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Deepwater Drillship Probabilistic Risk Assessment (PRA)

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DISCLAIMER

ACKNOWLEDGEMENTS

To correctly perform a PRA requires both a source of PRA expertise and a "Subject Matter Expert" on the equipment and processes being modeled. NASA S&MA has supplied the PRA expertise and BSEE has supplied the Subject Matter Experts. The Subject Matter Experts on this project were Earl Shanks and Mike Worden. They spent many days advising and educating the PRA Team on drilling operations and interpreting data. This project would not have been possible without their help.

REVISION AND HISTORY PAGE

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ACRONYMS AND ABBREVIATIONS

Acronym/ Abbreviation	Description
ABS	American Bureau of Shipping
API	American Petroleum Institute
BHA	Bottom Hole Assembly
BOP	Blowout Preventer
BSEE	Bureau of Safety and Environmental Enforcement
BSR	Blind Shear Ram
BV	Bureau Veritas (France)
CREAM	Cognitive Reliability and Error Analysis Method
CCF	Common Cause Failure
CFP	Cognitive Failure Probability
CHRAC	CREAM HRA Calculator
CPC	Common Performance Condition
CSR	Casing Shear Ram
D-RAD	Drilling – Risk Analysis Database (NASA's Oil and Gas Industry database)
DGPS	Differential Global Positioning System
DMAS	Deadman/Autoshear
DNV	Det Norske Veritas
DP	Dynamic Positioning
DPC	Dynamic Positioning Controller
DPO	Dynamic Positioning Operator
DPOS	Dynamic Positioning Operating Station
DPS	Dynamic Positioning System
ECD	Equivalent Circulating Density
ED	Emergency Disconnect
EDS	Emergency Disconnect Sequence
EF	Error Factor
ESD	Event Sequence Diagram
GAMUT	Global Alpha Model Uncertainty Tool
GoM	Gulf of Mexico
GPS	Global Positioning System
HPHT	High Pressure High Temperature
HPR	Hydroacoustic Position Reference
HRA	Human Reliability Analysis
IE	Initiating Event
IBOP	Internal Blowout Preventer
IMO	International Maritime Organization (UK)
JSC	Johnson Space Center
LMRP	Lower Marine Riser Package
LR	Lloyd's Register (UK)
MLD	Master Logic Diagram
MODU	Mobile Offshore Drilling Unit

Acronym/ Abbreviation	**Description**
MSC	Maritime Safety Committee
NASA	National Aeronautics and Space Administration
NPRD	Non-electronic Parts Reliability Data
OREDA	Offshore and Onshore Reliability Data
PRA	Probabilistic Risk Assessment
RCM	Rigid Conduit Manifold
ROV	Remotely Operated Vehicle
S&MA	Safety and Mission Assurance
SAA	Space Act Agreement
SAPHIRE	Systems Analysis Program for Hands-on Integrated Reliability Evaluations
SINTEF	The Foundation for Scientific and Industrial Research
TD	Total Depth
TVD	True Vertical Depth
VFD	Variable Frequency Drive
VRS	Vertical Reference Sensor
WAR	Well Activity Report

1 EXECUTIVE SUMMARY

1.1 Overview and Scope

As part of an Interagency Agreement between the National Air and Space Administration (NASA) and the Bureau of Safety and Environmental Enforcement (BSEE), NASA was tasked to conduct a Probabilistic Risk Assessment (PRA) that quantifies the risk of an uncontained hydrocarbon release from an offshore deepwater well. The analysis was conducted assuming that well operations would take place in deep water in the Gulf of Mexico (GoM).

The PRA evaluated the probability of a hydrocarbon release from a deepwater well by answering three basic questions:

1. What kinds of events or scenarios can occur (i.e., what can go wrong)?
2. What are the likelihoods and associated uncertainties of the events or scenarios?
3. What consequences could result from these events or scenarios (e.g., environmental release of hydrocarbons)?

The primary systems modeled in this study are the Blowout Preventer (BOP) and Dynamic Positioning System (DPS). Support systems for each of these are also modeled at a high level.

The end states that include damage prior to the well being stabilized were of primary interest for this study. These end states included a large hydrocarbon release to the environment. This model identified different end states depending on how the well is killed after a release. A well that is eventually controlled via a relief well will generally have a much larger release than one killed by Remotely Operated Vehicle (ROV) intervention because the time involved is significantly longer. The three main end states used in this study to capture these release scenarios are:

- ROVCONTAIN – The well is contained during an uncontrolled release by ROV intervention
- CAPPINGSTACKCONTAIN – The well is contained during an uncontrolled release by placement of a capping stack
- RELIEFWELLSEAL – The well is sealed during an uncontrolled release by one or more relief wells

1.2 Methodology

The PRA methodology utilized in this study is based on the Probabilistic Risk Assessment Procedures Guide for Offshore Applications [1]. The BOP PRA was constructed using PRA software, Version 8.1.4 of the Systems Analysis Program for Hands-on Integrated Reliability Evaluations (SAPHIRE) developed by Idaho National Laboratory [2].

The PRA methodology can be summarized in five steps as outlined below:

Step 1 - Objective of the study

Step 2 - Initiating Events (IE) and End States

Step 3 – Event Trees

Step 4 – Fault Trees

Step 5 – Model Quantification

The methodology used to generate the data for the components modeled in the Integrated PRA has evolved over time and has been applied previously to numerous projects at NASA. The data sources and calculated failure rates for all of the components modeled in this analysis are provided in the Drilling Risk Analysis Database (D-RAD) [3], NASA's Oil & Gas component failure database.

The primary data sources used to obtain surrogate data in this analysis are:

1. Offshore and Onshore Reliability Data (OREDA) 6th Edition [4].
2. The Foundation for Scientific and Industrial Research (SINTEF) Reliability Data for Safety Instrumented Systems 2013 Edition [5].
3. Non-electronic Parts Reliability Data (NPRD)-2016 from Quanterion Solutions Inc.[6].

The first two are the preferred sources since they contain data specific to oil industry applications.

1.3 Results Summary

The overall results for a loss of containment (uncontrolled hydrocarbon release) are given in Table 1-1. The end states for ROVCONTAIN, CAPPINGSTACKCONTAIN, and RELIEFWELLSEAL were combined into a single end state INIBO for initial blowout. All results are based on a truncation cutoff of 1.00E-11. Because the model is based on two main types of events, kicks and loss of position, the results from INIBO were further broken down to determine the contribution from each type of initiating event. The overall result, 4.00E-4 per well is equivalent to 1 in 41.7 years for a loss of containment based on an average number of deepwater wells drilled per year, using DPS, in the GoM. The overall risk is essentially evenly split between the two types of initiating events.

Table 1-1: Overall Results for Loss of Containment for a Deepwater Exploration Well

Description	End State	Frequency (per well)	1 in X[1] (Years)	Number of Cut Sets
Loss of Containment	INIBO	4.00E-04	41.7	506490
Loss of Containment due to Kicks	KICKSONLY	1.99E-04	83.8	80535
Loss of Containment due to Loss of Position	LOSSOFPOSITION	2.01E-04	82.9	425955

Initiating events are broken down further in Table 1-2. *Drift-off* and *kicks while drilling* are by far the largest contributors. Drift-off includes scenarios where some hardware has failed (e.g., thrusters, power) and with the existing weather conditions, the rig drifts into the red watch circle. Kicks while drilling are dominant risk contributors because kicks are more likely while drilling ahead and the drill string is across the BOP the vast majority of the time during any drilling operation.

[1] Based on 60 DPS-rig-drilled exploration wells/year

Table 1-2: Loss of Containment Initiating Event Contributions

Initiators	Percent Contribution
Drift-off	45.4%
Kicks while drilling	44.2%
Kicks while running casing	3.4%
Kicks with nothing across the BOP	2.3%
Drive-off Human Error	0.7%
Drive-off Position Reference	0.0%
Push-off	0.0%

1.4 Conclusions

The overall results of the model agree well with GoM experience. Review of the selected results of interest leads to the following conclusions:

1. The original intent of the analysis was to model a deepwater High Pressure / High Temperature (HPHT) exploration well. Because of a lack of data specific to HPHT wells, the model was developed on a more generic basis, but the overall logic of the model is relevant to an HPHT well. To evaluate an HPHT well, additional data required is:
    a. Kick frequency developed for HPHT wells
    b. Failure rates of BOP components rated for HPHT wells (20k)
    c. Duration of an HPHT well from spudding to total depth
2. The model was developed for a generic deepwater exploration well using a DPS rig. In this sense, average data was used for kick frequency and the time from spudding to total depth. Kick frequency can vary by the type of well, e.g., exploration/development, new/sidetrack, so individual well risk can vary from kick frequency. The time from spudding to total depth also can vary significantly with the type of well. Specific well information may be put in the model based on the characteristics of the well to arrive at a more specific estimate for a given well. In addition, the BOP and vessel details vary which may cause some differences in results.
3. For DPS rigs, the estimated risk of an uncontrolled hydrocarbon release is evenly split between kicks and loss of position events. For rigs not using DPS, the loss of position risk would not exist; however, other risks such as failed mooring lines (similar to a loss of position on a DPS rig) or failure of jackup legs are present and not applicable to DPS rigs. Based on the review of Well Activity Report (WAR) data [7], these risks for other rigs appear to have a much lower frequency than a loss of position, and therefore imply that the risk is higher for DPS rigs than non-DPS rigs.
4. The loss of position/emergency disconnect frequency developed for the model agrees very well with recent GoM experience; however, anecdotally the cause of many of the recent events is an inadvertent disconnect which is not modeled. An inadvertent disconnect is one caused by mistakenly activating the disconnect system or possibly activating it during maintenance activities. In addition, a concurrent review of equipment failure rates shows many of the contributors to loss of position (requiring an emergency disconnect) may be somewhat lower than what is used in the model.

5. Perhaps an obvious conclusion is that the highest risk contribution for an uncontrolled hydrocarbon release is when the reservoir has been reached and drillpipe is across the BOP, since the drilling phase time is longer than other phases, and the probability of a kick is higher during drilling.

1.5 Recommendations

This model represents the first attempt at developing a comprehensive deepwater exploration well model, and although the overall results appear to be quite reasonable, there is always room for improvement. Some suggestions for future work include:

1. Update the model with improved failure rates and initiating event frequencies. The work performed in references [8], [9] and [10] includes developing equipment failure rates and kick frequencies based on recent GoM data. Indications are that the generic failure rates and kick frequencies in the model may be, in many cases, conservative. It is recommended to continually update the data taking into account new operational experience and technological advances.
2. Add initiating events that are not currently included. Inadvertent emergency disconnect is particularly important as mentioned in Conclusion 4. It is also recommended to review other data from the data analysis reports [9][10], to determine whether other failure events should be included in the model. One such event already identified is the probability of a stuck pipe during well control activities.
3. Evaluate in more detail the well stabilization process after shut in, e.g., after emergency disconnect, ROV intervention and well capping.
4. Refine certain parameter values used in the model. There are several parameters included in the model that have an effect on results, but their values have been assumed without rigorous research These values could be further refined, and include:
    a. Probability that the riser will part if the rig does not disconnect
    b. Probability of an underground blowout
    c. Human error to space out after a kick

2 STUDY OVERVIEW

As part of an Interagency Agreement between NASA and BSEE, NASA was tasked to conduct a Probabilistic Risk Assessment (PRA) that quantifies the risk of an uncontained hydrocarbon release from an offshore deepwater well. The basic techniques and methods used follow those in the Probabilistic Risk Assessment Procedures Guide for Offshore Applications [1]. The analysis was conducted assuming that well operations would take place in deep water in the GoM. The team responsible for performing this analysis is provided in PRA TEAM.

2.1 Purpose

The purpose of this report is to document the deepwater drillship PRA model including the results and the associated findings and conclusions.

2.2 PRA Methodology

The PRA methodology utilized in this study is based on the BSEE Probabilistic Risk Assessment Procedures Guide for Offshore Applications [1], and the reader is referred to this document to obtain a more detailed explanation on the risk assessment methodology. The BOP PRA was constructed using PRA software, Version 8.1.4 of the Systems Analysis Program for Hands-on Integrated Reliability Evaluations (SAPHIRE) developed by Idaho National Laboratory [2].

The PRA methodology can be summarized in five steps as outlined below:

Step 1 - Objective of the study:

The first and foremost step in the development of any risk model is to determine the objective of the study and carefully scope the problem under analysis in relation to applicable regulations and guidelines. Some of the factors to consider at this stage are:

- Systems or functions under consideration, broken down to an appropriate level of detail, e.g., the BOP system, the DPS system
- Boundaries of the analysis
- Modes of operation
- External events to include and to exclude
- Types of undesirable events under consideration
- Consequences of interest, also called “end states” (e.g., fatalities, oil spill, equipment damage)
- Type of initiating events to consider

Step 2 - Initiating Events and End States:

The next step involves determining what perturbations to the process, or IEs, present a challenge to the systems or functions that could lead to a particular end state(s). There may be many IEs, and some of them may be grouped together based on their similar response or effect on the system or process.

In addition to defining the end states, in many cases it is beneficial to define what a successful end state would be. For instance, if the end state of interest was an uncontrolled release of hydrocarbons to the environment during exploration drilling, the success state may be defined in different ways depending on the goals of the analysis. If the goal is to evaluate the likelihood of an accident, the success end state may be defined as successful control of the well by the blowout preventer (BOP). If the goal is to evaluate the likelihood of a release as a function of the magnitude of release, considerations beyond the BOP must be taken into account such as ROV intervention and well capping.

Step 3 – Event Trees:

Event trees are developed for modeling specific accident sequences. Each event tree starts with an initiating event and progresses logically to a particular end state. Event trees are used in conjunction with fault trees to quantify the frequency of occurrence for each end state. One event tree is developed for each IE (or group of similar IEs). The graphical event tree is a set of branches/paths that starts with the IE, followed by a number of pivotal events determined through the accident progression/critical function assessment. Each of the pivotal events has a potential success or failure path (although in some cases more than a binary state is possible), and they are usually ordered as a time sequence of the response to the IE.

Step 4 – Fault Trees:

Fault trees are used to model each one of the pivotal events defined in the event trees. Each fault tree starts with a “Top Event” that represents the failure or condition of interest, and identifies all credible ways in which the failure condition can be brought about. This is done sequentially by deductive failure analysis, until the lowest level is reached, expressed in terms of “basic events.” There can be several combinations of basic events that can cause the Top Event. Each one of these combinations is called a cut set. The fault tree models capture hardware failures, software failures, human errors, environmental conditions, etc., unless specifically specified as out of scope. The basic events are modeled at a level such that failure statistics are generally available (for the same or comparable operations). This permits failure rates or probabilities to be estimated and assigned to each basic event.

Step 5 – Model Quantification:

Once event trees and their associated fault trees have been developed, initiating event frequencies estimated, and all basic event probabilities have been assigned, the PRA model is ready to be quantified. The procedure is to link all the fault trees with the corresponding pivotal event in the event tree logic diagram. Fault trees and event trees are said to be "linked" when the fault trees for pivotal events and the event trees containing those pivotal events are tied together properly in the software being used to evaluate the accident sequence cut sets. The model can then be evaluated quantitatively.

2.3 PRA Scope

2.3.1 Overall Scope

PRA is a comprehensive and structured process for analyzing risk in engineered systems and/or processes. It attempts to quantify rare event probabilities of failures and takes into account all possible events or influences that could reasonably affect the system or process being studied. The PRA will evaluate the probability of a hydrocarbon release from a deepwater well by answering the three basic questions:

1. What kinds of events or scenarios can occur (i.e., what can go wrong)?
2. What are the likelihoods and associated uncertainties of the events or scenarios?
3. What consequences could result from these events or scenarios (e.g., environmental release of hydrocarbons)?

The scenarios and consequences for the PRA model are evaluated from spudding the well until Total Depth is achieved. This does not include running or cementing production casing, as exploration wells are often abandoned after the reservoir is evaluated. Other high level assumptions are given later in this section.

2.3.2 Systems Included

The primary systems modeled in this study are the Blowout Preventer and the Dynamic Positioning System. Support systems for each of these are also modeled at a high level. Both systems include dependencies on:

- Surface Electrical Power (generation and distribution)
- Freshwater Cooling (for thrusters and electric power generation)
- Seawater Cooling (for freshwater cooling)

In addition, the BOP is dependent on surface hydraulics.

A remotely operated vehicle and capping stack are considered for incident management, but the hardware is not specifically modeled. Only the well/BOP conditions that would prevent them from succeeding are included.

The drill floor equipment such as the top drive, riser recoil system, and drawworks are not modeled.

2.3.3 End States

The end states are determined when a stable condition has been met in the well. For the purposes of this PRA, the well has been stabilized when the well is killed or safely shut in after an emergency disconnect (ED).

The end states that include damage prior to the well being stabilized are of primary interest for this study. These end states include a large hydrocarbon release to the environment. Since not all hydrocarbon releases are equal, the larger the releases are more consequential. This model identifies different end states depending on how the well is killed after a release. A well that is eventually controlled via a relief well will generally have a much larger release than one killed by ROV intervention because the time required to conduct the operation is significantly longer. The three main end states used in this study to capture these release scenarios are:

- ROVCONTAIN – The well is contained during an uncontrolled release by ROV intervention

- CAPPINGSTACKCONTAIN – The well is contained during an uncontrolled release by placement of a capping stack
- RELIEFWELLSEAL – The well is sealed during an uncontrolled release by one or more relief wells

A hydrocarbon release, for the PRA, is defined as one coming from the wellbore, not from other rig sources such as fuel tanks.

In addition, other end states are developed related to the state of the well after an ED is attempted in terms of the functioning of the disconnect sequence. Failure to isolate the choke and kill lines during the disconnect will also result in a hydrocarbon release to the environment. The release rates are considered to be much smaller than those possible through the annulus and do not pose a threat to the crew since the release would be subsea by the wellhead. Since an ED is a significant event, the disconnect end states were created so the probability of an ED failure could be estimated. The end states associated with an emergency disconnect are:

- SHUTINDISCONNECTED (-H) – Considered a safe state for the well, the well is shut in on the blind shear ram and a disconnect was successful or the riser parted. The "-H" is present on the end state if hydrocarbons were present during the disconnect. Since a disconnect may occur at any time, hydrocarbons may or may not be present in the well.
- SHUTINNOTDISCONNECTED (-H) – This end state reflects the well being shut in on the blind shear ram, but the disconnect was not successful, so the rig is still tethered to the well.
- NOTSHUTINDISCONNECTED – This end state captures scenarios where the well has not been shut in but was disconnected or the riser parted. It is only applicable for scenarios where no hydrocarbons are present since similar scenarios with hydrocarbons are propagated to incident management to stop the release.
- NOTSHUTINNOTDISCONNECTED – Similar to the NOTSHUTINDISCONNECTED end state but the disconnect was not successful.
- NOTSHUTIN-NOTDISCONN-NHLMRPDISCONN – Similar to the NOTSHUTINNOTDISCONNECTED end state, but the riser parts. No hydrocarbons are present.
- C&KLEAK - The well is shut in on the blind shear ram, but after the disconnect one or more choke and kill lines do not isolate leaving a leak path.
- C&KLEAKNOT DISCONNECTED - The well is shut in on the blind shear ram, and one or more choke and kill line do not isolate leaving a leak path. The disconnect is not successful.

2.3.4 General Assumptions

There are many assumptions with any PRA. General assumptions that apply to the overall model are provided in this section. Assumptions that apply to specific aspects of the model are provided in the sections of this report where they are discussed (e.g., system assumptions with the system descriptions).

Well

The well is an exploration well located in deep water in the Gulf of Mexico.

The length of time considered for the model from spudding to Total Depth (TD) is 70 days.

Drillship Configuration

Drilling rig configurations and the DPS system that control them can vary widely within the industry. As a result, the DPS and the vessel on which it is installed are modeled based on a "generic" configuration. The system architecture modeled has been established by the system level expert based on considerable experience with Class 3 Mobile Offshore Drilling Units (MODUs) currently in operation.

BOP Configuration

There are any number of hardware configurations used in subsea BOPs. This analysis assumes a "generic" hardware configuration, which in this case includes two Annulars, three Variable Pipe Rams, one Blind Shear Ram (BSR), and one Casing Shear Ram (CSR). The BOP also includes redundant controls (i.e., yellow and blue control pods). Under normal operating conditions, the BOP is operated topside from the drilling rig; however, under emergency conditions when topside control has been compromised, the BOP is assumed to have both deadman and autoshear capabilities.

Well Kicks

All kicks are considered to contain hydrocarbons, and therefore a potential for hydrocarbon release.

Well Control

Two methods are considered for well control, circulating out the kick and bullheading. Failure of both of these methods requires other incident management techniques to stabilize the well.

The modeling of failures related to the ROV intervention was limited to the components considered part of the BOP system. Failures related to the ROV themselves were not modeled, based on the observation that ROV intervention is conducted over a period of days, so there would be a high probability of recovery.

3 PRA MODEL

The first step after establishing the end states of interest is to determine the initiating events that are applicable.

3.1 Initiating Events

This section documents the initiating events that were identified for the deepwater drillship model. The initiating events are shown in the Master Logic Diagram (MLD) in Figure 3-1.

The MLD documents the initiating events that can lead to an excessive pressure differential (delta p) between the wellbore and the formation. The pressure can be either high in the formation or low in the wellbore to induce an influx (kick). It is noted that the pressure differential may also be caused by nonhydrocarbon fluids such as brine in the formation, but the following discussion assumes all events are related to hydrocarbons being present. The structure of the MLD and initiating events (in italics) are described below.

3.1.1 Low bottom hole fluid pressure

The primary barrier for preventing a kick from occurring is the pressure exerted by the column of drilling fluid (mud) in the wellbore. The pressure in the wellbore is maintained at a higher level than that of the formation (i.e., overbalanced), and therefore prevents hydrocarbons from being released into the wellbore. The MLD breaks the influx of hydrocarbons due to low bottom hole pressure down into one operational event and two classes of events:

Swabbing

Swabbing is an operational event that occurs when tripping out. If the tripping is done too fast, it may create a slight vacuum in the wellbore that will temporarily reduce pressure in the well bore resulting on a loss of the bottom hole pressure overbalance and allowing hydrocarbons in the wellbore.

Because tripping out requires that the stands of drillpipe be removed, whenever a connection is broken, the swabbing will stop until the drillpipe is moving out again. With each stand of pipe, a small amount of hydrocarbons may enter the wellbore, assuming the permeability allows it. The hydrocarbons have a lower density than the drilling mud, and therefore, when they combine, the result will be a mud with slightly lower density. If this process continues for enough time, the density of the mud may become low enough that the formation starts to flow without further swabbing being necessary. The lower the differential area between the drilling bottom hole assembly and the borehole, the more likely swabbing will occur.

Underbalanced mud

The pressure at the bottom hole is based on the static head from the mud column along with the dynamic pressure provided by the frictional losses from the mud flow. The static head is based on the mud weight (density). If the mud is statically underbalanced, hydrocarbons may flow into the wellbore when there is a loss of dynamic pressure due to making a connection, mud pump failure, etc. Two initiating events were found to lead to this condition.

Low Equivalent Circulating Density (ECD)

The combination of the static and dynamic pressure from the mud provide the overbalance required to maintain the primary barrier to a potential hydrocarbon release. Wells drilled in the GoM typically have low drilling margins. Drilling margin is the difference between the pore pressure and fracture gradient of the formation. The total pressure exerted by the mud must be between the pore pressure and fracture gradient. With low drilling margins, loss of the dynamic pressure contribution (e.g., when making a connection) may be enough to lose the overbalance and allow the well to flow. Loss of mud flow (i.e., dynamic pressure) can occur if the mud pumps fail or if tripping is occurring since mud flow is stopped for that operation.

Gas cut mud

Drilling mud is specifically made up for a given well condition to provide the necessary overbalance with respect to the pore pressure, but underbalanced with respect to the formation fracture gradient. If gas is present in the formation or cuttings, it can become entrained in the mud and effectively lower its density. This can result in the bottom hole pressure falling below the pore pressure causing the well to flow.

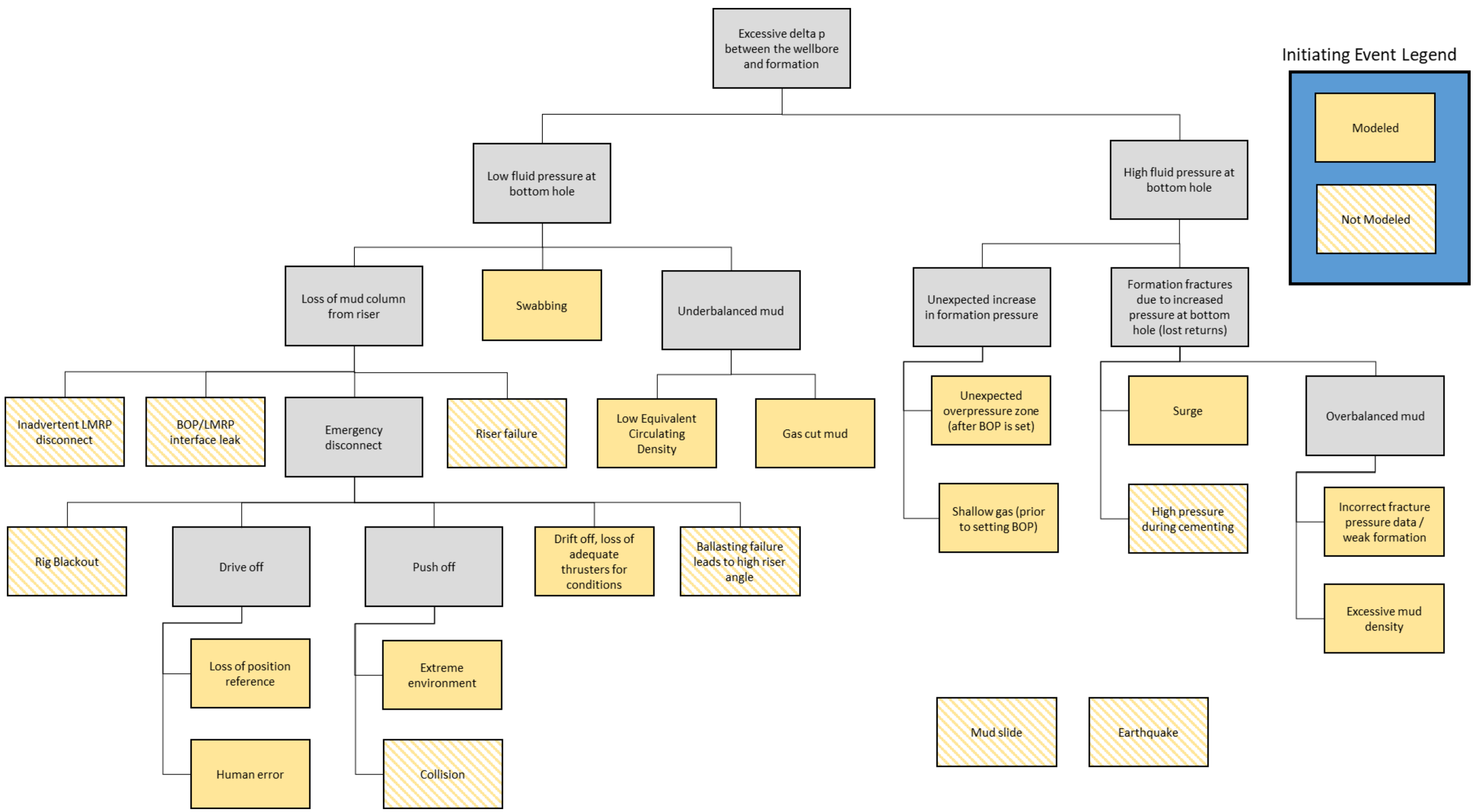


Figure 3-1: Master Logic Diagram

Loss of mud column from riser

The overbalance required to prevent influxes in the wellbore is dependent on the static head provided by the mud column from the wellbore through the riser. The density of the drilling mud is greater than seawater, and therefore any replacement of the mud with seawater would negatively affect the drilling margin and could lead to a kick. Two basic type of events fit into this category, a Lower Marine Riser Package (LMRP) disconnect and a riser/BOP failure/leak. These types of events may occur at any time after the BOP is set and hydrocarbons are not necessarily present, especially if the event occurs prior to reaching the reservoir.

Inadvertent LMRP disconnect

When the LMRP disconnects from the lower stack, the effect is that the mud column is replaced by seawater and overbalance is lost. This creates conditions that could result is a kick. While a disconnect is necessary in emergency conditions, an inadvertent LMRP disconnect in which the well is not properly shut in is a potential hazard. Inadvertent LMRP disconnects can be the result of human error or improper testing/ maintenance.

BOP/LMRP interface leak

A leak in the BOP may result in a loss of static head in the mud column and a corresponding decrease in overbalance. The BOP/LMRP has several interfaces where a leak could occur including the LMRP/lower stack interface and the wellhead connector. As with the disconnect, a leak may occur at any time, but kick may or may not occur depending on the presence of hydrocarbons.

Riser failure

The riser connects the BOP and the rig and consists of many segments. If the riser parts and has a significant loss of drilling mud, the effect is similar to a BOP/LMRP leak on the required overbalance. One significant difference, however, is that a parted riser could result in a loss of hydraulic and electrical communication between the rig and the BOP. If downhole communications and control are lost, a deadman system will be activated that will shut in the well. Potential causes of riser failure include stress, overpressure, fatigue, or dropped objects.

Emergency disconnect

Emergency disconnects have the same effect as an inadvertent LMRP disconnect, but are required to prevent other severe consequences. There are several conditions that may require an emergency disconnect discussed below.

Drift-off, loss of adequate thrusters for conditions

The DPS and thrusters are designed so that no single failure will result in a loss of stationkeeping capability for expected environmental conditions (for a Dynamic Positioning Class 3 drillship). Severe events such as a rig blackout or partial blackout, however, may go beyond the normal design criteria. This initiating event is really a set of conditions based on the DPS/thruster design coupled with environmental conditions. Failure of multiple thrusters, in specific locations, along with environmental conditions may result in an emergency disconnect if the red watch circle is reached.

Ballasting failure leads to high riser angle

To prevent damage to the BOP and well, the drillpipe, and therefore riser, must be maintained within a few degrees of vertical. A failure in ballasting can lead to a riser angle that would require an emergency disconnect to prevent damage. This event is the only emergency disconnect considered as an initiator that is *not* due to a loss of position, and is not currently in the model.

Rig Blackout

A loss of all rig electrical power due to equipment failure or other events such as fire/explosion would result in a deadman condition that should lead to an emergency disconnect whether or not there is a loss of station keeping. Uninterruptable power supplies and hydraulic accumulators would power the emergency disconnect sequence.

Drive-off

Drive-off scenarios involve the rig being powered by thrusters and attempting to move to a location in or outside the red area of the DPS watch circle. Drive-off scenarios are potentially more severe than other emergency disconnects since the rig velocity can be significantly higher than in other cases. These scenarios require a fast response, and would provide greater stresses on the riser if the disconnect did not occur; they also provide little or no time for the driller to space out the drillpipe.

Loss of position reference

Equipment failure is a potential cause for a drive-off event. The typical DPS system has multiple sensors to provide feedback to the DPS computers on the current position of the vessel and environmental conditions that could impact the station keeping capability of the vessel. The typical sensors for DPS include Global Positioning System (GPS) antennas, hydroacoustic position reference sensors, and wind sensors, all of which have redundancy. A failure of the DPS to know where the rig is, or erroneous environmental inputs can cause the DPS to move the rig to a location in or beyond the red watch circle.

Human error

Besides equipment failure, human error may also result in a drive-off scenario. In situations such as an approaching squall or storm or when operations directly above the BOP are not advisable, the Dynamic Positioning Operator (DPO) will enter an offset to compensate for the expected conditions. If the offset is incorrectly entered, it may result in a move that is on or outside the red watch circle.

Push-off

Push-off is when the rig is moved by external forces, and may result in reaching the red watch circle, therefore requiring an emergency disconnect. For this model, two types of events have been labeled as push-off and are discussed below.

Extreme environment

Extreme environmental conditions may cause a push-off event leading to an emergency disconnect. For this analysis, a push-off has been defined as one where all thruster capabilities are available and operating, but the conditions are so extreme that the DPS cannot adequately compensate and keep the rig on station. Because of the design of the current fleet of rigs, the type of conditions required would be a rare event.

Collision

The second event labeled as a push-off is a collision with another vessel. The size of a drillship or any deepwater rig is substantial, and the colliding vessel would have to be sizeable itself and not a routine tender for the collision to result in a significant displacement of the rig. Rigs are not typically put in shipping lanes and therefore this is considered a very low probability event and not in the current model scope.

3.1.2 High fluid pressure at bottom hole

An unexpectedly high pore pressure may also be the cause of a well kick. On the formation side, a higher than expected formation pressure can result in an underbalanced condition and influx. On the other hand, a high pressure in the wellbore may cause some of the drilling mud to enter the formation. These losses will reduce the static head, which in turn can result in an underbalanced condition leading to a kick. The structure of the MLD breaks this condition down into three classes of events:

Unexpected increase in formation pressure

With exploration wells, the geology is known only from seismic surveys and more uncertainty exists in areas that have not yet been drilled yet. If an area with high pressure is encountered while drilling, a well kick may occur.

Unexpected overpressure zone (after BOP is set)

This initiating event is as discussed above with the specification that the BOP is on the wellhead. This initiator assumes liquid and/or gas is present, and the BOP is required to prevent a significant release to the environment.

Shallow gas (prior to setting BOP)

Similar to the unexpected overpressure zone without the BOP in place, so the True Vertical Depth (TVD) of the well is relatively shallow and well before any significant hydrocarbons are expected. In this case smaller pockets of gas can occur in deepwater, and are released directly to the environment. Because these are relatively small in deepwater in the GoM, the gas is typically dispersed and not a major environmental concern.

Formation fractures due to increased pressure at bottom hole (lost returns)

If the wellbore pressure exceeds the fracture gradient, the formation can fracture and allow drilling fluid to enter the formation. This will result in drilling fluid losses and in the worst case there can be a total loss of returns. If losses occur, a reduction in the static head may occur with an accompanying underbalanced condition leading to a kick.

Surge

Surge is analogous to the swabbing phenomenon in reverse. When tripping in drillpipe, or running casing, a small differential area between the drilling bottom hole assembly or casing string and the borehole wall can lead to a pressure increase and losses if the string is lowered too fast.

High pressure during cementing

High pressure during cementing was identified as a potential initiator but has not been included in the model at this time.

Overbalanced mud

This type of event is the opposite of underbalanced mud. The ECD must remain under the fracture gradient to prevent fracturing the formation and losses of drilling fluid because an excessive static head from the mud could cause an overbalanced condition leading to losses.

Incorrect fracture pressure data / weak formation

The uncertainty in the formation characteristics for an exploration well can lead to the fracture gradient being overestimated. With the relatively small drilling margins seen in the GoM, overestimating the fracture gradient may lead to damaging the formation and losing drilling fluid. A kick can result, or in the worst case an underground blowout.

Excessive mud density

This is the opposite of the underbalanced static head to the point where the excessive mud density causes losses to the formation and eventually results in a kick or, similar to the incorrect fracture pressure data, in the worst case an underground blowout.

Other

Two external events on the MLD, mud slides and earthquakes, were listed as they can affect the well or wellhead integrity. Because of the uncertainty on the specific effects of these events, they have not been developed in the model at this time.

3.1.3 Applicability of Initiators by Drilling Phase

Exploration drilling consists of many phases from initially spudding the well to running and cementing casing after drilling. In addition, the probability that hydrocarbons will be present at a given location varies between wells, so initiating events must be developed in a way that takes these dependencies into account.

Figure 3-2 shows how an exploration well was broken down as a function of time and processes, and initiating events were then assigned as to their applicability. The breakdown consists of three main phases of well development, running the surface casing, running the intermediate casing/liners, and drilling into the reservoir. Each of these are discussed below as they relate to initiating events.

Surface casing

The first phase of a well after arriving on location is spudding the well and running the surface casing. This phase starts with the DPS maintaining position, and the initial borehole is started by drilling or jetting with no BOP in place. Surface conductor and surface casing is run and cemented in place along with the wellhead.

Because in this phase of operations the rig must remain on station over the wellbore, all loss of position initiators (drive-off, drift-off, push-off) are applicable. While any of these initiators is potentially severe in consequences for the well, the potential for a kick due to a loss of the mud column does not exist since the

BOP is not yet set. The only other initiating event applicable during this stage is drilling into an overpressure zone with shallow gas. In deepwater, shallow gas is not as much a concern since it will be dispersed significantly by the time it reaches the surface. It is more of a concern for shallow water where it can affect the buoyancy or anchoring of the rig. Shallow water flows can also occur and be hazardous, but this study only evaluates the risk of hydrocarbon releases.

Intermediate casing

The next phase of a well is running the intermediate casing. This phase starts when the BOP is set and the riser maintains the mud column to provide the necessary overbalance. Based on the well design, several strings of intermediate casing or liners may be required. For each well segment, the well is drilled to the proper depth, casing or liner is run, and cementing is performed for each casing/liner.

Overall, for this phase, all initiating events are applicable, although swabbing and surge are applicable only when running casing or tripping in/out of the borehole. Because this area of the well is generally above the reservoir, hydrocarbons are not expected, but can occur. The frequency for a hydrocarbon kick in this area should be less than that in the reservoir.

Production zone

The last well segment considered is the production zone. This is the area where hydrocarbons are expected and essentially all initiating events are applicable. The model is defined only until the Total Depth in production zone is reached; it does consider the running of the production string. Without considering the production casing, any high pressure induced during cementing and surge while running the production casing is considered out of scope for the exploration well.

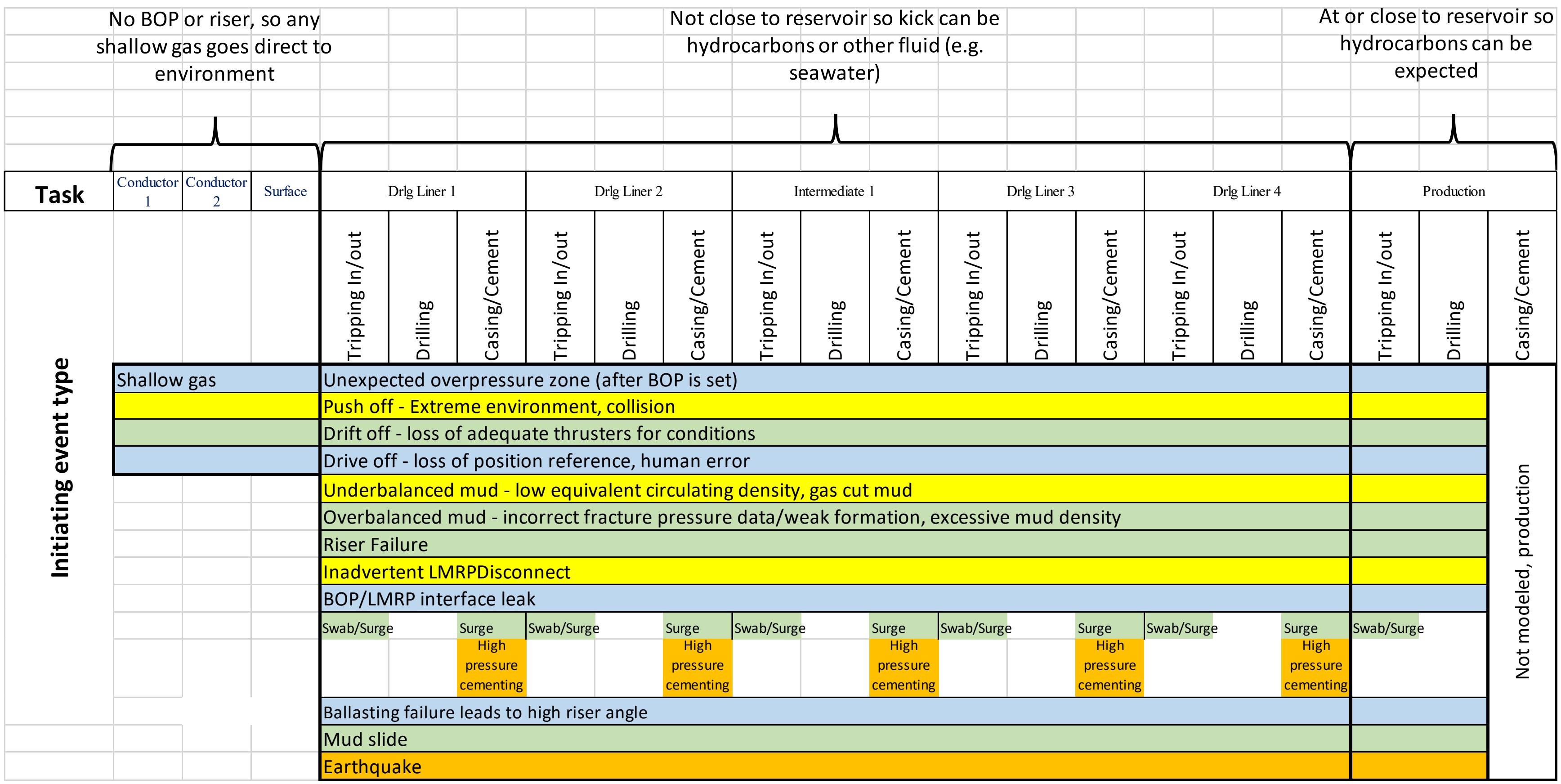


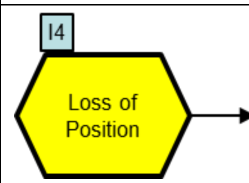
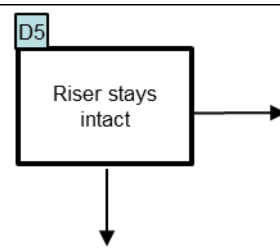
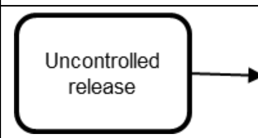
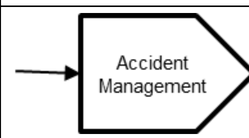
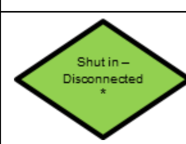
Figure 3-2: Applicability of Initiating Events During Various Drilling Phases

3.2 Event Sequence Diagrams

Based on the initiating events identified in the previous section, event sequence diagrams were developed to understand the accident sequence progression from the initiating event to hydrocarbon releases. Initiating events were first broken into their two main causes, a well kick during normal well operations and a well kick caused by a loss of the mud column, primarily due to a loss of position. Because early discussions found that the type of well operation occurring when the kick occurred mattered from a response perspective, well operations were broken into three categories, drilling, running casing, and nothing across the BOP. Event sequence diagrams were created for the loss of position and the three types of well operations, and they are discussed in the following subsections.

The Event Sequence Diagrams (ESD) are essentially flowcharts. The blocks shown in the ESDs are described in Table 3-1 below:

Table 3-1: Event Sequence Diagram Legend

Block Description	Block Example
Initiating events are indicated with a yellow hexagonal block. These are used to start the ESDs. The blue box on the top left is an identifier used to associate with a write-up in the appropriate section(s) describing the ESD.	
Actions are identified with a rectangular block. These actions are considered critical to the outcome of scenarios and may be either equipment based or human based. These blocks will always have two paths, the one to the right indicates success of the block and the down path indicates failure.	
Additional information is shown in rounded rectangular blocks. These may be just a status or other information to help clarify the scenario.	
"Transfer out" events are shown in pentagonal blocks. They are used to indicate a continuation of the scenario on another ESD with the name of the continuation ESD shown in the block. These blocks will only have a single arrow entering the block.	
"Transfer in" events are shown in pentagonal blocks. They are used to indicate the entry point from a continuation of the scenario on another ESD with the name of the previous ESD shown in the block. These blocks will only have a single arrow leaving the block	
Diamond shaped blocks are used for end states. The end state is shown in the block and the color indicates whether the scenario ended in a stable state (green), an abnormal state (but no release) (orange), or an environmental release (red).	

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3.2.1 Well Kick While Drilling ESD

Drilling is the most time consuming part of constructing a well, and a large percentage of kicks occur with drillpipe across the BOP. This ESD (Figure 3-3) starts with a kick while drilling or at least drillpipe present across the BOP. The drilling function in the context of this ESD includes tripping in/out when kicks may occur from swabbing or low static head when making a connection.

I1 Well Kick while drilling

This initiating event captures all of the assumed kick frequencies that can occur while drilling.

A1 Kick detected prior to reaching BOP

Given that a kick has occurred, the first required action is to detect it. The driller has primary responsibility for this and has several variables, i.e., return flow, pit volume that can be monitored to indicate a kick has occurred. In addition, the detection must occur prior to the formation fluid reaching the BOP, otherwise hydrocarbons could reach the rig floor and be a potential hazard for the crew. Kicks have various causes, and environments vary from well to well, so each kick is unique and may have a different level of detectability. For this model, no distinction is made on the kick intensity. This event models the probability that the driller recognizes the kick before it reaches the BOP and takes appropriate actions, including stopping drillpipe rotation (if drilling), stopping the mud pumps, and closing the annular or pipe rams.

If the driller fails to recognize the kick on time, formation fluid would get past the BOP and a potentially hazardous situation can occur on the rig floor. In such a case, the model assumes that the crew will initiate an emergency disconnect as soon as they recognize the situation.

A2 Close annular preventer or pipe ram to seal annulus

Once the kick has been detected, it is necessary to shut in the well to preclude a hydrocarbon release. There are generally several options for performing this task. The first is typically to shut in the well using an annular preventer. On many BOPs there are redundant annular preventers (upper and lower), and only one is required to seal the annulus. The annulars typically have a lower pressure rating than the rams, so depending on the shut-in pressure, they may not be effective at shutting in the well. In addition to the annulars, a pipe ram may be used, and they are also redundant with many BOPs having three. The pipe rams generally have a higher pressure rating than the annulars. Should the annulars or pipe rams fail due to a control system failure, the driller may switch from the selected control pod to the redundant pod. The human action to identify the failure and make the switch is included in this event. Failure to successfully perform this task may result in formation fluid getting past the BOP, and will require more drastic means of well control, i.e., shearing the drill string.

A3 Float valve or Internal Blowout Preventer (IBOP) seal drill string

If the annulus has been shut in, there still exists a possibility that the formation fluid could enter the drillpipe and result in a hydrocarbon release. For this reason, a float valve is included in the drill string, which essentially acts like a check valve to prevent back flow. A second means of preventing backflow is using the IBOP. This is a valve not normally attached to the drill string, but available on the drill floor. It can be manually installed if a kick is encountered. For this analysis, it is assumed that the float valve is installed and a human action is required to install the IBOP.

If the path up the drillpipe is not closed, the drillpipe must be sheared and the blind shear ram is required to seal the well.

If the annulus is sealed and there is no backflow through the drillpipe, a normal well kill operation can begin. In this case, a drillpipe is still across the BOP, and can therefore be used to circulate out the kick.

A4 Close Casing Shear Ram

Failure to seal the annulus with the annular preventers or pipe rams will potentially result in a hydrocarbon release after a kick has occurred. If it is not possible to shut in the well with those means, the blind shear ram must be used. Prior to closing the blind shear ram, the casing shear ram may be activated. Most BOP stacks have this second shear ram, and its purpose is only to shear and is not designed to seal the well. Its shearing force is greater than that of the blind shear ram, and therefore has a higher chance of successfully cutting through any tubular present. Operating the casing shear before the blind shear increases the chance that the drillpipe will be cut and the blind shear ram is more reliable sealing the well on an open hole. There is no requirement that the casing shear be used prior to the blind shear during manual actuations, and different operators have different strategies, but for this analysis it is assumed that the casing shear is activated first. The casing shear is assumed to be able to sever all but drillpipe tool joints and casing couplings.

A5 Close Blind Shear Ram

The blind shear ram is required for shutting in the well when other methods have failed. In this model, the blind shear ram is attempted after the casing shear ram has been activated since the probability of success is conditional on whether there is a drillpipe across the BOP. Having a drillpipe across the BOP greatly reduces the chances of the blind shear ram sealing the well, so the outcome of the casing shear activation is required to be known before a probability can be assigned.

If the blind shear ram is successful, the well is shut in and the well kill process can begin. In this case, the drillpipe has been sheared and may have fallen into the wellbore, so the kill process can be more difficult.

If the blind shear ram fails to seal the well, formation fluid will potentially reach the drill floor and create a personnel hazard. The model assumes that under these circumstances an emergency disconnect is required. The diverter (not modeled) is in place to provide time for the crew to evacuate if needed. An environmental release will occur.

A6 Initiate Emergency Disconnect

If formation fluid is flowing past the BOP, an imminent hazard to the crew exists. An emergency disconnect is required to minimize the hazard to the crew and also provides another attempt to activate the shear rams through a diverse control logic separate from the manual activation. Initiation of an emergency disconnect is a very significant and costly event, and the human action to initiate it is modeled separately because of its importance.

If the emergency disconnect is initiated, the signal is sent to the BOP and a sequence of events occurs in order to safely shut the BOP and seal the well. Once this is complete, the LMRP is disconnected from the BOP stack and the rig floats freely with no more communication with the well. Once the disconnect occurs, the autoshear function will occur and attempt to close the shear rams if they has not previously closed.

The BOP is normally aligned to either the blue or yellow pod for control. In response to a kick, a failure in the control system may be remedied by switching from the blue to the yellow pod, or vice versa. In a disconnect sequence, there is generally not time to diagnose a failure and switch pod control, so the redundant controls are not credited in this analysis for the disconnect.

A failure to initiate the emergency disconnect is assumed to result in hydrocarbons reaching the drill floor. Once this occurs, a fire/explosion can occur and it is assumed that the scenario becomes more of an incident management than a normal shut in and well kill process.

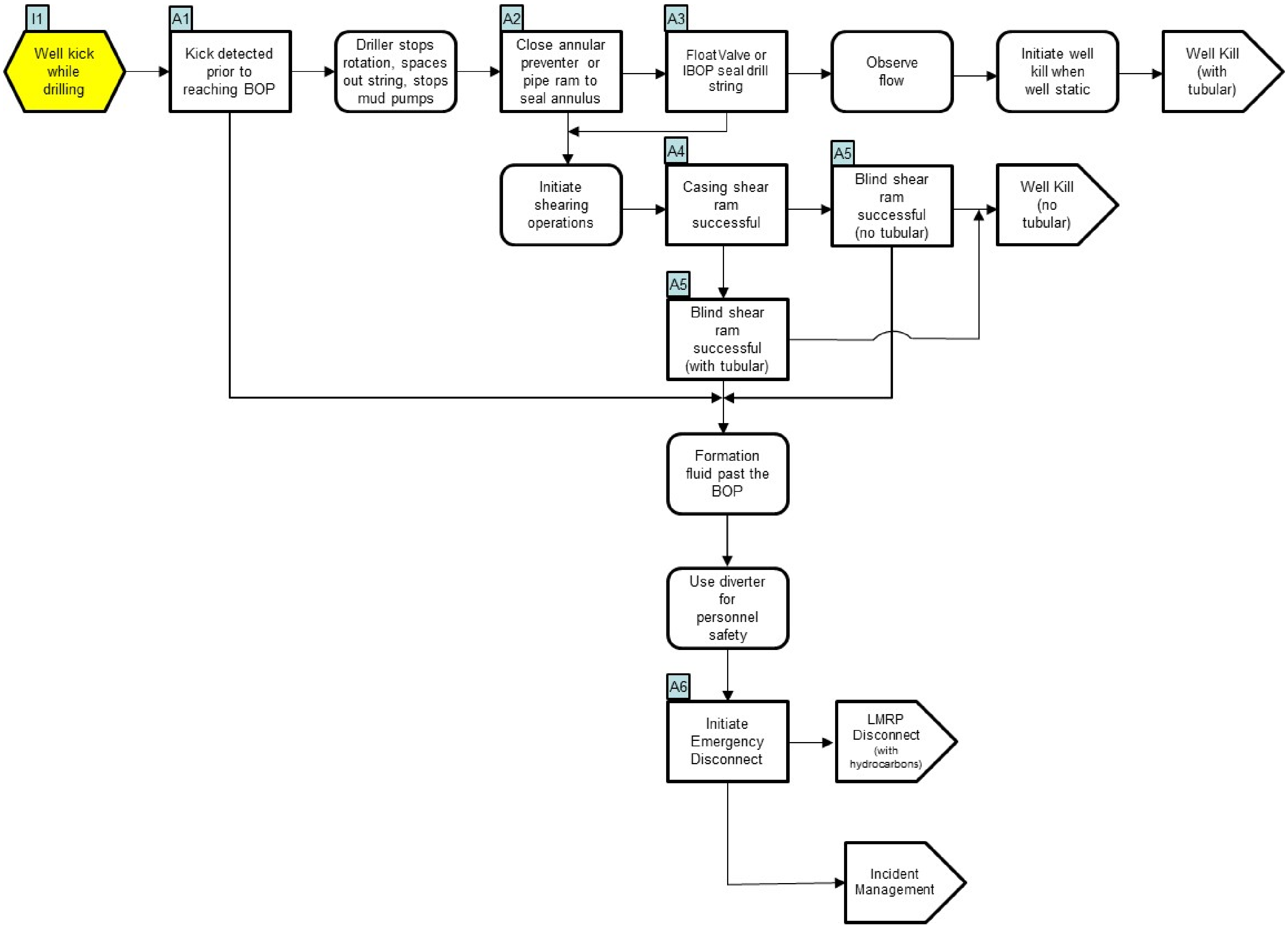

Figure 3-3: Well Kick While Drilling

3.2.2 Well Kick While Running Casing ESD

After drilling each well interval, casing is cemented in place before the next interval is drilled. When casing is across the BOP, the casing shear is generally the only shear ram that can shear casing. Some blind shear rams may be able to shear smaller production interval casing, but no credit is taken for that. The ESD (Figure 3-4) accounts for the requirement of the casing shear working if casing is across the BOP. While running casing, depending on the casing length, either the casing or the drillpipe used to run the casing will be across the BOP. The ESD applies to only when casing is across the BOP.

I2 Well kick while running casing

This initiating event captures all of the assumed kick frequencies that can occur while running casing.

A1 Kick detected prior to reaching BOP

Given that a kick has occurred, the first required action is to detect it. The driller has primary responsibility for this and has several variables, i.e., return flow, pit volume that can be monitored to indicate a kick has occurred. In addition, the detection must occur prior to the formation fluid reaching the BOP, otherwise hydrocarbons could reach the rig floor and be a potential hazard for the crew. Kicks have various causes, and environments vary from well to well, so each kick is unique and may have a different level of detectability. For this model, no distinction is made on the kick intensity. This event models the probability that the driller recognizes the kick before it reaches the BOP and takes appropriate actions including closing the annulars.

If the formation fluid gets past the BOP before the well is shut in, a potentially hazardous situation can occur on the rig floor. The diverter (not modeled) will reroute any hydrocarbon flow overboard providing time for an orderly evacuation. An emergency disconnect is assumed to be required in this scenario.

A7 Close annular preventer to seal annulus

Once the kick has been detected, it is necessary to shut in the well to preclude a hydrocarbon release. The first action is typically to shut in the well using an annular preventer. On many BOPs there are redundant annular preventers (upper and lower), and only one is required to seal the annulus. The annulars typically have a lower pressure rating than the rams, so depending on the shut in pressure, they may not be effective at shutting in the well, however they can shut in on any tubular or an open hole. In addition to the annulars, a pipe ram may be used if its design has a variable bore. This is not assumed to be the case for this model, so only the annulars are assumed to be capable of shutting in the well while running casing. Should the annular fail due to control system failure, the driller may switch from the selected control pod to the redundant pod. The human action to identify the failure and make the switch is included in this event. Failure to successfully perform this task will result in formation fluid getting past the BOP and will require more drastic means of well control, i.e., shearing the drill string.

A8 Casing shoe float valve prevents backflow

If the annulus has been shut in, there still exists a possibility that the formation fluid could enter the casing string and result in a hydrocarbon release. For this reason, a float valve is included in the casing shoe, and essentially acts like a check valve to prevent back flow.

If the path up the casing string is not closed, the casing must be sheared with the casing shear, and the blind shear ram is required to seal the well.

If the annulus is sealed and there is no backflow through the casing string, a normal well kill operation can begin.

A4 Close Casing shear ram

Failure to seal the annulus with the annular preventers will potentially result in a hydrocarbon release after a kick has occurred. If it is not possible to shut in the well with the annulars, the blind shear ram must be used. Prior to closing the blind shear ram, when casing is across the BOP, the casing shear ram must be activated. It is the only shear ram capable of cutting casing. The casing shear is assumed to be able to sever all but drillpipe tool joints and casing couplings.

If the casing shear ram is successful, the blind shear ram is activated to seal the well. If the casing shear ram is not successful, formation fluid will potentially reach the drill floor and create a personnel hazard. The diverter (not modeled) is in place to provide time for the crew to evacuate if needed, and an emergency disconnect is required.

A5 Close Blind shear ram

The blind shear ram is required for shutting in the well when other methods have failed. In this model, the blind shear ram is attempted after the casing shear ram has been successfully activated since the probability of success is conditional on whether there is casing across the BOP. If the casing is not sheared, the blind shear ram is assumed to be unsuccessful.

If the blind shear ram is successful, the well is shut in and the well kill process can begin. In this case, the casing has been sheared and fallen into the wellbore, so the kill process can be more difficult.

If the blind shear ram fails to seal the well, formation fluid will potentially reach the drill floor and create a personnel hazard. The diverter (not modeled) is in place to provide time for the crew to evacuate if needed, and an emergency disconnect is required.

A6 Initiate Emergency Disconnect

If formation fluid is flowing past the BOP, an imminent hazard to the crew exists. An emergency disconnect is required to minimize the hazard to the crew and also provides another attempt to activate the shear rams through a diverse control logic separate from the manual activation. Initiation of an emergency disconnect is a very significant and costly event, and the human action to initiate it is modeled separately because of its importance.

If the emergency disconnect is initiated, the signal is sent to the BOP and a sequence of events occurs in order to safely shut the BOP and seal the well. Once this is complete, the LMRP is disconnected from the BOP stack and the rig floats freely with no more communication with the well. Once the disconnect occurs, the autoshear function will occur and attempt to close the shear rams if they has not previously closed.

The BOP is normally aligned to either the blue or yellow pod for control. In response to a kick, a failure in the control system may be remedied by switching from the blue to the yellow pod, or vice versa. In a disconnect sequence, there is generally not time to diagnose a failure and switch pod control, so the redundant controls are not credited in this analysis for the disconnect.

A failure to initiate the emergency disconnect is assumed to result in hydrocarbons reaching the drill floor. Once this occurs, a fire/explosion can occur and it is assumed that the scenario becomes more of an incident management than a normal shut in and well kill process.

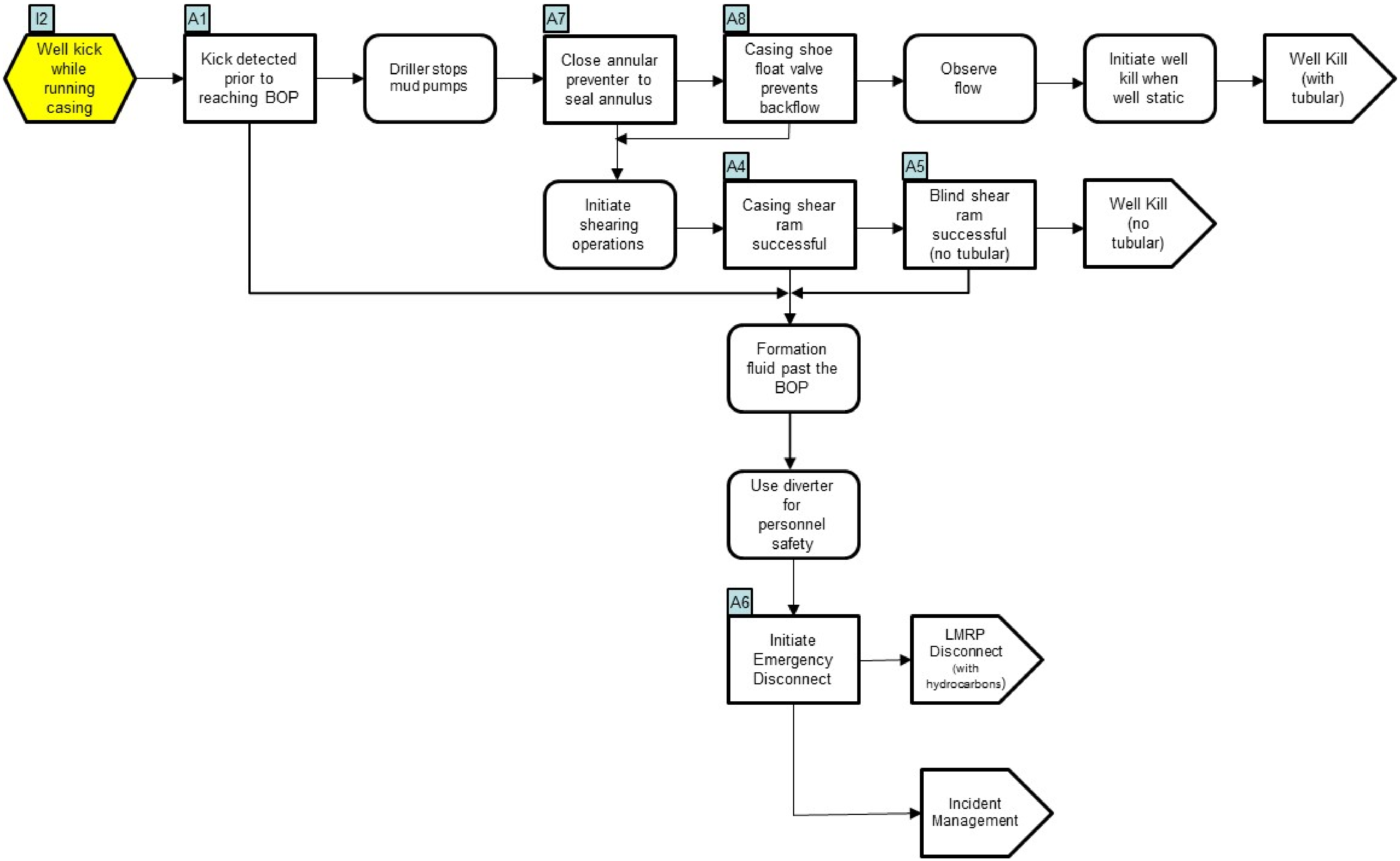

Figure 3-4: Well Kick While Running Casing

3.2.3 Well Kick With Nothing Across the BOP ESD

There are times when no tubulars are across the BOP. In these cases there is limited capability to shut in the well as the pipe rams will not seal an open hole and the CSR does not have sealing capabilities. The ESD (Figure 3-5) only credits the annulars and the blind shear ram with being able to shut in the well.

I3 Well kick with nothing across the BOP

This initiating event captures all of the assumed kick frequencies that can occur when nothing is across the BOP.

A1 Kick detected prior to reaching BOP

Given that a kick has occurred, the first required action is to detect it. The driller has primary responsibility for this and has several variables, i.e., return flow, pit volume that can be monitored to indicate a kick has occurred. In addition, the detection must occur prior to the formation fluid reaching the BOP, otherwise hydrocarbons could reach the rig floor and be a potential hazard for the crew. Kicks have various causes, and environments vary from well to well, so each kick is unique and may have a different level of detectability. For this model, no distinction is made on the kick intensity. This event models the probability that the driller recognizes the kick before it reaches the BOP and takes appropriate first action closing the annulars.

If the formation fluid gets past the BOP before the well is shut in, a potentially hazardous situation can occur on the rig floor. The diverter (not modeled) will reroute any hydrocarbon flow overboard providing time for an orderly evacuation. An emergency disconnect is assumed to be required in this scenario.

A7 Close annular preventer to seal annulus

Once the kick has been detected, it is necessary to shut in the well to preclude a hydrocarbon release. When nothing is across the BOP, the only stack component other than the blind shear ram able to shut in the well is an annular preventer. On many BOPs there are redundant annular preventers (upper and lower), and only one is required to seal the annulus. The annulars typically have a lower pressure rating than the rams, so depending on the shut in pressure, they may not be effective at shutting in the well, however they can shut in on any tubular or an open hole. Should the annular fail due to control system failure, the driller may switch from the selected control pod to the redundant pod. The human action to identify the failure and make the switch is included in this event. Failure to successfully perform this task will result in formation fluid getting past the BOP and will require the blind shear ram to be closed.

A5 Close Blind shear ram

The blind shear ram is required for shutting in the well when other methods have failed. In this model, the blind shear ram is normally attempted after the casing shear ram has been successfully activated. However, for the scenario when nothing is across the BOP, the casing shear does not provide a necessary function since there is no tubular to shear, and therefore not included.

If the blind shear ram is successful, the well is shut in and the well kill process can begin with nothing across the BOP.

If the blind shear ram fails to seal the well, formation fluid will potentially reach the drill floor and create a personnel hazard. The diverter (not modeled) is in place to provide time for the crew to evacuate if needed, and an emergency disconnect is required.

A6 Initiate Emergency Disconnect

If formation fluid is flowing past the BOP, an imminent hazard to the crew exists. An emergency disconnect is required to minimize the hazard to the crew and also provides another attempt to activate the shear rams through a diverse control logic separate from the manual activation. Initiation of an emergency disconnect is a very significant and costly event, and the human action to initiate it is modeled separately because of its importance.

If the emergency disconnect is initiated, the signal is sent to the BOP and a sequence of events occurs in order to safely shut the BOP and seal the well. Once this is complete, the LMRP is disconnected from the BOP stack and the rig floats freely with no more communication with the well. Once the disconnect occurs, the autoshear function will occur and attempt to close the shear rams if they has not previously closed.

The BOP is normally aligned to either the blue or yellow pod for control. In response to a kick, a failure in the control system may be remedied by switching from the blue to the yellow pod, or vice versa. In a disconnect sequence, there is generally not time to diagnose a failure and switch pod control, so the redundant controls are not credited in this analysis for the disconnect.

A failure to initiate the emergency disconnect is assumed to result in hydrocarbons reaching the drill floor. Once this occurs, a fire/explosion can occur and it is assumed that the scenario becomes more of an incident management than a normal shut in and well kill process.

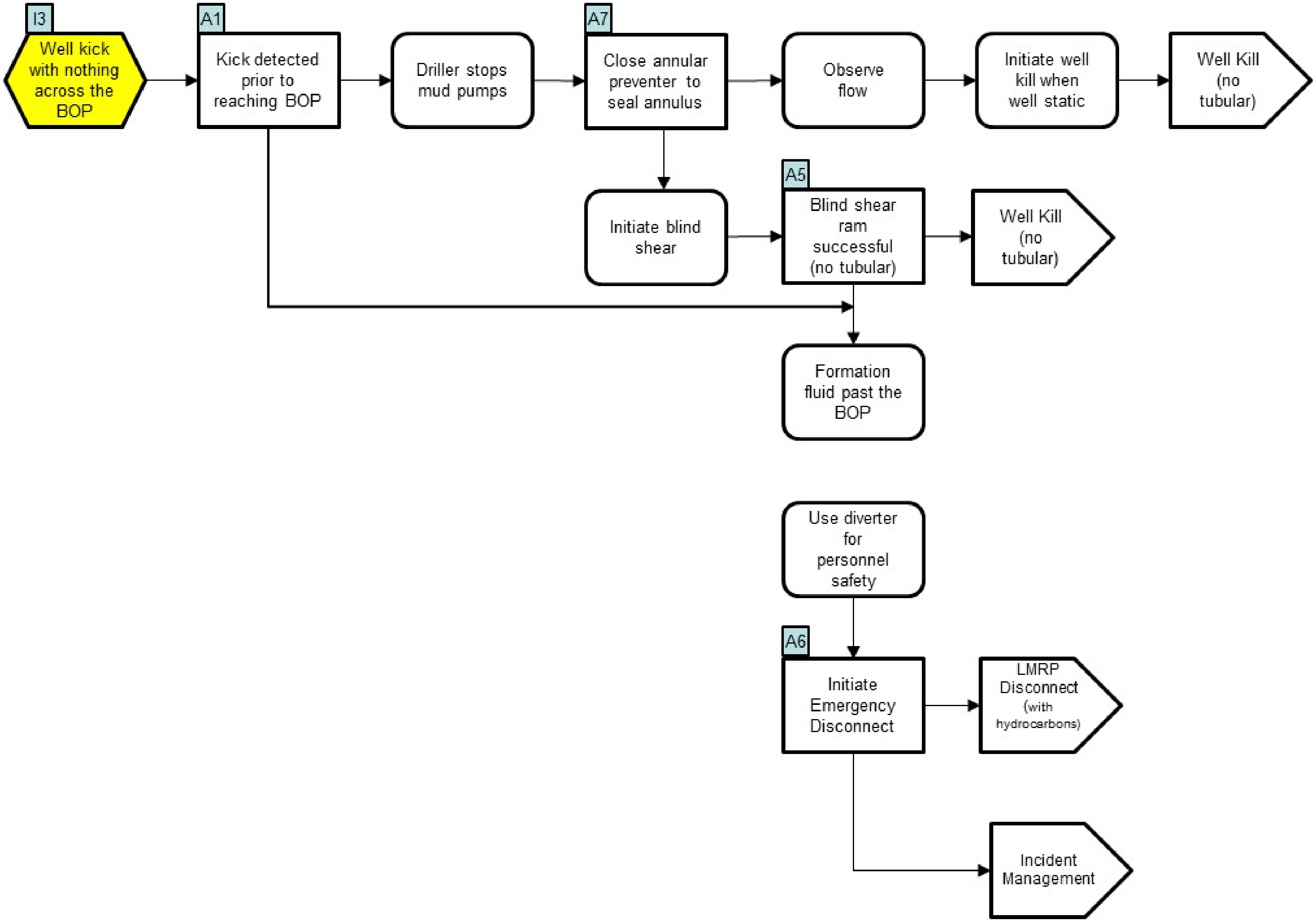

Figure 3-5: Well Kick With Nothing Across the BOP

3.2.4 Well Kill ESD

Once a kick has occurred and the well has been shut in, the well must be killed to reach a stable condition. This ESD (Figure 3-6) is entered as a transfer from the kick ESDs after the well has been successfully shut in. Each kick is unique and may be approached differently to kill the well, but the two main methods normally used are to circulate the kick out through the choke line with the drillpipe at the bottom, or bullheading and forcing the kick back into the formation with high pressure and flow. This ESD does not apply to rigs that have been disconnected from the well. A well is considered stable if the well kill has been successful.

K1 Maintain Position During Well Kill

Killing a well may take a few hours, a few days, or even more than a week. During this time, the rig must maintain position to stabilize the well. This event is essentially the same as the loss of position initiating event; however, it applies only to the well kick initiating event sequences, and the mission time to keep position is the time to kill the well rather than the time to drill the well.

As long as position is maintained, killing the well will continue. Should position be lost, the sequences will proceed like a loss of position event. One difference is that a loss of position initiating event may or may not result in a hydrocarbon release depending on whether hydrocarbons are present at the time. In the well kill sequences, hydrocarbons are, by definition, present since the sequences are a response to a kick.

K2 Strip in Drillpipe

The optimal way to perform most well kills is to have drillpipe at the bottom and circulate the kick out through the choke system. If pipe is not across the BOP, drillpipe can be stripped in through the annular, or if necessary using the pipe rams.

If stripping in pipe is successful (when pipe was not already present), the well kill can proceed with circulating the kick out bottoms up. If stripping in pipe is unsuccessful, then bullheading is assumed to be performed through the kill line.

K3 Choke & Kill Lines Maintain Backpressure

With the well shut in with the annular or pipe rams, the choke line provides the means to circulate out the kick and increase the mud weight. Circulation down the drillpipe and up the choke line also maintains the appropriate backpressure on the well which will stop the well from flowing and maintain the integrity of the formation.

A pressure below the pore pressure will allow the well to start flowing again, while too high a backpressure may result in damage to the formation and an underground blowout. Success of the choke & kill system along with the ability to circulate out the kick bottoms up is assumed to result in a stable well. Failure to maintain the appropriate backpressure is assumed to result in a need to shut in the well with the blind shear ram.

A4 Close Casing shear ram

If well pressure cannot be maintained appropriately, uncontrolled flow may occur or significant damage to the formation may occur. It is assumed, at this point, that shutting in the well with the blind shear ram would be appropriate. Prior to closing the blind shear ram, the casing shear ram is generally activated if there is pipe across the BOP. The casing shear is assumed to be able to sever all but drillpipe tool joints and casing couplings.

If the casing shear ram is successful, the blind shear is activated to seal the well. If the casing shear ram is not successful, the blind shear ram will have a higher probability of failure if a pipe is present.

A5 Close Blind shear ram

The blind shear ram is required for shutting in the well when other methods have failed. In this model, the blind shear ram is attempted after the casing shear ram has been activated since the probability of success is conditional on whether there is pipe across the BOP. If the pipe is not sheared, or a tool joint is present, the blind shear ram is assumed to not be successful.

If the blind shear ram is successful at this point in the scenario, bullheading is still possible to kill the well.

If the blind shear ram fails to seal the well, formation fluid will potentially reach the drill floor and create a personnel hazard. The diverter (not modeled) is in place to provide time for the crew to evacuate the rig if needed, and an emergency disconnect is required.

K4 Kill the Well by Bullheading

If circulating the kick out bottoms up is not possible because drillpipe is not present, bullheading may be used to kill the well. Bullheading is forcibly pumping mud into the well so the kick will be forced back into the formation. This is inherently risky as it can lead to a breakdown of the formation and an underground blowout. However, if bullheading is successful, the well is killed and in a stable condition.

A6 Initiate Emergency Disconnect

If control of the well is lost during well kill procedures, an imminent hazard to the crew exists. An emergency disconnect is required to minimize the hazard to the crew and to attempt to activate the shear rams through a diverse control logic separate from the manual activation. Initiation of an emergency disconnect is a very significant and costly event, and the human action to initiate an Emergency Disconnect Sequence (EDSS) is modeled separately because of its importance.

If the emergency disconnect is initiated, the signal is sent to the BOP and a sequence of events occurs in order to safely shut the BOP and seal the well. Once this is complete, the LMRP is disconnected from the BOP stack and the rig floats freely with no more communication with the well. Once the LMRP lifts off the stack, the autoshear function will occur and attempt to close the shear rams if they have not previously closed.

The BOP is normally aligned to either the blue or yellow pod for control. In response to a kick, a failure in the control system may be remedied by switch from the blue to the yellow pod, or vice versa. In a disconnect sequence, there is generally not time to diagnose a failure and switching pod control, so the redundant controls are not credited in this analysis for the disconnect.

A failure to initiate the emergency disconnect is assumed to result in hydrocarbons reaching the drill floor. Once this occurs, a fire/explosion can occur and it is assumed that the scenario becomes more of an incident management than a normal shut in and well kill process.

D3 Riser Stays Intact

Should the LMRP fail to disconnect, the riser will experience forces that may challenge the riser structural capability if the rig has moved into the red watch circle. During well kill, a loss of position failure will challenge the structure, but if the ED is due to well conditions, the red watch circle may not be violated with stationkeeping capability intact. If the riser stays intact, including the electrical and hydraulic connections, the deadman/autoshear function will not occur and the BOP will remain in its current state. If the blind shear ram has failed to close through the normal EDS, it will remain open, and if hydrocarbons are present, will have an extended release and these sequences proceed to the incident management ESD.

If the riser parts, including the electrical and hydraulic connections, the deadman function will be triggered and attempt to close the shear rams if they are not already closed. The sequences with the riser parting transfer to the deadman ESD.

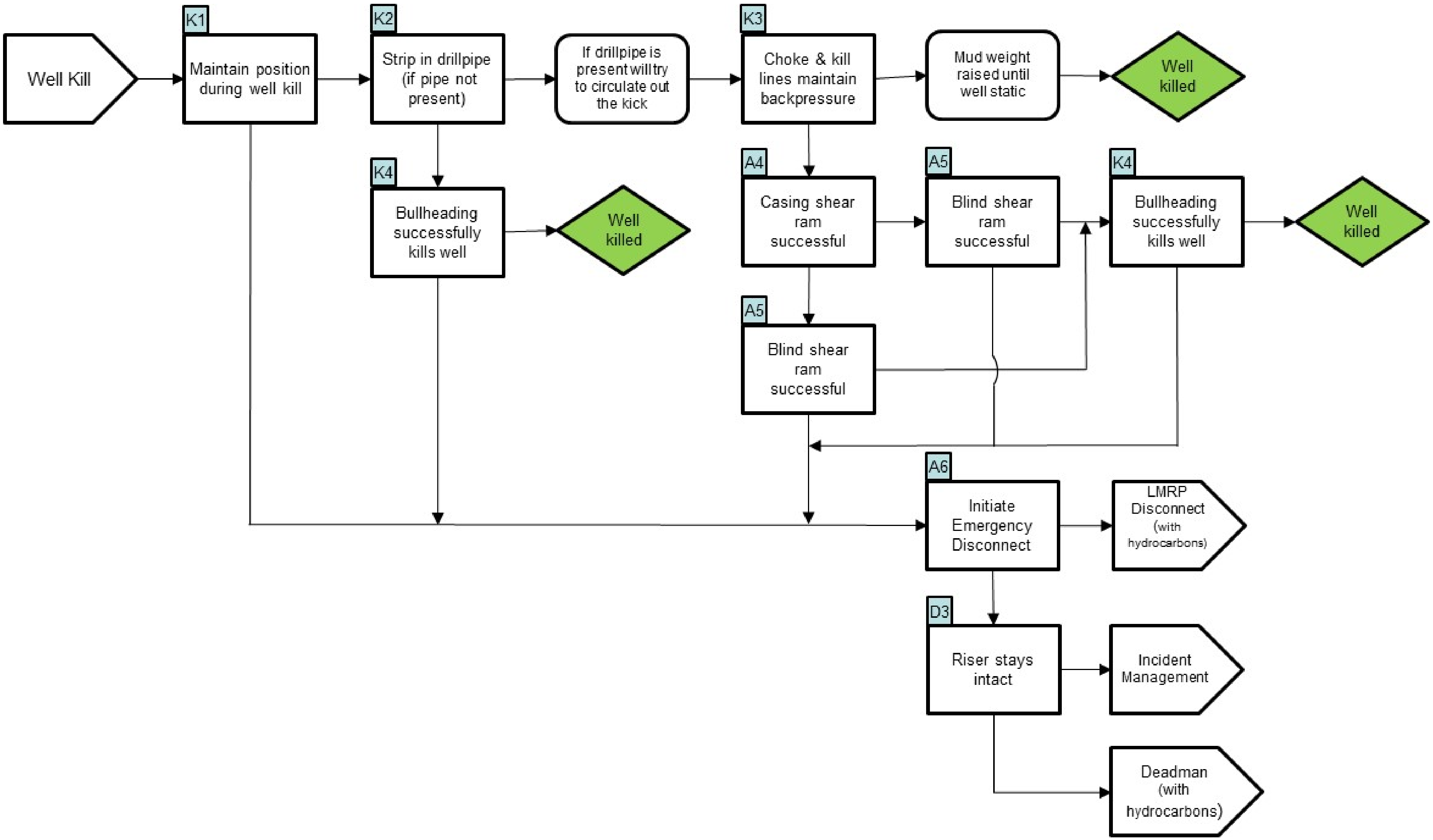

Figure 3-6: Well Kill

3.2.5 Loss of Position ESD

Loss of position is the second major class of initiating events in the model besides kicks. The initiating event assumes that the red watch circle has been reached so the first response is the initiation of an ED. If this occurs the disconnect sequence starts and attempts to shut in the well and disconnect the LMRP from the lower stack. The ESD shows an input to the EDS that comes from other well kick scenarios that have led to a need to disconnect, and the sequence is the same for all initiators. The loss of position initiator can occur at any time in the well development, so there may or may not be hydrocarbons present. One ESD is provided for each case, and the only difference is the end states. For the case where hydrocarbons are present (Figure 3-7), releases can occur and further incident management may be required if elements of the ED fail. For the case where hydrocarbons are not present (Figure 3-8), the end states collect the frequencies of different states of the BOP such as shut in and disconnected to not shut in and not disconnected.

I4 Loss of Position

The loss of position initiator accounts for drift-off, drive-off, and push-off.

A6 Initiate Emergency Disconnect

When a loss of position occurs and the red watch circle is reached, an emergency disconnect is required to minimize the hazard to the crew. At the same time an ED triggers another path to activate the shear rams through a diverse control logic separate from the manual activation. Initiation of an emergency disconnect is a very significant and costly event, and the human action to initiate it is modeled separately because of its importance.

If the emergency disconnect is initiated, the signal is sent to the BOP and a sequence of events occurs in order to safely shut the BOP and seal the well. Once this is complete, the LMRP is disconnected from the BOP stack and the rig floats freely with no more communication with the well. Once the disconnect occurs, the autoshear function will occur and attempt to close the shear rams if they have not previously closed.

The BOP is normally aligned to either the blue or yellow pod for control. In response to a kick, a failure in the control system may be remedied by switching from the blue to the yellow pod, or vice versa. In a disconnect sequence, there is generally no time to diagnose a failure and switch pod control, so the redundant controls are not credited in this analysis for the disconnect. Hydrocarbons may or may not be present when a disconnect occurs depending on the depth and status of the wellbore. If hydrocarbons are present, failures in the disconnect sequence may result in a release of hydrocarbons and present a hazard to the crew, else a failure to disconnect properly may result in a damaged well.

D1 Isolate Choke & Kill Lines

When the LMRP is disconnected from the lower stack, the choke & kill lines are disconnected. The disconnection of the choke & kill lines leave a potential path open to the environment that is protected by two isolation valves in series for each choke & kill line. These valves are fail safe in that loss of the hydraulics from the separation should cause the spring operator to automatically close if they are open. During most operations they are normally closed, but still subject to leaks.

A4 Close Casing shear ram

The casing shear ram is assumed to be automatically activated before the blind shear ram during an emergency disconnect in case there is drillpipe or casing across the BOP. It is the only shear ram capable of cutting through casing. The casing shear ram is assumed to be able to sever all but drillpipe tool joints and casing couplings.

For an emergency disconnect, the initial activation of the casing shear and blind shear rams is done as part of the disconnect sequence where topsides hydraulics are used to close the rams. A second attempt is made at closing the shear rams after the LMRP has separated by the autoshear function.

A5 Close Blind shear ram

The blind shear ram is required for shutting in the well when other methods have failed. In this model, the blind shear ram is attempted after the casing shear ram has been activated since the probability of success is conditional on whether there is any pipe across the BOP. If the pipe is casing and is not sheared, the blind shear ram is assumed to be unsuccessful, if drillpipe is present and not sheared, a higher probability of failure is used.

If the blind shear ram is successful, the well is shut in and the LMRP disconnect is started. If the blind shear ram fails to seal the well, formation fluid will potentially reach the drill floor and create a personnel hazard. A successful disconnect will minimize this hazard but still result in an uncontrolled release of hydrocarbons if they are present.

D2 LMRP Disconnects from the Stack

After the BOP has been put in a safe condition and the well shut in, the disconnect of the LMRP takes place. It is assumed that three main connection points need to be separated for a successful disconnect. The riser connector and choke & kill line lines have robust connections and all have redundant unlocking mechanisms; both mechanisms would have to fail in order to not successfully disconnect any of the three connections.

If the blind shear ram has closed, and the disconnect is successful, the model assumes a stable state has been reached. If the blind shear ram has closed, but the disconnect failed, the riser may be challenged and part.

D3 Riser Stays Intact

Should the LMRP fail to disconnect, the riser will experience forces that may challenge its structural capability when the rig has moved into the red watch circle. If the riser stays intact, including the electrical and hydraulic connections, the Deadman / Autoshear (DMAS) function will not occur and the BOP will remain in its current state. If the blind shear ram has failed to close through the normal EDS, the well will remain open; during this scenario, if hydrocarbons are present, an extended hydrocarbon release will occur and these sequences proceed to the incident management ESD.

If the riser parts, including the electrical and hydraulic connections, the deadman function will be triggered to attempt to close the shear rams if they are not already closed. The sequences with the riser parting transfer to the deadman ESD.

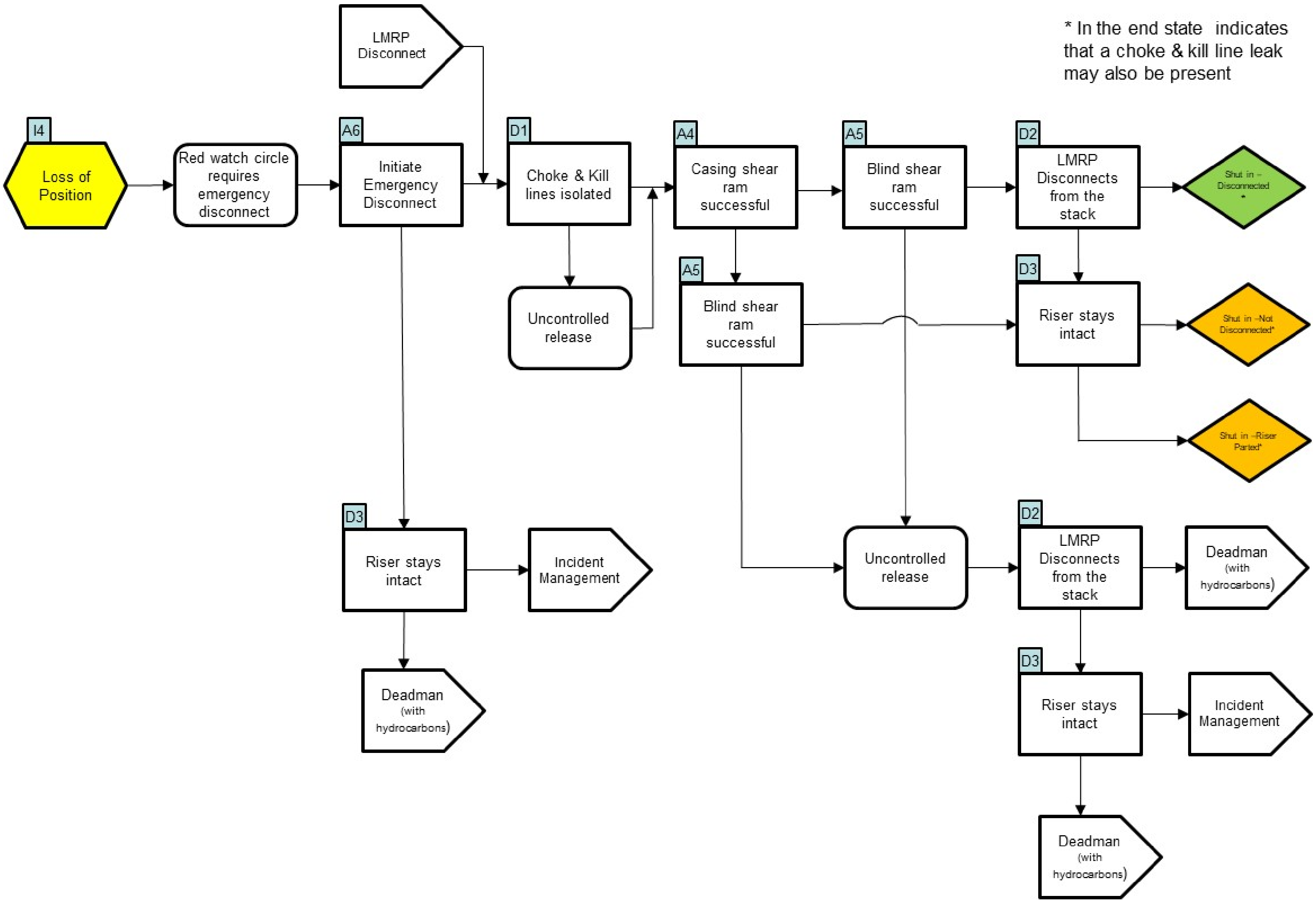

Figure 3-7: Emergency Disconnect With Hydrocarbons Present

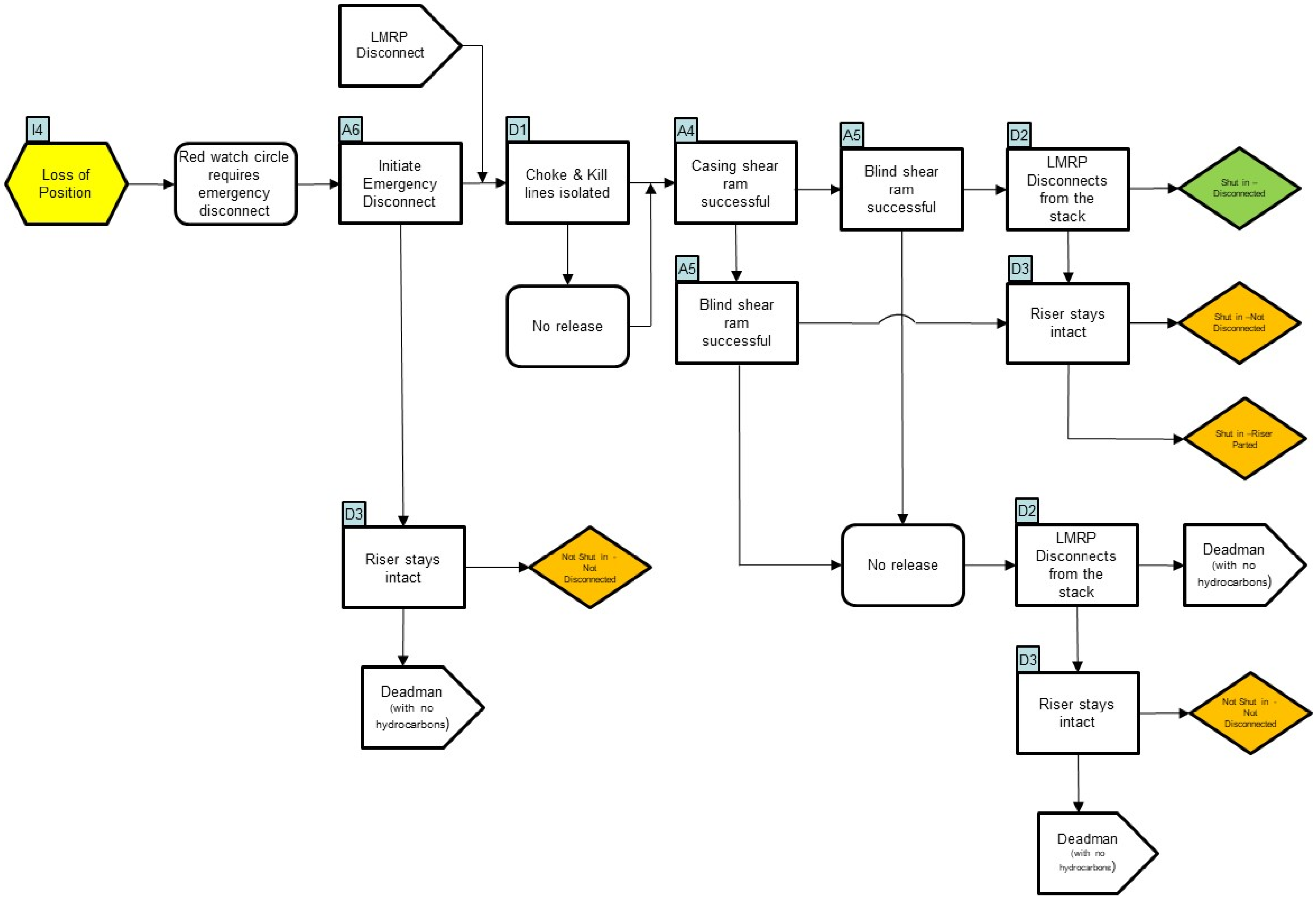

Figure 3-8: Emergency Disconnect With No Hydrocarbons Present

3.2.6 Deadman/Autoshear ESD

After an LMRP disconnect, the autoshear function is triggered and the shear rams are cycled close. The casing shear ram is closed first followed by the blind shear ram. This function provides a redundant closing mechanism if the EDS has previously failed.

The deadman function essentially does the same sequence of events as autoshear, but is triggered by a concurrent loss of electrical power and hydraulics from the topsides systems. This would be the case for sequences such as having the riser part. In these types of sequences, the deadman closing of the blind shear ram is the only attempt as the EDS has not been triggered, so it has no redundancy.

Because a disconnect can occur with or without hydrocarbons present, an ESD is developed for both cases (Figure 3-9 and Figure 3-10). Like the loss of position ESDs, the only differences are the end states, and the sequences with hydrocarbons can be escalated to incident management scenarios beyond normal well control techniques.

D4 Close Casing shear ram (DMAS)

The DMAS activation of the casing shear ram has the same functional sequence as a nominal closing, but performed automatically, and uses the subsea accumulators in lieu of using the topside hydraulics. A timing circuit is in place to ensure that the casing shear cuts any pipe across the BOP prior to the blind shear ram closing. Should this timing circuit fail (starts closing the BSR early), it would be equivalent to the casing shear failing as pipe would still be across the BOP.

D5 Close Blind shear ram (DMAS)

The DMAS activation of the blind shear ram follows the casing shear ram based on the timing circuit and also uses the subsea accumulators. If the blind shear ram has not been closed previously, this is the last possible conventional method of closing it. As with a nominal closing, the blind shear ram is attempted after the casing shear ram has been successfully activated since the probability of success is conditional on whether there is any pipe across the BOP. If the pipe is casing and is not sheared, the blind shear ram is assumed to not be successful; if drillpipe is present and not sheared, a higher probability of failure is used.

If the blind shear ram is successful, the well is shut in and a disconnect is started. If the blind shear ram fails to seal the well, formation fluid will potentially reach the drill floor and create a personnel hazard if the rig has not disconnected.

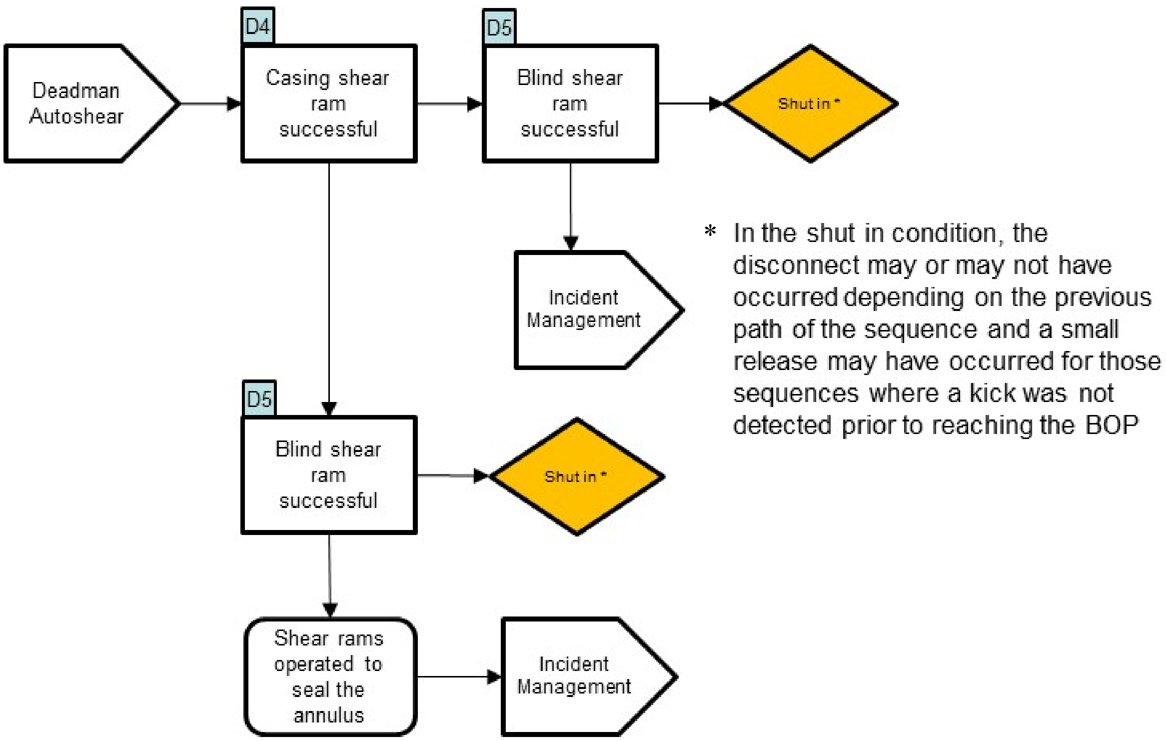

Figure 3-9: Deadman With Hydrocarbons Present

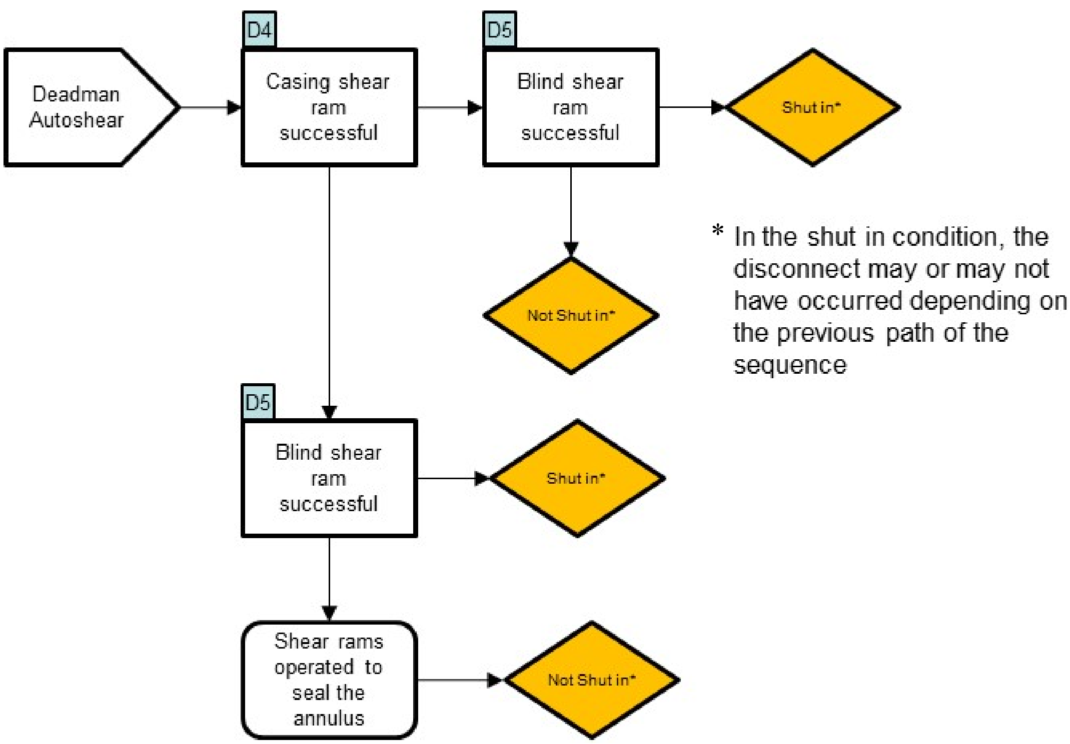

Figure 3-10: Deadman With No Hydrocarbons Present

3.2.7 Incident Management ESD

The incident management ESD (see Figure 3-11) is entered from other scenarios when conventional means of killing the well have been tried, but failed. Scenarios entering this ESD are those where there is an uncontrolled flow of hydrocarbons from the well. The events in the ESD are treated at a high level, i.e., no detailed fault trees were developed, because at this point the conditions could vary widely. The three incident management possibilities considered are ROV intervention, use of a capping stack, and, as a last resort, a relief well. No sequences go beyond this ESD as it is assumed a relief well will eventually be successful.

M1 ROV closes the Blind Shear Ram

If normal well control processes have failed to shut in the well and the well is flowing freely, significant hydrocarbon releases may be occurring jeopardizing both the crew and the environment. The scenarios then become incident management with alternate means of shutting in the well.

The quickest means of shutting in the well during this stage is using an ROV to remotely close the blind shear ram. ROVs are required to be available when drilling wells, and can successfully shut in the well within hours if needed and conditions are amenable to using the ROV. The ROV attaches itself to the BOP via a flying lead and can pump hydraulic fluid or seawater to the blind shear ram. To be successful, the blind shear ram failure that occurred attempting normal methods to close cannot impact the ROV. Failures such as the ram cylinder jamming or gross leakage in the hydraulic path will cause the ROV to fail too.

If the ROV is successful, the scenarios end with a hydrocarbon release stopped by the ROV. A relief well would still be needed to permanently seal the well, and is assumed to be successful at a later point. Relief wells (2) are assumed to be planned and started as soon as possible after normal methods have failed.

If the ROV is not capable of shutting in the well, a capping stack is the next incident management option considered.

M2 Capping Stack shuts in the well

Since the Macondo accident, capping stack technology has been developed and required to be available in the event of uncontrolled flow from a well. The capping stack is shore based and can take up to a week to deploy, and depending on the conditions, can be readily installed or require more time to prepare the interface with the well.

Conditions affecting the ability of the capping stack to be readily attached include:

- The LMRP has not completely separated from the lower stack,
- The BOP is tilted at an angle that must be corrected,
- The release is in a section of the BOP that cannot be contained by the capping stack (e.g., well head seal).

In this model, it is assumed that a capping stack can be successful in all cases except when an underground blowout occurs.

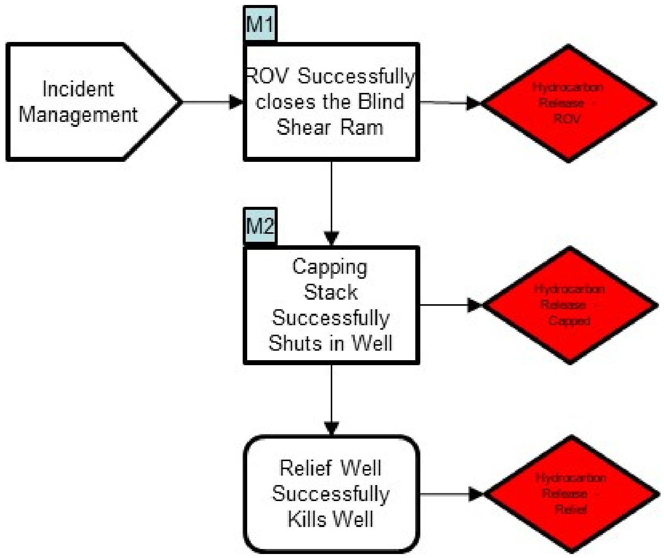

Figure 3-11: Incident Management

3.3 Event Tree Development

Once the accident progression paths are understood by constructing the ESDs, the next step is to build event trees for scenario quantification. An event tree is a graphic that displays scenarios potentially resulting from a specific IE (or a group of functionally similar IEs). An event tree distills the pivotal event scenario definitions from the ESD and presents this information in a tree structure that is used to help classify scenarios according to their consequences and perform a quantification of the scenarios. The headings of the event tree are the IE, which is the starting point, the pivotal events showing success or failure of mitigating/ aggravating events, and lastly the transfer end state to bin the consequence of each scenario. Each individual path through the event tree is a "sequence." The event-tree pivotal events are linked to fault trees, and the pivotal event names match the corresponding fault-tree top-event descriptions.

