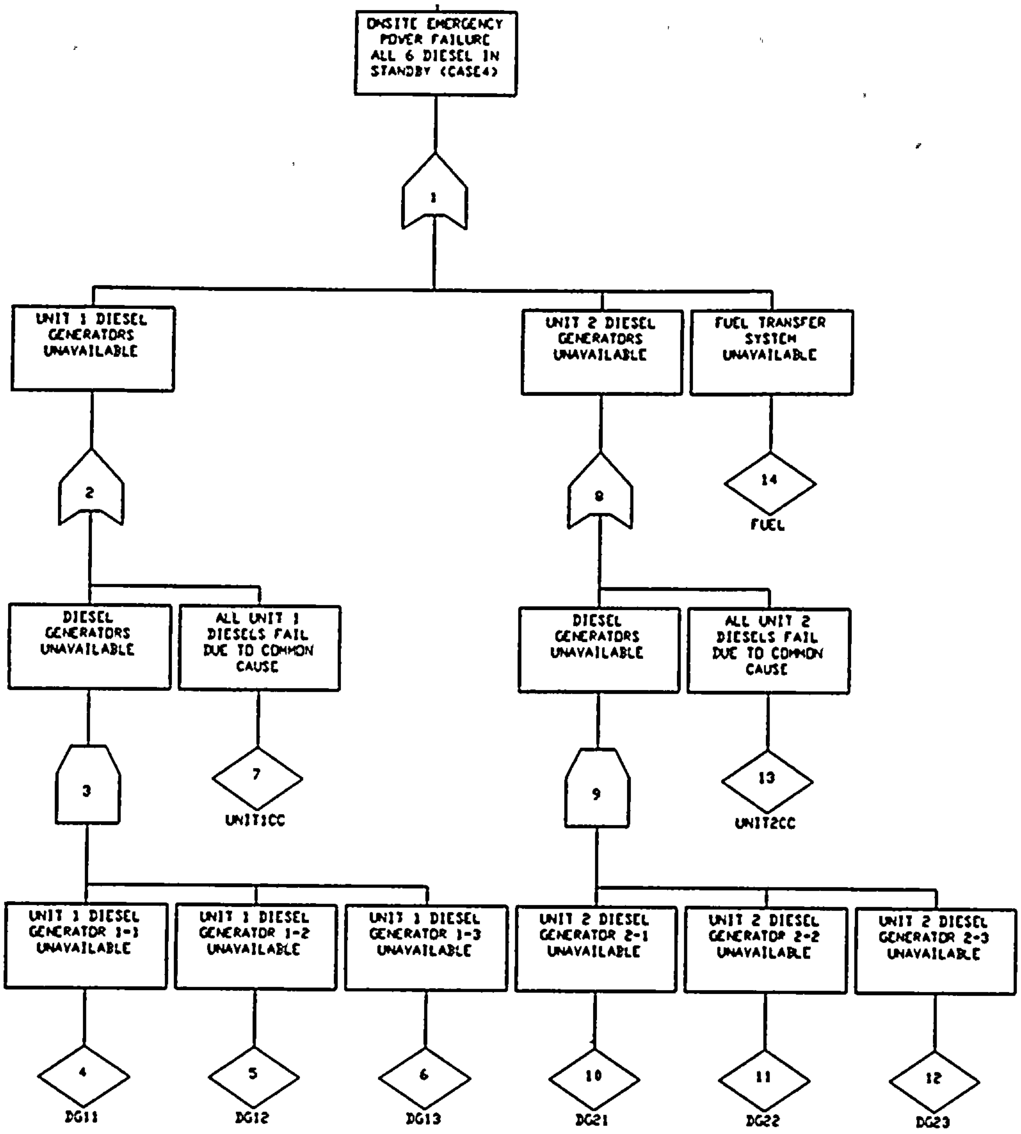
DIABLO CANYON
LOOP EVENT & SWING DG OUT OF SERVICE
(CASE2)