Event trees were developed based on the techniques used in [1]. In addition to the logic structure, event tree rules were necessary to properly develop sequences based on conditional probabilities. In SAPHIRE, event tree rules are logical equations that guide the program to substitute fault trees based on the conditions along a specific sequence. For example, in the Well Kick While Drilling ESD, a drillpipe is initially across the BOP. When the BSR is called on to shear pipe, however, one of three conditions may exist based on previous events. The casing shear ram is actuated prior to the BSR, if it is successful, there will be no pipe across the BOP when the BSR shears. The BSR being successful with no pipe across the BOP is a high probability event. If the casing shear ram (CSR) fails then pipe will still be across the BOP, and in this state, the BSR has a much lower chance of being able to shear and seal the well. In addition, if the CSR fails, and the pipe is not spaced out, a tool joint could be present at the BSR shear plane, and this would result in failure of the BSR. The event tree rules allow all of these type of conditions to be properly accounted for by substituting the correct fault trees for the specific conditions in a sequence. The use of event tree rules allows a more generalized event tree to be utilized for varying conditions rather than having to map out all specific sequences.

Table 3-2 shows the event trees develop for the model, and EVENT TREES provides the graphical event trees and the event tree rules associated with each. Not all event trees have rules associated with them.

Table 3-2: Event Sequence Diagram – Event Tree Cross Reference

ESD	Event Tree	Comments
N/A	EXPLORATIONOPS	This event tree is the first in the model and ties the loss of position and kick event trees together so they are all quantified together
Well Kick While Drilling	DRILLING	
Well Kick While Running Casing	CASING	
Well Kick With Nothing Across the BOP	NOTHING_BOP	
Well Kill	WELLKILL	
Loss of Position	LOSSOFPOSITION	This event tree is used to organize the loss of position event into when it occurs in the drilling process and if there are hydrocarbons present or not.
Loss of Position	LMRPDISCONNECT	The LMRP disconnect was treated separate from the loss of position event tree because sequences that are from kick events may lead to a disconnect as well as the loss of position event. Since all LMRP disconnect scenarios follow the same sequence it is more efficient to use a common event tree. This event tree is used when hydrocarbons are present, and does not include the DMAS function.
Loss of Position	LMRPDISCONNECTNHC	This event tree is the same as the LMRPDISCONNECT event tree, but is used only for loss of position scenarios in which hydrocarbons are not present. The end states in the event tree reflect that.
Deadman/Autoshear	DEADMAN	This event tree models the DMAS function following a disconnect or the deadman function following a loss of hydraulic and electrical communication with the rig. Some scenarios such as when the riser parts would bypass the autoshear function and go directly to the deadman function. This event tree is used for scenarios when hydrocarbons are present.
Deadman/Autoshear	DEADMAN-NHC	This event tree is the same as the DEADMAN event tree, but is used only for scenarios in which hydrocarbons are not present. The end states in the event tree reflect that.
Accident Management	ACCIDENTMANAGEMENT	

3.4 Fault Tree Development

The fault trees in the PRA model define the system failure logic and other events that are used for quantification. In most cases, these fault trees are arranged into a top level tree and several sub-trees. Sub-trees are generally used for functions that are shared between multiple parts of the model such as parts of the electric power system. In some cases, multiple fault trees were built to handle the conditions for different scenarios. For instance, for the BSR, the failure probability of the BSR itself changes if there is drillpipe across the BOP or there is nothing across the BOP. Two fault trees were needed to represent the system with the controls remaining the same (since they are independent of what is across the BOP), but the failure probability of the BSR being represented by distinct basic events in each fault tree. The fault trees were constructed in accordance with [1], and a list of all of the fault trees used is shown in Table 3-3. The graphical fault trees are contained in FAULT TREES while the basic event naming convention is given in BASIC EVENT NAMING CONVENTION.

SYSTEM ANALYSES describes all the systems modelled, including assumptions. MODEL DATA DEVELOPMENT includes the data analysis for this PRA, and COMMON CAUSE EVENT DESCRIPTIONS contains the common cause failure data analysis performed. BASIC EVENT LISTING lists all the basic events used in the PRA model and their parameters,

Table 3-3: Fault Trees used in the Drillship Model

Fault Tree	Description	Event Tree(s)
CAPSTACK	Capping Stack Fails to Contain Well	INCIDENTMANAGEMENT
CAPSTACKBULL	Capping Stack Ineffective due to underground blowout	INCIDENTMANAGEMENT
ROV	ROV Fails to Operate BOP to Seal the Well	INCIDENTMANAGEMENT
ROV_CSED	Unable to close or lock the Blind Shear Ram with casing across the BOP with the ROV	INCIDENTMANAGEMENT
ROV_CSED_NONSHEARABLES	Unable to close or lock the Blind Shear Ram with casing across the BOP with the ROV	INCIDENTMANAGEMENT
ROV_CSED_NONSHRBL_BSCC	Unable to close or lock the BOP with casing with the ROV when case coupling across the BSR	INCIDENTMANAGEMENT
ROV_CSED_NONSHRBL_CSCC	Unable to close or lock the BSR with casing across the BOP with the ROV when case coupling across the CSR	INCIDENTMANAGEMENT
ROV_CSED_NONSHRBLS_DO	Unable to close or lock the Blind Shear Ram with casing across the BOP with the ROV - Drive-off	INCIDENTMANAGEMENT
ROV_DRED	Unable to close or lock the Blind Shear Ram with drill string across the BOP with the ROV	INCIDENTMANAGEMENT

Fault Tree	**Description**	**Event Tree(s)**
ROV_DRED_NONSHEARABLES	Unable to close or lock the Blind Shear Ram with drill string across the BOP with the ROV	INCIDENTMANAGEMENT
ROV_DRED_NONSHRBLS_DO	Unable to close or lock the Blind Shear Ram with drill string across the BOP with the ROV - Drive-off	INCIDENTMANAGEMENT
ROV_NABED	Unable to close or lock the Blind Shear Ram with nothing across the BOP with the ROV	INCIDENTMANAGEMENT
ROV1	Unable to Contain Well with ROV due to BOP failure or formation failure	INCIDENTMANAGEMENT
BLIND_SHEAR_FAIL_CS	BSR fails to operate when casing is present	CASING
CASE_SHOE_FAILS	Casing Shoe float Valve Fails To Close and prevent back flow	CASING
CASING_SHEAR_FAIL_CS	CSR fails while running casing	CASING
BLIND_SHEAR_FAIL_MN	BSR fails to shut in well during manual actuation	CASING, DRILLING
NONSHEARABLE_BSCC	Casing coupling across the blind shear ram	CASING, LMRPDISCONNECT, LMRPDISCONNECTNHC, DEADMAN, DEADMANNHC
NONSHEARABLE_CSCC	Casing coupling across the casing shear ram	CASING, LMRPDISCONNECT, LMRPDISCONNECTNHC, DEADMAN, DEADMANNHC
ANNULAR_PIPERAM_DR	Failure to seal the annulus with the annulars or pipe rams	DRILLING
BLIND_SHEAR_FAIL_DR	BSR fails to operate when drill string is present	DRILLING
CASING_SHEAR_FAIL_DR	Casing shear fails when drill string is present	DRILLING
IBOP_FLTVLV_FAILS	Float Valve and IBOP Fails To Close or is not present	DRILLING
NONSHEARABLE_BSTJ	Nonshearable across the blind shear ram	DRILLING, LMRPDISCONNECT, LMRPDISCONNECTNHC, DEADMAN, DEADMANNHC
NONSHEARABLE_CSTJ	Nonshearable across the casing shear ram	DRILLING, LMRPDISCONNECT, LMRPDISCONNECTNHC, DEADMAN, DEADMANNHC
CASINGKICK_IC	Well Kick While Running Casing intermediate casing	EXPLORATIONOPS

Fault Tree	Description	Event Tree(s)
CASINGKICK_PZ	Well Kick While Running Casing in the reservoir	EXPLORATIONOPS
CASINGKICK_SC	Well Kick While Running Casing during surface casing operations	EXPLORATIONOPS
DRIFT-OFFPUSH-OFF_IEFT_FRE	Loss of stationkeeping due to drift-off/push-off (Events per Well)	EXPLORATIONOPS
DRILLKICK_IC	Well Kick While Drilling, intermediate casing ops	EXPLORATIONOPS
DRILLKICK_PZ	Well Kick While Drilling, reservoir ops	EXPLORATIONOPS
DRILLKICK_SC	Well Kick While Drilling during surface casing operations	EXPLORATIONOPS
DRIVE-OFF_IEFT_FRE	Loss of stationkeeping due to drive-off as an Initiating Event	EXPLORATIONOPS
EMPTY_BOP_KICK_IC	Kick with Nothing Across the BOP intermediate casing ops	EXPLORATIONOPS
EMPTY_BOP_KICK_PZ	Kick with Nothing Across BOP in the reservoir	EXPLORATIONOPS
EMPTY_BOP_KICK_SC	Well Kick during surface casing operations with nothing across the BOP	EXPLORATIONOPS
LOSSOFPOSITION	Loss of position	EXPLORATIONOPS
WELLSTATUS	Well operation when kick occurs	EXPLORATIONOPS
AUTOSHEAR_EDBS	Autoshear BSR fails to shut in well after emergency disconnect	LMRPDISCONNECT, LMRPDISCONNECTNHC
AUTOSHEAR_EDCS	Autoshear CSR fails to shear after emergency disconnect	LMRPDISCONNECT, LMRPDISCONNECTNHC
BLIND_SHEAR_FAIL_ED	BSR fails to shut in well during Emergency Disconnect	LMRPDISCONNECT, LMRPDISCONNECTNHC
BLIND_SHEAR_FAIL_EDCS	BSR fails to shut in well with casing - Emergency Disconnect	LMRPDISCONNECT, LMRPDISCONNECTNHC
BLIND_SHEAR_FAIL_EDCS1	BSR fails to shut in well previous failure or nonshearable when casing present - Emergency Disconnect	LMRPDISCONNECT, LMRPDISCONNECTNHC
BLIND_SHEAR_FAIL_EDDR	BSR fails to shut in Well with drillpipe - Emergency Disconnect	LMRPDISCONNECT, LMRPDISCONNECTNHC
BLIND_SHEAR_FAIL_EDDR1	BSR fails to shut in well previous failure or nonshearable when drillpipe is present - Emergency Disconnect	LMRPDISCONNECT, LMRPDISCONNECTNHC
BLIND_SHEAR_FAIL_EDNAB	BSR fails to shut in well nothing across the BOP - Emergency Disconnect	LMRPDISCONNECT, LMRPDISCONNECTNHC
C&KISOLATE	Failure to Isolate the Choke and Kill Lines	LMRPDISCONNECT, LMRPDISCONNECTNHC
CASING_SHEAR_FAIL_ED	CSR fails - Emergency Disconnect	LMRPDISCONNECT, LMRPDISCONNECTNHC

Fault Tree	Description	Event Tree(s)
CASING_SHEAR_FAIL_EDCS	Casing shear fails while running casing - Emergency Disconnect	LMRPDISCONNECT, LMRPDISCONNECTNHC
CASING_SHEAR_FAIL_EDCS1	Setting casing shear to failed state while running casing (previously failed) - Emergency Disconnect	LMRPDISCONNECT, LMRPDISCONNECTNHC
CASING_SHEAR_FAIL_EDDR	CSR fails with drillpipe - Emergency Disconnect	LMRPDISCONNECT, LMRPDISCONNECTNHC
CASING_SHEAR_FAIL_EDDR1	Setting casing shear to failed state when drillpipe is across (previously failed) - Emergency Disconnect	LMRPDISCONNECT, LMRPDISCONNECTNHC
CASING_SHEAR_FAIL_EDNAB	Casing Shear not required if nothing across the BOP - Emergency Disconnect	LMRPDISCONNECT, LMRPDISCONNECTNHC
DISCONNECT	Failure to Disconnect the LMRP	LMRPDISCONNECT, LMRPDISCONNECTNHC
NONSHEARABLE_BSCC1	Nonshearable across the BSR set to 1 when casing across (nonshearable present from previous event tree)	LMRPDISCONNECT, LMRPDISCONNECTNHC
NONSHEARABLE_BSNAB	Nothing across the BOP	LMRPDISCONNECT, LMRPDISCONNECTNHC
NONSHEARABLE_BSTJ1	Nonshearable across the BSR set to 1 when drillpipe across (nonshearable present from previous event tree)	LMRPDISCONNECT, LMRPDISCONNECTNHC
NONSHEARABLE_CSCC1	Nonshearable across the CSR set to 1 when casing across (nonshearable present from previous event tree)	LMRPDISCONNECT, LMRPDISCONNECTNHC
NONSHEARABLE_CSNAB	Nothing across the BOP	LMRPDISCONNECT, LMRPDISCONNECTNHC
NONSHEARABLE_CSTJ1	Nonshearable across the CSR set to 1 when drillpipe across (nonshearable present from previous event tree)	LMRPDISCONNECT, LMRPDISCONNECTNHC
NONSHEARABLE_EDBS	Nonshearable across the blind shear ram (Emergency Disconnect)	LMRPDISCONNECT, LMRPDISCONNECTNHC
NONSHEARABLE_EDCS	Nonshearable across the casing shear ram (Emergency Disconnect)	LMRPDISCONNECT, LMRPDISCONNECTNHC
RISER_PARTS_KICK	Ensure that riser doesn't part during a well kick	LMRPDISCONNECT, LMRPDISCONNECTNHC
AUTOSHEAR_EDBSCS	Autoshear BSR fails to shut in well when casing is present after emergency disconnect	LMRPDISCONNECT, LMRPDISCONNECTNHC, DEADMAN, DEADMANNHC
AUTOSHEAR_EDBSDP	Autoshear BSR fails to shut in well when drillpipe is present after emergency disconnect	LMRPDISCONNECT, LMRPDISCONNECTNHC, DEADMAN, DEADMANNHC

Fault Tree	Description	Event Tree(s)
AUTOSHEAR_EDBSNAB	Autoshear BSR fails to shut in well after emergency disconnect - nothing across the BOP	LMRPDISCONNECT, LMRPDISCONNECTNHC, DEADMAN, DEADMANNHC
AUTOSHEAR_EDCSCS	Autoshear CSR fails to shear casing after emergency disconnect	LMRPDISCONNECT, LMRPDISCONNECTNHC, DEADMAN, DEADMANNHC
AUTOSHEAR_EDCSDP	Autoshear CSR fails to shear pipe after emergency disconnect	LMRPDISCONNECT, LMRPDISCONNECTNHC, DEADMAN, DEADMANNHC
AUTOSHEAR_EDCSNAB	Autoshear CSR set to Prob = 0 (FALSE) when nothing across the BOP	LMRPDISCONNECT, LMRPDISCONNECTNHC, DEADMAN, DEADMANNHC
NONSHEARABLE_BS0	Nonshearable across the blind shear set to 0	LMRPDISCONNECT, LMRPDISCONNECTNHC, DEADMAN, DEADMANNHC
NONSHEARABLE_BSCCDO	Casing coupling across the blind shear ram - Drive-off	LMRPDISCONNECT, LMRPDISCONNECTNHC, DEADMAN, DEADMANNHC
NONSHEARABLE_BSTJDO	Drillpipe tool joint across the blind shear ram - Drive-off	LMRPDISCONNECT, LMRPDISCONNECTNHC, DEADMAN, DEADMANNHC
NONSHEARABLE_CS0	Nonshearable across the casing shear set to 0	LMRPDISCONNECT, LMRPDISCONNECTNHC, DEADMAN, DEADMANNHC
NONSHEARABLE_CSCCDO	Casing coupling across the casing shear ram - Drive-off	LMRPDISCONNECT, LMRPDISCONNECTNHC, DEADMAN, DEADMANNHC
NONSHEARABLE_CSTJDO	Drillpipe tool joint across the casing shear ram - Drive-off	LMRPDISCONNECT, LMRPDISCONNECTNHC, DEADMAN, DEADMANNHC
DRILLSTRINGIN_IC	Drill String In - Intermediate Casing	LOSSOFPOSITION
DRILLSTRINGIN_PZ	Drill String In - Production Zone	LOSSOFPOSITION
EMERGDIS_POS	Failure to initiate an emergency disconnect after loss of position	LOSSOFPOSITION
HYDROCARBONS	Hydrocarbons Present	LOSSOFPOSITION
INTERMEDIATECASING	Intermediate Casing	LOSSOFPOSITION
LOCATION	Well Segment	LOSSOFPOSITION

Fault Tree	Description	Event Tree(s)
OPENHOLE_IC	Open Hole - Intermediate Casing	LOSSOFPOSITION
OPENHOLE_PZ	Open Hole - Production Zone	LOSSOFPOSITION
PRODUCTIONZONE	Production Zone	LOSSOFPOSITION
RISER_PARTS_DRIVE	Riser parts following a loss of location due to drive-off	LOSSOFPOSITION
RUNNINGCASING_IC	Running Casing - Intermediate Casing	LOSSOFPOSITION
RUNNINGCASING_PZ	Running Casing - Production Zone	LOSSOFPOSITION
WELLSTATUS-POS	Well Operation when loss of stationkeeping occurs	LOSSOFPOSITION
RISER_PARTS	Riser parts following a failed disconnect	LOSSOFPOSITION, WELLKILL, LMRPDISCONNECT, LMRPDISCONNECTNHC
ANNULARS_FAIL	Annulars fails to close and shut in well	NOTHING_BOP, CASING
BLIND_SHEAR_FAIL_NAB	BSR fails to operate when nothing is across the BOP	NOTHING_BOP, CASING, DRILLING
EMERGDIS	Failure to initiate an emergency disconnect when needed	NOTHING_BOP, CASING, DRILLING
KICKDETECT	Driller fails to identify a kick has occurred before it reaches the BOP	NOTHING_BOP, CASING, DRILLING
BLIND_SHEAR_FAIL_CSWK	BSR fails to operate when casing is present - Well Kill	WELLKILL
BLIND_SHEAR_FAIL_DRWK	BSR fails to operate when drill string is present - Well Kill	WELLKILL
BLIND_SHEAR_FAIL_NABWK	BSR fails to operate when nothing is across the BOP - Well Kill	WELLKILL
BLIND_SHEAR_FAIL_WK	BSR fails to operate - Well Kill	WELLKILL
BULLHEAD	Failure to maintain formation integrity while bullheading leads to underground blowout	WELLKILL
CASING_SHEAR_FAIL_CSWK	Casing shear fails while running casing - Well Kill	WELLKILL
CASING_SHEAR_FAIL_DRWK	Casing shear fails while drilling - Well Kill	WELLKILL
CASING_SHEAR_FAIL_WK	CSR fails to operate - Well Kill	WELLKILL
DRIFT-OFFPUSH-OFF_KICK	Loss of stationkeeping due to drift-off/push-off during a kick control	WELLKILL
DRIVE-OFF_KICK	Loss of stationkeeping due to drive-off during kick control	WELLKILL
EMERGDIS_WK	Failure to initiate an emergency disconnect during Well Kill	WELLKILL
FORMPRESS	Failure to maintain backpressure using choke and kill lines	WELLKILL
LOSS_POSITION_KICK	Loss of Position During Well Control	WELLKILL

Fault Tree	Description	Event Tree(s)
NONSHEARABLE_BSCCWK	Casing coupling across the blind shear ram - Well Kill	WELLKILL
NONSHEARABLE_BSTJWK	Nonshearable across the blind shear ram when drillpipe is present - Well Kill	WELLKILL
NONSHEARABLE_BSWK	Nonshearable across the blind shear ram - Well Kill	WELLKILL
NONSHEARABLE_CSCCWK	Casing coupling across the casing shear ram - Well Kill	WELLKILL
NONSHEARABLE_CSTJWK	Nonshearable across the casing shear ram when drillpipe is present- Well Kill	WELLKILL
NONSHEARABLE_CSWK	Nonshearable across the casing shear ram - Well Kill	WELLKILL
PIPE	Drillpipe Not Across the BOP	WELLKILL
PIPE1	Drillpipe is not across the BOP	WELLKILL
STRIP	Failure to Strip in Pipe	WELLKILL

3.5 Human Reliability Analysis

Human Reliability Analysis (HRA) is the predictive study of human errors, typically in safety critical domains like nuclear power generation and human space missions, and now extended to offshore oil and gas operations. Human error, in this context, describes any action or inaction taken by people that increases the likelihood of an uncontrolled release of hydrocarbons. It should be noted that human actions can be added to recover or improve the system performance but then the probability of failure to perform these recovery/improvements must be estimated. The term "human error" carries with it negative implications often implying that blame may be attributed to an individual. Generally, HRA does not view human error as the product of individual weaknesses but rather as the result of circumstantial and situational factors that affect human performance. These factors are commonly referred to as performance shaping factors, which serve to enhance or degrade human performance relative to a reference point or baseline.

HRA is often depicted as consisting of three distinct phases [11]:

1. Modeling of the potential contributors to human error. This phase usually includes some type of task analysis to breakdown an overall sequence of events into smaller units suitable for analysis.
2. Identification of the potential contributors to human error. At this point, relevant performance shaping factors are selected, such as available time to perform the human action and degraded conditions affecting the human operator.
3. Quantification of human errors. This is when a human error probability is calculated. These estimates generally range from 1.00E-4 to 1.0 (or guaranteed failed) [12].

3.5.1 HRA Introduction

Human performance is critical to the safe operation of the drilling rig. Human interactions occur during normal operation, and in response to specific events. During the course of operations required for drilling and completion of a well, human interactions with equipment can induce failures that could increase the likelihood of an uncontrolled release of hydrocarbons or they may prevent a release through recovery and control actions. HRA is a method used to assess, both qualitatively and quantitatively, the probability of occurrence of human failures during complex operations. Modeling human actions with their corresponding failure in a PRA provides a more complete picture of the overall risk and risk contributions.

Not all HRA events result in scenarios that are significant risk contributors, therefore only HRA events that would contribute significantly to the total risk were selected to be modeled. In this case, ten HRA items considered significant were modeled. The Cognitive Reliability and Error Analysis Method (CREAM) [13] approach was used to evaluate the HRA events. NASA developed an automated version of CREAM known as CREAM HRA Calculator (CHRAC) [14] which was used to perform the actual HRA calculations. To understand HRA in more detail it is recommended to first read U.S. Nuclear Regulatory Commission Regulation NUREG/CR-1278 [12] and then CREAM [13], as the details of performing these methodologies are not discussed here. NUREG/CR-1278 is considered a major milestone in HRA modeling and is a first generation methodology. CREAM is considered a second generation methodology.

3.5.2 Identified Human Actions

The detailed worksheets generated by the CHRAC application for each of the HRA events modeled are provided in PRA HRA WORKSHEETS. Table 3-4 provides a summary of these events as well as the calculated risk probabilities and associated error factors (EF). The contribution to the overall results will be discussed in more detail in the results and conclusions portion of this report.

Table 3-4: Human Reliability Events Modeled

Basic Event Name	Descriptions	Probability	EF
BOP-HUM-ERR-CS-HANGOFF	Driller fails to position casing properly before activating shear ram (assumed not possible; event set to IGNORE)	Ignore	-
BOP-HUM-ERR-DP-HANGOFF	Driller fails to position drillpipe properly before activating shear ram	1.60E-01	5.0
BOP-HUM-ERR-EMERGDIS	Operator fails to initiate emergency disconnect successfully	4.90E-04	13.8
BOP-HUM-ERR-IBOP1	Human error - failure to install IBOP	1.60E-01	5.0
BOP-HUM-ERR-KICKDET	Operator fails to realize a kick has occurred or does not take timely action	3.70E-04	7.7
BOP-HUM-ERR-PODSEL	Operator failure to manually shift to the blue pod after yellow pod failure	1.24E-04	5.3
DPS-HUM-ERR-CSRECOV	Human Error Failure to Adequately Recover from Control System Failure in Which Drive-off is Initiated	4.30E-03	7.2
DPS-HUM-ERR-JOYSTICK	Human Error Failure to Control Vessel Using the Independent Joystick	8.00E-02	10.0
D-W-S-STRM-OFST-HRA	Human Error Resulting in Incorrectly Entering the Offset into the DPS (Extreme Weather; Winter Storm; Squall)	4.20E-05	4.9
DPS-WEA-HRA-PREP	Human Error Failure to Orient the Vessel for the Onset of Elevated Weather	8.10E-04	3.2

4 RESULTS

4.1 Overall Results

The overall results for a loss of containment (uncontrolled hydrocarbon release) are given in Table 4-1. The end states for ROVCONTAIN, CAPPINGSTACKCONTAIN, and RELIEFWELLSEAL were combined into a single end state of INIBO for initial blowout. Combining the three different end states results in some cut sets being minimalized out, so the overall frequency is slightly lower than the simple sum of the three end states. All results are based on a truncation cutoff of 1.00E-11. Because the model is based on two main types of events, kicks and loss of position, the results from INIBO were further broken down to determine the contribution from each type of initiating event. The overall result, 4.00E-4 per well is equivalent to 1 in 41.7 years for a loss of containment based on an average number of deepwater wells drilled per year, using DPS, in the GoM. The overall risk is essentially evenly split between the two types of initiating events.

Table 4-1: Overall Results for Loss of Containment for a Deepwater Exploration Well

Description	End State	Frequency (per well)	1 in X (Years)	Number of Cut Sets
Loss of Containment	INIBO	4.00E-04	41.7	506490
Loss of Containment due to Kicks	KICKSONLY	1.99E-04	83.8	80535
Loss of Containment due to Loss of Position	LOSSOFPOSITION	2.01E-04	82.9	425955

Initiating events are broken down further in Table 4-2. Drift-off and kicks while drilling are by far the largest contributors. Drift-off includes scenarios where some hardware has failed (e.g., thrusters, power) and with the existing weather conditions, the rig drifts into the red watch circle. The conditions considered vary between nominal relatively calm weather to extreme weather that the rig would normally be able to compensate for with the correct actions and hardware available. Kicks while drilling are dominant risk contributors because kicks are more likely while drilling and the drill string is across the BOP the vast majority of the time.

Table 4-2: Loss of Containment Initiating Event Percentage Contributions

Initiators	(%)
Drift-off	49.5
Kicks while drilling	44.3
Kicks while running casing	3.4
Kicks with nothing across the BOP	2.3
Drive-off Human Error	0.7
Drive-off Position Reference	0.0
Push-off	0.0

The frequency for loss of containment was further broken down into some selected contributors of interest as shown in Table 4-3. The risk metric used is the Fussell-Vesely importance. This measure is the percentage of risk that the selected contributor is included in. From the table it is clear that the percentages add up to greater than 100 percent. This is because in most cases the scenarios involve multiple contributors and are counted in each case. For example, if a loss of position occurs because of a loss of a generator, and the blind shear ram fails following the loss of position, the percent contribution of that scenario is counted for both the generator and the blind shear ram. If either succeeded, the scenario would not occur. Leaks in the BOP controls, electric power, and the actual BSR are the three leading contributors. BOP leaks are the primary risk contributors since many of the components contributing to leaks are single failure points such as dump valves or shuttle valves. In these cases, small leaks may still allow a full closing of the rams. Further information on actual leaks would be needed to refine the failure rate estimates by leak size. Electric power is a close second leading contributor, primarily because of its contribution to loss of position. Electric power includes the generation, distribution, and emergency shutdown system. The emergency shutdown system is a sizable portion of the overall contribution because a single failure may take out multiple generators. Common cause is included in each contributor as applicable, but is also broken out in the table to estimate the effect of common cause by itself from all sources. Common cause contributes a fairly high percentage (>20 percent), which is somewhat expected since there is a significant amount of redundancy in many critical functions, and common cause is generally more likely to fail redundant components than multiple independent failures. Nonshearables (tool joints and case couplings) account for almost 10 percent of the scenarios, primarily having a tool joint across the casing shear ram. Human error also accounts for almost 10 percent of the risk. The largest human error contributor is failure to space out the drillpipe. This value impacts the likelihood of having a nonshearable across a shear ram and is currently a screening value, although a current review of kick events suggests that the value may not change because the frequency of a stuck pipe during a kick is similar to the human error screening value used. Pipe rams and annulars are very low contributors as they are used to kill the well but credit is not taken for sealing the well.

Table 4-3: Selected Overall Contributors for Loss of Containment (Fussell-Vesely importance measure)

Overall Contributors	F-V (%)
BOP leaks (internal and external)	45.8
Electric Power Generation/Distribution/Control	41.5
Blind Shear Ram (no controls)	23.8
BOP Pressure Regulators	23.2
Common Cause Failures	20.6
Failure to space out drillpipe	7.8
Tool joint present in CSR	7.1
Sea Water/ Fresh Water Cooling	7.1
BOP Subsea Electronics Module	3.4
Casing Shear Ram (no controls)	1.5
Case Coupling present in CSR	1.2
Tool joint present in BSR	1.1
Failure to perform emergency disconnect	0.8
Failure to detect kick	0.8
Annulars (no controls)	0.3
Failure to switch pods after failure	0.1
Case Coupling present in BSR	0.1
Failure to install IBOP	0.0
Pipe Rams (no controls)	0.0

The top 20 cut sets for the overall risk are given in Appendix J.

4.2 Kick Results

The kick results for loss of containment were isolated and broken down first by when the kick occurred shown in Table 4-4. As previously mentioned, more kicks occur while drilling, and the drill string is across the BOP the vast majority of the time, so kicks with the drill string across the BOP are by far the largest contributors. The results in the table do not reflect that the drill string is across the BOP while running casing after the casing has been lowered through the BOP. While this does not necessarily affect the kick frequency, the response would be different since drill string is easier to shear. The kick frequency with nothing across the BOP is low, but because some BOP components (e.g., pipe rams) are not capable of sealing the well on an open hole, the conditional probability of a loss of containment is higher.

Table 4-4: Percentage Contributions for Operation When Kick Occurs Leading to Loss of Containment

Operation When Kick Occurs	(%)
Kick While Drilling	88.7
Kick While Running Casing	6.8
Kick with Nothing Across the BOP	4.5

The kick results were further analyzed to determine what percentage of the uncontrolled release frequency occurred during the well kill process. The results showed a frequency of uncontrolled release of 5.55E-6/well, or about 3 percent of the total for an uncontrolled release after the well had been initially contained.

Selected kick contributors of interest to a loss of containment are shown in Table 4-5. BOP leaks and pressure regulation are the top two contributors for kicks, albeit somewhat higher than the overall results, but electric power is decreased by a factor of five. This is because BOP failures remain important for all scenarios, but loss of position in kick scenarios can only occur during the shorter timeframe of well kill process. The nonshearable contribution is lower since failure to space out the drillpipe is less likely than during drive-off scenarios.

Table 4-5: Selected Kick Contributors for Loss of Containment (Fussell-Vesely Importance Measure)

Kick Contributors	F-V (%)
BOP leaks (internal and external)	52.4
BOP Pressure Regulators	37.4
Electric Power Generation/Distribution/Control	8.2
BOP Subsea Electronics Module	6.7
Failure to space out drillpipe	3.2
Blind Shear Ram (no controls)	2.0
Tool joint present in CSR	1.8
Failure to detect kick	1.5
Tool joint present in BSR	1.4
Case Coupling present in CSR	0.8
Annulars (no controls)	0.6
Sea Water/ Fresh Water Cooling	0.5
Casing Shear Ram (no controls)	0.4
Failure to switch pods after failure	0.1
Case Coupling present in BSR	0.1
Failure to perform emergency disconnect	0.1
Failure to install IBOP	0.0
Pipe Rams (no controls)	0.0

The top 20 cut sets for kick risk are given in Appendix J.

4.3 Loss of Position Results

A hydrocarbon release following a loss of position requires two conditions, first a failure during the emergency disconnect leaves the well open, and secondly, hydrocarbons must be present in the uncased section of the well. For this analysis, a significant amount of hydrocarbons was assumed to be present whenever the drilling was taking place in the reservoir section of the well (assumed to be the last section in a well design), but only five percent of the time when in intermediate casing sections. A loss of containment leading to a large hydrocarbon release, based on these assumptions, was found to be much more likely while drilling in the reservoir as indicated in Table 4-6.

Table 4-6: Percentage Contributions for Operation When Loss of Position Occurs Leading to a Loss of Containment

Operation When Loss of Position Occurs (with hydrocarbons present)	(%)
Reservoir	94.5
Intermediate Casing	5.2

Table 4-7 shows selected contributors of interest to loss of position scenarios. By far the largest contributor is a loss of electric power which leads to drift-off. The blind shear ram itself is second, primarily because well kill does not take place in these scenarios so the annulars and pipe rams are not useful and it is more likely that spacing out drillpipe will not occur leaving the blind shear ram vulnerable to nonshearables, which are also show to be higher contributors for loss of position versus the kicks or overall results. Human error (e.g., orienting the vessel, drive-off) account for about nine percent of the risk. Equipment cooling also is higher for these scenarios since it can lead to loss of electric power and drift-off.

Table 4-7: Selected Loss of Position Contributors for Loss of Containment (Fussell-Vesely Importance Measure)

Loss of Position Contributors	F-V (%)
Electric Power Generation/Distribution/Control	74.6
Blind Shear Ram (no controls)	45.4
BOP leaks (internal and external)	39.3
Sea Water/ Fresh Water Cooling	13.7
Failure to space out drillpipe	12.3
Tool joint present in CSR	12.3
BOP Pressure Regulators	9.1
Failure to Properly Orient the Vessel for Weather	7.7
Blind Shear Ram Lock	3.1
Casing Shear Ram (no controls)	2.6
Failure to perform emergency disconnect	1.6
Case Coupling present in CSR	1.5
Incorrectly Entering the Offset into the DPS	1.3
Drive-off due to human error	1.3
Tool joint present in BSR	0.7
BOP Subsea Electronics Module	0.1
Failure to Recover from Drive-off	0.0
Case Coupling present in BSR	0.0

The top 20 cut sets for loss of position risk are given in Appendix J.

4.3.1 Controlled Loss of Containment Results

The previous results have been based on an initial loss of containment and failure of the well control process leading to an uncontrolled loss of containment. In some cases where the kick has progressed past the BOP, it may be possible to shut in the well, with an emergency disconnect. In these cases hydrocarbons may reach the rig floor if they continue up the riser, and this would create a hazard for personnel. The scenarios involving this type of event are related to failure of the initial kick detection before it reaches the BOP. A review of end states for an emergency disconnect, not proceeding to incident management, provided a frequency of 1.77E-4/well. Using the estimate of 60 DPS drilled wells per year provides a frequency of about 0.011 / year.

4.3.2 Emergency Disconnect Results

For loss of position scenarios, the emergency disconnect is explicitly modeled, and a loss of position can occur at any time during the drilling process. Table 4-8 shows the conditional probability of what operation is being conducted at the time of occurrence, given a loss of position has occurred. This is an assumption and would vary well to well.

Table 4-8: Percentage Contributions for Operation When Loss of Position Occurs

Operation When Loss of Position Occurs	(%)
Surface Casing	13%
Intermediate Casing	47%
Reservoir	40%

The end states for the non-hydrocarbon releases were reviewed to estimate the frequency of different conditions that may exist after an emergency disconnect. These conditions include whether the well is shut in by the BSR and whether a disconnect occurred. For this review, the status of the choke and kill isolation valves was not considered. The results are shown in Table 4-9. The vast majority of the time, the well is left in the safest condition, shut in and disconnected. The cases when the well is not disconnected are the least frequent because in the generic model, the unlatching of both the riser and choke and kill lines has redundant paths to unlatch. The "not shut in" case is slightly more frequent than the failure to disconnect because there are more single failure points, including the BSR itself.

Table 4-9: Percentage Contributions for Well Condition After an Emergency Disconnect

Condition After Emergency Disconnect	Frequency (per Well)	(%)
SHUTIN - DISCONNECTED	1.78E-02	98.3%
NOT SHUTIN - DISCONNECTED	2.51E-04	1.4%
SHUTIN - NOT DISCONNECTED	4.58E-05	0.3%
NOT SHUTIN - NOT DISCONNECTED	2.96E-05	0.2%

4.4 Uncertainty

An uncertainty analysis was performed on a loss of containment for the overall result as well as for kicks and loss of position events. For the overall and loss of position cases, a reduced number of cut sets was used to make the analysis more manageable in terms of run time. The top 95 percent (approximately) of cut sets were used and the results were scaled up. The analysis is based on 50,000 replications and is shown in Figure 4-1.

The results show that the mean values are about 25 percent higher than the point estimates for the overall loss of containment and almost 50 percent higher for loss of position. Loss of containment due to kicks presented a more modest 10 percent increase. The reason for the higher mean values is that like components are correlated and have wide uncertainties. This tends to stretch out distributions with multiple like components in the cut sets, and because lognormal distributions are used, the means shift accordingly. From Figure 4-1, the loss of position results have a very large uncertainty, and this is the main contributor to the shift in the overall results. The mean values from the uncertainty analysis are compared to the point estimates in Table 4-10.

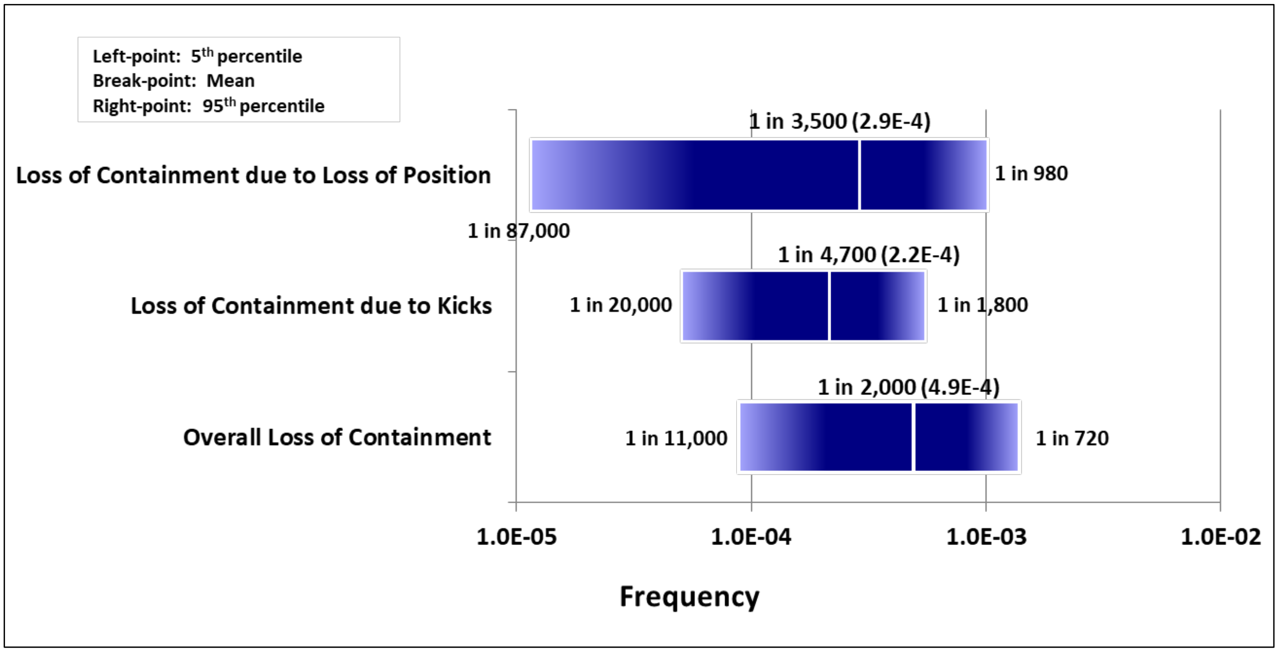

Figure 4-1: Uncertainty Results for Loss of Containment ("1 in" values are on a per well basis)

Table 4-10: Comparison of Point Estimates and Mean Results

Case	Point Estimate	Mean	Difference
Overall Loss of Containment	4.00E-4	4.90E-4	+22.5%
Loss of Containment due to Kicks	1.99E-4	2.20E-4	+11%
Loss of Containment due to Loss of Position	2.01E-4	2.90E-4	+44%

4.5 Comparison with GoM Experience

The objective of this analysis is to produce a credible PRA modeling a deepwater well in the GoM. Because there has been extensive experience with US operators in the GoM, the model was first compared to experience. Deepwater well drilling in the GoM started in approximately 1998, based on Application for Permit to Drill (APD) data [15], so through 2018, approximately 1260 wells have been drilled by DPS vessels. Based on a borehole query performed on the BSEE on–line datacenter from 1998-2018, an estimated 1438 wells had been drilled by DPS rigs. Only one uncontrolled loss of containment event has occurred in the GoM from a deepwater drilling rig, the Macondo well in 2010. Figure 4-2 shows the uncertainty from the PRA model and the GoM experience and how the actual GoM experience based on the borehole query matches up. The results appear to show good agreement for the overall frequency of uncontrolled loss of containment events.

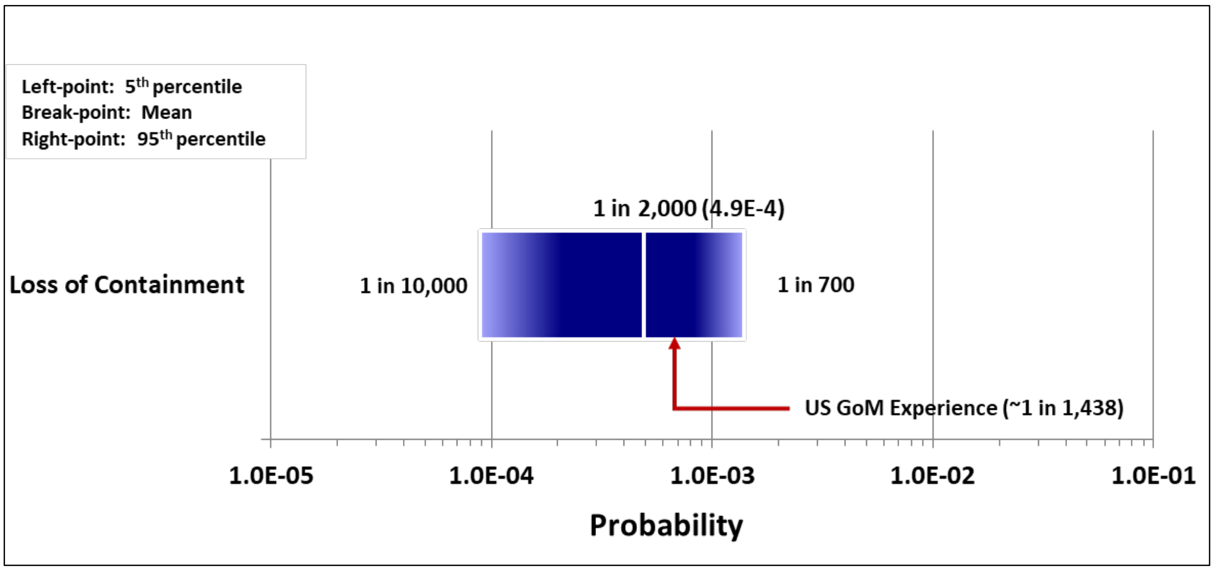

Figure 4-2: PRA Model Results vs. Deepwater Drilling Experience for Uncontrolled Loss of Containment in the GoM

Emergency disconnects are also high visibility events that can easily be compared. Table 4-11 shows the emergency disconnects that have occurred by year in the GoM, with an average frequency of about 1.2/year. The loss of position fault trees (DRIFT-OFFPUSH-OFF_IEFT_FRE and DRIVE-OFF_IEFT_FRE) were solved and combined to get a frequency of 2.15E-2/year. Using the average of 60 DPS wells drilled per year yields an annual frequency of 1.29/year for loss of position events. This appears to be in good agreement with experience.

Table 4-11: Emergency Disconnects in the GoM by Year

Year	Disconnect
2004	0
2005	2
2006	3
2007	1
2008	0
2009	1
2010	0
2011	2
2012	2
2013	2
2014	3
2015	1
2016	1
2017	0
2018 (through July)	0

4.6 Conclusions

The overall results of the model agree well with GoM experience. Review of the selected results of interest leads to the following conclusions:

1. The original intent of the analysis was to model a deepwater HPHT exploration well. Because of a lack of data specific to HPHT wells, the model was developed on a more generic basis, but the overall logic of the model is relevant to an HPHT well. To evaluate an HPHT well, additional data required is:
    a. Kick frequency developed for HPHT wells
    b. Failure rates of BOP components rated for HPHT wells (20k)
    c. Duration of an HPHT well from spudding to total depth
2. The model was developed for a generic deepwater exploration well using a DPS rig. In this sense, average data was used for kick frequency and the time from spudding to total depth. Kick frequency can vary by the type of well, e.g., exploration/development, new/sidetrack, so individual well risk can vary from kick frequency. The time from spudding to total depth also can vary significantly with the type of well. Specific well information may be put in the model based on the characteristics of the well to arrive at a more specific estimate for a given well. In addition, the BOP and vessel details vary which may cause some differences in results.
3. For DPS rigs, the estimated risk of an uncontrolled hydrocarbon release is evenly split between kicks and loss of position events. For rigs not using DPS, the loss of position risk would not exist; however, other risks such as failed mooring lines (similar to a loss of position on a DPS rig) or failure of jackup legs are present and not applicable to DPS rigs. Based on the review of WAR data, these risks for other rigs appear to have a much lower frequency than a loss of position, and therefore imply that the risk is higher for DPS rigs than non-DPS rigs.

4. The loss of position/emergency disconnect frequency developed for the model agrees very well with recent GoM experience; however, anecdotally the cause of many of the recent events is an inadvertent disconnect which is not modeled. An inadvertent disconnect is one caused by mistakenly activating the disconnect system or possibly activating it during maintenance activities. In addition, a concurrent review of equipment failure rates shows many of the contributors to loss of position (requiring and emergency disconnect) may be somewhat lower than what is used in the model.
5. Perhaps an obvious conclusion is that the highest risk contribution for an uncontrolled hydrocarbon release is when the reservoir has been reached and drillpipe is across the BOP, since the drilling phase time is longer than other phases, and the probability of a kick is higher during drilling.

4.7 Recommendations

This model represents the first attempt at developing a comprehensive deepwater exploration well model, and although the overall results appear to be quite reasonable, there is always room for improvement. Some suggestions for future work include:

1. Update the model with improved failure rates and initiating event frequencies. The work performed in references [8], [9] and [10] includes developing equipment failure rates and kick frequencies based on recent GoM data. Indications are that the generic failure rates and kick frequencies in the model may be, in many cases, conservative. It is recommended to continually update the data taking into account new operational experience and technological advances.
2. Add initiating events that are not currently included. Inadvertent emergency disconnect is particularly important as mentioned in Conclusion 4. It is also recommended to review other data from the data analysis reports [9] [10], to determine whether other failure events should be included in the model. One such event already identified is the probability of a stuck pipe during well control activities.
3. Evaluate in more detail the well stabilization process after shut in, e.g., after emergency disconnect, ROV intervention and well capping.
4. Refine certain parameter values used in the model. There are several parameters included in the model that have an effect on results, but their values have been assumed without rigorous research These values could be further refined, and include:
    a. Probability that the riser will part if the rig does not disconnect
    b. Probability of an underground blowout
    c. Human error to space out after a kick

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APPENDIX A- PRA TEAM

Table A- 1: PRA Team

Name	Employer	E-mail Address	PRA Team Role
Roger Boyer	NASA	roger.l.boyer@nasa.gov	Project Manager
Robert Cross	NASA	robert.cross-1@nasa.gov	NASA Modelling lead
Jorge Ballesio	SAIC	jorge.ballesio@nasa.gov	SAIC modelling co-lead
Eric Thigpen	SAIC	eric.b.thigpen@nasa.gov	SAIC modelling co-lead
Bruce Reistle	NASA	bruce.c.reistle@nasa.gov	Data Analysis Lead
Mike Worden	BSEE	mike.worden@bsee.gov	Subject Matter Expert
Earl Shanks	BSEE	forrest.shanks@bsee.gov	Subject Matter Expert

APPENDIX B- EVENT TREES

B.1 EXPLORATION OPERATIONS EVENT TREE

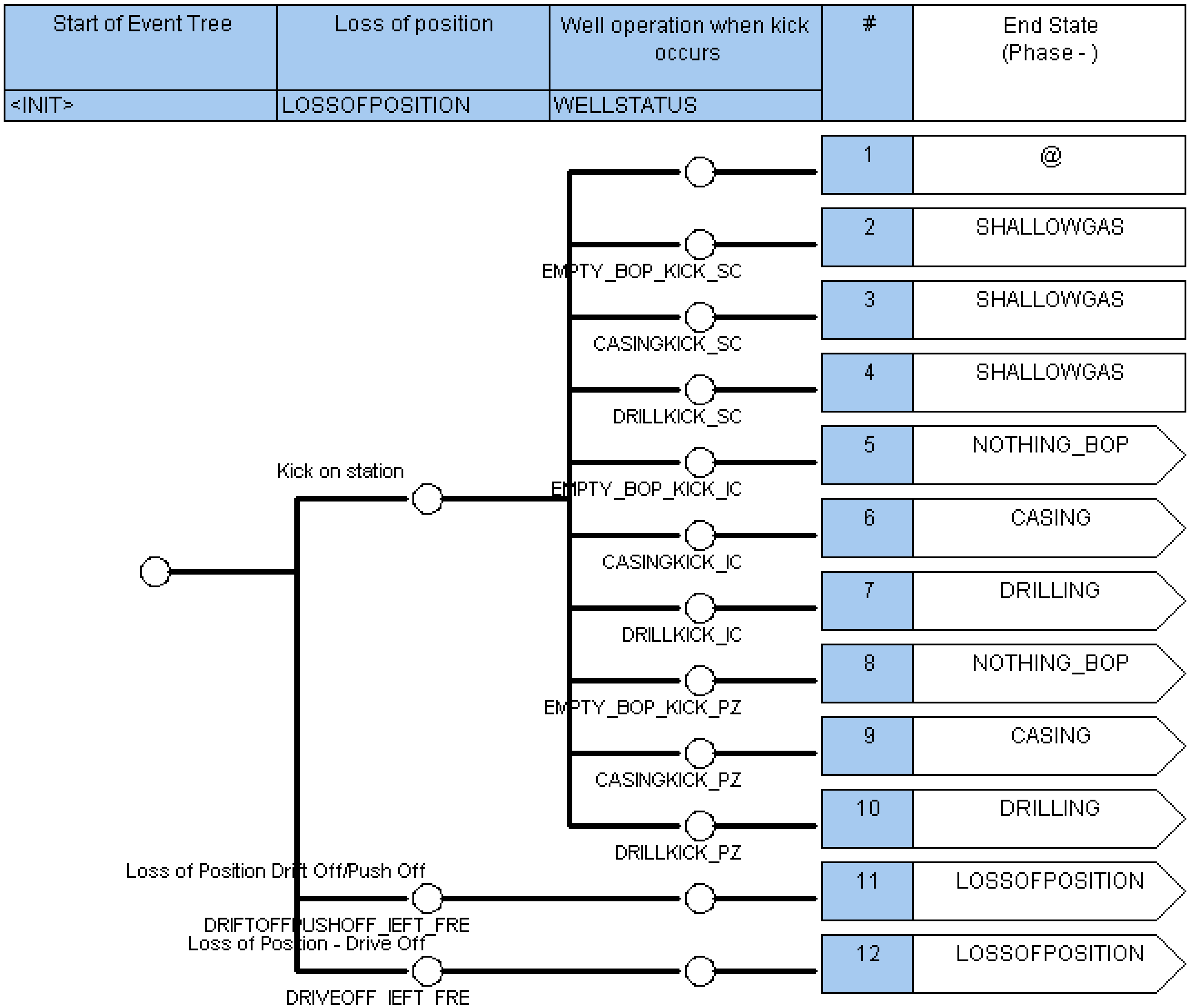

Figure B- 1: EXPLORATIONOPS Event Tree

B.2 KICK WITH NOTHING ACROSS THE BOP EVENT TREE

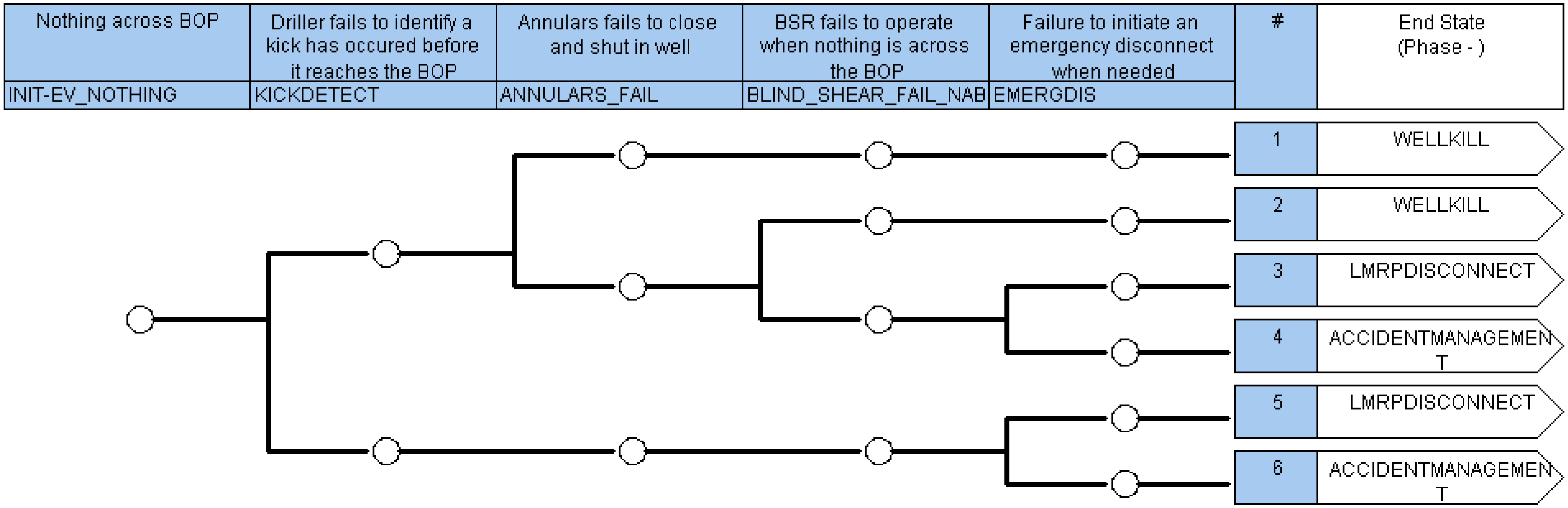

Figure B- 2: NOTHING_BOP Event Tree

B.3 KICK WHILE RUNNING CASING EVENT TREE

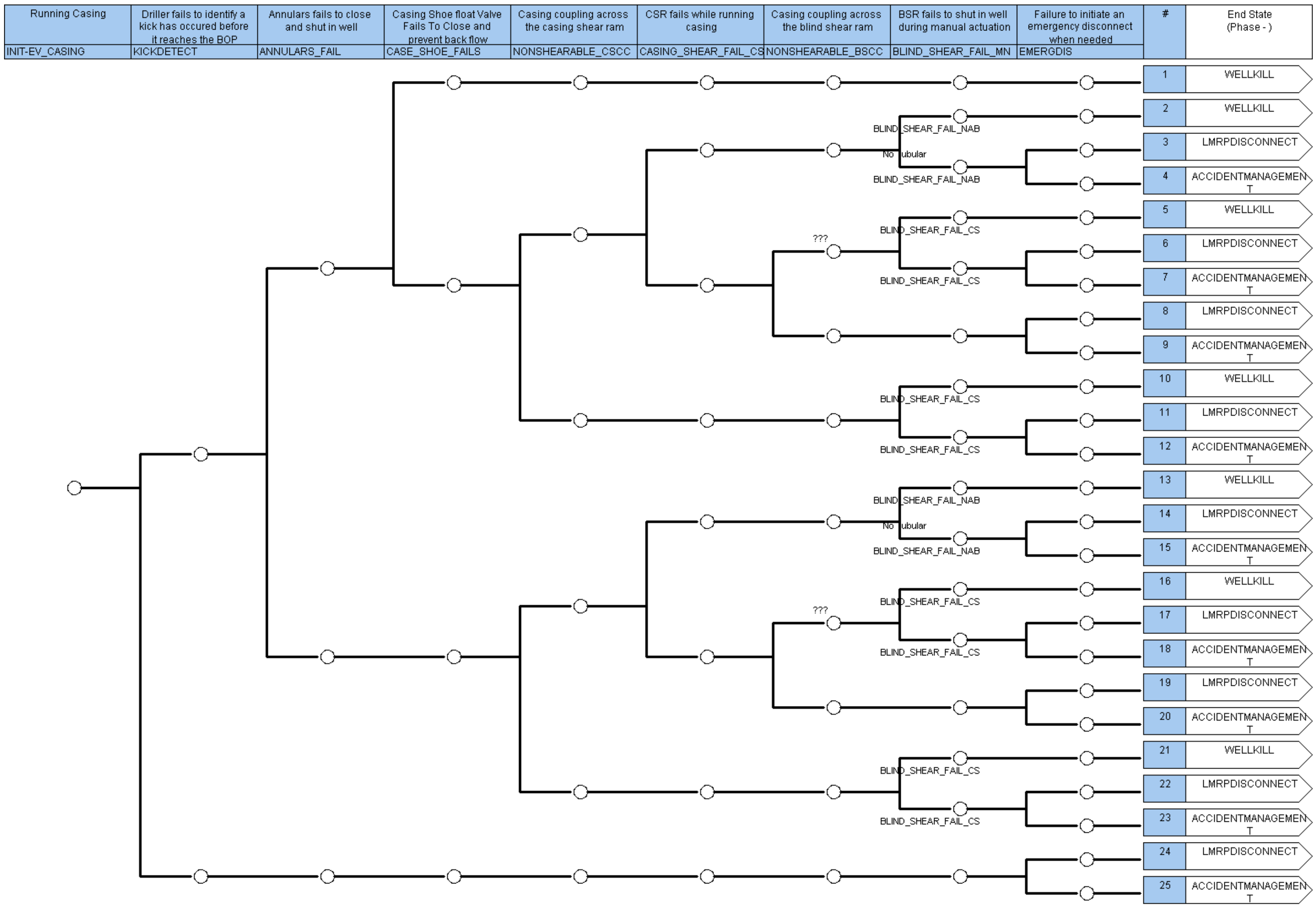

Figure B- 3: CASING Event Tree

B.4 KICK WHILE RUNNING DRILLPIPE EVENT TREE

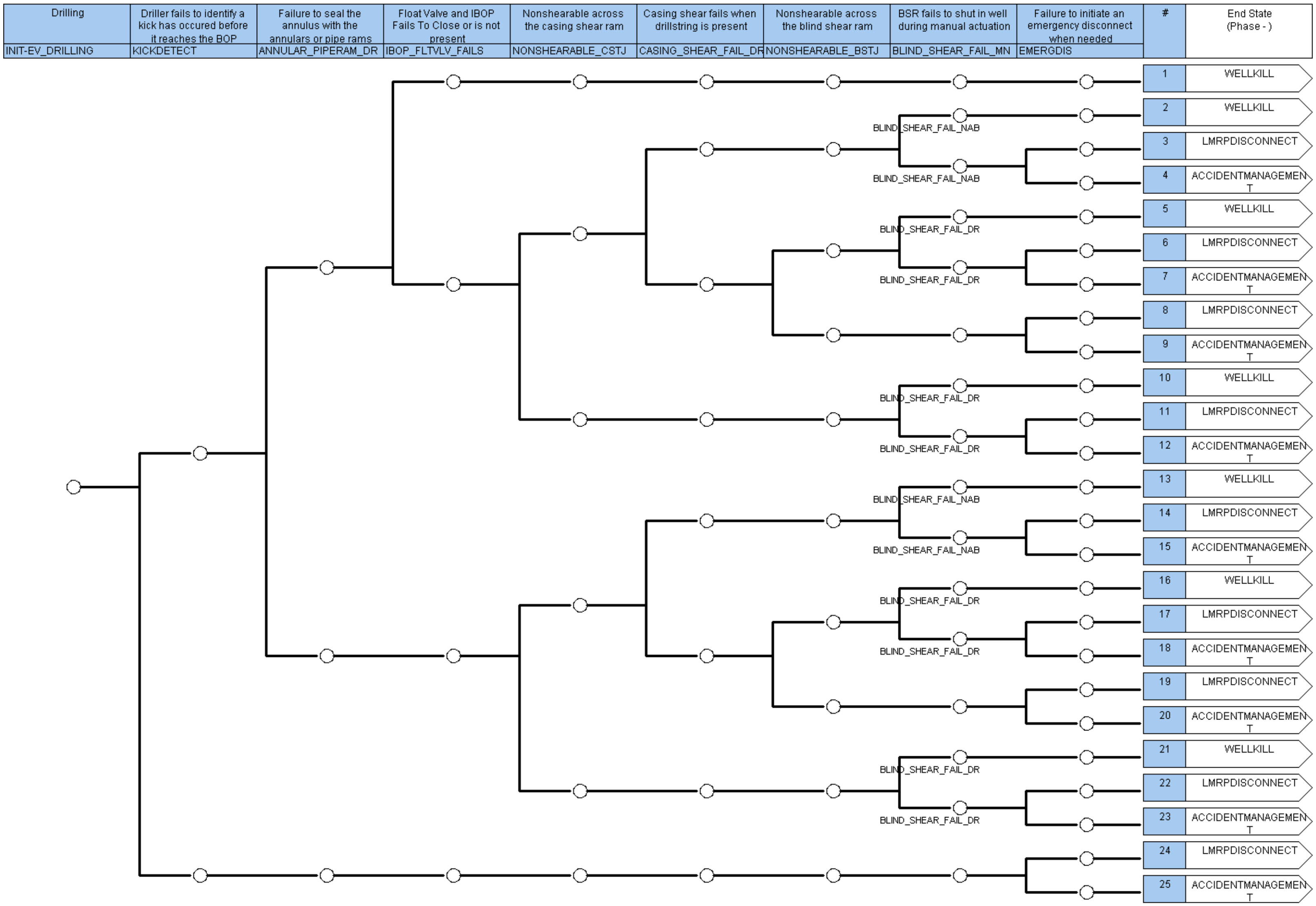

Figure B- 4: DRILLING Event Tree

B.5 LOSS OF POSITION EVENT TREE

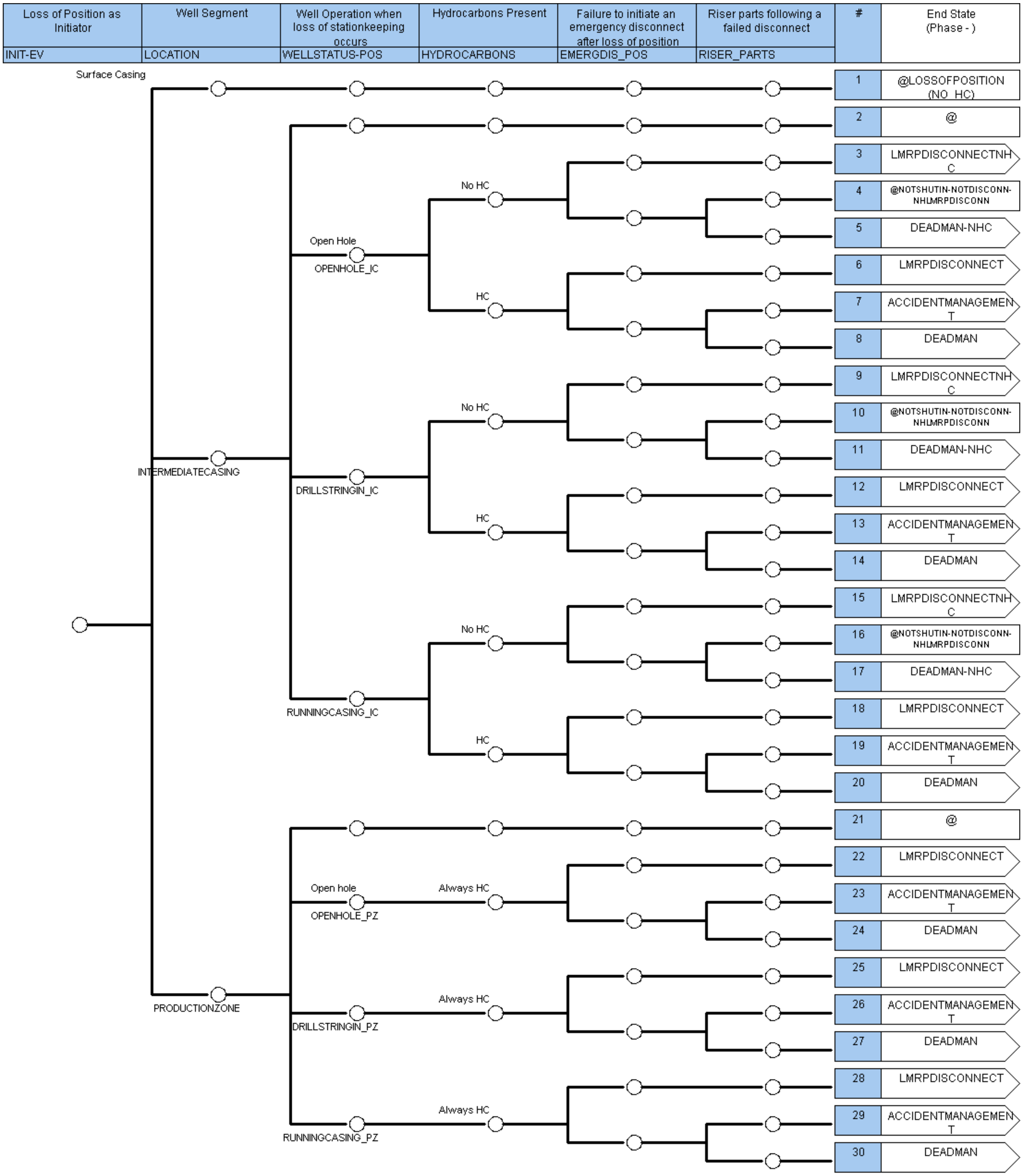

Figure B- 5: LOSSOFPOSITION Event Tree

```
|LINKAGE RULES FOR LOSSOFPOSITION EVENT TREE

| ENSURE THAT RISER PARTS IN THE EVENT OF A LOSS OF POSITION DUE TO DRIVE-OFF
IF DRIVE-OFF_IEFT_FRE THEN
RISER_PARTS = RISER_PARTS_DRIVE;
/RISER_PARTS = RISER_PARTS_DRIVE;
ENDIF
```

B.6 WELL KILL EVENT TREE

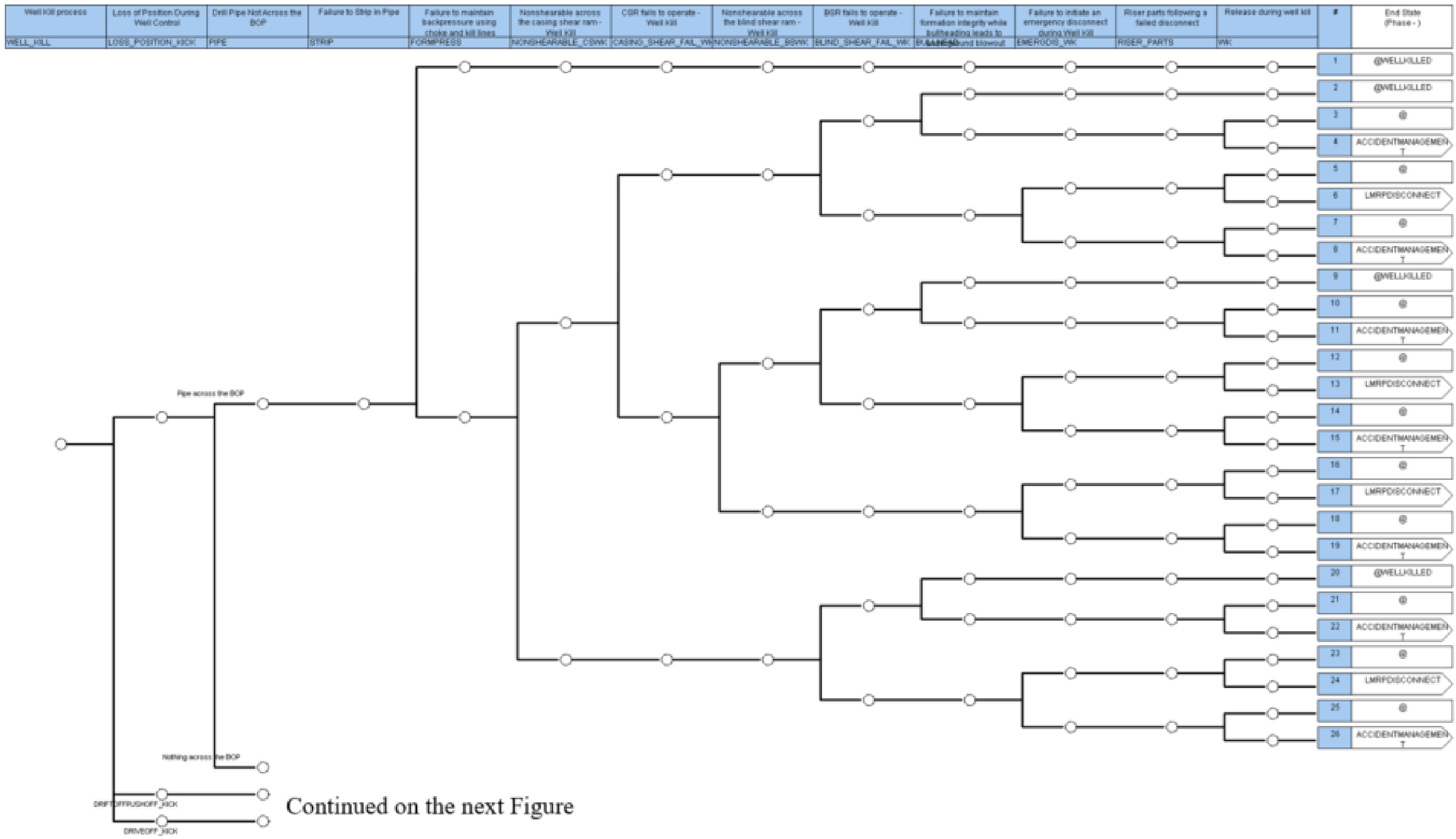

Figure B- 6: WELLKILL Event Tree

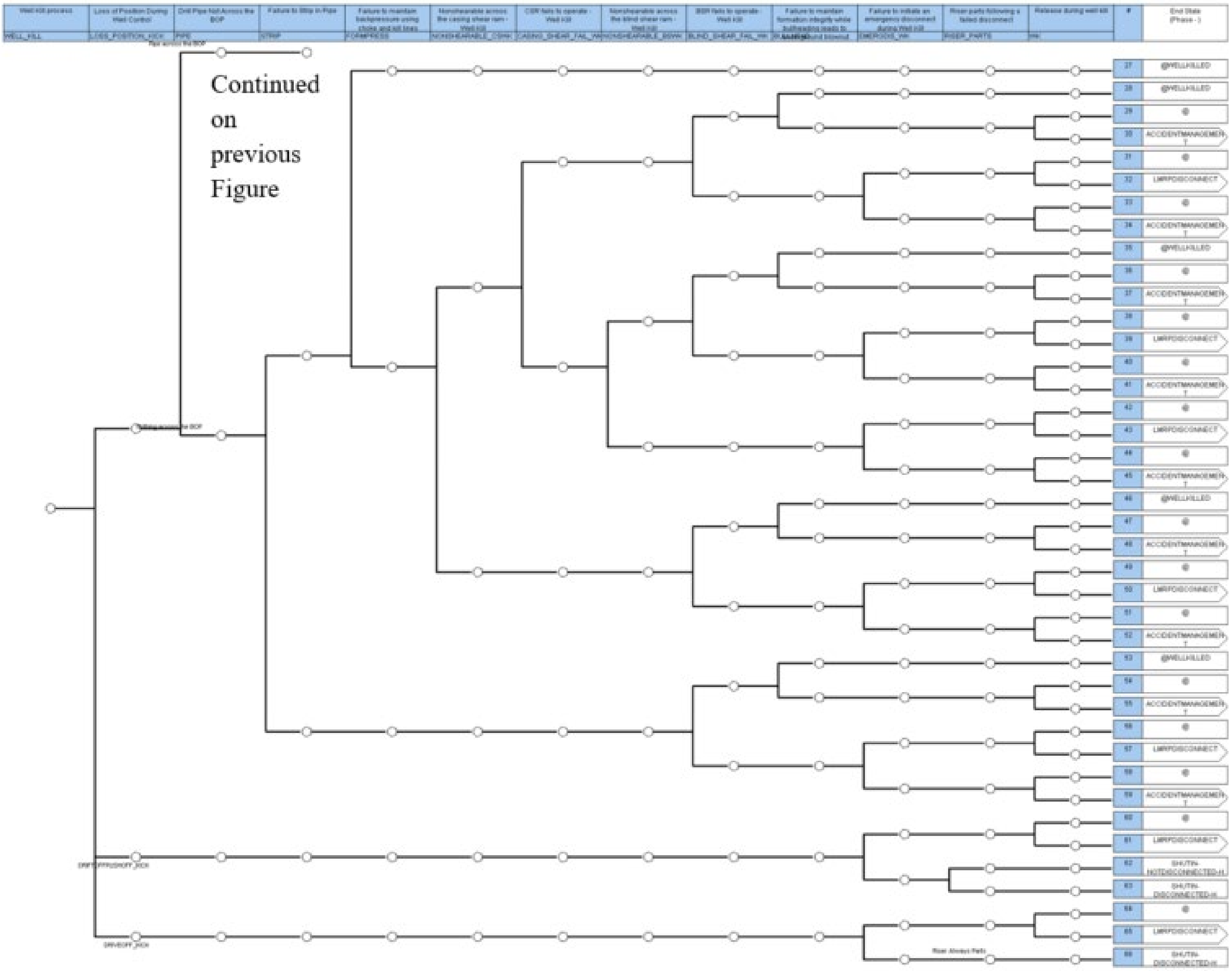

Figure B- 7: WELLKILL Event Tree (Continued)

```
|**************************************************************************************************
|**************************************************************************************************
|*****                                                                                        *****
|*****                                                                                        *****
|*****                    LINKAGE RULES FOR WELLKILL EVENT TREE                               *****
|*****                         DATED 12 JUNE 2018                                             *****
|*****                                                                                        *****
|*****                                                                                        *****
|*****                                                                                        *****
|**************************************************************************************************
|**************************************************************************************************



|**************************************************************************************************
|*****                                                                                        *****
|*****     DEFINE MACROS:   THESE MACROS DETERMINE WHAT IS ACROSS THE BOP (CSR AND BSR)       *****
|*****          AT THE TIME OF THE TRANSFER TO THIS WELLKILL EVENT TREE                       *****
|*****                                                                                        *****
|**************************************************************************************************


|************ MACROS DEFINED FOR SCENARIOS COMING FROM CASING, DRILLING AND NOTHING_BOP EVENT TREES


|KICK WITH CASING AND SEALED WITH ANNULAR  FROM CASING EVENT TREE
CASING_ANNULAR = (CASINGKICK_IC + CASINGKICK_PZ)* /ANNULARS_FAIL * /CASE_SHOE_FAILS ;
```

|KICK WITH DRILLPIPE AND SEALED WITH ANNULAR OR PIPERAM FROM DRILLING EVENT TREE:

DRILLPIPE_ANNULAR = (DRILLKICK_IC + DRILLKICK_PZ) * /ANNULAR_PIPERAM_DR * /IBOP_FLTVLV_FAILS ;

|OPEN HOLE (NOTHING ACROSS BOP) - NOTE THAT EMERGENCY DISCONNECT INITIATION IS NOT INCLUDED IN THIS MACRO, IT IS ADDED LATER IN THE RULES AS NEEDED:

OPENHOLE = (EMPTY_BOP_KICK_IC + EMPTY_BOP_KICK_PZ + |OPEN HOLE WHEN KICK OCCURS

(CASINGKICK_IC + CASINGKICK_PZ) * (/CASING_SHEAR_FAIL_CS + /BLIND_SHEAR_FAIL_CS) + |CASING WHEN KICK OCCURS BUT LATER SHEARED BY EITHER CSR OR BSR

(DRILLKICK_IC + DRILLKICK_PZ) * (/CASING_SHEAR_FAIL_DR + /BLIND_SHEAR_FAIL_DR)) ; |DRILLPIPE WHEN KICK OCCURS BUT LATER SHEARED BY EITHER CSR OR BSR

|***

|***

|***

|***** *****

|***** ASSIGN NONSHEARABLES AND CSR/BSR FAULT TREES ACCORDING TO WHAT IS

ACROSS THE BOP AT THE TIME OF ACTUATION *****

|***** FOR SEQUENCES COMING FROM THE KICK EVENT TREES

(CASING, DRILLING OR NOTHING_BOP) *****

|***** *****

|***

|***

|***** OPEN HOLE AT THE TIME OF WELL KILL *****

|***

|SELECTS FAULT TREE TO ENABLE SEQUENCES TO TAKE THE RIGHT PATH BASED

```
|ON WHETHER THERE IS DRILLPIPE ACROSS THE BOP TO CIRCULATE OUT THE KICK AND KILL THE WELL
IF OPENHOLE  THEN                                   | NOTHING ACROSS THE BOP
PIPE = PIPE1;                                       | SUBSTITUTES TOP EVENT PIPE BY PIPE1 WHICH SETS PROBABILITY = 1 (ALWAYS THE BOTTOM PATH,
                                                     FAILURE, IN THIS CASE MEANING "DRILLPIPE NOT ACROSS THE BOP", I.E. OPEN HOLE
/PIPE= SKIP(PIPE)   ;                               | IGNORES THE SUCCESS PATH (I.E. TUBULAR PRESENT)
ELSEIF CASING_ANNULAR + DRILLPIPE_ANNULAR THEN      | CASING OR DRILLPIPE ARE ACROSS THE BOP (SEALED WITH ANNULAR / PIPERAM
PIPE = SKIP(PIPE);                                  | IGNORES THE FAILURE PATH
ENDIF

|SELECTS FAULT TREES TO ASSIGN TOP EVENTS FOR NONSHEARABLES AND CASING SHEAR RAM  WELLKILL
IF CASING_ANNULAR THEN                              | CASING IS ACROSS THE BOP AND BOP SEALED WITH ANNULAR
NONSHEARABLE_CSWK = NONSHEARABLE_CSCCWK ;           | SUBSTITUTES WITH THE NONSHEARABLE FAULT TREE FOR CSR RUNNING CASING
/NONSHEARABLE_CSWK = NONSHEARABLE_CSCCWK ;
NONSHEARABLE_BSWK = NONSHEARABLE_BSCCWK ;           | SUBSTITUTES WITH THE NONSHEARABLE FAULT TREE FOR BSR RUNNING CASING
/NONSHEARABLE_BSWK = NONSHEARABLE_BSCCWK ;
CASING_SHEAR_FAIL_WK = CASING_SHEAR_FAIL_CSWK ;     | SUBSTITUTES WITH CSR FAULT TREE RUNNING CASING
/CASING_SHEAR_FAIL_WK = CASING_SHEAR_FAIL_CSWK ;
ELSEIF DRILLPIPE_ANNULAR THEN                       | DRILLPIPE IS ACROSS THE BOP AND BOP SEALED WITH ANNULAR OR PIPERAM
NONSHEARABLE_CSWK = NONSHEARABLE_CSTJWK ;           | SUBSTITUTES WITH THE NONSHEARABLE FAULT TREE FOR CSR RUNNING DRILLPIPE
/NONSHEARABLE_CSWK = NONSHEARABLE_CSTJWK ;
NONSHEARABLE_BSWK = NONSHEARABLE_BSTJWK ;           | SUBSTITUTES WITH THE NONSHEARABLE FAULT TREE FOR BSR RUNNING DRILLPIPE
/NONSHEARABLE_BSWK = NONSHEARABLE_BSTJWK ;
CASING_SHEAR_FAIL_WK = CASING_SHEAR_FAIL_DRWK ;     | SUBSTITUTES WITH CSR FAULT TREE RUNNING DRILLPIPE
/CASING_SHEAR_FAIL_WK = CASING_SHEAR_FAIL_DRWK ;
ELSEIF /LOSS_POSITION_KICK * OPENHOLE * /STRIP THEN | STARTS WITH OPEN HOLE BUT THEN STRIPPING DRILLPIPE ACROSS THE BOP SUCCEEDS AND THE
```

```
                                                     NEED TO SHEAR HE DRILLPIPE DUE TO FAILURE TO MAINTAIN BACKPRESSURE
NONSHEARABLE_CSWK = NONSHEARABLE_CSTJWK ;            | SUBSTITUTES WITH THE NONSHEARABLE FAULT TREE FOR CSR RUNNING DRILLPIPE
/NONSHEARABLE_CSWK = NONSHEARABLE_CSTJWK ;
NONSHEARABLE_BSWK = NONSHEARABLE_BSTJWK ;            | SUBSTITUTES WITH THE NONSHEARABLE FAULT TREE FOR BSR RUNNING DRILLPIPE
/NONSHEARABLE_BSWK = NONSHEARABLE_BSTJWK ;
CASING_SHEAR_FAIL_WK = CASING_SHEAR_FAIL_DRWK ;      | SUBSTITUTES WITH CSR FAULT TREE RUNNING DRILLPIPE
/CASING_SHEAR_FAIL_WK = CASING_SHEAR_FAIL_DRWK ;
ENDIF


|SELECTS FAULT TREES TO ASSIGN TOP EVENTS FOR BLIND SHEAR RAM WELLKILL    | CASING IN THE BOP AND NONSHEARABLE ACROSS THE CSR OR CSR FAILED TO
                                                                            SHEAR THE CASING
IF CASING_ANNULAR * ( NONSHEARABLE_CSWK + CASING_SHEAR_FAIL_WK ) THEN     | SUBSTITUTES WITH BSR FAULT TREE RUNNING CASING
BLIND_SHEAR_FAIL_WK = BLIND_SHEAR_FAIL_CSWK ;
/BLIND_SHEAR_FAIL_WK = BLIND_SHEAR_FAIL_CSWK ;
ELSEIF DRILLPIPE_ANNULAR * ( NONSHEARABLE_CSWK + CASING_SHEAR_FAIL_WK ) THEN   | DRILLPIPE IN THE BOP AND NONSHEARABLE ACROSS THE CSR OR CSR
FAILED TO SHEAR THE DRILLPIPE
BLIND_SHEAR_FAIL_WK = BLIND_SHEAR_FAIL_DRWK ;                                  | SUBSTITUTES WITH BSR FAULT TREE RUNNING DRILLPIPE
/BLIND_SHEAR_FAIL_WK = BLIND_SHEAR_FAIL_DRWK ;
ELSEIF ( CASING_ANNULAR + DRILLPIPE_ANNULAR ) * /CASING_SHEAR_FAIL_WK THEN     | CASING OR DRILLPIPE WAS SHEARED BY CSR, THEREFORE OPEN HOLE
BLIND_SHEAR_FAIL_WK = BLIND_SHEAR_FAIL_NABWK ;                                 | SUBSTITUTES WITH BSR FAULT TREE NOTHING ACROSS BOP
/BLIND_SHEAR_FAIL_WK = BLIND_SHEAR_FAIL_NABWK ;
ELSEIF /STRIP * ( NONSHEARABLE_CSWK + CASING_SHEAR_FAIL_WK ) THEN              | STRIPPING SUCCEEDS, BUT FAILURE TO MAINTAIN BACKPRESSURE
                                                                                 FORCES THE NEED TO SEAL THE BOP, HOWEVER EITHER NONSHEARABLE
                                                                                 IS PRESENT ACROSS THE CSR, OR CSR FAILS TO SHEAR, THEREFORE
                                                                                 DRILLPIPE IS ACROSS THE BOP
```

```
BLIND_SHEAR_FAIL_WK = BLIND_SHEAR_FAIL_DRWK ;            | SUBSTITUTES WITH BSR FAULT TREE RUNNING DRILLPIPE
/BLIND_SHEAR_FAIL_WK = BLIND_SHEAR_FAIL_DRWK ;
ELSEIF /STRIP * /CASING_SHEAR_FAIL_WK THEN               | STRIPPING SUCCEEDS, BUT FAILURE TO MAINTAIN BACKPRESSURE
                                                           FORCES THE NEED TO SEAL THE BOP, CSR SUCCEEEDS, THEREFORE OPEN
                                                           HOLE
BLIND_SHEAR_FAIL_WK = BLIND_SHEAR_FAIL_NABWK ;           | SUBSTITUTES WITH BSR FAULT TREE NOTHING ACROSS BOP
/BLIND_SHEAR_FAIL_WK = BLIND_SHEAR_FAIL_NABWK ;
ELSEIF STRIP THEN                                        | STRIPPING FAILS, THEREFORE ASSUMED NOTHING IS ACROSS THE BOP
BLIND_SHEAR_FAIL_WK = BLIND_SHEAR_FAIL_NABWK ;           | SUBSTITUTES WITH BSR FAULT TREE NOTHING ACROSS BOP
/BLIND_SHEAR_FAIL_WK = BLIND_SHEAR_FAIL_NABWK ;
ENDIF
```

B.7 LMRP DISCONNECT EVENT TREE

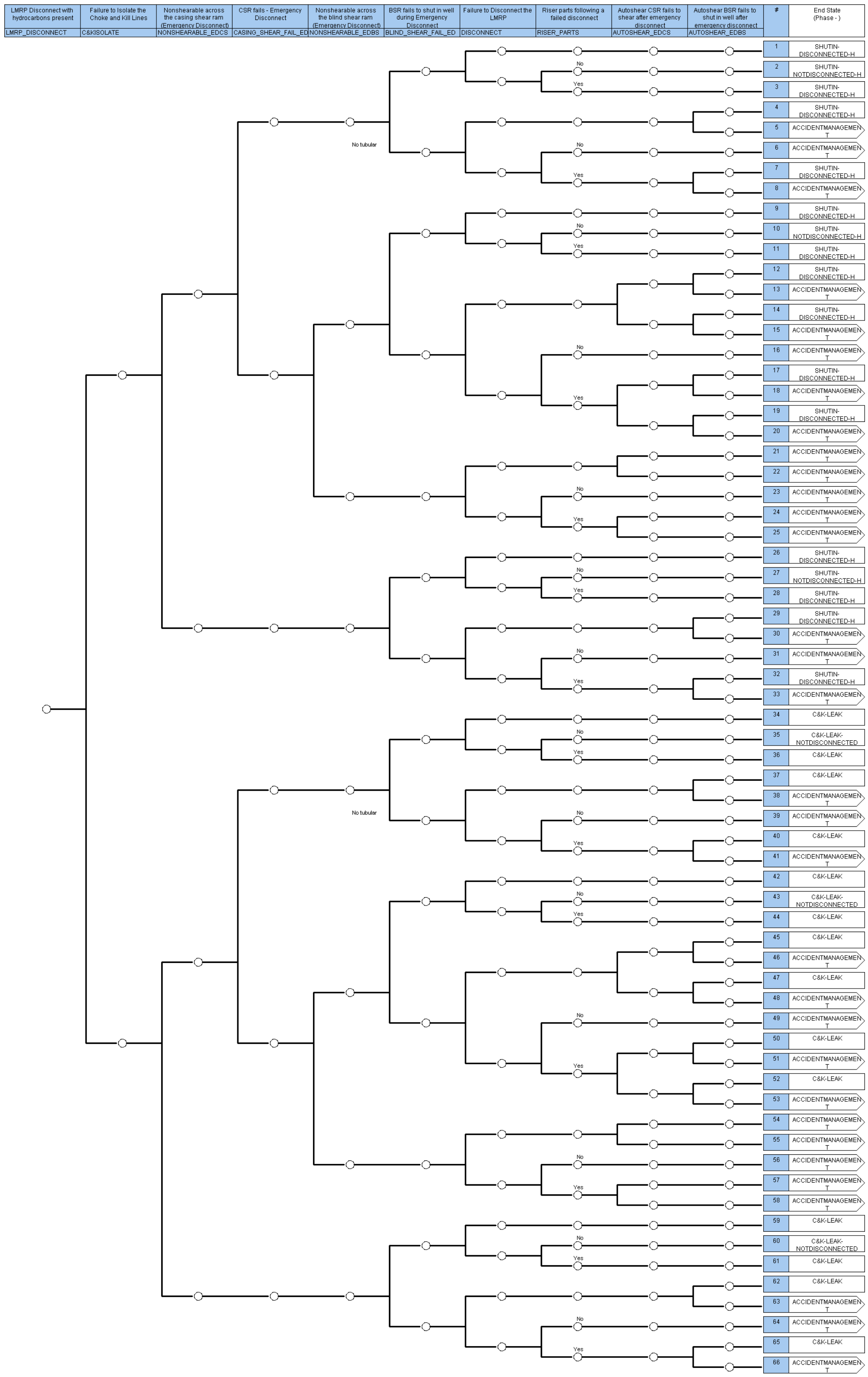

Figure B- 8: LMRPDISCONNECT Event Tree

```
|************************************************************************************************************************************
|************************************************************************************************************************************
|*****                                                                                                                         *****
|*****                                                                                                                         *****
|*****                          LINKAGE RULES FOR LMRP_DISCONNECT EVENT TREE                                                   *****
|*****                                DATED 21 JUNE 2018                                                                       *****
|*****                                                                                                                         *****
|*****                                                                                                                         *****
|************************************************************************************************************************************
|************************************************************************************************************************************

|************************************************************************************************************************************
|*****                                                                                                                         *****
|*****          DEFINE MACROS:   THESE MACROS DETERMINE WHAT IS ACROSS THE BOP (CSR AND BSR)                                   *****
|*****             AT THE TIME OF THE TRANSFER TO THIS LMRP_DISCONNECT EVENT TREE                                              *****
|*****           (TRANSFERS FROM THE KICK EVENT TREES: CASING, DRILLING AND NOTHING_BOP                                        *****
|*****                  AS WELL AS FROM LOSS OF POSITION AND WELKILL EVENT TREES)                                              *****
|*****                                                                                                                         *****
|************************************************************************************************************************************

|******* MACROS DEFINED FOR SCENARIOS COMING DIRECTLY FROM CASING, DRILLING AND NOTHING_BOP EVENT TREES ************
|KICK WITH CASING AND SEALED WITH ANNULAR  FROM CASING EVENT TREE
CASING_ANNULAR = (CASINGKICK_IC + CASINGKICK_PZ)* /ANNULARS_FAIL * /CASE_SHOE_FAILS ;
```

|KICK WITH DRILLPIPE AND SEALED WITH ANNULAR OR PIPERAM FROM DRILLING EVENT TREE:

DRILLPIPE_ANNULAR = (DRILLKICK_IC + DRILLKICK_PZ) * /ANNULAR_PIPERAM_DR * /IBOP_FLTVLV_FAILS ;

|UNDETECTED KICK WITH CASING FROM CASING EVENT TREE AND EMERGENCY DISCONNECT INITIATED:

CASING_KICKNOTDET = (CASINGKICK_IC + CASINGKICK_PZ) * KICKDETECT * /EMERGDIS ;

|UNDETECTED KICK WITH DRILLPIPE FROM DRILLING EVENT TREE AND EMERGENCY DISCONNECT INITIATED:

DRILLPIPE_KICKNOTDET = (DRILLKICK_IC + DRILLKICK_PZ) * KICKDETECT * /EMERGDIS ;

|CASING PRESENT (NO NONSHEARABLES) AND EMERGENCY DISCONNECT INITIATED - NOTE THAT FOR THIS TO HAPPEN, BOTH CSR AND BSR HAD FAILED BEFORE THE INITIATION OF EMERGENCY DISCONNECT:

CASING = (CASINGKICK_IC + CASINGKICK_PZ) * CASING_SHEAR_FAIL_CS * BLIND_SHEAR_FAIL_CS * /EMERGDIS ;

|CASING PRESENT, NONSHEARABLE CASE COUPLING ACROSS THE BSR AND EMERGENCY DISCONNECT INITIATED - NOTE THAT FOR THIS TO HAPPEN, CSR HAD FAILED BEFORE THE INITIATION OF EMERGENCY DISCONNECT:

CASING_NONSHEAR_BSCC = (CASINGKICK_IC + CASINGKICK_PZ) * CASING_SHEAR_FAIL_CS * NONSHEARABLE_BSCC * /EMERGDIS ;

|CASING PRESENT, NONSHEARABLE CASE COUPLING ACROSS THE CSR AND EMERGENCY DISCONNECT INITIATED - NOTE THAT FOR THIS TO HAPPEN, BSR HAD FAILED BEFORE THE INITIATION OF EMERGENCY DISCONNECT:

CASING_NONSHEAR_CSCC = (CASINGKICK_IC + CASINGKICK_PZ) * NONSHEARABLE_CSCC * BLIND_SHEAR_FAIL_CS * /EMERGDIS ;

|DRILLPIPE PRESENT (NO NONSHEARABLES) AND EMERGENCY DISCONNECT INITIATED - NOTE THAT FOR THIS TO HAPPEN, BOTH CSR AND BSR HAD FAILED BEFORE THE INITIATION OF EMERGENCY DISCONNECT:

DRILLPIPE = (DRILLKICK_IC + DRILLKICK_PZ) * CASING_SHEAR_FAIL_DR * BLIND_SHEAR_FAIL_DR * /EMERGDIS ;

|DRILLPIPE PRESENT, NONSHEARABLE TOOLJOINT ACROSS THE BSR AND EMERGENCY DISCONNECT INITIATED - NOTE THAT FOR THIS TO HAPPEN, CSR HAD FAILED BEFORE THE INITIATION OF EMERGENCY DISCONNECT:

DRILLPIPE_NONSHEAR_BSTJ = (DRILLKICK_IC + DRILLKICK_PZ) * CASING_SHEAR_FAIL_DR * NONSHEARABLE_BSTJ * /EMERGDIS ;

|DRILLPIPE PRESENT, NONSHEARABLE TOOLJOINT ACROSS THE CSR AND EMERGENCY DISCONNECT INITIATED - NOTE THAT FOR THIS TO HAPPEN, BSR HAD FAILED BEFORE THE INITIATION OF EMERGENCY DISCONNECT:

DRILLPIPE_NONSHEAR_CSTJ = (DRILLKICK_IC + DRILLKICK_PZ) * NONSHEARABLE_CSTJ * BLIND_SHEAR_FAIL_DR * /EMERGDIS ;

|OPEN HOLE (NOTHING ACROSS BOP) - NOTE THAT EMERGENCY DISCONNECT INITIATION IS NOT INCLUDED IN THIS MACRO, IT IS ADDED LATER IN THE RULES AS NEEDED:

```
OPENHOLE = EMPTY_BOP_KICK_IC + EMPTY_BOP_KICK_PZ +                                    |OPEN HOLE WHEN KICK OCCURS
     (CASINGKICK_IC + CASINGKICK_PZ) * ( /CASING_SHEAR_FAIL_CS + /BLIND_SHEAR_FAIL_CS) +   |CASING WHEN KICK OCCURS BUT LATER SHEARED
     (DRILLKICK_IC + DRILLKICK_PZ) * ( /CASING_SHEAR_FAIL_DR + /BLIND_SHEAR_FAIL_DR) ;     |DRILLPIPE WHEN KICK OCCURS BUT LATER SHEARED
```

|************ MACROS DEFINED FOR SCENARIOS COMING FROM WELL KILL EVENT TREE **

|KICK WITH CASING AND SEALED WITH ANNULAR FROM CASING EVENT TREE, TRANSFER TO WELLKILL, FAILURE TO MAINTAIN BACKPRESSURE, AND FAILED TO SHEAR CASING DURING WELLKILL OPERATIONS:

CASING_WK = CASING_ANNULAR * /NONSHEARABLE_CSWK * CASING_SHEAR_FAIL_WK * /NONSHEARABLE_BSWK * BLIND_SHEAR_FAIL_WK * /EMERGDIS_WK ;

| CSR AND BSR BOTH FAILED TO SHEAR CASING DURING WELLKILL. NO NONSHEARABLES ACROSS CSR OR BSR

CASING_WK_LOP = CASING_ANNULAR * (DRIFT-OFFPUSH-OFF_KICK + DRIVE-OFF_KICK) * /EMERGDIS_WK ;

| CASING ACROSS THE BOP SEALED WITH ANNULAR, LOSS OF POSITION DURING WELLKILL, SO CASING IS STILL THROUGH THE BOP

CASING_NONSHEAR_CSWK = CASING_ANNULAR * NONSHEARABLE_CSWK * BLIND_SHEAR_FAIL_WK * /EMERGDIS_WK ;

| NONSHEARABLE ACROSS CSR, AND BSR FAILED DURING WELLKILL

CASING_NONSHEAR_BSWK = CASING_ANNULAR * /NONSHEARABLE_CSWK * CASING_SHEAR_FAIL_WK * NONSHEARABLE_BSWK * /EMERGDIS_WK ;

| CSR FAILED DURING WELLKILL AND NONSHEARABLE ACROSS

BSR

|KICK WITH DRILLPIPE AND SEALED WITH ANNULAR OR PIPERAM FROM DRILLING EVENT TREE, TRANSFER TO WELLKILL, FAILURE TO MAINTAIN BACKPRESSURE, AND FAILED TO SHEAR DRILLPIPE DURING WELLKILL OPERATIONS:

DRILLPIPE_WK = DRILLPIPE_ANNULAR * /NONSHEARABLE_CSWK * CASING_SHEAR_FAIL_WK * /NONSHEARABLE_BSWK * BLIND_SHEAR_FAIL_WK * /EMERGDIS_WK +

| CSR AND BSR BOTH FAILED TO SHEAR DRILLPIPE DURING WELLKILL. NO NONSHEARABLES ACROSS CSR OR BSR ;

OPENHOLE * /STRIP * CASING_SHEAR_FAIL_WK * BLIND_SHEAR_FAIL_WK * /EMERGDIS_WK ;

| STARTS WITH OPEN HOLE, BOP SEALED, STRIPPING, CSR AND BSR FAIL TO SHEAR THE DRILLPIPE

DRILLPIPE_WK_LOP = DRILLPIPE_ANNULAR * (DRIFT-OFFPUSH-OFF_KICK + DRIVE-OFF_KICK) * /EMERGDIS_WK ;

| DRILLPIPE ACROSS THE BOP SEALED WITH ANNULAR/PIPERAM, LOSS OF POSITION DURING WELLKILL, SO DRILLPIPE IS STILL THROUGH THE BOP

DRILLPIPE_NONSHEAR_CSWK = DRILLPIPE_ANNULAR * NONSHEARABLE_CSWK * BLIND_SHEAR_FAIL_WK * /EMERGDIS_WK +

| DRILLPIPE SEALED WITH ANNULAR OR PIPERAM, AND NONSHEARABLE ACROSS CSR, AND BSR FAILED DURING WELLKILL

OPENHOLE * /STRIP * NONSHEARABLE_CSWK * BLIND_SHEAR_FAIL_WK * /EMERGDIS_WK ;

| OPENHOLE, BUT THEN ADDING DRILLPIPE FOR STRIPPING, AND TOOLJOINT ACROSS THE CSR WHEN SHEARING IS NEEDED DUE TO FAILURE TO MAINTAIN BACKPRESSURE, AND BSR FAILS TO SHEAR THE DRILLPIPE

DRILLPIPE_NONSHEAR_BSWK = DRILLPIPE_ANNULAR * /NONSHEARABLE_CSWK * CASING_SHEAR_FAIL_WK * NONSHEARABLE_BSWK * /EMERGDIS_WK +

| CSR FAILED DURING WELLKILL AND NONSHEARABLE ACROSS BSR

OPENHOLE * /STRIP * NONSHEARABLE_BSWK * /EMERGDIS_WK ; | OPENHOLE, BUT THEN ADDING DRILLPIPE FOR STRIPPING, AND TOOLJOINT ACROSS THE BSR WHEN SHEARING IS NEEDED DUE TO FAILURE TO MAINTAIN BACKPRESSURE

|OPENHOLE TRANSFERS FROM WELLKILL - NOTE THAT THIS MACRO INCLUDES SUCCESS OF EMERGENCY DISCONNECT INITIATION DURING WELL KILL:

OPENHOLE_WK = OPENHOLE * STRIP * /EMERGDIS_WK + | OPENHOLE SINCE COMING INTO WELLKILL EVENT TREE, AND STRIPPING PIPE FAILED, AND EMERGENCY DISCONNECT INITIATION

OPENHOLE * /STRIP * (/CASING_SHEAR_FAIL_WK + /BLIND_SHEAR_FAIL_WK) * /EMERGDIS_WK +

| STARTS WITH OPEN HOLE, BUT THEN ADDING DRILLPIPE FOR STRIPPING, AND DRILLPIPE SHEARED BY CSR OR BSR, AND EMERGENCY DISCONNECT INITIATION

OPENHOLE * (DRIFT-OFFPUSH-OFF_KICK + DRIVE-OFF_KICK) * /EMERGDIS_WK + | OPENHOLE WHEN COMING INTO WELLKILL, BUT POSITIONKEEPING IS LOST FORCING EMERGENCY DISCONNECT INITIATION.

CASING_ANNULAR * (/CASING_SHEAR_FAIL_WK + /BLIND_SHEAR_FAIL_WK) * /EMERGDIS_WK +

| CASING SEALED WITH ANNULAR FROM CASING EVENT TREE, TRANSFER TO WELLKILL, FAILURE TO MAINTAIN BACKPRESSURE, AND CASING SHEARED BY CSR OR BSR DURING WELLKILL OPERATIONS

DRILLPIPE_ANNULAR *(/CASING_SHEAR_FAIL_WK + /BLIND_SHEAR_FAIL_WK) * /EMERGDIS_WK ;

| DRILLPIPE SEALED WITH ANNULAR/PIPERAM FROM DRILLING EVENT TREE, TRANSFER TO WELLKILL, FAILURE TO MAINTAIN BACKPRESSURE, AND DRILLPIPE SHEARED BY CSR OR BSR DURING WELLKILL OPERATIONS

|************ MACROS DEFINED FOR SCENARIOS COMING FROM LOSS OF POSITION EVENT TREE ***

```
|CASING PRESENT WHEN DRIFT-OFF / PUSH-OFF OR WHEN DRIVE-OFF

CASING_DRIFT =  DRIFT-OFFPUSH-OFF_IEFT_FRE * (RUNNINGCASING_IC + RUNNINGCASING_PZ) * /EMERGDIS_POS   ;

CASING_DRIVE-OFF =  DRIVE-OFF_IEFT_FRE * (RUNNINGCASING_IC + RUNNINGCASING_PZ) * /EMERGDIS_POS ;


|DRILLPIPE PRESENT WHEN DRIFT-OFF / PUSH-OFF  OR WHEN DRIVE-OFF

DRILLPIPE_DRIFT  = DRIFT-OFFPUSH-OFF_IEFT_FRE * (DRILLSTRINGIN_IC + DRILLSTRINGIN_PZ) * /EMERGDIS_POS ;

DRILLPIPE_DRIVE-OFF  = DRIVE-OFF_IEFT_FRE * (DRILLSTRINGIN_IC + DRILLSTRINGIN_PZ) * /EMERGDIS_POS ;


|OPEN HOLE WHEN DRIFT-OFF / PUSH-OFF  OR WHEN DRIVE-OFF

OPENHOLE_DRIFTORDRIVE-OFF =  ( DRIFT-OFFPUSH-OFF_IEFT_FRE + DRIVE-OFF_IEFT_FRE ) * (OPENHOLE_IC + OPENHOLE_PZ) * /EMERGDIS_POS  ;


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|*****************************************************************************************************************
|*****                                                                                                       *****
|*****ASSIGN NONSHEARABLES AND CSR/BSR FAULT TREES ACCORDING TO WHAT IS ACROSS THE BOP AT THE TIME OF ACTUATION*****
|*****          FOR SEQUENCES COMING FROM THE KICK EVENT TREES (CASING, DRILLING OR NOTHING_BOP)             *****
|*****                                                                                                       *****
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 |*****                              OPEN HOLE AT THE TIME OF EDS INITIATION                                 *****
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|ASSIGNING NONSHEARABLE_EDCS, NONSHEARABLE_EDBS, CSR, BSR, AUTOSHEAR_CS AND AUTOSHEAR_BS FAULT TREES WHEN NOTHING IS ACROSS THE BOP AT THE TIME OF EMERGENCY DISCONNECT

IF ( OPENHOLE * /EMERGDIS + OPENHOLE_WK ) THEN             | NOTHING IS ACROSS THE BOP AND EMERGENCY DISCONNECT IS INITIATED
/NONSHEARABLE_EDCS = NONSHEARABLE_CSNAB ;                  | SETS PROBABILITY OF NONSHEARABLE ACROSS CSR = 0 SINCE NOTHING IS ACROSS THE BOP
                                                            (THEREFORE ALL SEQUENCES WILL GO THROUGH THE SUCCESS BRANCH, NO
                                                           NONSHEARABLES, WITH PROB = 1)
NONSHEARABLE_EDCS = SKIP(NONSHEARABLE_EDCS) ;              | SKIPS THE FAILURE PATH
/NONSHEARABLE_EDBS = NONSHEARABLE_BSNAB ;                   | SAME FOR NONSHEARABLE ACROSS BSR
NONSHEARABLE_EDBS = SKIP(NONSHEARABLE_EDBS) ;               | SKIPS THE FAILURE PATH
/CASING_SHEAR_FAIL_ED = CASING_SHEAR_FAIL_EDNAB ;          | SETS CSR FAILURE PROBABILITY = 0 SINCE CSR IS NOT REQUIRED WHEN EMPTY HOLE
                                                            (THEREFORE ALL SEQUENCES WILL GO THROUGH THE SUCCESS BRANCH WITH PROB = 1)
CASING_SHEAR_FAIL_ED = SKIP(CASING_SHEAR_FAIL_ED) ;        | SKIPS THE FAILURE PATH
/BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDNAB ;             | SUBSTITUTES BSR FAILURE WITH THE BSR FAULT TREE WHEN NOTHING IS ACROSS THE
                                                            BOP (BSR NEEDS TO CLOSE IN ORDER TO SEAL THE WELL)
BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDNAB ;
/AUTOSHEAR_EDCS = AUTOSHEAR_EDCSNAB    ;                    | SETS AUTOSHEAR CSR FAILURE PROBABILITY = 0 SINCE CSR IS NOT REQUIRED WHEN
                                                            EMPTY HOLE (THEREFORE ALL SEQUENCES WILL GO THROUGH THE SUCCESS BRANCH WITH
                                                            PROB = 1)
AUTOSHEAR_EDCS = SKIP(AUTOSHEAR_EDCS)    ;                 | SKIPS THE FAILURE PATH
/AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB    ;                    | SUBSTITUTES AUTOSHEAR BSR FAILURE WITH THE AUTOSHEAR BSR FAULT TREE WHEN
                                                            NOTHING IS ACROSS THE BOP (BSR NEEDS TO CLOSE IN ORDER TO SEAL THE WELL)
AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB    ;
ENDIF

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|*****   CASING ACROSS THE BOP WITH OR WITHOUT NONSHEARABLE ACROSS CSR OR BSR AT THE TIME OF EDS INITIATION   *****
|*******************************************************************************************************************
|ASSIGNING NONSHEARABLE_EDCS, NONSHEARABLE_EDBS, AND CSR FAULT TREES WHEN CASING IS ACROSS THE CSR AT THE TIME OF EMERGENCY DISCONNECT
IF CASING_NONSHEAR_CSCC + CASING_NONSHEAR_CSWK  THEN          | NONSHEARABLE ACROSS THE CSR PRESENT IN CASING EVENT TREE
/NONSHEARABLE_EDCS = SKIP(NONSHEARABLE_EDCS)   ;              | SETS PROBABILITY OF NONSHEARABLE ACROSS CSR = 1 WHERE NONSHEARABLES WERE
                                                                PRESENT ACROSS CSR IN PREVIOUS EVENT TREE AND SKIPS THE SUCCESS PATH
NONSHEARABLE_EDCS = NONSHEARABLE_CSCC1   ;
/BLIND_SHEAR_FAIL_ED = SKIP(BLIND_SHEAR_FAIL_ED);             | SETS BSR FAILURE PROBABILITY = 1 SINCE BSR HAS FAILED BEFORE (FAILED STATE, NO
                                                                RECOVERY ALLOWED) (NO NEED TO SUBSTITUTE CSR FAILURE SINCE THIS TOP EVENT IS
                                                                SKIPPED DUE TO THE NONSHEARABLE
BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDCS1;
ELSEIF CASING_NONSHEAR_BSCC + CASING_NONSHEAR_BSWK THEN       | NONSHEARABLE ACROSS THE BSR PRESENT IN CASING EVENT TREE
/NONSHEARABLE_EDCS = NONSHEARABLE_CS0   ;                     | SETS PROBABILITY OF NONSHEARABLE ACROSS CSR = 0 WHERE NONSHEARABLES WERE
                                                                PRESENT ACROSS BSR IN PREVIOUS EVENT TREE (NOT POSSIBLE TO HAVE NON SHEARABLES
                                                                IN BOTH RAMS AT THE SAME TIME)
NONSHEARABLE_EDCS = SKIP(NONSHEARABLE_EDCS)   ;               | SKIPS THE FAILURE PATH
/NONSHEARABLE_EDBS = SKIP(NONSHEARABLE_EDBS)   ;              | SETS PROBABILITY OF NONSHEARABLE ACROSS BSR = 1 WHERE NONSHEARABLES WERE
                                                                PRESENT ACROSS BSR IN PREVIOUS EVENT TREE
NONSHEARABLE_EDBS = NONSHEARABLE_BSCC1   ;
/CASING_SHEAR_FAIL_ED = SKIP(CASING_SHEAR_FAIL_ED) ;          | SETS CSR FAILURE PROBABILITY = 1 SINCE CSR HAS FAILED BEFORE (FAILED STATE, NO
                                                                RECOVERY ALLOWED) AND SKIPS THE SUCCESS PATH
CASING_SHEAR_FAIL_ED = CASING_SHEAR_FAIL_EDCS1 ;
ELSEIF CASING + CASING_WK THEN                                | IF THERE IS CASING (WITHOUT NONSHEARABLES ACROSS THE BOP) AT THE TIME OF EDS
                                                                ACTUATION, IT MEANS THAT BOTH CSR AND BSR HAVE FAILED BEFORE
/NONSHEARABLE_EDCS = NONSHEARABLE_CS0   ;                     | SETS PROBABILITY OF NONSHEARABLE ACROSS CSR = 0 SINCE NONSHEARABLES NOT
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                                                          PRESENT BEFORE
NONSHEARABLE_EDCS = SKIP(NONSHEARABLE_EDCS)   ;           | SKIPS THE FAILURE PATH
/NONSHEARABLE_EDBS = NONSHEARABLE_BS0   ;                 | SAME FOR PROBABILITY OF NONSHEARABLE ACROSS BSR
NONSHEARABLE_EDBS = SKIP(NONSHEARABLE_EDBS)   ;           | SKIPS THE FAILURE PATH
/CASING_SHEAR_FAIL_ED = SKIP(CASING_SHEAR_FAIL_ED) ;      | SETS CSR FAILURE PROBABILITY = 1 SINCE CSR HAS FAILED BEFORE (FAILED STATE, NO
                                                          RECOVERY ALLOWED)
CASING_SHEAR_FAIL_ED = CASING_SHEAR_FAIL_EDCS1 ;          | SKIPS THE FAILURE PATH
/BLIND_SHEAR_FAIL_ED = SKIP(BLIND_SHEAR_FAIL_ED) ;        | SETS BSR FAILURE PROBABILITY = 1 SINCE BSR HAS FAILED BEFORE (FAILED STATE, NO
                                                          RECOVERY ALLOWED)
BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDCS1 ;
ELSIF CASING_KICKNOTDET + CASING_WK_LOP THEN               | KICK WAS NOT DETECTED, SO NOTHING HAS BEEN QUESTIONED IN EARLIER EVENT TREES
/NONSHEARABLE_EDCS = NONSHEARABLE_CSCC ;                  | SUBSTITUTES WITH THE NONSHEARABLE FAULT TREE FOR CSR RUNNING CASING
NONSHEARABLE_EDCS = NONSHEARABLE_CSCC ;
/NONSHEARABLE_EDBS = NONSHEARABLE_BSCC ;                  | SUBSTITUTES WITH THE NONSHEARABLE FAULT TREE FOR BSR RUNNING CASING
NONSHEARABLE_EDBS = NONSHEARABLE_BSCC ;
/CASING_SHEAR_FAIL_ED = CASING_SHEAR_FAIL_EDCS ;          | SUBSTITUTES CSR FAILURE WITH THE CSR FAULT TREE WHEN CASING IS ACROSS THE BOP
CASING_SHEAR_FAIL_ED = CASING_SHEAR_FAIL_EDCS ;
ENDIF

|ASSIGNING BSR FAULT TREES WHEN CASING  IS ACROSS THE BOP AT THE TIME OF LMRP DISCONNECT (EDS) AND KICK WAS NOT DETECTED
IF ( CASING_KICKNOTDET + CASING_WK_LOP ) * /CASING_SHEAR_FAIL_ED THEN        | CSR SUCCESSFULLY SHEARED THE CASING DURING EDS
/BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDNAB;                               | SUBSTITUTES BSR FAILURE WITH THE BSR FAULT TREE WHEN NOTHING
                                                                             IS ACROSS THE BOP (BSR NEEDS TO CLOSE IN ORDER TO SEAL THE WELL)
BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDNAB;
ELSEIF ( CASING_KICKNOTDET + CASING_WK_LOP ) * ( CASING_SHEAR_FAIL_ED + NONSHEARABLE_EDCS)  THEN
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                                                  | CASING THROUGH BOP THAT WAS NOT SHEARED
                                                  BY CSR DUE TO CSR FAILURE IN EDS OR NONSHEARABLE PRESENT
                                                   ACROSS THE CSR
/BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDCS ;     | SUBSTITUTES BSR FAILURE WITH THE BSR FAULT TREE WHEN CASING IS
                                                   ACROSS THE BOP
BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDCS ;
ENDIF

|ASSIGNING AUTOSHEAR CSR FAULT TREES WHEN CASING IS ACROSS THE BOP AT THE TIME OF AUTOSHEAR ACTUATION AFTER LMRP DISCONNECT
IF (CASING + CASING_WK + CASING_KICKNOTDET + CASING_WK_LOP ) * CASING_SHEAR_FAIL_ED * BLIND_SHEAR_FAIL_ED THEN
                                                  | NEITHER CSR NOR BSR COULD SHEAR THE CASING DURING EDS
/AUTOSHEAR_EDCS = AUTOSHEAR_EDCSCS   ;            | SUBSTITUTES AUTOSHEAR CSR FAILURE WITH THE FAULT TREE WHEN
                                                   CASING IS ACROSS THE BOP
AUTOSHEAR_EDCS = AUTOSHEAR_EDCSCS   ;
ELSEIF (CASING + CASING_WK + CASING_KICKNOTDET + CASING_WK_LOP) * NONSHEARABLE_EDBS + CASING_NONSHEAR_BSCC  THEN
                                                  | NONSHEARABLE IN BSR, THEREFORE BSR IS SKIPPED
                                                  AND CASING IS STILL ACROSS THE BOP
/AUTOSHEAR_EDCS = AUTOSHEAR_EDCSCS   ;            | SUBSTITUTES AUTOSHEAR CSR FAILURE WITH THE FAULT TREE WHEN
                                                   CASING IS ACROSS THE BOP
AUTOSHEAR_EDCS = AUTOSHEAR_EDCSCS   ;
ENDIF

|ASSIGNING AUTOSHEAR BSR FAULT TREES WHEN CASING  IS ACROSS THE BOP AT THE TIME OF AUTOSHEAR ACTUATION AFTER LMRP DISCONNECT
IF (CASING + CASING_WK + CASING_KICKNOTDET + CASING_WK_LOP ) * CASING_SHEAR_FAIL_ED * BLIND_SHEAR_FAIL_ED * AUTOSHEAR_EDCS THEN
                                                        | NEITHER CSR, BSR, NOR AUTOSHEAR_CSR COULD SHEAR THE
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CASING DURING EDS

/AUTOSHEAR_EDBS = AUTOSHEAR_EDBSCS ; | SUBSTITUTES AUTOSHEAR CSR FAILURE WITH THE FAULT TREE WHEN CASING IS ACROSS THE BOP

AUTOSHEAR_EDBS = AUTOSHEAR_EDBSCS ;

ELSEIF (CASING + CASING_WK + CASING_KICKNOTDET + CASING_WK_LOP) * ((CASING_SHEAR_FAIL_ED * BLIND_SHEAR_FAIL_ED * /AUTOSHEAR_EDCS) + /CASING_SHEAR_FAIL_ED) THEN | NEITHER CSR, BSR, NOR AUTOSHEAR_CSR COULD SHEAR THE CASING DURING EDS

/AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB ; | SUBSTITUTES AUTOSHEAR CSR FAILURE WITH THE FAULT TREE WHEN NOTHING IS ACROSS THE BOP

AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB ;

ELSEIF ((CASING_KICKNOTDET + CASING_WK_LOP) * NONSHEARABLE_EDBS + CASING_NONSHEAR_BSCC + CASING_NONSHEAR_BSWK) * /AUTOSHEAR_EDCS THEN

| NONSHEARABLE ACROSS THE BSR (EITHER COMING FROM CASING EVENT TREE OR ON KICK DETECTION FAILURE) AND CSR AUTOSHEAR FAILURE

/AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB ; | SUBSTITUTES AUTOSHEAR CSR FAILURE WITH THE FAULT TREE WHEN CASING IS ACROSS THE BOP

AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB ;

ELSEIF ((CASING_KICKNOTDET + CASING_WK_LOP) * NONSHEARABLE_EDCS + CASING_NONSHEAR_CSCC + CASING_NONSHEAR_CSWK) * BLIND_SHEAR_FAIL_ED THEN | NONSHEARABLE ACROSS THE CSR (EITHER COMING FROM CASING EVENT TREE OR ON KICK DETECTION FAILURE) AND BSR FAILURE DURING EDS

/AUTOSHEAR_EDBS = AUTOSHEAR_EDBSCS ; | SUBSTITUTES AUTOSHEAR BSR FAILURE WITH THE FAULT TREE WHEN CASING IS ACROSS THE BOP

AUTOSHEAR_EDBS = AUTOSHEAR_EDBSCS ;

ELSEIF CASING_NONSHEAR_BSCC + CASING_NONSHEAR_BSWK THEN | IF CASE COUPLING IS ACROSS BSR AT THE TIME OF AUTOSHEAR ACTUATION, BUT

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/AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB   ;                | SUBSTITUTES AUTOSHEAR CSR FAILURE WITH THE FAULT
                                                         TREE WHEN CASING IS ACROSS THE BOP
AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB   ;
ENDIF

|****************************************************************************************************************
|***** DRILLPIPE ACROSS THE BOP WITH OR WITHOUT NONSHEARABLE ACROSS CSR OR BSR AT THE TIME OF EDS INITIATION     *****
|****************************************************************************************************************
|ASSIGNING NONSHEARABLE_EDCS, NONSHEARABLE_EDBS, AND CSR FAULT TREES WHEN DRILLPIPE IS ACROSS THE CSR AT THE TIME OF EMERGENCY DISCONNECT
IF DRILLPIPE_NONSHEAR_CSTJ + DRILLPIPE_NONSHEAR_CSWK THEN          | NONSHEARABLE ACROSS THE CSR PRESENT IN DRILLING EVENT TREE
/NONSHEARABLE_EDCS = SKIP(NONSHEARABLE_EDCS)   ;                   | SETS PROBABILITY OF NONSHEARABLE ACROSS CSR = 1 WHERE
                                                                     NONSHEARABLES WERE PRESENT ACROSS CSR IN PREVIOUS EVENT TREE
                                                                    AND SKIPS THE SUCCESS PATH
NONSHEARABLE_EDCS = NONSHEARABLE_CSTJ1   ;
/BLIND_SHEAR_FAIL_ED = SKIP(BLIND_SHEAR_FAIL_ED) ;                 | SETS BSR FAILURE PROBABILITY = 1 SINCE BSR HAS FAILED BEFORE
                                                                     (FAILED STATE, NO RECOVERY ALLOWED) (NO NEED TO SUBSTITUTE CSR
                                                                     FAILURE SINCE THIS TOP EVENT IS SKIPPED DUE TO THE NONSHEARABLE)
BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDDR1;
ELSEIF DRILLPIPE_NONSHEAR_BSTJ + DRILLPIPE_NONSHEAR_BSWK THEN      | NONSHEARABLE ACROSS THE BSR PRESENT IN DRILLING EVENT TREE
/NONSHEARABLE_EDCS = NONSHEARABLE_CS0   ;                          | SETS PROBABILITY OF NONSHEARABLE ACROSS CSR = 0 WHERE
                                                                     NONSHEARABLES WERE PRESENT ACROSS BSR IN PREVIOUS EVENT TREE
                                                                     (NOT POSSIBLE TO HAVE NON SHEARABLES IN BOTH RAMS AT THE SAME
                                                                     TIME)
NONSHEARABLE_EDCS = SKIP(NONSHEARABLE_EDCS)   ;                    | SKIPS THE FAILURE PATH
/NONSHEARABLE_EDBS = SKIP(NONSHEARABLE_EDBS)   ;                   | SETS PROBABILITY OF NONSHEARABLE ACROSS BSR = 1 WHERE
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                                                            NONSHEARABLES WERE PRESENT ACROSS BSR IN PREVIOUS EVENT TREE
NONSHEARABLE_EDBS = NONSHEARABLE_BSTJ1   ;
/CASING_SHEAR_FAIL_ED = SKIP(CASING_SHEAR_FAIL_ED) ;        | SETS CSR FAILURE PROBABILITY = 1 SINCE CSR HAS FAILED BEFORE
                                                            (FAILED STATE, NO RECOVERY ALLOWED) AND SKIPS THE SUCCESS PATH
CASING_SHEAR_FAIL_ED = CASING_SHEAR_FAIL_EDDR1 ;
ELSEIF DRILLPIPE + DRILLPIPE_WK THEN                        | IF THERE IS DRILLPIPE (WITHOUT NONSHEARABLES ACROSS THE BOP) AT
                                                            THE TIME OF EDS ACTUATION, IT MEANS THAT BOTH CSR AND BSR HAVE
                                                            FAILED BEFORE
/NONSHEARABLE_EDCS = NONSHEARABLE_CS0   ;                   | SETS PROBABILITY OF NONSHEARABLE ACROSS CSR = 0 SINCE
                                                            NONSHEARABLES NOT PRESENT BEFORE
NONSHEARABLE_EDCS = SKIP(NONSHEARABLE_EDCS)   ;             | SKIPS THE FAILURE PATH
/NONSHEARABLE_EDBS = NONSHEARABLE_BS0   ;                   | SAME FOR PROBABILITY OF NONSHEARABLE ACROSS BSR
NONSHEARABLE_EDBS = SKIP(NONSHEARABLE_EDBS)   ;             | SKIPS THE FAILURE PATH
/CASING_SHEAR_FAIL_ED = SKIP(CASING_SHEAR_FAIL_ED) ;        | SETS CSR FAILURE PROBABILITY = 1 SINCE CSR HAS FAILED BEFORE
                                                            (FAILED STATE, NO RECOVERY ALLOWED) AND SKIPS THE SUCCESS PATH
CASING_SHEAR_FAIL_ED = CASING_SHEAR_FAIL_EDDR1 ;
/BLIND_SHEAR_FAIL_ED = SKIP(BLIND_SHEAR_FAIL_ED) ;          | SETS BSR FAILURE PROBABILITY = 1 SINCE BSR HAS FAILED BEFORE
                                                            (FAILED STATE, NO RECOVERY ALLOWED) AND SKIPS THE SUCCESS PATH
BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDDR1 ;
ELSIF DRILLPIPE_KICKNOTDET + DRILLPIPE_WK_LOP THEN      |   KICK WAS NOT DETECTED, SO NOTHING HAS BEEN QUESTIONED IN
                                                            EARLIER EVENT TREES
/NONSHEARABLE_EDCS = NONSHEARABLE_CSTJ ;                    | SUBSTITUTES WITH THE NONSHEARABLE FAULT TREE FOR CSR RUNNING
                                                            DRILLPIPE
NONSHEARABLE_EDCS = NONSHEARABLE_CSTJ ;
/NONSHEARABLE_EDBS = NONSHEARABLE_BSTJ ;                    | SUBSTITUTES WITH THE NONSHEARABLE FAULT TREE FOR BSR RUNNING
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                                                              DRILLPIPE
NONSHEARABLE_EDBS = NONSHEARABLE_BSTJ ;
/CASING_SHEAR_FAIL_ED = CASING_SHEAR_FAIL_EDDR ;              | SUBSTITUTES CSR FAILURE WITH THE CSR FAULT TREE WHEN DRILLPIPE
                                                              IS ACROSS THE BOP
CASING_SHEAR_FAIL_ED = CASING_SHEAR_FAIL_EDDR ;
ENDIF

|ASSIGNING BSR FAULT TREES WHEN DRILLPIPE IS ACROSS THE BOP AT THE TIME OF LMRP DISCONNECT (EDS) AND KICK WAS NOT DETECTED
IF ( DRILLPIPE_KICKNOTDET + DRILLPIPE_WK_LOP ) * /CASING_SHEAR_FAIL_ED THEN     | CSR SUCCESSFULLY SHEARED THE DRILLPIPE DURING EDS
/BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDNAB;                  | SUBSTITUTES BSR FAILURE WITH THE BSR FAULT TREE WHEN
                                                                NOTHING IS ACROSS THE BOP (BSR NEEDS TO CLOSE IN ORDER
                                                                TO SEAL THE WELL)
BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDNAB;
ELSEIF ( DRILLPIPE_KICKNOTDET + DRILLPIPE_WK_LOP ) * ( CASING_SHEAR_FAIL_ED + NONSHEARABLE_EDCS)  THEN
                                                              | DRILLPIPE THROUGH BOP THAT WAS NOT SHEARED BY CSR DUE TO CSR
                                                              FAILURE IN EDS OR NONSHEARABLE PRESENT ACROSS THE CSR
/BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDDR ;                | SUBSTITUTES BSR FAILURE WITH THE BSR FAULT TREE WHEN DRILLPIPE
                                                              IS ACROSS THE BOP
BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDDR ;
ENDIF

|ASSIGNING AUTOSHEAR CSR FAULT TREES WHEN DRILLPIPE IS ACROSS THE BOP AT THE TIME OF AUTOSHEAR ACTUATION AFTER LMRP DISCONNECT (EDS)
IF (DRILLPIPE + DRILLPIPE_WK + DRILLPIPE_KICKNOTDET + DRILLPIPE_WK_LOP ) * CASING_SHEAR_FAIL_ED * BLIND_SHEAR_FAIL_ED THEN
                                                              | NEITHER CSR NOR BSR COULD SHEAR THE DRILLPIPE DURING EDS
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/AUTOSHEAR_EDCS = AUTOSHEAR_EDCSDP ; | SUBSTITUTES AUTOSHEAR CSR FAILURE WITH THE FAULT TREE WHEN DRILLPIPE IS ACROSS THE BOP

AUTOSHEAR_EDCS = AUTOSHEAR_EDCSDP ;

ELSEIF (DRILLPIPE + DRILLPIPE_WK + DRILLPIPE_KICKNOTDET + DRILLPIPE_WK_LOP) * NONSHEARABLE_EDBS + DRILLPIPE_NONSHEAR_BSTJ + DRILLPIPE_NONSHEAR_BSWK THEN

| NONSHEARABLE IN BSR, THEREFORE BSR IS SKIPPED AND DRILLPIPE IS STILL ACROSS THE BOP

/AUTOSHEAR_EDCS = AUTOSHEAR_EDCSDP ; | SUBSTITUTES AUTOSHEAR CSR FAILURE WITH THE FAULT TREE WHEN DRILLPIPE IS ACROSS THE BOP

AUTOSHEAR_EDCS = AUTOSHEAR_EDCSDP ;

ENDIF

|ASSIGNING AUTOSHEAR BSR FAULT TREES WHEN DRILLPIPE IS ACROSS THE BOP AT THE TIME OF AUTOSHEAR ACTUATION AFTER LMRP DISCONNECT (EDS)

IF (DRILLPIPE + DRILLPIPE_WK + DRILLPIPE_KICKNOTDET + DRILLPIPE_WK_LOP) * CASING_SHEAR_FAIL_ED * BLIND_SHEAR_FAIL_ED * AUTOSHEAR_EDCS THEN

| NEITHER CSR, BSR, NOR AUTOSHEAR_CSR COULD SHEAR THE DRILLPIPE DURING EDS

/AUTOSHEAR_EDBS = AUTOSHEAR_EDBSDP ; | SUBSTITUTES AUTOSHEAR CSR FAILURE WITH THE FAULT TREE WHEN DRILLPIPE IS ACROSS THE BOP

AUTOSHEAR_EDBS = AUTOSHEAR_EDBSDP ;

ELSEIF (DRILLPIPE + DRILLPIPE_WK + DRILLPIPE_KICKNOTDET + DRILLPIPE_WK_LOP) * ((CASING_SHEAR_FAIL_ED * BLIND_SHEAR_FAIL_ED * /AUTOSHEAR_EDCS) + /CASING_SHEAR_FAIL_ED) THEN | NEITHER CSR, BSR, NOR AUTOSHEAR_CSR COULD SHEAR THE DRILLPIPE DURING EDS

/AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB ; | SUBSTITUTES AUTOSHEAR CSR FAILURE WITH THE FAULT TREE WHEN NOTHING IS ACROSS THE BOP

AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB ;

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  ELSEIF ( DRILLPIPE_KICKNOTDET + DRILLPIPE_WK_LOP ) * NONSHEARABLE_EDBS * /AUTOSHEAR_EDCS + ( DRILLPIPE_NONSHEAR_BSTJ + DRILLPIPE_NONSHEAR_BSWK
) * /AUTOSHEAR_EDCS THEN          | NONSHEARABLE ACROSS THE BSR (EITHER COMING FROM DRILLING
                                    EVENT TREE OR ON KICK DETECTION FAILURE) AND CSR AUTOSHEAR
                                    FAILURE
  /AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB ;   | SUBSTITUTES AUTOSHEAR CSR FAILURE WITH THE FAULT TREE WHEN
                                    DRILLPIPE IS ACROSS THE BOP
  AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB ;
  ELSEIF (DRILLPIPE + DRILLPIPE_WK + DRILLPIPE_KICKNOTDET + DRILLPIPE_WK_LOP ) * NONSHEARABLE_EDCS * BLIND_SHEAR_FAIL_ED + (
DRILLPIPE_NONSHEAR_CSTJ + DRILLPIPE_NONSHEAR_CSWK ) * BLIND_SHEAR_FAIL_ED THEN
                                  | NONSHEARABLE ACROSS THE CSR (EITHER COMING FROM DRILLING
                                    EVENT TREE OR ON KICK DETECTION FAILURE) AND BSR FAILURE
                                    DURING EDS
  /AUTOSHEAR_EDBS =  AUTOSHEAR_EDBSDP ;   | SUBSTITUTES AUTOSHEAR BSR FAILURE WITH THE FAULT TREE WHEN
                                    DRILLPIPE IS ACROSS THE BOP
  AUTOSHEAR_EDBS =  AUTOSHEAR_EDBSDP ;
  ELSEIF DRILLPIPE_NONSHEAR_BSTJ + DRILLPIPE_NONSHEAR_BSWK THEN   | IF TOOLJOINT IS ACROSS BSR AT THE TIME OF AUTOSHEAR
                                    ACTUATION, BUT
  /AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB ;   | SUBSTITUTES AUTOSHEAR CSR FAILURE WITH THE FAULT TREE
                                    WHEN DRILLPIPE IS ACROSS THE BOP
  AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB ;
  ENDIF

|*****************************************************************************************************************
|*****                                                                                                      *****
|***** ASSIGN NONSHEARABLES AND CSR/BSR FAULT TREES ACCORDING TO WHAT IS ACROSS THE BOP AT THE TIME OF ACTUATION*****
|*****            FOR SEQUENCES COMING FROM THE LOSS OF POSITION EVENT TREE                                 *****
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|*****                                                                                                   *****
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   |*****                         OPEN HOLE AT THE TIME OF EDS INITIATION                               *****
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|ASSIGNING NONSHEARABLE_EDCS, NONSHEARABLE_EDBS, CSR, BSR, AUTOSHEAR_CS AND AUTOSHEAR_BS FAULT TREES WHEN NOTHING IS ACROSS THE BOP AT THE TIME OF LMRP DISCONNECT (EDS)

IF OPENHOLE_DRIFTORDRIVE-OFF THEN | NOTHING IS ACROSS THE BOP AT THE TIME OF LOSS OF POSITION AND INITIATION OF EMERGENCY DISCONNECT

/NONSHEARABLE_EDCS = NONSHEARABLE_CSNAB ; | SETS PROBABILITY OF NONSHEARABLE ACROSS CSR = 0 SINCE NOTHING IS ACROSS THE BOP (THEREFORE ALL SEQUENCES WILL GO THROUGH THE SUCCESS BRANCH, NO NONSHEARABLES, WITH PROB = 1)

NONSHEARABLE_EDCS = NONSHEARABLE_CSNAB ;

/NONSHEARABLE_EDBS = NONSHEARABLE_BSNAB ; | SAME FOR NONSHEARABLE ACROSS BSR

NONSHEARABLE_EDBS = NONSHEARABLE_BSNAB ;

/CASING_SHEAR_FAIL_ED = CASING_SHEAR_FAIL_EDNAB ; | SETS CSR FAILURE PROBABILITY = 0 SINCE CSR IS NOT REQUIRED WHEN EMPTY HOLE (THEREFORE ALL SEQUENCES WILL GO THROUGH THE SUCCESS BRANCH WITH PROB = 1)

CASING_SHEAR_FAIL_ED = CASING_SHEAR_FAIL_EDNAB ;

/BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDNAB ; | SUBSTITUTES BSR FAILURE WITH THE BSR FAULT TREE WHEN NOTHING IS ACROSS THE BOP (BSR NEEDS TO CLOSE IN ORDER TO SEAL THE WELL)

BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDNAB ;

/AUTOSHEAR_EDCS = AUTOSHEAR_EDCSNAB ; | SETS AUTOSHEAR CSR FAILURE PROBABILITY = 0 SINCE CSR IS NOT REQUIRED WHEN EMPTY HOLE (THEREFORE ALL SEQUENCES WILL GO THROUGH THE SUCCESS BRANCH WITH PROB = 1)

AUTOSHEAR_EDCS = AUTOSHEAR_EDCSNAB ;

/AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB ; | SUBSTITUTES AUTOSHEAR BSR FAILURE WITH THE AUTOSHEAR BSR FAULT TREE WHEN NOTHING IS ACROSS THE BOP (BSR NEEDS TO CLOSE IN ORDER TO SEAL THE WELL)

AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB ;

ENDIF

```
|****************************************************************************************************************
|***** CASING ACROSS THE BOP WITH OR WITHOUT NONSHEARABLE ACROSS CSR OR BSR AT THE TIME OF LOSS OF POSITION AND EDS INITIATION *****
|****************************************************************************************************************
|ASSIGNING NONSHEARABLE_EDCS, NONSHEARABLE_EDBS, AND CSR FAULT TREES WHEN CASING IS ACROSS THE CSR AT THE TIME OF LOSS OF POSITION AND LMRP DISCONNECT (EDS)

IF CASING_DRIFT THEN                    | DRIFT-OFF OR PUSH-OFF SCENARIO AT THE TIME THAT CASING IS ACROSS THE BOP
/NONSHEARABLE_EDCS = NONSHEARABLE_CSCC ;          | SUBSTITUTES WITH THE NONSHEARABLE FAULT TREE FOR CSR RUNNING CASING
NONSHEARABLE_EDCS = NONSHEARABLE_CSCC ;
/NONSHEARABLE_EDBS = NONSHEARABLE_BSCC ;          | SUBSTITUTES WITH THE NONSHEARABLE FAULT TREE FOR BSR RUNNING CASING
NONSHEARABLE_EDBS = NONSHEARABLE_BSCC ;
/CASING_SHEAR_FAIL_ED = CASING_SHEAR_FAIL_EDCS ;    | SUBSTITUTES CSR FAILURE WITH THE CSR FAULT TREE WHEN CASING IS ACROSS THE BOP
CASING_SHEAR_FAIL_ED = CASING_SHEAR_FAIL_EDCS ;
ELSEIF CASING_DRIVE-OFF THEN                    | DRIVE-OFF SCENARIO AT THE TIME THAT CASING IS ACROSS THE BOP
/NONSHEARABLE_EDCS = NONSHEARABLE_CSCCDO ;          | SUBSTITUTES WITH THE NONSHEARABLE FAULT TREE FOR CSR RUNNING CASING BUT WITHOUT THE REPOSITIONING RECOVERY
NONSHEARABLE_EDCS = NONSHEARABLE_CSCCDO ;
/NONSHEARABLE_EDBS = NONSHEARABLE_BSCCDO ;          | SUBSTITUTES WITH THE NONSHEARABLE FAULT TREE FOR BSR RUNNING CASING BUT WITHOUT THE REPOSITIONING RECOVERY
NONSHEARABLE_EDBS = NONSHEARABLE_BSCCDO ;
/CASING_SHEAR_FAIL_ED = CASING_SHEAR_FAIL_EDCS ;    | SUBSTITUTES CSR FAILURE WITH THE CSR FAULT TREE WHEN CASING IS ACROSS THE BOP
CASING_SHEAR_FAIL_ED = CASING_SHEAR_FAIL_EDCS ;
ENDIF

|ASSIGNING BSR FAULT TREES WHEN CASING IS ACROSS THE BOP AT THE TIME OF LOSS OF POSITION AND EMERGENCY DISCONNECT
```

IF (CASING_DRIFT + CASING_DRIVE-OFF) * /CASING_SHEAR_FAIL_ED THEN | CSR SUCCESSFULLY SHEARED THE CASING DURING EDS

/BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDNAB; | SUBSTITUTES BSR FAILURE WITH THE BSR FAULT TREE WHEN NOTHING IS ACROSS THE BOP (BSR NEEDS TO CLOSE IN ORDER TO SEAL THE WELL)

BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDNAB;

ELSEIF (CASING_DRIFT + CASING_DRIVE-OFF) * (CASING_SHEAR_FAIL_ED + NONSHEARABLE_EDCS) THEN | CASING THROUGH BOP THAT WAS NOT SHEARED BY CSR DUE TO CSR FAILURE IN EDS OR NONSHEARABLE PRESENT ACROSS THE CSR

/BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDCS ; | SUBSTITUTES BSR FAILURE WITH THE BSR FAULT TREE WHEN CASING IS ACROSS THE BOP

BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDCS ;

ENDIF

|ASSIGNING AUTOSHEAR CSR FAULT TREES WHEN CASING IS ACROSS THE BOP AT THE TIME OF AUTOSHEAR ACTUATION AFTER LMRP DISCONNECT

IF (CASING_DRIFT + CASING_DRIVE-OFF) * CASING_SHEAR_FAIL_ED * BLIND_SHEAR_FAIL_ED THEN | NEITHER CSR NOR BSR COULD SHEAR THE CASING DURING EDS

/AUTOSHEAR_EDCS = AUTOSHEAR_EDCSCS ; | SUBSTITUTES AUTOSHEAR CSR FAILURE WITH THE FAULT TREE WHEN CASING IS ACROSS THE BOP

AUTOSHEAR_EDCS = AUTOSHEAR_EDCSCS ;

ELSEIF (CASING_DRIFT + CASING_DRIVE-OFF) * NONSHEARABLE_EDBS THEN | NONSHEARABLE IN BSR, THEREFORE BSR IS SKIPPED AND CASING IS STILL ACROSS THE BOP

/AUTOSHEAR_EDCS = AUTOSHEAR_EDCSCS ; | SUBSTITUTES AUTOSHEAR CSR FAILURE WITH THE FAULT TREE WHEN CASING IS ACROSS THE BOP

AUTOSHEAR_EDCS = AUTOSHEAR_EDCSCS ;

ENDIF

|ASSIGNING AUTOSHEAR BSR FAULT TREES WHEN CASING IS ACROSS THE BOP AT THE TIME OF AUTOSHEAR ACTUATION AFTER LMRP DISCONNECT (EDS)

IF (CASING_DRIFT + CASING_DRIVE-OFF) * CASING_SHEAR_FAIL_ED * BLIND_SHEAR_FAIL_ED * AUTOSHEAR_EDCS THEN | NEITHER CSR, BSR, NOR AUTOSHEAR_CSR COULD SHEAR THE CASING DURING EDS

/AUTOSHEAR_EDBS = AUTOSHEAR_EDBSCS ; | SUBSTITUTES AUTOSHEAR CSR FAILURE WITH THE FAULT TREE WHEN CASING IS ACROSS THE BOP

```
AUTOSHEAR_EDBS = AUTOSHEAR_EDBSCS   ;

ELSEIF ( CASING_DRIFT + CASING_DRIVE-OFF ) * ((CASING_SHEAR_FAIL_ED * BLIND_SHEAR_FAIL_ED * /AUTOSHEAR_EDCS ) + /CASING_SHEAR_FAIL_ED ) THEN | NEITHER CSR, BSR, NOR AUTOSHEAR_CSR COULD SHEAR THE CASING DURING EDS

/AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB   ;     | SUBSTITUTES AUTOSHEAR CSR FAILURE WITH THE FAULT TREE WHEN NOTHING IS ACROSS THE BOP

AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB   ;

ELSEIF ( CASING_DRIFT + CASING_DRIVE-OFF ) * NONSHEARABLE_EDBS  * /AUTOSHEAR_EDCS THEN     | NONSHEARABLE ACROSS THE BSR AND CSR AUTOSHEAR FAILURE

/AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB   ;     | SUBSTITUTES AUTOSHEAR CSR FAILURE WITH THE FAULT TREE WHEN CASING IS ACROSS THE BOP

AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB   ;

ELSEIF ( CASING_DRIFT + CASING_DRIVE-OFF ) * NONSHEARABLE_EDCS  * BLIND_SHEAR_FAIL_ED THEN     | NONSHEARABLE ACROSS THE CSR AND BSR FAILURE DURING EDS

/AUTOSHEAR_EDBS =  AUTOSHEAR_EDBSCS   ;     | SUBSTITUTES AUTOSHEAR BSR FAILURE WITH THE FAULT TREE WHEN CASING IS ACROSS THE BOP

AUTOSHEAR_EDBS =  AUTOSHEAR_EDBSCS   ;

ENDIF


|************************************************************************************************************************

|***** DRILLPIPE ACROSS THE BOP WITH OR WITHOUT NONSHEARABLE ACROSS CSR OR BSR AT THE TIME OF LOSS OF POSITION AND EDS INITIATION *****

|************************************************************************************************************************

|ASSIGNING NONSHEARABLE_EDCS, NONSHEARABLE_EDBS, AND CSR FAULT TREES WHEN DRILLPIPE IS ACROSS THE CSR AT THE TIME OF LMRP DISCONNECT (EDS)

IF DRILLPIPE_DRIFT THEN     | DRIFT-OFF OR PUSH-OFF SCENARIO AT THE TIME THAT DRILLPIPE IS ACROSS THE BOP

/NONSHEARABLE_EDCS = NONSHEARABLE_CSTJ ;     | SUBSTITUTES WITH THE NONSHEARABLE FAULT TREE FOR CSR RUNNING DRILLPIPE

NONSHEARABLE_EDCS = NONSHEARABLE_CSTJ ;

/NONSHEARABLE_EDBS = NONSHEARABLE_BSTJ ;     | SUBSTITUTES WITH THE NONSHEARABLE FAULT TREE FOR BSR RUNNING DRILLPIPE

NONSHEARABLE_EDBS = NONSHEARABLE_BSTJ ;

/CASING_SHEAR_FAIL_ED = CASING_SHEAR_FAIL_EDDR ;     | SUBSTITUTES CSR FAILURE WITH THE CSR FAULT TREE WHEN DRILLPIPE IS ACROSS THE BOP
```

CASING_SHEAR_FAIL_ED = CASING_SHEAR_FAIL_EDDR ;

ELSEIF DRILLPIPE_DRIVE-OFF THEN | DRIVE-OFF SCENARIO AT THE TIME THAT DRILLPIPE IS ACROSS THE BOP

/NONSHEARABLE_EDCS = NONSHEARABLE_CSTJDO ; | SUBSTITUTES WITH THE NONSHEARABLE FAULT TREE FOR CSR RUNNING DRILLPIPE BUT WITHOUT THE REPOSITIONING RECOVERY

NONSHEARABLE_EDCS = NONSHEARABLE_CSTJDO ;

/NONSHEARABLE_EDBS = NONSHEARABLE_BSTJDO ; | SUBSTITUTES WITH THE NONSHEARABLE FAULT TREE FOR BSR RUNNING DRILLPIPE BUT WITHOUT THE REPOSITIONING RECOVERY

NONSHEARABLE_EDBS = NONSHEARABLE_BSTJDO ;

/CASING_SHEAR_FAIL_ED = CASING_SHEAR_FAIL_EDDR ; | SUBSTITUTES CSR FAILURE WITH THE CSR FAULT TREE WHEN DRILLPIPE IS ACROSS THE BOP

CASING_SHEAR_FAIL_ED = CASING_SHEAR_FAIL_EDDR ;

ENDIF

|ASSIGNING BSR FAULT TREES WHEN DRILLPIPE IS ACROSS THE BOP AT THE TIME OF LOSS OF POSITION AND EMERGENCY DISCONNECT

IF (DRILLPIPE_DRIFT + DRILLPIPE_DRIVE-OFF) * /CASING_SHEAR_FAIL_ED THEN | CSR SUCCESSFULLY SHEARED THE CASING DURING EDS

/BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDNAB; | SUBSTITUTES BSR FAILURE WITH THE BSR FAULT TREE WHEN NOTHING IS ACROSS THE BOP (BSR NEEDS TO CLOSE IN ORDER TO SEAL THE WELL)

BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDNAB;

ELSEIF (DRILLPIPE_DRIFT + DRILLPIPE_DRIVE-OFF) * (CASING_SHEAR_FAIL_ED + NONSHEARABLE_EDCS) THEN | CASING THROUGH BOP THAT WAS NOT SHEARED BY CSR DUE TO CSR FAILURE IN EDS OR NONSHEARABLE PRESENT ACROSS THE CSR

/BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDDR ; | SUBSTITUTES BSR FAILURE WITH THE BSR FAULT TREE WHEN DRILLPIPE IS ACROSS THE BOP

BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDDR ;

ENDIF

|ASSIGNING AUTOSHEAR CSR FAULT TREES WHEN DRILLPIPE IS ACROSS THE BOP AT THE TIME OF AUTOSHEAR ACTUATION AFTER LMRP DISCONNECT

IF (DRILLPIPE_DRIFT + DRILLPIPE_DRIVE-OFF) * CASING_SHEAR_FAIL_ED * BLIND_SHEAR_FAIL_ED THEN | NEITHER CSR NOR BSR COULD SHEAR THE DRILLPIPE DURING EDS

/AUTOSHEAR_EDCS = AUTOSHEAR_EDCSDP ; | SUBSTITUTES AUTOSHEAR CSR FAILURE WITH THE FAULT TREE WHEN DRILLPIPE IS ACROSS THE BOP

AUTOSHEAR_EDCS = AUTOSHEAR_EDCSDP ;

ELSEIF (DRILLPIPE_DRIFT + DRILLPIPE_DRIVE-OFF) * NONSHEARABLE_EDBS THEN | NONSHEARABLE IN BSR, THEREFORE BSR IS SKIPPED AND CASING IS STILL ACROSS THE BOP

/AUTOSHEAR_EDCS = AUTOSHEAR_EDCSDP ; | SUBSTITUTES AUTOSHEAR CSR FAILURE WITH THE FAULT TREE WHEN DRILLPIPE IS ACROSS THE BOP

AUTOSHEAR_EDCS = AUTOSHEAR_EDCSDP ;

ENDIF

|ASSIGNING AUTOSHEAR BSR FAULT TREES WHEN CASING IS ACROSS THE BOP AT THE TIME OF AUTOSHEAR ACTUATION AFTER LMRP DISCONNECT (EDS)

IF (DRILLPIPE_DRIFT + DRILLPIPE_DRIVE-OFF) * CASING_SHEAR_FAIL_ED * BLIND_SHEAR_FAIL_ED * AUTOSHEAR_EDCS THEN | NEITHER CSR, BSR, NOR AUTOSHEAR_CSR COULD SHEAR THE DRILLPIPE DURING EDS

/AUTOSHEAR_EDBS = AUTOSHEAR_EDBSDP ; | SUBSTITUTES AUTOSHEAR CSR FAILURE WITH THE FAULT TREE WHEN DRILLPIPE IS ACROSS THE BOP

AUTOSHEAR_EDBS = AUTOSHEAR_EDBSDP ;

ELSEIF (DRILLPIPE_DRIFT + DRILLPIPE_DRIVE-OFF) * ((CASING_SHEAR_FAIL_ED * BLIND_SHEAR_FAIL_ED * /AUTOSHEAR_EDCS) + /CASING_SHEAR_FAIL_ED) THEN | NEITHER CSR, BSR, NOR AUTOSHEAR_CSR COULD SHEAR THE DRILLPIPE DURING EDS

/AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB ; | SUBSTITUTES AUTOSHEAR CSR FAILURE WITH THE FAULT TREE WHEN NOTHING IS ACROSS THE BOP

AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB ;

ELSEIF (DRILLPIPE_DRIFT + DRILLPIPE_DRIVE-OFF) * NONSHEARABLE_EDBS * /AUTOSHEAR_EDCS THEN | NONSHEARABLE ACROSS THE BSR AND CSR AUTOSHEAR FAILURE

/AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB ; | SUBSTITUTES AUTOSHEAR CSR FAILURE WITH THE FAULT TREE WHEN DRILLPIPE IS ACROSS THE BOP

AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB ;

ELSEIF (DRILLPIPE_DRIFT + DRILLPIPE_DRIVE-OFF) * NONSHEARABLE_EDCS * BLIND_SHEAR_FAIL_ED THEN | NONSHEARABLE ACROSS THE CSR AND BSR FAILURE DURING EDS

/AUTOSHEAR_EDBS = AUTOSHEAR_EDBSDP ; | SUBSTITUTES AUTOSHEAR BSR FAILURE WITH THE FAULT TREE WHEN DRILLPIPE IS ACROSS THE BOP

```
   AUTOSHEAR_EDBS =  AUTOSHEAR_EDBSDP   ;

   ENDIF



| ENSURE THAT RISER PARTS IN THE EVENT OF A LOSS OF POSITION DUE TO DRIVE-OFF

IF (DRIVE-OFF_IEFT_FRE + DRIVE-OFF_KICK) THEN                    | IF DRIVE-OFF EVENT (EITHER AS INITIATOR, OR POST-INITIATOR DURING WELLKILL PROCESS)

/RISER_PARTS = SKIP(RISER_PARTS) ;                          | SETS RISER_PARTS PROBABILITY = 1 (I.E. FORCES PTHE RISER PARTING, AND SKIPS THE SUCCESS PATH (RISER
DOES NOT PART)

RISER_PARTS = RISER_PARTS_DRIVE ;

ELSEIF (DRIFT-OFFPUSH-OFF_IEFT_FRE + DRIFT-OFFPUSH-OFF_KICK)  THEN

                        ;                       |DO NOTHING (KEEP TOP EVENT AS RISER_PARTS)


ELSE                                             | ENSURE THAT RISER STAYS INTACT DURING A WELL KICK WHERE THERE IS NO LOSS OF POSITION (DRILLSHIP CAN STAY IN PLACE
AFTER LMRP DISCONNECT)

/RISER_PARTS = RISER_PARTS_KICK  ;                          | SETS RISER_PARTS PROBABILITY = 0, MEANING RISER NEVER PARTS

RISER_PARTS = SKIP(RISER_PARTS) ;                           | SKIPS THE FAILURE PATH (SINCE RISER NEVER PARTS FOR A KICK WITHOUT LOSS OF POSITION)

ENDIF
```

B.7 INCIDENT MANAGEMENT EVENT TREE

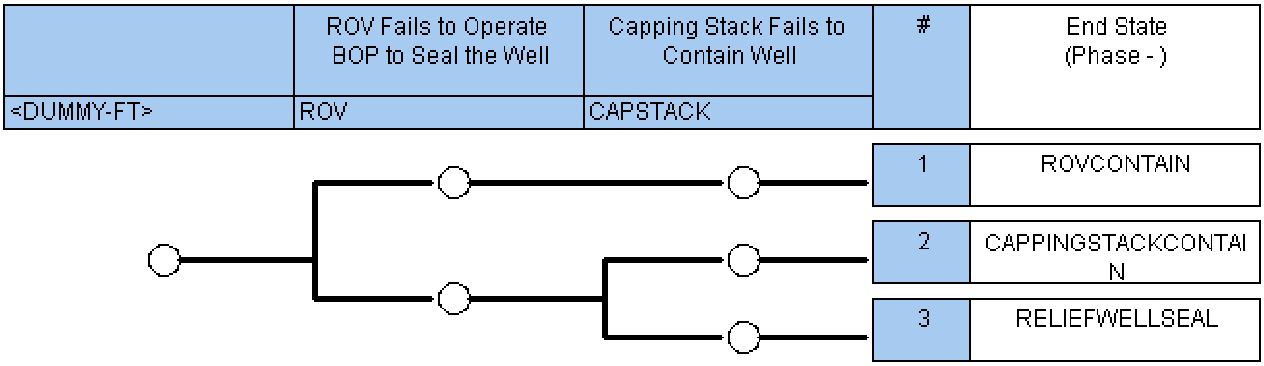

Figure B- 9: ACCCIDENTMANAGEMENT Event Tree

```
|*************************************************************************************************************************************
|*************************************************************************************************************************************
|*****                                                                                                                          *****
|*****                                                                                                                          *****
|*****                                  LINKAGE RULES FOR ACCIDENTMANAGEMENT EVENT TREE                                         *****
|*****                                              DATED 21 JUNE 2018                                                          *****
|*****                                                                                                                          *****
|*****                                                                                                                          *****
|*****                                                                                                                          *****
|*************************************************************************************************************************************
|*************************************************************************************************************************************

|*************************************************************************************************************************************
|*****                                                                                                                          *****
|*****              DEFINE MACROS:   THESE MACROS DETERMINE WHAT IS ACROSS THE BOP (CSR AND BSR)                                *****
|*****              AT THE TIME OF THE TRANSFER TO THIS ACCIDENTMANAGEMENT EVENT TREE                                           *****
|*****              (TRANSFERS FROM THE KICK EVENT TREES: CASING, DRILLING AND NOTHING_BOP                                      *****
|*****              AS WELL AS FROM LOSS OF POSITION, LMRP_DISCONNECT DEADMAN AND WELKILL EVENT TREES)                          *****
|*****                                                                                                                          *****
|*************************************************************************************************************************************

|************ MACROS DEFINED FOR SCENARIOS WITHIN CASING, DRILLING AND NOTHING_BOP EVENT TREES *************************************

|UNDETECTED KICK WITH CASING FROM CASING EVENT TREE AND EMERGENCY DISCONNECT INITIATED:
```

CASING_KICKNOTDET = (CASINGKICK_IC + CASINGKICK_PZ) * KICKDETECT * EMERGDIS ;

|UNDETECTED KICK WITH DRILLPIPE FROM DRILLING EVENT TREE AND EMERGENCY DISCONNECT INITIATED:

DRILLPIPE_KICKNOTDET = (DRILLKICK_IC + DRILLKICK_PZ) * KICKDETECT * EMERGDIS ;

|KICK WITH CASING AND SEALED WITH ANNULAR FROM CASING EVENT TREE

CASING_ANNULAR = (CASINGKICK_IC + CASINGKICK_PZ)* /ANNULARS_FAIL * /CASE_SHOE_FAILS ;

|KICK WITH DRILLPIPE AND SEALED WITH ANNULAR OR PIPERAM FROM DRILLING EVENT TREE:

DRILLPIPE_ANNULAR = (DRILLKICK_IC + DRILLKICK_PZ) * /ANNULAR_PIPERAM_DR * /IBOP_FLTVLV_FAILS ;

|CASING PRESENT (NO NONSHEARABLES) AND EMERGENCY DISCONNECT INITIATED - NOTE THAT FOR THIS TO HAPPEN, BOTH CSR AND BSR HAD FAILED BEFORE THE INITIATION OF EMERGENCY DISCONNECT:

CASING = (CASINGKICK_IC + CASINGKICK_PZ) * CASING_SHEAR_FAIL_CS * BLIND_SHEAR_FAIL_CS * EMERGDIS ;

|CASING PRESENT, NONSHEARABLE CASE COUPLING ACROSS THE BSR AND EMERGENCY DISCONNECT INITIATED - NOTE THAT FOR THIS TO HAPPEN, CSR HAD FAILED BEFORE THE INITIATION OF EMERGENCY DISCONNECT:

CASING_NONSHEAR_BSCC = (CASINGKICK_IC + CASINGKICK_PZ) * CASING_SHEAR_FAIL_CS * NONSHEARABLE_BSCC * EMERGDIS ;

|CASING PRESENT, NONSHEARABLE CASE COUPLING ACROSS THE CSR AND EMERGENCY DISCONNECT INITIATED - NOTE THAT FOR THIS TO HAPPEN, BSR HAD FAILED BEFORE THE INITIATION OF EMERGENCY DISCONNECT:

CASING_NONSHEAR_CSCC = (CASINGKICK_IC + CASINGKICK_PZ) * NONSHEARABLE_CSCC * BLIND_SHEAR_FAIL_CS * EMERGDIS ;

|DRILLPIPE PRESENT (NO NONSHEARABLES) AND EMERGENCY DISCONNECT INITIATED - NOTE THAT FOR THIS TO HAPPEN, BOTH CSR AND BSR HAD FAILED BEFORE THE INITIATION OF EMERGENCY DISCONNECT:

DRILLPIPE = (DRILLKICK_IC + DRILLKICK_PZ) * CASING_SHEAR_FAIL_DR * BLIND_SHEAR_FAIL_DR * EMERGDIS ;

```
|DRILLPIPE PRESENT, NONSHEARABLE TOOLJOINT ACROSS THE BSR AND EMERGENCY DISCONNECT INITIATED - NOTE THAT FOR THIS TO HAPPEN, CSR HAD FAILED BEFORE THE INITIATION OF EMERGENCY DISCONNECT:

DRILLPIPE_NONSHEAR_BSTJ =  (DRILLKICK_IC + DRILLKICK_PZ) * CASING_SHEAR_FAIL_DR * NONSHEARABLE_BSTJ * EMERGDIS  ;


|DRILLPIPE PRESENT, NONSHEARABLE TOOLJOINT ACROSS THE CSR AND EMERGENCY DISCONNECT INITIATED - NOTE THAT FOR THIS TO HAPPEN, BSR HAD FAILED BEFORE THE INITIATION OF EMERGENCY DISCONNECT:

DRILLPIPE_NONSHEAR_CSTJ = (DRILLKICK_IC + DRILLKICK_PZ) * NONSHEARABLE_CSTJ * BLIND_SHEAR_FAIL_DR * EMERGDIS  ;


|OPEN HOLE (NOTHING ACROSS BOP) - NOTE THAT EMERGENCY DISCONNECT INITIATION IS NOT INCLUDED IN THIS MACRO, IT IS ADDED LATER IN THE RULES AS NEEDED:

|CHECK IF THIS MACRO IS USED IN THIS EVENT TREE

OPENHOLE = EMPTY_BOP_KICK_IC + EMPTY_BOP_KICK_PZ +                                                          |OPEN HOLE WHEN KICK OCCURS

     (CASINGKICK_IC + CASINGKICK_PZ) * ( /CASING_SHEAR_FAIL_CS + /BLIND_SHEAR_FAIL_CS)  +   |CASING WHEN KICK OCCURS BUT LATER SHEARED

     (DRILLKICK_IC + DRILLKICK_PZ) * ( /CASING_SHEAR_FAIL_DR + /BLIND_SHEAR_FAIL_DR)  ;     |DRILLPIPE WHEN KICK OCCURS BUT LATER SHEARED



|************ MACROS DEFINED FOR SCENARIOS WITHIN LOSS OF POSITION EVENT TREE ******************************************

|CASING PRESENT WHEN DRIFT-OFF / PUSH-OFF OR WHEN DRIVE-OFF

CASING_DRIFT =  DRIFT-OFFPUSH-OFF_IEFT_FRE * (RUNNINGCASING_IC + RUNNINGCASING_PZ) * EMERGDIS_POS   ;


CASING_DRIVE-OFF =  DRIVE-OFF_IEFT_FRE * (RUNNINGCASING_IC + RUNNINGCASING_PZ) * EMERGDIS_POS ;


|DRILLPIPE PRESENT WHEN DRIFT-OFF / PUSH-OFF  OR WHEN DRIVE-OFF

DRILLPIPE_DRIFT  = DRIFT-OFFPUSH-OFF_IEFT_FRE * (DRILLSTRINGIN_IC + DRILLSTRINGIN_PZ) * EMERGDIS_POS ;


DRILLPIPE_DRIVE-OFF  = DRIVE-OFF_IEFT_FRE * (DRILLSTRINGIN_IC + DRILLSTRINGIN_PZ) * EMERGDIS_POS ;
```

|OPEN HOLE WHEN DRIFT-OFF / PUSH-OFF OR WHEN DRIVE-OFF

OPENHOLE_DRIFTORDRIVE-OFF = (DRIFT-OFFPUSH-OFF_IEFT_FRE + DRIVE-OFF_IEFT_FRE) * (OPENHOLE_IC + OPENHOLE_PZ) * EMERGDIS_POS ;

|************ MACROS DEFINED FOR SCENARIOS WITHIN WELL KILL EVENT TREE **

|KICK WITH CASING AND SEALED WITH ANNULAR FROM CASING EVENT TREE, TRANSFER TO WELLKILL, FAILURE TO MAINTAIN BACKPRESSURE, AND FAILED TO SHEAR CASING DURING WELLKILL OPERATIONS:

CASING_WK = CASING_ANNULAR * /NONSHEARABLE_CSWK * CASING_SHEAR_FAIL_WK * /NONSHEARABLE_BSWK * BLIND_SHEAR_FAIL_WK * EMERGDIS_WK ;

| CSR AND BSR BOTH FAILED TO SHEAR CASING DURING WELLKILL. NO NONSHEARABLES ACROSS CSR OR BSR

|CASING_WK_LOP = CASING_ANNULAR * (DRIFT-OFFPUSH-OFF_KICK + DRIVE-OFF_KICK) * EMERGDIS_WK ;

| CASING ACROSS THE BOP SEALED WITH ANNULAR, LOSS OF POSITION DURING WELLKILL, SO CASING IS STILL THROUGH THE BOP

CASING_NONSHEAR_CSWK = CASING_ANNULAR * NONSHEARABLE_CSWK * BLIND_SHEAR_FAIL_WK * EMERGDIS_WK ;

| NONSHEARABLE ACROSS CSR, AND BSR FAILED DURING WELLKILL

CASING_NONSHEAR_BSWK = CASING_ANNULAR * /NONSHEARABLE_CSWK * CASING_SHEAR_FAIL_WK * NONSHEARABLE_BSWK * EMERGDIS_WK ;

| CSR FAILED DURING WELLKILL AND NONSHEARABLE ACROSS BSR

|KICK WITH DRILLPIPE AND SEALED WITH ANNULAR OR PIPERAM FROM DRILLING EVENT TREE, TRANSFER TO WELLKILL, FAILURE TO MAINTAIN BACKPRESSURE, AND FAILED TO SHEAR DRILLPIPE DURING WELLKILL OPERATIONS:

DRILLPIPE_WK = DRILLPIPE_ANNULAR * /NONSHEARABLE_CSWK * CASING_SHEAR_FAIL_WK * /NONSHEARABLE_BSWK * BLIND_SHEAR_FAIL_WK * EMERGDIS_WK +

| CSR AND BSR BOTH FAILED TO SHEAR DRILLPIPE DURING WELLKILL. NO NONSHEARABLES ACROSS CSR OR BSR ;

OPENHOLE * /STRIP * CASING_SHEAR_FAIL_WK * BLIND_SHEAR_FAIL_WK * EMERGDIS_WK ; | STARTS WITH OPEN HOLE, BOP SEALED , STRIPPING, CSR AND BSR FAIL TO SHEAR THE DRILLPIPE

| DRILLPIPE_WK_LOP = DRILLPIPE_ANNULAR * (DRIFT-OFFPUSH-OFF_KICK + DRIVE-OFF_KICK) * EMERGDIS_WK ; | DRILLPIPE ACROSS THE BOP SEALED WITH ANNULAR/PIPERAM, LOSS OF POSITION DURING WELLKILL, SO DRILLPIPE IS STILL THROUGH THE BOP

DRILLPIPE_NONSHEAR_CSWK = DRILLPIPE_ANNULAR * NONSHEARABLE_CSWK * BLIND_SHEAR_FAIL_WK * EMERGDIS_WK +

| DRILLPIPE SEALED WITH ANNULAR OR PIPERAM, AND NONSHEARABLE ACROSS CSR, AND BSR FAILED DURING WELLKILL

OPENHOLE * /STRIP * NONSHEARABLE_CSWK * BLIND_SHEAR_FAIL_WK * EMERGDIS_WK ;

| OPENHOLE, BUT THEN ADDING DRILLPIPE FOR STRIPPING, AND TOOLJOINT ACROSS THE CSR WHEN SHEARING IS NEEDED DUE TO FAILURE TO MAINTAIN BACKPRESSURE, AND BSR FAILS TO SHEAR THE DRILLPIPE

DRILLPIPE_NONSHEAR_BSWK = DRILLPIPE_ANNULAR * /NONSHEARABLE_CSWK * CASING_SHEAR_FAIL_WK * NONSHEARABLE_BSWK * EMERGDIS_WK +

| CSR FAILED DURING WELLKILL AND NONSHEARABLE ACROSS BSR

OPENHOLE * /STRIP * NONSHEARABLE_BSWK * /EMERGDIS_WK ; | OPENHOLE, BUT THEN ADDING DRILLPIPE FOR STRIPPING, AND TOOLJOINT ACROSS THE BSR WHEN SHEARING IS NEEDED DUE TO FAILURE TO MAINTAIN BACKPRESSURE

```
|OPENHOLE TRANSFERS FROM WELLKILL:
OPENHOLE_ED = OPENHOLE * STRIP * EMERGDIS_WK +     | OPENHOLE SINCE COMING INTO WELLKILL EVENT TREE, AND STRIPPING
                                                     PIPE FAILED, AND EMERGENCY DISCONNECT INITIATION
    OPENHOLE * /STRIP * ( /CASING_SHEAR_FAIL_WK + /BLIND_SHEAR_FAIL_WK) * EMERGDIS_WK +     | STARTS WITH OPEN HOLE, BUT THEN ADDING
                                                     DRILLPIPE FOR STRIPPING, AND DRILLPIPE SHEARED
                                                     BY CSR OR BSR, AND EMERGENCY DISCONNECT
                                                     INITIATION
    OPENHOLE * (DRIFT-OFFPUSH-OFF_KICK + DRIVE-OFF_KICK ) * EMERGDIS_WK  +     | OPENHOLE WHEN COMING INTO WELLKILL, BUT
                                                     POSITIONKEEPING IS LOST FORCING EMERGENCY DISCONNECT
                                                     INITIATION.
    CASING_ANNULAR  * ( /CASING_SHEAR_FAIL_WK + /BLIND_SHEAR_FAIL_WK) * EMERGDIS_WK +     | CASING SEALED WITH ANNULAR FROM CASING
                                                     EVENT TREE, TRANSFER TO WELLKILL, FAILURE TO
                                                     MAINTAIN BACKPRESSURE, AND CASING SHEARED BY
                                                     CSR OR BSR DURING WELLKILL OPERATIONS
    DRILLPIPE_ANNULAR *( /CASING_SHEAR_FAIL_WK + /BLIND_SHEAR_FAIL_WK) * EMERGDIS_WK ;     | DRILLPIPE SEALED WITH ANNULAR/PIPERAM  FROM
                                                     DRILLING EVENT TREE, TRANSFER TO WELLKILL,
                                                     FAILURE TO MAINTAIN BACKPRESSURE, AND
                                                     DRILLPIPE SHEARED BY CSR OR BSR DURING
                                                     WELLKILL OPERATIONS

|*******************************************************************************************************************
|*******************************************************************************************************************
```

```
|**********************************************************************************************************************************
|*****                                                                                                                       *****
|*****          ASSIGN ROV FAULT TREES  ACCORDING TO WHAT IS ACROSS THE BOP AT THE TIME OF ROV OINTERVENTION                 *****
|*****             FOR SEQUENCES COMING FROM THE KICK EVENT TREES (CASING, DRILLING OR NOTHING_BOP)                         *****
|*****             LOSS OF POSITION INITIATOR, LMRPDISCONNECT, WELLKILL AND DEADMAN EVENT TREES                             *****
|*****                                                                                                                       *****
|**********************************************************************************************************************************

|*******************************************************************************************************************************
|*****                                      BULLHEADING DURING WELLKILL                                                  *****
|*******************************************************************************************************************************
| If the formation breaks down during bullheading, the BOP has no effect if an underground blowout occurs, so a capping stack is considered failed
IF BULLHEAD THEN
  /ROV = ROV1 ;
  ROV = ROV1 ;
  /CAPSTACK = CAPSTACKBULL ;
  CAPSTACK = CAPSTACKBULL ;
ENDIF

|*******************************************************************************************************************************
|*****        TRANSFERS FROM LOSS OF POSITION EVENT TREE AND KICK NOT DETECTED CASES                                  *****
|*******************************************************************************************************************************
| NOTE THAT FOR THESE SCENARIOS NONSHEARABLES HAVE NOT BEEN CHECKED YET, SO THE ROV FAULT TREES ARE REPLACED WITH TREES THAT INCLUDE THE NONSHEARBLE EVENTS ACCORDINGLY
```

```
IF  CASING_DRIFT * /RISER_PARTS + CASING_KICKNOTDET THEN                |CASING ACROSS THE BOP, DRIFT-OFF/PUSH-OFF CASE OR KICK NOT DETECTED
    /ROV = ROV_CSED_NONSHEARABLES   ;
    ROV = ROV_CSED_NONSHEARABLES    ;
ELSEIF CASING_DRIVE-OFF * /RISER_PARTS THEN                             |CASING ACROSS THE BOP, DRIVE-OFF CASE
    /ROV = ROV_CSED_NONSHRBLS_DO    ;
    ROV = ROV_CSED_NONSHRBLS_DO     ;
ELSEIF DRILLPIPE_DRIFT * /RISER_PARTS + DRILLPIPE_KICKNOTDET THEN       |DRILLPIPE ACROSS THE BOP, DRIFT-OFF/PUSH-OFF CASE OR KICK NOT DETECTED
    /ROV = ROV_DRED_NONSHEARABLES   ;
    ROV = ROV_DRED_NONSHEARABLES    ;
ELSEIF DRILLPIPE_DRIVE-OFF * /RISER_PARTS THEN                          |DRILLPIPE ACROSS THE BOP, DRIVE-OFF CASE
    /ROV = ROV_DRED_NONSHRBLS_DO    ;
    ROV = ROV_DRED_NONSHRBLS_DO     ;
ELSEIF OPENHOLE_DRIFTORDRIVE-OFF * /RISER_PARTS THEN                    |NOTHING ACROSS THE BOP, DRIFT-OFF/PUSH-OFF AND DRIVE-OFF SCENARIOS
    /ROV = ROV_NABED                ;
    ROV = ROV_NABED                 ;
ENDIF

|****************************************************************************************************************
|*****    TRANSFERS FROM LOSS OF POSITION EVENT TREE TO DEADMAN TO ACCIDENT MANAGEMENT WHEN CASING ACROSS THE BOP    *****
|****************************************************************************************************************
IF  ( CASING_DRIFT + CASING_DRIVE-OFF) * RISER_PARTS *  /NONSHEARABLE_EDCS * /AUTOSHEAR_EDCS * AUTOSHEAR_EDBS THEN
                                                                        |CASING ACROSS THE BOP ORIGINALLY, SHEARED BY CSR AUTOSHEAR, DRIFT
                                                                         OFF/PUSH-OFF CASE
    /ROV = ROV_NABED   ;
    ROV = ROV_NABED    ;
```

```
ELSEIF ( CASING_DRIFT + CASING_DRIVE-OFF) * RISER_PARTS *  /NONSHEARABLE_EDCS * AUTOSHEAR_EDCS * AUTOSHEAR_EDBS THEN
    /ROV = ROV_CSED   ;
    ROV = ROV_CSED    ;
ELSEIF ( CASING_DRIFT + CASING_DRIVE-OFF) * RISER_PARTS *  NONSHEARABLE_EDCS * AUTOSHEAR_EDBS THEN        |CASING ACROSS THE BOP, DRIVE-OFF CASE
    /ROV = ROV_CSED_NONSHRBL_CSCC    ;
    ROV = ROV_CSED_NONSHRBL_CSCC     ;
ELSEIF ( CASING_DRIFT + CASING_DRIVE-OFF) * RISER_PARTS *  NONSHEARABLE_EDBS   THEN        |DRILLPIPE ACROSS THE BOP, DRIFT-OFF/PUSH-OFF CASE
    /ROV = ROV_CSED_NONSHRBL_BSCC    ;
    ROV = ROV_CSED_NONSHRBL_BSCC     ;
ENDIF

|**********************************************************************************************************
|*****     TRANSFERS FROM LOSS OF POSITION EVENT TREE TO DEADMAN TO ACCIDENT MANAGEMENT WHEN DRILLPIPE ACROSS THE BOP     *****
|**********************************************************************************************************
IF  ( DRILLPIPE_DRIFT + DRILLPIPE_DRIVE-OFF) * RISER_PARTS *  /NONSHEARABLE_EDCS * /AUTOSHEAR_EDCS * AUTOSHEAR_EDBS THEN
                                                                    |DRILLPIPE ACROSS THE BOP ORIGINALLY, SHEARED BY CSR AUTOSHEAR,
                                                                     DRIFT-OFF/PUSH-OFF CASE
    /ROV = ROV_NABED   ;
    ROV = ROV_NABED    ;
ELSEIF ( DRILLPIPE_DRIFT + DRILLPIPE_DRIVE-OFF ) * RISER_PARTS *  /NONSHEARABLE_EDCS * AUTOSHEAR_EDCS * AUTOSHEAR_EDBS THEN
                                                                    |DRILLPIPE ACROSS THE BOP, DRIFT-OFF/PUSH-OFF OR DRIVE-OFF CASE
    /ROV = ROV_DRED   ;
    ROV = ROV_DRED    ;
ELSEIF ( DRILLPIPE_DRIFT + DRILLPIPE_DRIVE-OFF ) * RISER_PARTS *  NONSHEARABLE_EDCS * AUTOSHEAR_EDBS THEN        |DRILLPIPE ACROSS THE BOP, DRIVE-OFF
                                                                                                                  CASE  OR DRIVE-OFF CASE,
```

```
                                                                                 NONSHEARABLE ACROSS THE CSR
   /ROV = ROV_DRED   ;
   ROV = ROV_DRED   ;
ELSEIF ( DRILLPIPE_DRIFT + DRILLPIPE_DRIVE-OFF ) * RISER_PARTS *  NONSHEARABLE_EDBS   THEN   |DRILLPIPE ACROSS THE BOP, DRIFT-OFF/PUSH-OFF CASE,
                                                                                 NONSHEARABLE ACROSS BSR (AT THIS TIME THE
                                                                                 MODEL DOES NOT GIVE CREDIT TO CSR CUTTING
                                                                                 DRILLPIPE DURING ROV INTERVENTION, THEREFORE
                                                                                 ROV SET TO GUARANTEED FAILURE P=1)
   /ROV = ROV1   ;
   ROV = ROV1   ;
ENDIF

|**************************************************************************************************************
|*****   TRANSFERS FROM LOSS OF POSITION EVENT TREE TO DEADMAN TO ACCIDENT MANAGEMENT WHEN NOTHING ACROSS THE BOP   *****
|**************************************************************************************************************
IF OPENHOLE_DRIFTORDRIVE-OFF * RISER_PARTS THEN        |NOTHING ACROSS THE BOP, DRIFT-OFF/PUSH-OFF AND DRIVE-OFF SCENARIOS
   /ROV = ROV_NABED  ;
   ROV = ROV_NABED  ;
ENDIF

|**************************************************************************************************************
|*****                              TRANSFERS FROM CASING EVENT TREE                              *****
|**************************************************************************************************************
IF CASING THEN                                          |CASING ACROSS THE BOP
   /ROV = ROV_CSED   ;
```

```
     ROV = ROV_CSED    ;                                          |CASE COUPLING ACROSS THE BSR FROM PREVIOUS EVENT TREE
ELSEIF CASING_NONSHEAR_BSCC  THEN
     /ROV = ROV_CSED_NONSHRBL_BSCC    ;
     ROV = ROV_CSED_NONSHRBL_BSCC     ;
ELSEIF CASING_NONSHEAR_CSCC  THEN                                 |CASE COUPLING ACROSS THE CSR FROM PREVIOUS EVENT TREE
     /ROV = ROV_CSED_NONSHRBL_CSCC    ;
     ROV = ROV_CSED_NONSHRBL_CSCC     ;
ELSEIF (CASINGKICK_IC + CASINGKICK_PZ) * /CASING_SHEAR_FAIL_CS * EMERGDIS THEN       | OPEN HOLE  (CASING KICK, CSR SUCCEEDS
     /ROV = ROV_NABED   ;
     ROV = ROV_NABED    ;
ENDIF

|*****************************************************************************************************************
|*****                           TRANSFERS FROM DRILLING EVENT TREE                                    *****
|*****************************************************************************************************************
IF DRILLPIPE + DRILLPIPE_NONSHEAR_CSTJ THEN                 | DRILLPIPE ACROSS THE BOP OR DRILLPIPE + TOOLJOINT ACROSS THE CSR - CURRENT MODEL
                                                            DOES NOT GIVE CREDIT TO CSR IN CUTTING DRILLPIPE DURING ROV INTERVENTION
     /ROV = ROV_DRED   ;
     ROV = ROV_DRED    ;                                    | DRILLPIPE ACROSS THE BOP, TOOLJOINT ACROSS THE BSR - CURRENT MODEL DOES NOT GIVE
                                                             CREDIT TO CSR IN CUTTING DRILLPIPE DURING ROV INTERVENTION, THEREFORE ROV SET TO
                                                             GUARANTEED FAILURE (P=1)
ELSEIF DRILLPIPE_NONSHEAR_BSTJ  THEN
     /ROV = ROV1    ;
     ROV = ROV1     ;
ELSEIF (DRILLKICK_IC + DRILLKICK_PZ) *  /CASING_SHEAR_FAIL_DR * EMERGDIS THEN       | OPEN HOLE  (DRILLING KICK, CSR SUCCEEDS)
```

```
    /ROV = ROV_NABED   ;
    ROV = ROV_NABED    ;
ENDIF

| TRANSFERS FROM NOTHING_BOP EVENT TREE
IF (EMPTY_BOP_KICK_IC + EMPTY_BOP_KICK_PZ) * EMERGDIS * RISER_PARTS THEN      | OPEN HOLE KICK , TRANSFERS TO ACCIDENT MANAGEMENT
    /ROV = ROV_NABED   ;
    ROV = ROV_NABED    ;
ENDIF

|**************************************************************************************************************
|*****     TRANSFERS FROM KICK EVENT TREES TO WELLKILL TO ACCIDENT MANAGEMENT WHEN CASING ACROSS THE BOP     *****
|**************************************************************************************************************
IF  CASING_WK  THEN                                  |CASING ACROSS THE BOP, CSR AND BSR BOTH FAILED TO SHEAR CASING DURING WELLKILL. NO
                                                      NONSHEARABLES ACROSS CSR OR BSR
    /ROV = ROV_CSED   ;
    ROV = ROV_CSED    ;
ELSEIF CASING_NONSHEAR_CSWK THEN                     | NONSHEARABLE ACROSS CSR, AND BSR FAILED DURING WELLKILL
    /ROV = ROV_CSED_NONSHRBL_CSCC    ;
    ROV = ROV_CSED_NONSHRBL_CSCC     ;
ELSEIF CASING_NONSHEAR_BSWK   THEN                   | CSR FAILED DURING WELLKILL AND NONSHEARABLE ACROSS BSR
    /ROV = ROV_CSED_NONSHRBL_BSCC    ;
    ROV = ROV_CSED_NONSHRBL_BSCC     ;
ENDIF
```

```
|**********************************************************************************************************
|*****     TRANSFERS FROM KICK EVENT TREES TO WELLKILL TO ACCIDENT MANAGEMENT WHEN DRILLPIPE ACROSS THE BOP     *****
|**********************************************************************************************************
IF  DRILLPIPE_WK + DRILLPIPE_NONSHEAR_CSWK THEN          |CURRENT MODEL DOES NOT GIVE CREDIT TO CSR IN CUTTING DRILLPIPE
    /ROV = ROV_DRED   ;
    ROV = ROV_DRED    ;
ELSEIF DRILLPIPE_NONSHEAR_BSWK  THEN
    /ROV = ROV1   ;
    ROV = ROV1    ;
ENDIF

|**********************************************************************************************************
|*****     TRANSFERS FROM KICK EVENT TREES TO WELLKILL TO ACCIDENT MANAGEMENT WHEN NOTHING ACROSS THE BOP     *****
|**********************************************************************************************************
IF OPENHOLE_ED  THEN
    /ROV = ROV_NABED   ;
    ROV = ROV_NABED    ;
ENDIF

|**********************************************************************************************************
|*****                TRANSFERS FROM LMRP_DISCONNECT TO ACCIDENT MANAGEMENT                *****
|**********************************************************************************************************
IF ( /EMERGDIS + /EMERGDIS_POS + /EMERGDIS_WK ) * ( /CASING_SHEAR_FAIL_ED + /AUTOSHEAR_EDCS )   THEN
                                             | NOTHING ACROSS THE BOP WHEN TRANSFERRING TO ACCIDENT MANAGEMENT
    /ROV = ROV_NABED   ;
```

```
    ROV = ROV_NABED    ;

ELSEIF ( /EMERGDIS + /EMERGDIS_POS + /EMERGDIS_WK ) * ( AUTOSHEAR_EDBSCS * AUTOSHEAR_EDCSCS) +
                                                        | CASING ACROSS THE BOP, CSR AND BSR BOTH FAILED IN AUTOSHEAR
    ( /EMERGDIS + /EMERGDIS_POS + /EMERGDIS_WK ) * ( CASING_SHEAR_FAIL_EDCS + CASING_SHEAR_FAIL_EDCS1) * ( BLIND_SHEAR_FAIL_EDCS + BLIND_SHEAR_FAIL_EDCS1) THEN
                                                        | CASING ACROSS THE BOP, CSR AND BSR BOTH FAILED TO SHEAR CASING BEFORE.
                                                        NO NONSHEARABLES ACROSS CSR OR BSR
    /ROV = ROV_CSED   ;
    ROV = ROV_CSED    ;
ELSEIF ( /EMERGDIS + /EMERGDIS_POS + /EMERGDIS_WK ) * ( NONSHEARABLE_CSCC + NONSHEARABLE_CSCCDO + NONSHEARABLE_CSCC1 ) THEN
                                                        | NONSHEARABLE ACROSS CSR, AND BSR FAILED BEFORE, CASING ACROSS BOP
    /ROV = ROV_CSED_NONSHRBL_CSCC    ;
    ROV = ROV_CSED_NONSHRBL_CSCC     ;
ELSEIF ( /EMERGDIS + /EMERGDIS_POS + /EMERGDIS_WK )  * ( NONSHEARABLE_BSCC + NONSHEARABLE_BSCCDO + NONSHEARABLE_BSCC1 ) THEN
                                                        | CSR FAILED BEFORE AND NONSHEARABLE ACROSS BSR, CASING ACROSS BOP
    /ROV = ROV_CSED_NONSHRBL_BSCC    ;
    ROV = ROV_CSED_NONSHRBL_BSCC     ;
ELSEIF ( /EMERGDIS + /EMERGDIS_POS + /EMERGDIS_WK ) * ( AUTOSHEAR_EDBSDP * AUTOSHEAR_EDCSDP) +     | CASING ACROSS THE BOP, CSR AND BSR BOTH
                                                                                                   FAILED IN AUTOSHEAR
    ( /EMERGDIS + /EMERGDIS_POS + /EMERGDIS_WK ) * ( CASING_SHEAR_FAIL_EDDR + CASING_SHEAR_FAIL_EDDR1) * ( BLIND_SHEAR_FAIL_EDDR + BLIND_SHEAR_FAIL_EDDR1) +
                                                                                                   | DRILLPIPE ACROSS THE BOP, CSR AND BSR BOTH
                                                                                                   FAILED TO SHEAR BEFORE. NO NONSHEARABLES
                                                                                                   ACROSS CSR OR BSR
    ( /EMERGDIS + /EMERGDIS_POS + /EMERGDIS_WK ) * ( NONSHEARABLE_CSTJ + NONSHEARABLE_CSTJDO + NONSHEARABLE_CSTJ1 )  THEN
                                                        | DRILLPIPE ACROSS THE BOP, CSR FAILED DUE TO NONSHEARABLES ACROSS THE
                                                        CSR  (AT THIS TIME THE MODEL DOES NOT GIVE CREDIT TO CSR CUTTING
```

```
                                                            DRILLPIPE DURING ROV INTERVENTION)
  /ROV = ROV_DRED   ;
  ROV = ROV_DRED    ;
ELSEIF ( /EMERGDIS + /EMERGDIS_POS + /EMERGDIS_WK )  * ( NONSHEARABLE_BSTJ + NONSHEARABLE_BSTJDO + NONSHEARABLE_BSTJ1 ) THEN
                                                            | CSR FAILED BEFORE AND NONSHEARABLE ACROSS BSR  (AT THIS TIME THE
                                                            MODEL DOES NOT GIVE CREDIT TO CSR CUTTING DRILLPIPE DURING ROV
                                                            INTERVENTION, THEREFORE ROV SET TO GUARANTEED FAILURE P=1)
  /ROV = ROV1    ;
  ROV = ROV1     ;
ENDIF
```

B.8 DEADMAN EVENT TREE

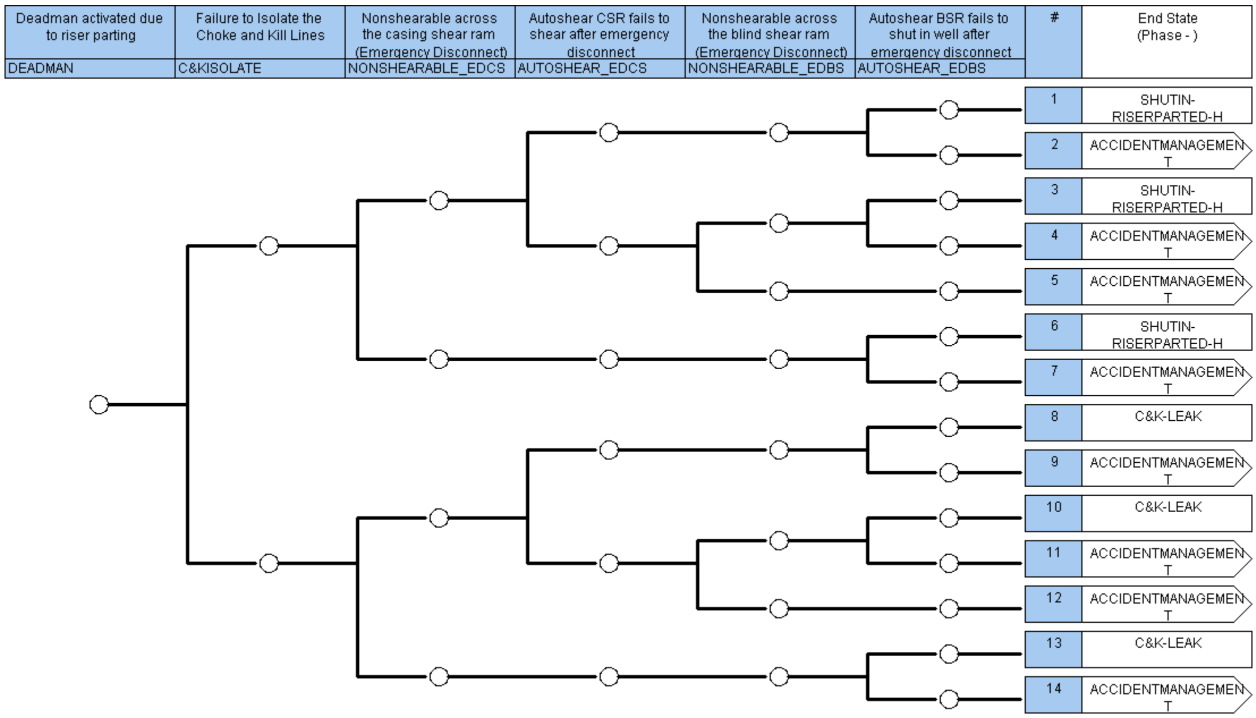

Figure B- 10: DEADMAN Event Tree

```
|***********************************************************************************************************
|***********************************************************************************************************
|*****                                                                                                 *****
|*****                                                                                                 *****
|*****                          LINKAGE RULES FOR DEADMAN EVENT TREE                                   *****
|*****                                DATED 3 AUGUST 2018                                              *****
|*****           REVISED TO ADD RULES FOR THE TRANSFER FROM INADVERTENT LMRP DISCONNECT ET             *****
|*****                                                                                                 *****
|*****                                                                                                 *****
|***********************************************************************************************************
|***********************************************************************************************************

|ASSIGN PROBABILITY OF NONSHEARABLE ACROSS THE CASING SHEAR RAM AND BLIND SHEAR RAM

IF DRIFT-OFFPUSH-OFF_IEFT_FRE * (RUNNINGCASING_IC + RUNNINGCASING_PZ)  THEN     |THIS ACCOUNTS FOR CASING ACROSS THE BOP LOSS OF POSITION DRIFT-OFF/PUSH-OFF SCENARIOS

NONSHEARABLE_EDCS = NONSHEARABLE_CSCC;

/NONSHEARABLE_EDCS = NONSHEARABLE_CSCC;

NONSHEARABLE_EDBS = NONSHEARABLE_BSCC;

/NONSHEARABLE_EDBS = NONSHEARABLE_BSCC;

ELSEIF  ( DRIFT-OFF_IEFT_FRE + INIT(INADV_DISC_IEFT_FRE) ) * (RUNNINGCASING_IC + RUNNINGCASING_PZ) THEN

                                                                                 |THIS ACCOUNTS FOR CASING ACROSS THE BOP LOSS OF POSITION DRIVE-OFF SCENARIOS (NO CASE COUPLING REPOSITIONING ALLOWED)

NONSHEARABLE_EDCS = NONSHEARABLE_CSCCDO;

/NONSHEARABLE_EDCS = NONSHEARABLE_CSCCDO;

NONSHEARABLE_EDBS = NONSHEARABLE_BSCCDO;
```

```
/NONSHEARABLE_EDBS = NONSHEARABLE_BSCCDO;

ELSEIF DRIFT-OFFPUSH-OFF_IEFT_FRE * (DRILLSTRINGIN_IC + DRILLSTRINGIN_PZ)   THEN
                    |THIS ACCOUNTS FOR DRILLPIPE ACROSS THE BOP LOSS OF POSITION DRIFT-OFF/PUSH-OFF SCENARIOS

NONSHEARABLE_EDCS = NONSHEARABLE_CSTJ;

/NONSHEARABLE_EDCS = NONSHEARABLE_CSTJ;

NONSHEARABLE_EDBS = NONSHEARABLE_BSTJ;

/NONSHEARABLE_EDBS = NONSHEARABLE_BSTJ;

ELSEIF   ( DRIVE-OFF_IEFT_FRE + INIT(INADV_DISC_IEFT_FRE) ) * (DRILLSTRINGIN_IC + DRILLSTRINGIN_PZ)   THEN
                    |THIS ACCOUNTS FOR DRILLPIPE ACROSS THE BOP LOSS OF POSITION DRIVE-OFF SCENARIOS (NO TOOLJOINT REPOSITIONING ALLOWED)

NONSHEARABLE_EDCS = NONSHEARABLE_CSTJDO;

/NONSHEARABLE_EDCS = NONSHEARABLE_CSTJDO;

NONSHEARABLE_EDBS = NONSHEARABLE_BSTJDO;

/NONSHEARABLE_EDBS = NONSHEARABLE_BSTJDO;

ELSEIF (OPENHOLE_IC + OPENHOLE_PZ)  THEN          |THIS ACCOUNTS FOR EMPTY HOLE CASES (SET NONSHEARABLES EQUAL TO ZERO)

NONSHEARABLE_EDCS = SKIP(NONSHEARABLE_EDCS);

/NONSHEARABLE_EDCS = NONSHEARABLE_CS0;

NONSHEARABLE_EDBS = SKIP(NONSHEARABLE_EDBS);

/NONSHEARABLE_EDBS = NONSHEARABLE_BS0;

ENDIF


|ASSIGN AUTOSHEAR CASING SHEAR RAM FAILURE FAULT TREE BASED

|ON WHETHER THERE IS DRILLPIPE, CASING, OR NOTHING ACROSS THE BOP

IF(RUNNINGCASING_IC + RUNNINGCASING_PZ)  THEN          |THIS ACCOUNTS FOR CASING ACROSS THE BOP LOSS OF POSITION DRIFT-OFF/PUSH-OFF SCENARIOS
```

```
AUTOSHEAR_EDCS = AUTOSHEAR_EDCSCS;

/AUTOSHEAR_EDCS = AUTOSHEAR_EDCSCS;

ELSEIF  (DRILLSTRINGIN_IC + DRILLSTRINGIN_PZ)   THEN    |THIS ACCOUNTS FOR DRILLPIPE ACROSS THE BOP LOSS OF POSITION DRIFT-OFF/PUSH-OFF SCENARIOS

AUTOSHEAR_EDCS = AUTOSHEAR_EDCSDP;

/AUTOSHEAR_EDCS = AUTOSHEAR_EDCSDP;

ELSEIF (OPENHOLE_IC + OPENHOLE_PZ)  THEN                |THIS ACCOUNTS FOR EMPTY HOLE CASES (SET AUTOSHEAR CSR TO 0 OR FALSE)

AUTOSHEAR_EDCS = AUTOSHEAR_EDCSNAB;

/AUTOSHEAR_EDCS = AUTOSHEAR_EDCSNAB;

ENDIF


|ASSIGN AUTOSHEAR BLIND SHEAR RAM FAILURE FAULT TREE BASED

|ON WHETHER THERE IS DRILLPIPE, CASING, OR NOTHING ACROSS THE BOP

IF(RUNNINGCASING_IC + RUNNINGCASING_PZ) * ( AUTOSHEAR_EDCS + NONSHEARABLE_EDCS )  THEN
                                                        |THIS ACCOUNT FOR RUNNING CASING AND NONSHEARABLE
                                                        ACROSS CSR OR CSR FAILS

AUTOSHEAR_EDBS = AUTOSHEAR_EDBSCS;

/AUTOSHEAR_EDBS = AUTOSHEAR_EDBSCS;

ELSEIF  (DRILLSTRINGIN_IC + DRILLSTRINGIN_PZ) * ( AUTOSHEAR_EDCS + NONSHEARABLE_EDCS ) THEN
                                                        |THIS ACCOUNTS FOR DRILLPIPE ACROSS THE BOP AND
                                                        NONSHEARABLE ACROSS CSR OR CSR FAILS

AUTOSHEAR_EDBS = AUTOSHEAR_EDBSDP;

/AUTOSHEAR_EDBS = AUTOSHEAR_EDBSDP;

ELSEIF  OPENHOLE_IC  +  OPENHOLE_PZ  +   (  (DRILLSTRINGIN_IC  +  DRILLSTRINGIN_PZ)   *   /AUTOSHEAR_EDCS   )  +  (  (RUNNINGCASING_IC  +  RUNNINGCASING_PZ)  *
/AUTOSHEAR_EDCS  ) THEN                                 |THIS ACCOUNTS FOR EMPTY HOLE CASES

AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB;

/AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB;
```

ENDIF

B.9 LMRP DISCONNECT EVENT TREE

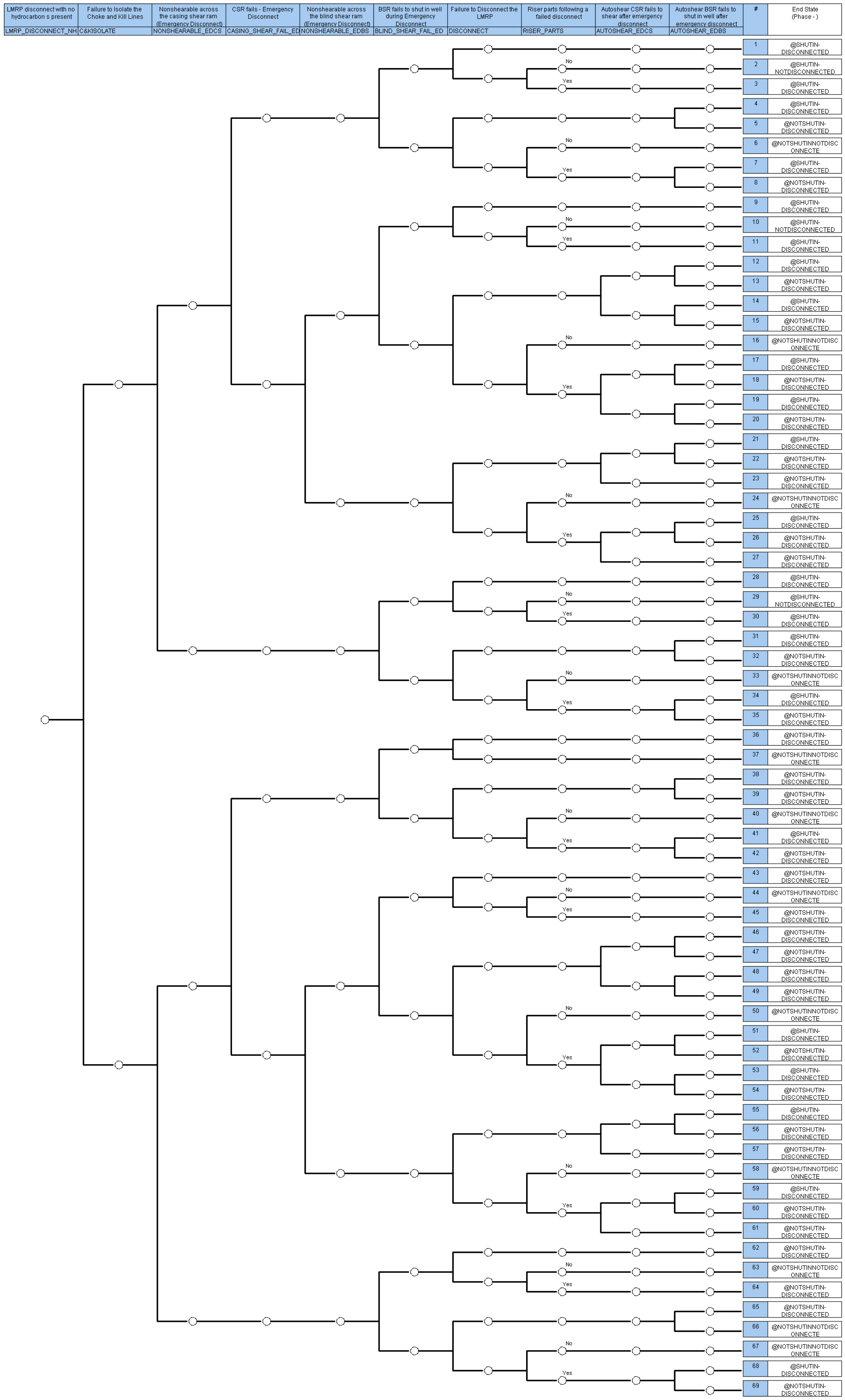

Figure B- 11: LMRPDISCONNECTNHC Event Tree

```
|***************************************************************************************************************
|***************************************************************************************************************
|*****                                                                                                     *****
|*****                                                                                                     *****
|*****                        LINKAGE RULES FOR LMRPDISCONNECTNHC EVENT TREE                               *****
|*****                           (SAME RULES AS FOR LMRPDISCONNECT E T )                                   *****
|*****                                   DATED 21 JUNE 2018                                                *****
|*****                                                                                                     ***** |
***************************************************************************************************************
|***************************************************************************************************************


|***************************************************************************************************************
|*****                                                                                                     *****
|*****         DEFINE MACROS:   THESE MACROS DETERMINE WHAT IS ACROSS THE BOP (CSR AND BSR)                *****
|*****           AT THE TIME OF THE TRANSFER TO THIS LMRP_DISCONNECT EVENT TREE                            *****
|*****         (TRANSFERS FROM THE KICK EVENT TREES: CASING, DRILLING AND NOTHING_BOP                      *****
|*****              AS WELL AS FROM LOSS OF POSITION AND WELKILL EVENT TREES)                              *****
|*****                                                                                                     *****
|***************************************************************************************************************

|******* MACROS DEFINED FOR SCENARIOS COMING DIRECTLY FROM CASING, DRILLING AND NOTHING_BOP EVENT TREES ************
|KICK WITH CASING AND SEALED WITH ANNULAR  FROM CASING EVENT TREE
CASING_ANNULAR = (CASINGKICK_IC + CASINGKICK_PZ)* /ANNULARS_FAIL * /CASE_SHOE_FAILS ;

|KICK WITH DRILLPIPE AND SEALED WITH ANNULAR OR PIPERAM FROM DRILLING EVENT TREE:
```

DRILLPIPE_ANNULAR = (DRILLKICK_IC + DRILLKICK_PZ) * /ANNULAR_PIPERAM_DR * /IBOP_FLTVLV_FAILS ;

|UNDETECTED KICK WITH CASING FROM CASING EVENT TREE AND EMERGENCY DISCONNECT INITIATED:

CASING_KICKNOTDET = (CASINGKICK_IC + CASINGKICK_PZ) * KICKDETECT * /EMERGDIS ;

|UNDETECTED KICK WITH DRILLPIPE FROM DRILLING EVENT TREE AND EMERGENCY DISCONNECT INITIATED:

DRILLPIPE_KICKNOTDET = (DRILLKICK_IC + DRILLKICK_PZ) * KICKDETECT * /EMERGDIS ;

|CASING PRESENT (NO NONSHEARABLES) AND EMERGENCY DISCONNECT INITIATED - NOTE THAT FOR THIS TO HAPPEN, BOTH CSR AND BSR HAD FAILED BEFORE THE INITIATION OF EMERGENCY DISCONNECT:

CASING = (CASINGKICK_IC + CASINGKICK_PZ) * CASING_SHEAR_FAIL_CS * BLIND_SHEAR_FAIL_CS * /EMERGDIS ;

|CASING PRESENT, NONSHEARABLE CASE COUPLING ACROSS THE BSR AND EMERGENCY DISCONNECT INITIATED - NOTE THAT FOR THIS TO HAPPEN, CSR HAD FAILED BEFORE THE INITIATION OF EMERGENCY DISCONNECT:

CASING_NONSHEAR_BSCC = (CASINGKICK_IC + CASINGKICK_PZ) * CASING_SHEAR_FAIL_CS * NONSHEARABLE_BSCC * /EMERGDIS ;

|CASING PRESENT, NONSHEARABLE CASE COUPLING ACROSS THE CSR AND EMERGENCY DISCONNECT INITIATED - NOTE THAT FOR THIS TO HAPPEN, BSR HAD FAILED BEFORE THE INITIATION OF EMERGENCY DISCONNECT:

CASING_NONSHEAR_CSCC = (CASINGKICK_IC + CASINGKICK_PZ) * NONSHEARABLE_CSCC * BLIND_SHEAR_FAIL_CS * /EMERGDIS ;

|DRILLPIPE PRESENT (NO NONSHEARABLES) AND EMERGENCY DISCONNECT INITIATED - NOTE THAT FOR THIS TO HAPPEN, BOTH CSR AND BSR HAD FAILED BEFORE THE INITIATION OF EMERGENCY DISCONNECT:

DRILLPIPE = (DRILLKICK_IC + DRILLKICK_PZ) * CASING_SHEAR_FAIL_DR * BLIND_SHEAR_FAIL_DR * /EMERGDIS ;

|DRILLPIPE PRESENT, NONSHEARABLE TOOLJOINT ACROSS THE BSR AND EMERGENCY DISCONNECT INITIATED - NOTE THAT FOR THIS TO HAPPEN, CSR HAD FAILED BEFORE THE INITIATION OF EMERGENCY DISCONNECT:

DRILLPIPE_NONSHEAR_BSTJ = (DRILLKICK_IC + DRILLKICK_PZ) * CASING_SHEAR_FAIL_DR * NONSHEARABLE_BSTJ * /EMERGDIS ;

|DRILLPIPE PRESENT, NONSHEARABLE TOOLJOINT ACROSS THE CSR AND EMERGENCY DISCONNECT INITIATED - NOTE THAT FOR THIS TO HAPPEN, BSR HAD FAILED BEFORE THE INITIATION OF EMERGENCY DISCONNECT:

```
DRILLPIPE_NONSHEAR_CSTJ = (DRILLKICK_IC + DRILLKICK_PZ) * NONSHEARABLE_CSTJ * BLIND_SHEAR_FAIL_DR * /EMERGDIS  ;
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|OPEN HOLE (NOTHING ACROSS BOP) - NOTE THAT EMERGENCY DISCONNECT INITIATION IS NOT INCLUDED IN THIS MACRO, IT IS ADDED LATER IN THE RULES AS NEEDED:

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OPENHOLE = EMPTY_BOP_KICK_IC + EMPTY_BOP_KICK_PZ +                                    |OPEN HOLE WHEN KICK OCCURS
     (CASINGKICK_IC + CASINGKICK_PZ) * ( /CASING_SHEAR_FAIL_CS + /BLIND_SHEAR_FAIL_CS)  +     |CASING WHEN KICK OCCURS BUT LATER SHEARED
     (DRILLKICK_IC + DRILLKICK_PZ) * ( /CASING_SHEAR_FAIL_DR + /BLIND_SHEAR_FAIL_DR)  ;       |DRILLPIPE WHEN KICK OCCURS BUT LATER SHEARED
```

|************ MACROS DEFINED FOR SCENARIOS COMING FROM WELL KILL EVENT TREE **

|KICK WITH CASING AND SEALED WITH ANNULAR FROM CASING EVENT TREE, TRANSFER TO WELLKILL, FAILURE TO MAINTAIN BACKPRESSURE, AND FAILED TO SHEAR CASING DURING WELLKILL OPERATIONS:

```
CASING_WK = CASING_ANNULAR  * /NONSHEARABLE_CSWK * CASING_SHEAR_FAIL_WK * /NONSHEARABLE_BSWK * BLIND_SHEAR_FAIL_WK * /EMERGDIS_WK ;
                                                                     | CSR AND BSR BOTH FAILED TO SHEAR CASING DURING
                                                                      WELLKILL. NO NONSHEARABLES ACROSS CSR OR BSR
CASING_WK_LOP = CASING_ANNULAR * (DRIFT-OFFPUSH-OFF_KICK + DRIVE-OFF_KICK ) * /EMERGDIS_WK   ;
                                                                     | CASING ACROSS THE BOP SEALED WITH ANNULAR, LOSS OF
                                                                      POSITION DURING WELLKILL, SO CASING IS STILL THROUGH
                                                                       THE BOP
CASING_NONSHEAR_CSWK =  CASING_ANNULAR * NONSHEARABLE_CSWK * BLIND_SHEAR_FAIL_WK * /EMERGDIS_WK   ;
                                                                     | NONSHEARABLE ACROSS CSR, AND BSR FAILED DURING
                                                                      WELLKILL
CASING_NONSHEAR_BSWK =  CASING_ANNULAR * /NONSHEARABLE_CSWK * CASING_SHEAR_FAIL_WK * NONSHEARABLE_BSWK * /EMERGDIS_WK  ;
                                                                     | CSR FAILED DURING WELLKILL AND NONSHEARABLE ACROSS
                                                                      BSR
```

|KICK WITH DRILLPIPE AND SEALED WITH ANNULAR OR PIPERAM FROM DRILLING EVENT TREE, TRANSFER TO WELLKILL, FAILURE TO MAINTAIN BACKPRESSURE, AND FAILED TO SHEAR DRILLPIPE DURING WELLKILL OPERATIONS:

DRILLPIPE_WK = DRILLPIPE_ANNULAR * /NONSHEARABLE_CSWK * CASING_SHEAR_FAIL_WK * /NONSHEARABLE_BSWK * BLIND_SHEAR_FAIL_WK * /EMERGDIS_WK +

| CSR AND BSR BOTH FAILED TO SHEAR DRILLPIPE DURING WELLKILL. NO NONSHEARABLES ACROSS CSR OR BSR ;

OPENHOLE * /STRIP * CASING_SHEAR_FAIL_WK * BLIND_SHEAR_FAIL_WK * /EMERGDIS_WK ;

| STARTS WITH OPEN HOLE, BOP SEALED, STRIPPING, CSR AND BSR FAIL TO SHEAR THE DRILLPIPE

DRILLPIPE_WK_LOP = DRILLPIPE_ANNULAR * (DRIFT-OFFPUSH-OFF_KICK + DRIVE-OFF_KICK) * /EMERGDIS_WK ;

| DRILLPIPE ACROSS THE BOP SEALED WITH ANNULAR/PIPERAM, LOSS OF POSITION DURING WELLKILL, SO DRILLPIPE IS STILL THROUGH THE BOP

DRILLPIPE_NONSHEAR_CSWK = DRILLPIPE_ANNULAR * NONSHEARABLE_CSWK * BLIND_SHEAR_FAIL_WK * /EMERGDIS_WK +

| DRILLPIPE SEALED WITH ANNULAR OR PIPERAM, AND NONSHEARABLE ACROSS CSR, AND BSR FAILED DURING WELLKILL

OPENHOLE * /STRIP * NONSHEARABLE_CSWK * BLIND_SHEAR_FAIL_WK * /EMERGDIS_WK ;

| OPENHOLE, BUT THEN ADDING DRILLPIPE FOR STRIPPING, AND TOOLJOINT ACROSS THE CSR WHEN SHEARING IS NEEDED DUE TO FAILURE TO MAINTAIN BACKPRESSURE, AND BSR FAILS TO SHEAR THE DRILLPIPE

DRILLPIPE_NONSHEAR_BSWK = DRILLPIPE_ANNULAR * /NONSHEARABLE_CSWK * CASING_SHEAR_FAIL_WK * NONSHEARABLE_BSWK * /EMERGDIS_WK +

| CSR FAILED DURING WELLKILL AND NONSHEARABLE ACROSS BSR

OPENHOLE * /STRIP * NONSHEARABLE_BSWK * /EMERGDIS_WK ;

| OPENHOLE, BUT THEN ADDING DRILLPIPE FOR STRIPPING,

AND TOOLJOINT ACROSS THE BSR WHEN SHEARING IS NEEDED DUE TO FAILURE TO MAINTAIN BACKPRESSURE

|OPENHOLE TRANSFERS FROM WELLKILL - NOTE THAT THIS MACRO INCLUDES SUCCESS OF EMERGENCY DISCONNECT INITIATION DURING WELL KILL:

OPENHOLE_WK = OPENHOLE * STRIP * /EMERGDIS_WK + | OPENHOLE SINCE COMING INTO WELLKILL EVENT TREE, AND STRIPPING PIPE FAILED, AND EMERGENCY DISCONNECT INITIATION

OPENHOLE * /STRIP * (/CASING_SHEAR_FAIL_WK + /BLIND_SHEAR_FAIL_WK) * /EMERGDIS_WK +

| STARTS WITH OPEN HOLE, BUT THEN ADDING DRILLPIPE FOR STRIPPING, AND DRILLPIPE SHEARED BY CSR OR BSR, AND EMERGENCY DISCONNECT INITIATION

OPENHOLE * (DRIFT-OFFPUSH-OFF_KICK + DRIVE-OFF_KICK) * /EMERGDIS_WK + | OPENHOLE WHEN COMING INTO WELLKILL, BUT POSITIONKEEPING IS LOST FORCING EMERGENCY DISCONNECT INITIATION.

CASING_ANNULAR * (/CASING_SHEAR_FAIL_WK + /BLIND_SHEAR_FAIL_WK) * /EMERGDIS_WK +

| CASING SEALED WITH ANNULAR FROM CASING EVENT TREE, TRANSFER TO WELLKILL, FAILURE TO MAINTAIN BACKPRESSURE, AND CASING SHEARED BY CSR OR BSR DURING WELLKILL OPERATIONS

DRILLPIPE_ANNULAR *(/CASING_SHEAR_FAIL_WK + /BLIND_SHEAR_FAIL_WK) * /EMERGDIS_WK ;

| DRILLPIPE SEALED WITH ANNULAR/PIPERAM FROM DRILLING EVENT TREE, TRANSFER TO WELLKILL, FAILURE TO MAINTAIN BACKPRESSURE, AND DRILLPIPE SHEARED BY CSR OR BSR DURING WELLKILL OPERATIONS

|************ MACROS DEFINED FOR SCENARIOS COMING FROM LOSS OF POSITION EVENT TREE **

|CASING PRESENT WHEN DRIFT-OFF / PUSH-OFF OR WHEN DRIVE-OFF

```
CASING_DRIFT =  DRIFT-OFFPUSH-OFF_IEFT_FRE * (RUNNINGCASING_IC + RUNNINGCASING_PZ) * /EMERGDIS_POS   ;

CASING_DRIVE-OFF =  DRIVE-OFF_IEFT_FRE * (RUNNINGCASING_IC + RUNNINGCASING_PZ) * /EMERGDIS_POS ;


|DRILLPIPE PRESENT WHEN DRIFT-OFF / PUSH-OFF  OR WHEN DRIVE-OFF

DRILLPIPE_DRIFT  = DRIFT-OFFPUSH-OFF_IEFT_FRE * (DRILLSTRINGIN_IC + DRILLSTRINGIN_PZ) * /EMERGDIS_POS ;

DRILLPIPE_DRIVE-OFF  = DRIVE-OFF_IEFT_FRE * (DRILLSTRINGIN_IC + DRILLSTRINGIN_PZ) * /EMERGDIS_POS ;


|OPEN HOLE WHEN DRIFT-OFF / PUSH-OFF  OR WHEN DRIVE-OFF

OPENHOLE_DRIFTORDRIVE-OFF =  ( DRIFT-OFFPUSH-OFF_IEFT_FRE + DRIVE-OFF_IEFT_FRE ) * (OPENHOLE_IC + OPENHOLE_PZ) * /EMERGDIS_POS  ;



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|*****                                                                                                                           *****

|*****ASSIGN NONSHEARABLES AND CSR/BSR FAULT TREES ACCORDING TO WHAT IS ACROSS THE BOP AT THE TIME OF ACTUATION*****

|*****                 FOR SEQUENCES COMING FROM THE KICK EVENT TREES (CASING, DRILLING OR NOTHING_BOP)                           *****

|*****                                                                                                                           *****

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  |*****                                       OPEN HOLE AT THE TIME OF EDS INITIATION                                           *****

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|ASSIGNING NONSHEARABLE_EDCS, NONSHEARABLE_EDBS, CSR, BSR, AUTOSHEAR_CS AND AUTOSHEAR_BS FAULT TREES WHEN NOTHING IS ACROSS THE BOP AT THE TIME OF EMERGENCY DISCONNECT

IF ( OPENHOLE * /EMERGDIS + OPENHOLE_WK ) THEN              | NOTHING IS ACROSS THE BOP AND EMERGENCY DISCONNECT IS INITIATED
/NONSHEARABLE_EDCS = NONSHEARABLE_CSNAB ;                   | SETS PROBABILITY OF NONSHEARABLE ACROSS CSR = 0 SINCE NOTHING IS ACROSS THE BOP
                                                             (THEREFORE ALL SEQUENCES WILL GO THROUGH THE SUCCESS BRANCH, NO
                                                            NONSHEARABLES, WITH PROB = 1)
NONSHEARABLE_EDCS = SKIP(NONSHEARABLE_EDCS) ;               | SKIPS THE FAILURE PATH
/NONSHEARABLE_EDBS = NONSHEARABLE_BSNAB ;                   | SAME FOR NONSHEARABLE ACROSS BSR
NONSHEARABLE_EDBS = SKIP(NONSHEARABLE_EDBS) ;               | SKIPS THE FAILURE PATH
/CASING_SHEAR_FAIL_ED = CASING_SHEAR_FAIL_EDNAB ;           | SETS CSR FAILURE PROBABILITY = 0 SINCE CSR IS NOT REQUIRED WHEN EMPTY HOLE
                                                             (THEREFORE ALL SEQUENCES WILL GO THROUGH THE SUCCESS BRANCH WITH PROB = 1)
CASING_SHEAR_FAIL_ED = SKIP(CASING_SHEAR_FAIL_ED) ;         | SKIPS THE FAILURE PATH
/BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDNAB ;             | SUBSTITUTES BSR FAILURE WITH THE BSR FAULT TREE WHEN NOTHING IS ACROSS THE
                                                            BOP (BSR NEEDS TO CLOSE IN ORDER TO SEAL THE WELL)
BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDNAB ;
/AUTOSHEAR_EDCS = AUTOSHEAR_EDCSNAB    ;                    | SETS AUTOSHEAR CSR FAILURE PROBABILITY = 0 SINCE CSR IS NOT REQUIRED WHEN
                                                            EMPTY HOLE (THEREFORE ALL SEQUENCES WILL GO THROUGH THE SUCCESS BRANCH WITH
                                                            PROB = 1)
AUTOSHEAR_EDCS = SKIP(AUTOSHEAR_EDCS)    ;                  | SKIPS THE FAILURE PATH
/AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB    ;                    | SUBSTITUTES AUTOSHEAR BSR FAILURE WITH THE AUTOSHEAR BSR FAULT TREE WHEN
                                                            NOTHING IS ACROSS THE BOP (BSR NEEDS TO CLOSE IN ORDER TO SEAL THE WELL)
AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB    ;
ENDIF

|***************************************************************************************************************
|*****    CASING ACROSS THE BOP WITH OR WITHOUT NONSHEARABLE ACROSS CSR OR BSR AT THE TIME OF EDS INITIATION     *****
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|*****************************************************************************************************************

|ASSIGNING NONSHEARABLE_EDCS, NONSHEARABLE_EDBS, AND CSR FAULT TREES WHEN CASING IS ACROSS THE CSR AT THE TIME OF EMERGENCY DISCONNECT

IF CASING_NONSHEAR_CSCC + CASING_NONSHEAR_CSWK  THEN          | NONSHEARABLE ACROSS THE CSR PRESENT IN CASING EVENT TREE

/NONSHEARABLE_EDCS = SKIP(NONSHEARABLE_EDCS)   ;              | SETS PROBABILITY OF NONSHEARABLE ACROSS CSR = 1 WHERE NONSHEARABLES WERE
                                                                PRESENT ACROSS CSR IN PREVIOUS EVENT TREE AND SKIPS THE SUCCESS PATH

NONSHEARABLE_EDCS = NONSHEARABLE_CSCC1   ;

/BLIND_SHEAR_FAIL_ED = SKIP(BLIND_SHEAR_FAIL_ED);             | SETS BSR FAILURE PROBABILITY = 1 SINCE BSR HAS FAILED BEFORE (FAILED STATE, NO
                                                                RECOVERY ALLOWED) (NO NEED TO SUBSTITUTE CSR FAILURE SINCE THIS TOP EVENT IS
                                                                SKIPPED DUE TO THE NONSHEARABLE

BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDCS1;

ELSEIF CASING_NONSHEAR_BSCC + CASING_NONSHEAR_BSWK THEN       | NONSHEARABLE ACROSS THE BSR PRESENT IN CASING EVENT TREE

/NONSHEARABLE_EDCS = NONSHEARABLE_CS0   ;                     | SETS PROBABILITY OF NONSHEARABLE ACROSS CSR = 0 WHERE NONSHEARABLES WERE
                                                                PRESENT ACROSS BSR IN PREVIOUS EVENT TREE (NOT POSSIBLE TO HAVE NON SHEARABLES
                                                                IN BOTH RAMS AT THE SAME TIME)

NONSHEARABLE_EDCS = SKIP(NONSHEARABLE_EDCS)   ;               | SKIPS THE FAILURE PATH

/NONSHEARABLE_EDBS = SKIP(NONSHEARABLE_EDBS)   ;              | SETS PROBABILITY OF NONSHEARABLE ACROSS BSR = 1 WHERE NONSHEARABLES WERE
                                                                PRESENT ACROSS BSR IN PREVIOUS EVENT TREE

NONSHEARABLE_EDBS = NONSHEARABLE_BSCC1   ;

/CASING_SHEAR_FAIL_ED = SKIP(CASING_SHEAR_FAIL_ED) ;          | SETS CSR FAILURE PROBABILITY = 1 SINCE CSR HAS FAILED BEFORE (FAILED STATE, NO
                                                                RECOVERY ALLOWED) AND SKIPS THE SUCCESS PATH

CASING_SHEAR_FAIL_ED = CASING_SHEAR_FAIL_EDCS1 ;

ELSEIF CASING + CASING_WK THEN                                | IF THERE IS CASING (WITHOUT NONSHEARABLES ACROSS THE BOP) AT THE TIME OF EDS
                                                                ACTUATION, IT MEANS THAT BOTH CSR AND BSR HAVE FAILED BEFORE

/NONSHEARABLE_EDCS = NONSHEARABLE_CS0   ;                     | SETS PROBABILITY OF NONSHEARABLE ACROSS CSR = 0 SINCE NONSHEARABLES NOT
                                                                PRESENT BEFORE
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```
NONSHEARABLE_EDCS = SKIP(NONSHEARABLE_EDCS)   ;                  | SKIPS THE FAILURE PATH
/NONSHEARABLE_EDBS = NONSHEARABLE_BS0   ;                        | SAME FOR PROBABILITY OF NONSHEARABLE ACROSS BSR
NONSHEARABLE_EDBS = SKIP(NONSHEARABLE_EDBS)   ;                  | SKIPS THE FAILURE PATH
/CASING_SHEAR_FAIL_ED = SKIP(CASING_SHEAR_FAIL_ED) ;             | SETS CSR FAILURE PROBABILITY = 1 SINCE CSR HAS FAILED BEFORE (FAILED STATE, NO
                                                                   RECOVERY ALLOWED)
CASING_SHEAR_FAIL_ED = CASING_SHEAR_FAIL_EDCS1 ;                 | SKIPS THE FAILURE PATH
/BLIND_SHEAR_FAIL_ED = SKIP(BLIND_SHEAR_FAIL_ED) ;               | SETS BSR FAILURE PROBABILITY = 1 SINCE BSR HAS FAILED BEFORE (FAILED STATE, NO
                                                                   RECOVERY ALLOWED)
BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDCS1 ;
ELSIF CASING_KICKNOTDET + CASING_WK_LOP THEN                     | KICK WAS NOT DETECTED, SO NOTHING HAS BEEN QUESTIONED IN EARLIER EVENT TREES
/NONSHEARABLE_EDCS = NONSHEARABLE_CSCC ;                         | SUBSTITUTES WITH THE NONSHEARABLE FAULT TREE FOR CSR RUNNING CASING
NONSHEARABLE_EDCS = NONSHEARABLE_CSCC ;
/NONSHEARABLE_EDBS = NONSHEARABLE_BSCC ;                         | SUBSTITUTES WITH THE NONSHEARABLE FAULT TREE FOR BSR RUNNING CASING
NONSHEARABLE_EDBS = NONSHEARABLE_BSCC ;
/CASING_SHEAR_FAIL_ED = CASING_SHEAR_FAIL_EDCS ;                 | SUBSTITUTES CSR FAILURE WITH THE CSR FAULT TREE WHEN CASING IS ACROSS THE BOP
CASING_SHEAR_FAIL_ED = CASING_SHEAR_FAIL_EDCS ;
ENDIF

|ASSIGNING BSR FAULT TREES WHEN CASING  IS ACROSS THE BOP AT THE TIME OF LMRP DISCONNECT (EDS) AND KICK WAS NOT DETECTED
IF ( CASING_KICKNOTDET + CASING_WK_LOP ) * /CASING_SHEAR_FAIL_ED THEN        | CSR SUCCESSFULLY SHEARED THE CASING DURING EDS
/BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDNAB;                              | SUBSTITUTES BSR FAILURE WITH THE BSR FAULT TREE WHEN NOTHING
                                                                              IS ACROSS THE BOP (BSR NEEDS TO CLOSE IN ORDER TO SEAL THE WELL)
BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDNAB;
ELSEIF ( CASING_KICKNOTDET + CASING_WK_LOP ) * ( CASING_SHEAR_FAIL_ED + NONSHEARABLE_EDCS)  THEN
                                                                            | CASING THROUGH BOP THAT WAS NOT SHEARED
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                                                 BY CSR DUE TO CSR FAILURE IN EDS OR NONSHEARABLE PRESENT
                                                 ACROSS THE CSR
/BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDCS ;   | SUBSTITUTES BSR FAILURE WITH THE BSR FAULT TREE WHEN CASING IS
                                                 ACROSS THE BOP
BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDCS ;
ENDIF

|ASSIGNING AUTOSHEAR CSR FAULT TREES WHEN CASING IS ACROSS THE BOP AT THE TIME OF AUTOSHEAR ACTUATION AFTER LMRP DISCONNECT
IF (CASING + CASING_WK + CASING_KICKNOTDET + CASING_WK_LOP ) * CASING_SHEAR_FAIL_ED * BLIND_SHEAR_FAIL_ED THEN
                                                 | NEITHER CSR NOR BSR COULD SHEAR THE CASING DURING EDS
/AUTOSHEAR_EDCS = AUTOSHEAR_EDCSCS   ;           | SUBSTITUTES AUTOSHEAR CSR FAILURE WITH THE FAULT TREE WHEN
                                                 CASING IS ACROSS THE BOP
AUTOSHEAR_EDCS = AUTOSHEAR_EDCSCS   ;
ELSEIF (CASING + CASING_WK + CASING_KICKNOTDET + CASING_WK_LOP) * NONSHEARABLE_EDBS + CASING_NONSHEAR_BSCC  THEN
                                                 | NONSHEARABLE IN BSR, THEREFORE BSR IS SKIPPED
                                                 AND CASING IS STILL ACROSS THE BOP
/AUTOSHEAR_EDCS = AUTOSHEAR_EDCSCS   ;           | SUBSTITUTES AUTOSHEAR CSR FAILURE WITH THE FAULT TREE WHEN
                                                 CASING IS ACROSS THE BOP
AUTOSHEAR_EDCS = AUTOSHEAR_EDCSCS   ;
ENDIF

|ASSIGNING AUTOSHEAR BSR FAULT TREES WHEN CASING  IS ACROSS THE BOP AT THE TIME OF AUTOSHEAR ACTUATION AFTER LMRP DISCONNECT
IF (CASING + CASING_WK + CASING_KICKNOTDET + CASING_WK_LOP ) * CASING_SHEAR_FAIL_ED * BLIND_SHEAR_FAIL_ED * AUTOSHEAR_EDCS THEN
                                                      | NEITHER CSR, BSR, NOR AUTOSHEAR_CSR COULD SHEAR THE
                                                      CASING DURING EDS
```

/AUTOSHEAR_EDBS = AUTOSHEAR_EDBSCS ; | SUBSTITUTES AUTOSHEAR CSR FAILURE WITH THE FAULT TREE WHEN CASING IS ACROSS THE BOP

AUTOSHEAR_EDBS = AUTOSHEAR_EDBSCS ;

ELSEIF (CASING + CASING_WK + CASING_KICKNOTDET + CASING_WK_LOP) * ((CASING_SHEAR_FAIL_ED * BLIND_SHEAR_FAIL_ED * /AUTOSHEAR_EDCS) + /CASING_SHEAR_FAIL_ED) THEN | NEITHER CSR, BSR, NOR AUTOSHEAR_CSR COULD SHEAR THE CASING DURING EDS

/AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB ; | SUBSTITUTES AUTOSHEAR CSR FAILURE WITH THE FAULT TREE WHEN NOTHING IS ACROSS THE BOP

AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB ;

ELSEIF ((CASING_KICKNOTDET + CASING_WK_LOP) * NONSHEARABLE_EDBS + CASING_NONSHEAR_BSCC + CASING_NONSHEAR_BSWK) * /AUTOSHEAR_EDCS THEN | NONSHEARABLE ACROSS THE BSR (EITHER COMING FROM CASING EVENT TREE OR ON KICK DETECTION FAILURE) AND CSR AUTOSHEAR FAILURE

/AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB ; | SUBSTITUTES AUTOSHEAR CSR FAILURE WITH THE FAULT TREE WHEN CASING IS ACROSS THE BOP

AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB ;

ELSEIF ((CASING_KICKNOTDET + CASING_WK_LOP) * NONSHEARABLE_EDCS + CASING_NONSHEAR_CSCC + CASING_NONSHEAR_CSWK) * BLIND_SHEAR_FAIL_ED THEN | NONSHEARABLE ACROSS THE CSR (EITHER COMING FROM CASING EVENT TREE OR ON KICK DETECTION FAILURE) AND BSR FAILURE DURING EDS

/AUTOSHEAR_EDBS = AUTOSHEAR_EDBSCS ; | SUBSTITUTES AUTOSHEAR BSR FAILURE WITH THE FAULT TREE WHEN CASING IS ACROSS THE BOP

AUTOSHEAR_EDBS = AUTOSHEAR_EDBSCS ;

ELSEIF CASING_NONSHEAR_BSCC + CASING_NONSHEAR_BSWK THEN | IF CASE COUPLING IS ACROSS BSR AT THE TIME OF AUTOSHEAR ACTUATION, BUT

/AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB ; | SUBSTITUTES AUTOSHEAR CSR FAILURE WITH THE FAULT

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                                                                        TREE WHEN CASING IS ACROSS THE BOP
AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB   ;
ENDIF

|***************************************************************************************************************
|***** DRILLPIPE ACROSS THE BOP WITH OR WITHOUT NONSHEARABLE ACROSS CSR OR BSR AT THE TIME OF EDS INITIATION     *****
|***************************************************************************************************************
|ASSIGNING NONSHEARABLE_EDCS, NONSHEARABLE_EDBS, AND CSR FAULT TREES WHEN DRILLPIPE IS ACROSS THE CSR AT THE TIME OF EMERGENCY DISCONNECT
IF DRILLPIPE_NONSHEAR_CSTJ + DRILLPIPE_NONSHEAR_CSWK THEN          | NONSHEARABLE ACROSS THE CSR PRESENT IN DRILLING EVENT TREE
/NONSHEARABLE_EDCS = SKIP(NONSHEARABLE_EDCS)   ;                   | SETS PROBABILITY OF NONSHEARABLE ACROSS CSR = 1 WHERE
                                                                    NONSHEARABLES WERE PRESENT ACROSS CSR IN PREVIOUS EVENT TREE
                                                                   AND SKIPS THE SUCCESS PATH
NONSHEARABLE_EDCS = NONSHEARABLE_CSTJ1   ;
/BLIND_SHEAR_FAIL_ED = SKIP(BLIND_SHEAR_FAIL_ED) ;                 | SETS BSR FAILURE PROBABILITY = 1 SINCE BSR HAS FAILED BEFORE
                                                                    (FAILED STATE, NO RECOVERY ALLOWED) (NO NEED TO SUBSTITUTE CSR
                                                                    FAILURE SINCE THIS TOP EVENT IS SKIPPED DUE TO THE NONSHEARABLE)
BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDDR1;
ELSEIF DRILLPIPE_NONSHEAR_BSTJ + DRILLPIPE_NONSHEAR_BSWK THEN      | NONSHEARABLE ACROSS THE BSR PRESENT IN DRILLING EVENT TREE
/NONSHEARABLE_EDCS = NONSHEARABLE_CS0   ;                          | SETS PROBABILITY OF NONSHEARABLE ACROSS CSR = 0 WHERE
                                                                    NONSHEARABLES WERE PRESENT ACROSS BSR IN PREVIOUS EVENT TREE
                                                                    (NOT POSSIBLE TO HAVE NON SHEARABLES IN BOTH RAMS AT THE SAME
                                                                    TIME)
NONSHEARABLE_EDCS = SKIP(NONSHEARABLE_EDCS)   ;                    | SKIPS THE FAILURE PATH
/NONSHEARABLE_EDBS = SKIP(NONSHEARABLE_EDBS)   ;                   | SETS PROBABILITY OF NONSHEARABLE ACROSS BSR = 1 WHERE
                                                                    NONSHEARABLES WERE PRESENT ACROSS BSR IN PREVIOUS EVENT TREE
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NONSHEARABLE_EDBS = NONSHEARABLE_BSTJ1   ;
/CASING_SHEAR_FAIL_ED = SKIP(CASING_SHEAR_FAIL_ED) ;          | SETS CSR FAILURE PROBABILITY = 1 SINCE CSR HAS FAILED BEFORE
                                                                (FAILED STATE, NO RECOVERY ALLOWED) AND SKIPS THE SUCCESS PATH
CASING_SHEAR_FAIL_ED = CASING_SHEAR_FAIL_EDDR1 ;
ELSEIF DRILLPIPE + DRILLPIPE_WK THEN                          | IF THERE IS DRILLPIPE (WITHOUT NONSHEARABLES ACROSS THE BOP) AT
                                                                THE TIME OF EDS ACTUATION, IT MEANS THAT BOTH CSR AND BSR HAVE
                                                                FAILED BEFORE
/NONSHEARABLE_EDCS = NONSHEARABLE_CS0   ;                     | SETS PROBABILITY OF NONSHEARABLE ACROSS CSR = 0 SINCE
                                                                NONSHEARABLES NOT PRESENT BEFORE
NONSHEARABLE_EDCS = SKIP(NONSHEARABLE_EDCS)   ;               | SKIPS THE FAILURE PATH
/NONSHEARABLE_EDBS = NONSHEARABLE_BS0   ;                     | SAME FOR PROBABILITY OF NONSHEARABLE ACROSS BSR
NONSHEARABLE_EDBS = SKIP(NONSHEARABLE_EDBS)   ;               | SKIPS THE FAILURE PATH
/CASING_SHEAR_FAIL_ED = SKIP(CASING_SHEAR_FAIL_ED) ;          | SETS CSR FAILURE PROBABILITY = 1 SINCE CSR HAS FAILED BEFORE
                                                                (FAILED STATE, NO RECOVERY ALLOWED) AND SKIPS THE SUCCESS PATH
CASING_SHEAR_FAIL_ED = CASING_SHEAR_FAIL_EDDR1 ;
/BLIND_SHEAR_FAIL_ED = SKIP(BLIND_SHEAR_FAIL_ED) ;            | SETS BSR FAILURE PROBABILITY = 1 SINCE BSR HAS FAILED BEFORE
                                                                (FAILED STATE, NO RECOVERY ALLOWED) AND SKIPS THE SUCCESS PATH
BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDDR1 ;
ELSIF DRILLPIPE_KICKNOTDET + DRILLPIPE_WK_LOP THEN      |       KICK WAS NOT DETECTED, SO NOTHING HAS BEEN QUESTIONED IN
                                                                EARLIER EVENT TREES
/NONSHEARABLE_EDCS = NONSHEARABLE_CSTJ ;                      | SUBSTITUTES WITH THE NONSHEARABLE FAULT TREE FOR CSR RUNNING
                                                                DRILLPIPE
NONSHEARABLE_EDCS = NONSHEARABLE_CSTJ ;
/NONSHEARABLE_EDBS = NONSHEARABLE_BSTJ ;                      | SUBSTITUTES WITH THE NONSHEARABLE FAULT TREE FOR BSR RUNNING
                                                                DRILLPIPE
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```
NONSHEARABLE_EDBS = NONSHEARABLE_BSTJ ;
/CASING_SHEAR_FAIL_ED = CASING_SHEAR_FAIL_EDDR ;          | SUBSTITUTES CSR FAILURE WITH THE CSR FAULT TREE WHEN DRILLPIPE
                                                            IS ACROSS THE BOP
CASING_SHEAR_FAIL_ED = CASING_SHEAR_FAIL_EDDR ;
ENDIF


|ASSIGNING BSR FAULT TREES WHEN DRILLPIPE IS ACROSS THE BOP AT THE TIME OF LMRP DISCONNECT (EDS) AND KICK WAS NOT DETECTED
IF ( DRILLPIPE_KICKNOTDET + DRILLPIPE_WK_LOP ) * /CASING_SHEAR_FAIL_ED THEN      | CSR SUCCESSFULLY SHEARED THE DRILLPIPE DURING EDS
/BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDNAB;            | SUBSTITUTES BSR FAILURE WITH THE BSR FAULT TREE WHEN
                                                          NOTHING IS ACROSS THE BOP (BSR NEEDS TO CLOSE IN ORDER
                                                           TO SEAL THE WELL)
BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDNAB;
ELSEIF ( DRILLPIPE_KICKNOTDET + DRILLPIPE_WK_LOP ) * ( CASING_SHEAR_FAIL_ED + NONSHEARABLE_EDCS)  THEN
                                                          | DRILLPIPE THROUGH BOP THAT WAS NOT SHEARED BY CSR DUE TO CSR
                                                            FAILURE IN EDS OR NONSHEARABLE PRESENT ACROSS THE CSR
/BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDDR ;            | SUBSTITUTES BSR FAILURE WITH THE BSR FAULT TREE WHEN DRILLPIPE
                                                            IS ACROSS THE BOP
BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDDR ;
ENDIF

|ASSIGNING AUTOSHEAR CSR FAULT TREES WHEN DRILLPIPE IS ACROSS THE BOP AT THE TIME OF AUTOSHEAR ACTUATION AFTER LMRP DISCONNECT (EDS)
IF (DRILLPIPE + DRILLPIPE_WK + DRILLPIPE_KICKNOTDET + DRILLPIPE_WK_LOP ) * CASING_SHEAR_FAIL_ED * BLIND_SHEAR_FAIL_ED THEN
                                                          | NEITHER CSR NOR BSR COULD SHEAR THE DRILLPIPE DURING EDS
/AUTOSHEAR_EDCS = AUTOSHEAR_EDCSDP   ;                    | SUBSTITUTES AUTOSHEAR CSR FAILURE WITH THE FAULT TREE
```

WHEN DRILLPIPE IS ACROSS THE BOP

AUTOSHEAR_EDCS = AUTOSHEAR_EDCSDP ;

ELSEIF (DRILLPIPE + DRILLPIPE_WK + DRILLPIPE_KICKNOTDET + DRILLPIPE_WK_LOP) * NONSHEARABLE_EDBS + DRILLPIPE_NONSHEAR_BSTJ + DRILLPIPE_NONSHEAR_BSWK THEN

| NONSHEARABLE IN BSR, THEREFORE BSR IS SKIPPED AND DRILLPIPE IS STILL ACROSS THE BOP

/AUTOSHEAR_EDCS = AUTOSHEAR_EDCSDP ; | SUBSTITUTES AUTOSHEAR CSR FAILURE WITH THE FAULT TREE WHEN DRILLPIPE IS ACROSS THE BOP

AUTOSHEAR_EDCS = AUTOSHEAR_EDCSDP ;

ENDIF

|ASSIGNING AUTOSHEAR BSR FAULT TREES WHEN DRILLPIPE IS ACROSS THE BOP AT THE TIME OF AUTOSHEAR ACTUATION AFTER LMRP DISCONNECT (EDS)

IF (DRILLPIPE + DRILLPIPE_WK + DRILLPIPE_KICKNOTDET + DRILLPIPE_WK_LOP) * CASING_SHEAR_FAIL_ED * BLIND_SHEAR_FAIL_ED * AUTOSHEAR_EDCS THEN

| NEITHER CSR, BSR, NOR AUTOSHEAR_CSR COULD SHEAR THE DRILLPIPE DURING EDS

/AUTOSHEAR_EDBS = AUTOSHEAR_EDBSDP ; | SUBSTITUTES AUTOSHEAR CSR FAILURE WITH THE FAULT TREE WHEN DRILLPIPE IS ACROSS THE BOP

AUTOSHEAR_EDBS = AUTOSHEAR_EDBSDP ;

ELSEIF (DRILLPIPE + DRILLPIPE_WK + DRILLPIPE_KICKNOTDET + DRILLPIPE_WK_LOP) * ((CASING_SHEAR_FAIL_ED * BLIND_SHEAR_FAIL_ED * /AUTOSHEAR_EDCS) + /CASING_SHEAR_FAIL_ED) THEN | NEITHER CSR, BSR, NOR AUTOSHEAR_CSR COULD SHEAR THE DRILLPIPE DURING EDS

/AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB ; | SUBSTITUTES AUTOSHEAR CSR FAILURE WITH THE FAULT TREE WHEN NOTHING IS ACROSS THE BOP

AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB ;

ELSEIF (DRILLPIPE_KICKNOTDET + DRILLPIPE_WK_LOP) * NONSHEARABLE_EDBS * /AUTOSHEAR_EDCS + (DRILLPIPE_NONSHEAR_BSTJ + DRILLPIPE_NONSHEAR_BSWK) * /AUTOSHEAR_EDCS THEN | NONSHEARABLE ACROSS THE BSR (EITHER COMING FROM DRILLING

```
                                                    EVENT TREE OR ON KICK DETECTION FAILURE) AND CSR AUTOSHEAR
                                                    FAILURE
  /AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB   ;           | SUBSTITUTES AUTOSHEAR CSR FAILURE WITH THE FAULT TREE WHEN
                                                    DRILLPIPE IS ACROSS THE BOP
  AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB   ;
  ELSEIF (DRILLPIPE + DRILLPIPE_WK + DRILLPIPE_KICKNOTDET + DRILLPIPE_WK_LOP ) * NONSHEARABLE_EDCS * BLIND_SHEAR_FAIL_ED + ( DRILLPIPE_NONSHEAR_CSTJ + DRILLPIPE_NONSHEAR_CSWK ) * BLIND_SHEAR_FAIL_ED THEN
                                                    | NONSHEARABLE ACROSS THE CSR (EITHER COMING FROM DRILLING
                                                    EVENT TREE OR ON KICK DETECTION FAILURE) AND BSR FAILURE
                                                    DURING EDS
  /AUTOSHEAR_EDBS =  AUTOSHEAR_EDBSDP   ;           | SUBSTITUTES AUTOSHEAR BSR FAILURE WITH THE FAULT TREE WHEN
                                                    DRILLPIPE IS ACROSS THE BOP
  AUTOSHEAR_EDBS =  AUTOSHEAR_EDBSDP   ;
  ELSEIF DRILLPIPE_NONSHEAR_BSTJ + DRILLPIPE_NONSHEAR_BSWK THEN      | IF TOOLJOINT IS ACROSS BSR AT THE TIME OF AUTOSHEAR
                                                    ACTUATION, BUT
  /AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB   ;           | SUBSTITUTES AUTOSHEAR CSR FAILURE WITH THE FAULT TREE
                                                    WHEN DRILLPIPE IS ACROSS THE BOP
  AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB   ;
  ENDIF

|*****************************************************************************************************
|*****                                                                                          *****
|***** ASSIGN NONSHEARABLES AND CSR/BSR FAULT TREES ACCORDING TO WHAT IS ACROSS THE BOP AT THE TIME OF ACTUATION*****
|*****                FOR SEQUENCES COMING FROM THE LOSS OF POSITION EVENT TREE                     *****
|*****                                                                                          *****
|*****************************************************************************************************
```

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|****************************************************************************************************
|*****                    OPEN HOLE AT THE TIME OF EDS INITIATION                    *****
|****************************************************************************************************
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|ASSIGNING NONSHEARABLE_EDCS, NONSHEARABLE_EDBS, CSR, BSR, AUTOSHEAR_CS AND AUTOSHEAR_BS FAULT TREES WHEN NOTHING IS ACROSS THE BOP AT THE TIME OF LMRP DISCONNECT (EDS)

IF OPENHOLE_DRIFTORDRIVE-OFF THEN | NOTHING IS ACROSS THE BOP AT THE TIME OF LOSS OF POSITION AND INITIATION OF EMERGENCY DISCONNECT

/NONSHEARABLE_EDCS = NONSHEARABLE_CSNAB ; | SETS PROBABILITY OF NONSHEARABLE ACROSS CSR = 0 SINCE NOTHING IS ACROSS THE BOP (THEREFORE ALL SEQUENCES WILL GO THROUGH THE SUCCESS BRANCH, NO NONSHEARABLES, WITH PROB = 1)

NONSHEARABLE_EDCS = NONSHEARABLE_CSNAB ;

/NONSHEARABLE_EDBS = NONSHEARABLE_BSNAB ; | SAME FOR NONSHEARABLE ACROSS BSR

NONSHEARABLE_EDBS = NONSHEARABLE_BSNAB ;

/CASING_SHEAR_FAIL_ED = CASING_SHEAR_FAIL_EDNAB ; | SETS CSR FAILURE PROBABILITY = 0 SINCE CSR IS NOT REQUIRED WHEN EMPTY HOLE (THEREFORE ALL SEQUENCES WILL GO THROUGH THE SUCCESS BRANCH WITH PROB = 1)

CASING_SHEAR_FAIL_ED = CASING_SHEAR_FAIL_EDNAB ;

/BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDNAB ; | SUBSTITUTES BSR FAILURE WITH THE BSR FAULT TREE WHEN NOTHING IS ACROSS THE BOP (BSR NEEDS TO CLOSE IN ORDER TO SEAL THE WELL)

BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDNAB ;

/AUTOSHEAR_EDCS = AUTOSHEAR_EDCSNAB ; | SETS AUTOSHEAR CSR FAILURE PROBABILITY = 0 SINCE CSR IS NOT REQUIRED WHEN EMPTY HOLE (THEREFORE ALL SEQUENCES WILL GO THROUGH THE SUCCESS BRANCH WITH PROB = 1)

AUTOSHEAR_EDCS = AUTOSHEAR_EDCSNAB ;

/AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB ; | SUBSTITUTES AUTOSHEAR BSR FAILURE WITH THE AUTOSHEAR BSR FAULT TREE WHEN NOTHING IS ACROSS THE BOP (BSR NEEDS TO CLOSE IN ORDER TO SEAL THE WELL)

AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB ;

ENDIF

```
|********************************************************************************************************
```

|***** CASING ACROSS THE BOP WITH OR WITHOUT NONSHEARABLE ACROSS CSR OR BSR AT THE TIME OF LOSS OF POSITION AND EDS INITIATION *****

|***

|ASSIGNING NONSHEARABLE_EDCS, NONSHEARABLE_EDBS, AND CSR FAULT TREES WHEN CASING IS ACROSS THE CSR AT THE TIME OF LOSS OF POSITION AND LMRP DISCONNECT (EDS)

IF CASING_DRIFT THEN | DRIFT-OFF OR PUSH-OFF SCENARIO AT THE TIME THAT CASING IS ACROSS THE BOP

/NONSHEARABLE_EDCS = NONSHEARABLE_CSCC ; | SUBSTITUTES WITH THE NONSHEARABLE FAULT TREE FOR CSR RUNNING CASING

NONSHEARABLE_EDCS = NONSHEARABLE_CSCC ;

/NONSHEARABLE_EDBS = NONSHEARABLE_BSCC ; | SUBSTITUTES WITH THE NONSHEARABLE FAULT TREE FOR BSR RUNNING CASING

NONSHEARABLE_EDBS = NONSHEARABLE_BSCC ;

/CASING_SHEAR_FAIL_ED = CASING_SHEAR_FAIL_EDCS ; | SUBSTITUTES CSR FAILURE WITH THE CSR FAULT TREE WHEN CASING IS ACROSS THE BOP

CASING_SHEAR_FAIL_ED = CASING_SHEAR_FAIL_EDCS ;

ELSEIF CASING_DRIVE-OFF THEN | DRIVE-OFF SCENARIO AT THE TIME THAT CASING IS ACROSS THE BOP

/NONSHEARABLE_EDCS = NONSHEARABLE_CSCCDO ; | SUBSTITUTES WITH THE NONSHEARABLE FAULT TREE FOR CSR RUNNING CASING BUT WITHOUT THE REPOSITIONING RECOVERY

NONSHEARABLE_EDCS = NONSHEARABLE_CSCCDO ;

/NONSHEARABLE_EDBS = NONSHEARABLE_BSCCDO ; | SUBSTITUTES WITH THE NONSHEARABLE FAULT TREE FOR BSR RUNNING CASING BUT WITHOUT THE REPOSITIONING RECOVERY

NONSHEARABLE_EDBS = NONSHEARABLE_BSCCDO ;

/CASING_SHEAR_FAIL_ED = CASING_SHEAR_FAIL_EDCS ; | SUBSTITUTES CSR FAILURE WITH THE CSR FAULT TREE WHEN CASING IS ACROSS THE BOP

CASING_SHEAR_FAIL_ED = CASING_SHEAR_FAIL_EDCS ;

ENDIF

|ASSIGNING BSR FAULT TREES WHEN CASING IS ACROSS THE BOP AT THE TIME OF LOSS OF POSITION AND EMERGENCY DISCONNECT

IF (CASING_DRIFT + CASING_DRIVE-OFF) * /CASING_SHEAR_FAIL_ED THEN | CSR SUCCESSFULLY SHEARED THE CASING DURING EDS

/BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDNAB; | SUBSTITUTES BSR FAILURE WITH THE BSR FAULT TREE WHEN NOTHING IS ACROSS THE BOP (BSR NEEDS TO CLOSE IN ORDER TO SEAL THE WELL)

BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDNAB;

ELSEIF (CASING_DRIFT + CASING_DRIVE-OFF) * (CASING_SHEAR_FAIL_ED + NONSHEARABLE_EDCS) THEN | CASING THROUGH BOP THAT WAS NOT SHEARED BY CSR DUE TO CSR FAILURE IN EDS OR NONSHEARABLE PRESENT ACROSS THE CSR

/BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDCS ; | SUBSTITUTES BSR FAILURE WITH THE BSR FAULT TREE WHEN CASING IS ACROSS THE BOP

BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDCS ;

ENDIF

|ASSIGNING AUTOSHEAR CSR FAULT TREES WHEN CASING IS ACROSS THE BOP AT THE TIME OF AUTOSHEAR ACTUATION AFTER LMRP DISCONNECT

IF (CASING_DRIFT + CASING_DRIVE-OFF) * CASING_SHEAR_FAIL_ED * BLIND_SHEAR_FAIL_ED THEN | NEITHER CSR NOR BSR COULD SHEAR THE CASING DURING EDS

/AUTOSHEAR_EDCS = AUTOSHEAR_EDCSCS ; | SUBSTITUTES AUTOSHEAR CSR FAILURE WITH THE FAULT TREE WHEN CASING IS ACROSS THE BOP

AUTOSHEAR_EDCS = AUTOSHEAR_EDCSCS ;

ELSEIF (CASING_DRIFT + CASING_DRIVE-OFF) * NONSHEARABLE_EDBS THEN | NONSHEARABLE IN BSR, THEREFORE BSR IS SKIPPED AND CASING IS STILL ACROSS THE BOP

/AUTOSHEAR_EDCS = AUTOSHEAR_EDCSCS ; | SUBSTITUTES AUTOSHEAR CSR FAILURE WITH THE FAULT TREE WHEN CASING IS ACROSS THE BOP

AUTOSHEAR_EDCS = AUTOSHEAR_EDCSCS ;

ENDIF

|ASSIGNING AUTOSHEAR BSR FAULT TREES WHEN CASING IS ACROSS THE BOP AT THE TIME OF AUTOSHEAR ACTUATION AFTER LMRP DISCONNECT (EDS)

IF (CASING_DRIFT + CASING_DRIVE-OFF) * CASING_SHEAR_FAIL_ED * BLIND_SHEAR_FAIL_ED * AUTOSHEAR_EDCS THEN | NEITHER CSR, BSR, NOR AUTOSHEAR_CSR COULD SHEAR THE CASING DURING EDS

/AUTOSHEAR_EDBS = AUTOSHEAR_EDBSCS ; | SUBSTITUTES AUTOSHEAR CSR FAILURE WITH THE FAULT TREE WHEN CASING IS ACROSS THE BOP

AUTOSHEAR_EDBS = AUTOSHEAR_EDBSCS ;

ELSEIF (CASING_DRIFT + CASING_DRIVE-OFF) * ((CASING_SHEAR_FAIL_ED * BLIND_SHEAR_FAIL_ED * /AUTOSHEAR_EDCS) + /CASING_SHEAR_FAIL_ED) THEN | NEITHER CSR, BSR, NOR AUTOSHEAR_CSR COULD SHEAR THE CASING DURING EDS

```
/AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB   ;                                    | SUBSTITUTES AUTOSHEAR CSR FAILURE WITH THE FAULT TREE WHEN NOTHING IS ACROSS THE BOP

AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB   ;

ELSEIF ( CASING_DRIFT + CASING_DRIVE-OFF ) * NONSHEARABLE_EDBS  * /AUTOSHEAR_EDCS THEN          | NONSHEARABLE ACROSS THE BSR AND CSR AUTOSHEAR FAILURE

/AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB   ;                                    | SUBSTITUTES AUTOSHEAR CSR FAILURE WITH THE FAULT TREE WHEN CASING IS ACROSS THE BOP

AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB   ;

ELSEIF ( CASING_DRIFT + CASING_DRIVE-OFF ) * NONSHEARABLE_EDCS  * BLIND_SHEAR_FAIL_ED THEN      | NONSHEARABLE ACROSS THE CSR AND BSR FAILURE DURING EDS

/AUTOSHEAR_EDBS =  AUTOSHEAR_EDBSCS   ;                                    | SUBSTITUTES AUTOSHEAR BSR FAILURE WITH THE FAULT TREE WHEN CASING IS ACROSS THE BOP

AUTOSHEAR_EDBS =  AUTOSHEAR_EDBSCS   ;

ENDIF


|****************************************************************************************************************************

|***** DRILLPIPE ACROSS THE BOP WITH OR WITHOUT NONSHEARABLE ACROSS CSR OR BSR AT THE TIME OF LOSS OF POSITION AND EDS INITIATION *****

|****************************************************************************************************************************

|ASSIGNING NONSHEARABLE_EDCS, NONSHEARABLE_EDBS, AND CSR FAULT TREES WHEN DRILLPIPE IS ACROSS THE CSR AT THE TIME OF LMRP DISCONNECT (EDS)

IF DRILLPIPE_DRIFT THEN                | DRIFT-OFF OR PUSH-OFF SCENARIO AT THE TIME THAT DRILLPIPE IS ACROSS THE BOP

/NONSHEARABLE_EDCS = NONSHEARABLE_CSTJ ;        | SUBSTITUTES WITH THE NONSHEARABLE FAULT TREE FOR CSR RUNNING DRILLPIPE

NONSHEARABLE_EDCS = NONSHEARABLE_CSTJ ;

/NONSHEARABLE_EDBS = NONSHEARABLE_BSTJ ;        | SUBSTITUTES WITH THE NONSHEARABLE FAULT TREE FOR BSR RUNNING DRILLPIPE

NONSHEARABLE_EDBS = NONSHEARABLE_BSTJ ;

/CASING_SHEAR_FAIL_ED = CASING_SHEAR_FAIL_EDDR ;     | SUBSTITUTES CSR FAILURE WITH THE CSR FAULT TREE WHEN DRILLPIPE IS ACROSS THE BOP

CASING_SHEAR_FAIL_ED = CASING_SHEAR_FAIL_EDDR ;

ELSEIF DRILLPIPE_DRIVE-OFF    THEN            | DRIVE-OFF SCENARIO AT THE TIME THAT DRILLPIPE IS ACROSS THE BOP
```

/NONSHEARABLE_EDCS = NONSHEARABLE_CSTJDO ; | SUBSTITUTES WITH THE NONSHEARABLE FAULT TREE FOR CSR RUNNING DRILLPIPE BUT WITHOUT THE REPOSITIONING RECOVERY

NONSHEARABLE_EDCS = NONSHEARABLE_CSTJDO ;

/NONSHEARABLE_EDBS = NONSHEARABLE_BSTJDO ; | SUBSTITUTES WITH THE NONSHEARABLE FAULT TREE FOR BSR RUNNING DRILLPIPE BUT WITHOUT THE REPOSITIONING RECOVERY

NONSHEARABLE_EDBS = NONSHEARABLE_BSTJDO ;

/CASING_SHEAR_FAIL_ED = CASING_SHEAR_FAIL_EDDR ; | SUBSTITUTES CSR FAILURE WITH THE CSR FAULT TREE WHEN DRILLPIPE IS ACROSS THE BOP

CASING_SHEAR_FAIL_ED = CASING_SHEAR_FAIL_EDDR ;

ENDIF

|ASSIGNING BSR FAULT TREES WHEN DRILLPIPE IS ACROSS THE BOP AT THE TIME OF LOSS OF POSITION AND EMERGENCY DISCONNECT

IF (DRILLPIPE_DRIFT + DRILLPIPE_DRIVE-OFF) * /CASING_SHEAR_FAIL_ED THEN | CSR SUCCESSFULLY SHEARED THE CASING DURING EDS

/BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDNAB; | SUBSTITUTES BSR FAILURE WITH THE BSR FAULT TREE WHEN NOTHING IS ACROSS THE BOP (BSR NEEDS TO CLOSE IN ORDER TO SEAL THE WELL)

BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDNAB;

ELSEIF (DRILLPIPE_DRIFT + DRILLPIPE_DRIVE-OFF) * (CASING_SHEAR_FAIL_ED + NONSHEARABLE_EDCS) THEN | CASING THROUGH BOP THAT WAS NOT SHEARED BY CSR DUE TO CSR FAILURE IN EDS OR NONSHEARABLE PRESENT ACROSS THE CSR

/BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDDR ; | SUBSTITUTES BSR FAILURE WITH THE BSR FAULT TREE WHEN DRILLPIPE IS ACROSS THE BOP

BLIND_SHEAR_FAIL_ED = BLIND_SHEAR_FAIL_EDDR ;

ENDIF

|ASSIGNING AUTOSHEAR CSR FAULT TREES WHEN DRILLPIPE IS ACROSS THE BOP AT THE TIME OF AUTOSHEAR ACTUATION AFTER LMRP DISCONNECT

IF (DRILLPIPE_DRIFT + DRILLPIPE_DRIVE-OFF) * CASING_SHEAR_FAIL_ED * BLIND_SHEAR_FAIL_ED THEN | NEITHER CSR NOR BSR COULD SHEAR THE DRILLPIPE DURING EDS

/AUTOSHEAR_EDCS = AUTOSHEAR_EDCSDP ; | SUBSTITUTES AUTOSHEAR CSR FAILURE WITH THE FAULT TREE WHEN DRILLPIPE IS ACROSS THE BOP

AUTOSHEAR_EDCS = AUTOSHEAR_EDCSDP ;

```
ELSEIF ( DRILLPIPE_DRIFT + DRILLPIPE_DRIVE-OFF ) * NONSHEARABLE_EDBS  THEN    | NONSHEARABLE IN BSR, THEREFORE BSR IS SKIPPED AND CASING IS STILL ACROSS THE BOP

/AUTOSHEAR_EDCS = AUTOSHEAR_EDCSDP   ;    | SUBSTITUTES AUTOSHEAR CSR FAILURE WITH THE FAULT TREE WHEN DRILLPIPE IS ACROSS THE BOP

AUTOSHEAR_EDCS = AUTOSHEAR_EDCSDP   ;

ENDIF


|ASSIGNING AUTOSHEAR BSR FAULT TREES WHEN CASING  IS ACROSS THE BOP AT THE TIME OF AUTOSHEAR ACTUATION AFTER LMRP DISCONNECT (EDS)

IF ( DRILLPIPE_DRIFT + DRILLPIPE_DRIVE-OFF ) * CASING_SHEAR_FAIL_ED * BLIND_SHEAR_FAIL_ED * AUTOSHEAR_EDCS THEN    | NEITHER CSR, BSR, NOR AUTOSHEAR_CSR COULD SHEAR THE DRILLPIPE DURING EDS

/AUTOSHEAR_EDBS = AUTOSHEAR_EDBSDP   ;    | SUBSTITUTES AUTOSHEAR CSR FAILURE WITH THE FAULT TREE WHEN DRILLPIPE IS ACROSS THE BOP

AUTOSHEAR_EDBS = AUTOSHEAR_EDBSDP   ;

ELSEIF ( DRILLPIPE_DRIFT + DRILLPIPE_DRIVE-OFF ) * ((CASING_SHEAR_FAIL_ED * BLIND_SHEAR_FAIL_ED * /AUTOSHEAR_EDCS ) + /CASING_SHEAR_FAIL_ED ) THEN | NEITHER CSR, BSR, NOR AUTOSHEAR_CSR COULD SHEAR THE DRILLPIPE DURING EDS

/AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB   ;    | SUBSTITUTES AUTOSHEAR CSR FAILURE WITH THE FAULT TREE WHEN NOTHING IS ACROSS THE BOP

AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB   ;

ELSEIF ( DRILLPIPE_DRIFT + DRILLPIPE_DRIVE-OFF ) * NONSHEARABLE_EDBS  * /AUTOSHEAR_EDCS THEN    | NONSHEARABLE ACROSS THE BSR AND CSR AUTOSHEAR FAILURE

/AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB   ;    | SUBSTITUTES AUTOSHEAR CSR FAILURE WITH THE FAULT TREE WHEN DRILLPIPE IS ACROSS THE BOP

AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB   ;

ELSEIF ( DRILLPIPE_DRIFT + DRILLPIPE_DRIVE-OFF ) * NONSHEARABLE_EDCS  * BLIND_SHEAR_FAIL_ED THEN    | NONSHEARABLE ACROSS THE CSR AND BSR FAILURE DURING EDS

/AUTOSHEAR_EDBS =  AUTOSHEAR_EDBSDP   ;    | SUBSTITUTES AUTOSHEAR BSR FAILURE WITH THE FAULT TREE WHEN DRILLPIPE IS ACROSS THE BOP

AUTOSHEAR_EDBS =  AUTOSHEAR_EDBSDP   ;

ENDIF
```

| ENSURE THAT RISER PARTS IN THE EVENT OF A LOSS OF POSITION DUE TO DRIVE-OFF

IF (DRIVE-OFF_IEFT_FRE + DRIVE-OFF_KICK) THEN | IF DRIVE-OFF EVENT (EITHER AS INITIATOR, OR POST-INITIATOR DURING WELLKILL PROCESS)

/RISER_PARTS = SKIP(RISER_PARTS) ; | SETS RISER_PARTS PROBABILITY = 1 (I.E. FORCES PTHE RISER PARTING, AND SKIPS THE SUCCESS PATH (RISER DOES NOT PART)

RISER_PARTS = RISER_PARTS_DRIVE ;

ELSEIF (DRIFT-OFFPUSH-OFF_IEFT_FRE + DRIFT-OFFPUSH-OFF_KICK) THEN

; |DO NOTHING (KEEP TOP EVENT AS RISER_PARTS)

ELSE | ENSURE THAT RISER STAYS INTACT DURING A WELL KICK WHERE THERE IS NO LOSS OF POSITION (DRILLSHIP CAN STAY IN PLACE AFTER LMRP DISCONNECT)

/RISER_PARTS = RISER_PARTS_KICK ; | SETS RISER_PARTS PROBABILITY = 0, MEANING RISER NEVER PARTS

RISER_PARTS = SKIP(RISER_PARTS) ; | SKIPS THE FAILURE PATH (SINCE RISER NEVER PARTS FOR A KICK WITHOUT LOSS OF POSITION)

ENDIF

B.10 DEADMAN EVENT TREE

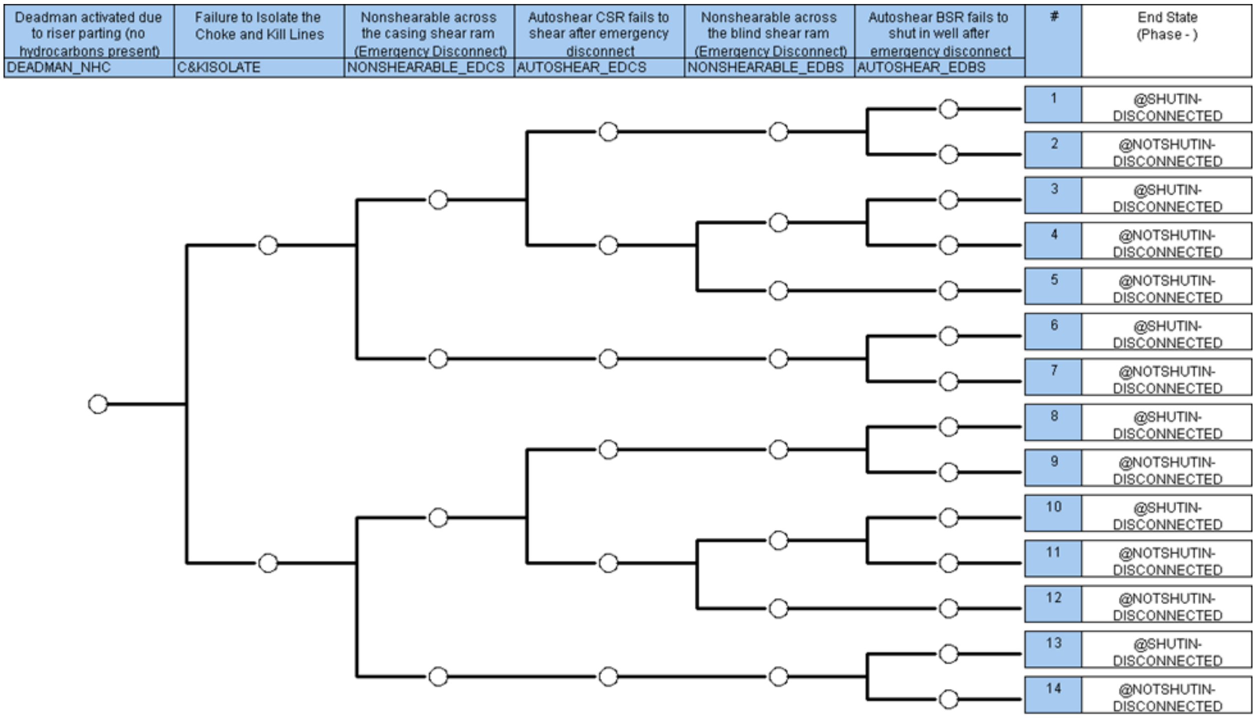

Figure B- 12: DEADMANNHC Event Tree

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|*****************************************************************************************************
|*****************************************************************************************************
|*****                                                                                          *****
|*****                                                                                          *****
|*****                    LINKAGE RULES FOR DEADMAN-NHC EVENT TREE                              *****
|*****                    (SAME RULES AS FOR DEADMAN EVENT TREE)                                *****
|*****                           DATED 3 AUGUST 2018                                            *****
|*****      REVISED TO ADD RULES FOR THE TRANSFER FROM INADVERTENT LMRP DISCONNECT ET           *****|
*****                                                                                           *****
|*****                                                                                          *****
|*****************************************************************************************************
|*****************************************************************************************************
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|ASSIGN PROBABILITY OF NONSHEARABLE ACROSS THE CASING SHEAR RAM AND BLIND SHEAR RAM

IF DRIFT-OFFPUSH-OFF_IEFT_FRE * (RUNNINGCASING_IC + RUNNINGCASING_PZ) THEN |THIS ACCOUNTS FOR CASING ACROSS THE BOP LOSS OF POSITION DRIFT-OFF/PUSH-OFF SCENARIOS

NONSHEARABLE_EDCS = NONSHEARABLE_CSCC;

/NONSHEARABLE_EDCS = NONSHEARABLE_CSCC;

NONSHEARABLE_EDBS = NONSHEARABLE_BSCC;

/NONSHEARABLE_EDBS = NONSHEARABLE_BSCC;

ELSEIF (DRIVE-OFF_IEFT_FRE + INIT(INADV_DISC_IEFT_FRE)) * (RUNNINGCASING_IC + RUNNINGCASING_PZ) THEN

|THIS ACCOUNTS FOR CASING ACROSS THE BOP LOSS OF POSITION DRIVE-OFF SCENARIOS (NO CASE COUPLING REPOSITIONING ALLOWED)

NONSHEARABLE_EDCS = NONSHEARABLE_CSCCDO;

/NONSHEARABLE_EDCS = NONSHEARABLE_CSCCDO;

```
NONSHEARABLE_EDBS = NONSHEARABLE_BSCCDO;
/NONSHEARABLE_EDBS = NONSHEARABLE_BSCCDO;
ELSEIF DRIFT-OFFPUSH-OFF_IEFT_FRE * (DRILLSTRINGIN_IC + DRILLSTRINGIN_PZ)   THEN
        |THIS ACCOUNTS FOR DRILLPIPE ACROSS THE BOP LOSS OF POSITION DRIFT-OFF/PUSH-OFF SCENARIOS
NONSHEARABLE_EDCS = NONSHEARABLE_CSTJ;
/NONSHEARABLE_EDCS = NONSHEARABLE_CSTJ;
NONSHEARABLE_EDBS = NONSHEARABLE_BSTJ;
/NONSHEARABLE_EDBS = NONSHEARABLE_BSTJ;
ELSEIF   ( DRIVE-OFF_IEFT_FRE + INIT(INADV_DISC_IEFT_FRE) ) * (DRILLSTRINGIN_IC + DRILLSTRINGIN_PZ)   THEN
        |THIS ACCOUNTS FOR DRILLPIPE ACROSS THE BOP LOSS OF POSITION DRIVE-OFF SCENARIOS (NO TOOLJOINT REPOSITIONING ALLOWED)
NONSHEARABLE_EDCS = NONSHEARABLE_CSTJDO;
/NONSHEARABLE_EDCS = NONSHEARABLE_CSTJDO;
NONSHEARABLE_EDBS = NONSHEARABLE_BSTJDO;
/NONSHEARABLE_EDBS = NONSHEARABLE_BSTJDO;
ELSEIF (OPENHOLE_IC + OPENHOLE_PZ)  THEN        |THIS ACCOUNTS FOR EMPTY HOLE CASES (SET NONSHEARABLES EQUAL TO ZERO)
NONSHEARABLE_EDCS = SKIP(NONSHEARABLE_EDCS);
/NONSHEARABLE_EDCS = NONSHEARABLE_CS0;
NONSHEARABLE_EDBS = SKIP(NONSHEARABLE_EDBS);
/NONSHEARABLE_EDBS = NONSHEARABLE_BS0;
ENDIF

|ASSIGN AUTOSHEAR CASING SHEAR RAM FAILURE FAULT TREE BASED
|ON WHETHER THERE IS DRILLPIPE, CASING, OR NOTHING ACROSS THE BOP
```

IF(RUNNINGCASING_IC + RUNNINGCASING_PZ) THEN |THIS ACCOUNTS FOR CASING ACROSS THE BOP LOSS OF POSITION DRIFT-OFF/PUSH-OFF SCENARIOS

AUTOSHEAR_EDCS = AUTOSHEAR_EDCSCS;

/AUTOSHEAR_EDCS = AUTOSHEAR_EDCSCS;

ELSEIF (DRILLSTRINGIN_IC + DRILLSTRINGIN_PZ) THEN |THIS ACCOUNTS FOR DRILLPIPE ACROSS THE BOP LOSS OF POSITION DRIFT-OFF/PUSH-OFF SCENARIOS

AUTOSHEAR_EDCS = AUTOSHEAR_EDCSDP;

/AUTOSHEAR_EDCS = AUTOSHEAR_EDCSDP;

ELSEIF (OPENHOLE_IC + OPENHOLE_PZ) THEN |THIS ACCOUNTS FOR EMPTY HOLE CASES (SET AUTOSHEAR CSR TO 0 OR FALSE)

AUTOSHEAR_EDCS = AUTOSHEAR_EDCSNAB;

/AUTOSHEAR_EDCS = AUTOSHEAR_EDCSNAB;

ENDIF

|ASSIGN AUTOSHEAR BLIND SHEAR RAM FAILURE FAULT TREE BASED

|ON WHETHER THERE IS DRILLPIPE, CASING, OR NOTHING ACROSS THE BOP

IF(RUNNINGCASING_IC + RUNNINGCASING_PZ) * (AUTOSHEAR_EDCS + NONSHEARABLE_EDCS) THEN

|THIS ACCOUNT FOR RUNNING CASING AND NONSHEARABLE ACROSS CSR OR CSR FAILS

AUTOSHEAR_EDBS = AUTOSHEAR_EDBSCS;

/AUTOSHEAR_EDBS = AUTOSHEAR_EDBSCS;

ELSEIF (DRILLSTRINGIN_IC + DRILLSTRINGIN_PZ) * (AUTOSHEAR_EDCS + NONSHEARABLE_EDCS) THEN

|THIS ACCOUNTS FOR DRILLPIPE ACROSS THE BOP AND NONSHEARABLE ACROSS CSR OR CSR FAILS

AUTOSHEAR_EDBS = AUTOSHEAR_EDBSDP;

/AUTOSHEAR_EDBS = AUTOSHEAR_EDBSDP;

ELSEIF OPENHOLE_IC + OPENHOLE_PZ + ((DRILLSTRINGIN_IC + DRILLSTRINGIN_PZ) * /AUTOSHEAR_EDCS) + ((RUNNINGCASING_IC + RUNNINGCASING_PZ) * /AUTOSHEAR_EDCS) THEN |THIS ACCOUNTS FOR EMPTY HOLE CASES

AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB;

/AUTOSHEAR_EDBS = AUTOSHEAR_EDBSNAB;

ENDIF

APPENDIX C- FAULT TREES

Table C- 1: Fault Tree / Event Tree Cross Reference

Fault Tree	Description	Event Tree(s)
CAPSTACK	Capping Stack Fails to Contain Well	ACCIDENTMANAGEMENT
CAPSTACKBULL	Capping Stack Ineffective due to underground blowout	ACCIDENTMANAGEMENT
ROV	ROV Fails to Operate BOP to Seal the Well	ACCIDENTMANAGEMENT
ROV_CSED	Unable to close or lock the Blind Shear Ram with casing across the BOP with the ROV	ACCIDENTMANAGEMENT
ROV_CSED_NONSHEARABLES	Unable to close or lock the Blind Shear Ram with casing across the BOP with the ROV	ACCIDENTMANAGEMENT
ROV_CSED_NONSHRBL_BSCC	Unable to close or lock the BOP with casing with the ROV when case coupling across the BSR	ACCIDENTMANAGEMENT
ROV_CSED_NONSHRBL_CSCC	Unable to close or lock the BSR with casing across the BOP with the ROV when case coupling across the CSR	ACCIDENTMANAGEMENT
ROV_CSED_NONSHRBLS_DO	Unable to close or lock the Blind Shear Ram with casing across the BOP with the ROV - Drive-off	ACCIDENTMANAGEMENT
ROV_DRED	Unable to close or lock the Blind Shear Ram with drill string across the BOP with the ROV	ACCIDENTMANAGEMENT
ROV_DRED_NONSHEARABLES	Unable to close or lock the Blind Shear Ram with drill string across the BOP with the ROV	ACCIDENTMANAGEMENT
ROV_DRED_NONSHRBLS_DO	Unable to close or lock the Blind Shear Ram with drill string across the BOP with the ROV - Drive-off	ACCIDENTMANAGEMENT
ROV_NABED	Unable to close or lock the Blind Shear Ram with nothing across the BOP with the ROV	ACCIDENTMANAGEMENT
ROV1	Unable to Contain Well with ROV due to BOP failure or formation failure	ACCIDENTMANAGEMENT
BLIND_SHEAR_FAIL_CS	BSR fails to operate when casing is present	CASING
CASE_SHOE_FAILS	Casing Shoe float Valve Fails To Close and prevent back flow	CASING
CASING_SHEAR_FAIL_CS	CSR fails while running casing	CASING
BLIND_SHEAR_FAIL_MN	BSR fails to shut in well during manual actuation	CASING, DRILLING

Fault Tree	Description	Event Tree(s)
NONSHEARABLE_BSCC	Casing coupling across the blind shear ram	CASING, LMRPDISCONNECT, LMRPDISCONNECTNHC, DEADMAN, DEADMANNHC
NONSHEARABLE_CSCC	Casing coupling across the casing shear ram	CASING, LMRPDISCONNECT, LMRPDISCONNECTNHC, DEADMAN, DEADMANNHC
ANNULAR_PIPERAM_DR	Failure to seal the annulus with the annulars or pipe rams	DRILLING
BLIND_SHEAR_FAIL_DR	BSR fails to operate when drill string is present	DRILLING
CASING_SHEAR_FAIL_DR	Casing shear fails when drillstring is present	DRILLING
IBOP_FLTVLV_FAILS	Float Valve and IBOP Fails To Close or is not present	DRILLING
NONSHEARABLE_BSTJ	Nonshearable across the blind shear ram	DRILLING, LMRPDISCONNECT, LMRPDISCONNECTNHC, DEADMAN, DEADMANNHC
NONSHEARABLE_CSTJ	Nonshearable across the casing shear ram	DRILLING, LMRPDISCONNECT, LMRPDISCONNECTNHC, DEADMAN, DEADMANNHC
CASINGKICK_IC	Well Kick While Running Casing intermediate casing	EXPLORATIONOPS
CASINGKICK_PZ	Well Kick While Running Casing in the reservoir	EXPLORATIONOPS
CASINGKICK_SC	Well Kick While Running Casing during surface casing operations	EXPLORATIONOPS
DRIFT-OFFPUSH-OFF_IEFT_FRE	Loss of stationkeeping due to drift-off/push-off (Events per Well)	EXPLORATIONOPS
DRILLKICK_IC	Well Kick While Drilling, intermediate casing ops	EXPLORATIONOPS
DRILLKICK_PZ	Well Kick While Drilling, reservoir ops	EXPLORATIONOPS
DRILLKICK_SC	Well Kick While Drilling during surface casing operations	EXPLORATIONOPS
DRIVE-OFF_IEFT_FRE	Loss of stationkeeping due to drive-off as an Initiating Event	EXPLORATIONOPS

Fault Tree	Description	Event Tree(s)
EMPTY_BOP_KICK_IC	Kick with Nothing Across the BOP intermediate casing ops	EXPLORATIONOPS
EMPTY_BOP_KICK_PZ	Kick with Nothing Across BOP in the reservoir	EXPLORATIONOPS
EMPTY_BOP_KICK_SC	Well Kick during surface casing operations with nothing across the BOP	EXPLORATIONOPS
LOSSOFPOSITION	Loss of position	EXPLORATIONOPS
WELLSTATUS	Well operation when kick occurs	EXPLORATIONOPS
AUTOSHEAR_EDBS	Autoshear BSR fails to shut in well after emergency disconnect	LMRPDISCONNECT, LMRPDISCONNECTNHC
AUTOSHEAR_EDCS	Autoshear CSR fails to shear after emergency disconnect	LMRPDISCONNECT, LMRPDISCONNECTNHC
BLIND_SHEAR_FAIL_ED	BSR fails to shut in well during Emergency Disconnect	LMRPDISCONNECT, LMRPDISCONNECTNHC
BLIND_SHEAR_FAIL_EDCS	BSR fails to shut in well with casing - Emergency Disconnect	LMRPDISCONNECT, LMRPDISCONNECTNHC
BLIND_SHEAR_FAIL_EDCS1	BSR fails to shut in well previous failure or nonshearable when casing present - Emergency Disconnect	LMRPDISCONNECT, LMRPDISCONNECTNHC
BLIND_SHEAR_FAIL_EDDR	BSR fails to shut in Well with drillpipe - Emergency Disconnect	LMRPDISCONNECT, LMRPDISCONNECTNHC
BLIND_SHEAR_FAIL_EDDR1	BSR fails to shut in well previous failure or nonshearable when drillpipe is present - Emergency Disconnect	LMRPDISCONNECT, LMRPDISCONNECTNHC
BLIND_SHEAR_FAIL_EDNAB	BSR fails to shut in well nothing across the BOP - Emergency Disconnect	LMRPDISCONNECT, LMRPDISCONNECTNHC
C&KISOLATE	Failure to Isolate the Choke and Kill Lines	LMRPDISCONNECT, LMRPDISCONNECTNHC
CASING_SHEAR_FAIL_ED	CSR fails - Emergency Disconnect	LMRPDISCONNECT, LMRPDISCONNECTNHC
CASING_SHEAR_FAIL_EDCS	Casing shear fails while running casing - Emergency Disconnect	LMRPDISCONNECT, LMRPDISCONNECTNHC

Fault Tree	**Description**	**Event Tree(s)**
CASING_SHEAR_FAIL_EDCS1	Setting casing shear to failed state while running casing (previously failed) - Emergency Disconnect	LMRPDISCONNECT, LMRPDISCONNECTNHC
CASING_SHEAR_FAIL_EDDR	CSR fails with drillpipe - Emergency Disconnect	LMRPDISCONNECT, LMRPDISCONNECTNHC
CASING_SHEAR_FAIL_EDDR1	Setting casing shear to failed state when drillpipe is across (previously failed) - Emergency Disconnect	LMRPDISCONNECT, LMRPDISCONNECTNHC
CASING_SHEAR_FAIL_EDNAB	Casing Shear not required if nothing across the BOP - Emergency Disconnect	LMRPDISCONNECT, LMRPDISCONNECTNHC
DISCONNECT	Failure to Disconnect the LMRP	LMRPDISCONNECT, LMRPDISCONNECTNHC
NONSHEARABLE_BSCC1	Nonshearable across the BSR set to 1 when casing across (nonshearable present from previous event tree)	LMRPDISCONNECT, LMRPDISCONNECTNHC
NONSHEARABLE_BSNAB	Nothing across the BOP	LMRPDISCONNECT, LMRPDISCONNECTNHC
NONSHEARABLE_BSTJ1	Nonshearable across the BSR set to 1 when drillpipe across (nonshearable present from previous event tree)	LMRPDISCONNECT, LMRPDISCONNECTNHC
NONSHEARABLE_CSCC1	Nonshearable across the CSR set to 1 when casing across (nonshearable present from previous event tree)	LMRPDISCONNECT, LMRPDISCONNECTNHC
NONSHEARABLE_CSNAB	Nothing across the BOP	LMRPDISCONNECT, LMRPDISCONNECTNHC
NONSHEARABLE_CSTJ1	Nonshearable across the CSR set to 1 when drillpipe across (nonshearable present from previous event tree)	LMRPDISCONNECT, LMRPDISCONNECTNHC
NONSHEARABLE_EDBS	Nonshearable across the blind shear ram (Emergency Disconnect)	LMRPDISCONNECT, LMRPDISCONNECTNHC
NONSHEARABLE_EDCS	Nonshearable across the casing shear ram (Emergency Disconnect)	LMRPDISCONNECT, LMRPDISCONNECTNHC
RISER_PARTS_KICK	Ensure that riser doesn't part during a well kick	LMRPDISCONNECT, LMRPDISCONNECTNHC

Fault Tree	Description	Event Tree(s)
AUTOSHEAR_EDBSCS	Autoshear BSR fails to shut in well when casing is present after emergency disconnect	LMRPDISCONNECT, LMRPDISCONNECTNHC, DEADMAN, DEADMANNHC
AUTOSHEAR_EDBSDP	Autoshear BSR fails to shut in well when drillpipe is present after emergency disconnect	LMRPDISCONNECT, LMRPDISCONNECTNHC, DEADMAN, DEADMANNHC
AUTOSHEAR_EDBSNAB	Autoshear BSR fails to shut in well after emergency disconnect - nothing across the BOP	LMRPDISCONNECT, LMRPDISCONNECTNHC, DEADMAN, DEADMANNHC
AUTOSHEAR_EDCSCS	Autoshear CSR fails to shear casing after emergency disconnect	LMRPDISCONNECT, LMRPDISCONNECTNHC, DEADMAN, DEADMANNHC
AUTOSHEAR_EDCSDP	Autoshear CSR fails to shear pipe after emergency disconnect	LMRPDISCONNECT, LMRPDISCONNECTNHC, DEADMAN, DEADMANNHC
AUTOSHEAR_EDCSNAB	Autoshear CSR set to Prob = 0 (FALSE) when nothing across the BOP	LMRPDISCONNECT, LMRPDISCONNECTNHC, DEADMAN, DEADMANNHC
NONSHEARABLE_BS0	Nonshearable across the blind shear set to 0	LMRPDISCONNECT, LMRPDISCONNECTNHC, DEADMAN, DEADMANNHC
NONSHEARABLE_BSCCDO	Casing coupling across the blind shear ram - drive-off	LMRPDISCONNECT, LMRPDISCONNECTNHC, DEADMAN, DEADMANNHC

Fault Tree	Description	Event Tree(s)
NONSHEARABLE_BSTJDO	Drillpipe tool joint across the blind shear ram - Drive-off	LMRPDISCONNECT, LMRPDISCONNECTNHC, DEADMAN, DEADMANNHC
NONSHEARABLE_CS0	Nonshearable across the casing shear set to 0	LMRPDISCONNECT, LMRPDISCONNECTNHC, DEADMAN, DEADMANNHC
NONSHEARABLE_CSCCDO	Casing coupling across the casing shear ram - Drive-off	LMRPDISCONNECT, LMRPDISCONNECTNHC, DEADMAN, DEADMANNHC
NONSHEARABLE_CSTJDO	Drillpipe tool joint across the casing shear ram - Drive-off	LMRPDISCONNECT, LMRPDISCONNECTNHC, DEADMAN, DEADMANNHC
DRILLSTRINGIN_IC	Drill String In - Intermediate Casing	LOSSOFPOSITION
DRILLSTRINGIN_PZ	Drill String In - Production Zone	LOSSOFPOSITION
EMERGDIS_POS	Failure to initiate an emergency disconnect after loss of position	LOSSOFPOSITION
HYDROCARBONS	Hydrocarbons Present	LOSSOFPOSITION
INTERMEDIATECASING	Intermediate Casing	LOSSOFPOSITION
LOCATION	Well Segment	LOSSOFPOSITION
OPENHOLE_IC	Open Hole - Intermediate Casing	LOSSOFPOSITION
OPENHOLE_PZ	Open Hole - Production Zone	LOSSOFPOSITION
PRODUCTIONZONE	Production Zone	LOSSOFPOSITION
RISER_PARTS_DRIVE	Riser parts following a loss of location due to drive-off	LOSSOFPOSITION
RUNNINGCASING_IC	Running Casing - Intermediate Casing	LOSSOFPOSITION
RUNNINGCASING_PZ	Running Casing - Production Zone	LOSSOFPOSITION
WELLSTATUS-POS	Well Operation when loss of stationkeeping occurs	LOSSOFPOSITION

Fault Tree	Description	Event Tree(s)
RISER_PARTS	Riser parts following a failed disconnect	LOSSOFPOSITION, WELLKILL, LMRPDISCONNECT, LMRPDISCONNECTNHC
ANNULARS_FAIL	Annulars fails to close and shut in well	NOTHING_BOP, CASING
BLIND_SHEAR_FAIL_NAB	BSR fails to operate when nothing is across the BOP	NOTHING_BOP, CASING, DRILLING
EMERGDIS	Failure to initiate an emergency disconnect when needed	NOTHING_BOP, CASING, DRILLING
KICKDETECT	Driller fails to identify a kick has occurred before it reaches the BOP	NOTHING_BOP, CASING, DRILLING
BLIND_SHEAR_FAIL_CSWK	BSR fails to operate when casing is present - Well Kill	WELLKILL
BLIND_SHEAR_FAIL_DRWK	BSR fails to operate when drill string is present - Well Kill	WELLKILL
BLIND_SHEAR_FAIL_NABWK	BSR fails to operate when nothing is across the BOP - Well Kill	WELLKILL
BLIND_SHEAR_FAIL_WK	BSR fails to operate - Well Kill	WELLKILL
BULLHEAD	Failure to maintain formation integrity while bullheading leads to underground blowout	WELLKILL
CASING_SHEAR_FAIL_CSWK	Casing shear fails while running casing - Well Kill	WELLKILL
CASING_SHEAR_FAIL_DRWK	Casing shear fails while drilling - Well Kill	WELLKILL
CASING_SHEAR_FAIL_WK	CSR fails to operate - Well Kill	WELLKILL
DRIFT-OFFPUSH-OFF_KICK	Loss of stationkeeping due to drift-off/push-off during a kick control	WELLKILL
DRIVE-OFF_KICK	Loss of stationkeeping due to drive-off during kick control	WELLKILL
EMERGDIS_WK	Failure to initiate an emergency disconnect during Well Kill	WELLKILL
FORMPRESS	Failure to maintain backpressure using choke and kill lines	WELLKILL
LOSS_POSITION_KICK	Loss of Position During Well Control	WELLKILL
NONSHEARABLE_BSCCWK	Casing coupling across the blind shear ram - Well Kill	WELLKILL
NONSHEARABLE_BSTJWK	Nonshearable across the blind shear ram when drillpipe is present - Well Kill	WELLKILL

Fault Tree	**Description**	**Event Tree(s)**
NONSHEARABLE_BSWK	Nonshearable across the blind shear ram - Well Kill	WELLKILL
NONSHEARABLE_CSCCWK	Casing coupling across the casing shear ram - Well Kill	WELLKILL
NONSHEARABLE_CSTJWK	Nonshearable across the casing shear ram when drillpipe is present- Well Kill	WELLKILL
NONSHEARABLE_CSWK	Nonshearable across the casing shear ram - Well Kill	WELLKILL
PIPE	Drillpipe Not Across the BOP	WELLKILL
PIPE1	Drillpipe is not across the BOP	WELLKILL
STRIP	Failure to Strip in Pipe	WELLKILL

Table C- 2 lists the graphical fault tree sections along with their associated figure numbers. Only the top events in each section are listed.

Table C- 2: Fault Tree Listing

Graphical Fault Tree Sections	Applicable Figure Numbers
Annulars/Pipe Rams	Figure C-1 through Figure C-17
Blind Shear Ram	Figure C-18 through Figure C-28
Casing Shear Ram	Figure C-29 through Figure C-35
Choke & Kill Isolation	Figure C-36
Stripping in Pipe	Figure C-37 through Figure C-40
Deadman/Autoshear	Figure C-41 through Figure C-52
5000 PSI Manifold	Figure C-53 through Figure C-55
3000 PSI Manifold	Figure C-56 through Figure C-57
Subsea Manifold	Figure C-58 through Figure C-59
Pilot System	Figure C-60 through Figure C-61
Subsea Electronics Module	Figure C-62
Emergency Disconnect	Figure C-63 through Figure C-64
IBOP/Casing Shoe	Figure C-65
ROV	Figure C-66 through Figure C-77
Capping Stack	Figure C-78
Surface Electrical Power Distribution	Figure C-79 through Figure C-80
Surface Electrical Power Generation	Figure C-81
Surface Hydraulics	Figure C-82 through Figure C-86
Drift-off/Push-off after a Kick	Figure C-87 through Figure C-89
Drive-off after a Kick	Figure C-90 through Figure C-92
Maintaining Formation Pressure with Choke & Kill	Figure C-93
Bullheading	Figure C-94
Well Condition	Figure C-95
Non-Shearables	Figure C-96 through Figure C-103
Kick Detection	Figure C-104
Kicks While Drilling	Figure C-105 through Figure C-107
Kicks While Running Casing	Figure C-108 through Figure C-110
Kicks with Nothing Across the BOP	Figure C-111 through Figure C-112
Drift-off/Push-off Initiator	Figure C-113 through Figure C-211
Drive-off Initiator	Figure C-211 through Figure C-213

C.1 ANNULARS/PIPERAMS

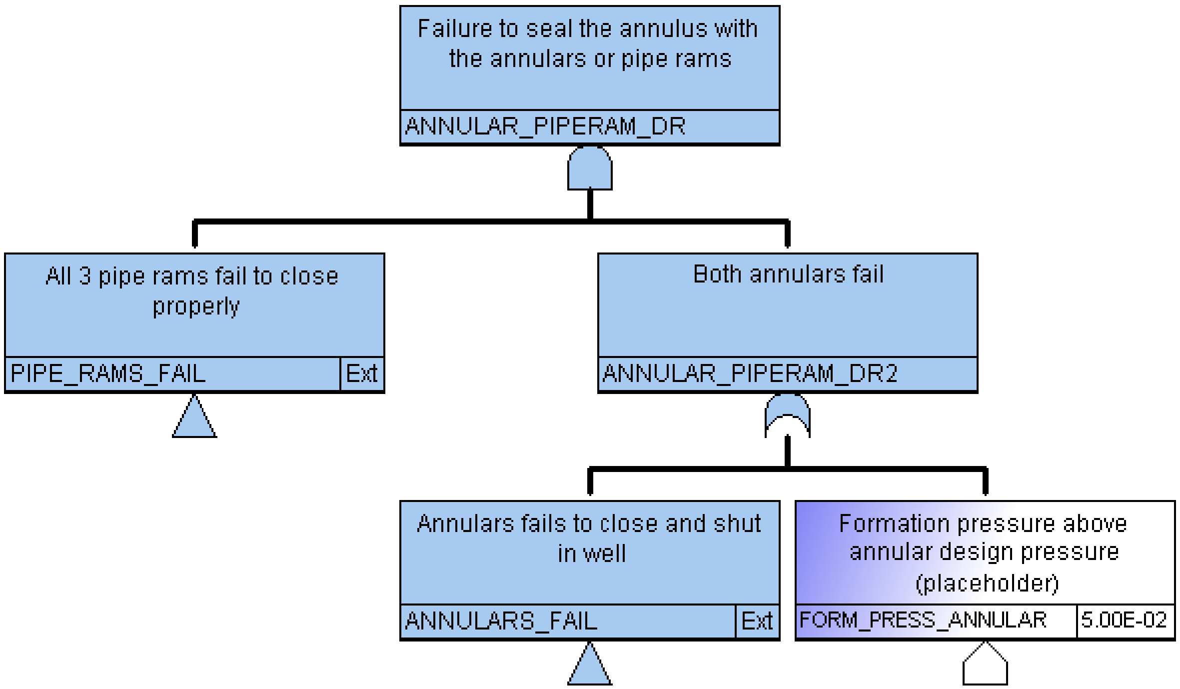


Figure C- 1: Annulars and Pipe Rams Fail to Close

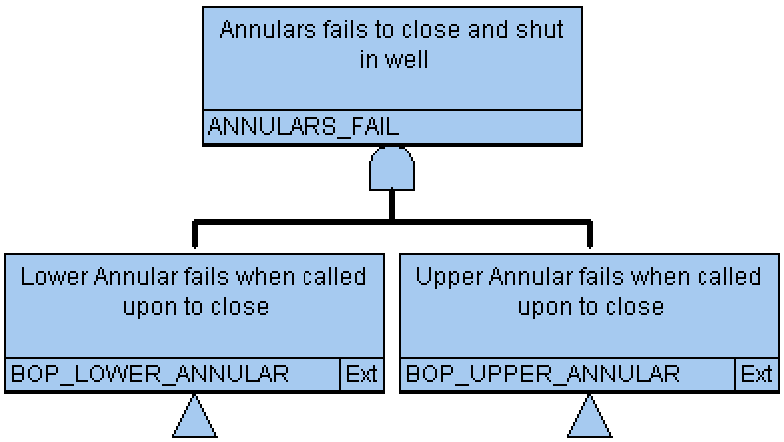


Figure C- 2: Annulars and Pipe Rams Fail to Close (Continued)

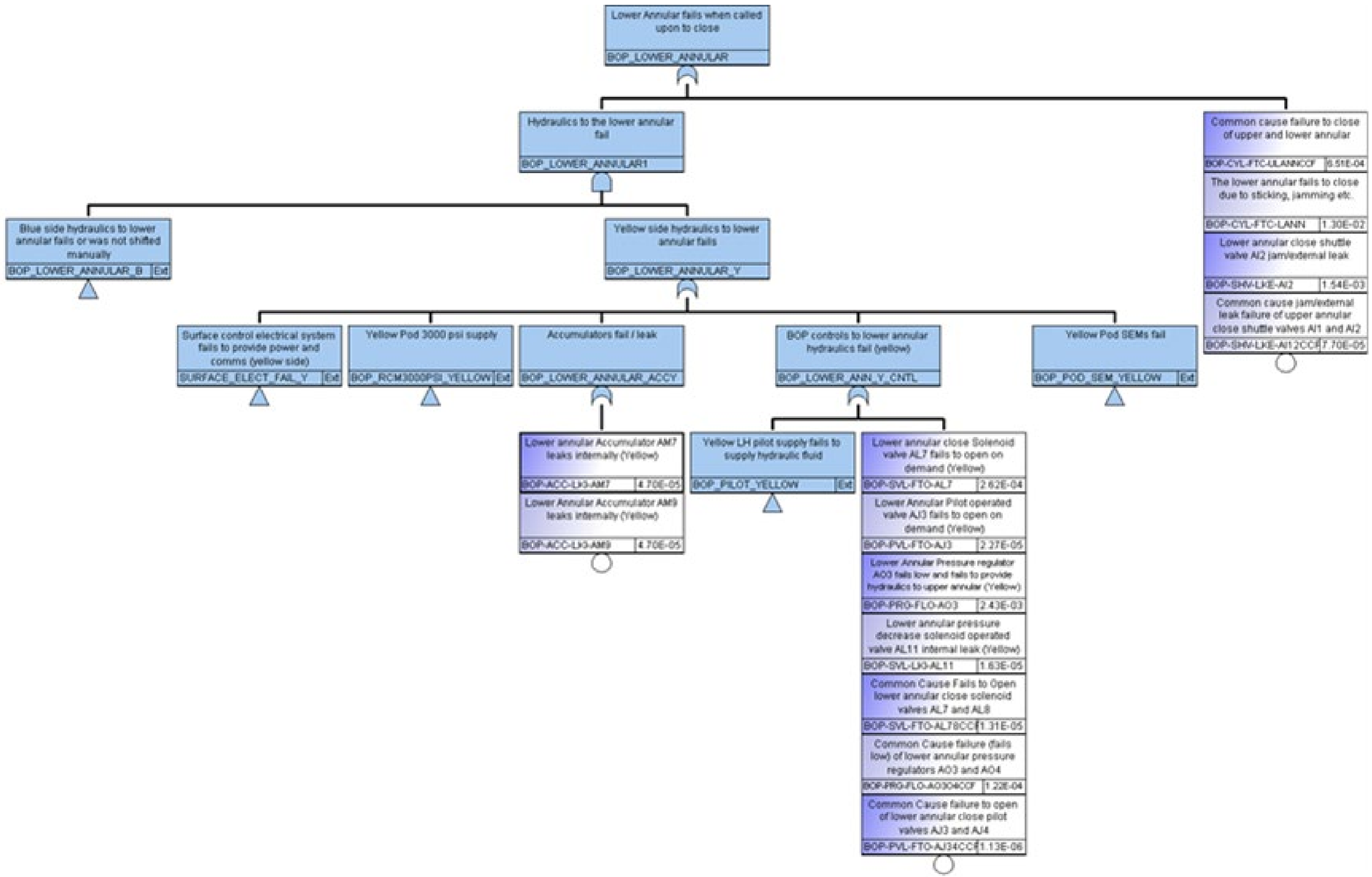


Figure C- 3: Annulars and Pipe Rams Fail to Close (Continued)

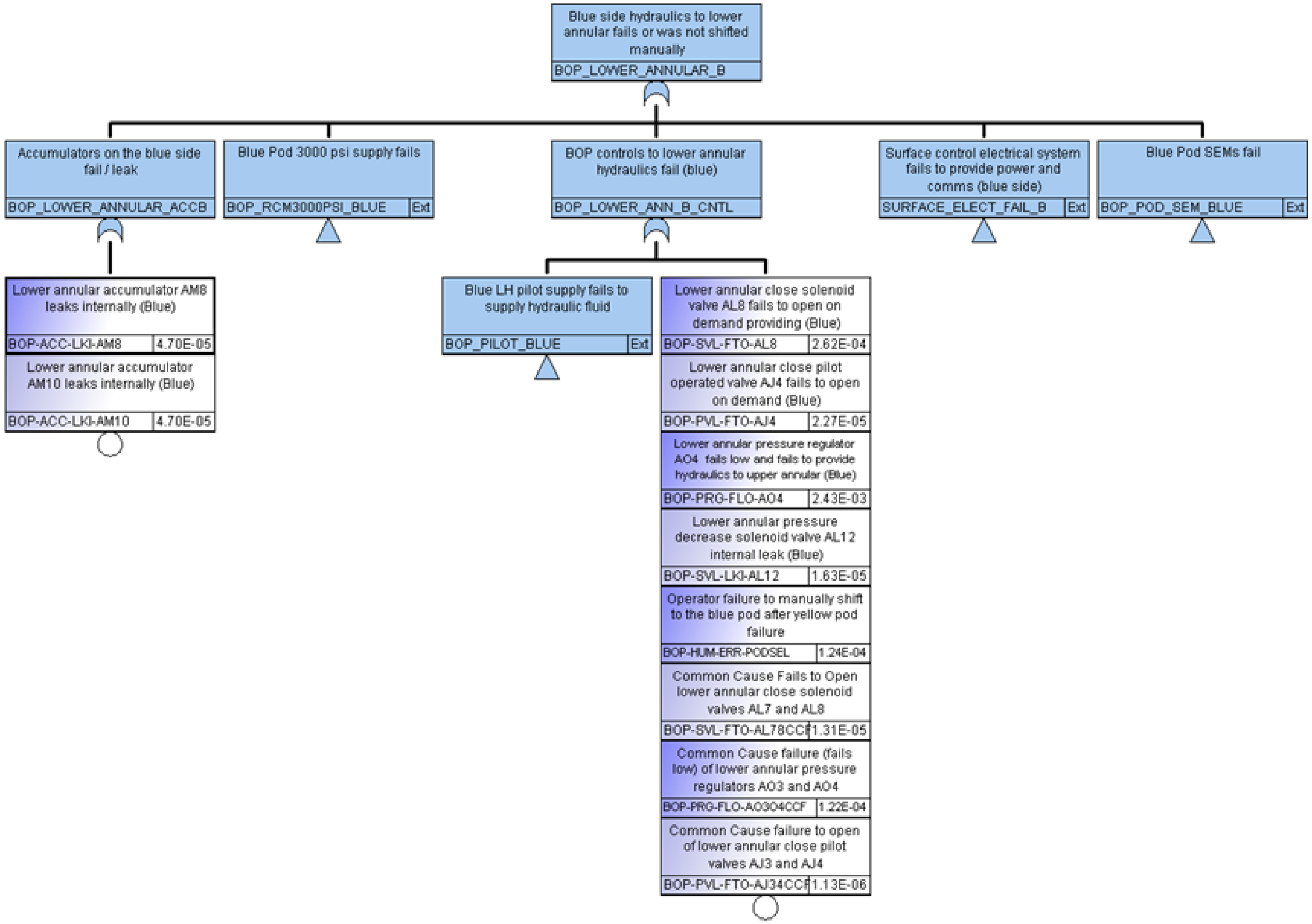


Figure C- 4: Annulars and Pipe Rams Fail to Close (Continued)

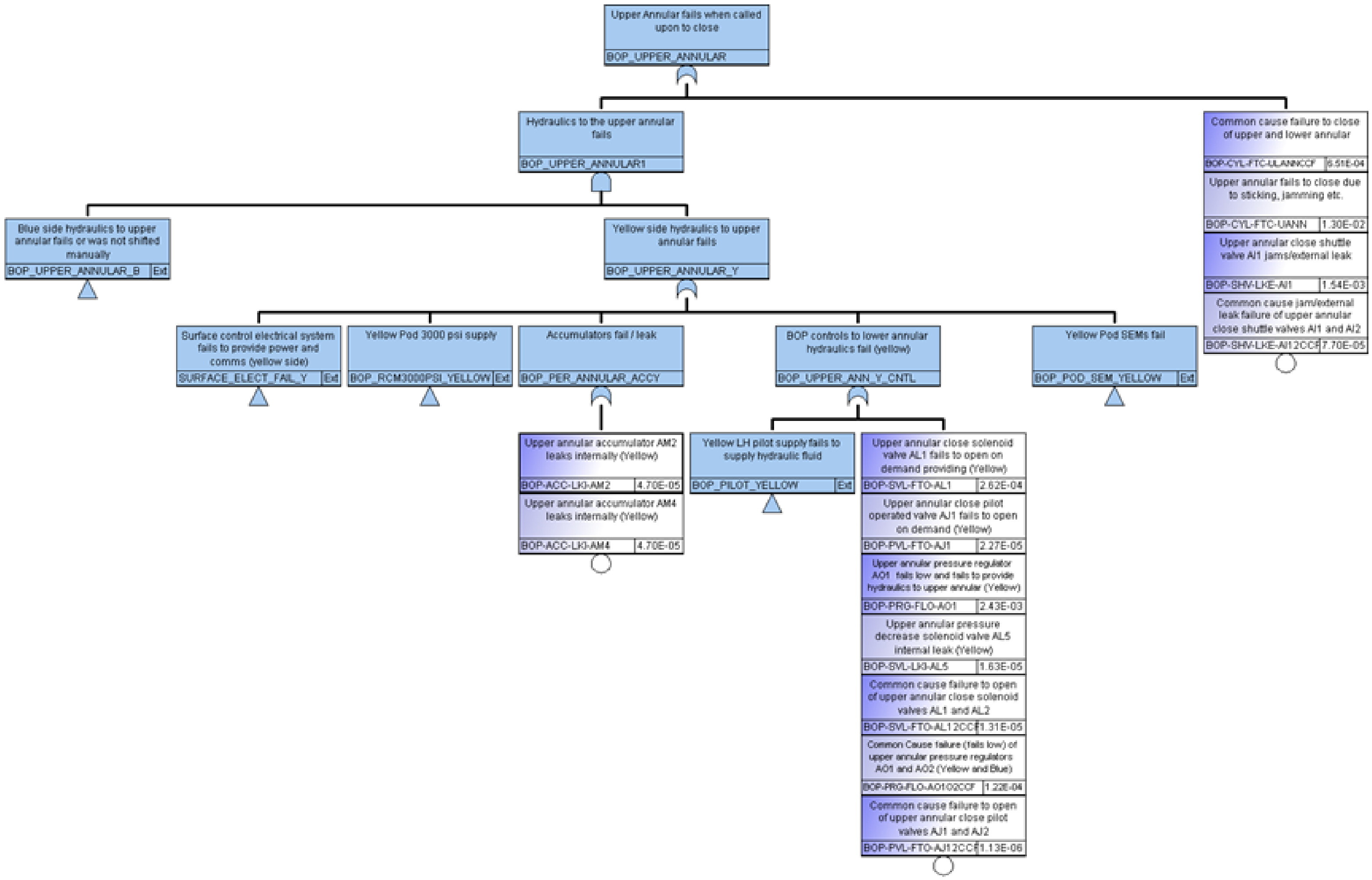


Figure C- 5: Annulars and Pipe Rams Fail to Close (Continued)

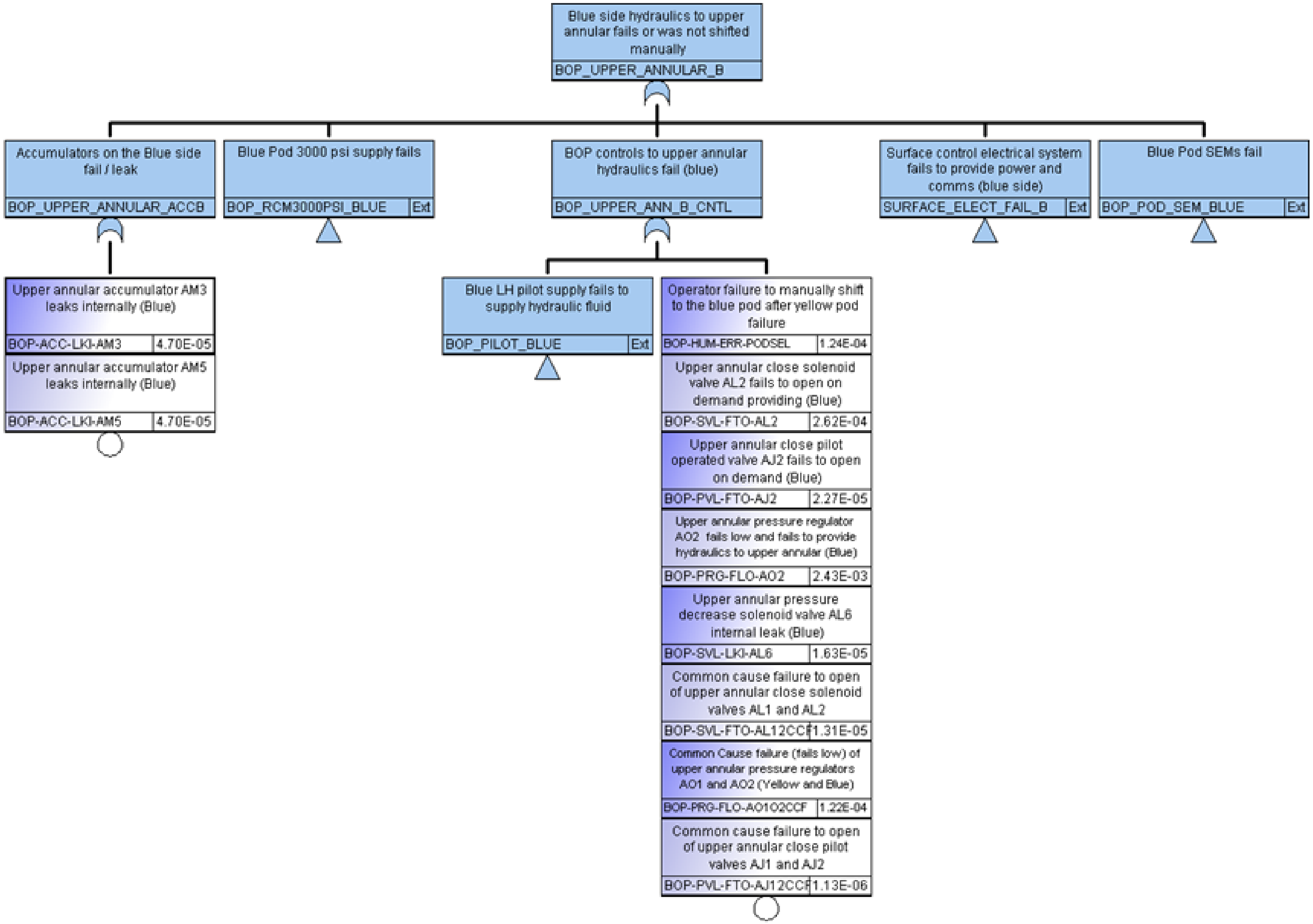


Figure C- 6: Annulars and Pipe Rams Fail to Close (Continued)