FIGURE D-7



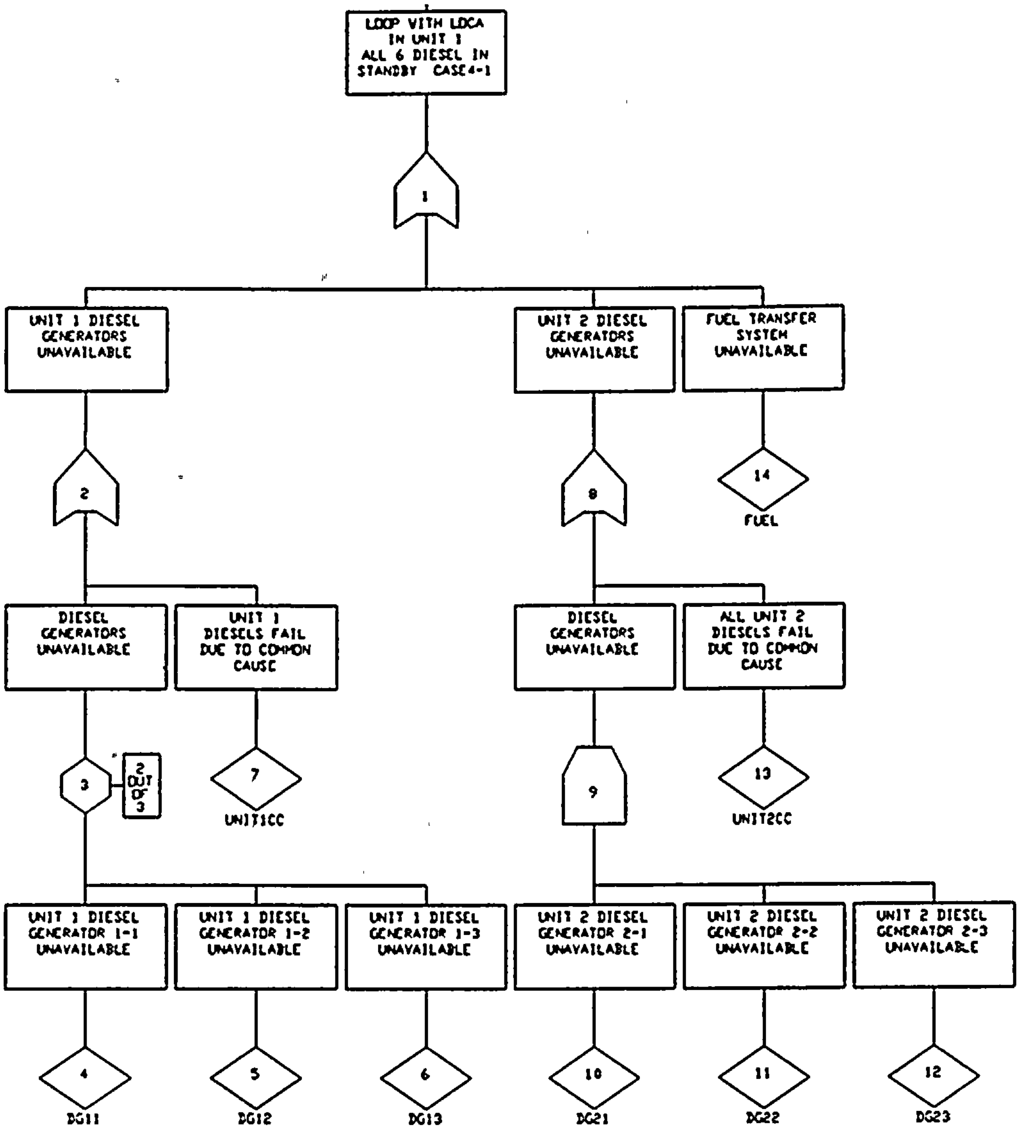
DIABLO CANYON
LOOP EVENT WITH LOCA IN UNIT 1
DG 1-2 OUT OF SERVICE
(CASE3)