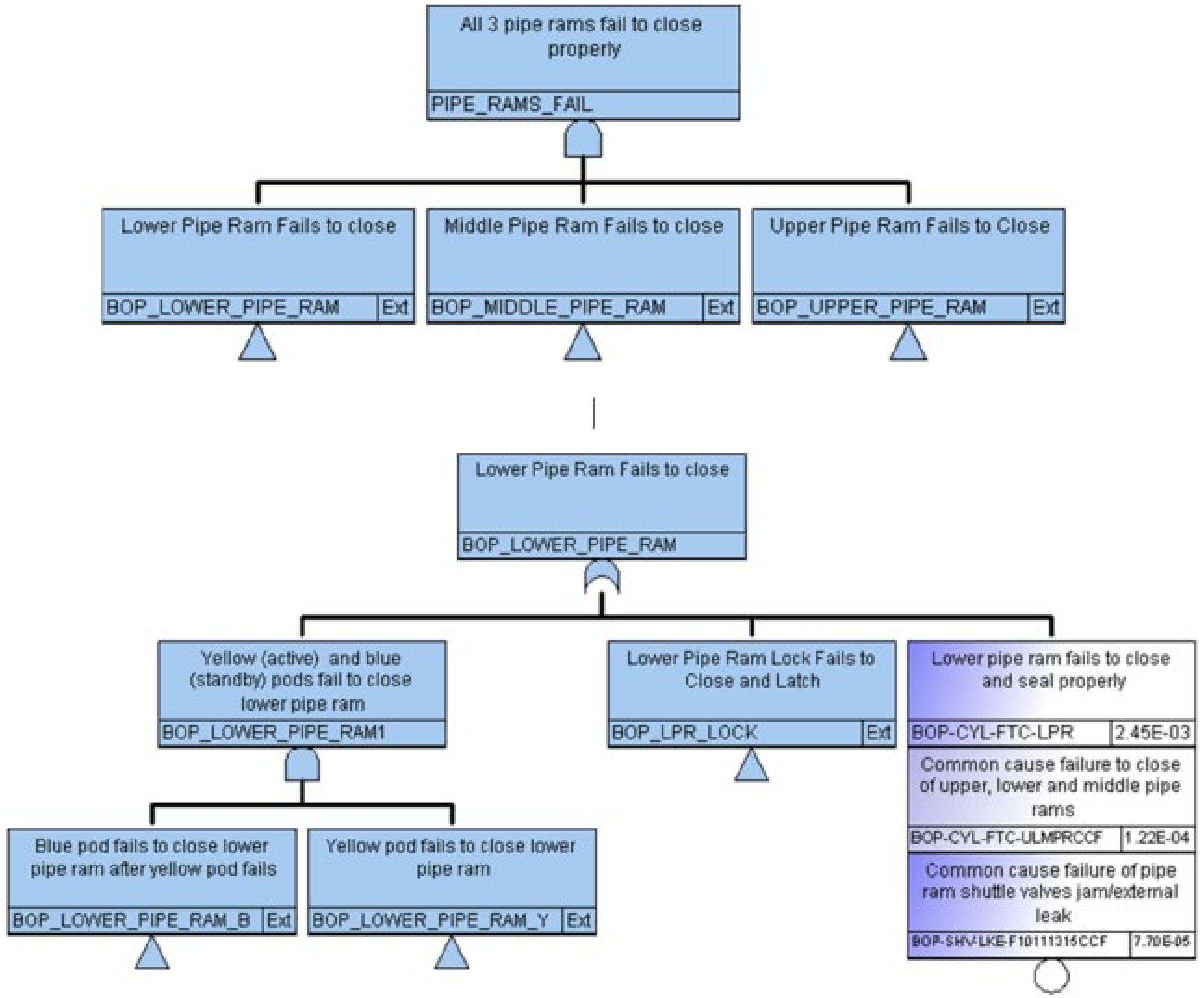

All 3 pipe rams fail to close properly
PIPE_RAMS_FAIL
Lower Pipe Ram Fails to close
BOP_LOWER_PIPE_RAM
Ext
Middle Pipe Ram Fails to close
BOP_MIDDLE_PIPE_RAM
Ext
Upper Pipe Ram Fails to Close
BOP_UPPER_PIPE_RAM
Ext
Lower Pipe Ram Fails to close
BOP_LOWER_PIPE_RAM
Yellow (active) and blue (standby) pods fail to close lower pipe ram
BOP_LOWER_PIPE_RAM1
Lower Pipe Ram Lock Fails to Close and Latch
BOP_LPR_LOCK
Ext
Lower pipe ram fails to close and seal properly
BOP-CYL-FTC-LPR
2.45E-03
Common cause failure to close of upper, lower and middle pipe rams
BOP-CYL-FTC-ULMPRCCF
1.22E-04
Common cause failure of pipe ram shuttle valves jam/external leak
BOP-SHV-LKE-F10111315CCF
7.70E-05
Blue pod fails to close lower pipe ram after yellow pod fails
BOP_LOWER_PIPE_RAM_B
Ext
Yellow pod fails to close lower pipe ram
BOP_LOWER_PIPE_RAM_Y
Ext

Figure C- 7: Annulars and Pipe Rams Fail to Close (Continued)

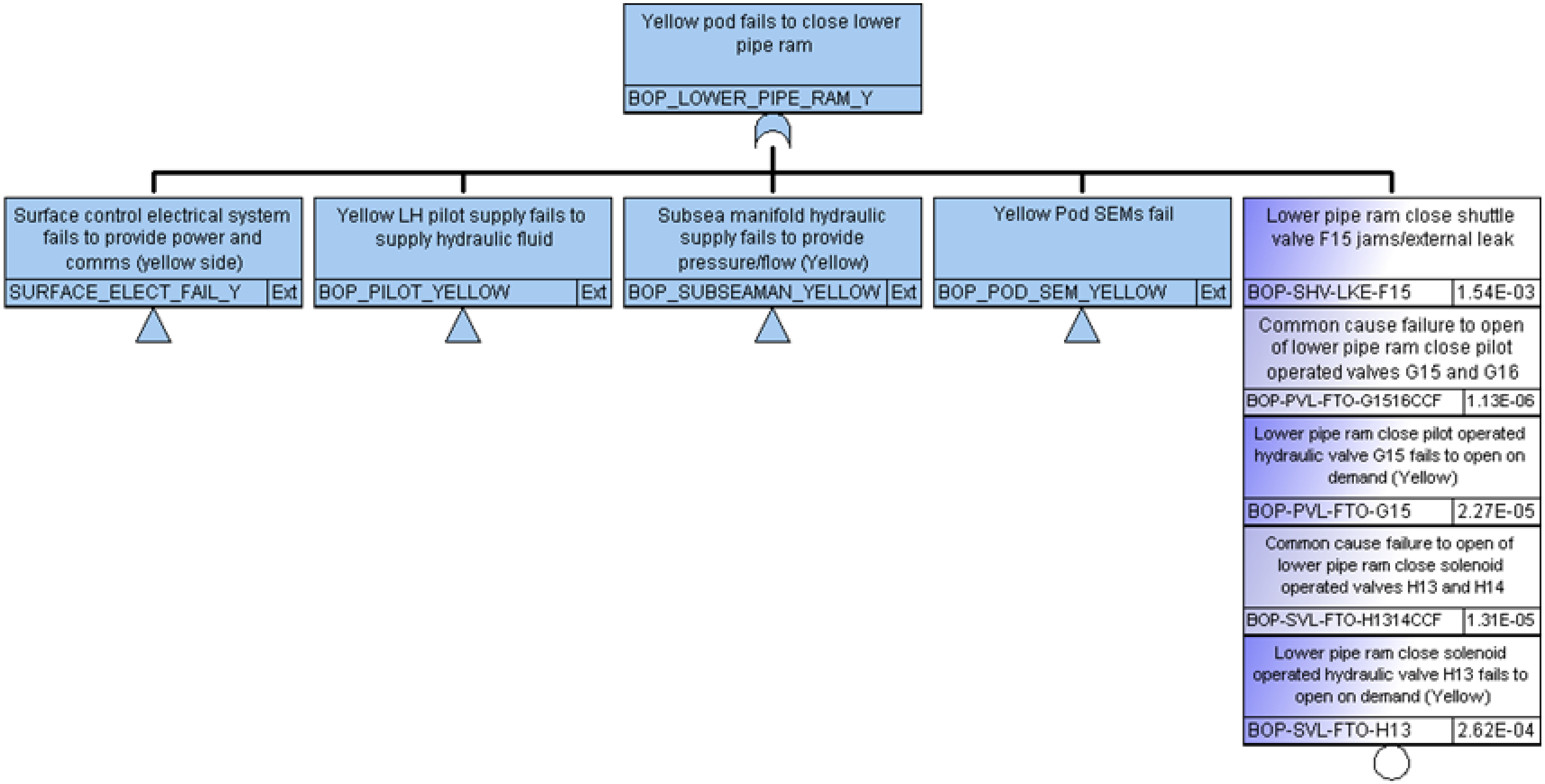


Figure C- 8: Annulars and Pipe Rams Fail to Close (Continued)

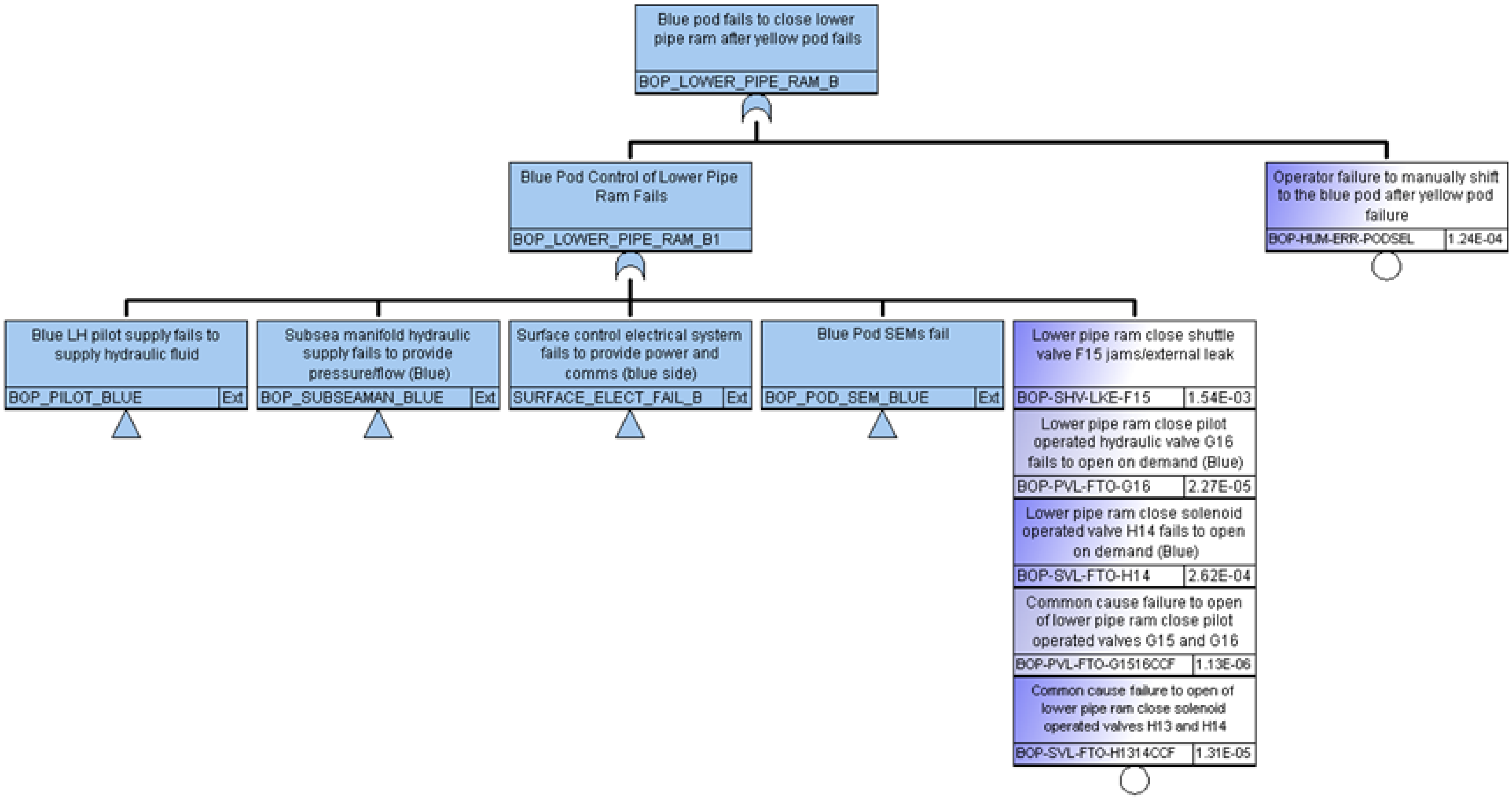


Figure C- 9: Annulars and Pipe Rams Fail to Close (Continued)

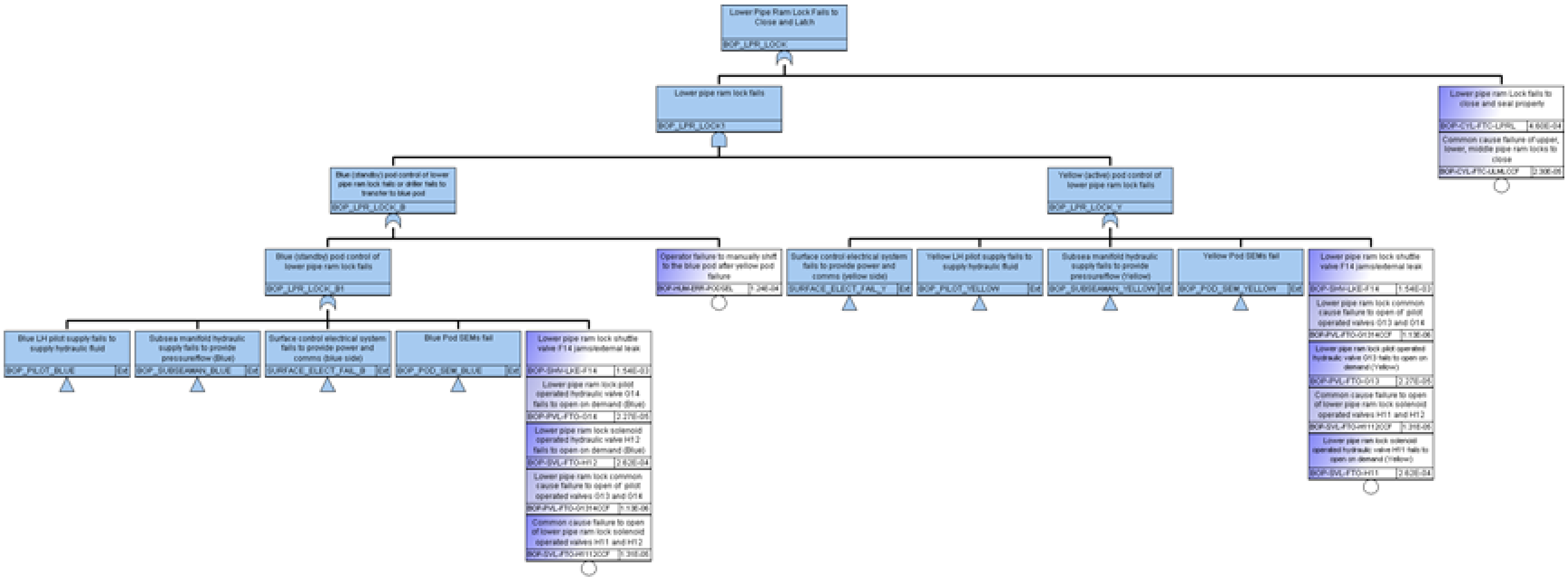


Figure C- 10: Annulars and Pipe Rams Fail to Close (Continued)

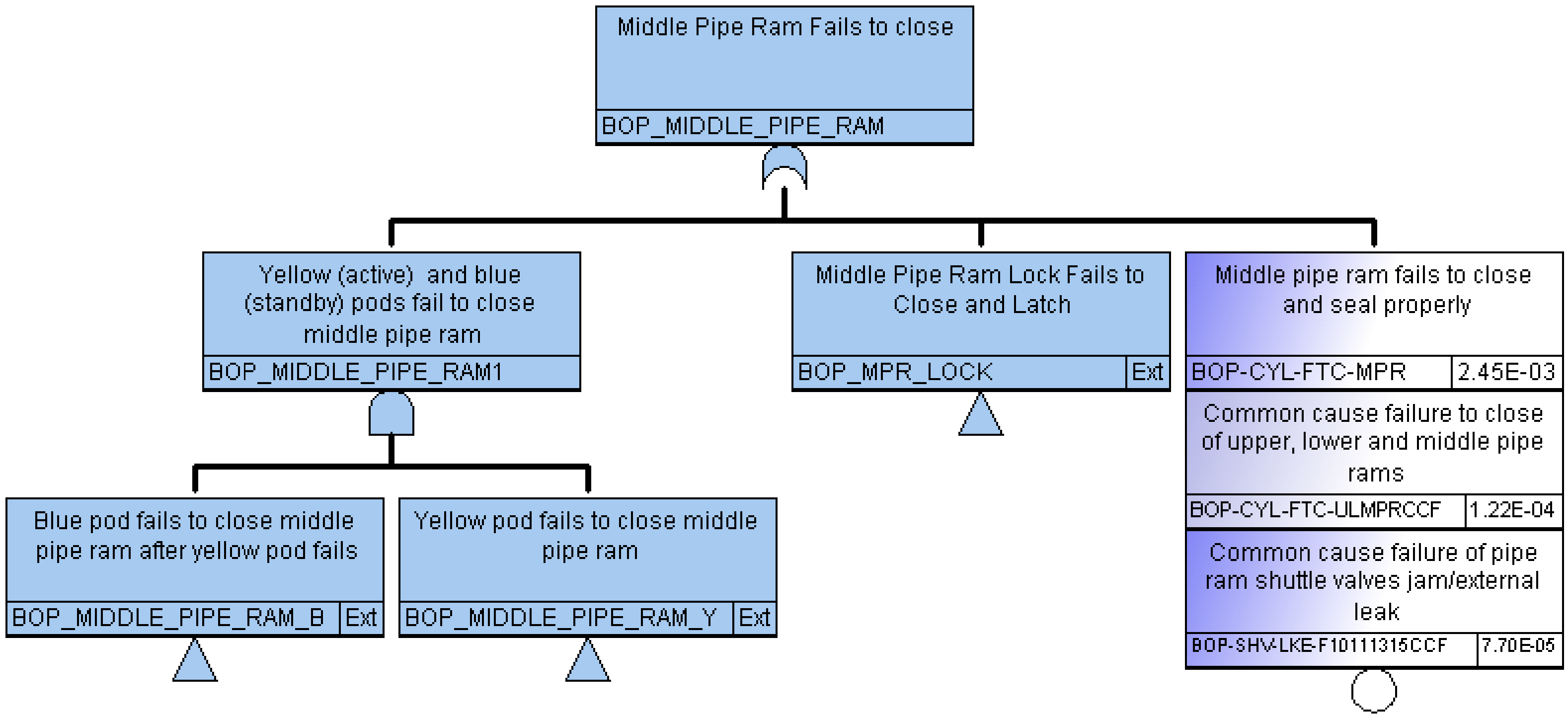


Figure C- 11: Annulars and Pipe Rams Fail to Close (Continued)

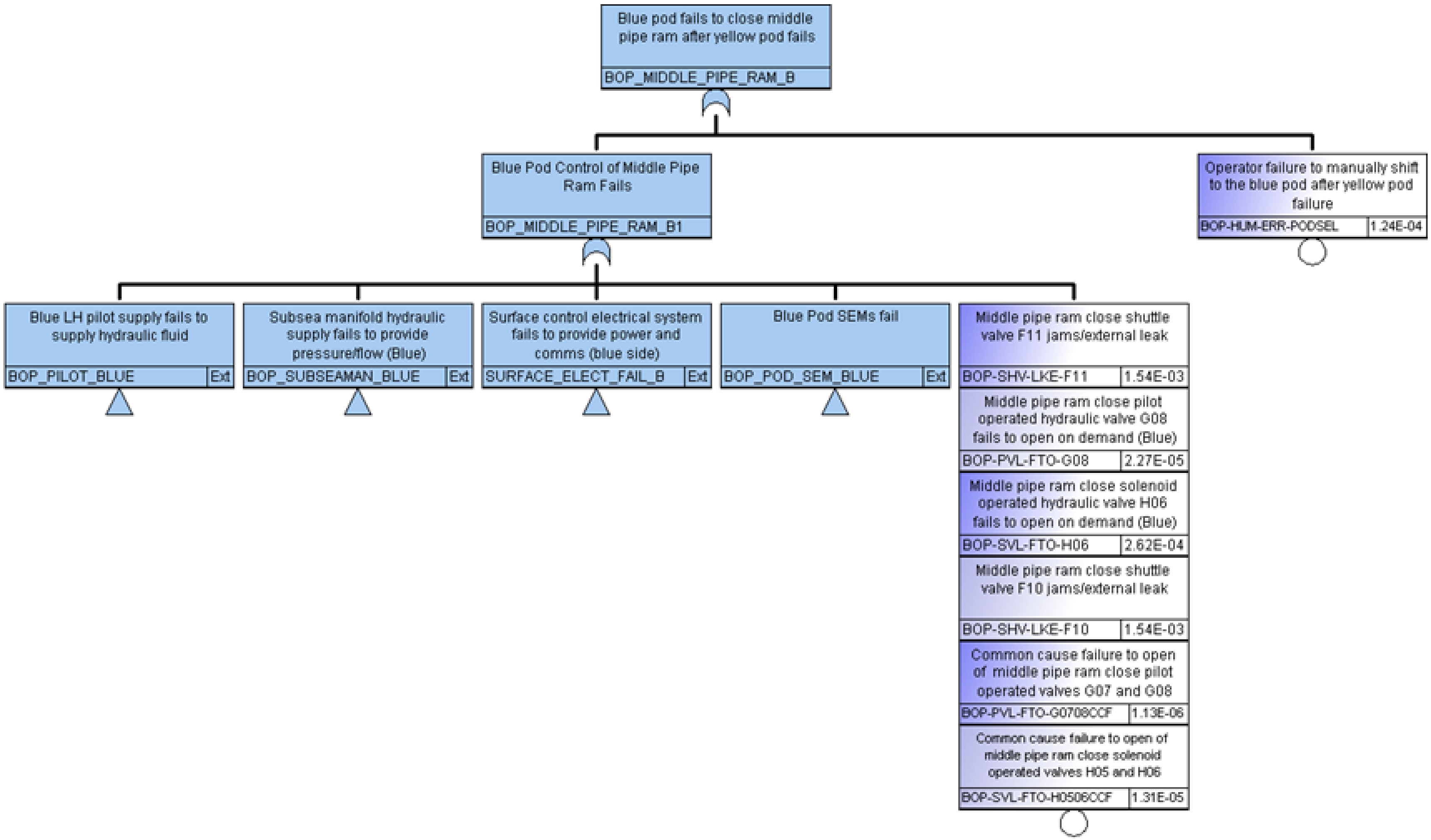


Figure C- 12: Annulars and Pipe Rams Fail to Close (Continued)

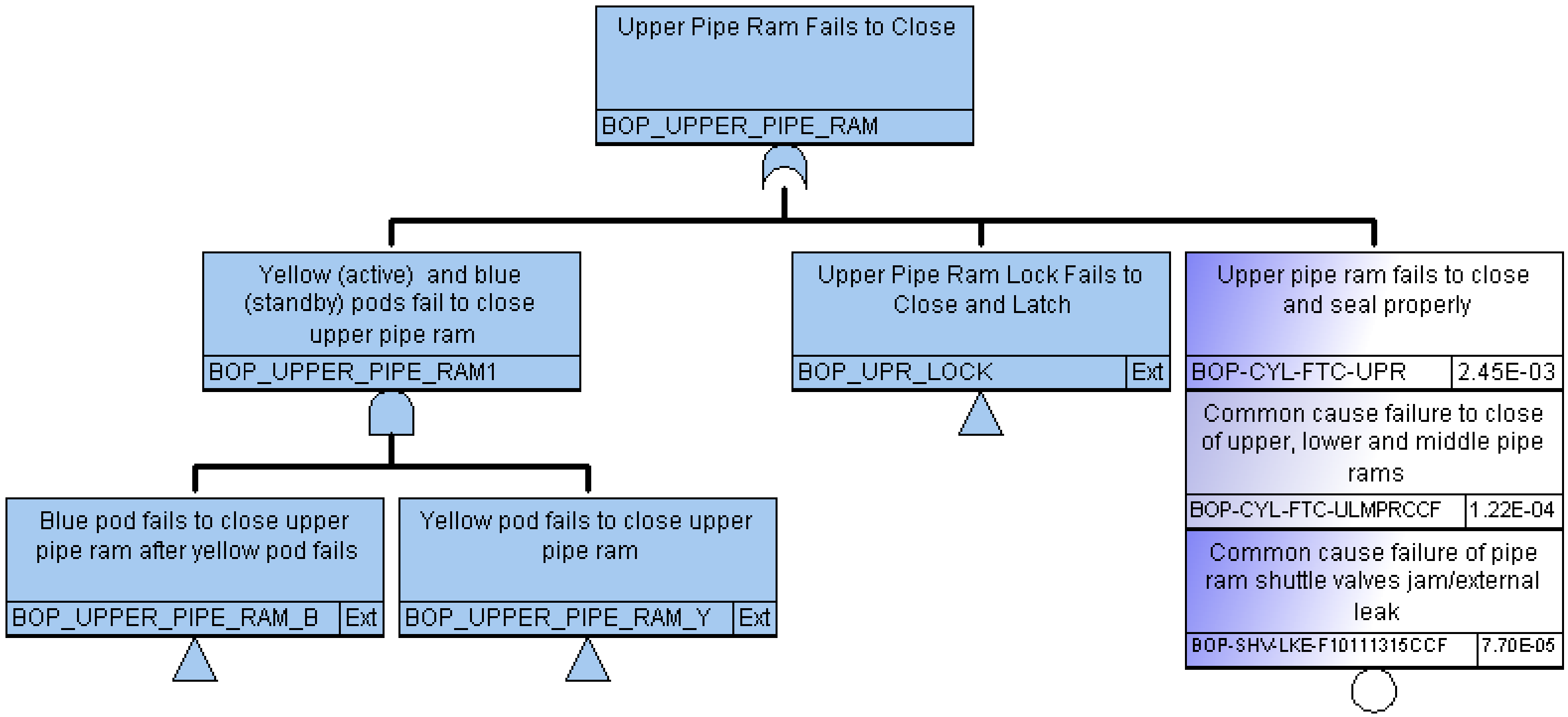


Figure C- 13: Annulars and Pipe Rams Fail to Close (Continued)

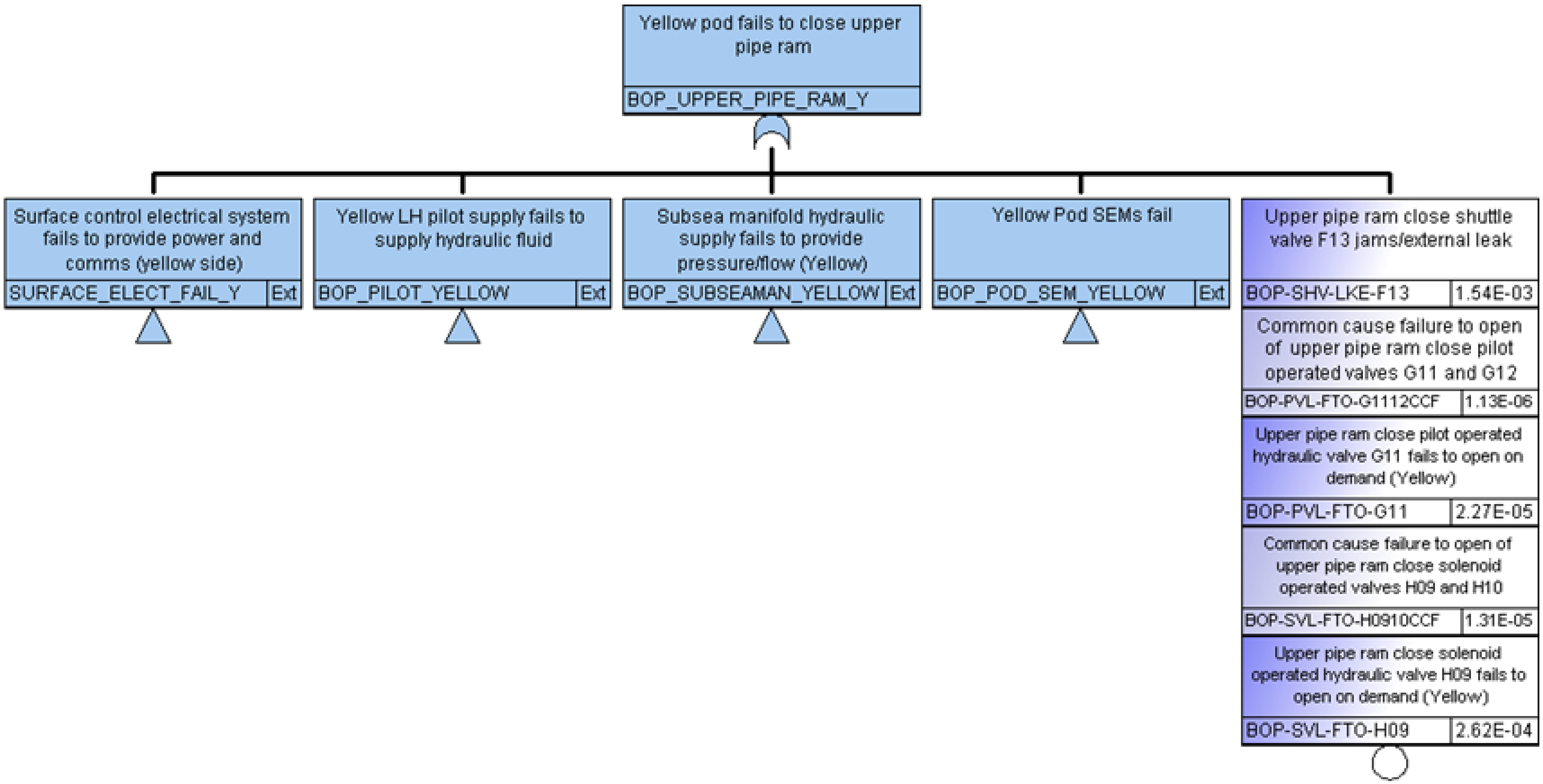


Figure C- 14: Annulars and Pipe Rams Fail to Close (Continued)

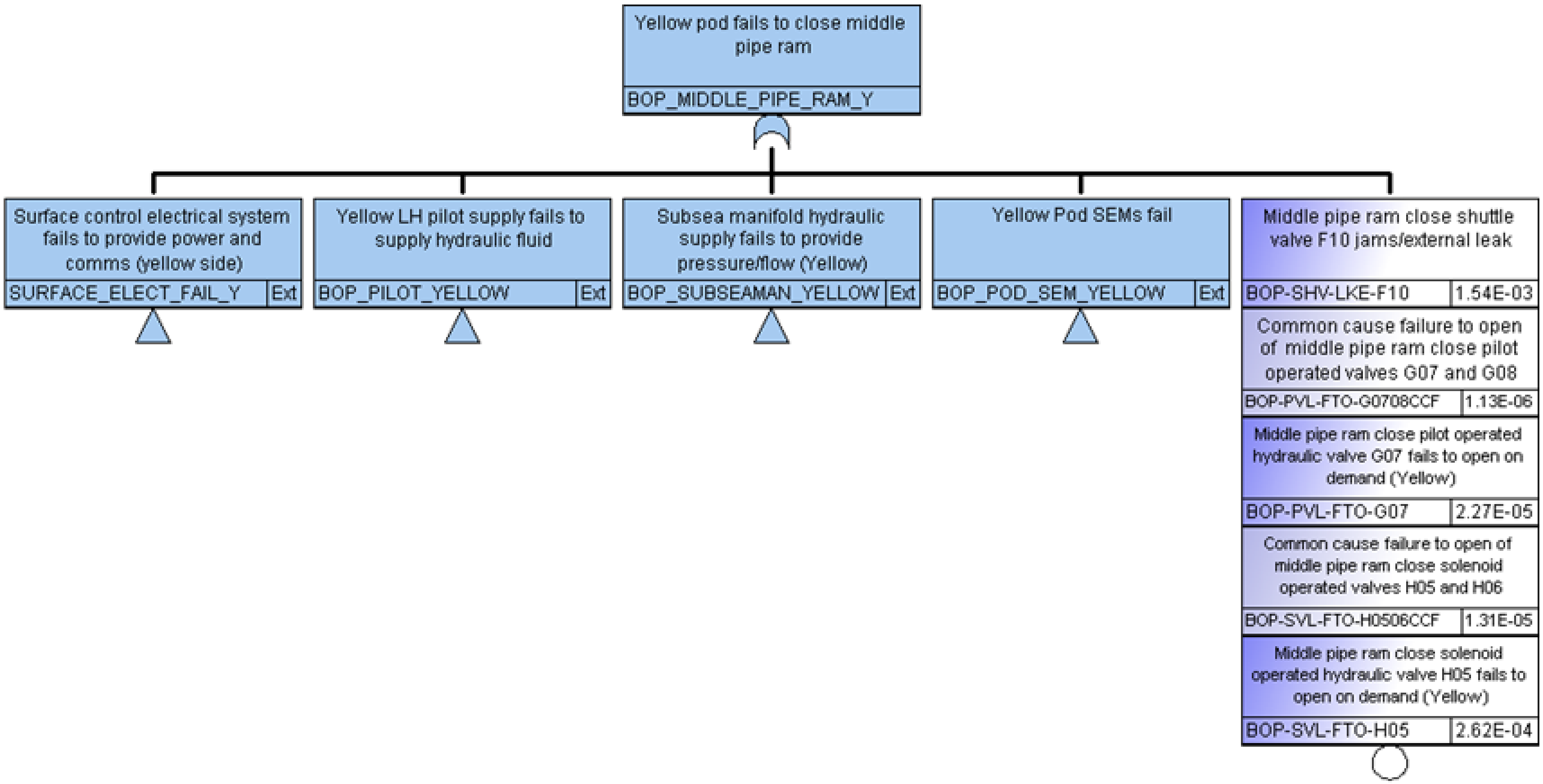


Figure C- 15: Annulars and Pipe Rams Fail to Close (Continued)

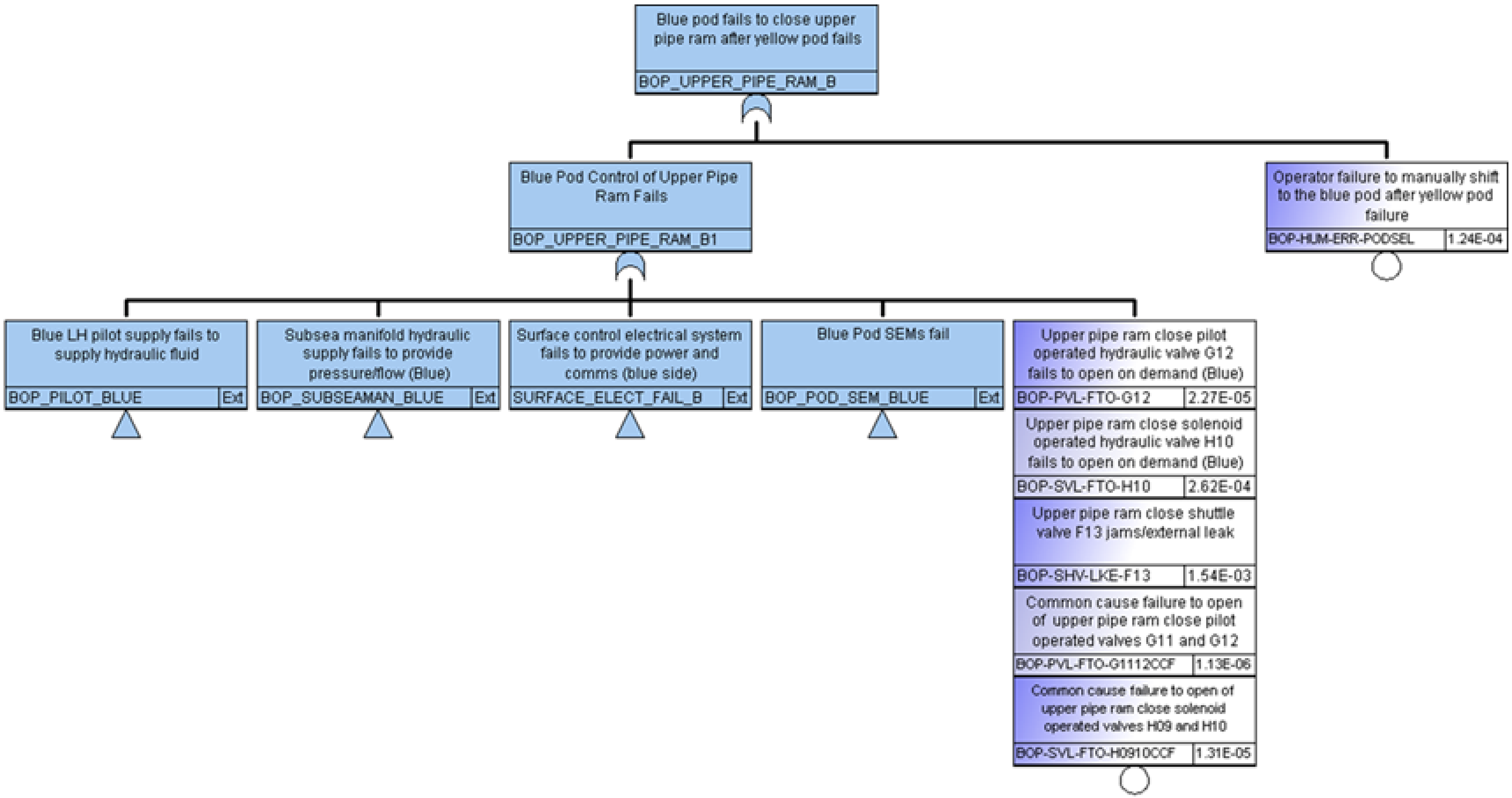


Figure C- 16: Annulars and Pipe Rams Fail to Close (Continued)

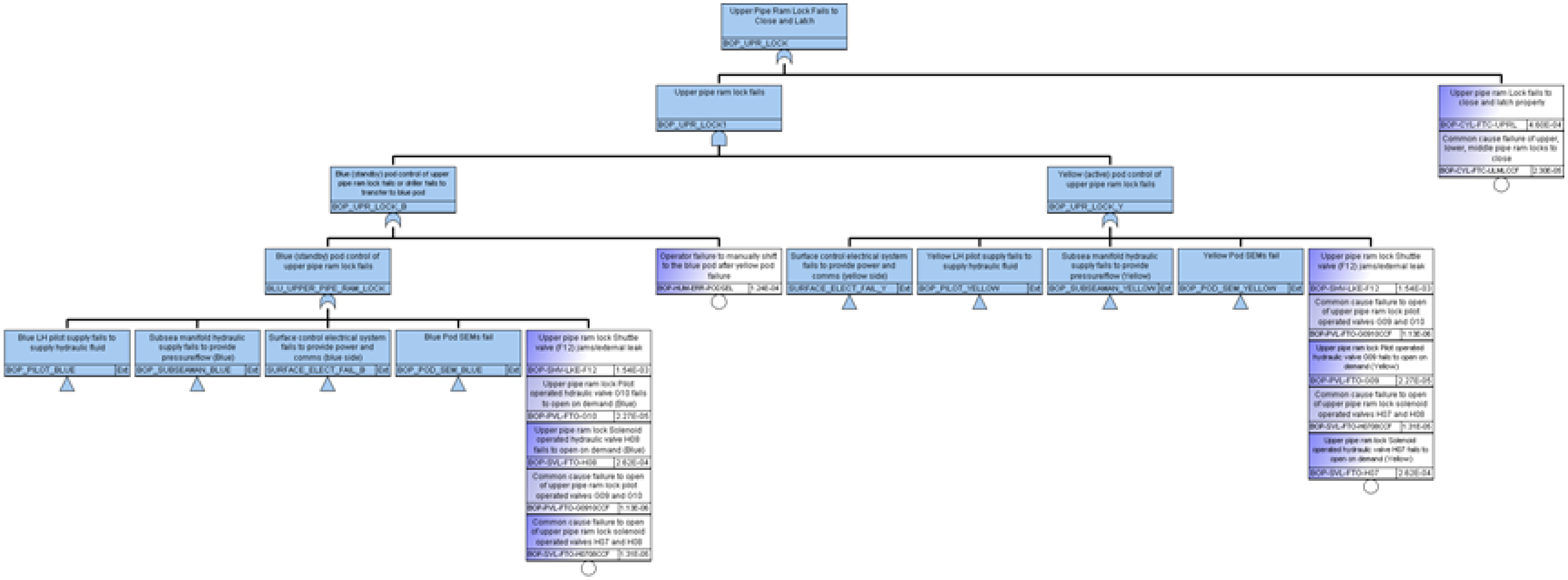


Figure C- 17: Annulars and Pipe Rams Fail to Close (Continued)

C.2 BLIND SHEAR RAM

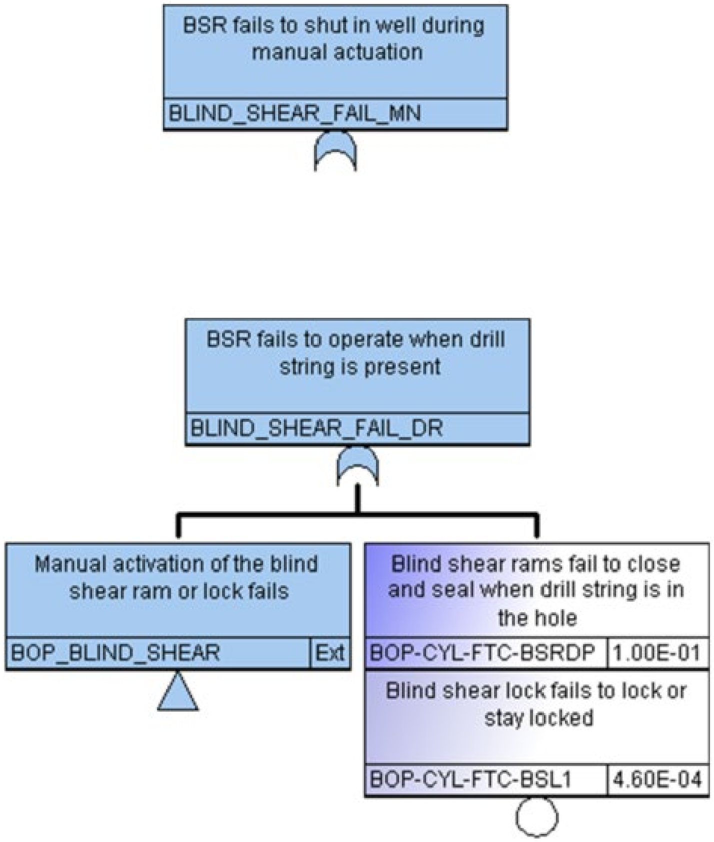


Figure C- 18: Blind Shear Ram

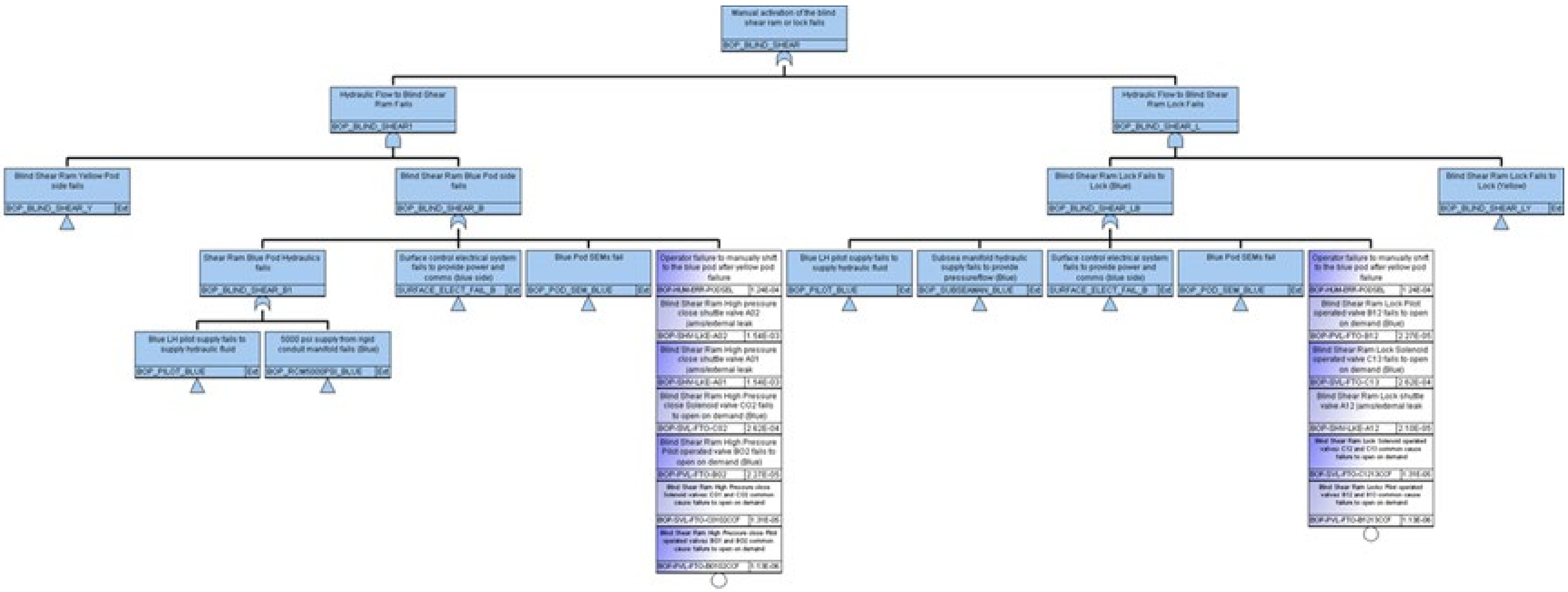


Figure C- 19: Blind Shear Ram (Continued)

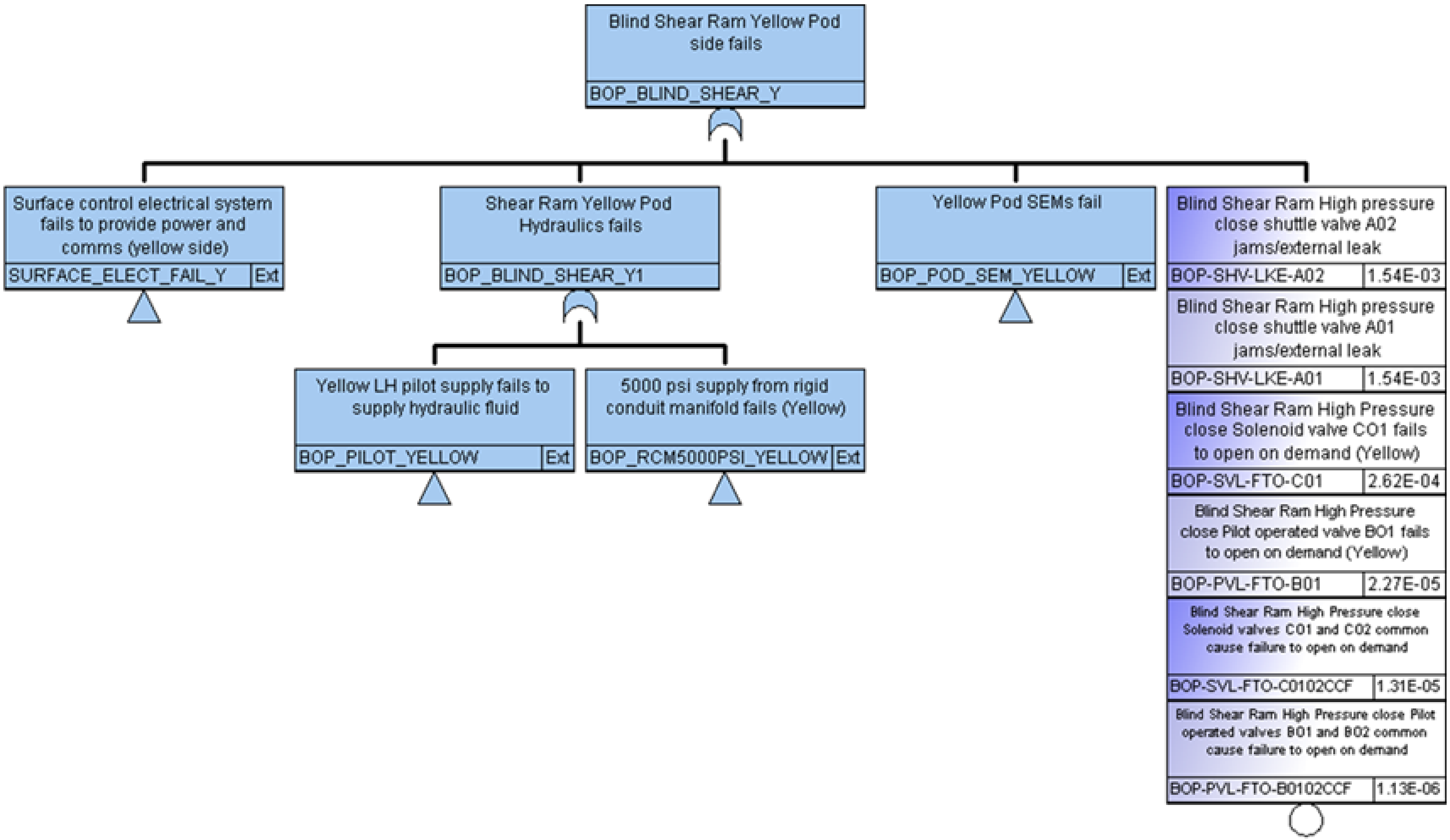


Figure C- 20: Blind Shear Ram (Continued)

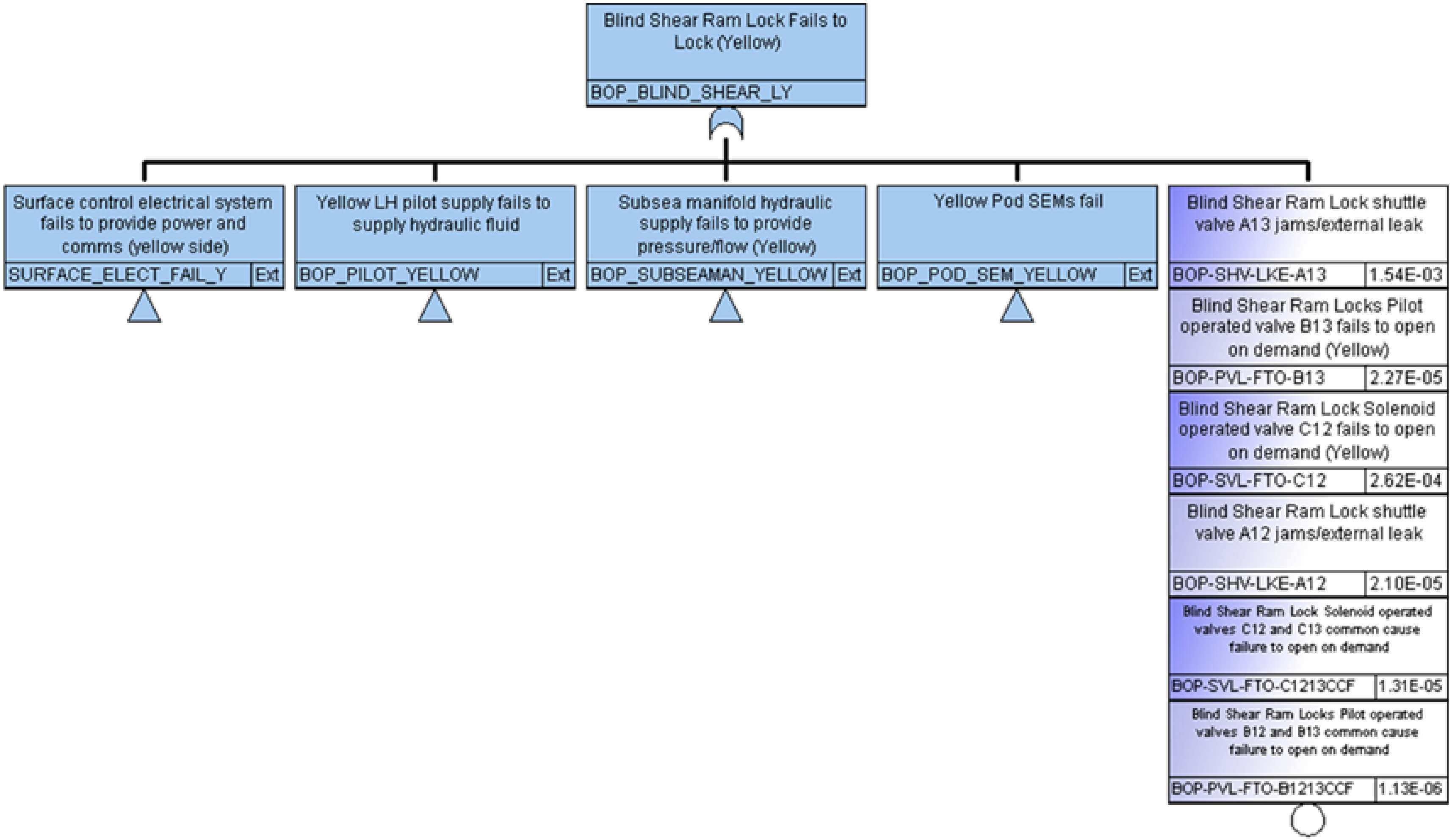
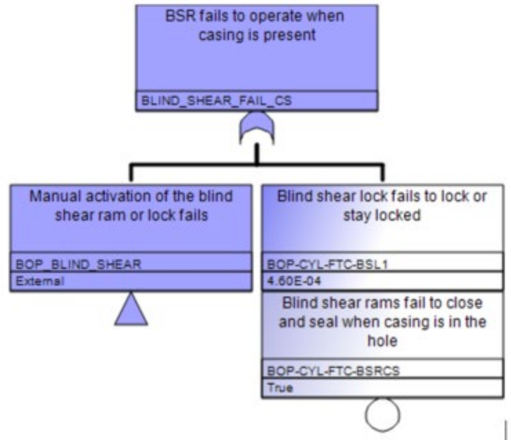


Figure C- 21: Blind Shear Ram (Continued)



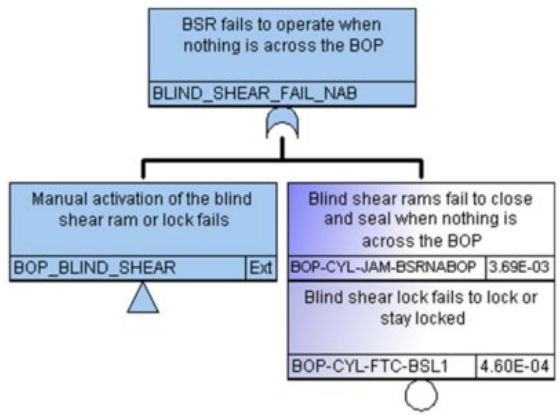
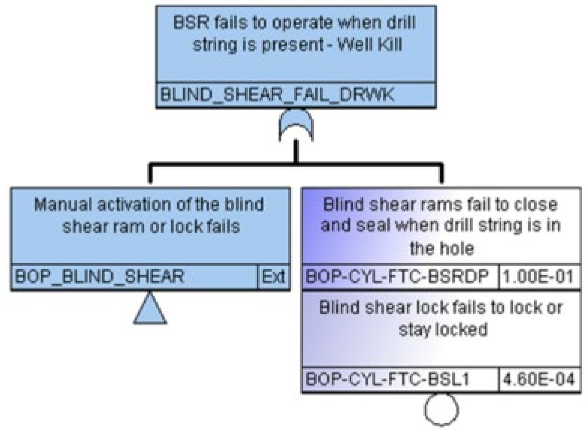


Figure C- 22: Blind Shear Ram (Continued)



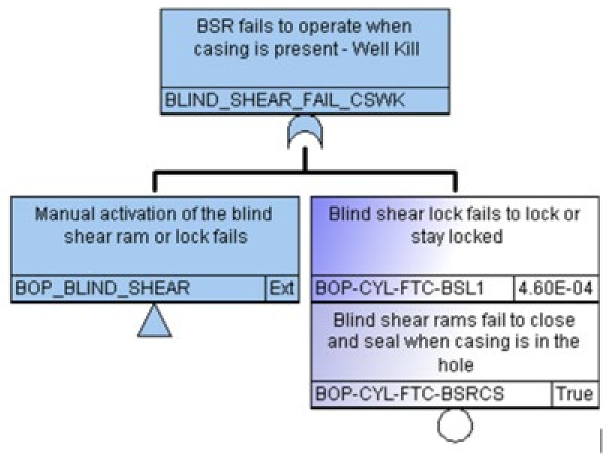


Figure C- 23: Blind Shear Ram (Continued)

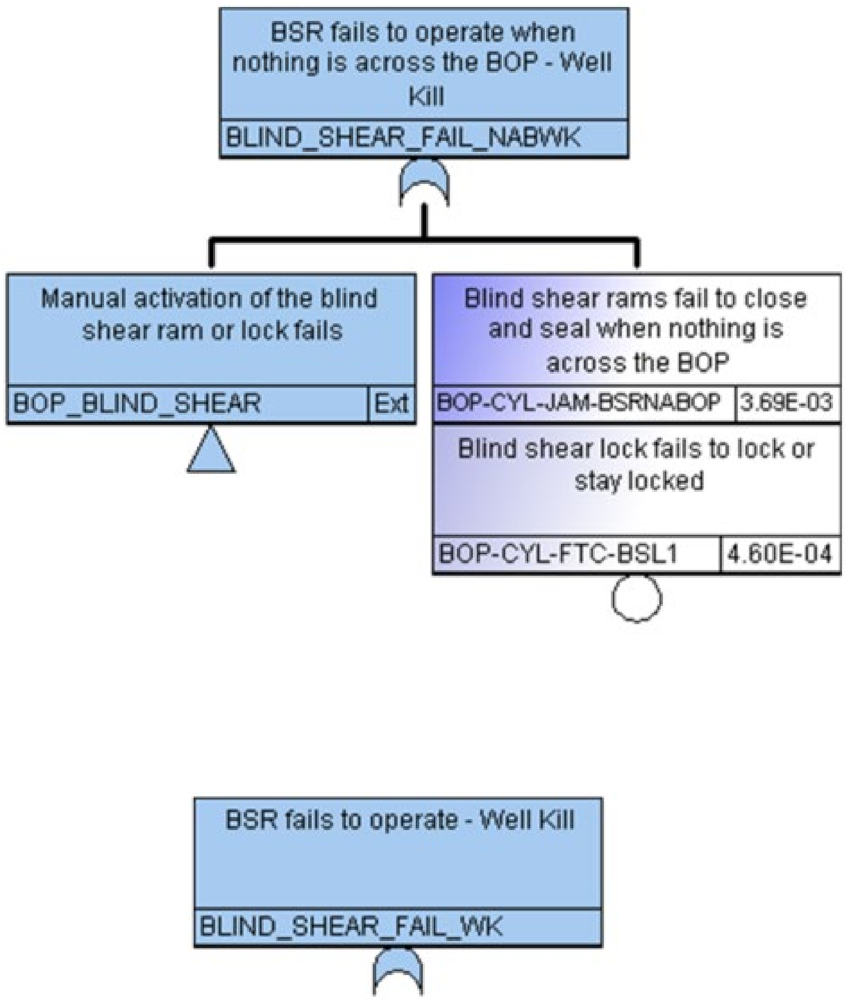


Figure C- 24: Blind Shear Ram (Continued)

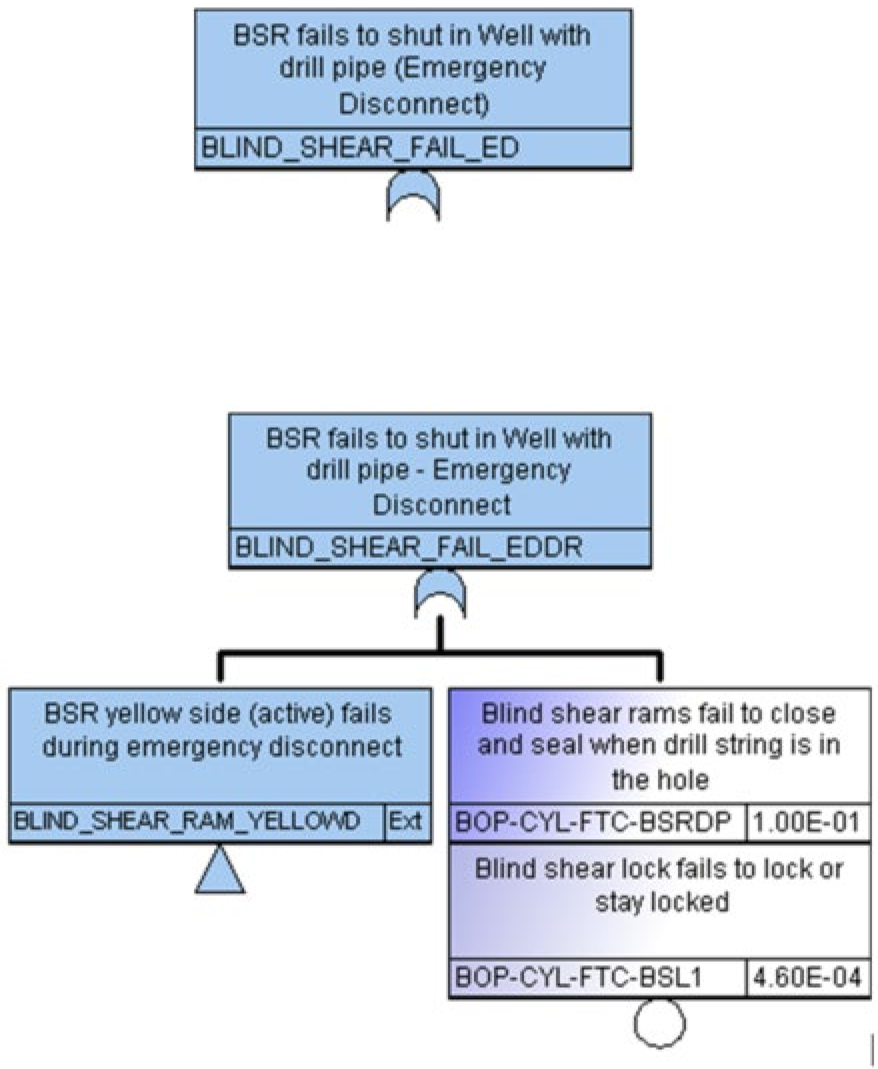


Figure C- 25: Blind Shear Ram (Continued)

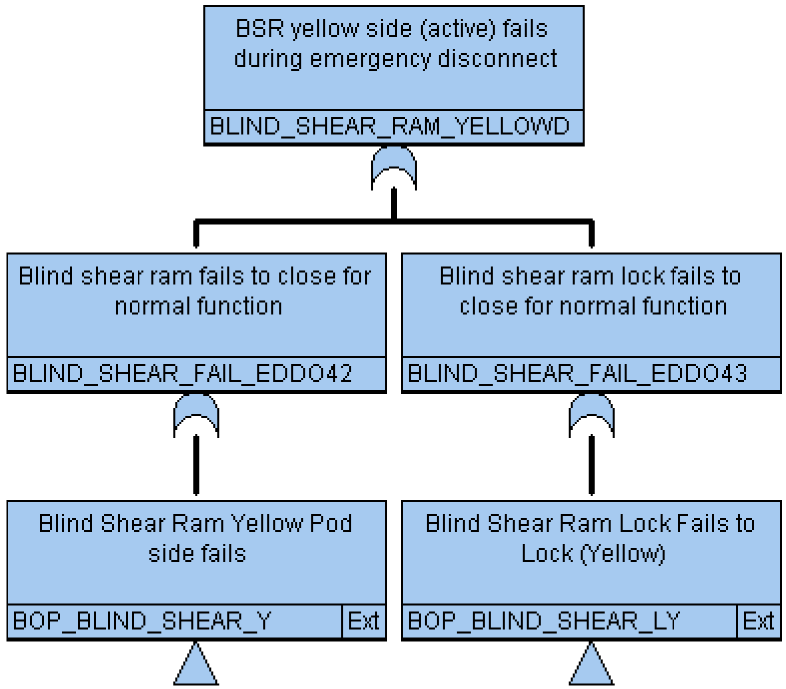


Figure C- 26: Blind Shear Ram (Continued)

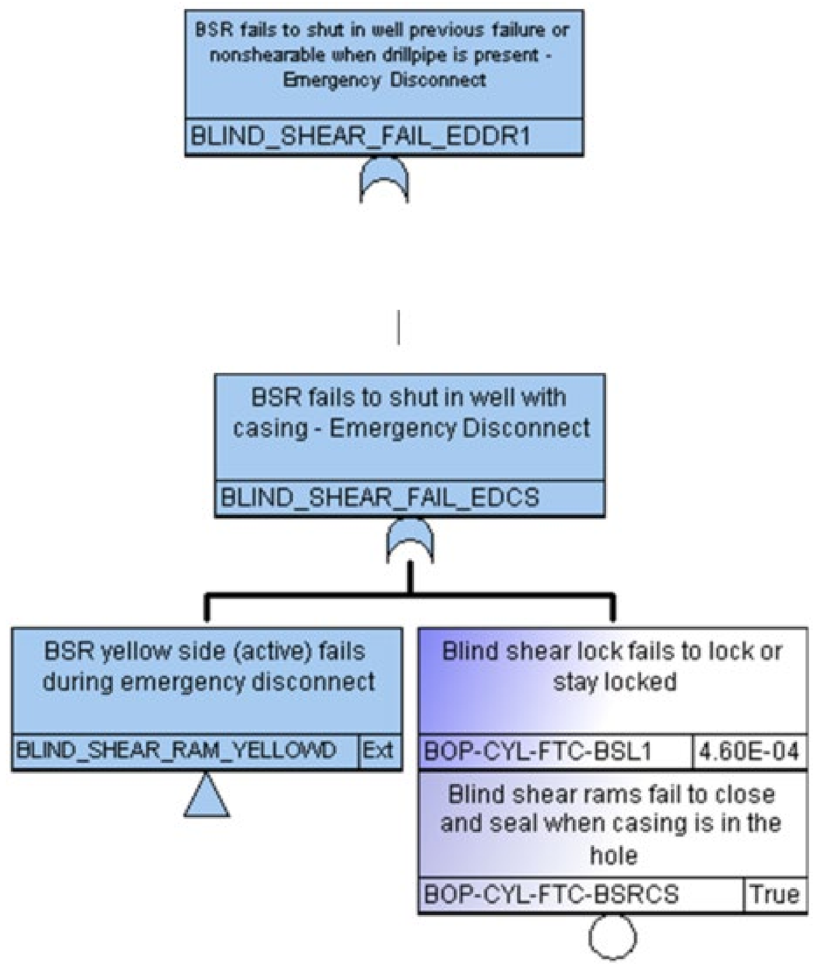


Figure C- 27: Blind Shear Ram (Continued)

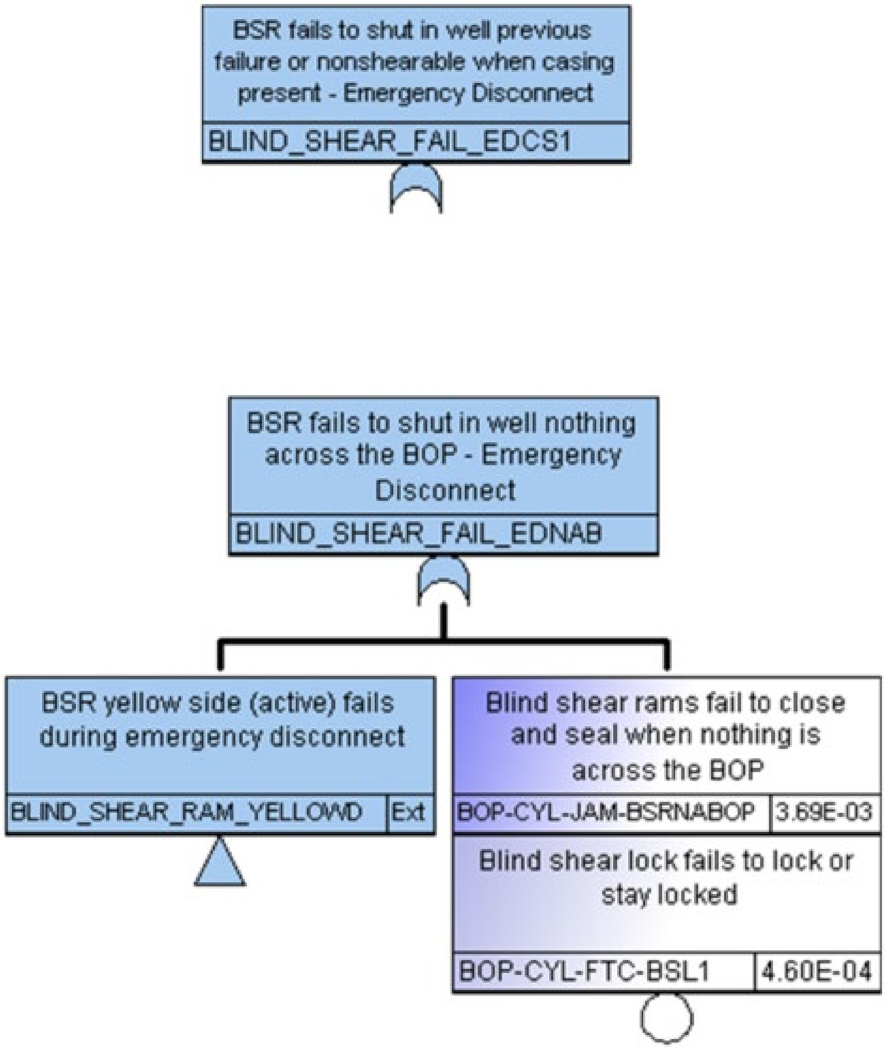


Figure C- 28: Blind Shear Ram (Continued)

C.3 CASING SHEAR RAM

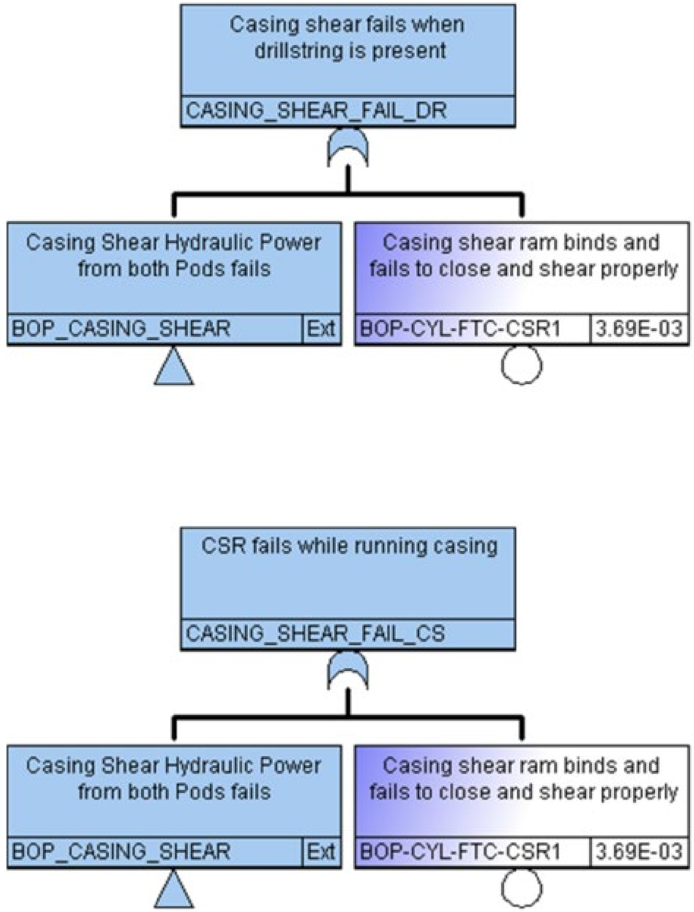


Figure C- 29: Casing Shear Ram

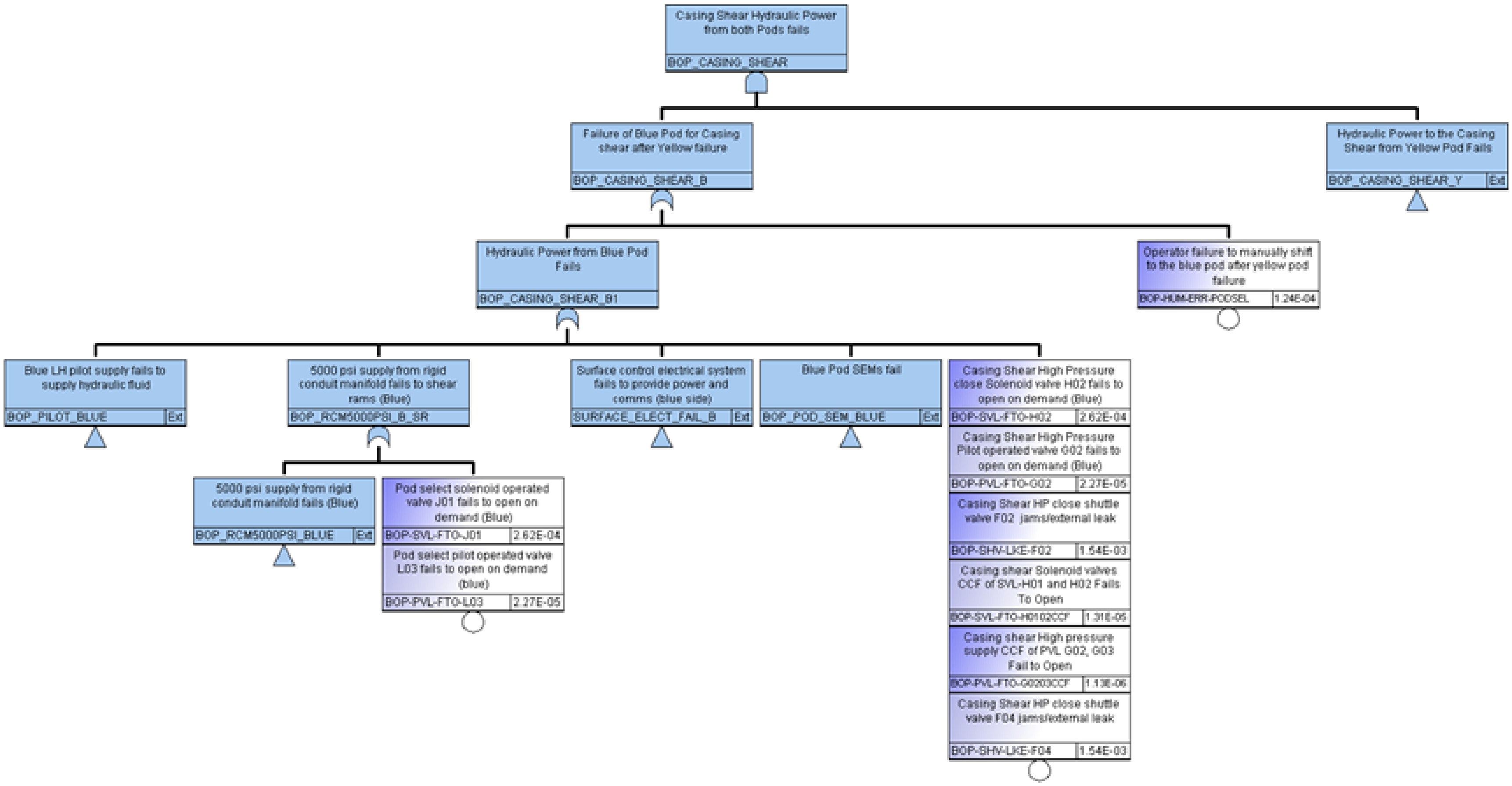


Figure C- 30: Casing Shear Ram (Continued)

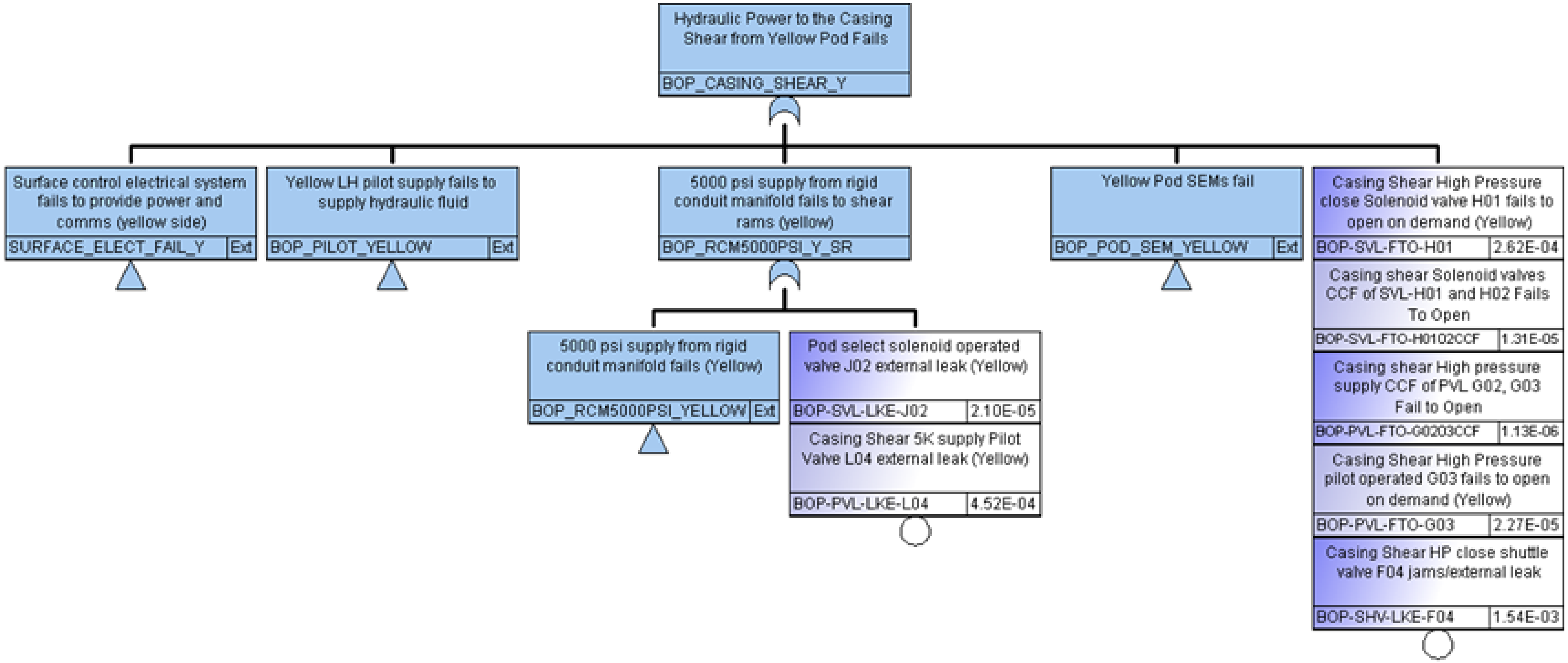
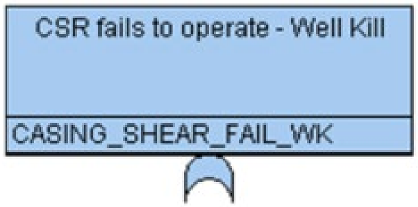


Figure C- 31: Casing Shear Ram (Continued)



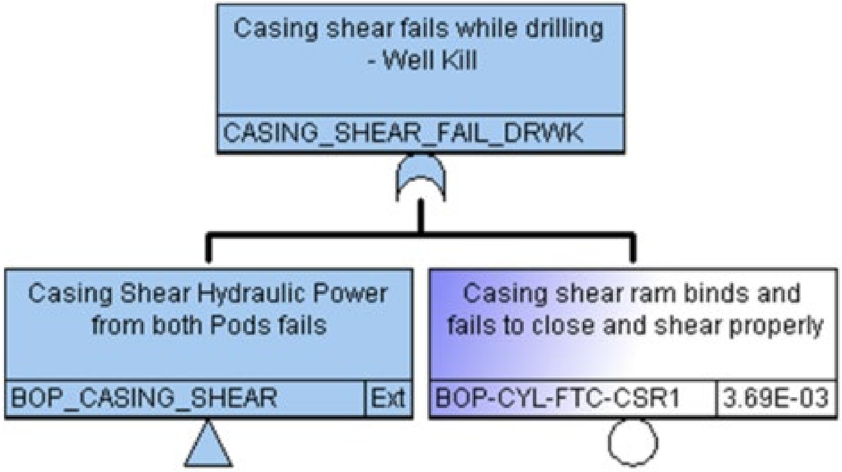


Figure C- 32: Casing Shear Ram (Continued)

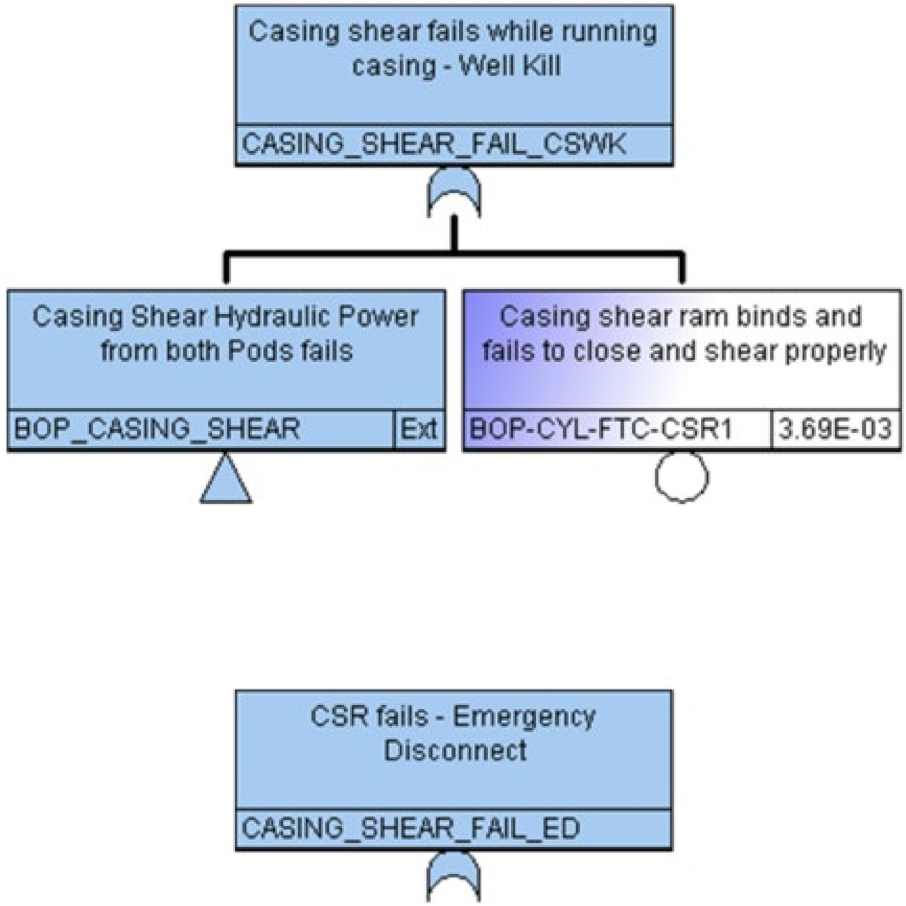


Figure C- 33: Casing Shear Ram (Continued)

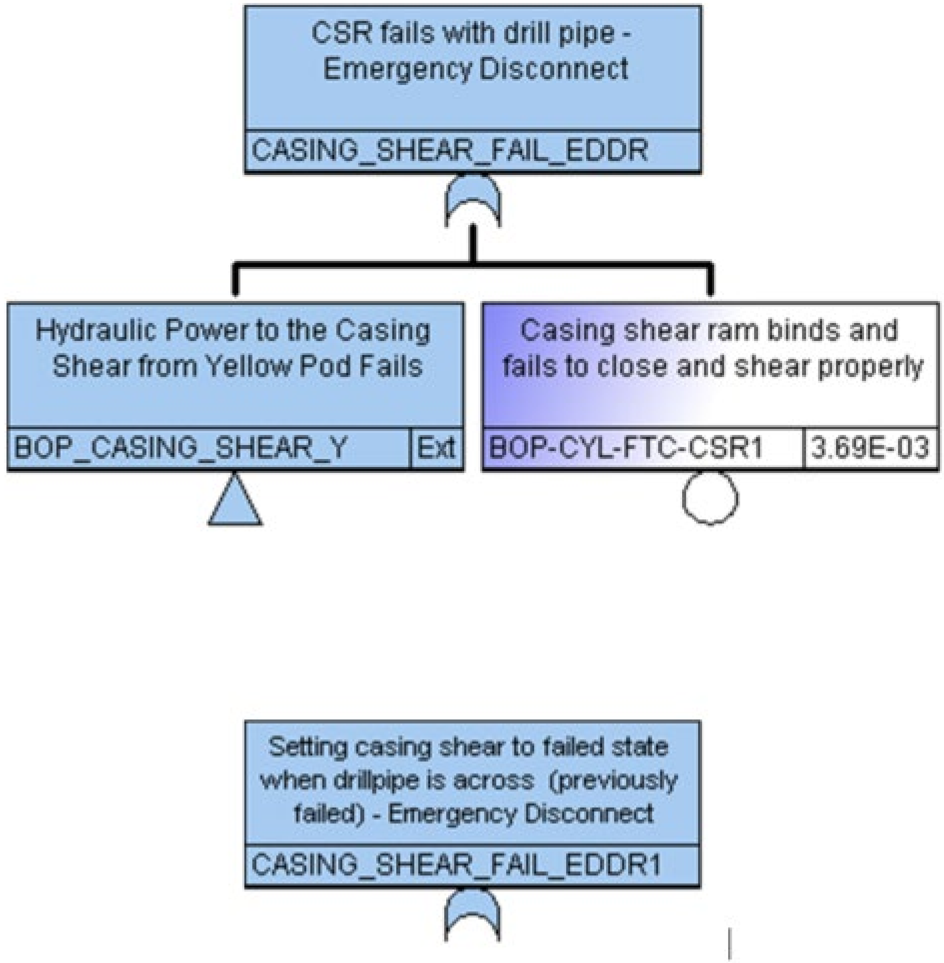


Figure C- 34: Casing Shear Ram (Continued)

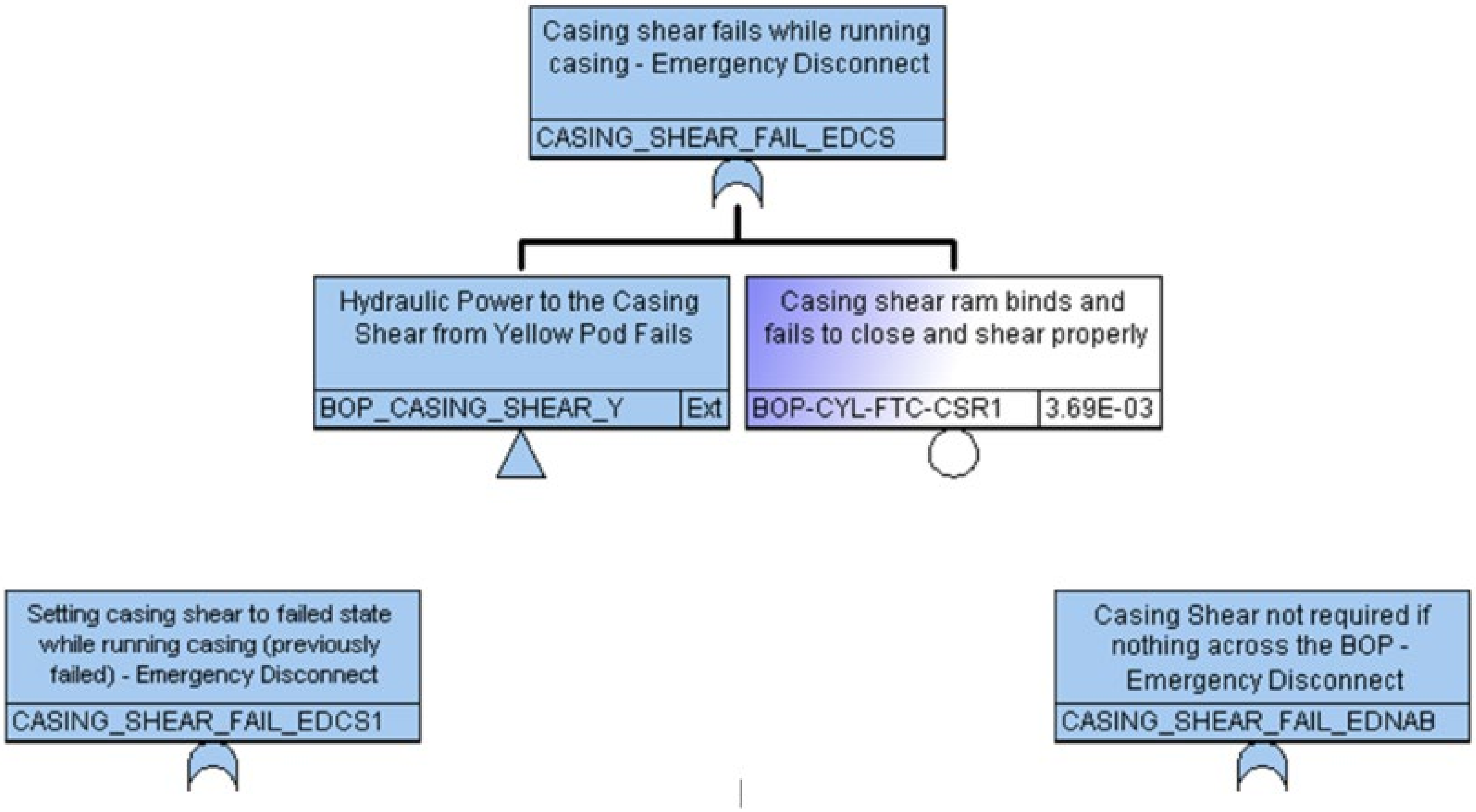


Figure C- 35: Casing Shear Ram (Continued)

C.4 CHOKE & KILL ISOLATION

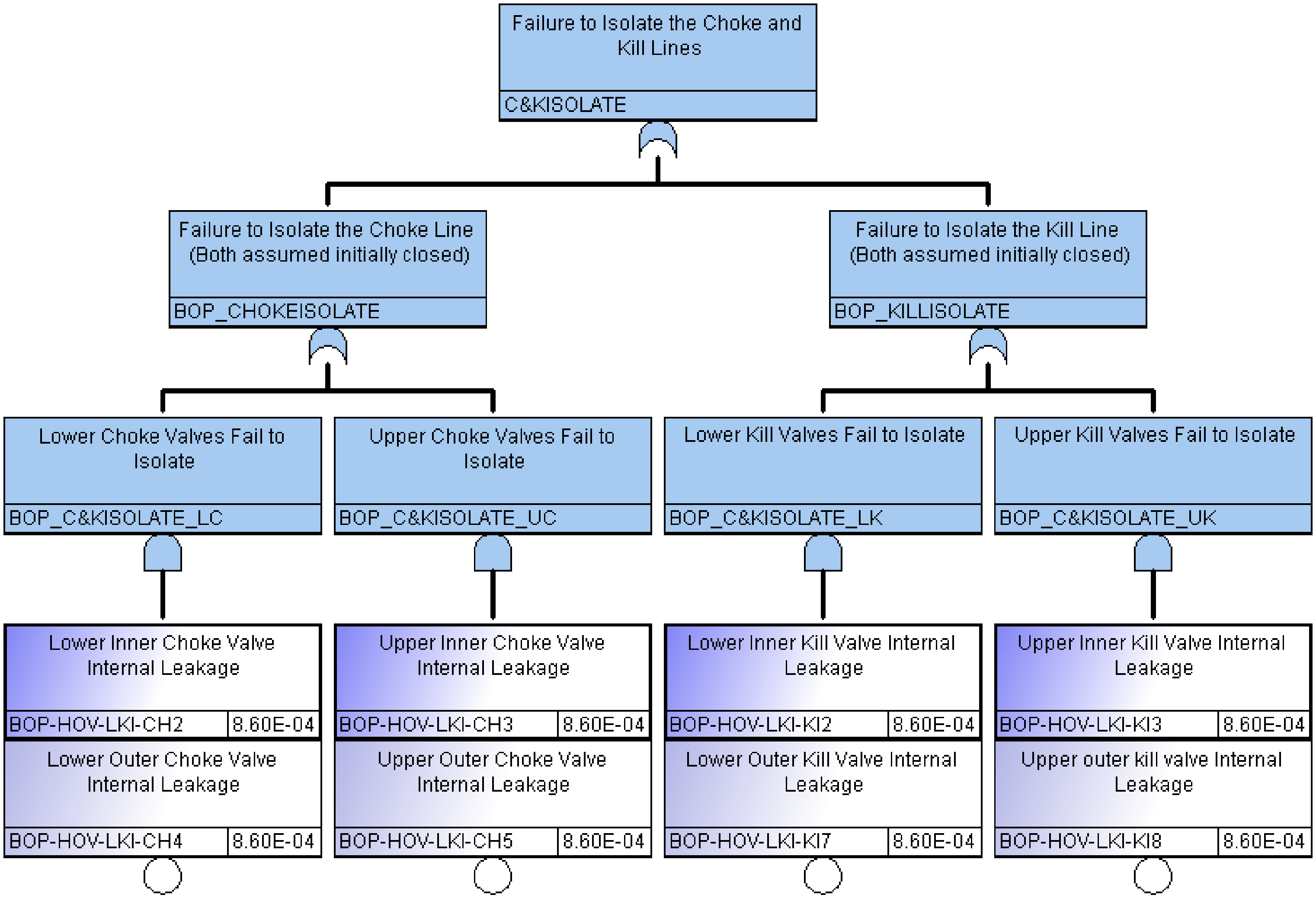


Figure C- 36: Choke and Kill Isolation

C.1 Stripping in Pipe

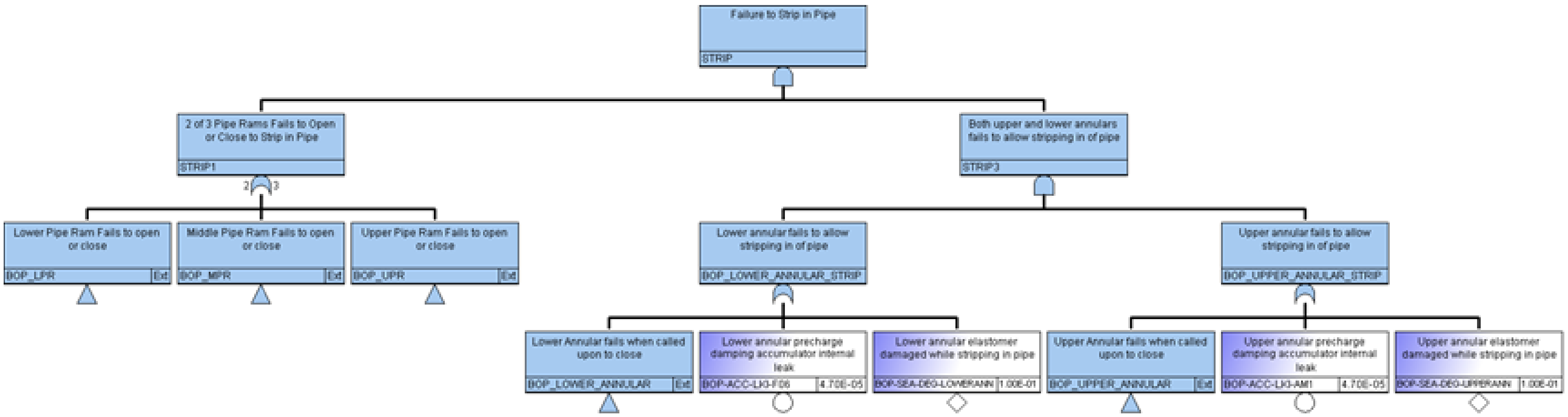


Figure C- 37: Failure to Strip in Pipe

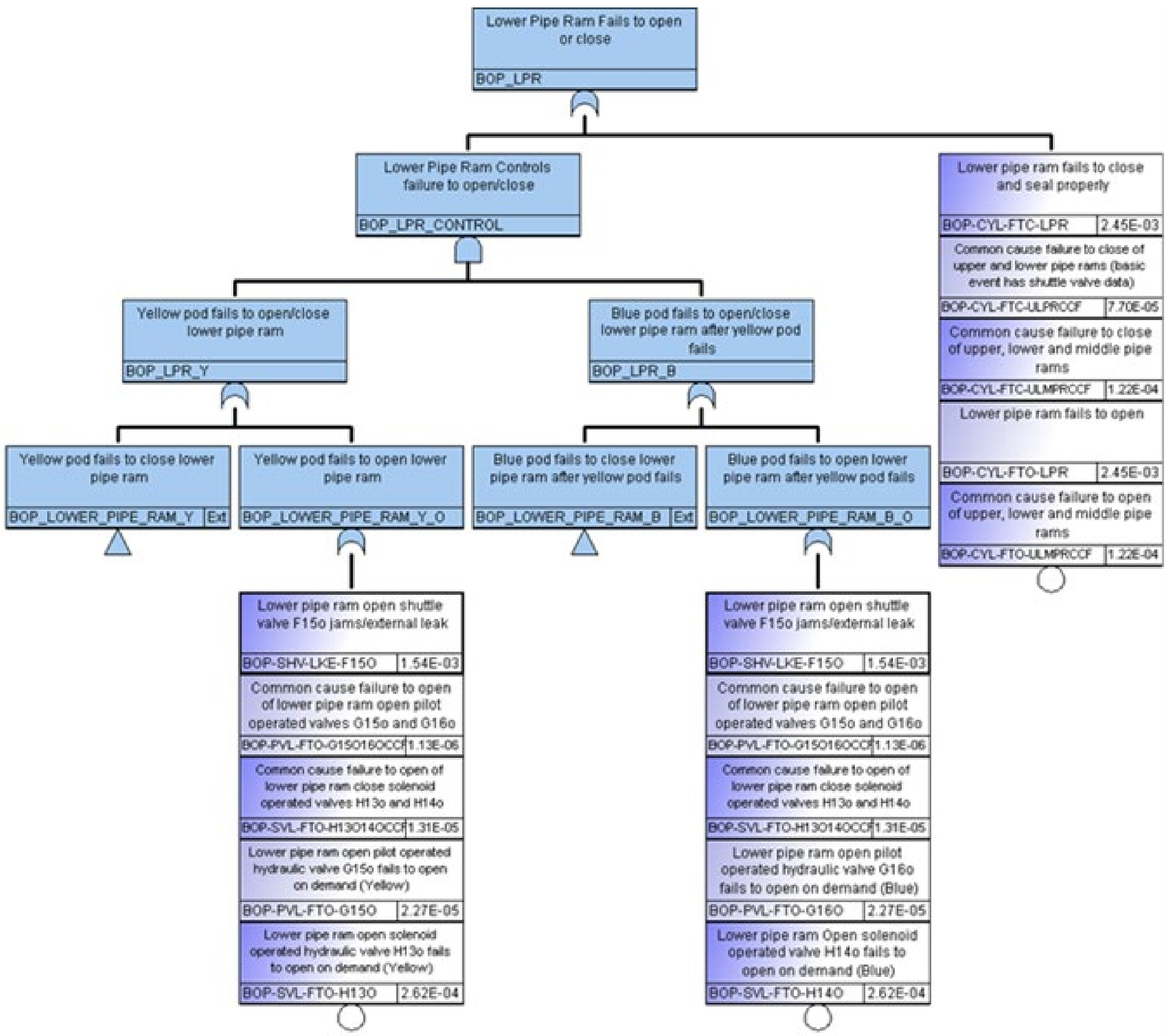


Figure C- 38: Failure of the Lower Pipe Ram to Open or Close

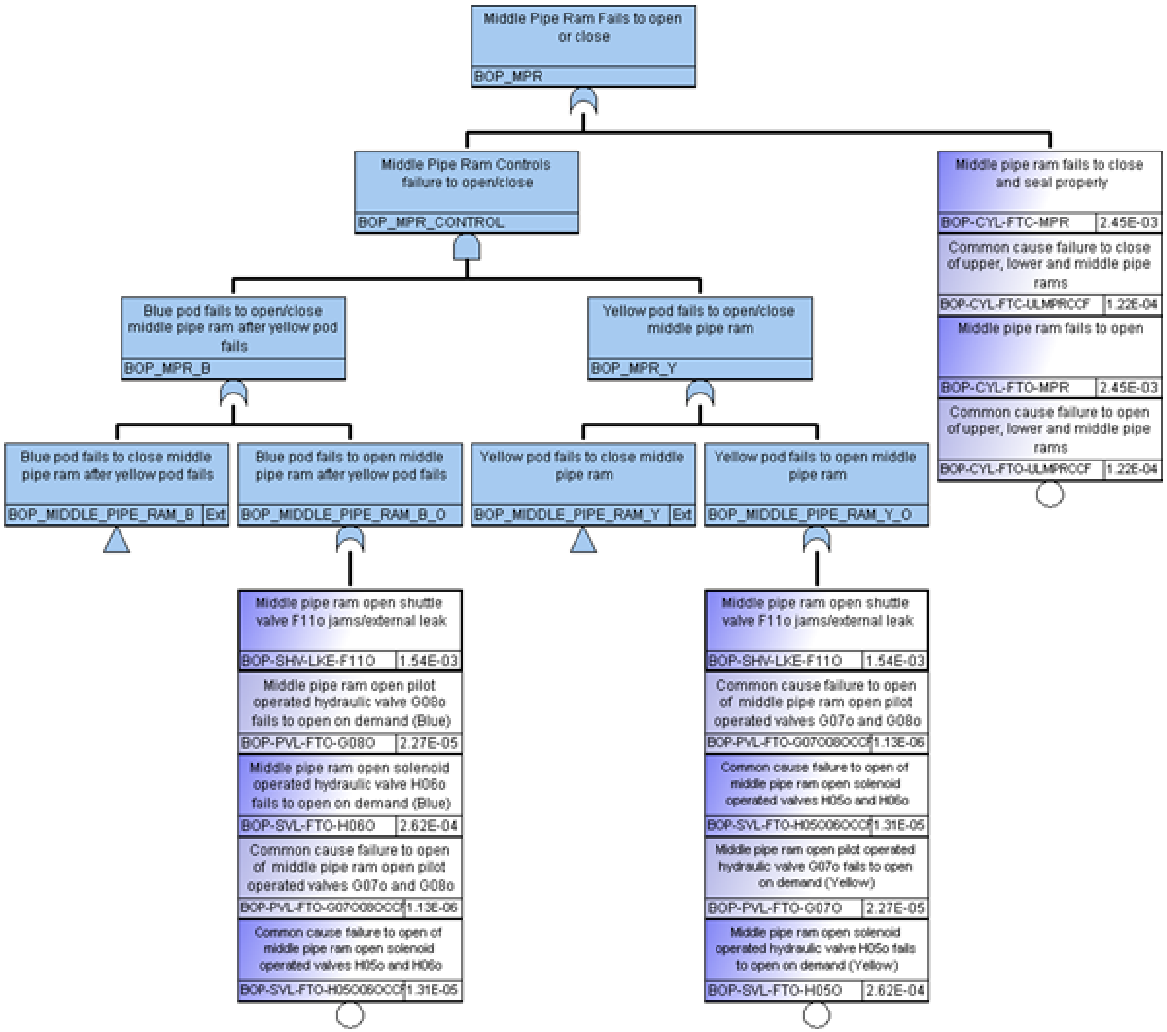


Figure C- 39: Failure of the Middle Pipe Ram to Open or Close

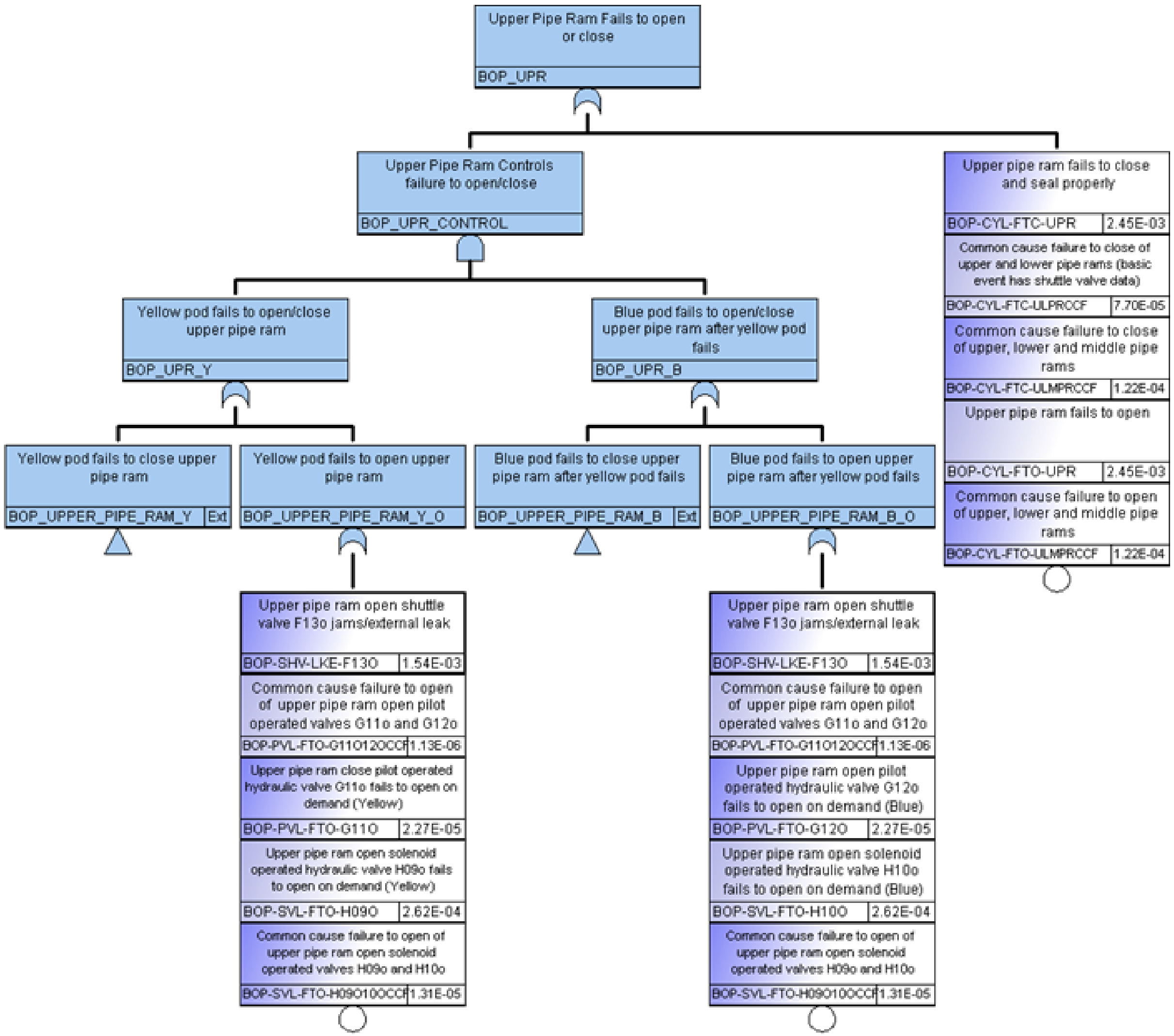


Figure C- 40: Failure of the Upper Pipe Ram to Open or Close

C.5 DEADMAN/AUTOSHEAR

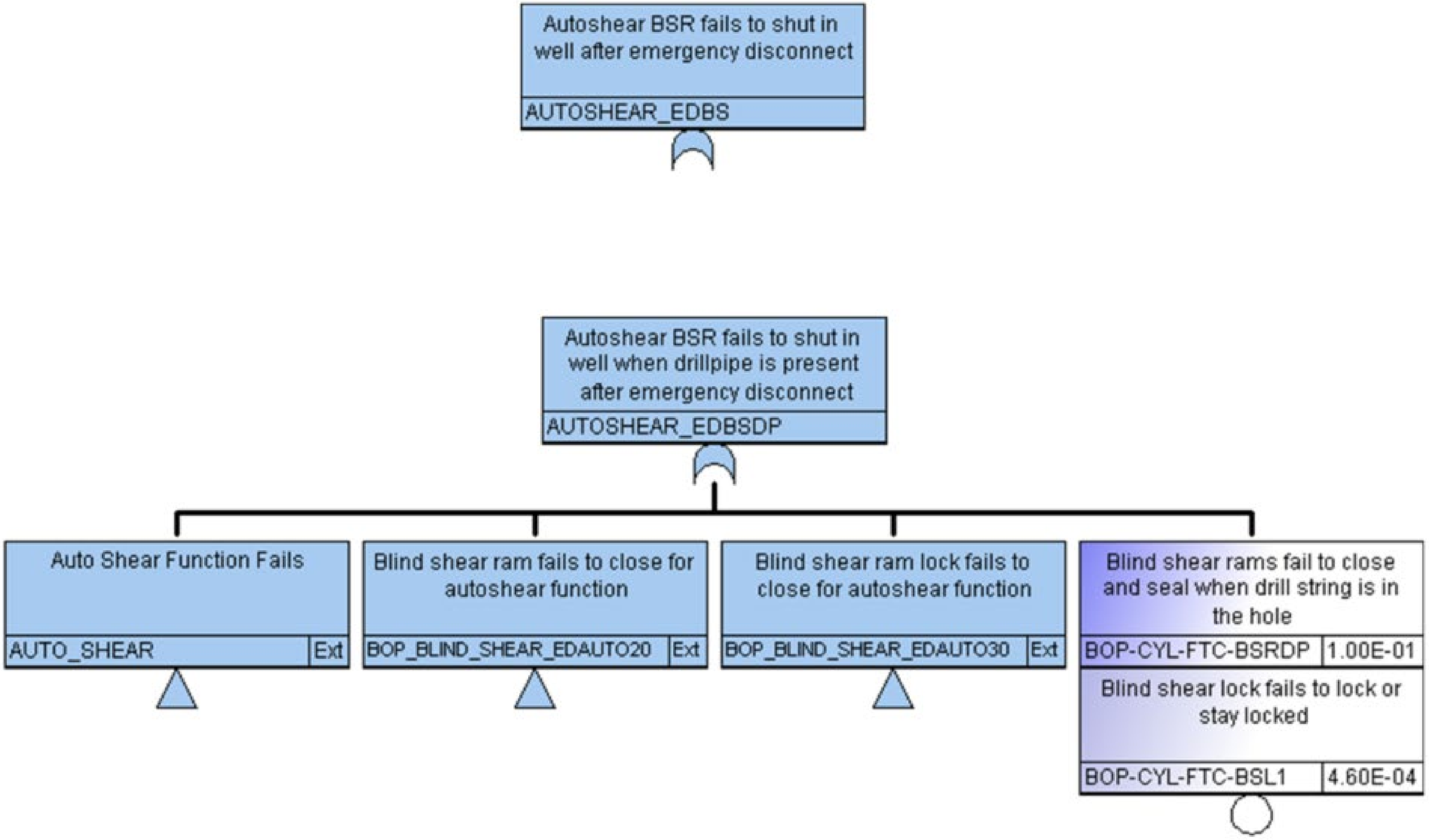


Figure C- 41: Deadman/Autoshear

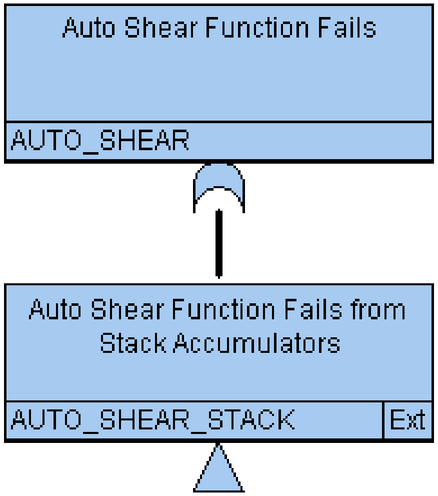


Figure C- 42: Deadman/Autoshear (Continued)

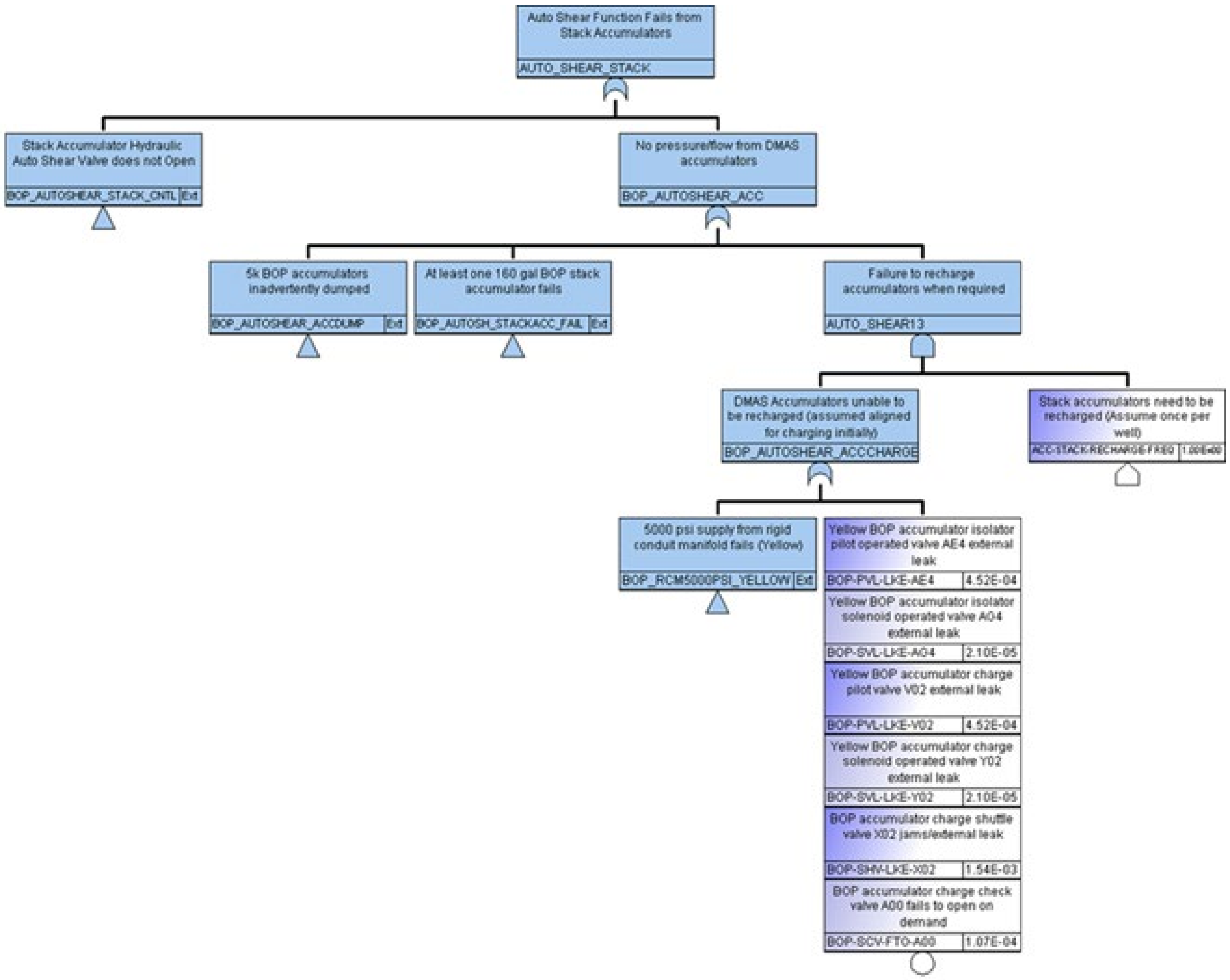


Figure C- 43: Deadman/Autoshear (Continued)

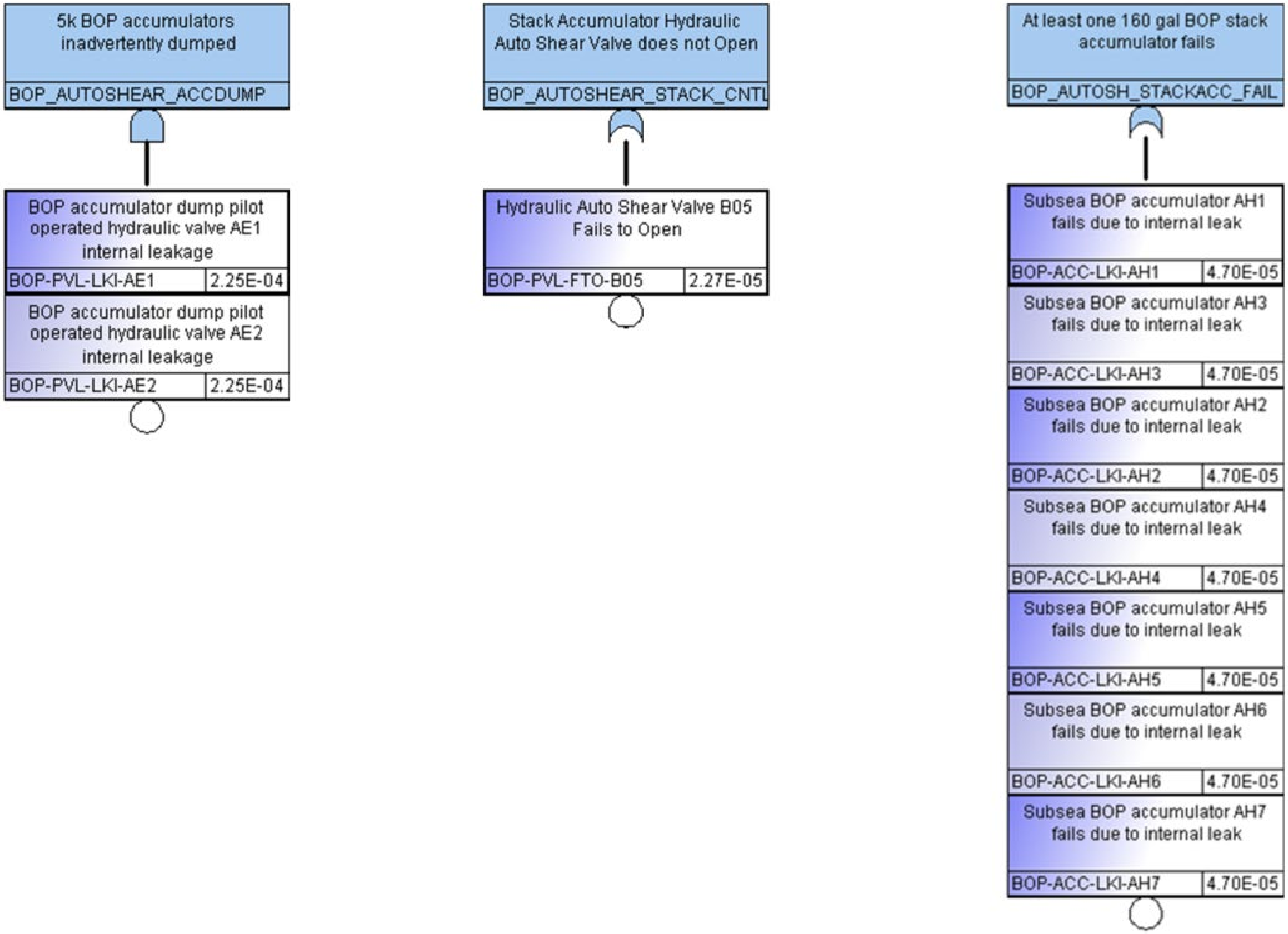


Figure C- 44: Deadman/Autoshear (Continued)

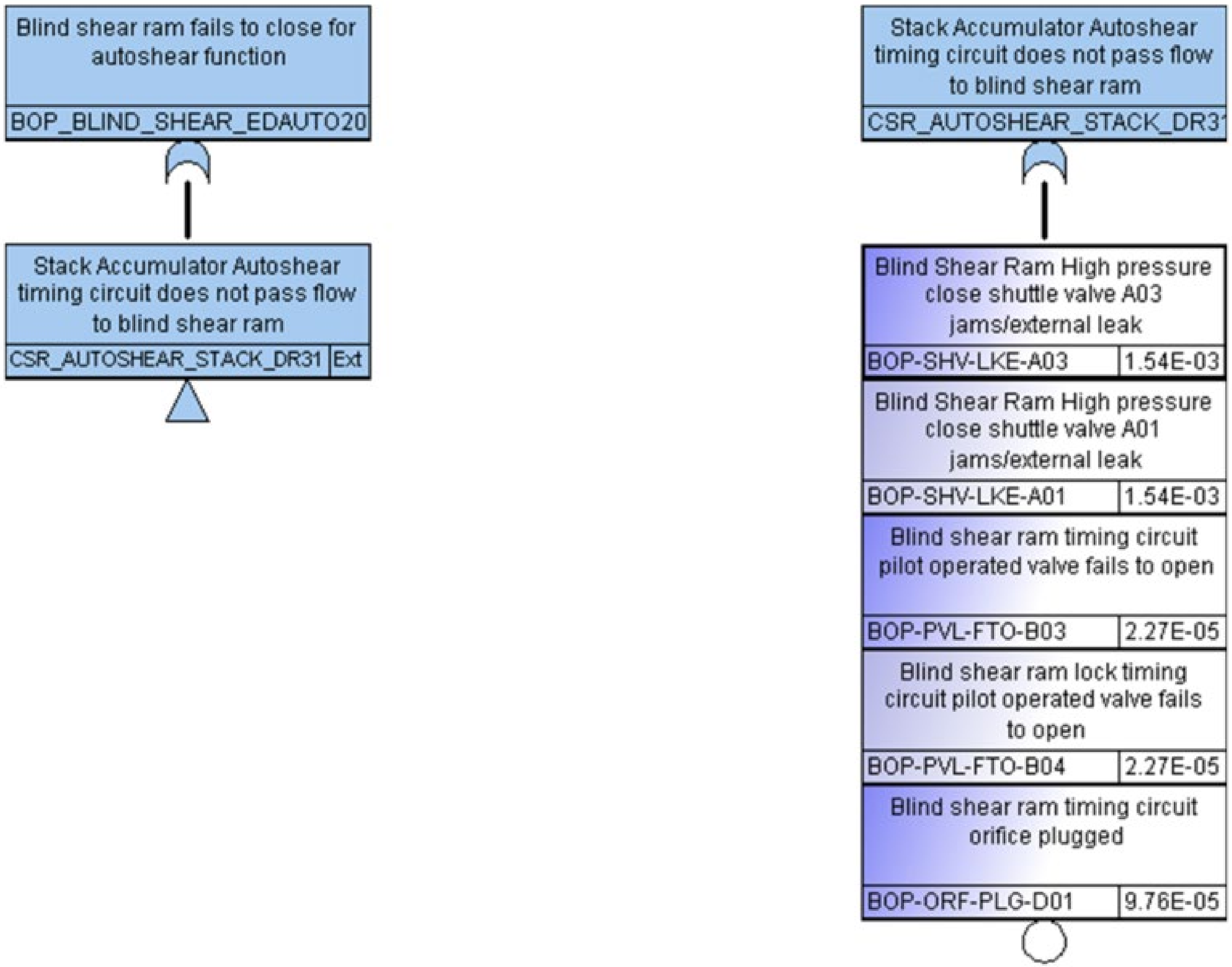


Figure C- 45: Deadman/Autoshear (Continued)

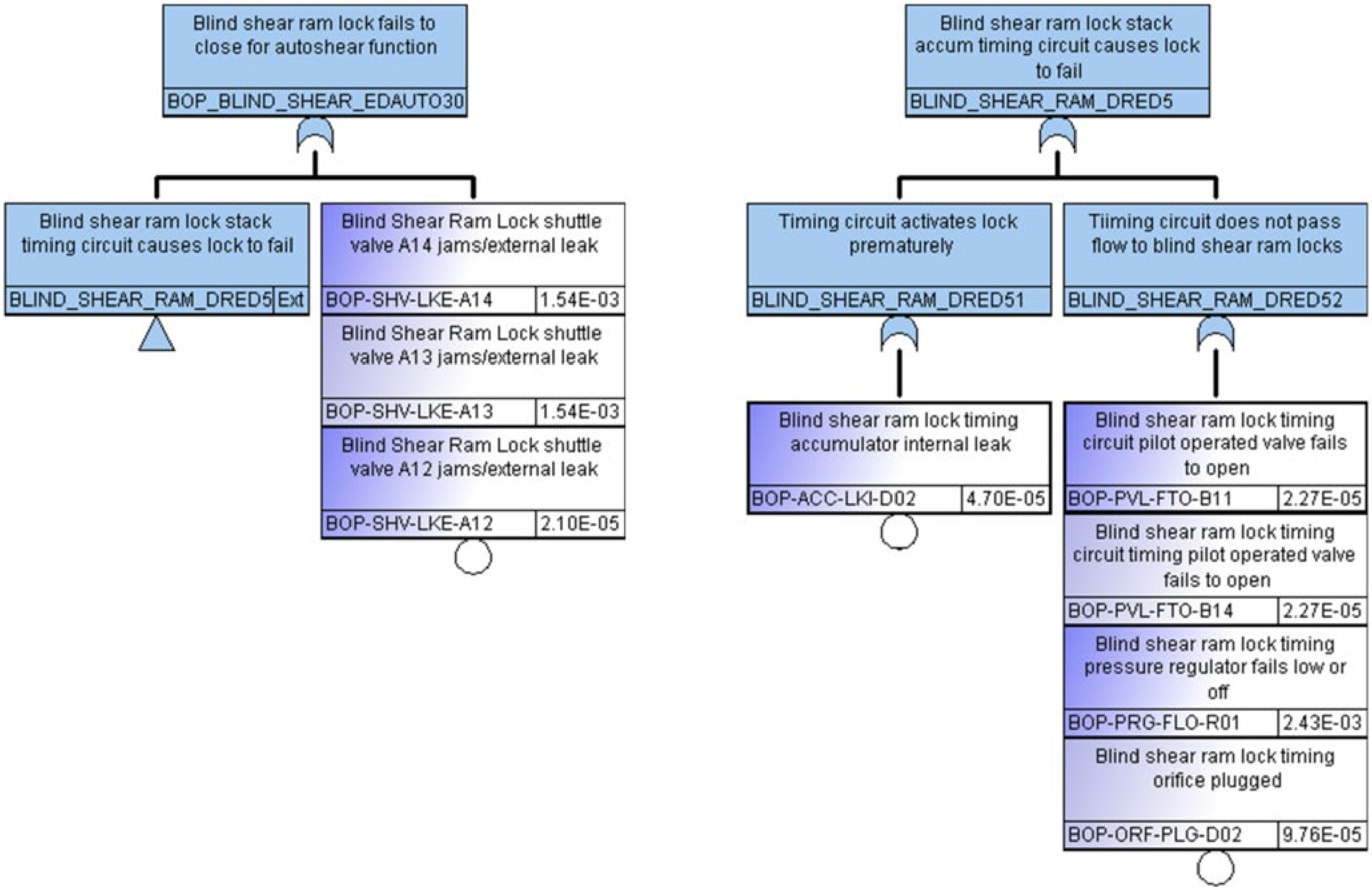


Figure C- 46: Deadman/Autoshear (Continued)

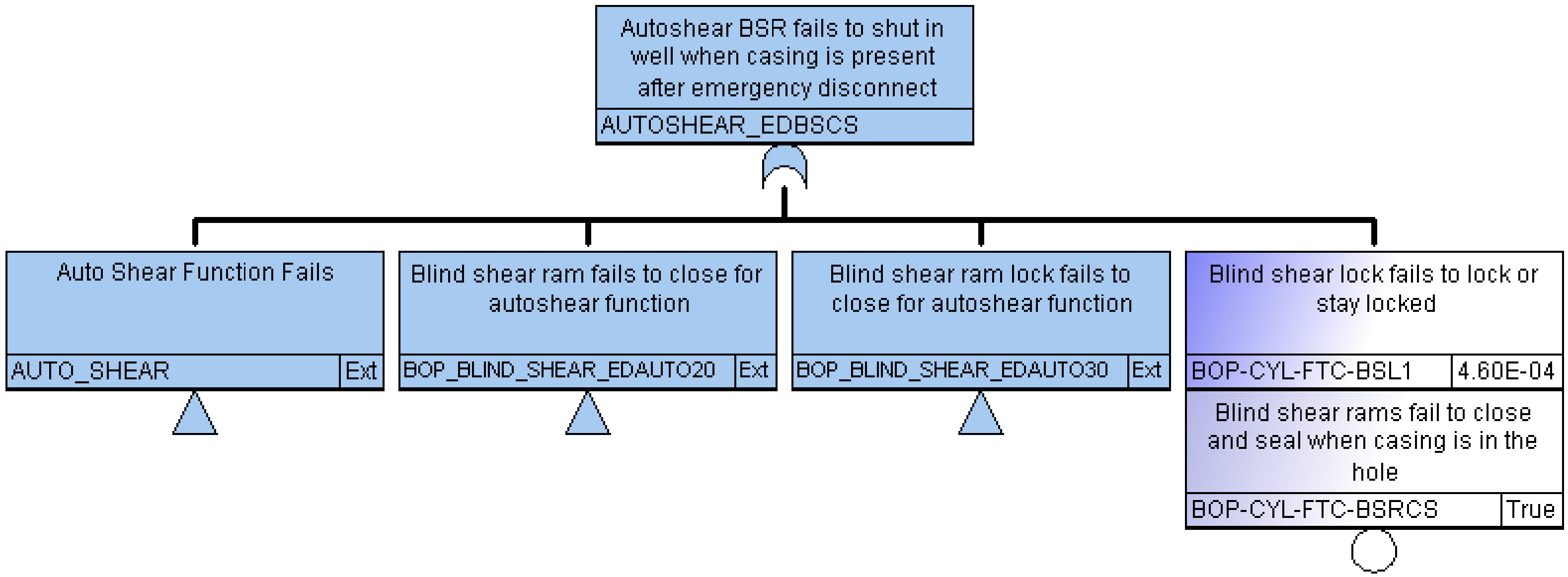


Figure C- 47: Deadman/Autoshear (Continued)

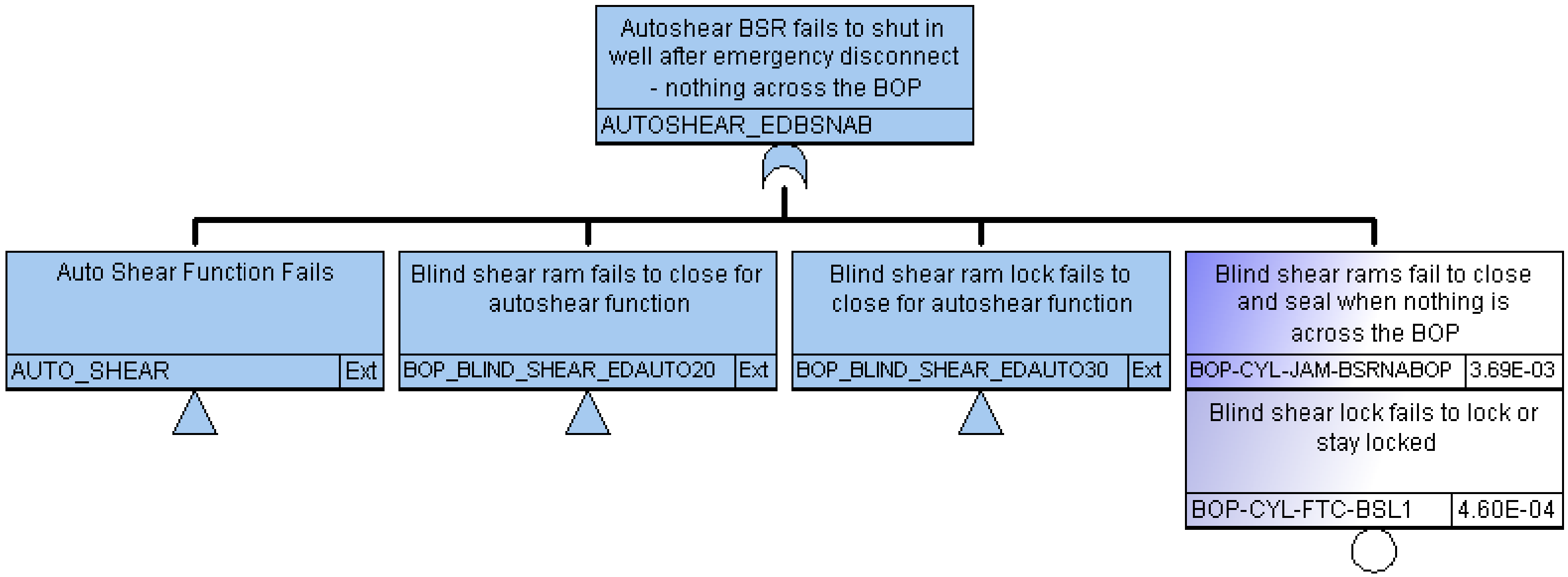


Figure C- 48: Deadman/Autoshear (Continued)

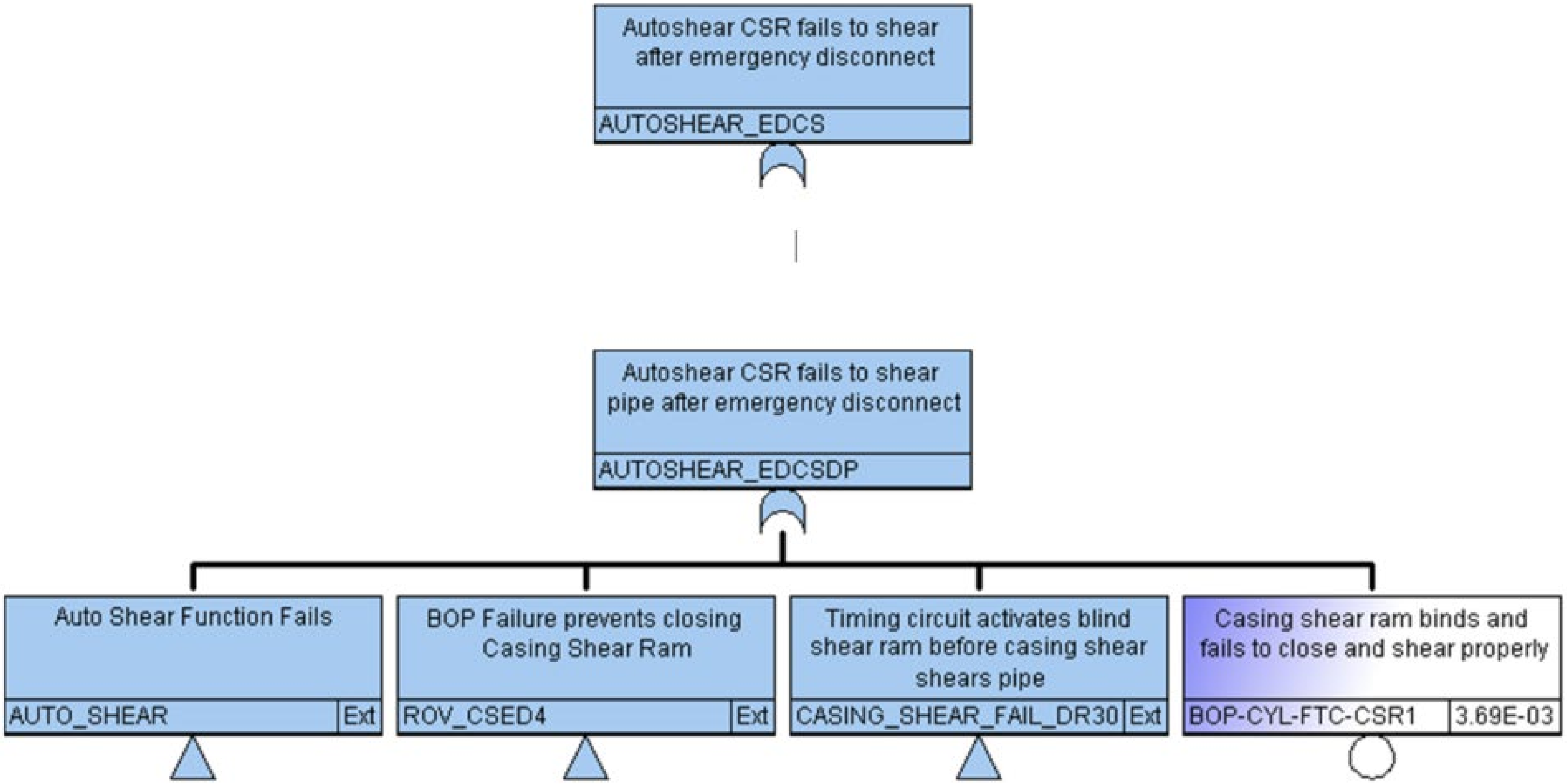


Figure C- 49: Deadman/Autoshear (Continued)

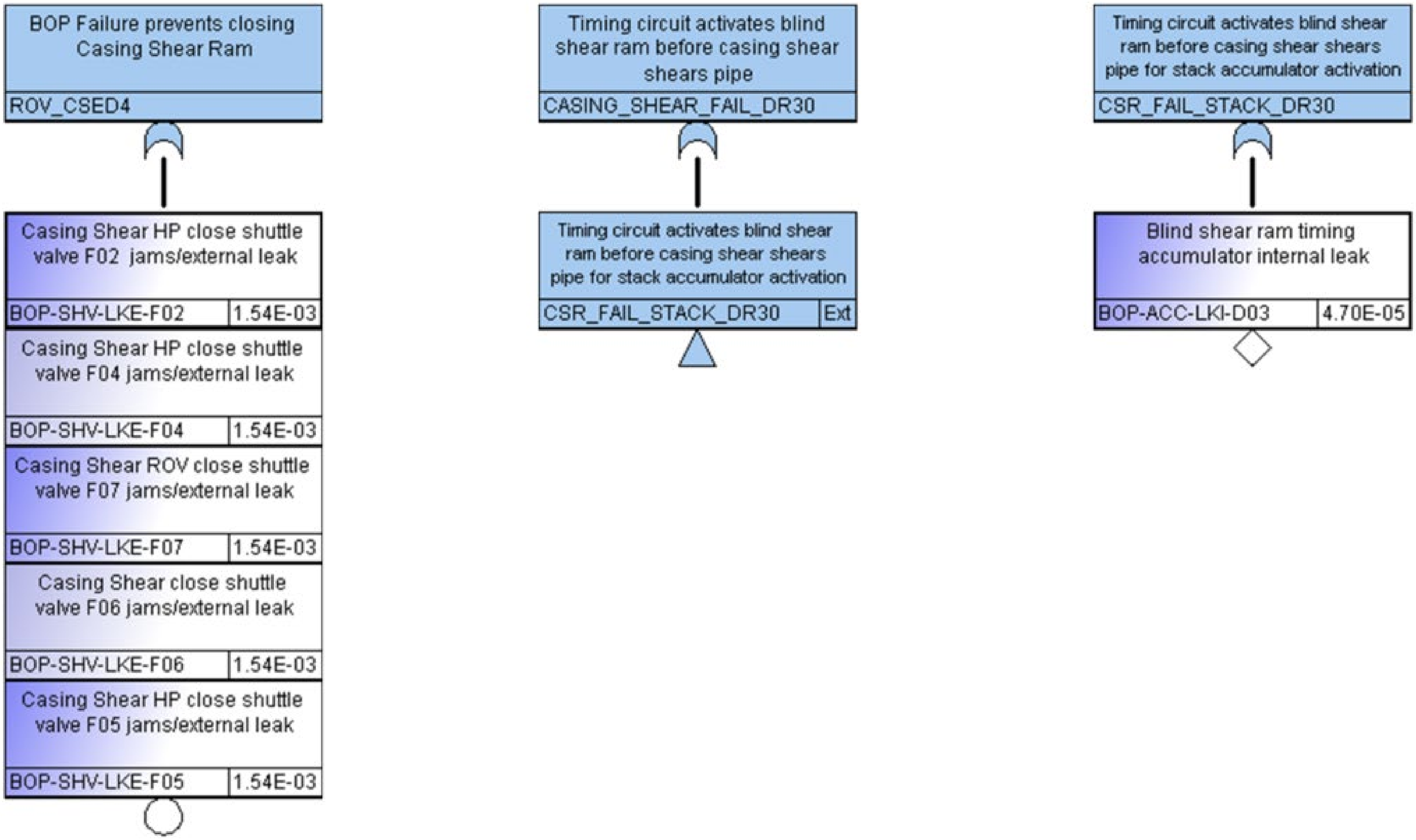
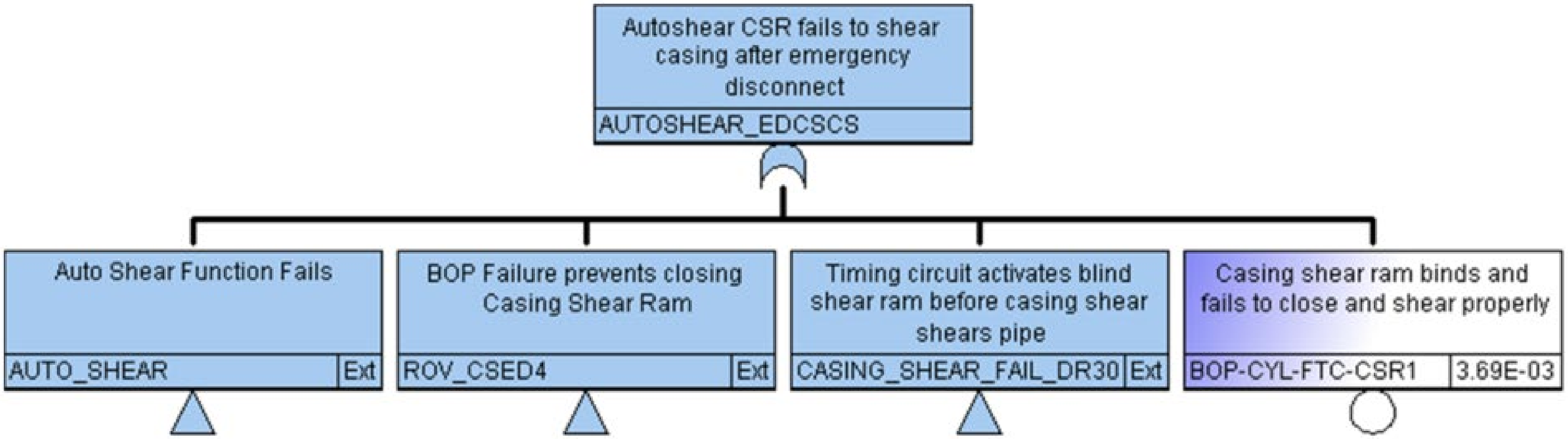


Figure C- 50: Deadman/Autoshear (Continued)



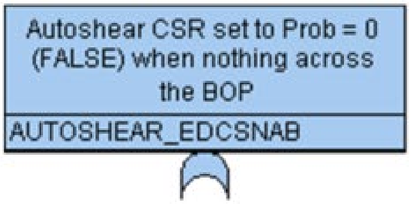


Figure C- 51: Deadman/Autoshear (Continued)

Figure C- 52: Deadman/Autoshear (Continued)

C.6 5000 PSI MANIFOLD

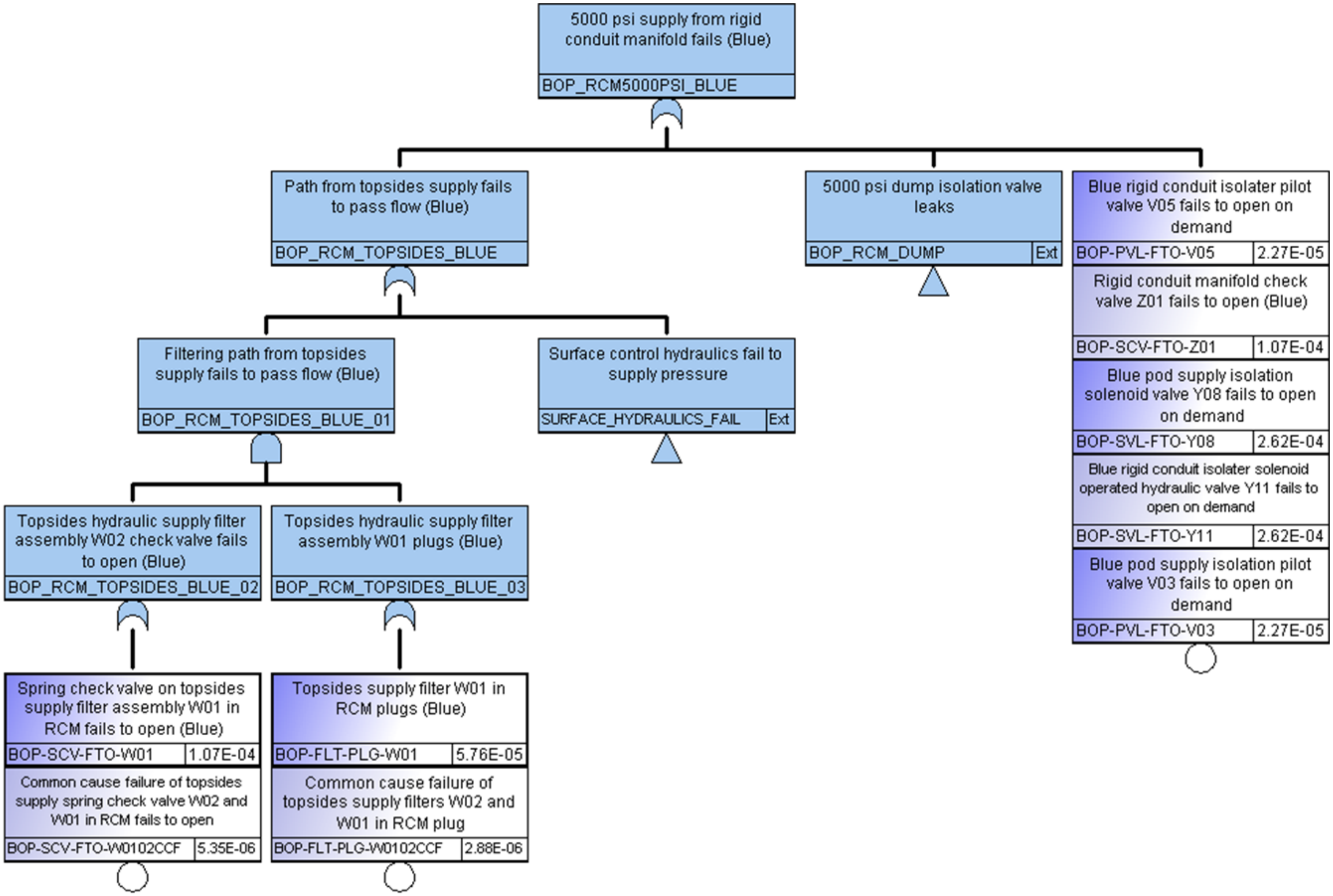


Figure C- 53: 5000 PSI Manifold Failure

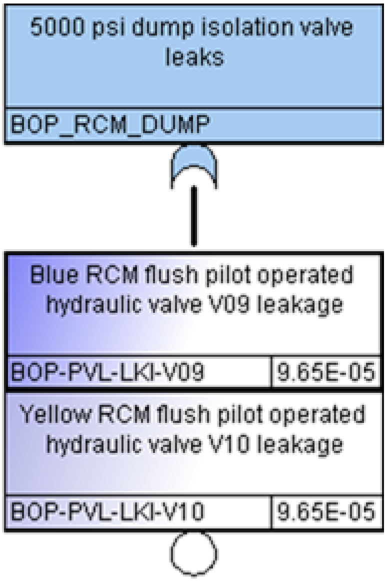


Figure C- 54: 5000 PSI Manifold Failure (Continued)

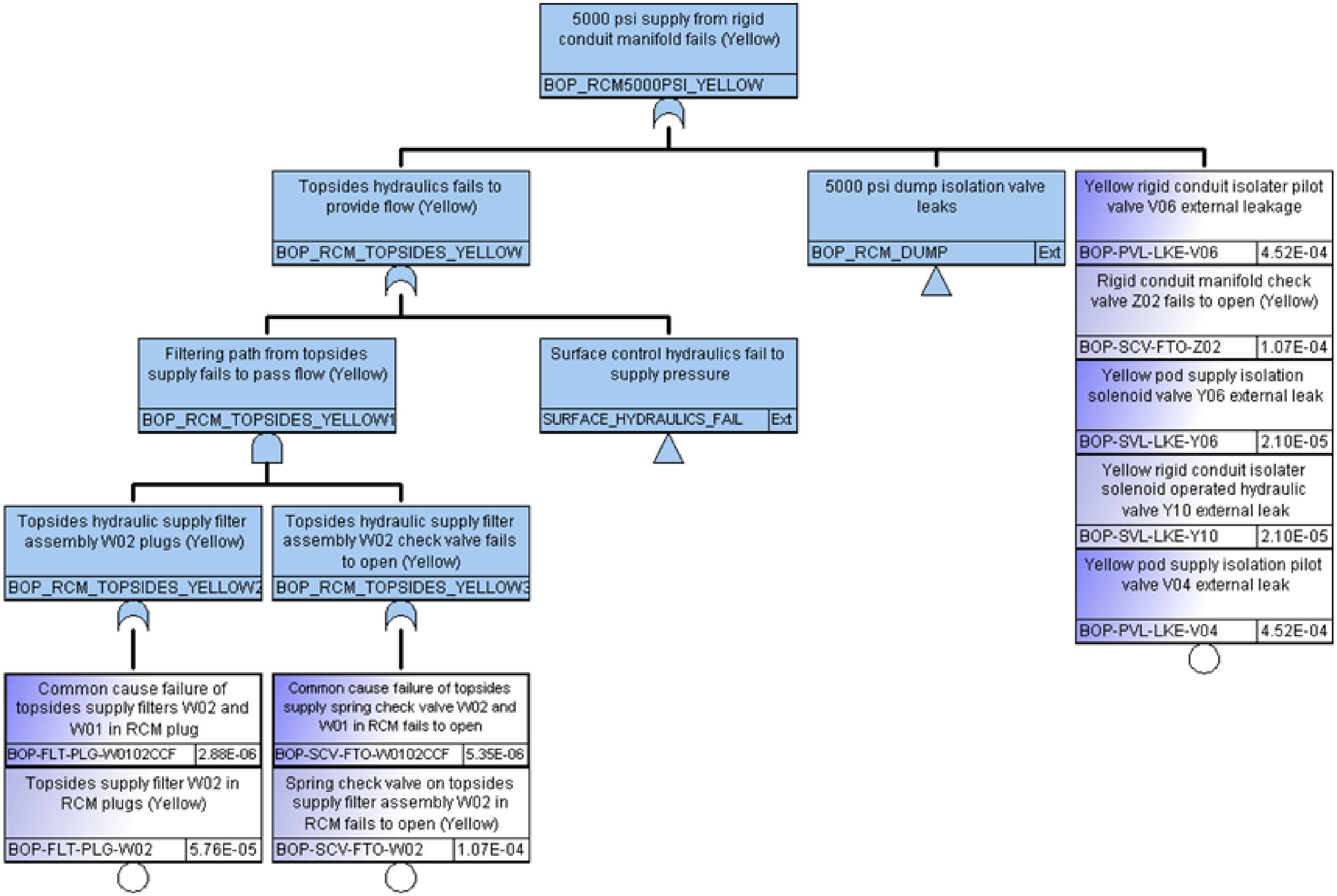


Figure C- 55: 5000 PSI Manifold Failure (Continued)

C.7 3000 PSI MANIFOLD

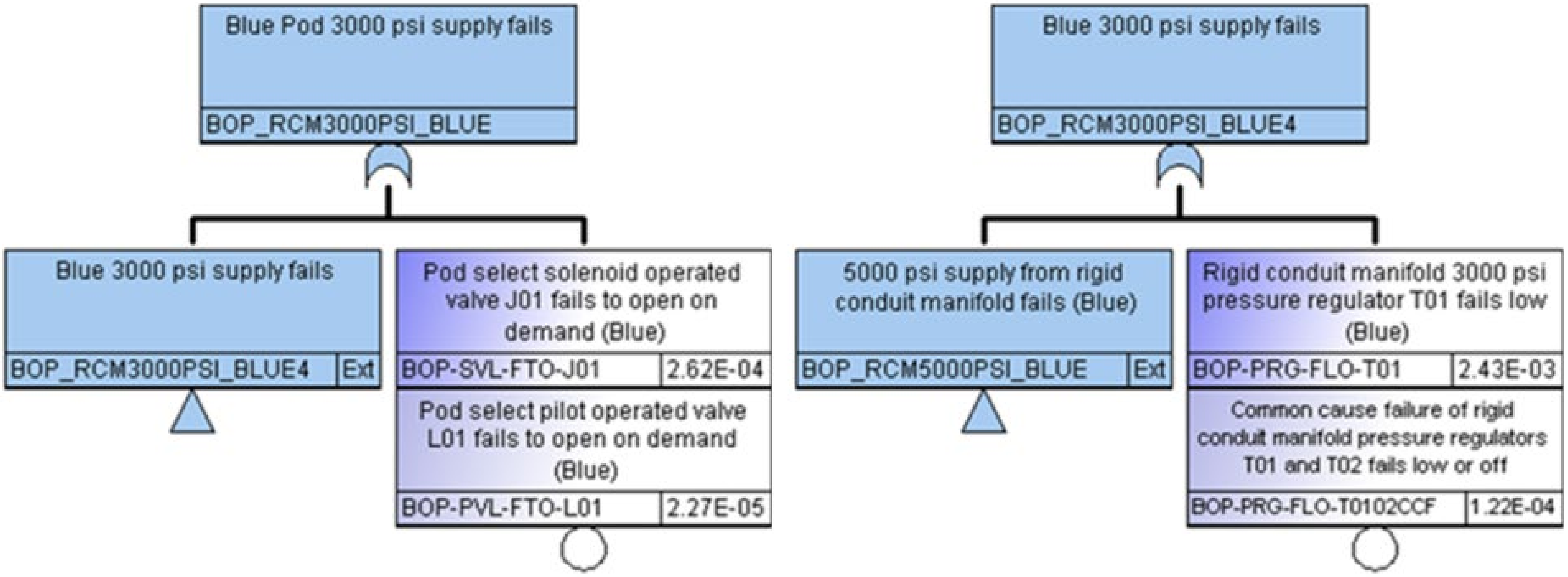


Figure C- 56: 3000 PSI Manifold Failure

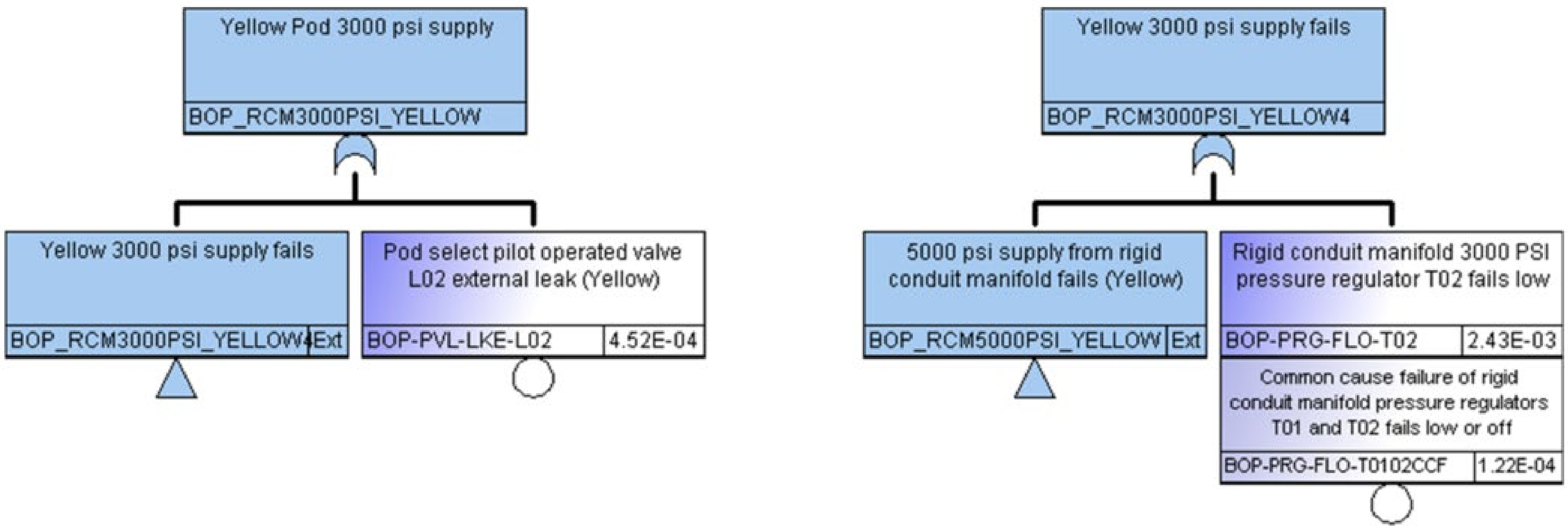


Figure C- 57: 3000 PSI Manifold Failure (Continued)

C.8 SUBSEA MANIFOLD

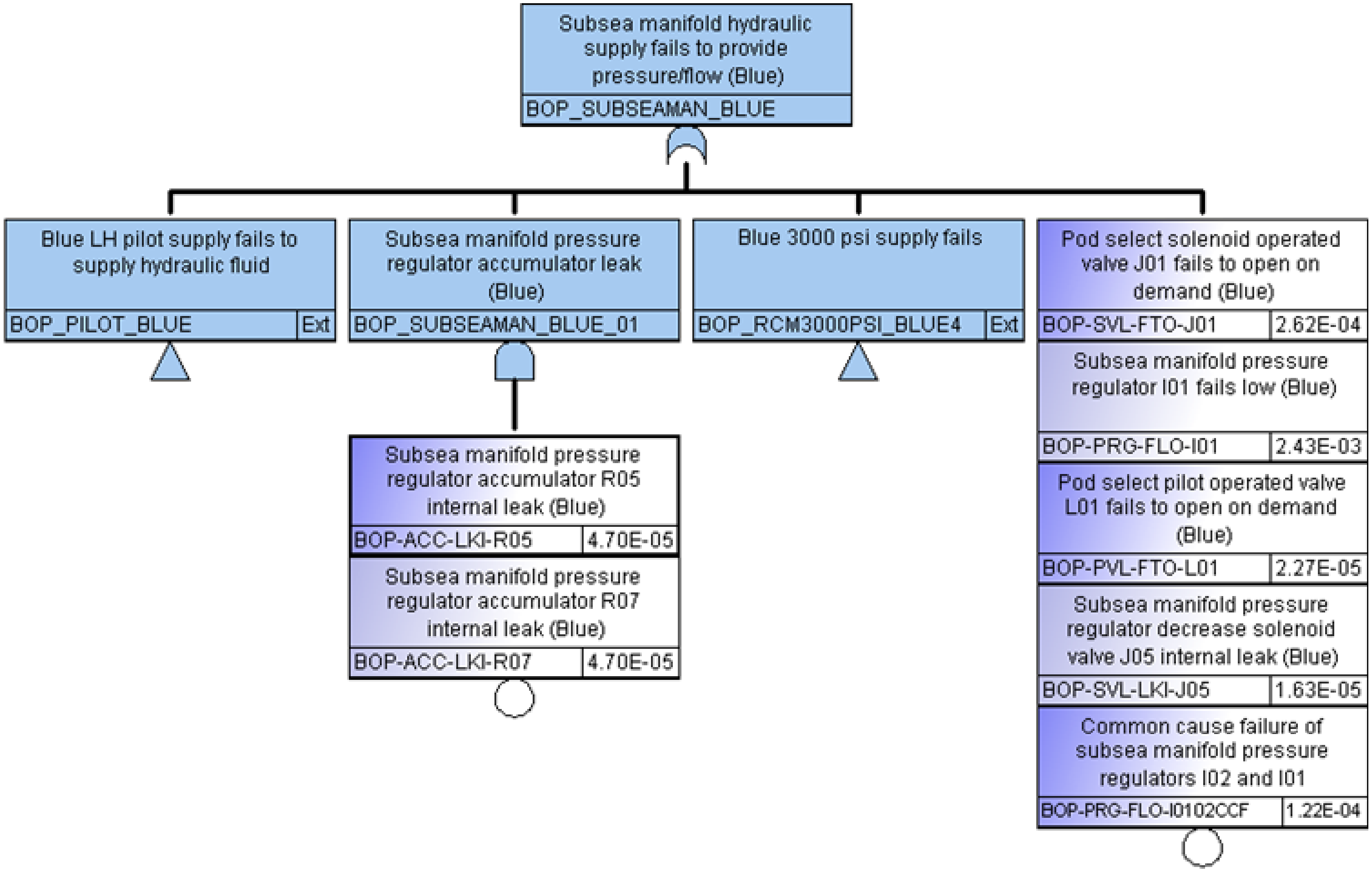


Figure C- 58: Subsea Manifold Failure

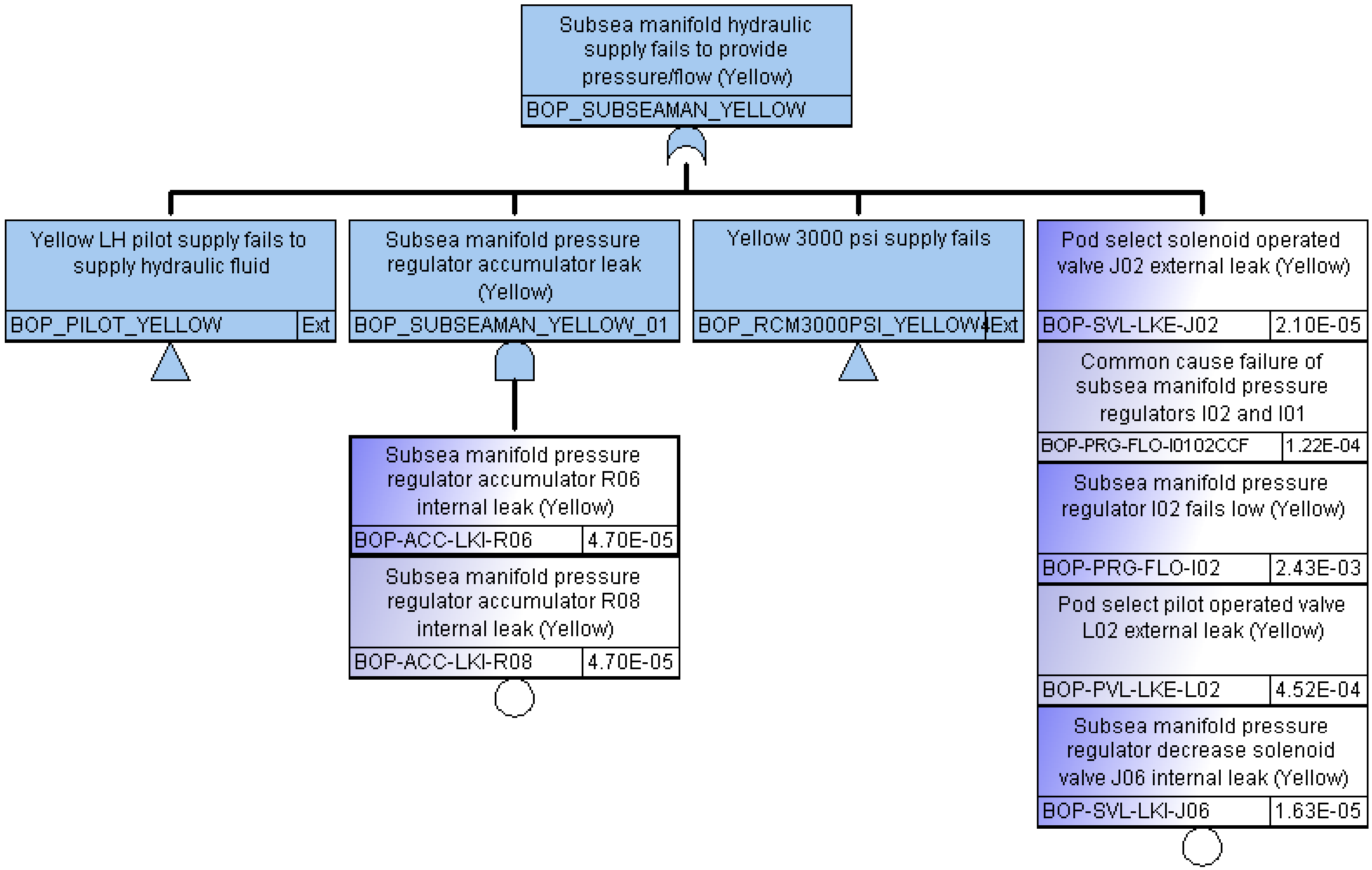


Figure C- 59: Subsea Manifold Failure (Continued)

C.9 PILOT SYSTEM

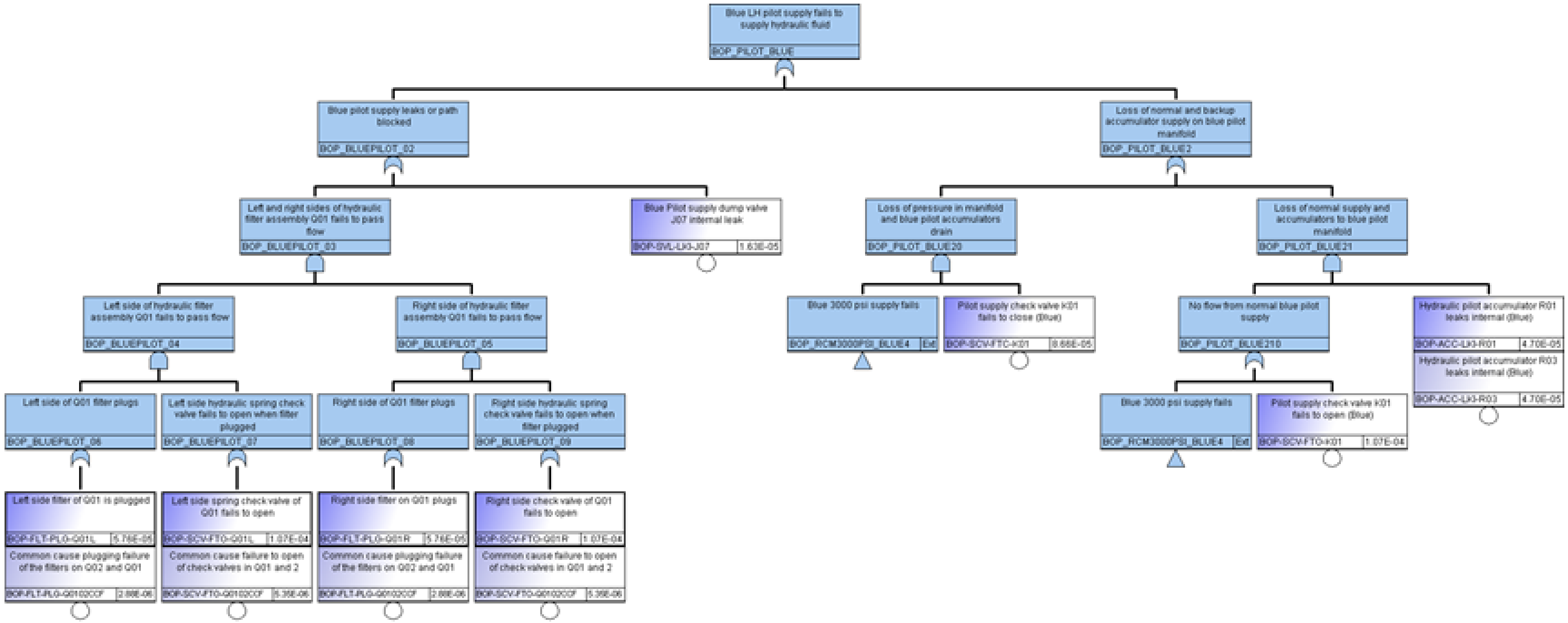


Figure C- 60: Pilot System Failure

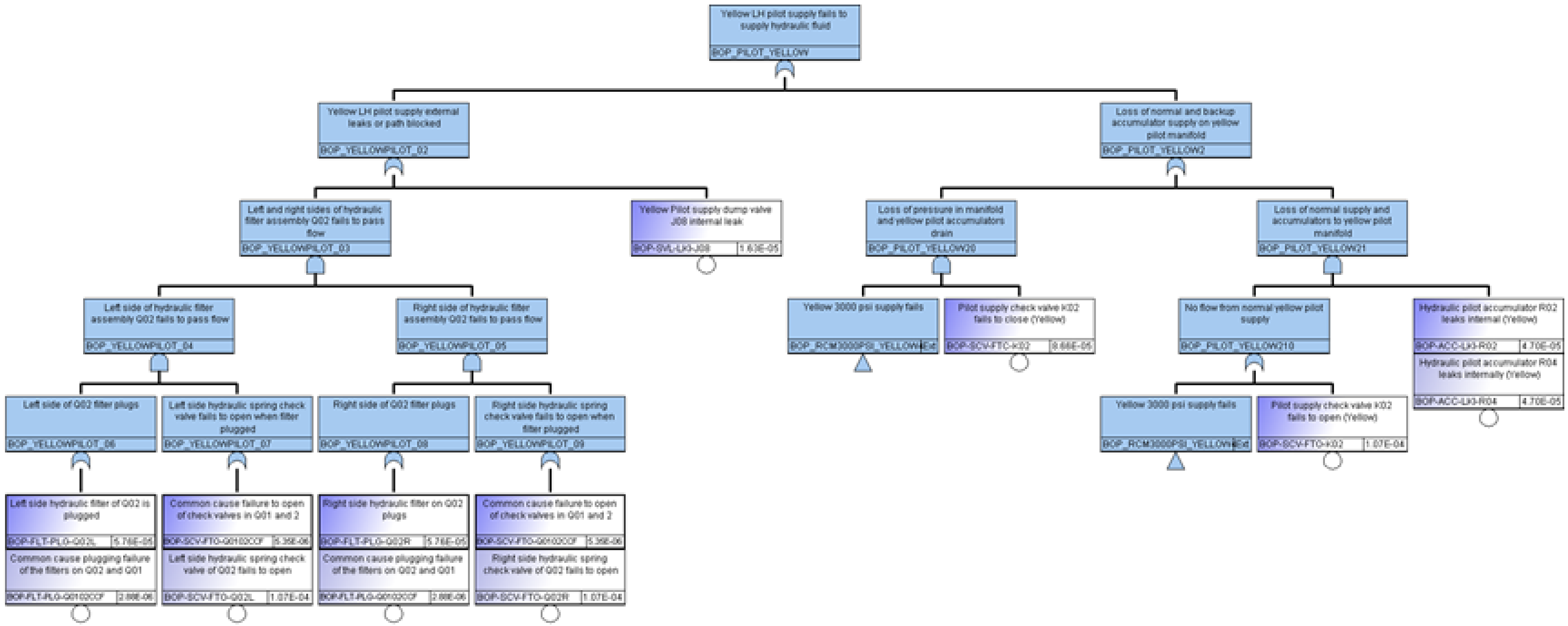


Figure C- 61: Pilot System Failure (Continued)

C.10 BOP SUBSEA ELECTRONICS MODULE

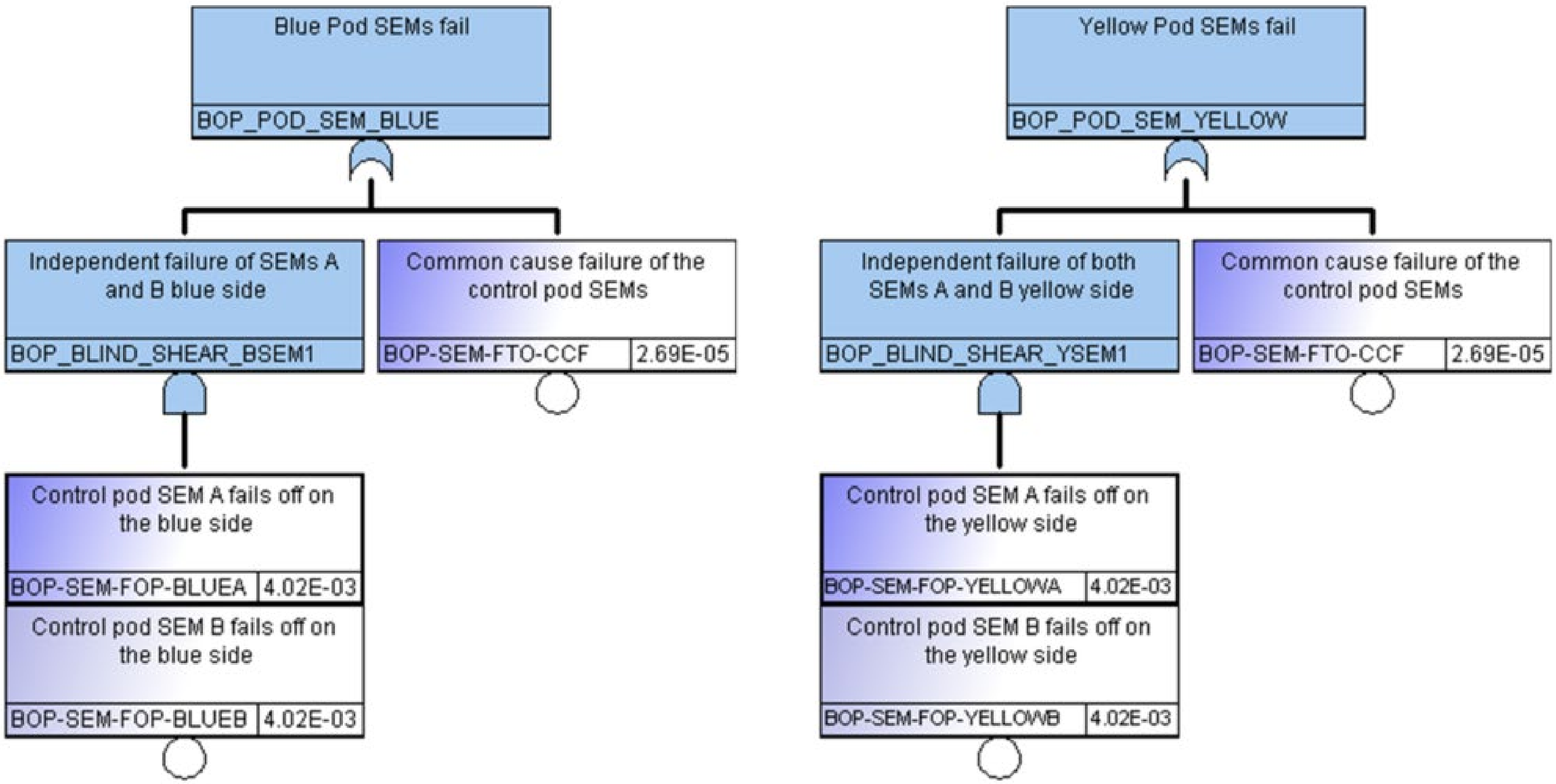


Figure C- 62: BOP Subsea Electronics Failure

C.11 EMERGENCY DISCONNECT

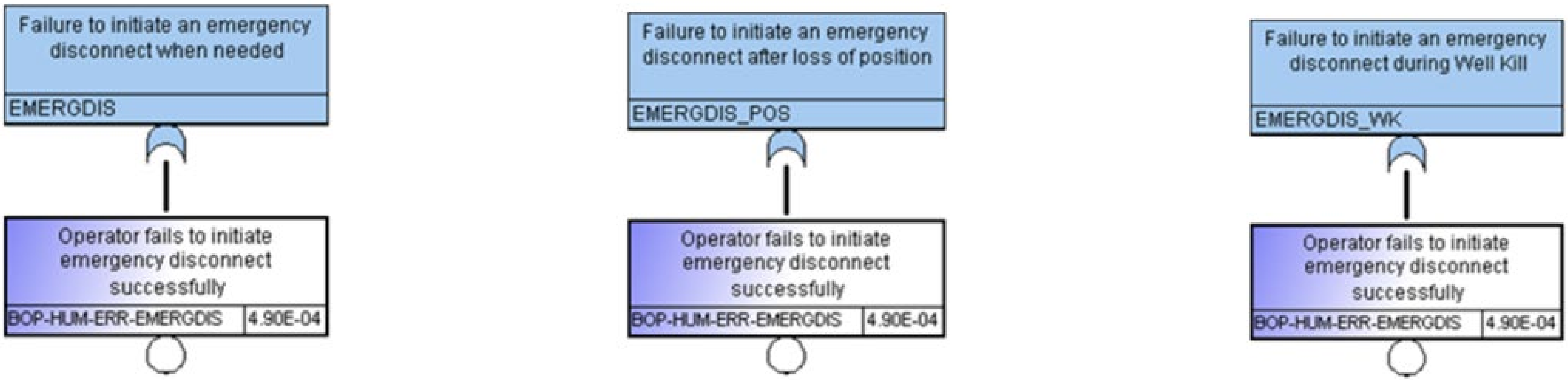


Figure C- 63: Emergency Disconnect

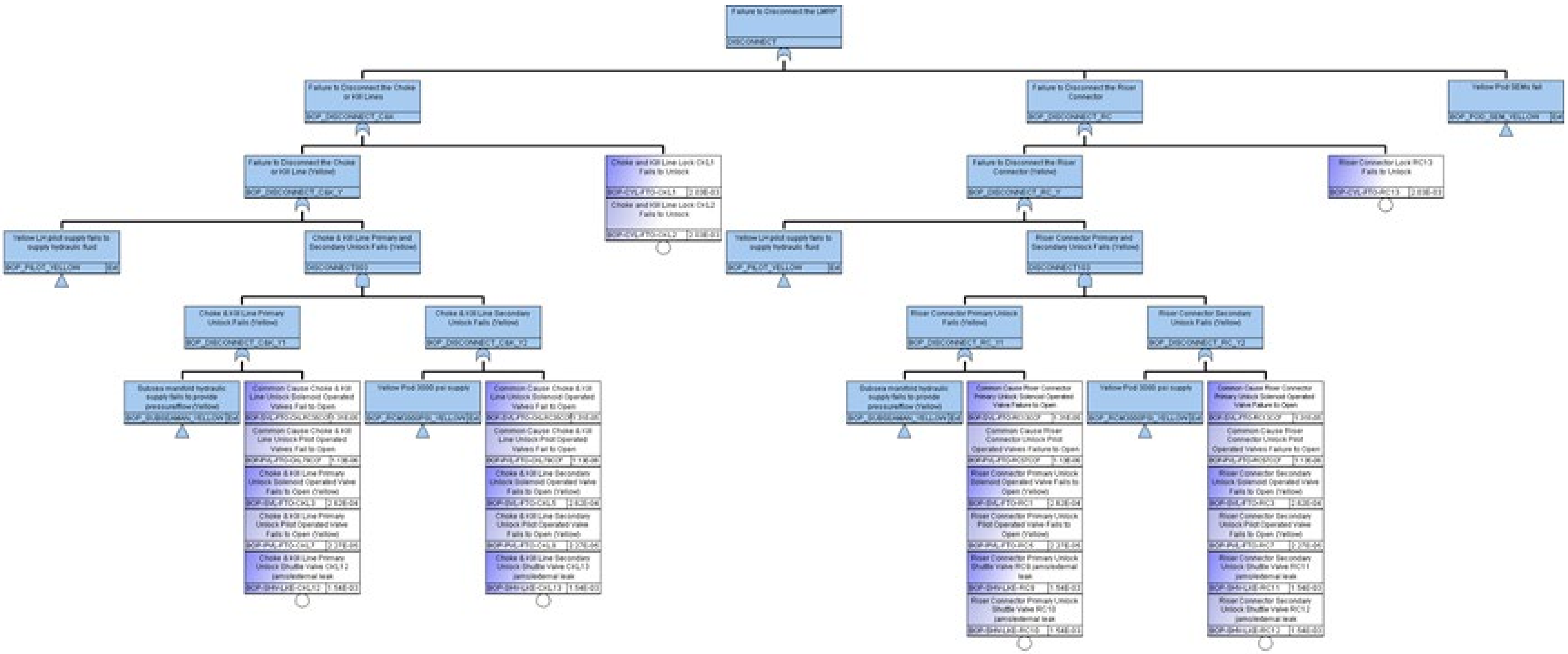


Figure C- 64: Emergency Disconnect (Continued)

C.12 IBOP/CASING SHOE FAILURE

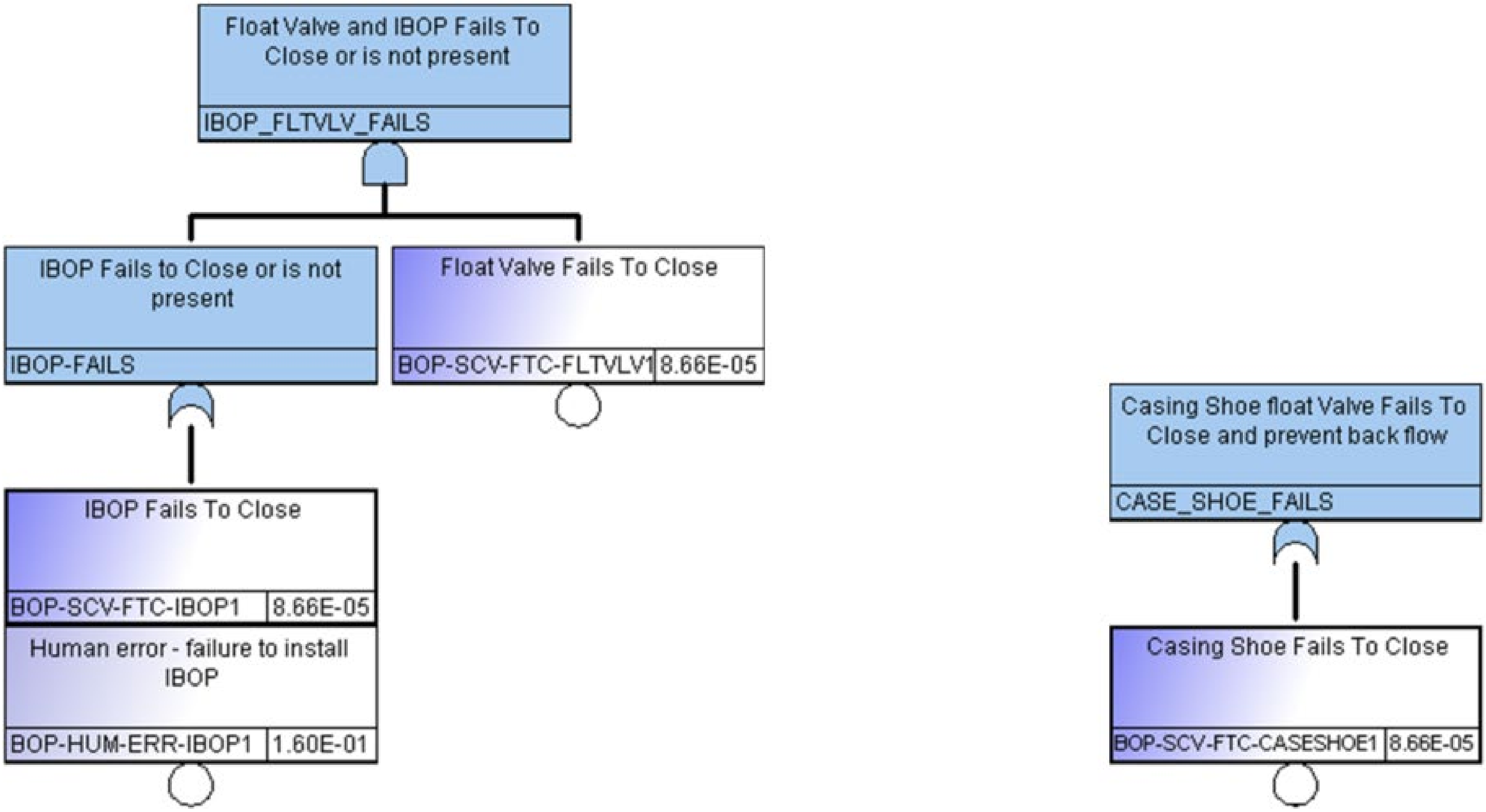


Figure C- 65: IBOP / Casing Shoe Failure

C.13 ROV

Figure C- 66: ROV Failure

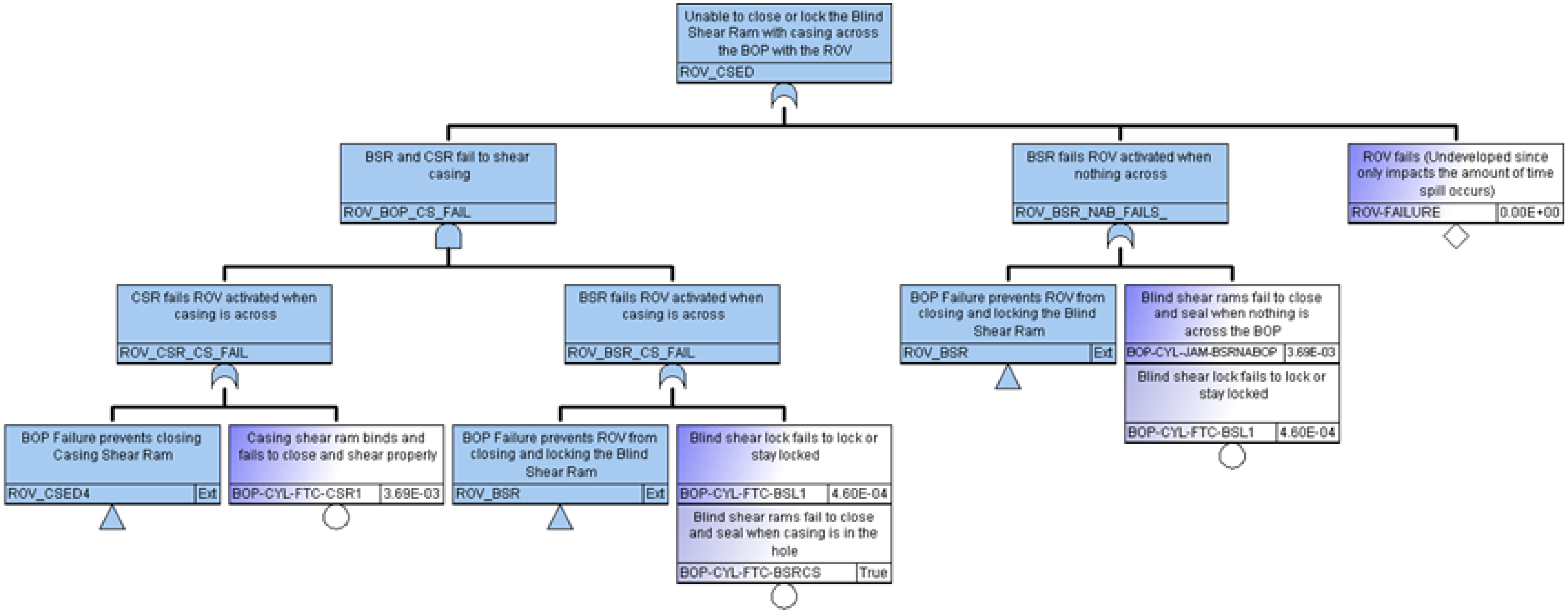


Figure C- 67: ROV Failure (Continued)

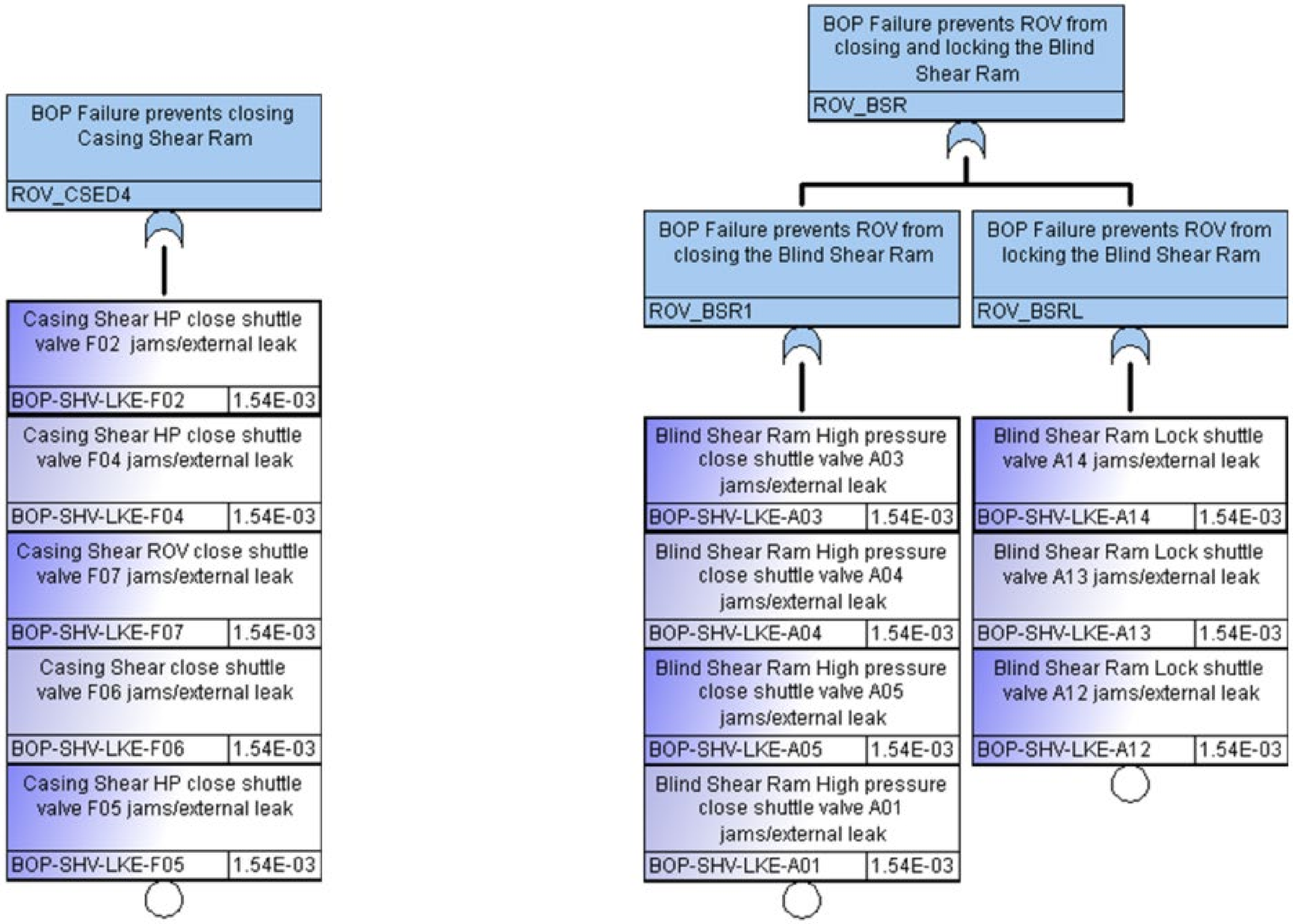


Figure C- 68: ROV Failure (Continued)

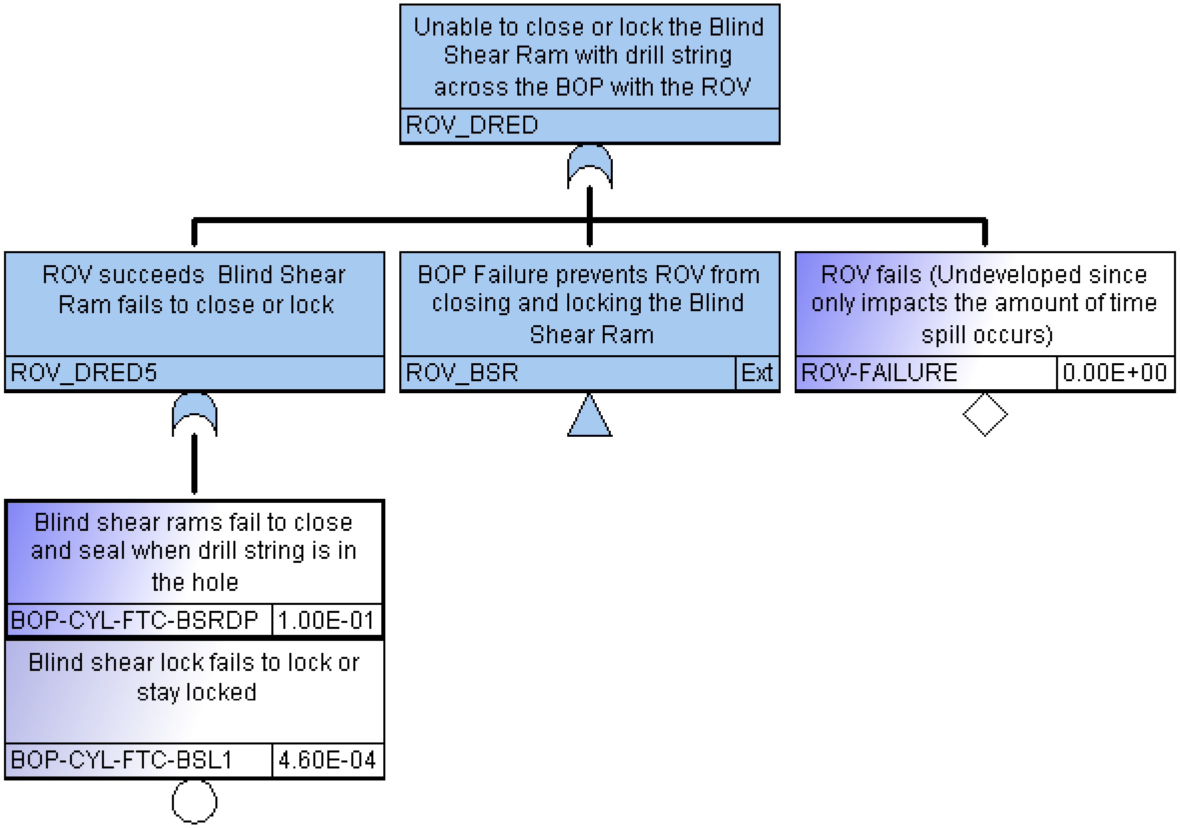


Figure C- 69: ROV Failure (Continued)

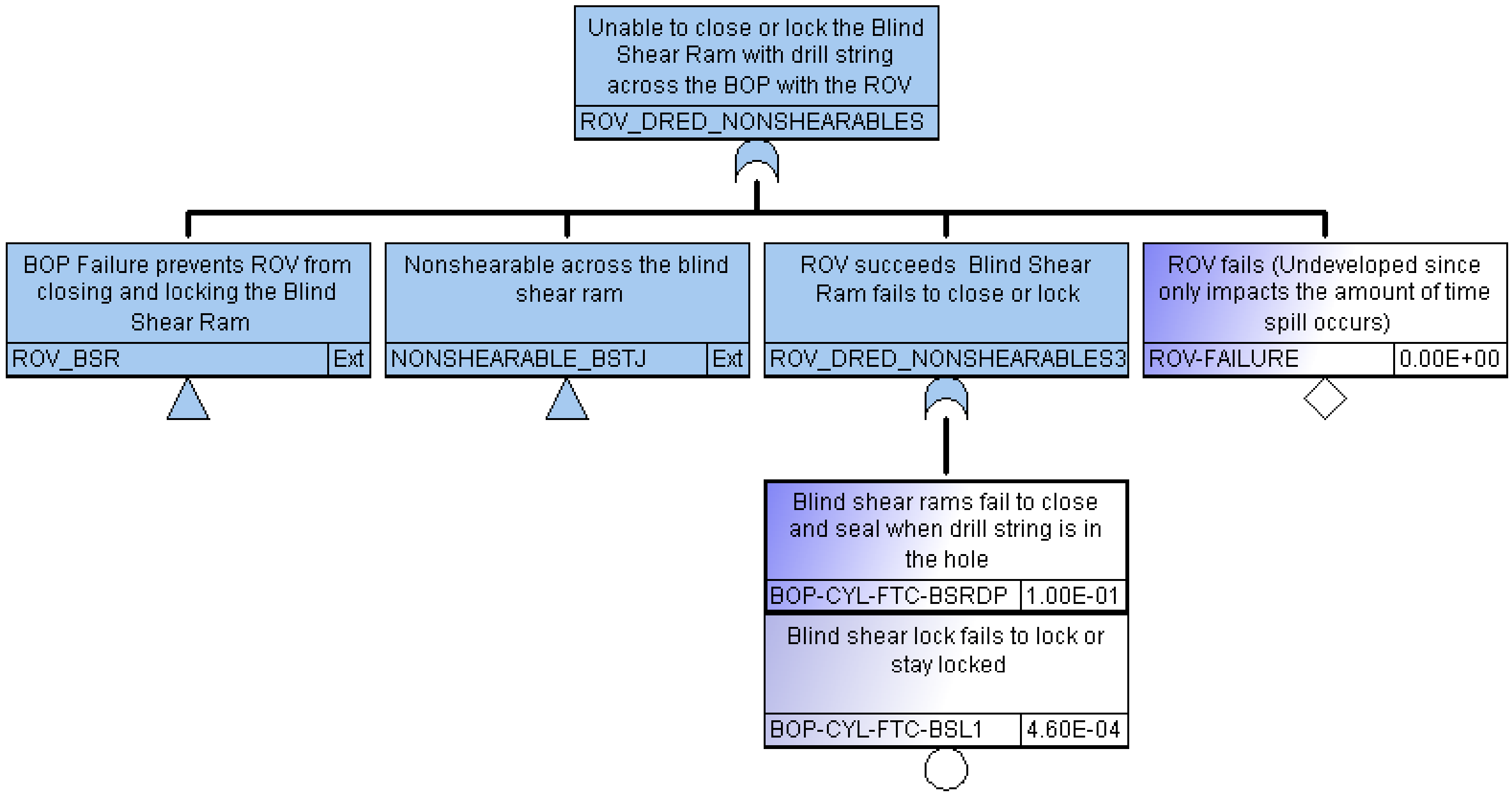


Figure C- 70: ROV Failure (Continued)

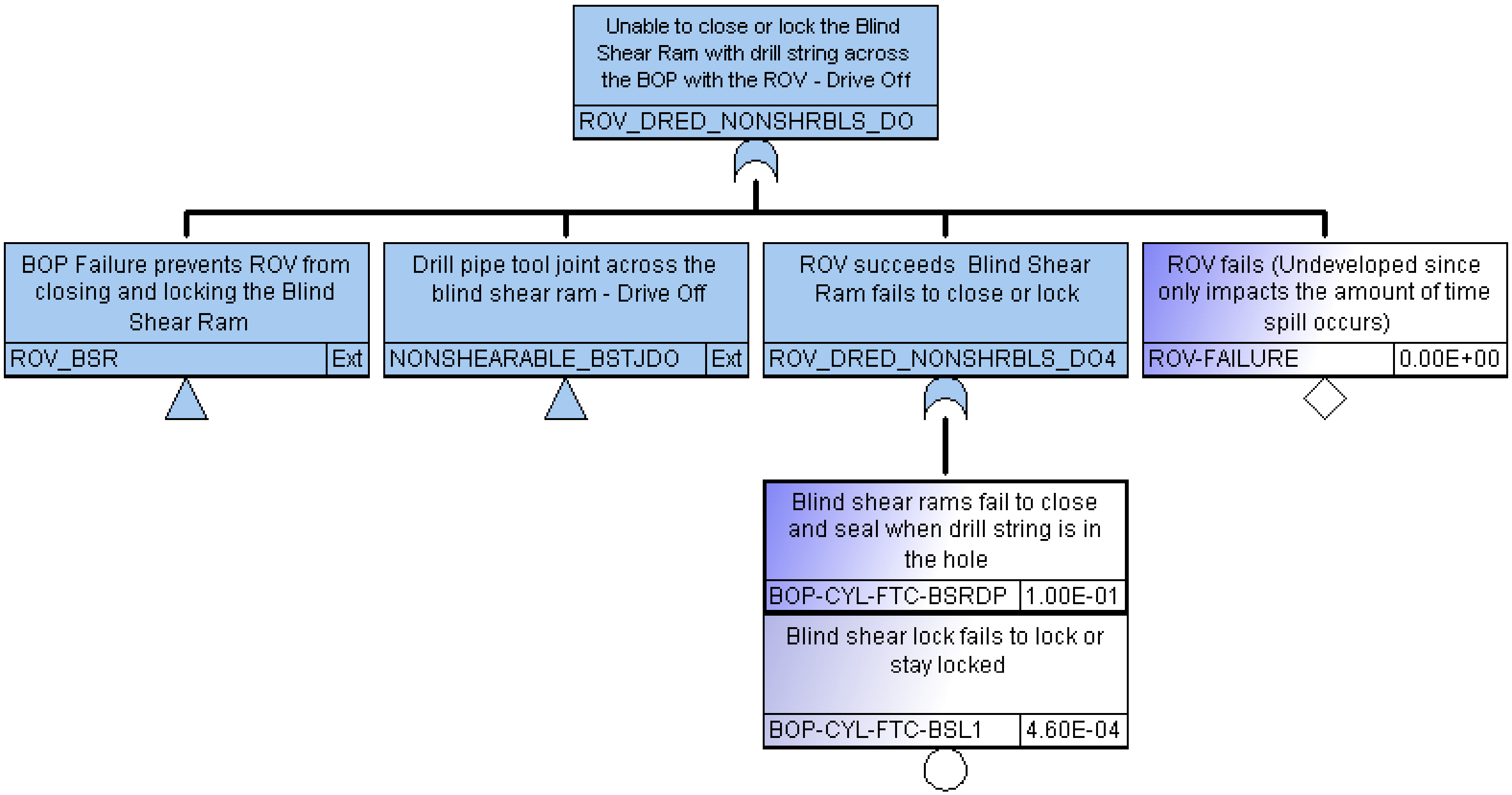


Figure C- 71: ROV Failure (Continued)

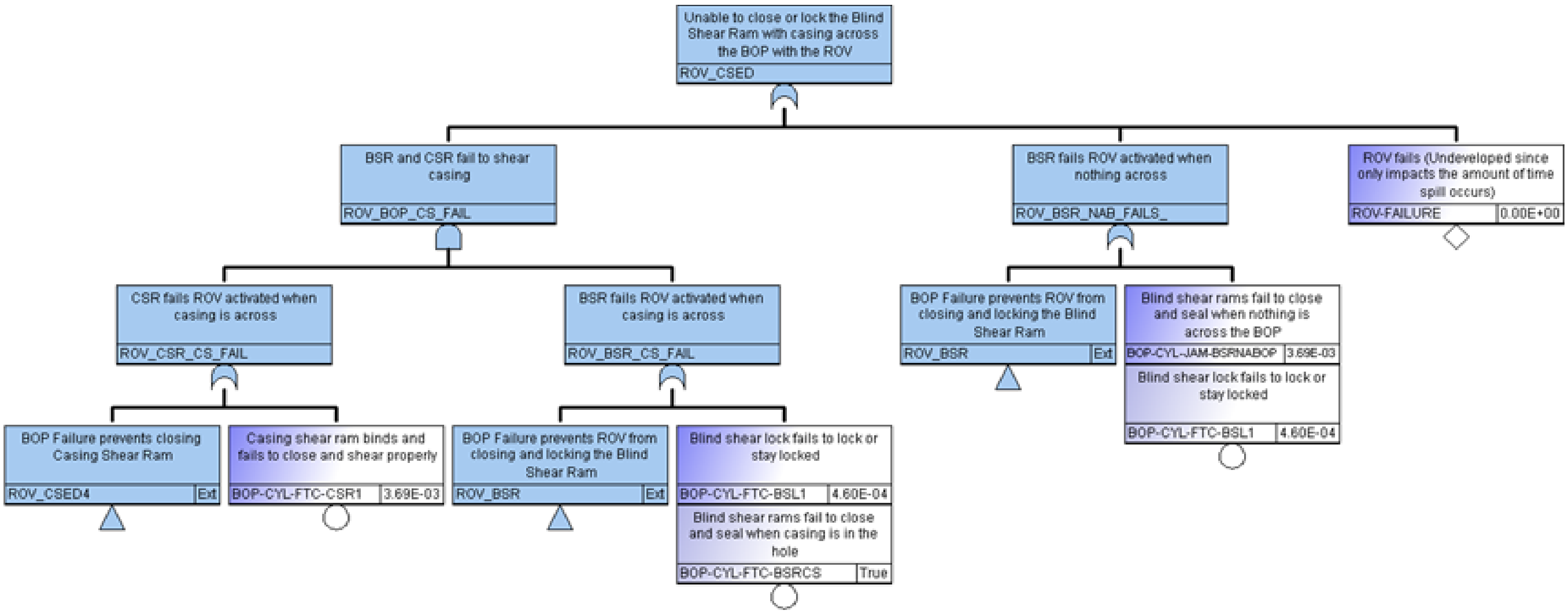


Figure C- 72: ROV Failure (Continued)