FIGURE D-8



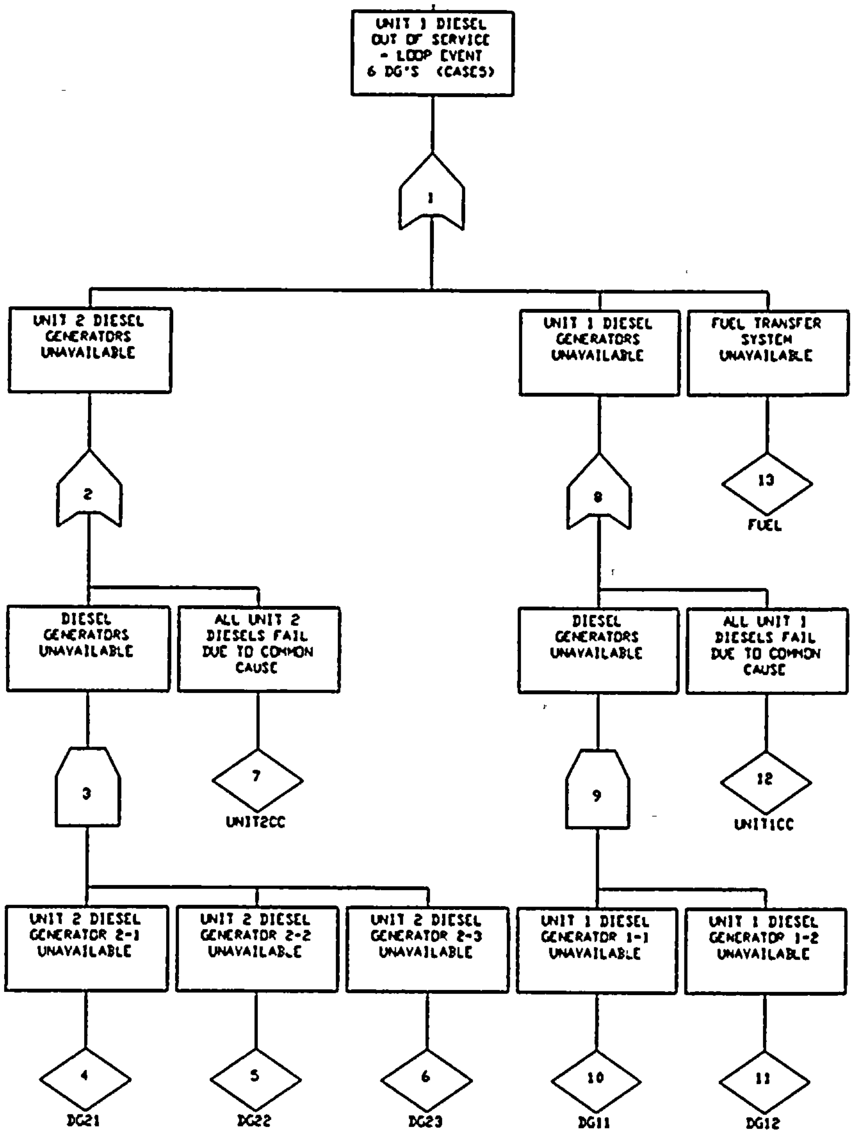
DIABLO CANYON
LOOP EVENT, SIX DG'S IN STANBY
(CASE4-LP)

FIGURE D-9



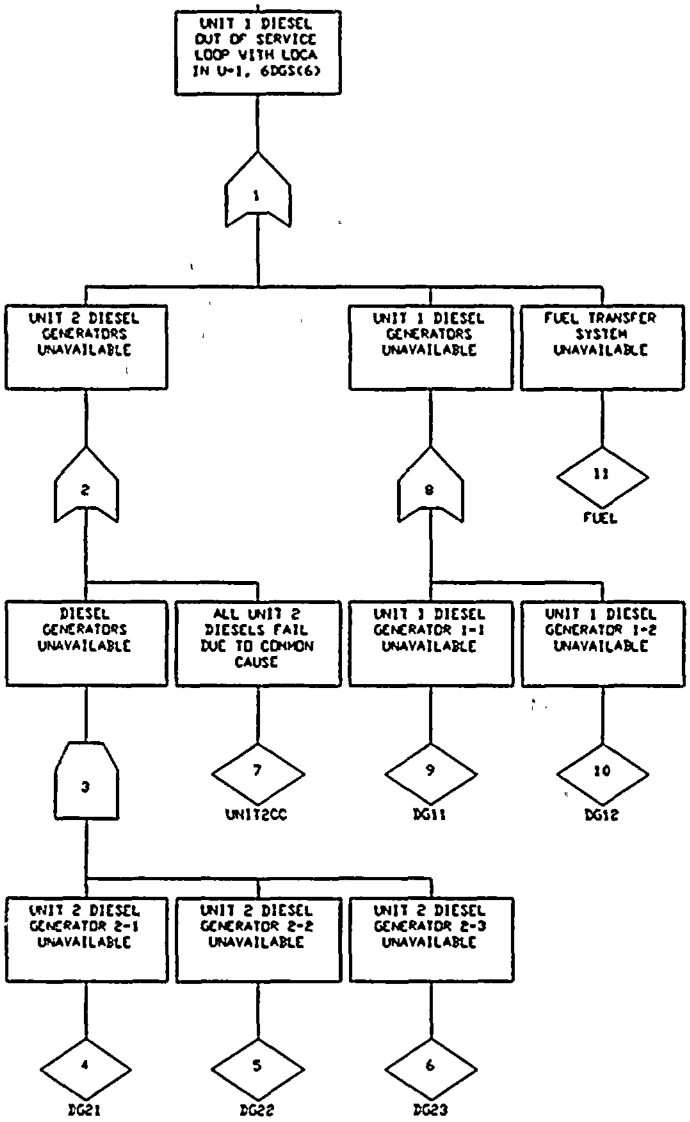
DIABLO CANYON
LOOP EVENT WITH LOCA IN UNIT 1
SIX DG'S IN STANDBY
(CASE4-1)

FIGURE D-10



DIABLO CANYON
LOOP EVENT & ONE DG OUT OF SERVICE
SIX DG CONFIGURATION
(CASE5)

FIGURE D-11



DIABLO CANYON
LOOP EVENT WITH LOCA IN UNIT 1
DG 1-2 OUT OF SERVICE
SIX DG CONFIGURATION
(CASE6)

FIGURE D-12