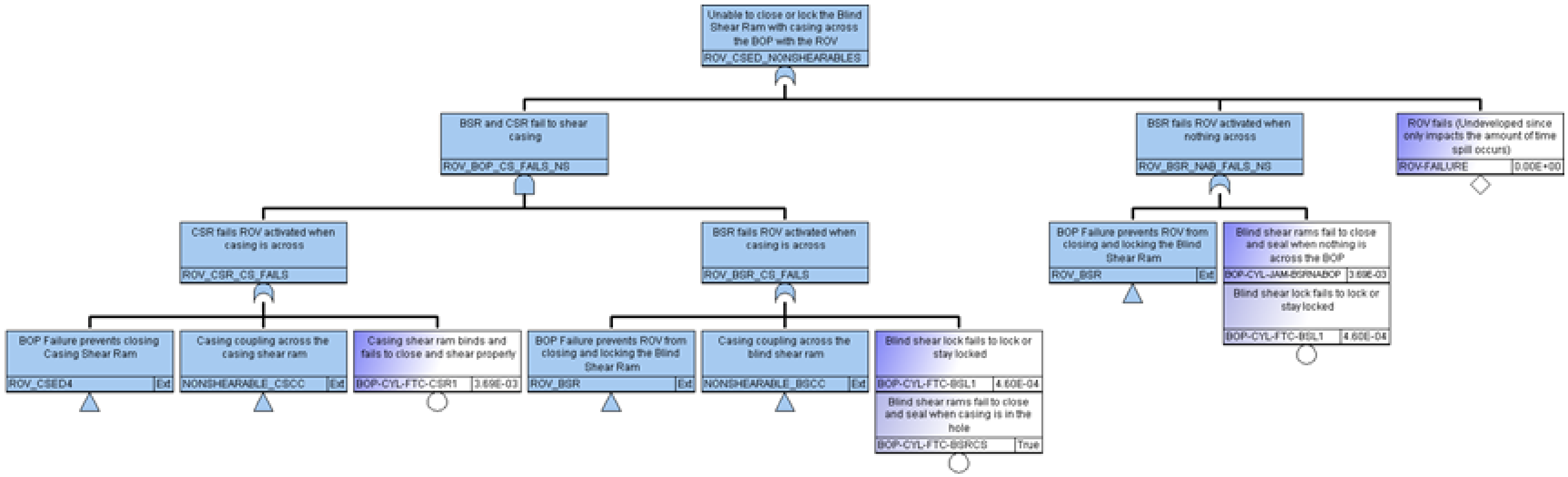


Figure C- 73: ROV Failure (Continued)

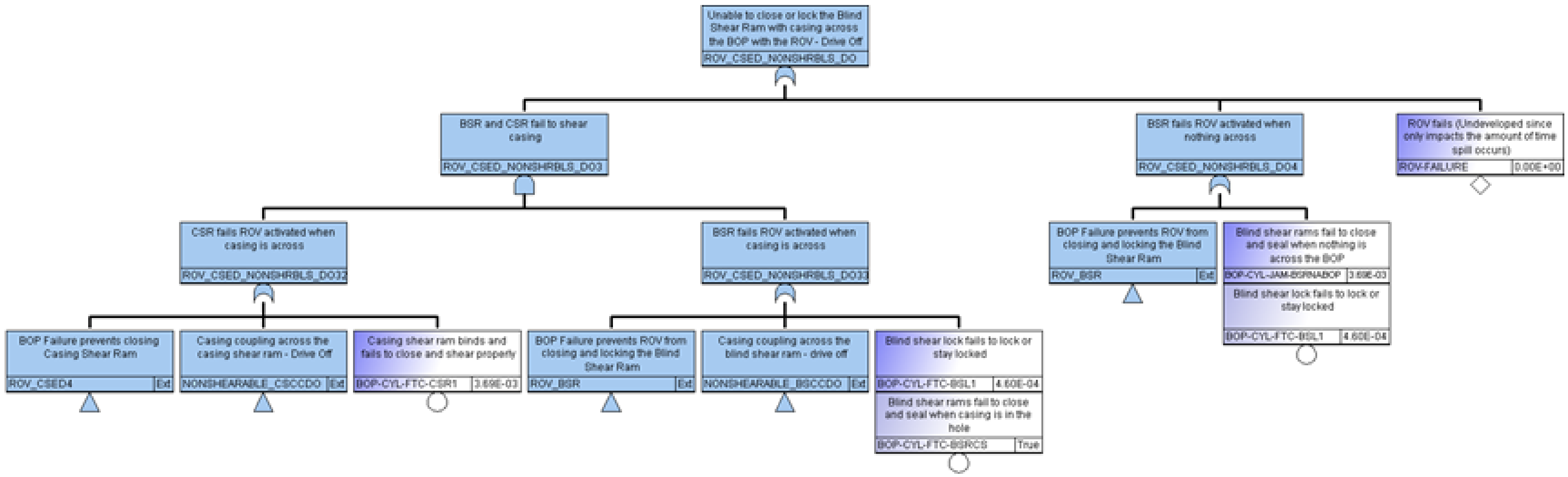


Figure C- 74: ROV Failure (Continued)

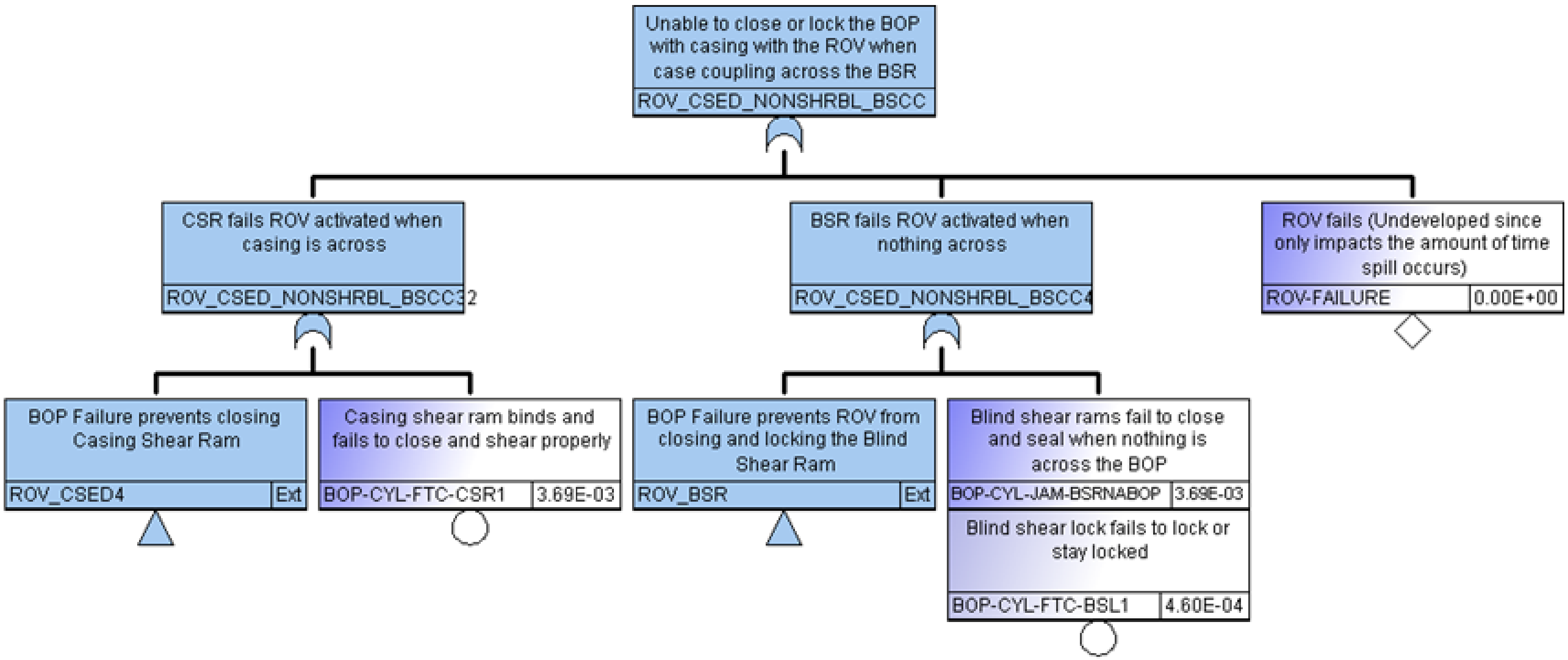


Figure C- 75: ROV Failure (Continued)

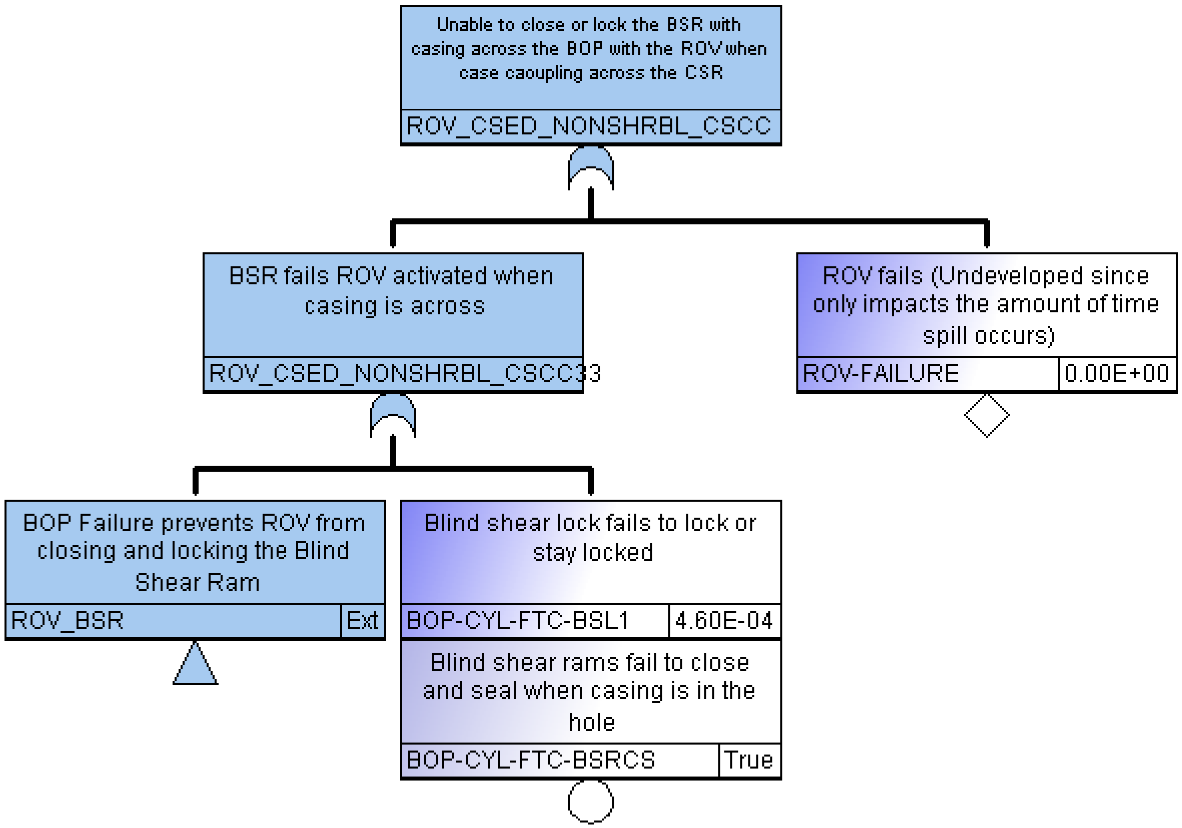


Figure C- 76: ROV Failure (Continued)

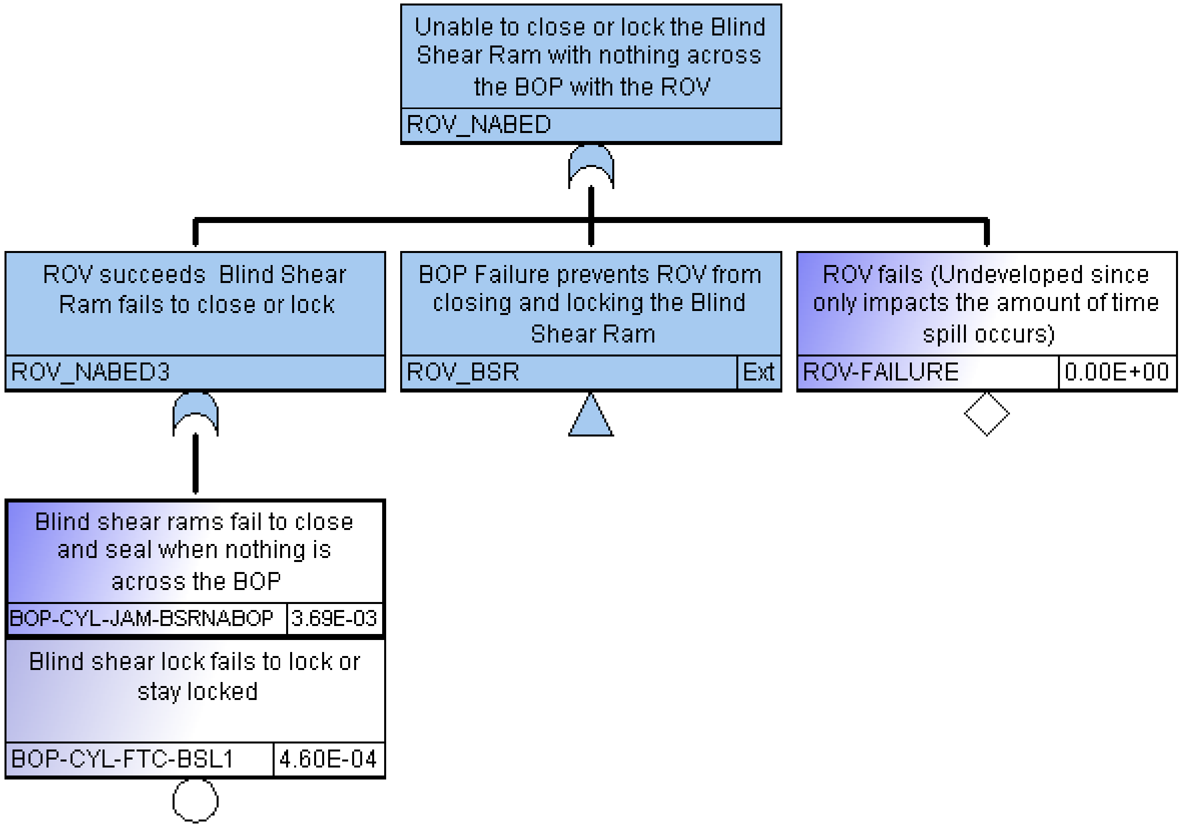


Figure C- 77: ROV Failure (Continued)

C.14 CAPPING STACK

Figure C- 78: Capping Stack Failure

C.15 SURFACE ELECTRICAL POWER DISTRIBUTION

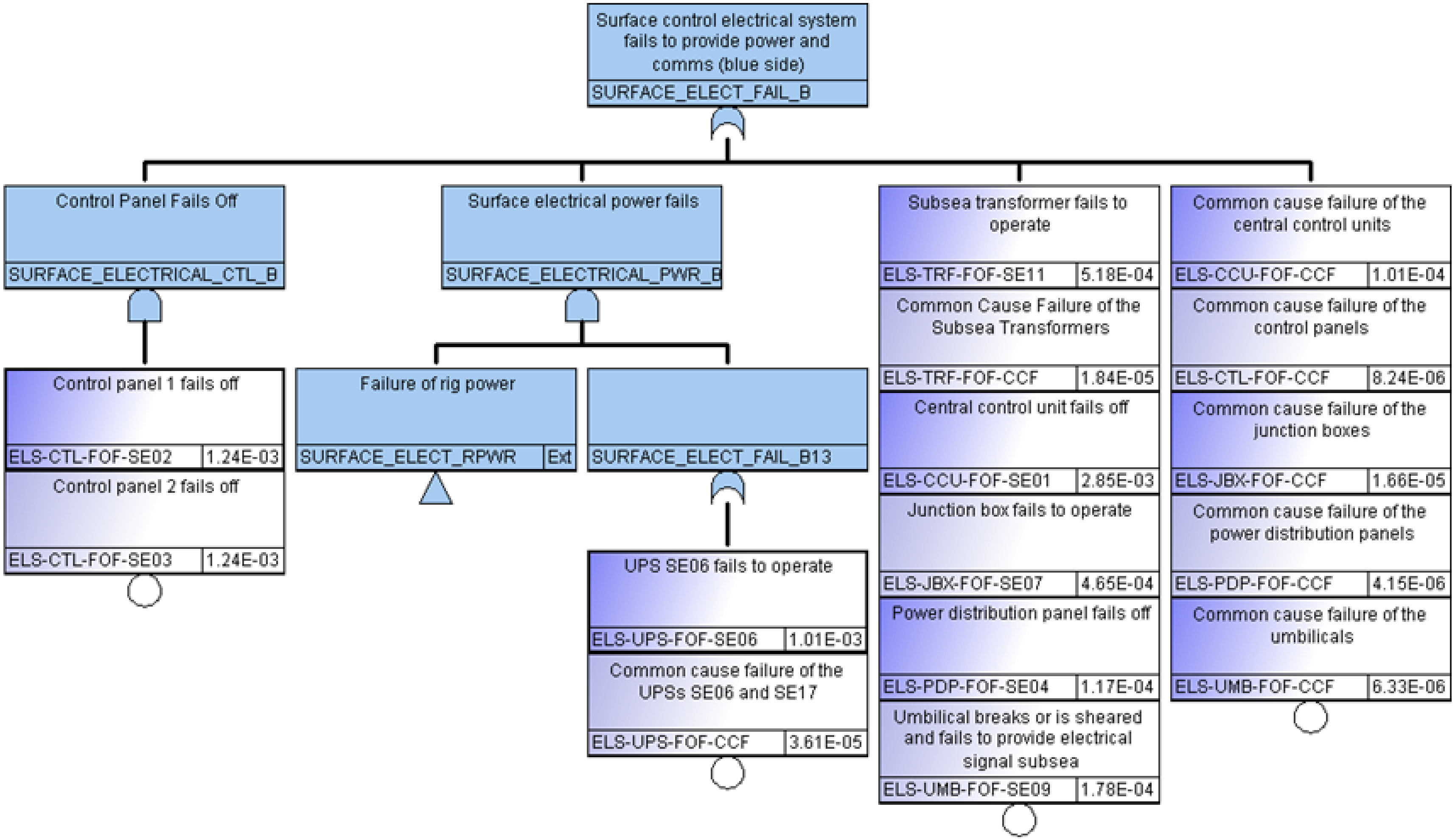


Figure C- 79: Surface Electrical Power Distribution Failure

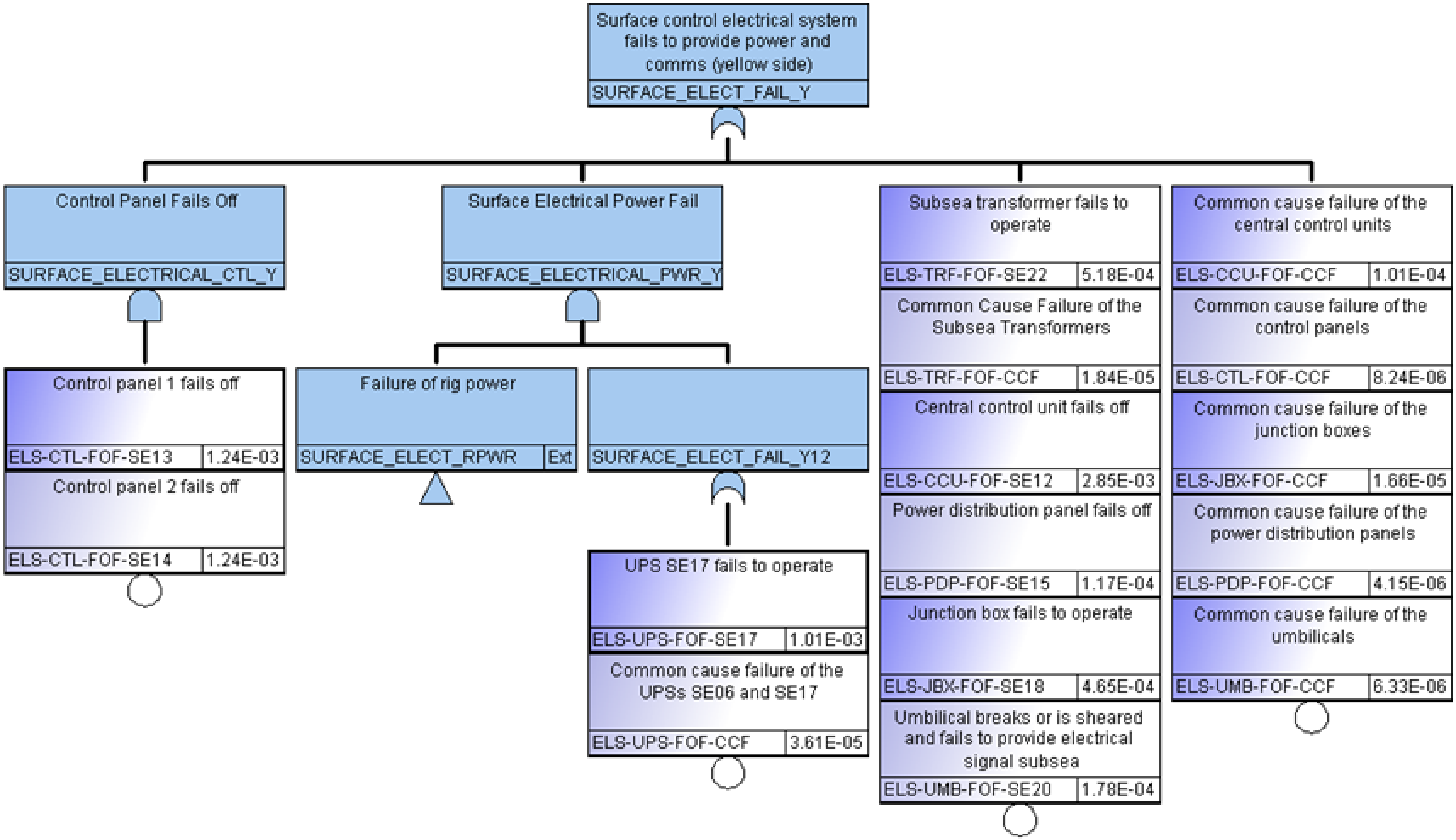


Figure C- 80: Surface Electrical Power Distribution Failure (Continued)

C.16 SURFACE ELECTRICAL POWER GENERATION

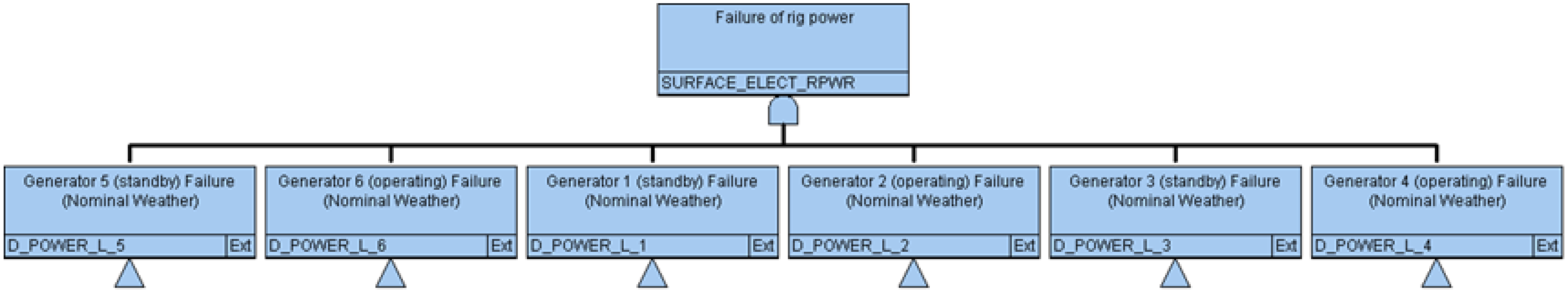


Figure C- 81: Surface Electrical Power Generation Failure

C.17 SURFACE HYDRAULICS

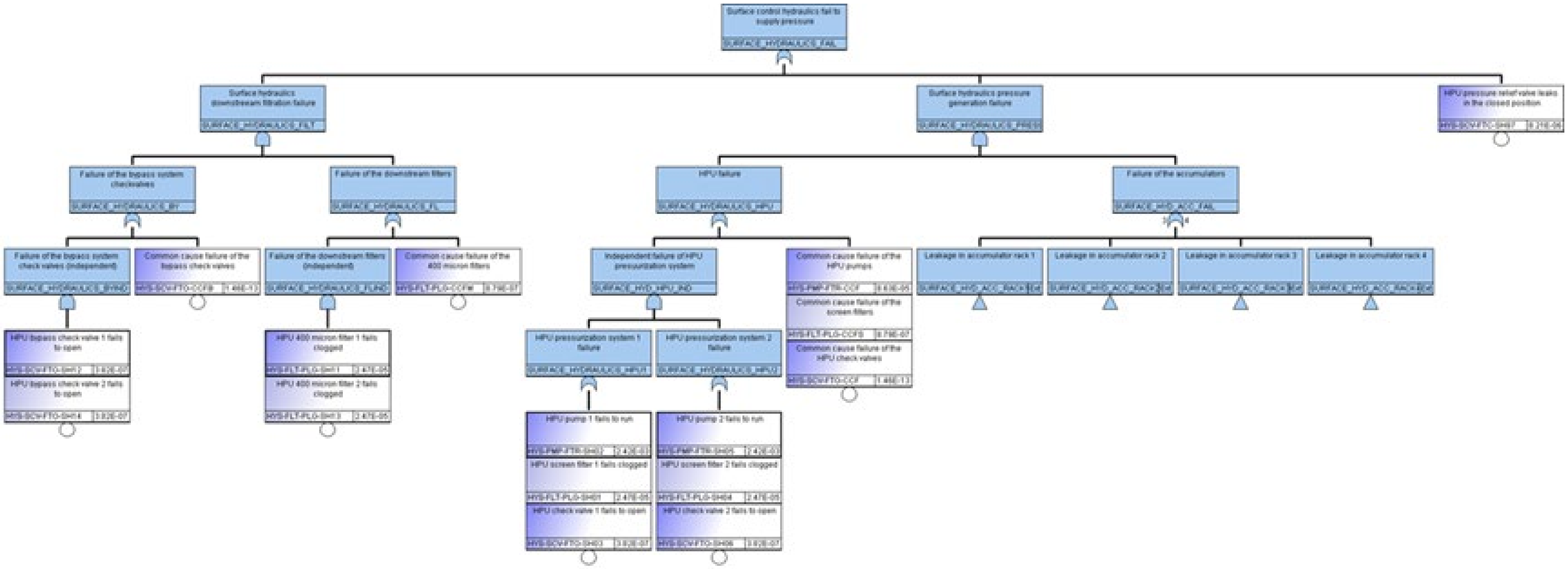


Figure C- 82: Surface Hydraulics System Failure

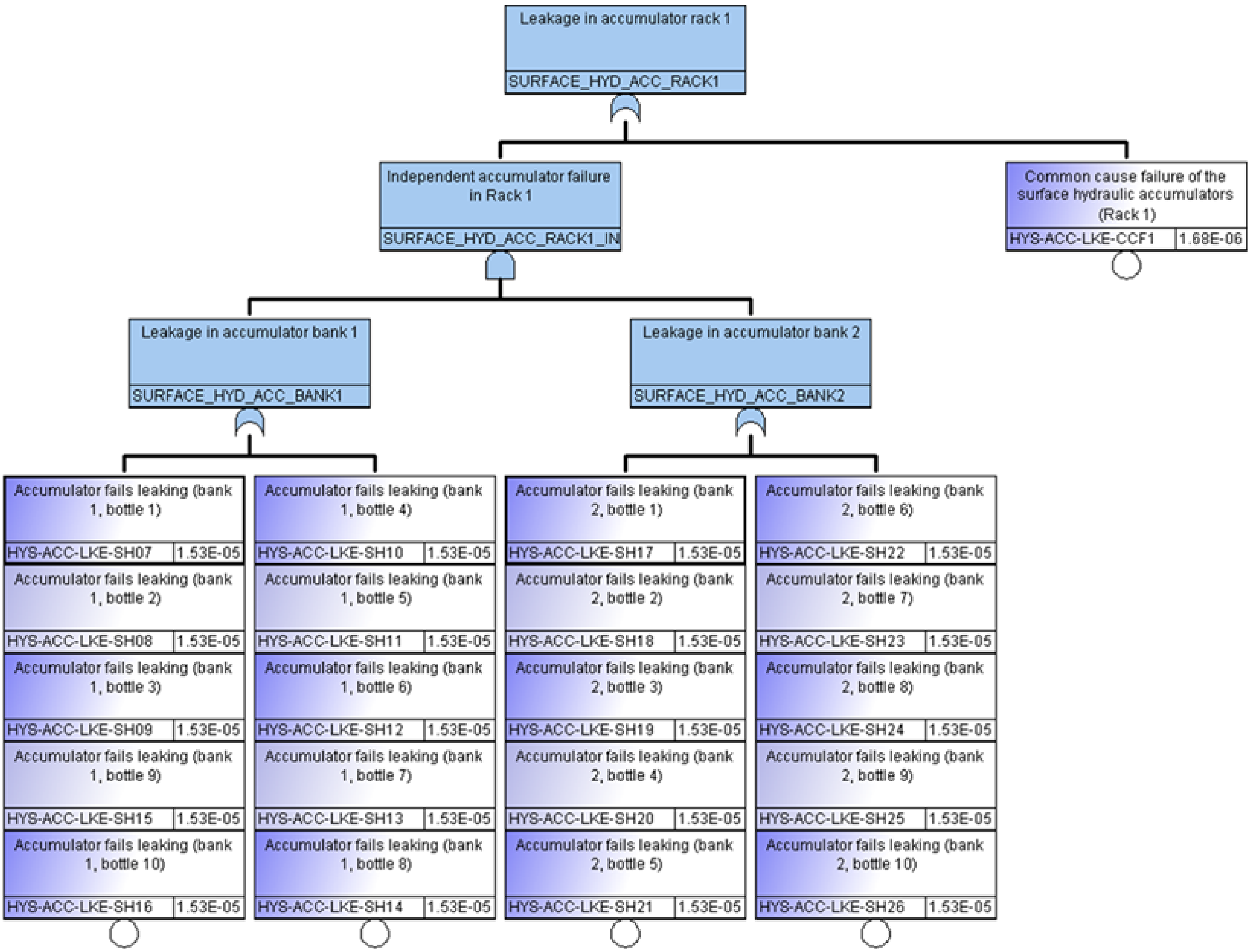


Figure C- 83: Surface Hydraulics System Failure (Continued)

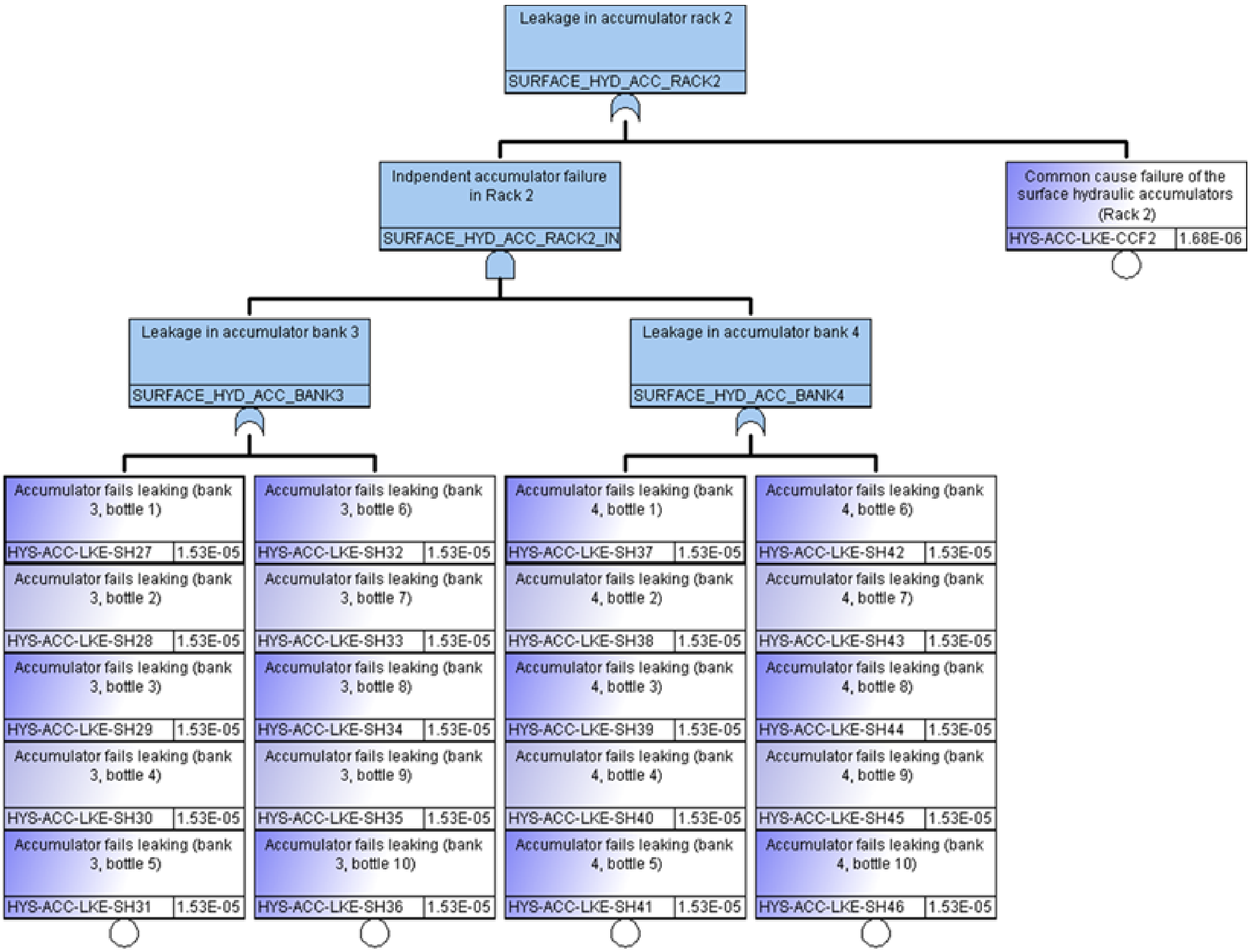


Figure C- 84: Surface Hydraulics System Failure (Continued)

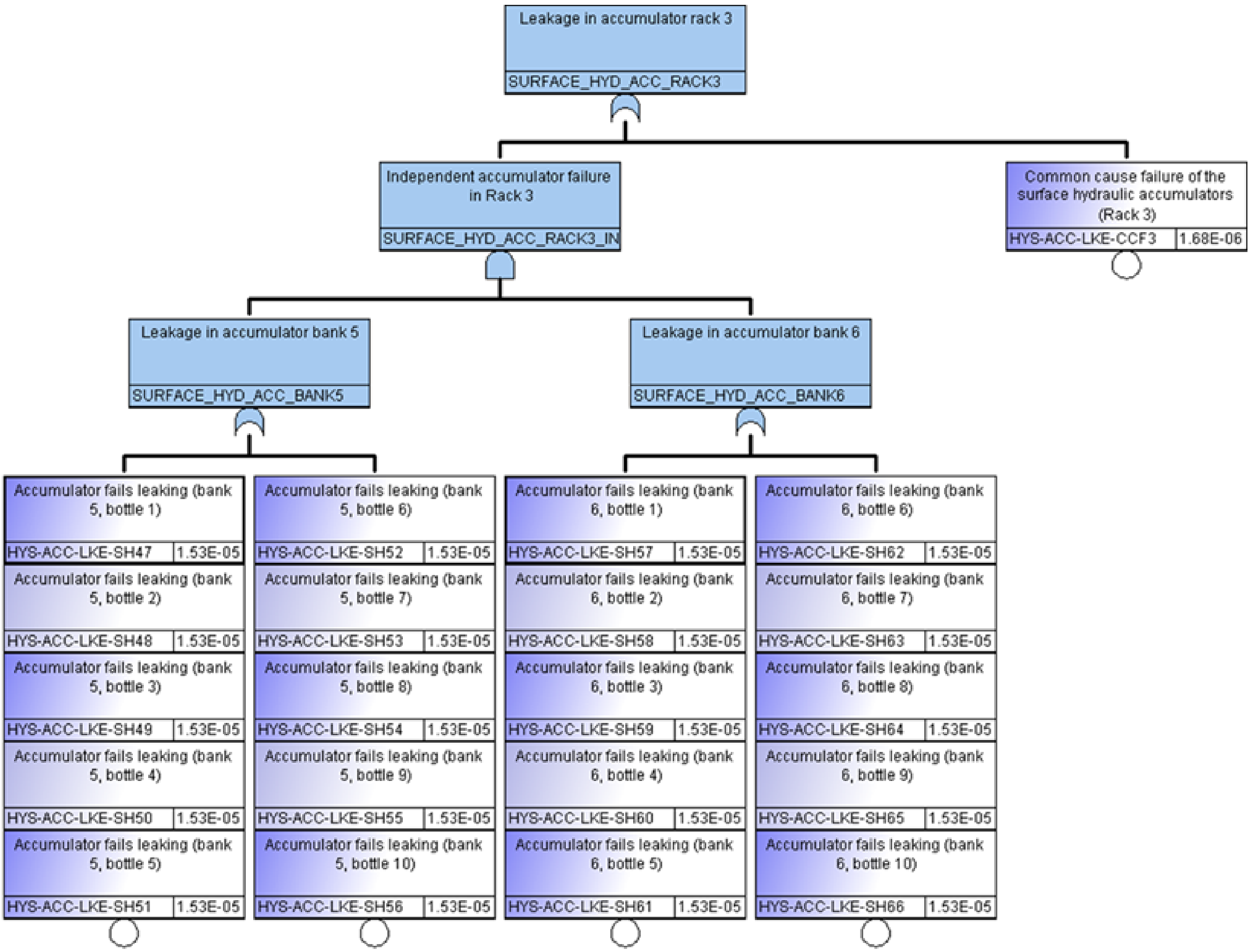


Figure C- 85: Surface Hydraulics System Failure (Continued)

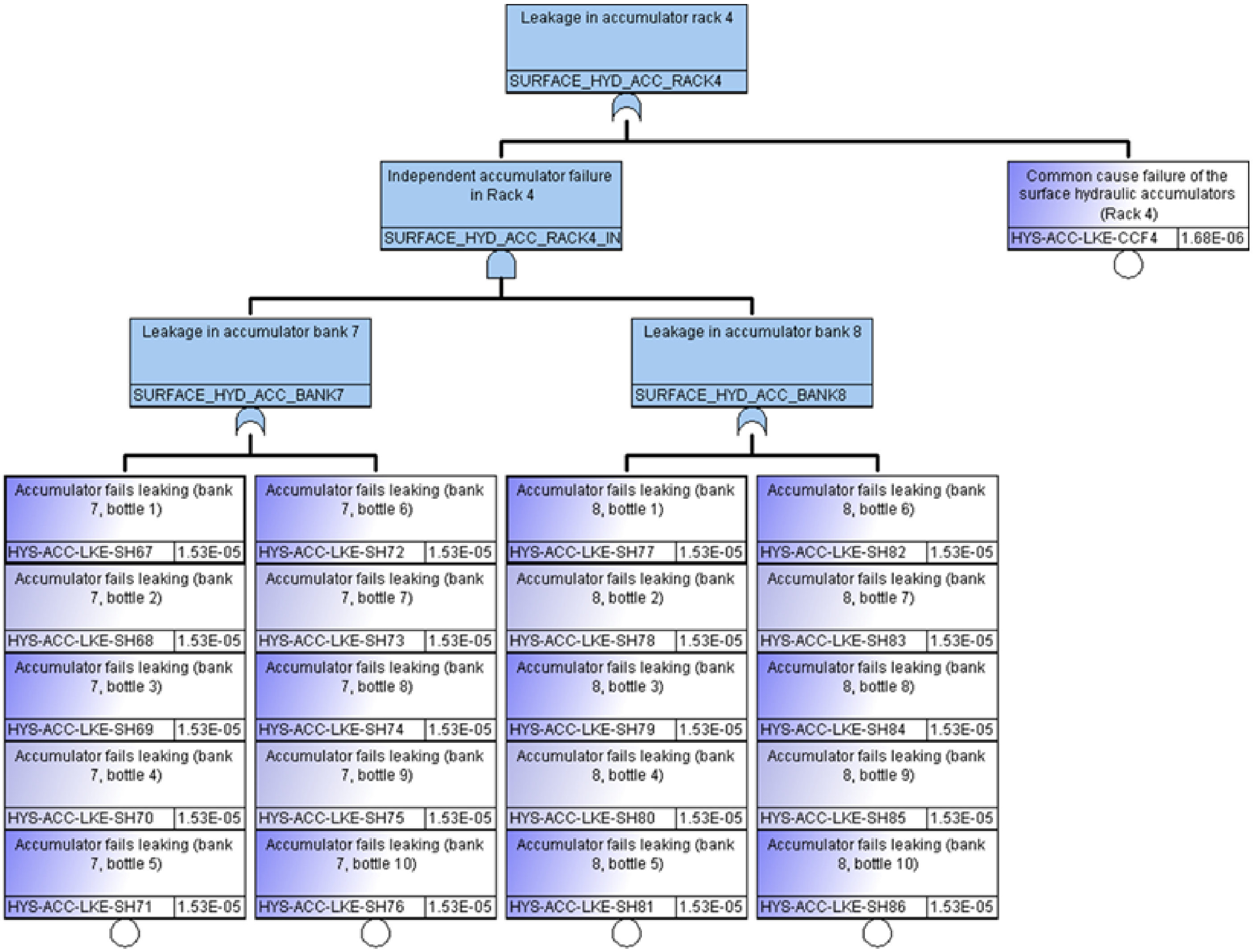


Figure C- 86: Surface Hydraulics System Failure (Continued)

C.18 DRIFT-OFF/PUSH-OFF AFTER A KICK

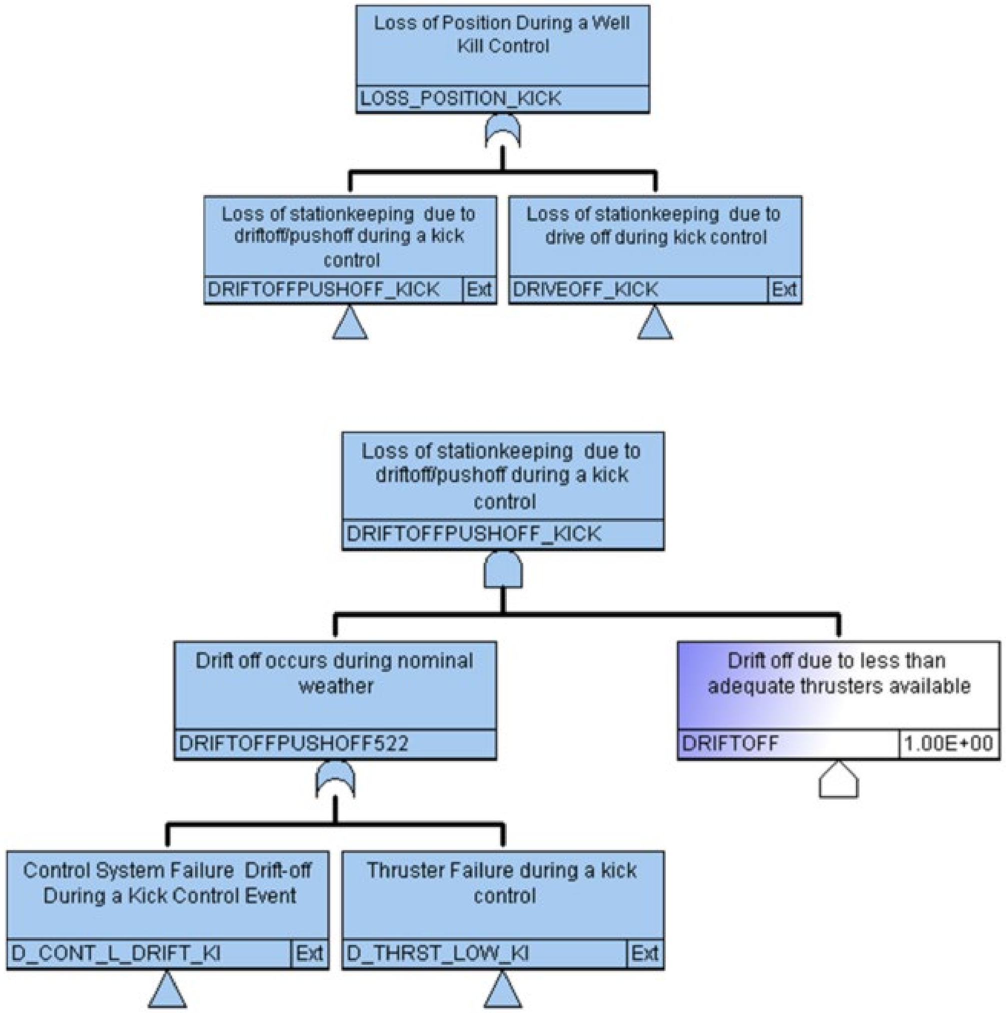


Figure C- 87: Drift-off/Push-off after a Kick

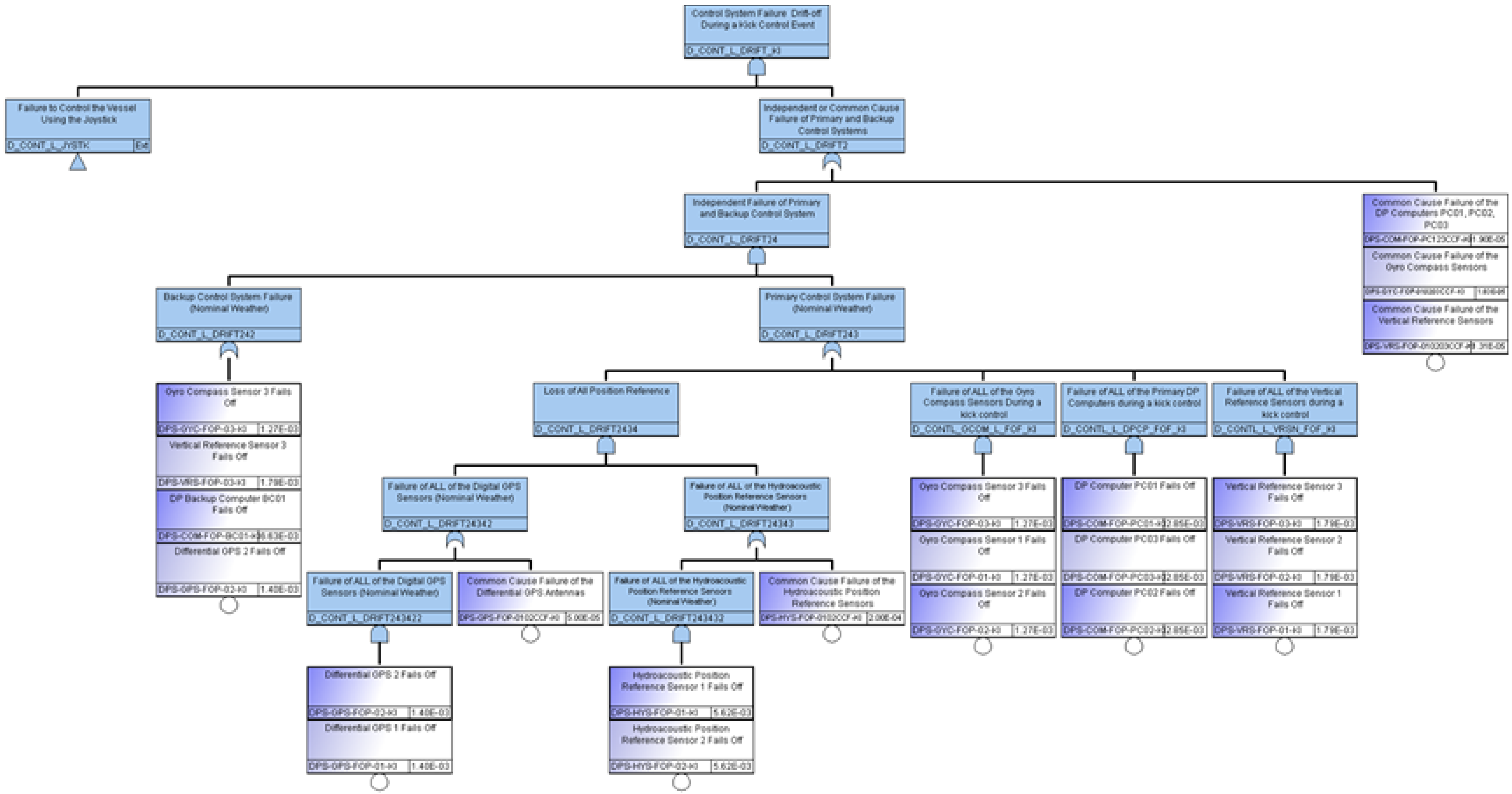
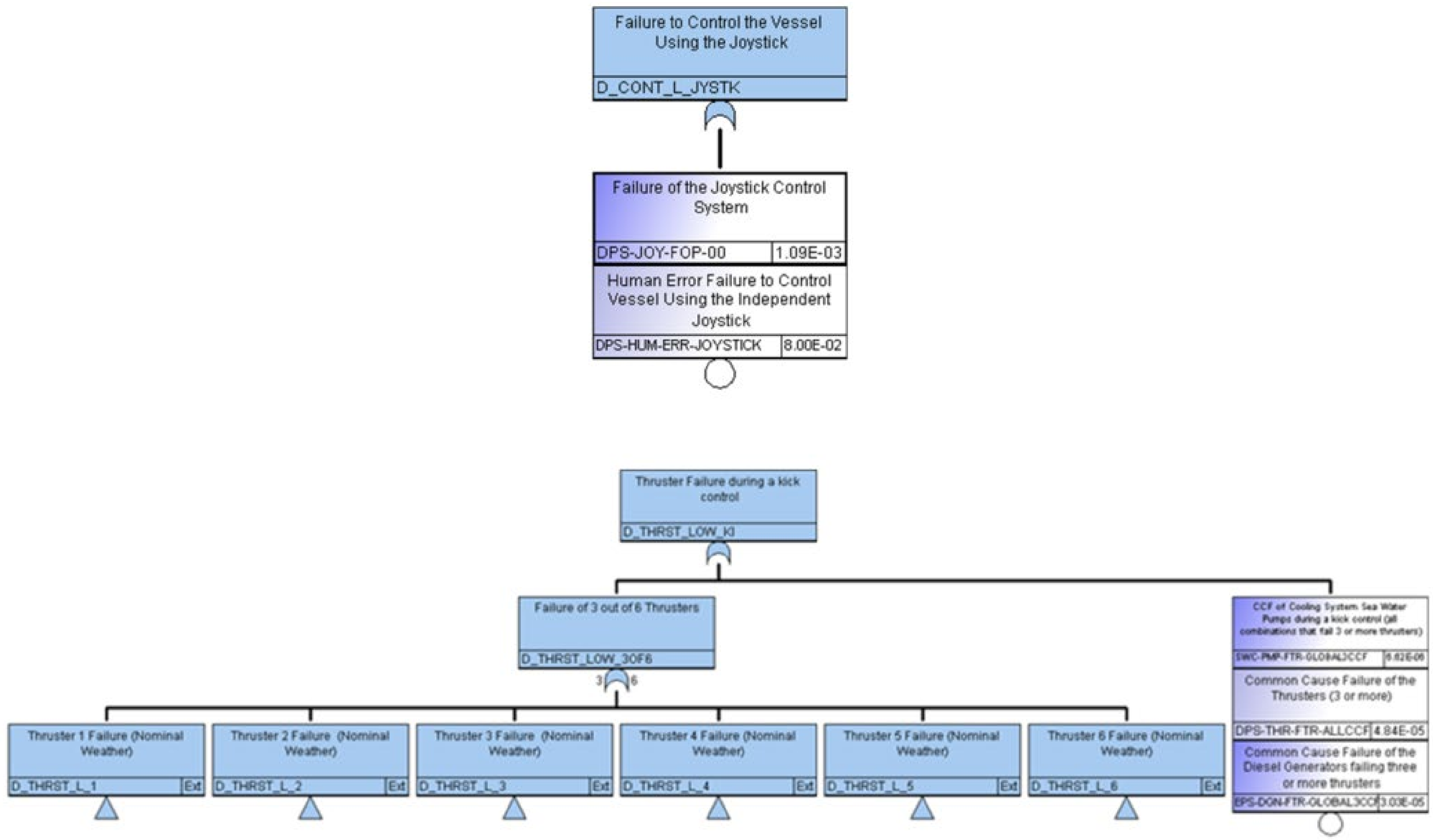


Figure C- 88: Drift-off/Push-off after a Kick (Continued)



Thruster failure transfers included in loss of position initiating event fault trees and not duplicated here

Figure C- 89: Drift-off/Push-off after a Kick (Continued)

C.19 DRIVE-OFF AFTER A KICK

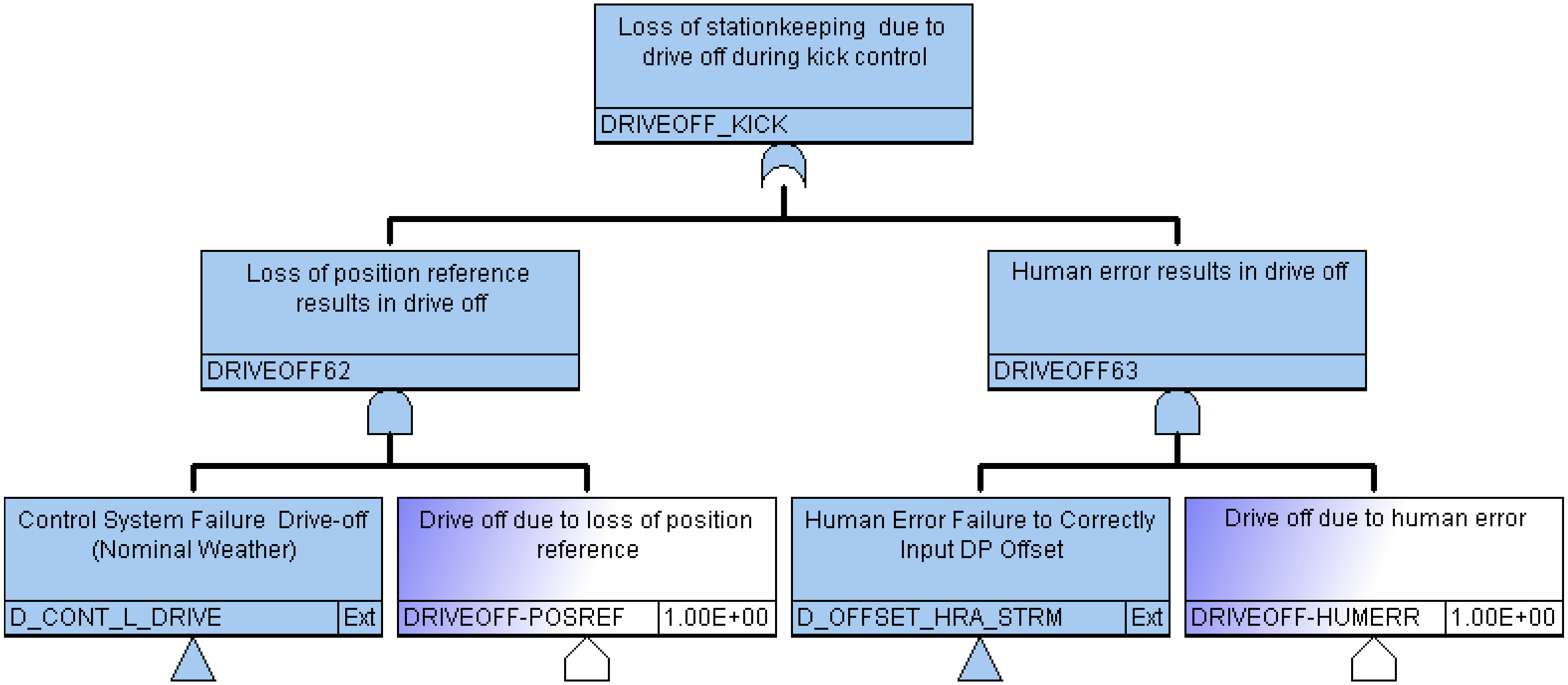


Figure C- 90: Drive-off after a Kick

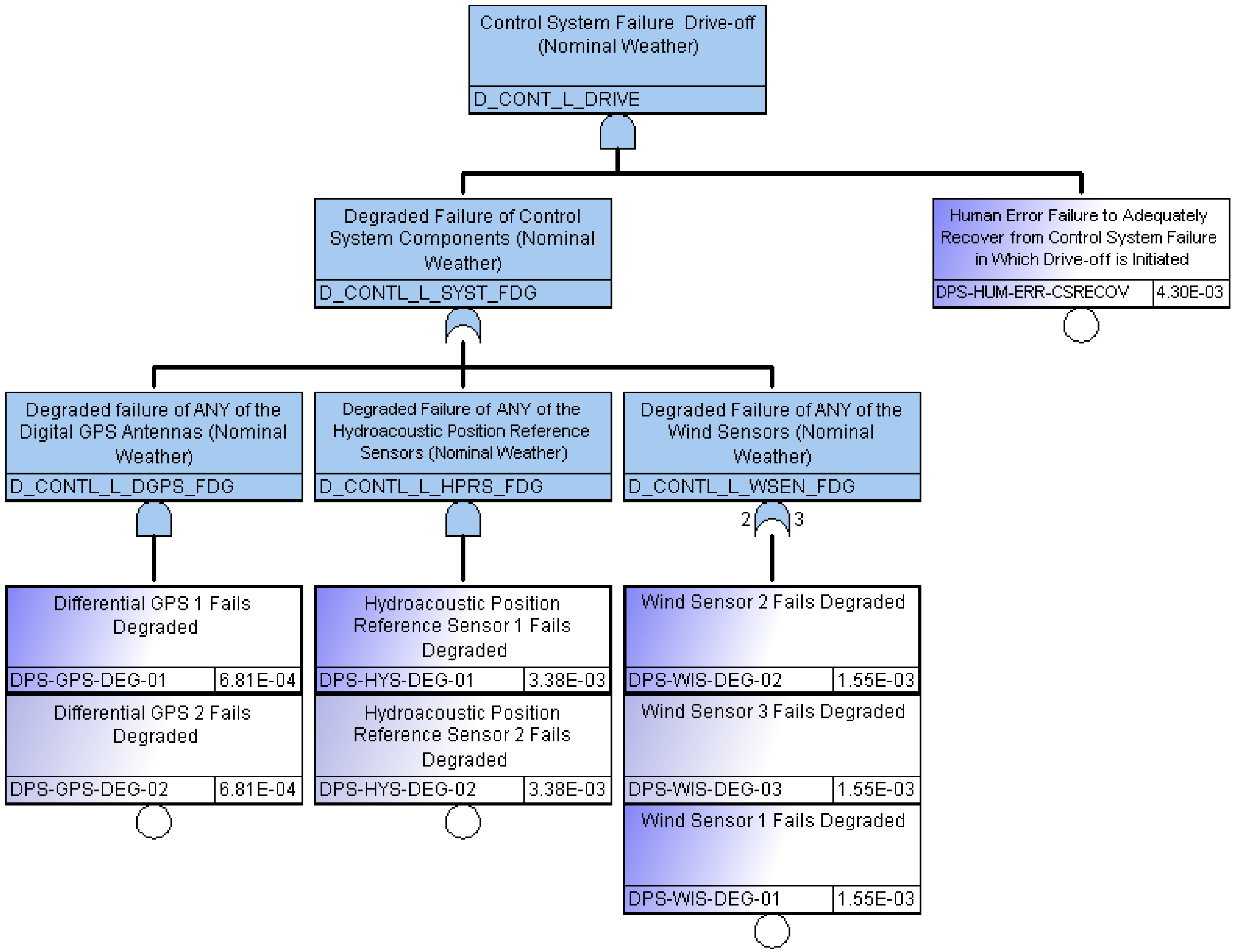


Figure C- 91: Drive-off after a Kick (Continued)

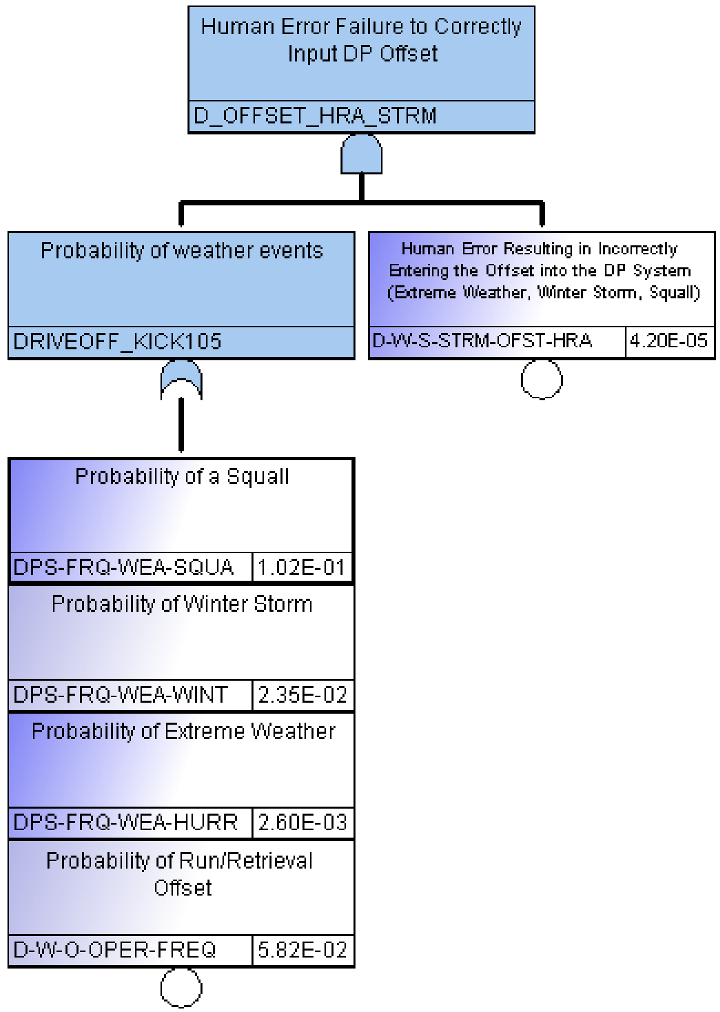


Figure C- 92: Drive-off after a Kick (Continued)

C.20 MAINTAINING FORMATION PRESSURE WITH CHOKE & KILL

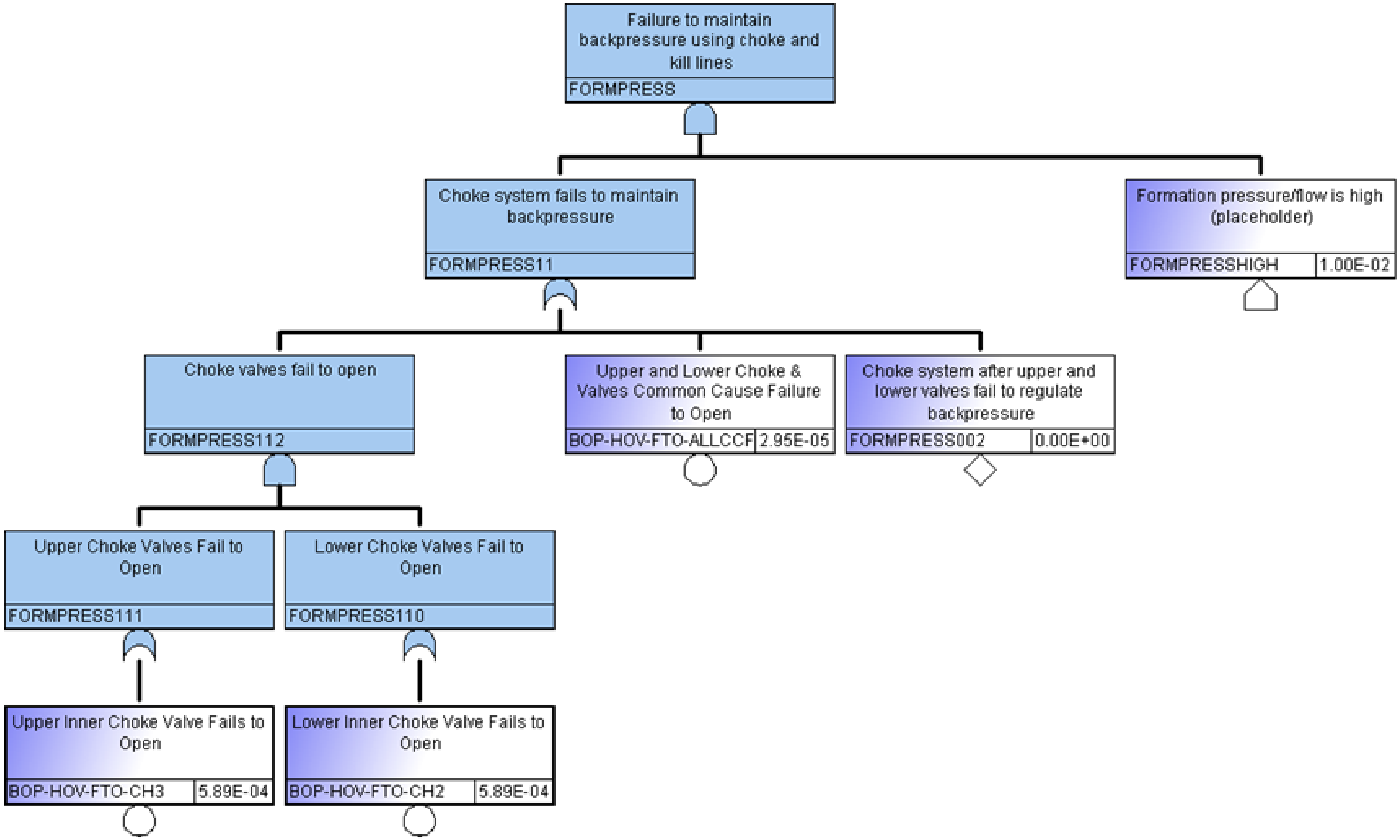


Figure C- 93: Failure to Maintain Formation Pressure after a Kick

C.21 BULLHEADING

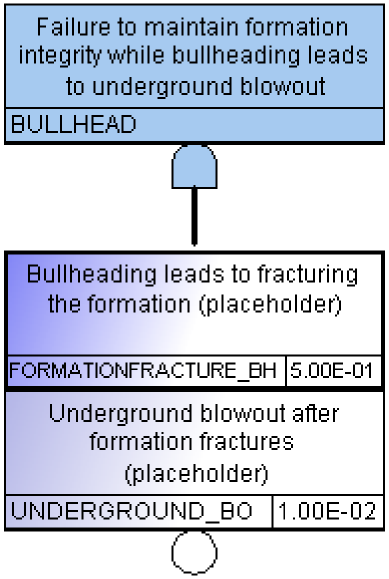


Figure C- 94: Failure to Maintain Formation Integrity when Bullheading

C.22 WELL CONDITION

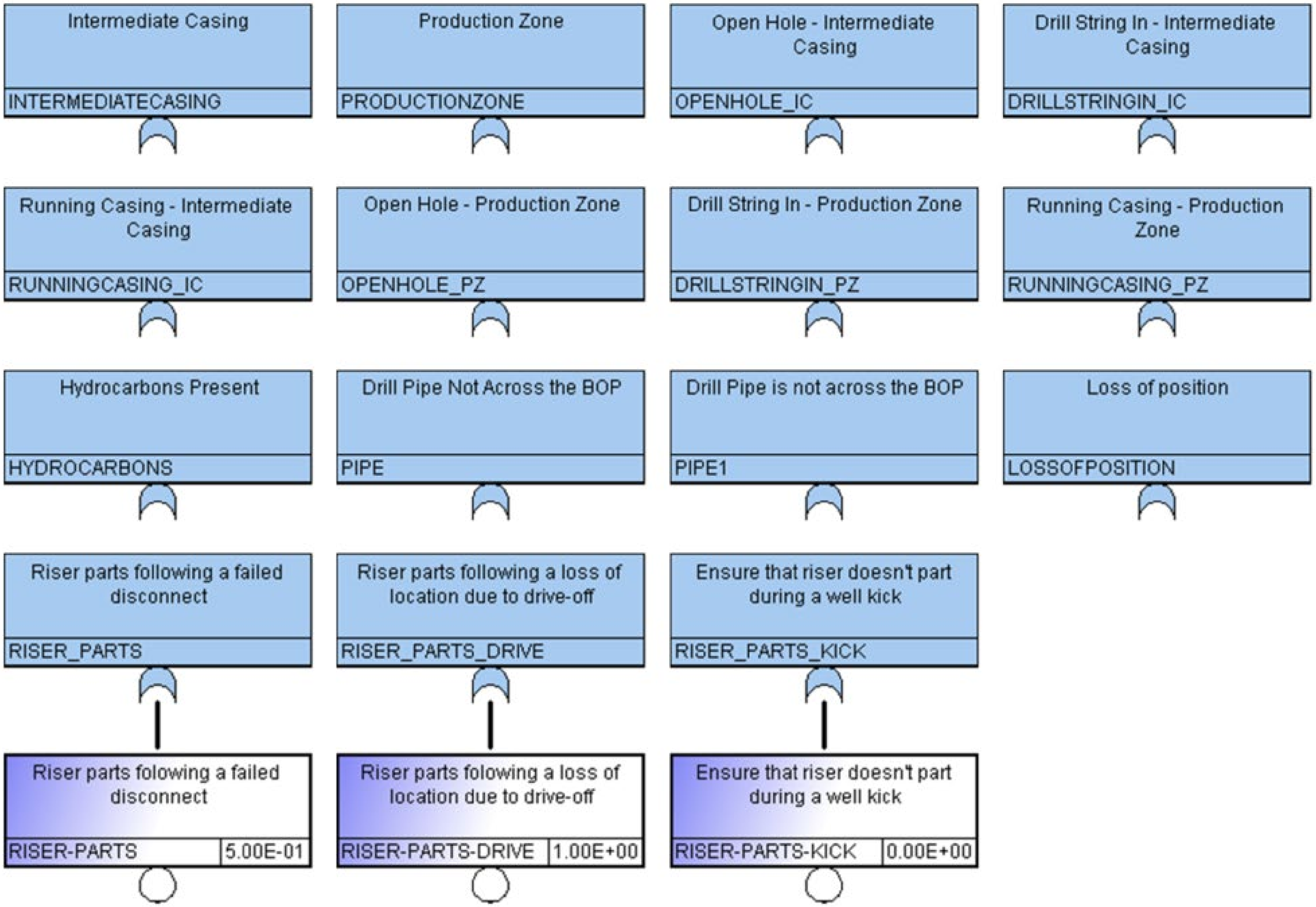


Figure C- 95: Well Condition Developed Events

C.23 NONSHEARABLES

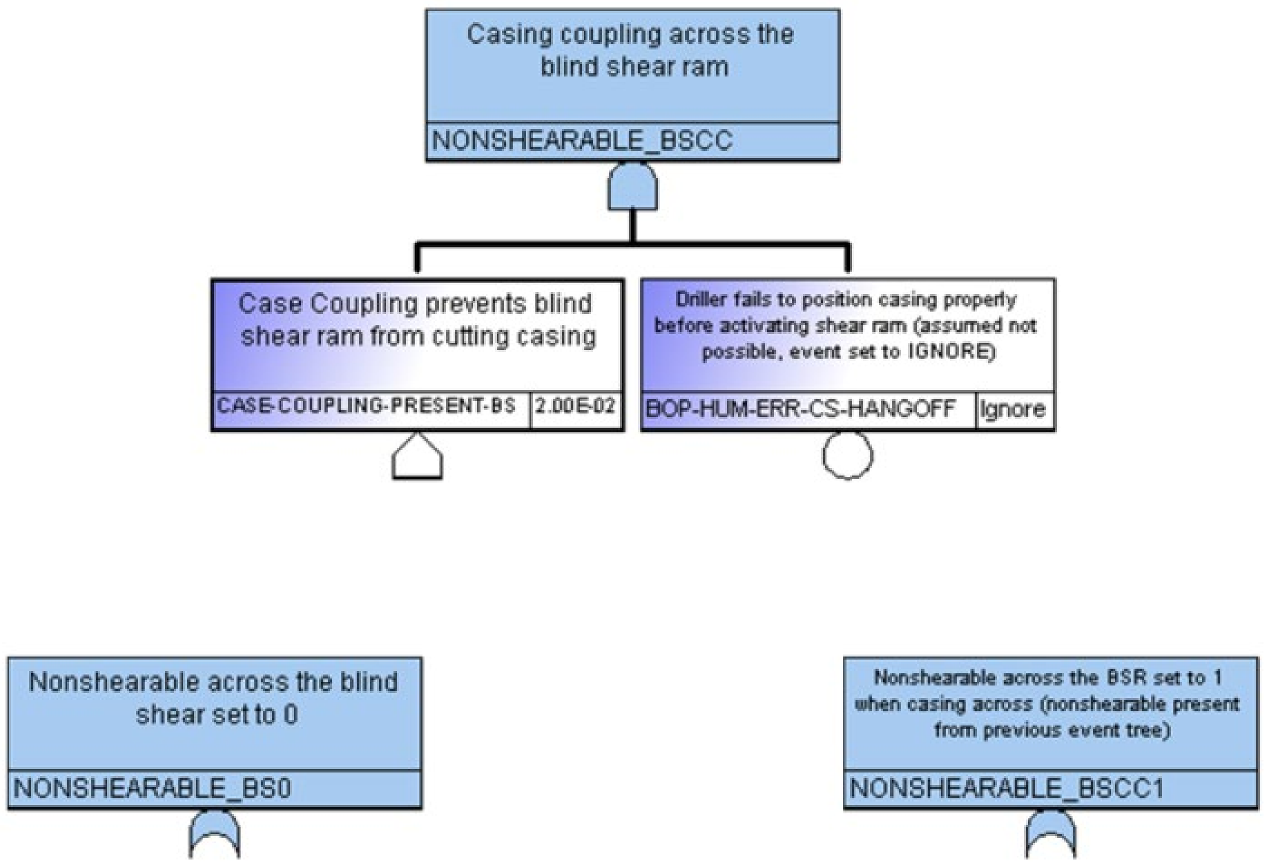


Figure C- 96: Nonshearables

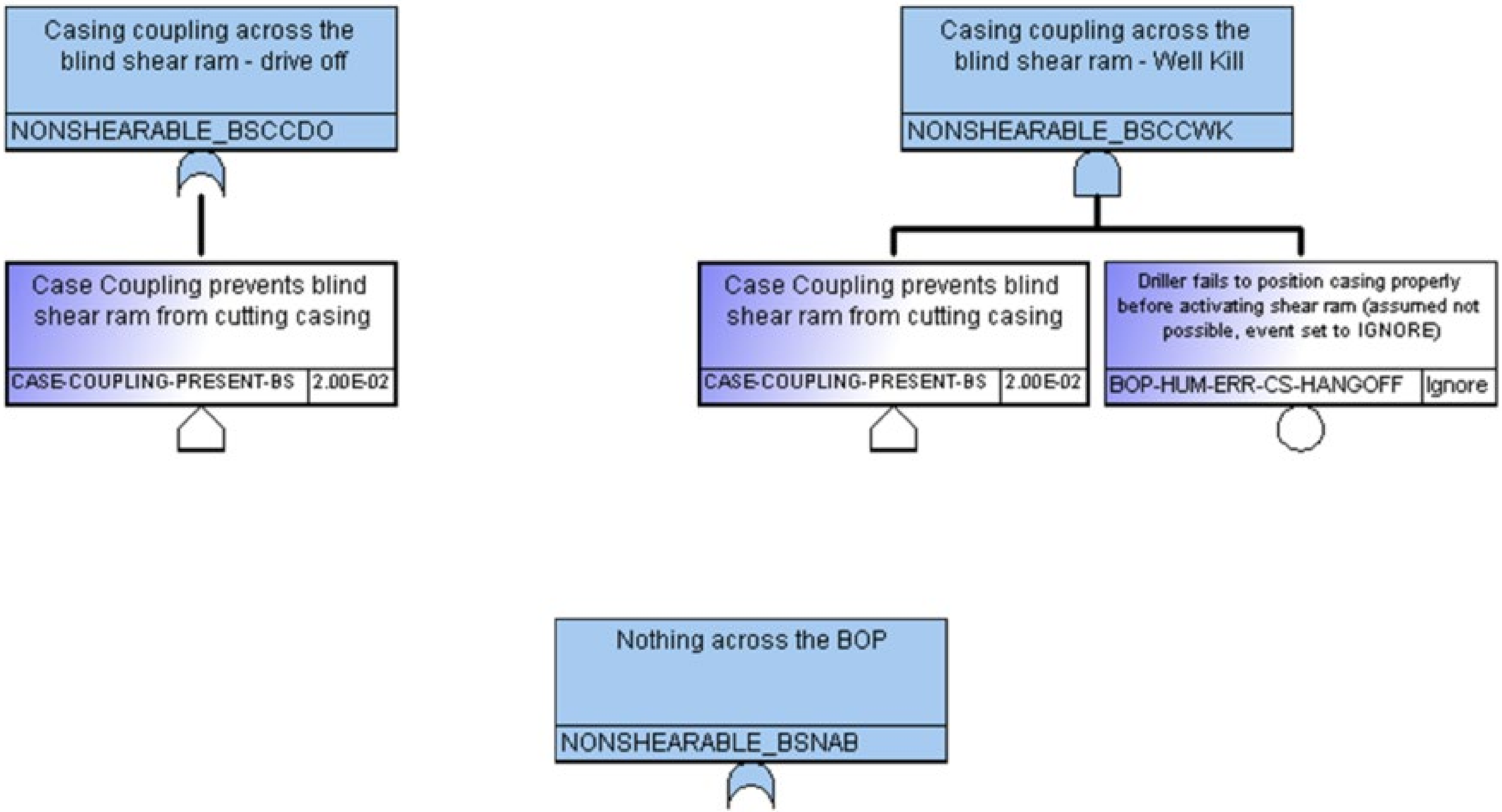


Figure C- 97: Nonshearables (Continued)

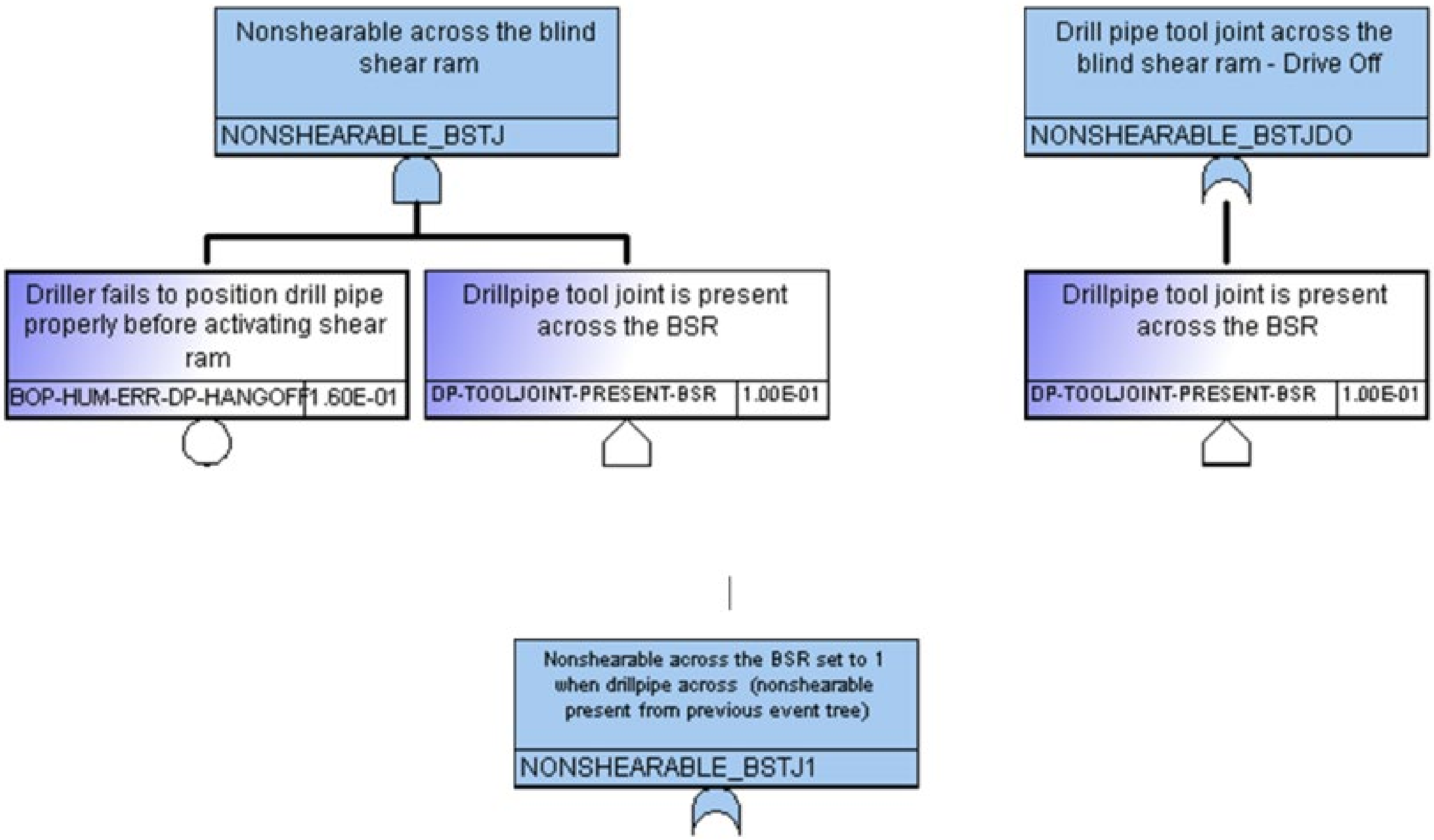


Figure C- 98: Nonshearables (Continued)

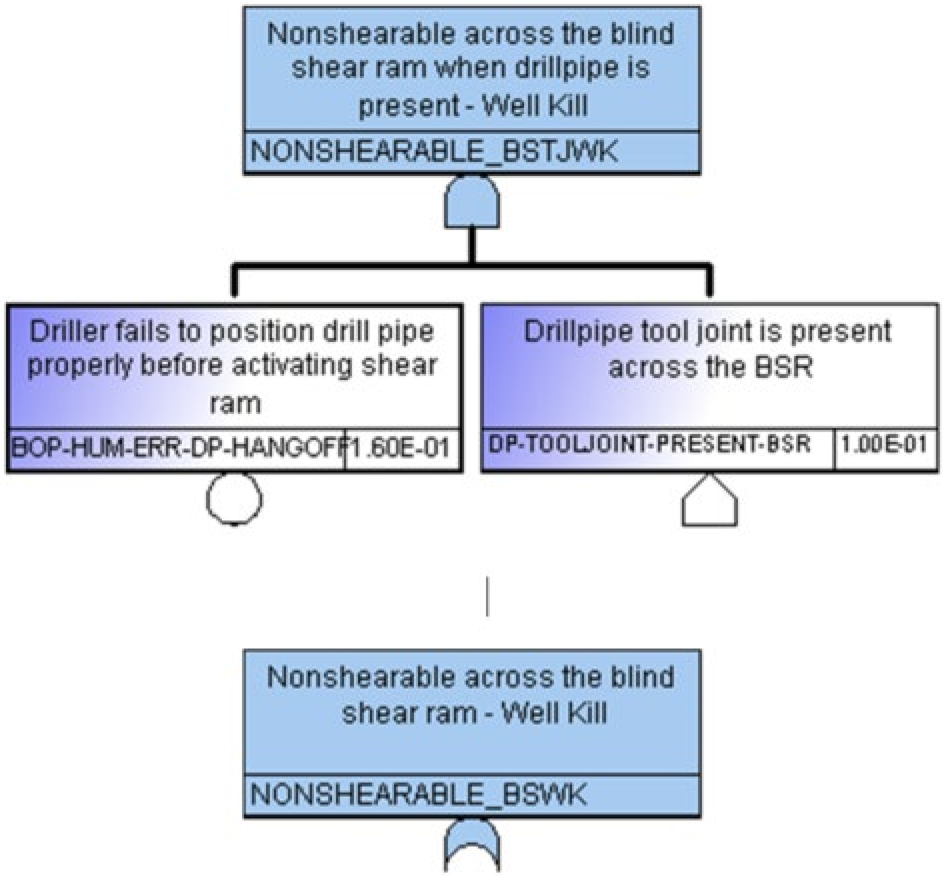


Figure C- 99: Nonshearables (Continued)

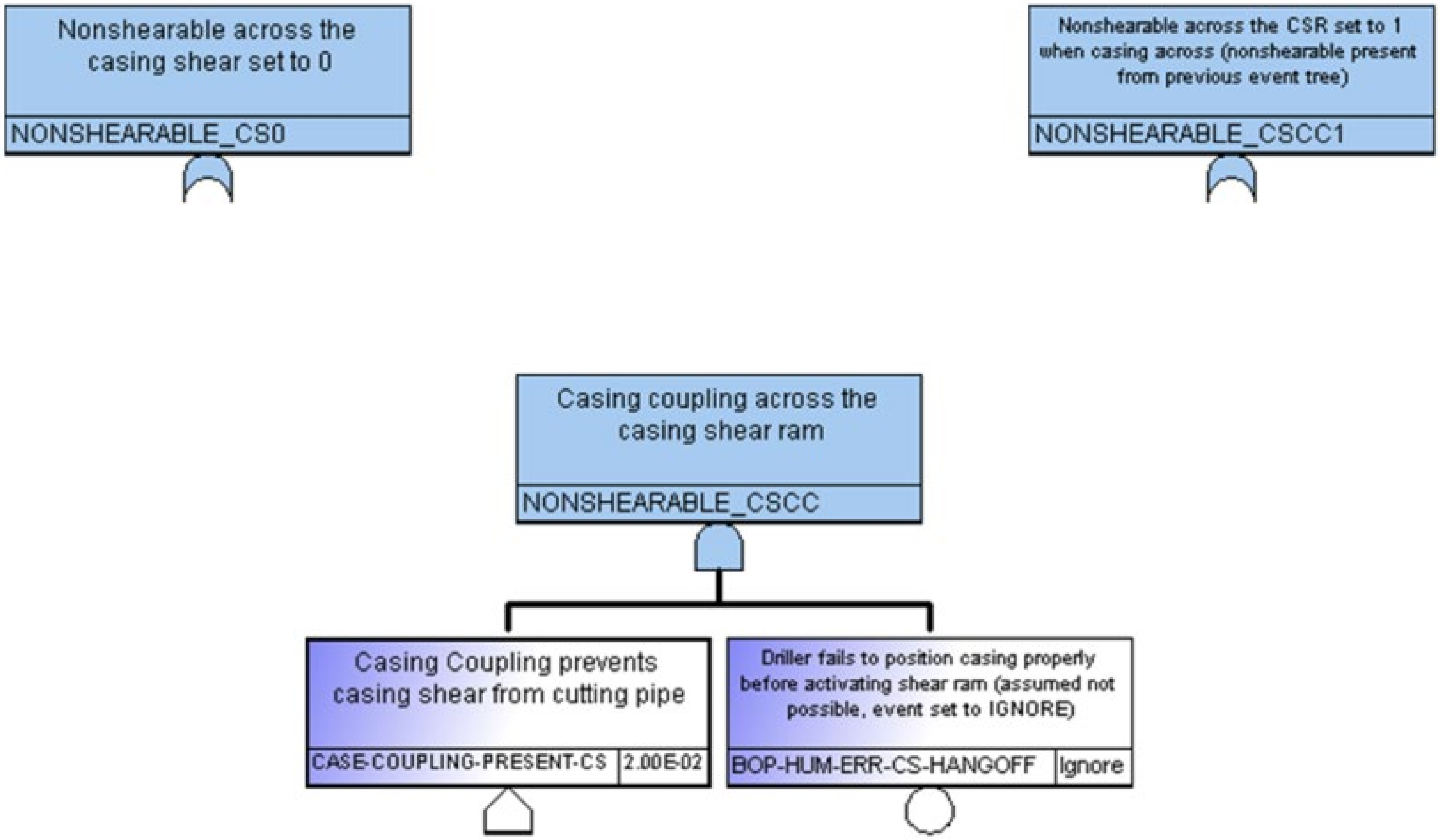


Figure C- 100: Nonshearables (Continued)

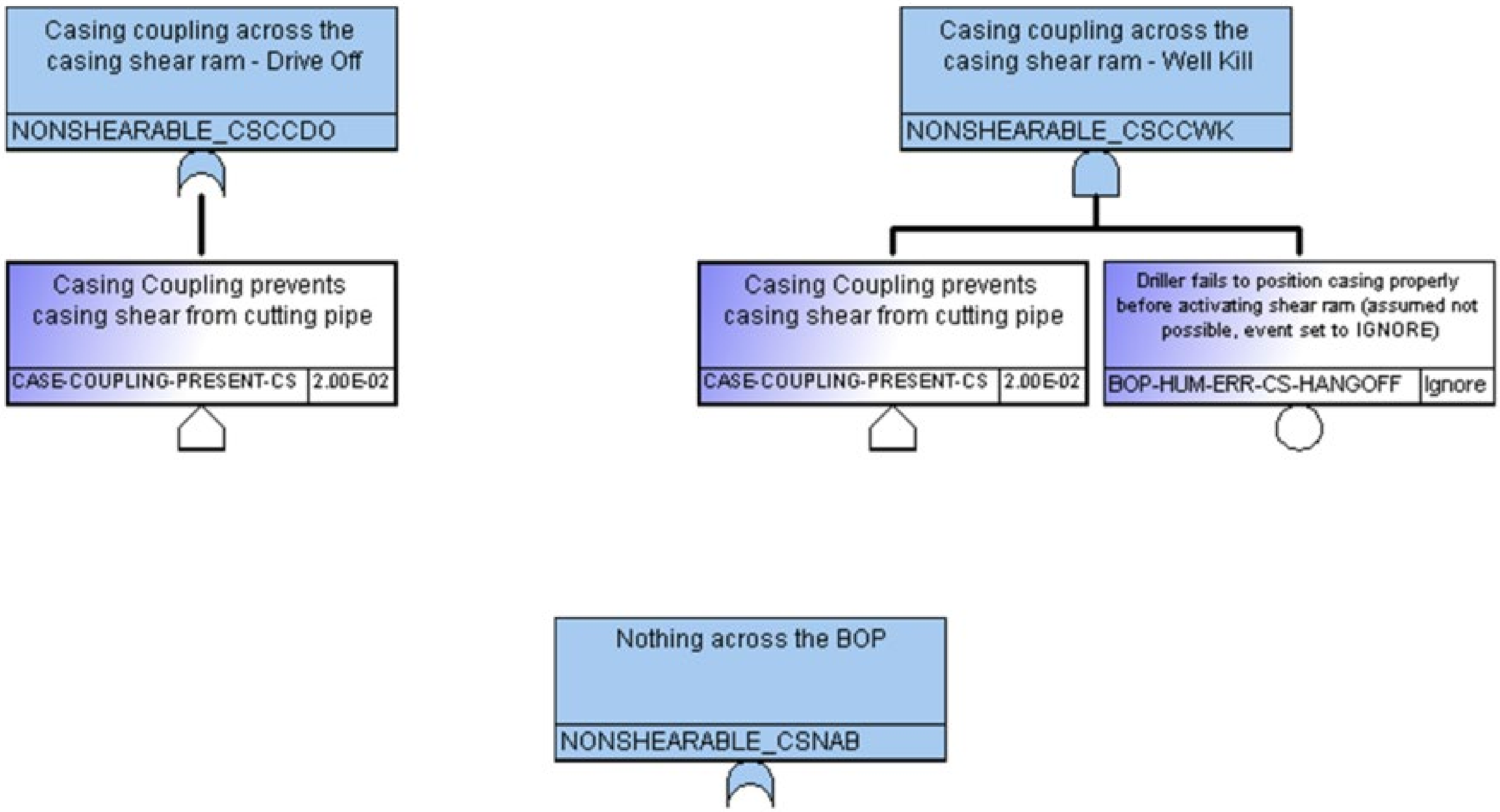


Figure C- 101: Nonshearables (Continued)

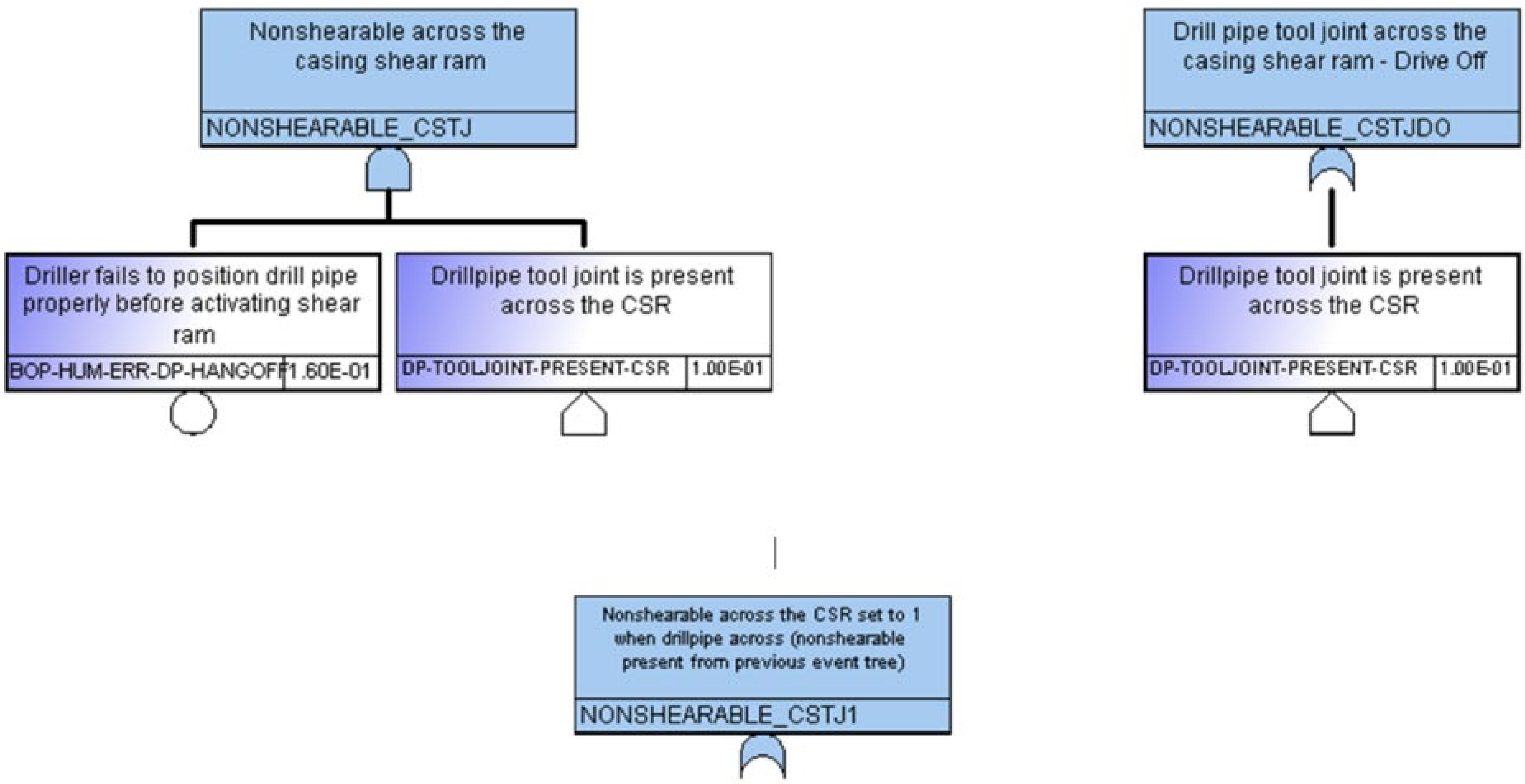


Figure C- 102: Nonshearables (Continued)

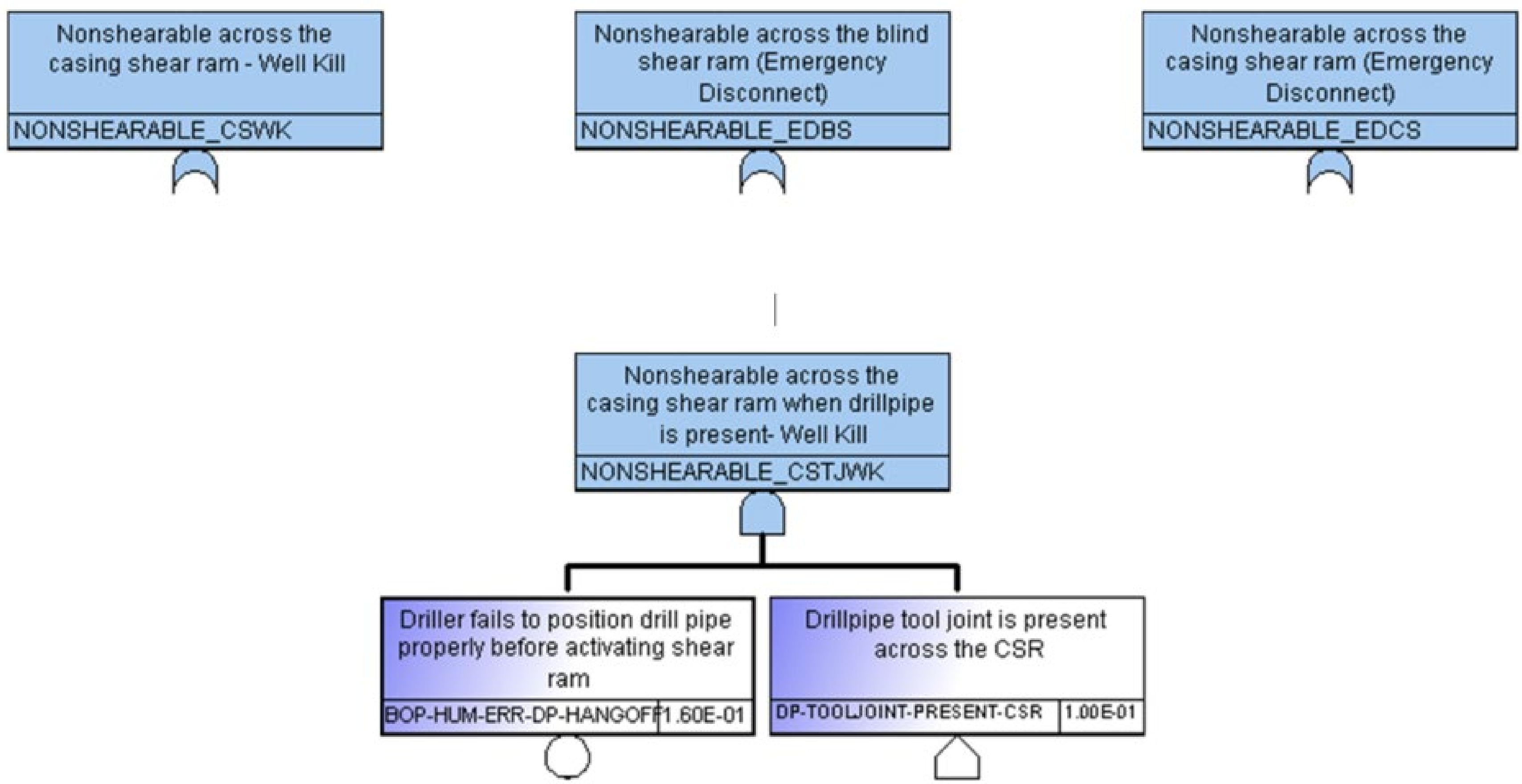


Figure C- 103: Nonshearables (Continued)

C.24 KICK DETECTION

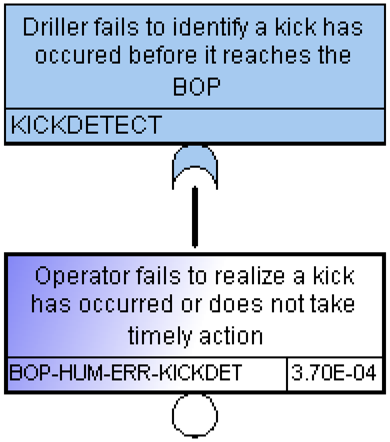


Figure C- 104: Failure to identify Kick

Initiating Event Fault Trees

C.25 KICKS WHILE DRILLING

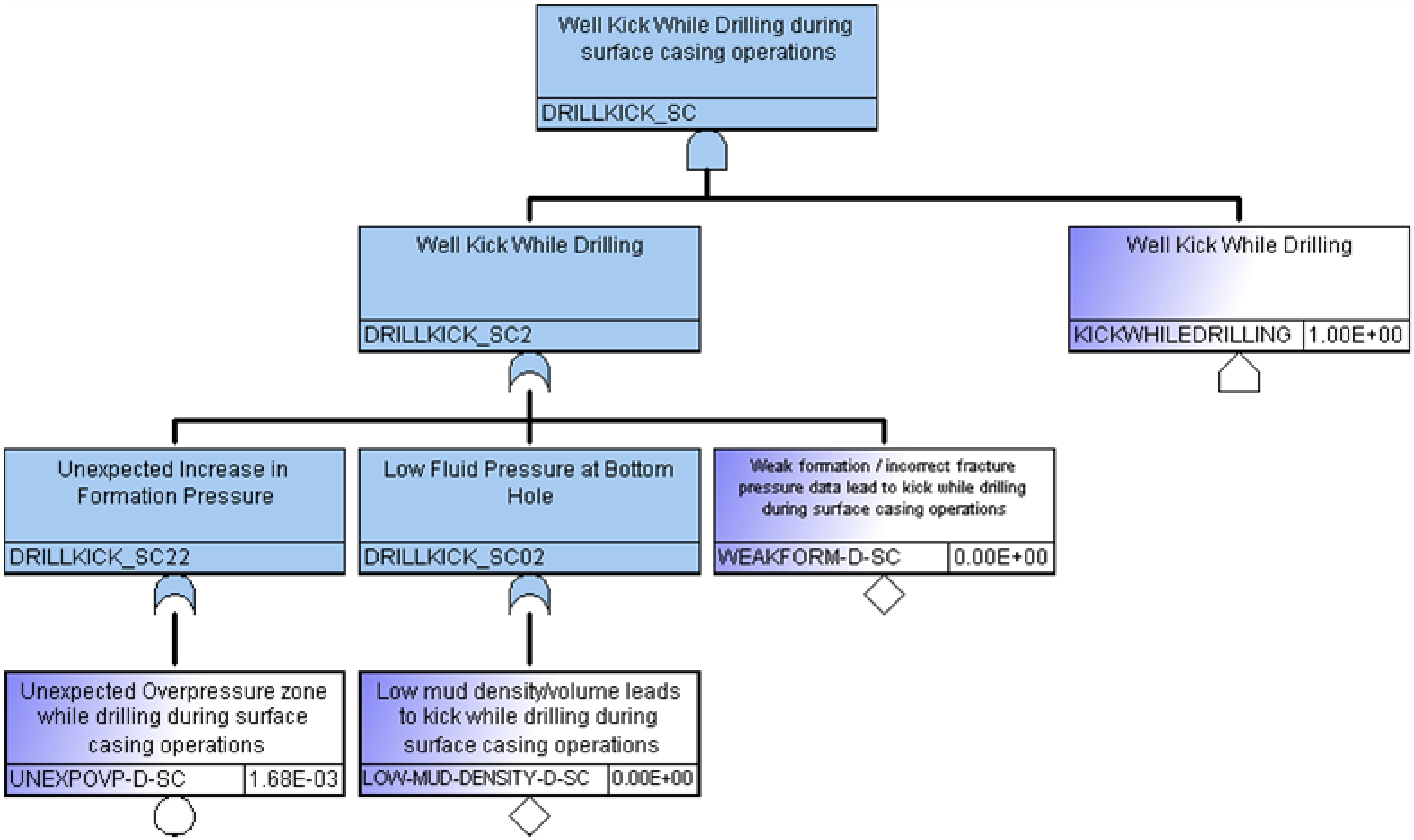


Figure C- 105: Initiating Events: Kicks While Drilling

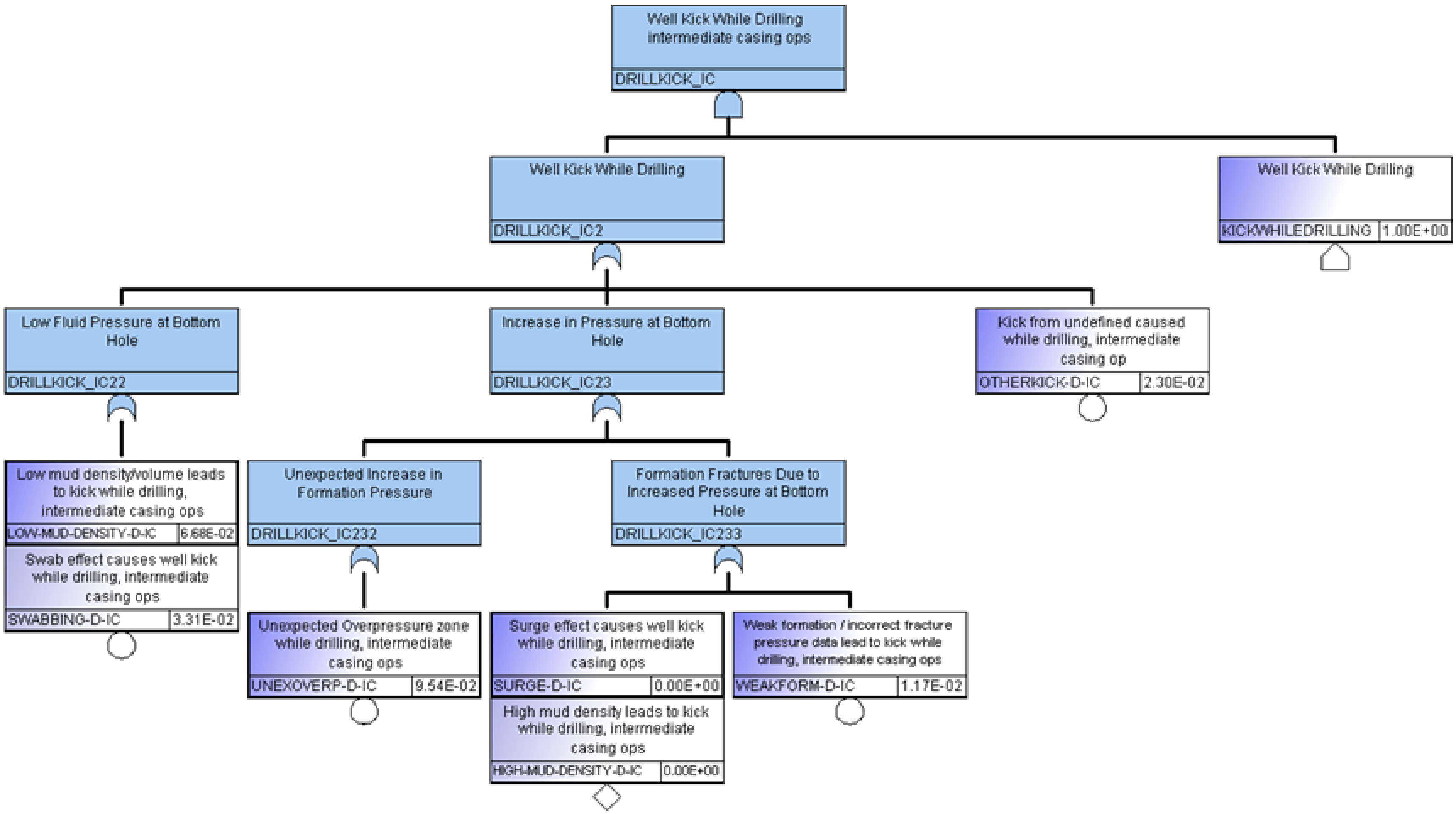


Figure C- 106: Initiating Events: Kicks While Drilling (Continued)

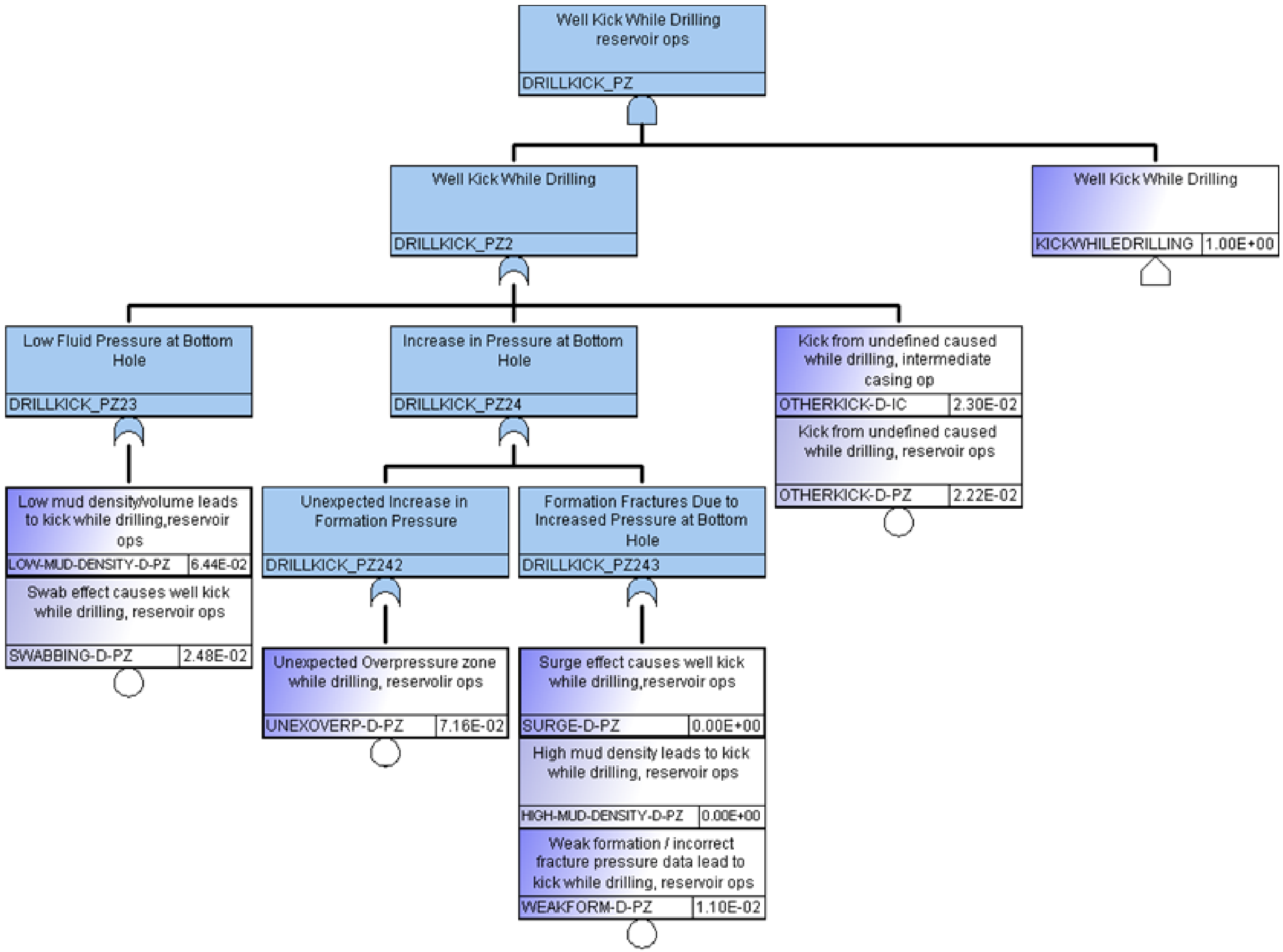


Figure C- 107: Initiating Events: Kicks While Drilling (Continued)

C.26 KICKS WHILE RUNNING CASING

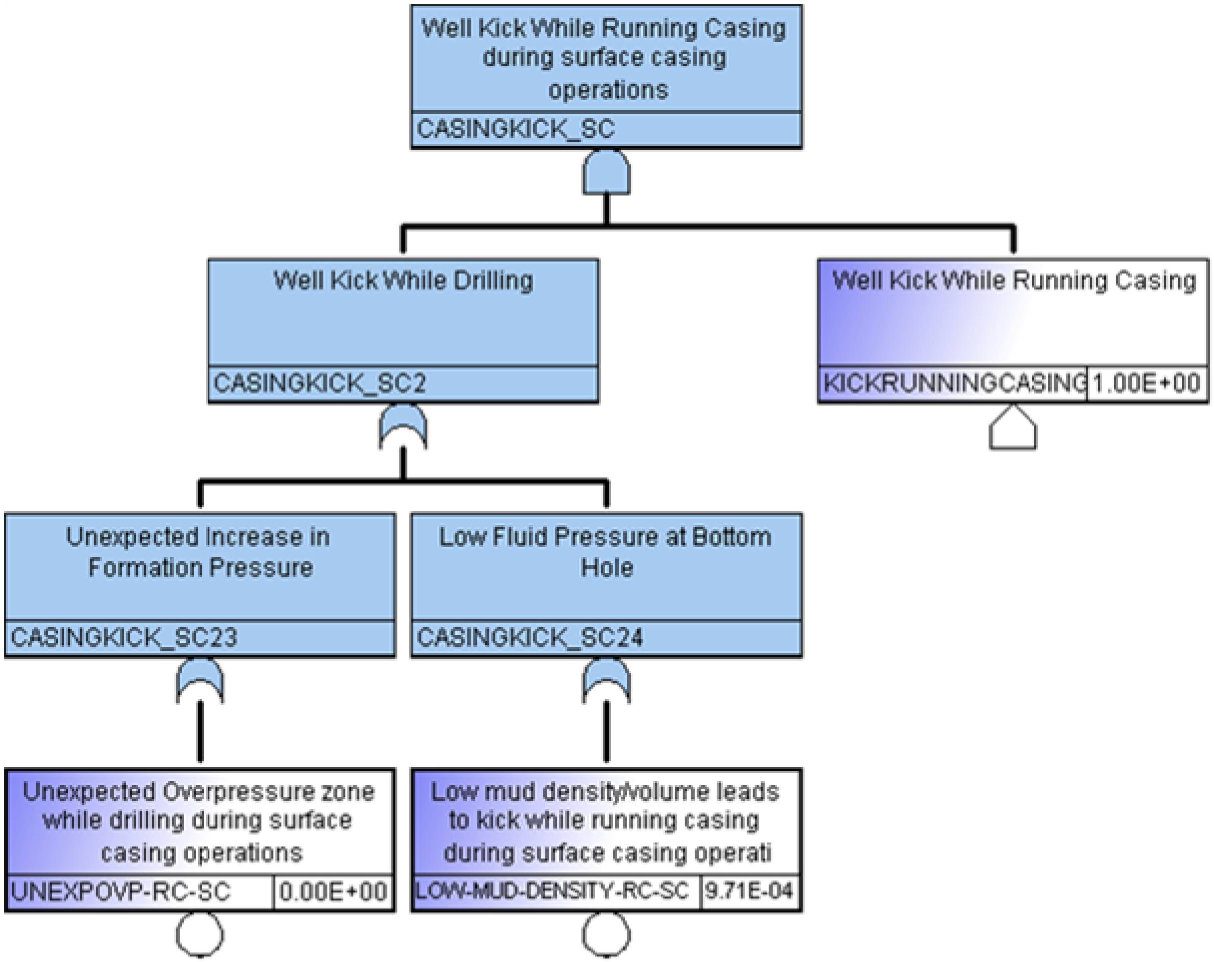


Figure C- 108: Initiating Events: Kicks While Running Casing

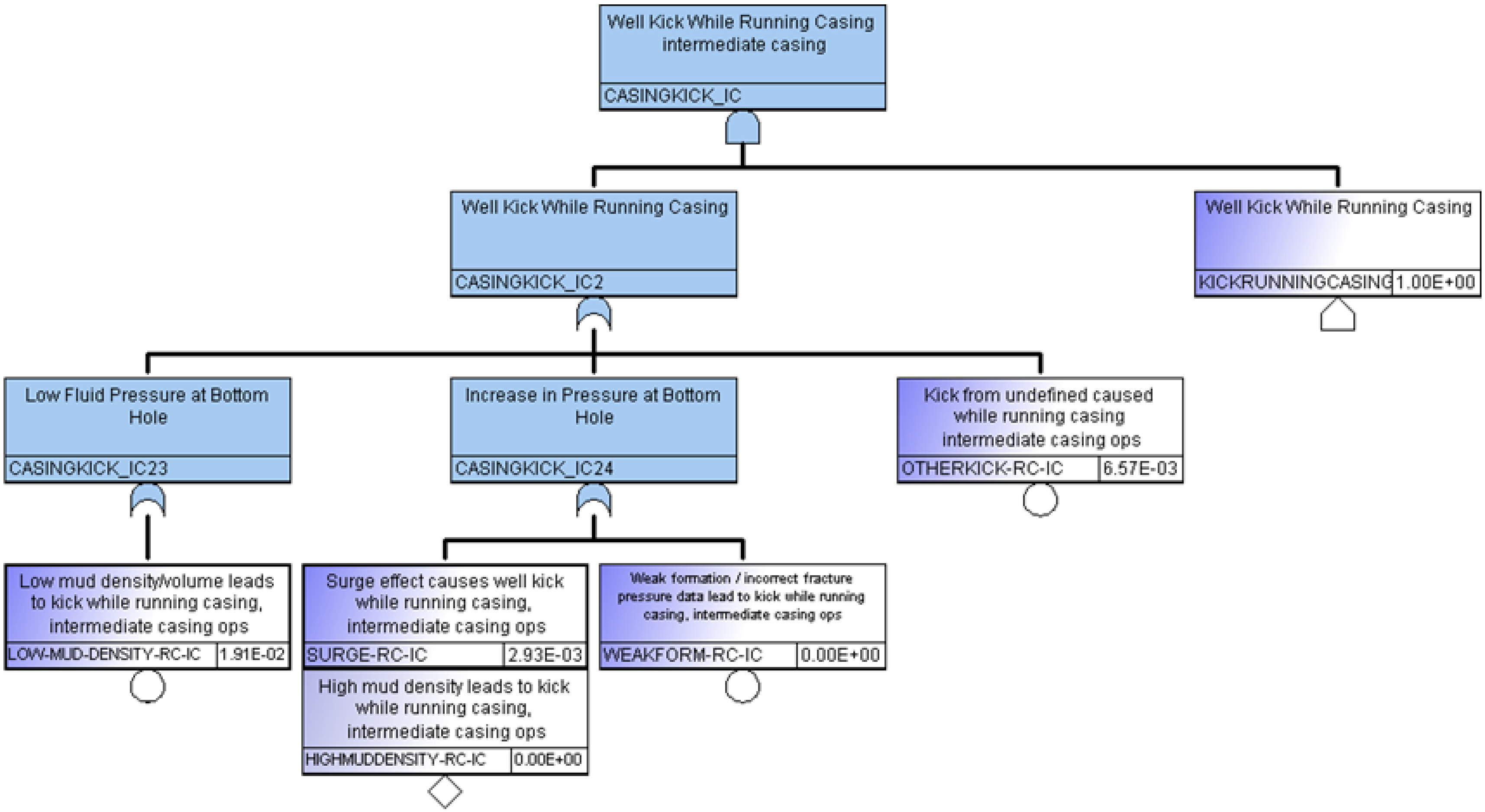


Figure C- 109: Initiating Events: Kicks While Running Casing (Continued)

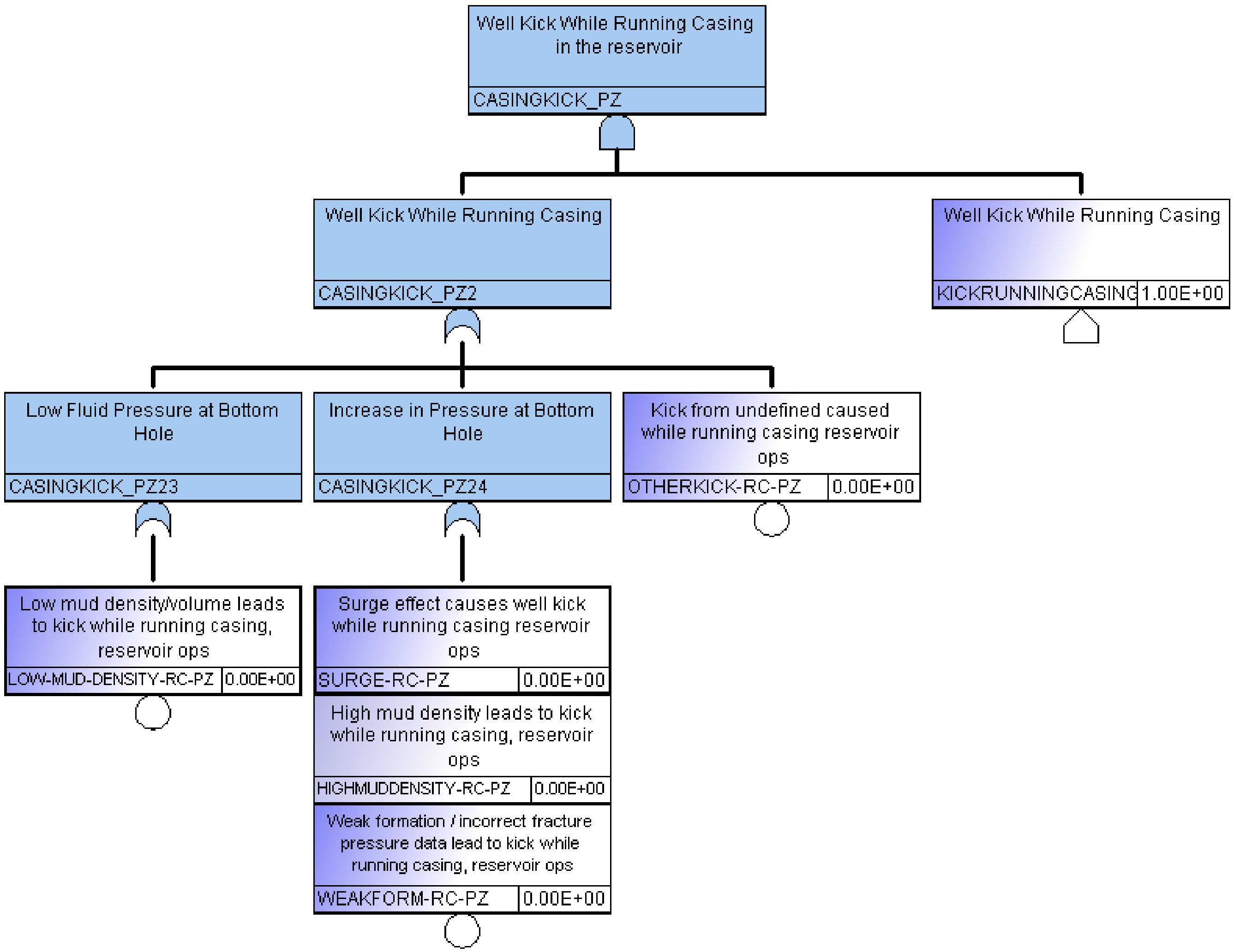


Figure C- 110: Initiating Events: Kicks While Running Casing (Continued)

C.27 KICKS WITH NOTING ACROSS THE BOP

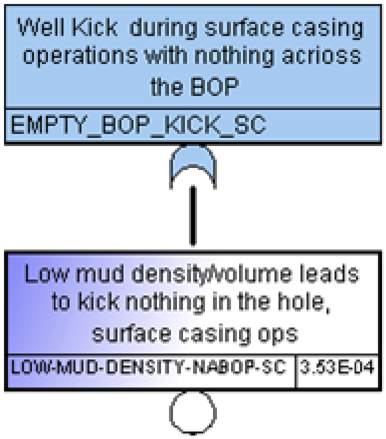


Figure C- 111: Initiating Events: Kicks While Nothing is Across the BOP

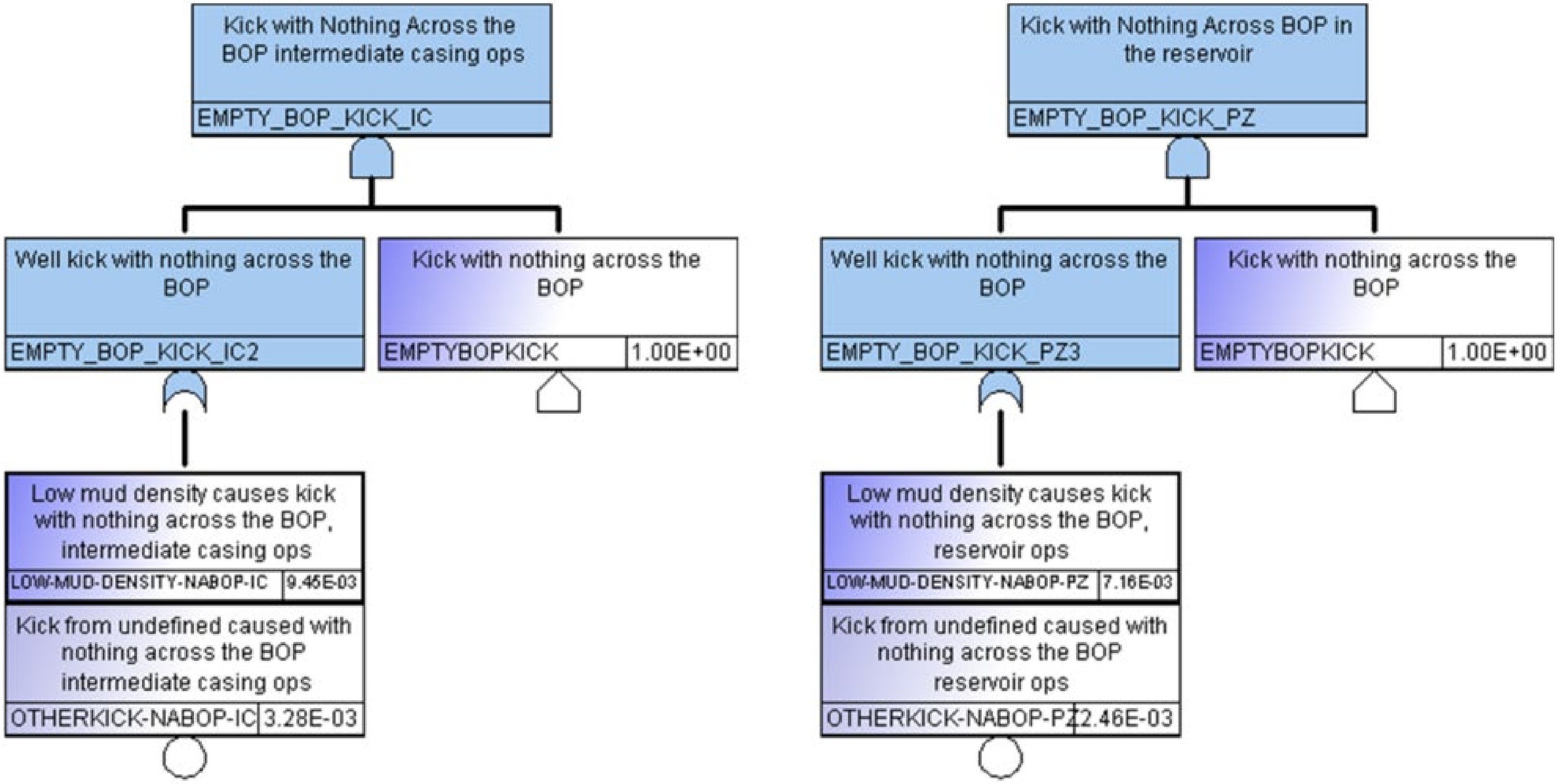


Figure C- 112: Initiating Events: Kicks While Nothing is Across the BOP (Continued)

C.28 DRIFT-OFF/PUSH-OFF INITIATOR

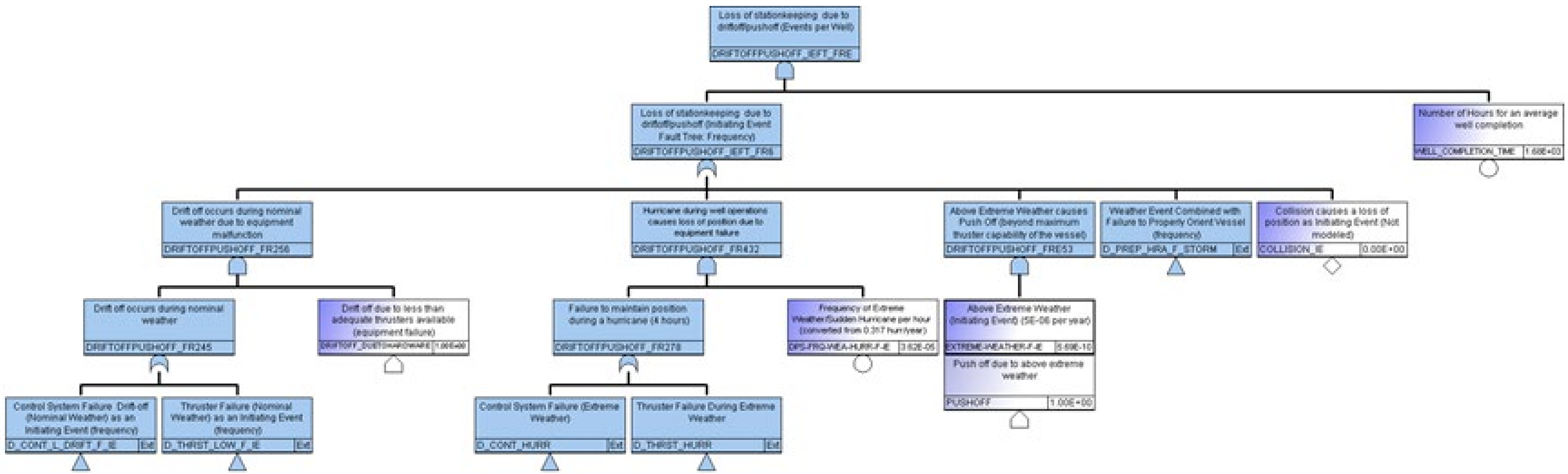


Figure C- 113: Initiating Events: Drift-off/Push-off

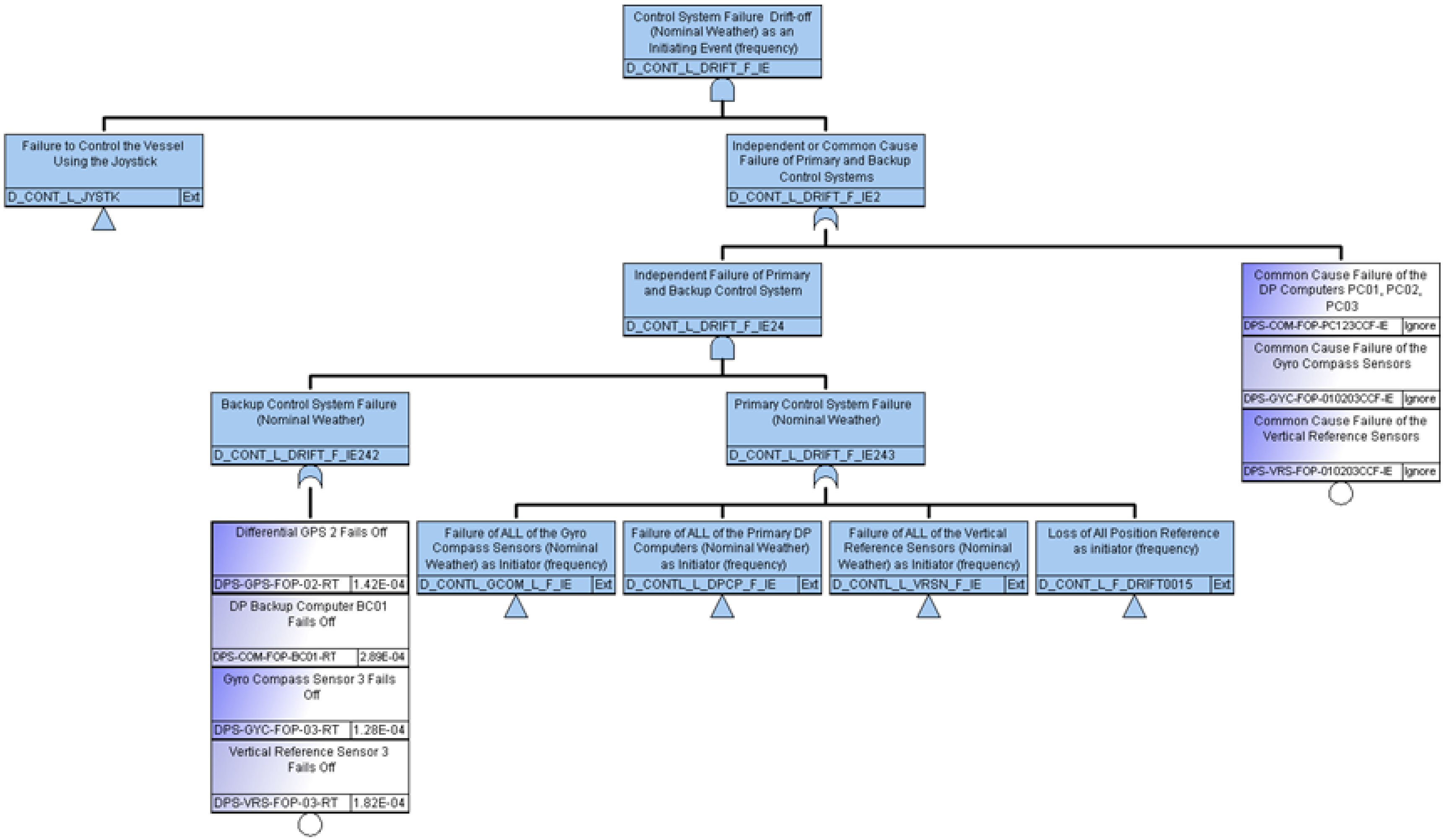


Figure C- 114: Initiating Events: Drift-off/Push-off (Continued)

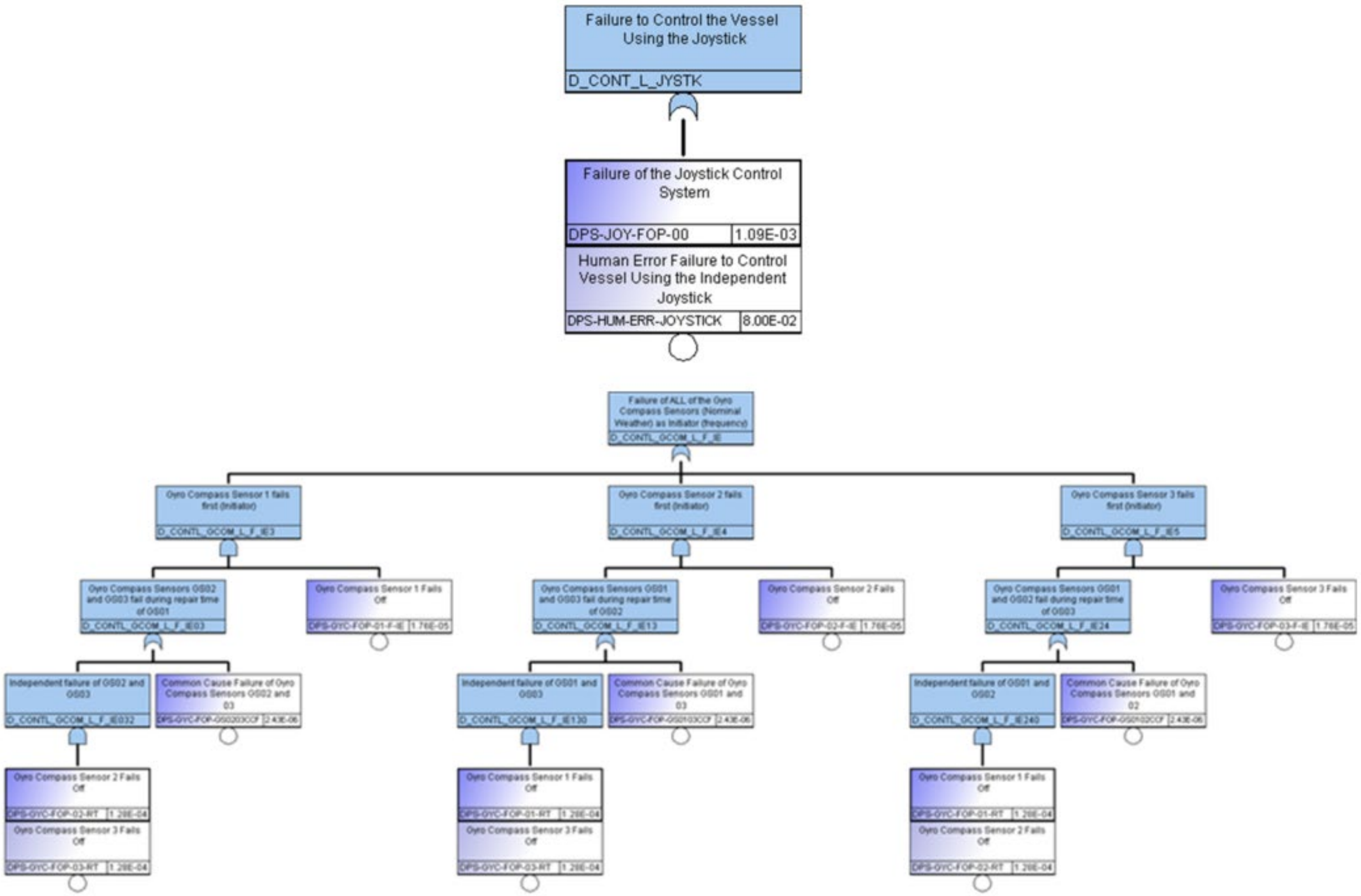


Figure C- 115: Initiating Events: Drift-off/Push-off (Continued)

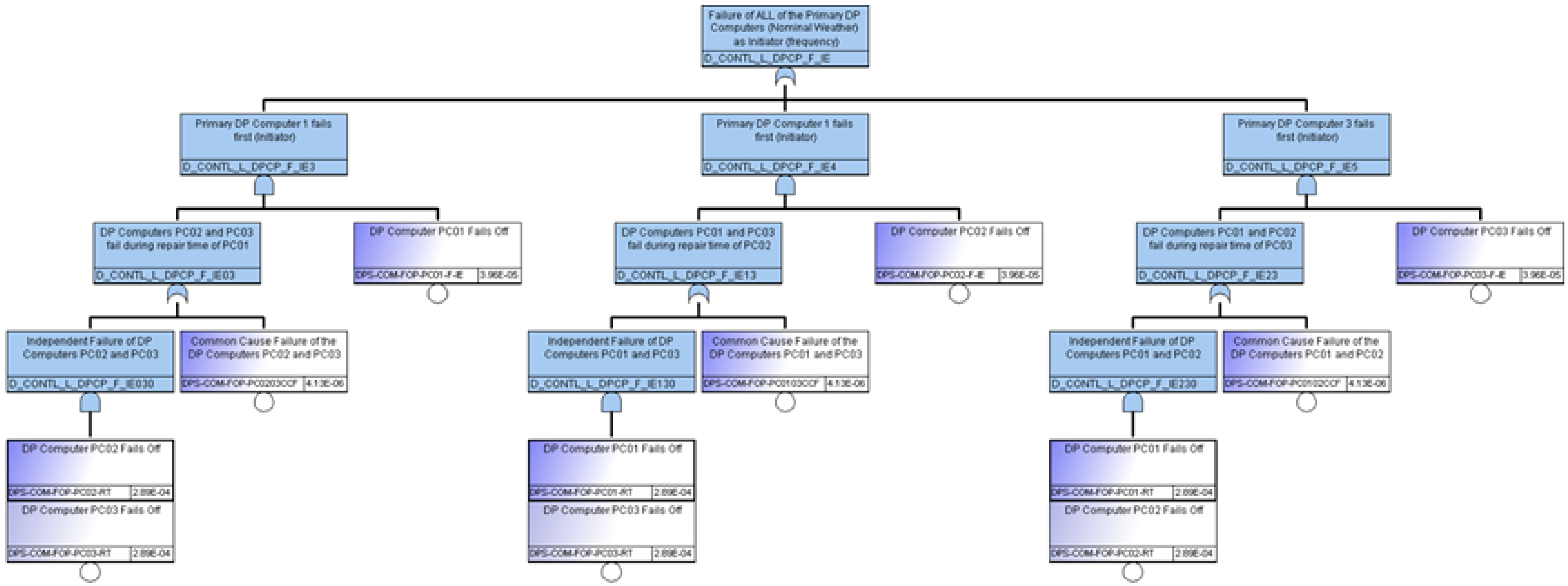


Figure C- 116: Initiating Events: Drift-off/Push-off (Continued)

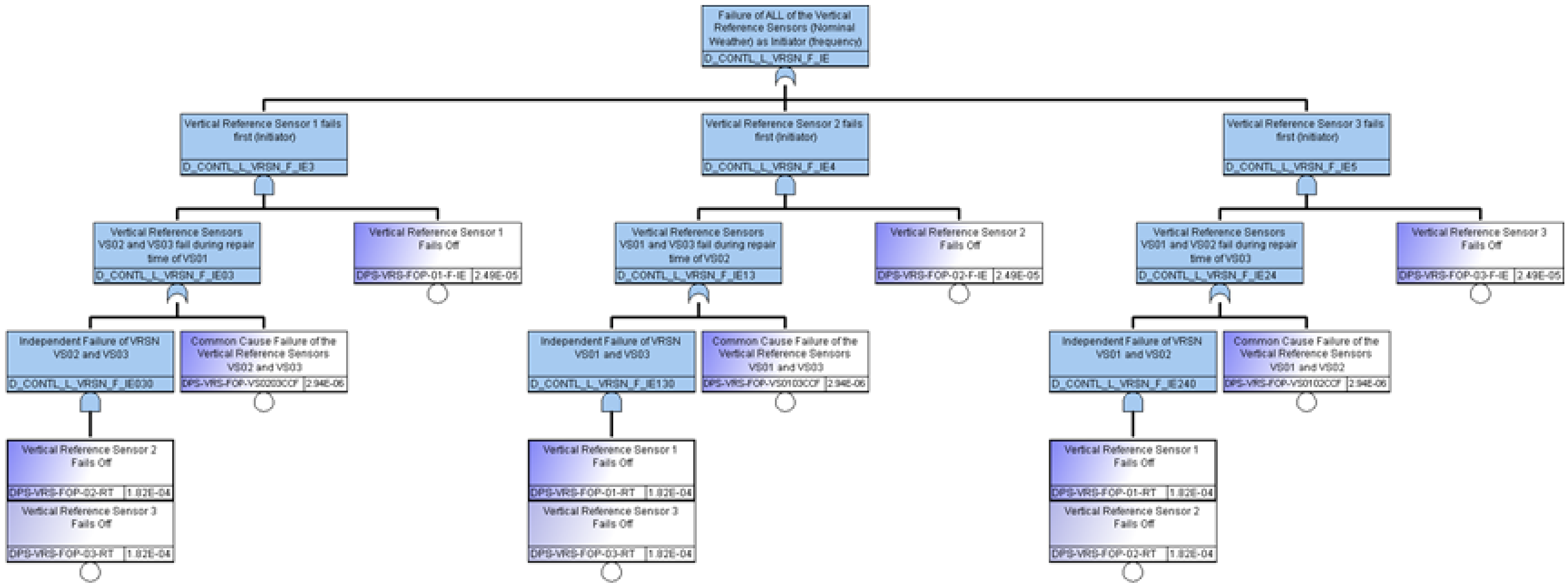


Figure C- 117: Initiating Events: Drift-off/Push-off (Continued)

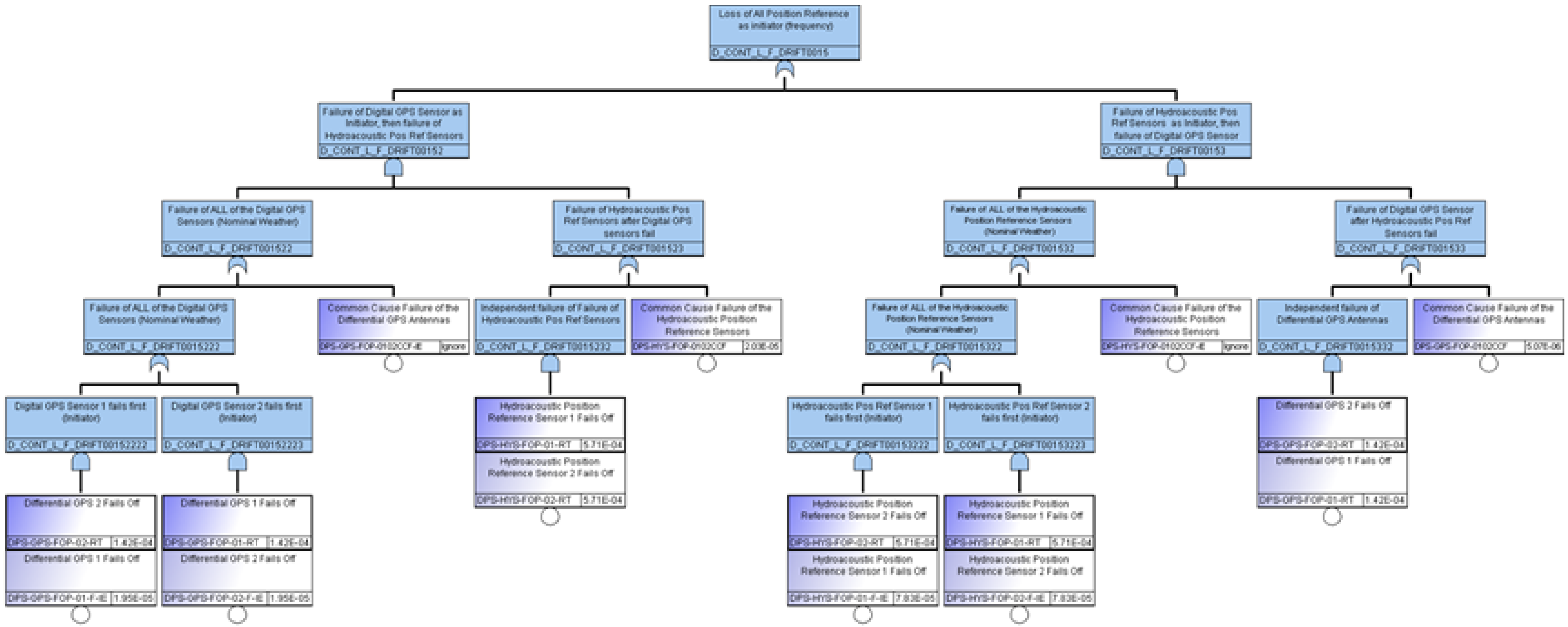


Figure C- 118: Initiating Events: Drift-off/Push-off (Continued)

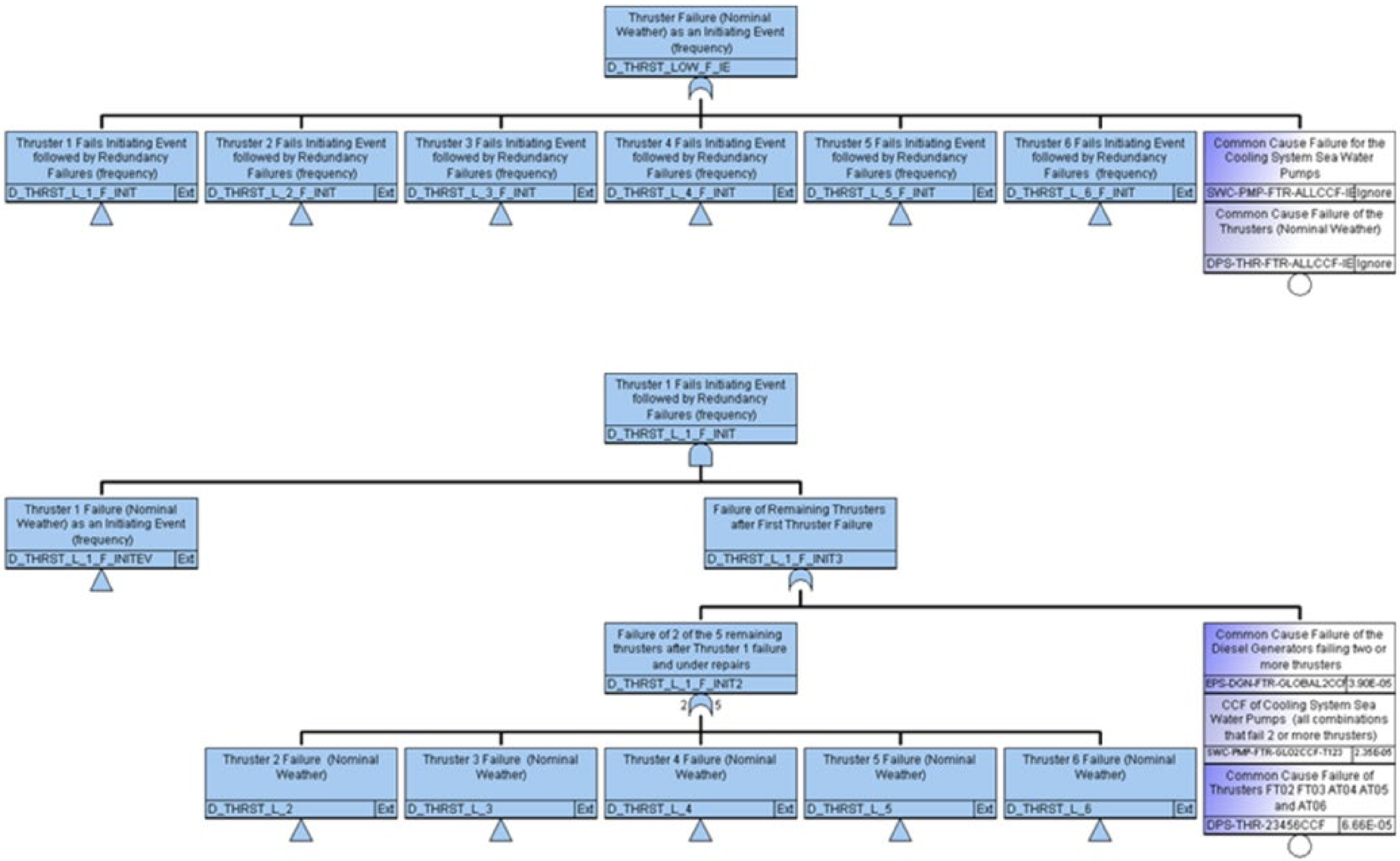


Figure C- 119: Initiating Events: Drift-off/Push-off (Continued)

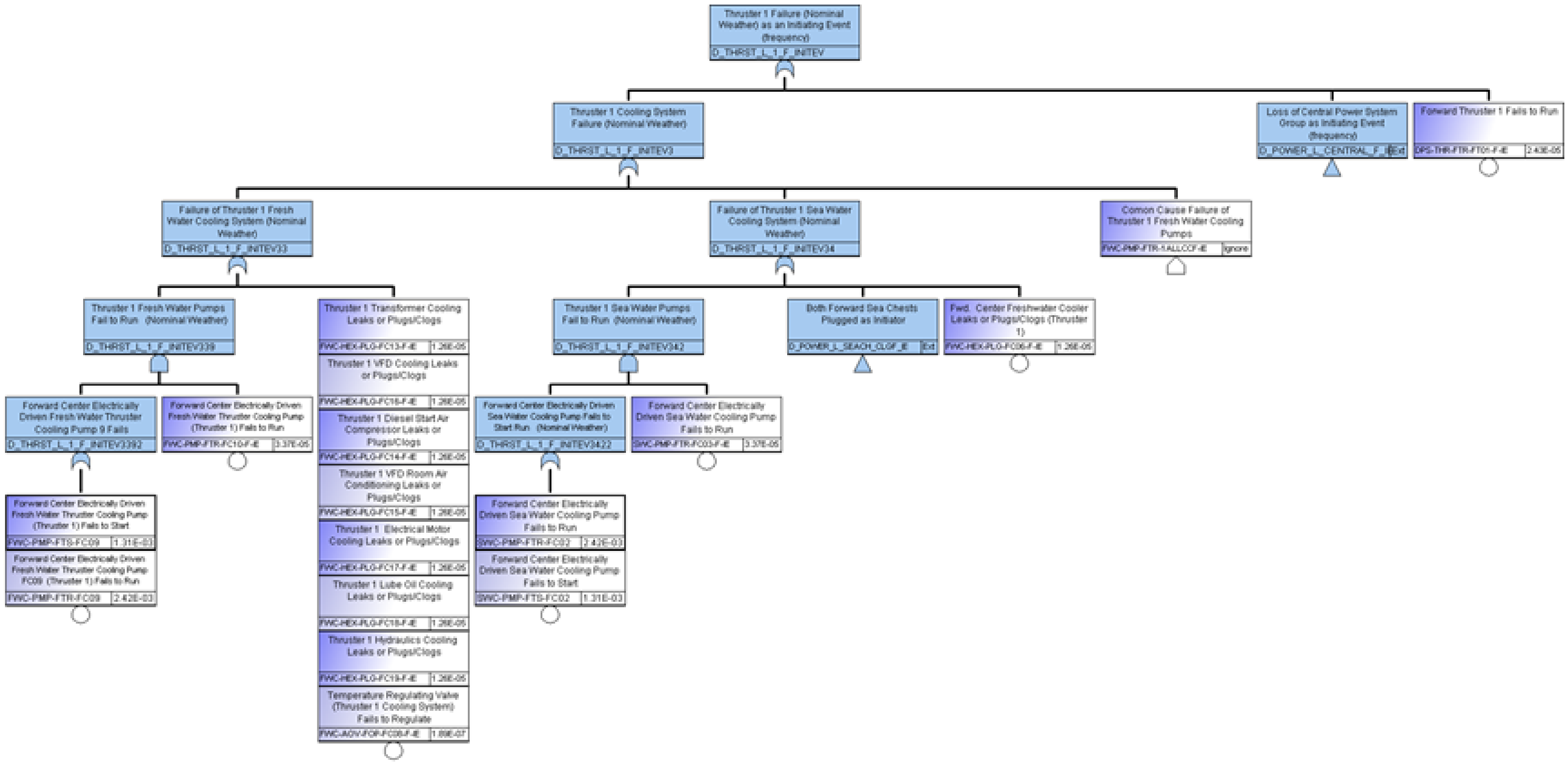


Figure C- 120: Initiating Events: Drift-off/Push-off (Continued)

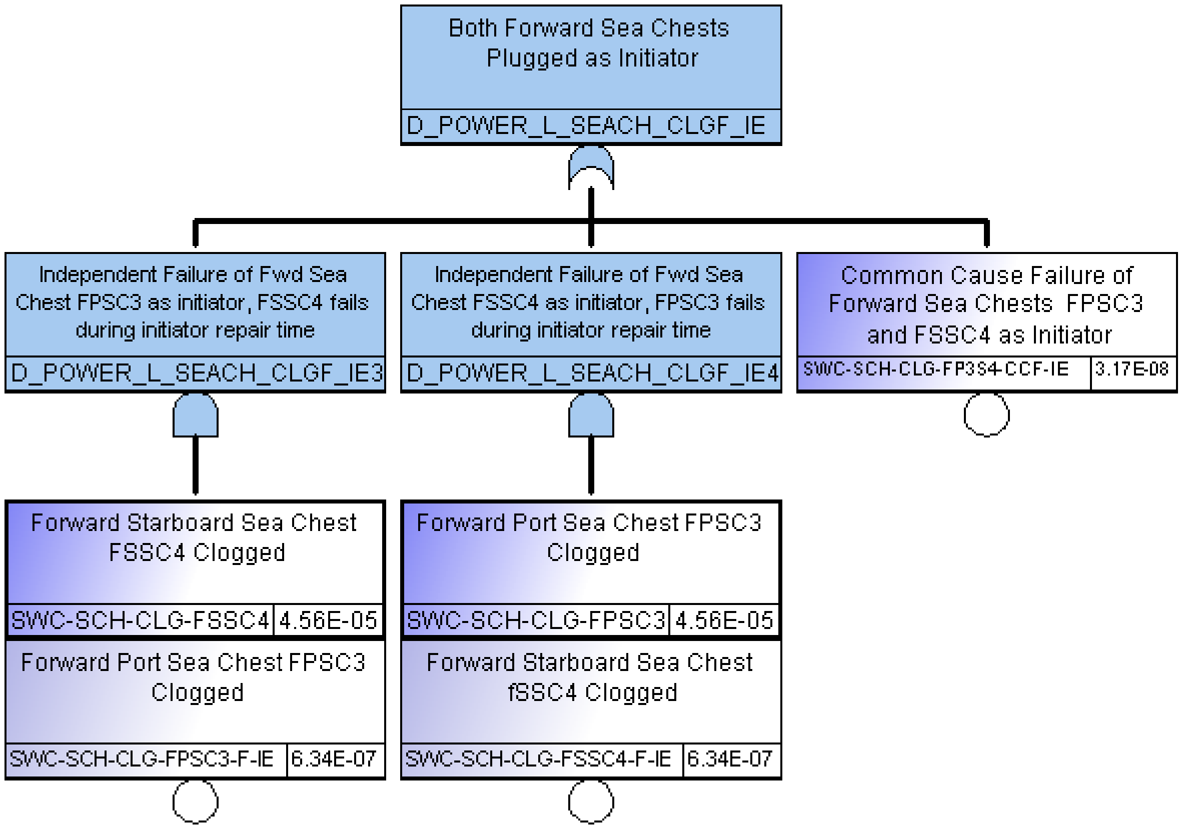


Figure C- 121: Initiating Events: Drift-off/Push-off (Continued)

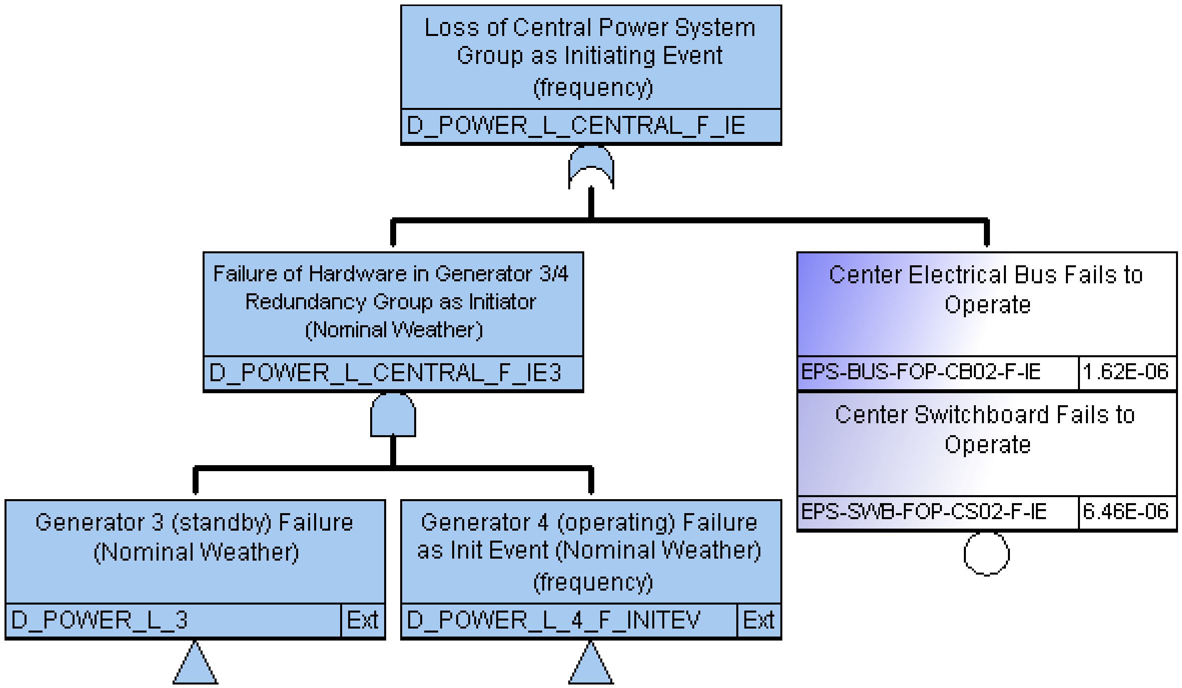


Figure C- 122: Initiating Events: Drift-off/Push-off (Continued)

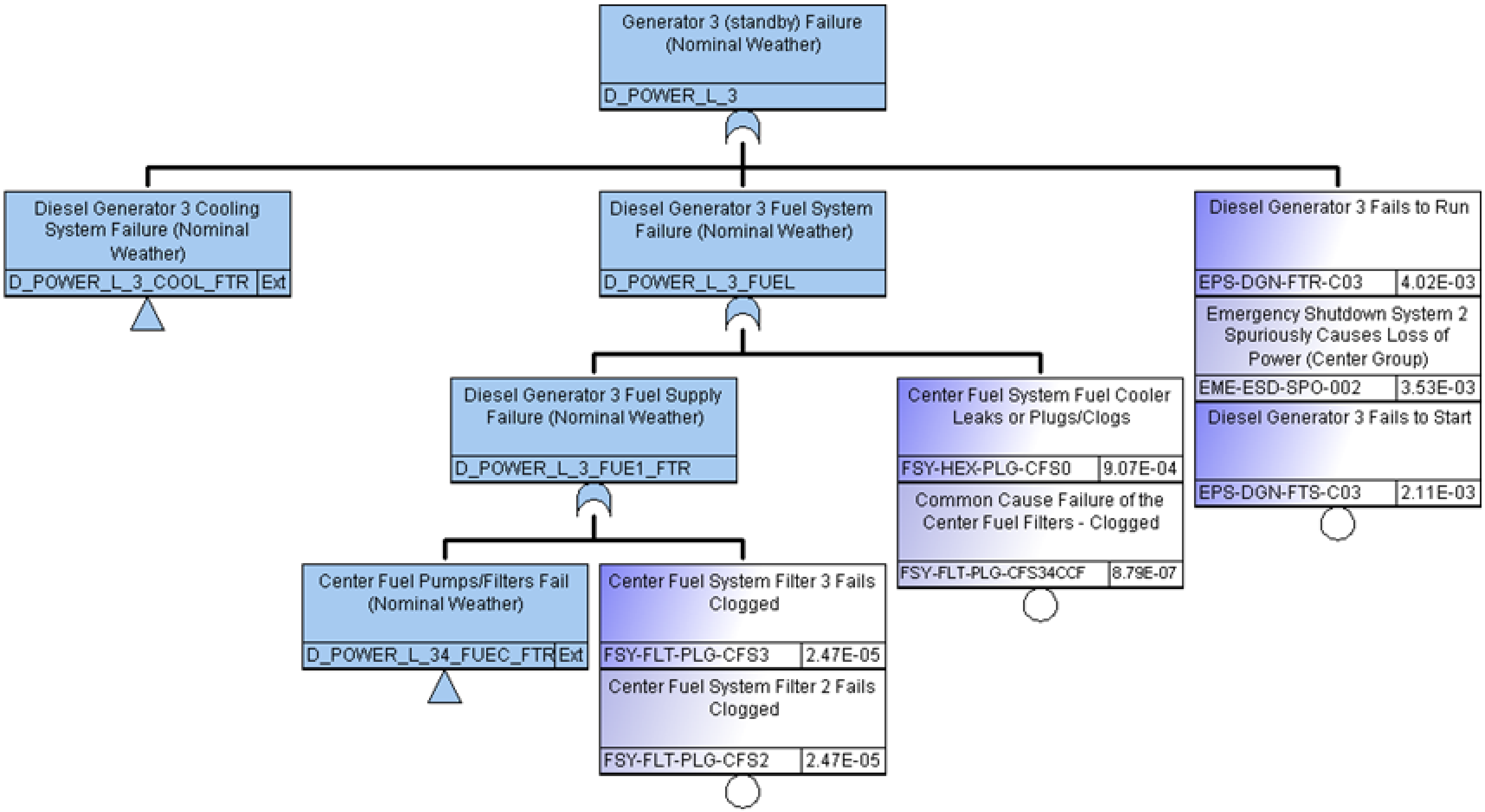


Figure C- 123: Initiating Events: Drift-off/Push-off (Continued)

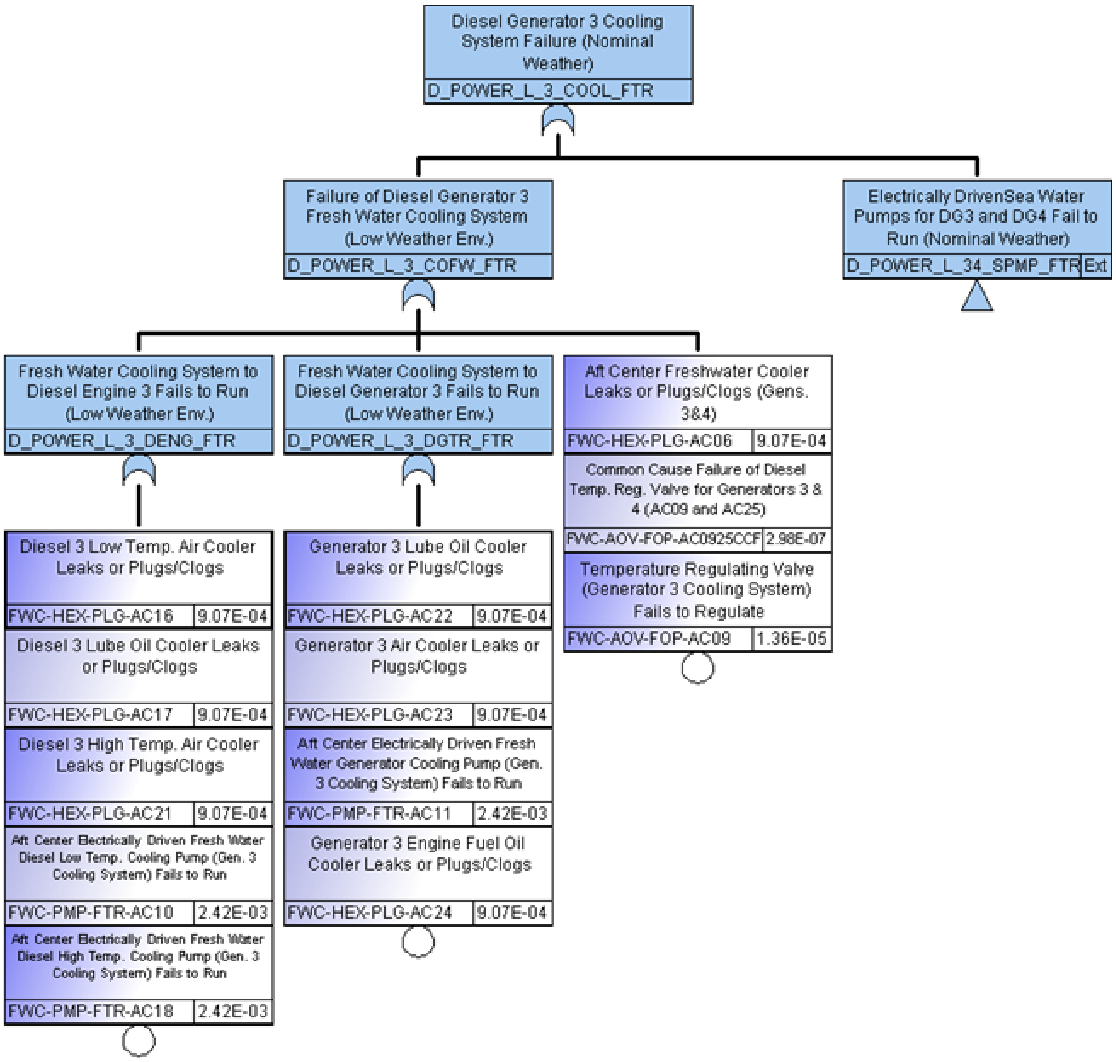


Figure C- 124: Initiating Events: Drift-off/Push-off (Continued)

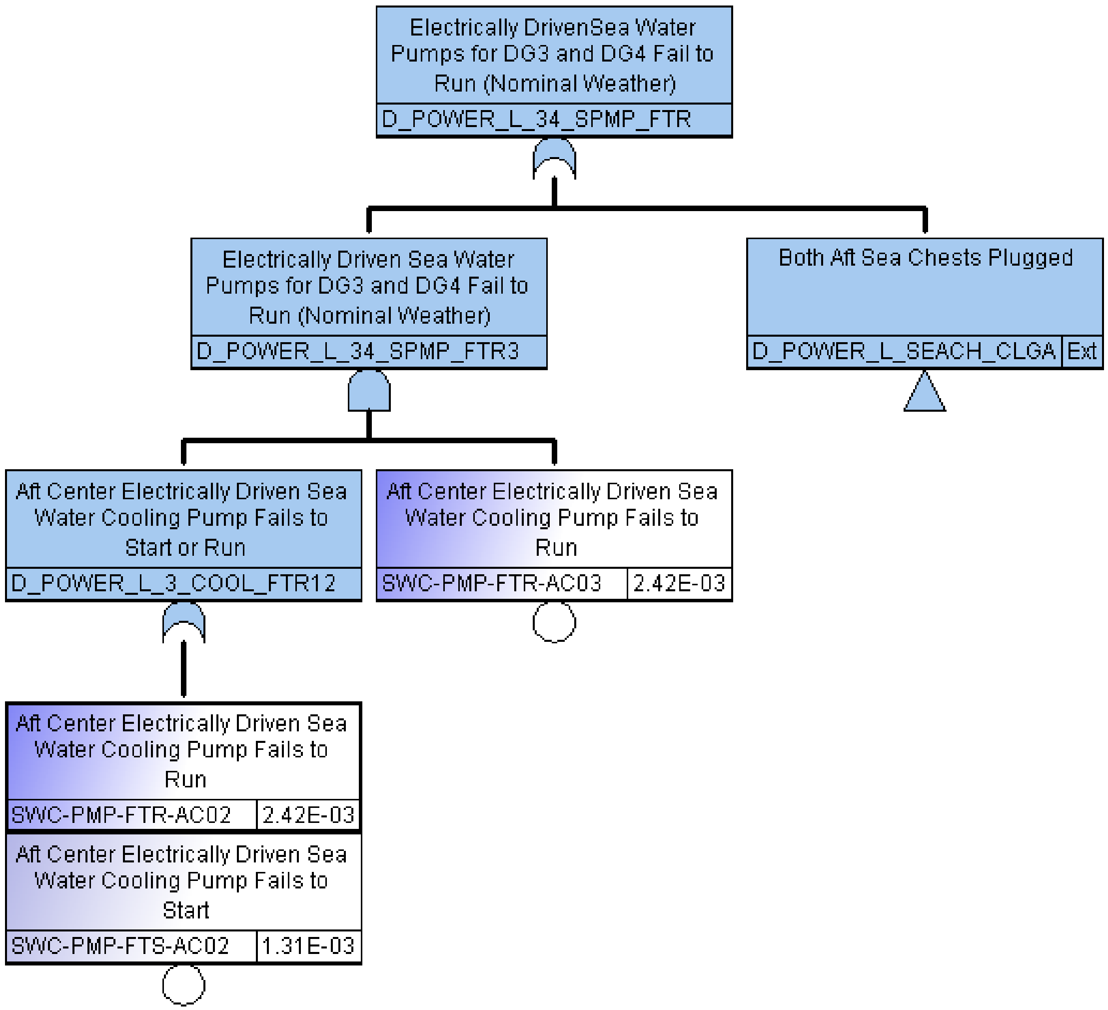


Figure C- 125: Initiating Events: Drift-off/Push-off (Continued)

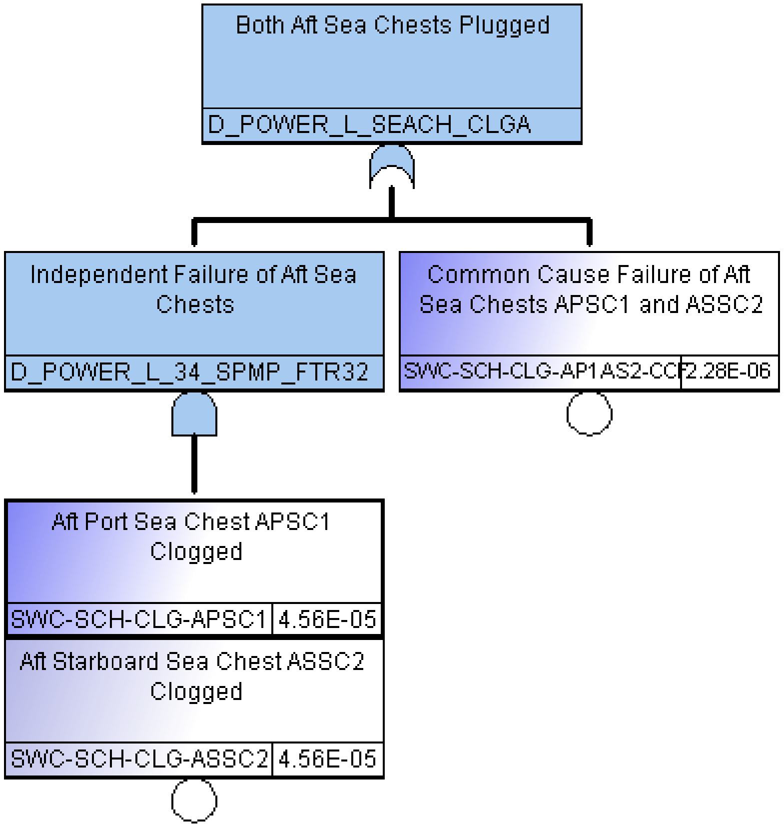


Figure C- 126: Initiating Events: Drift-off/Push-off (Continued)

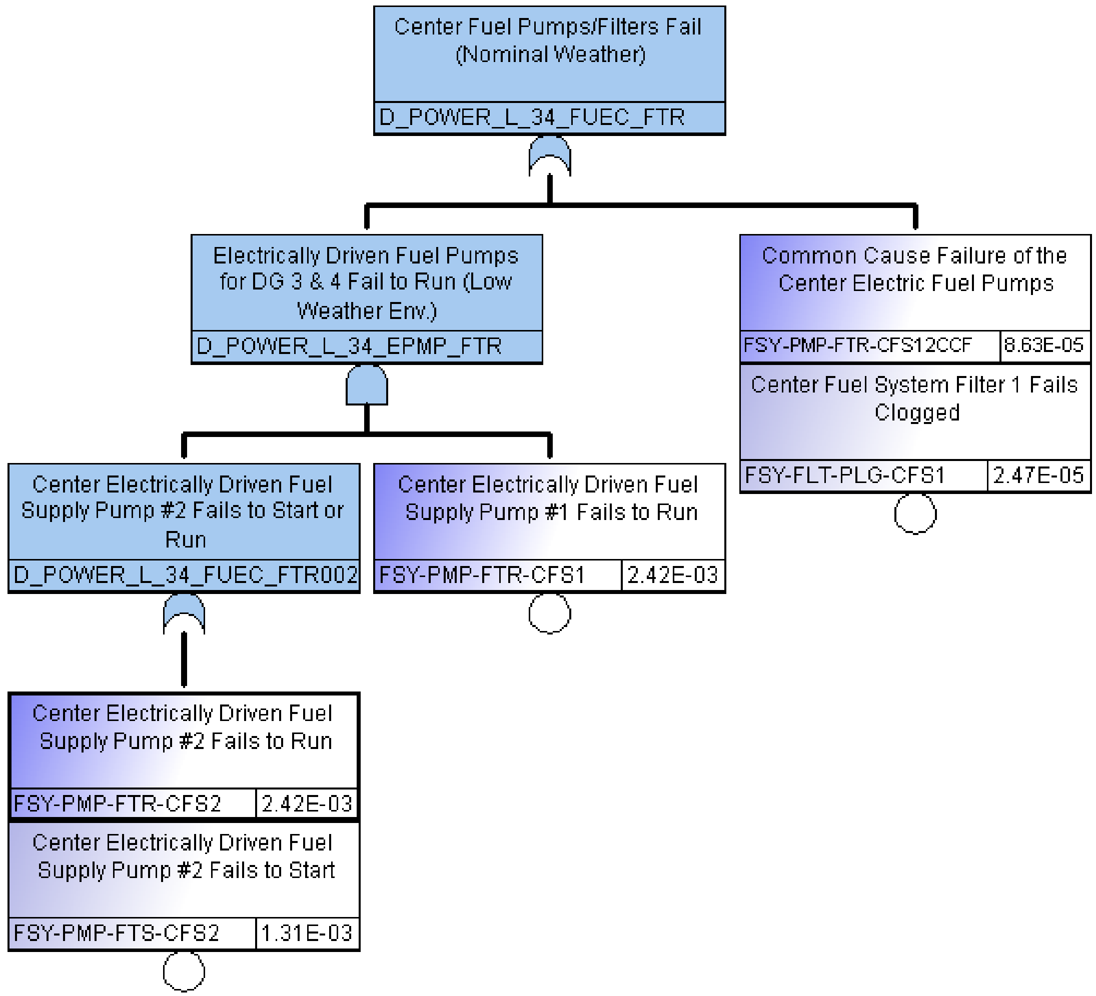


Figure C- 127: Initiating Events: Drift-off/Push-off (Continued)

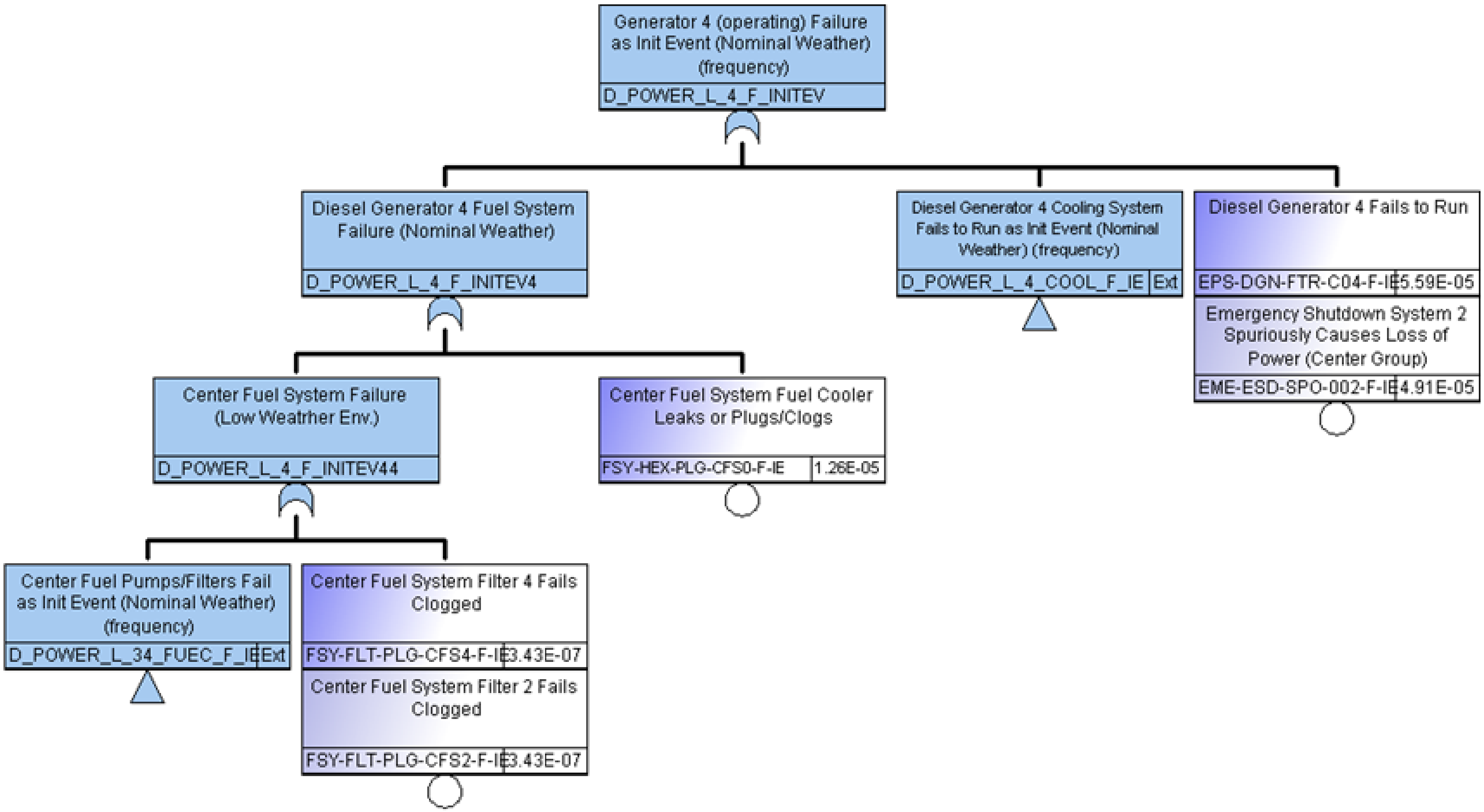


Figure C- 128: Initiating Events: Drift-off/Push-off (Continued)

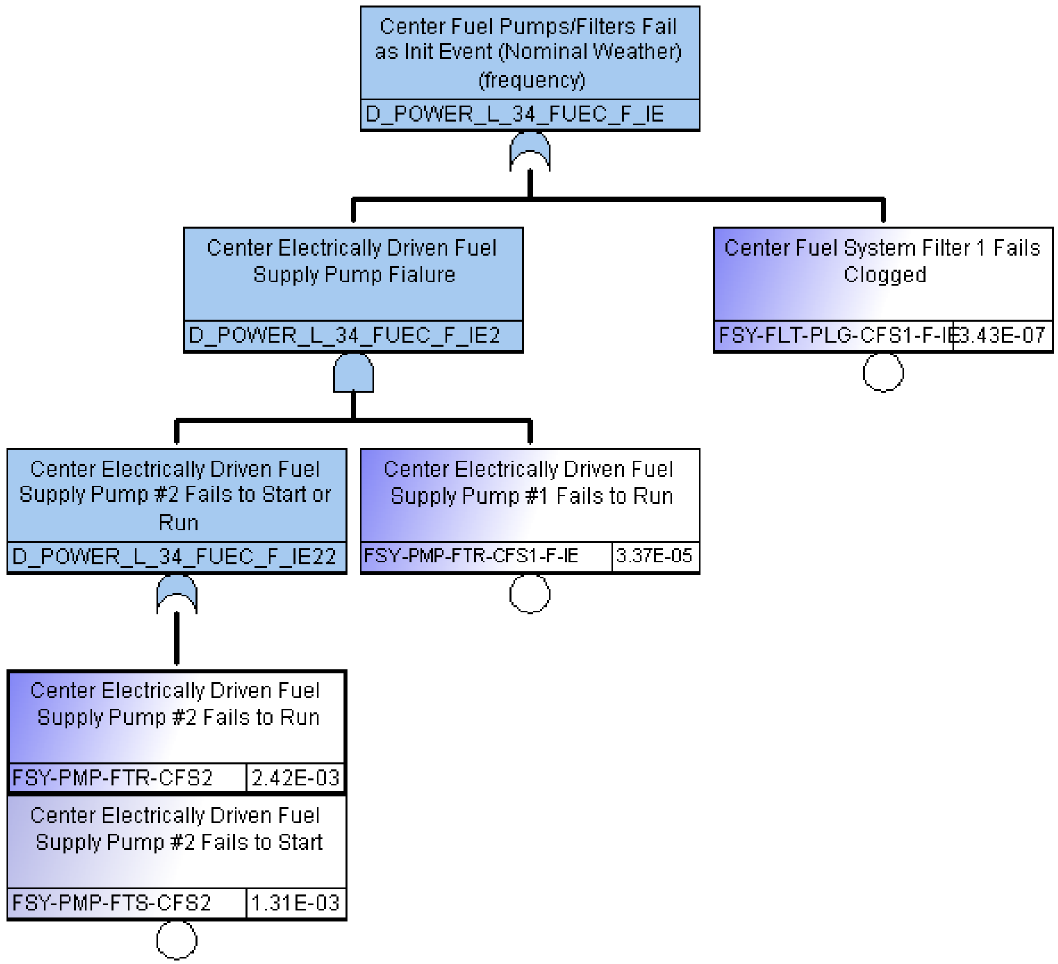


Figure C- 129: Initiating Events: Drift-off/Push-off (Continued)

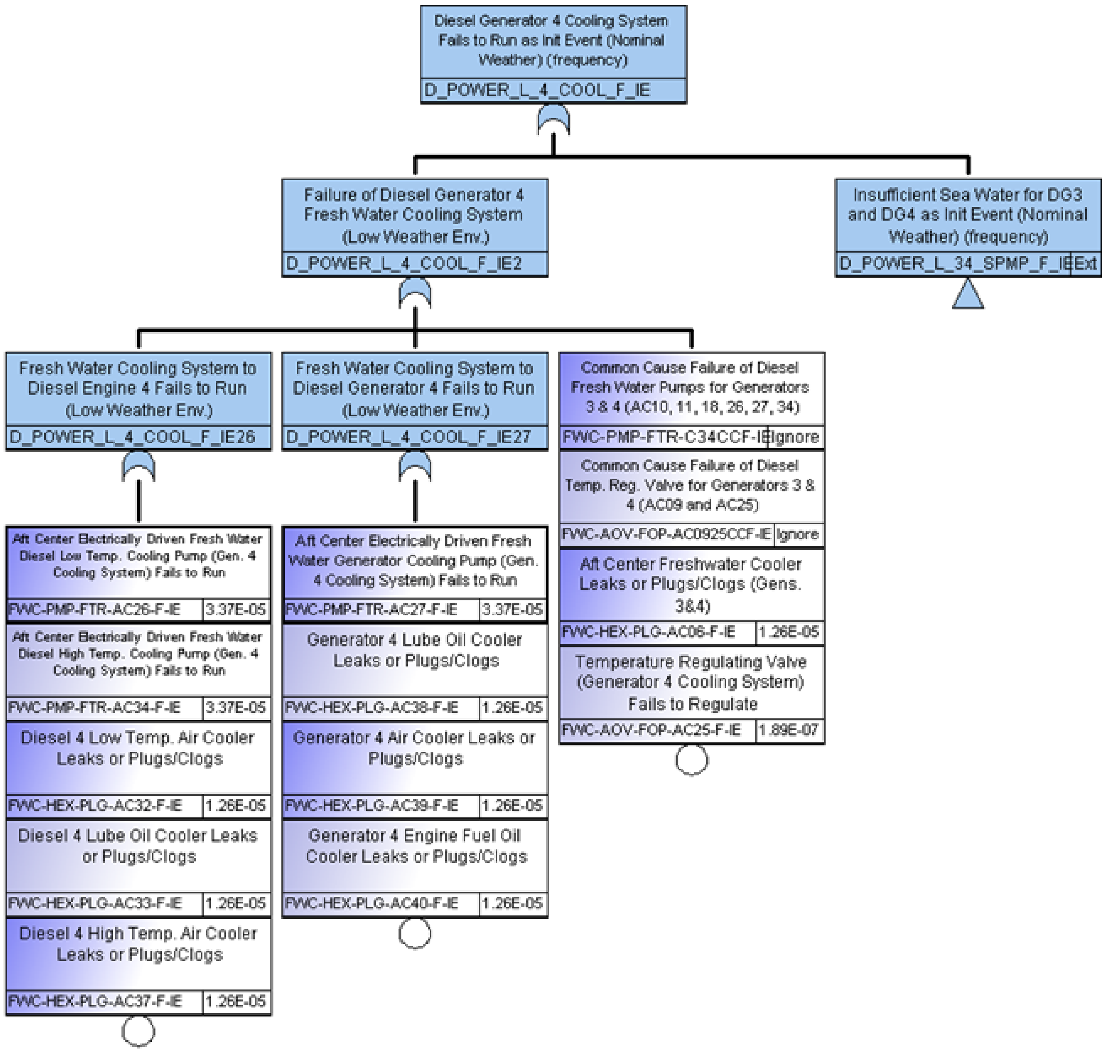


Figure C- 130: Initiating Events: Drift-off/Push-off (Continued)

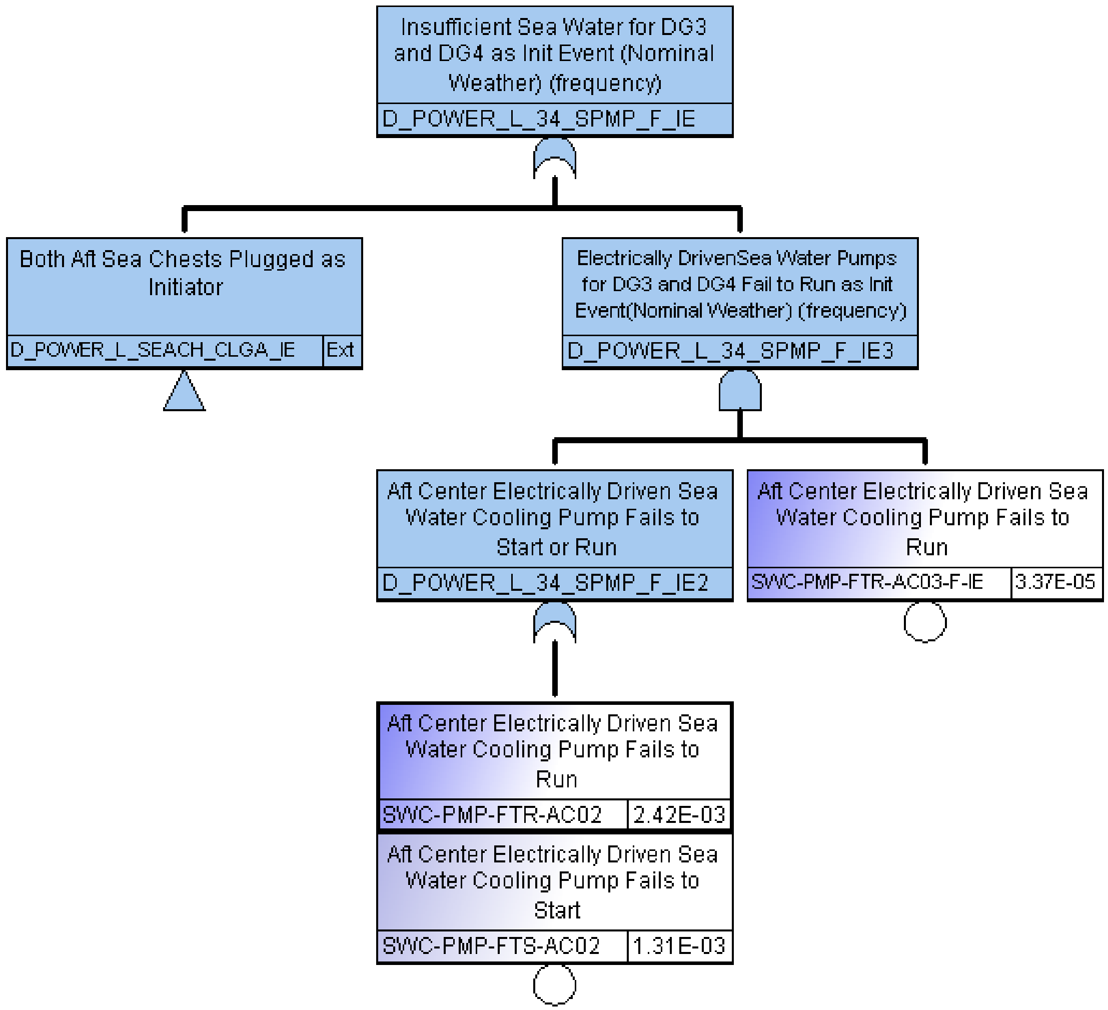


Figure C- 131: Initiating Events: Drift-off/Push-off (Continued)

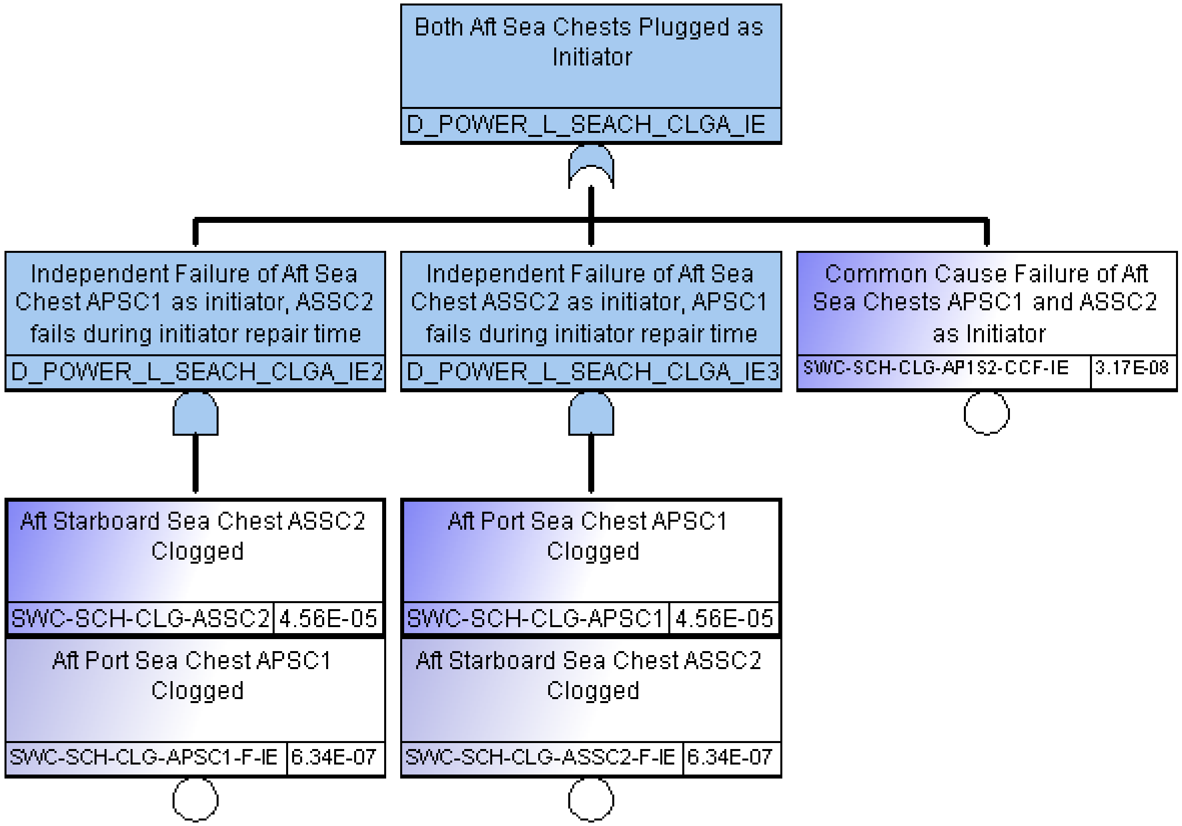


Figure C- 132: Initiating Events: Drift-off/Push-off (Continued)

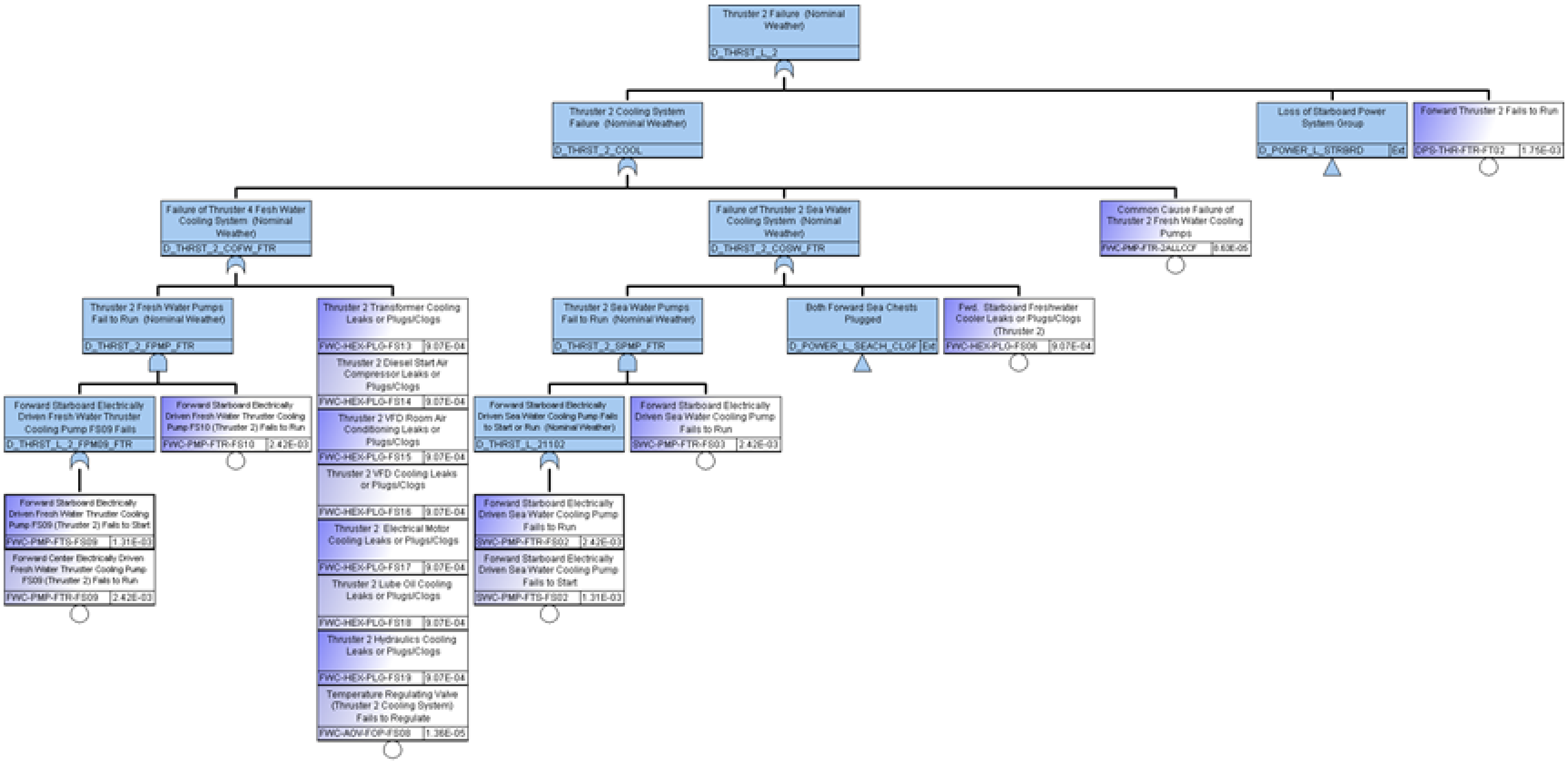


Figure C- 133: Initiating Events: Drift-off/Push-off (Continued)

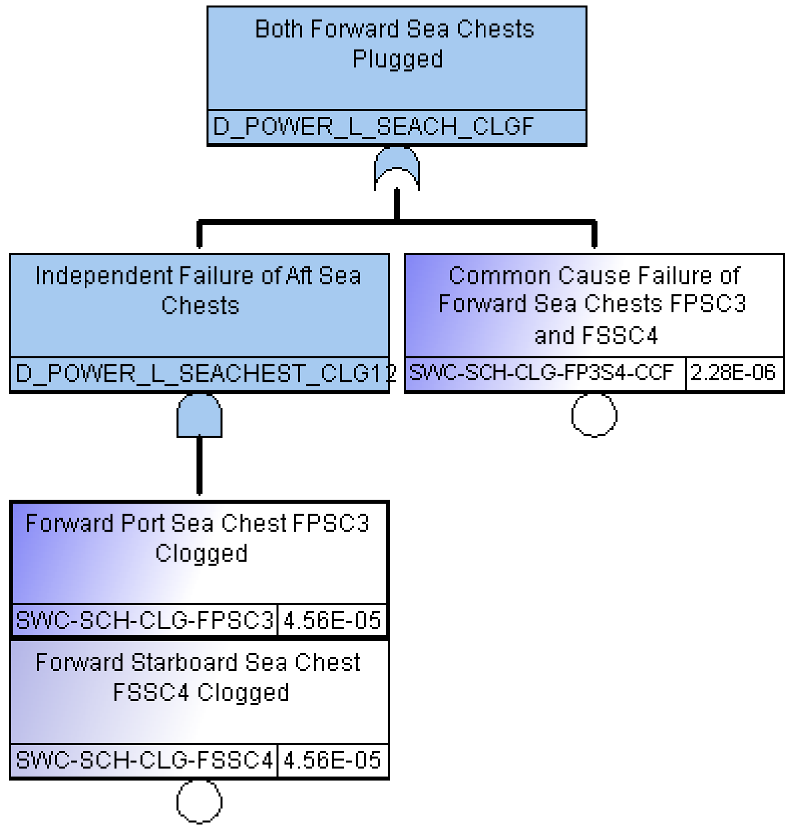


Figure C- 134: Initiating Events: Drift-off/Push-off (Continued)

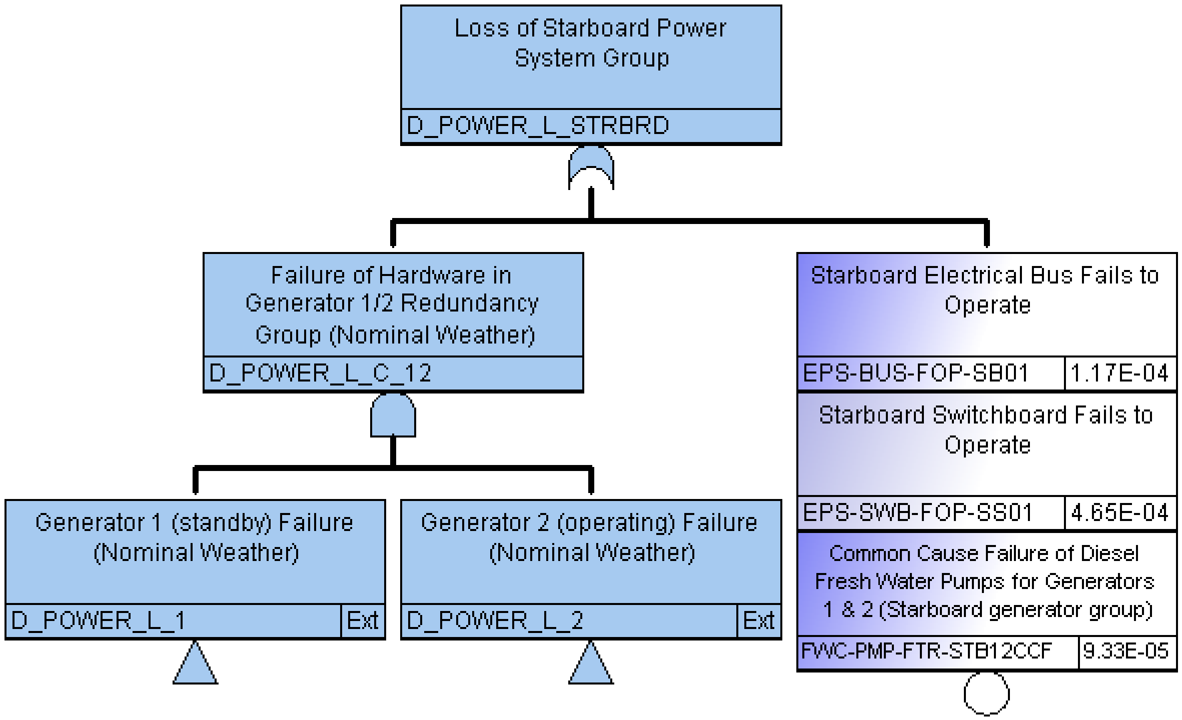


Figure C- 135: Initiating Events: Drift-off/Push-off (Continued)

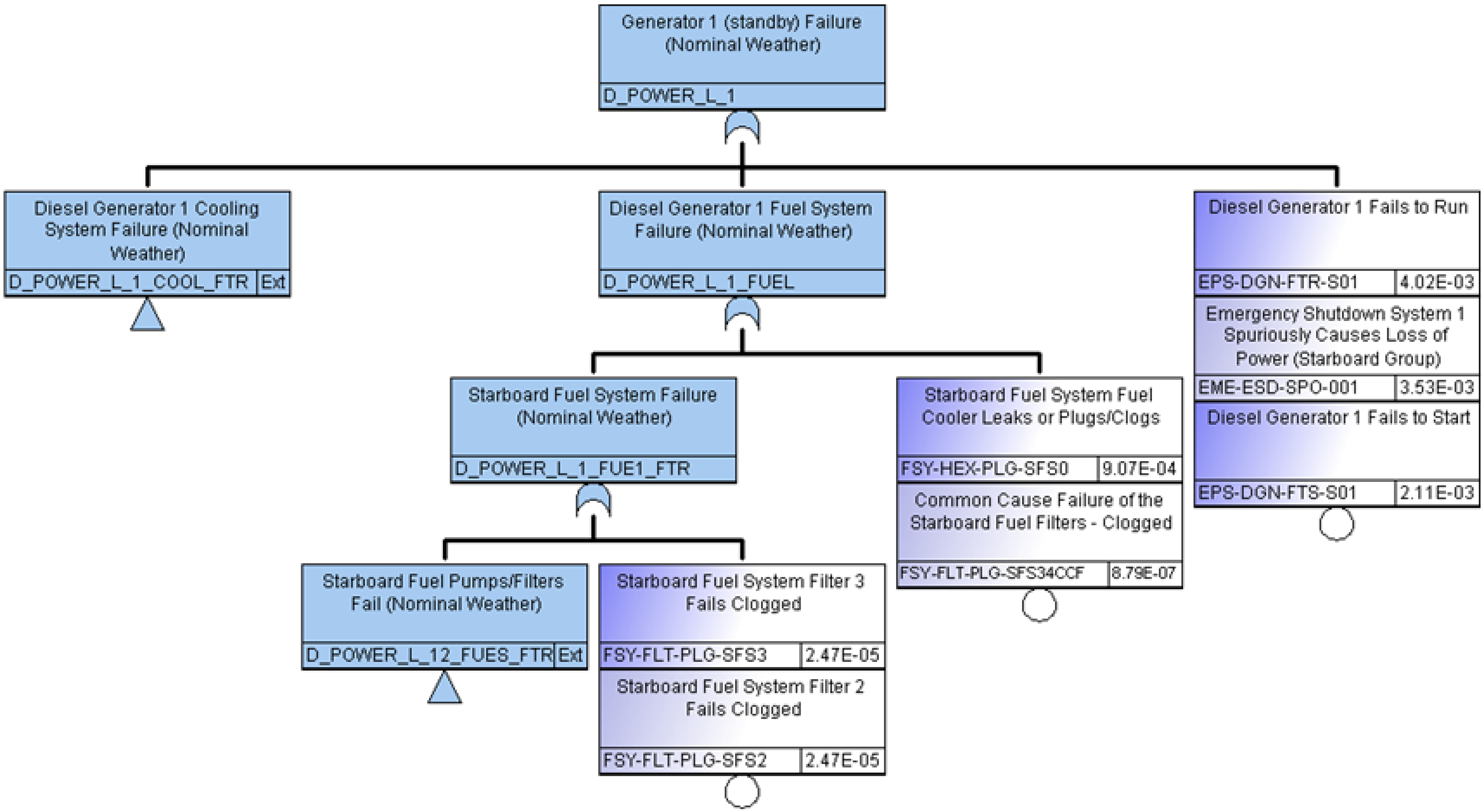


Figure C- 136: Initiating Events: Drift-off/Push-off (Continued)

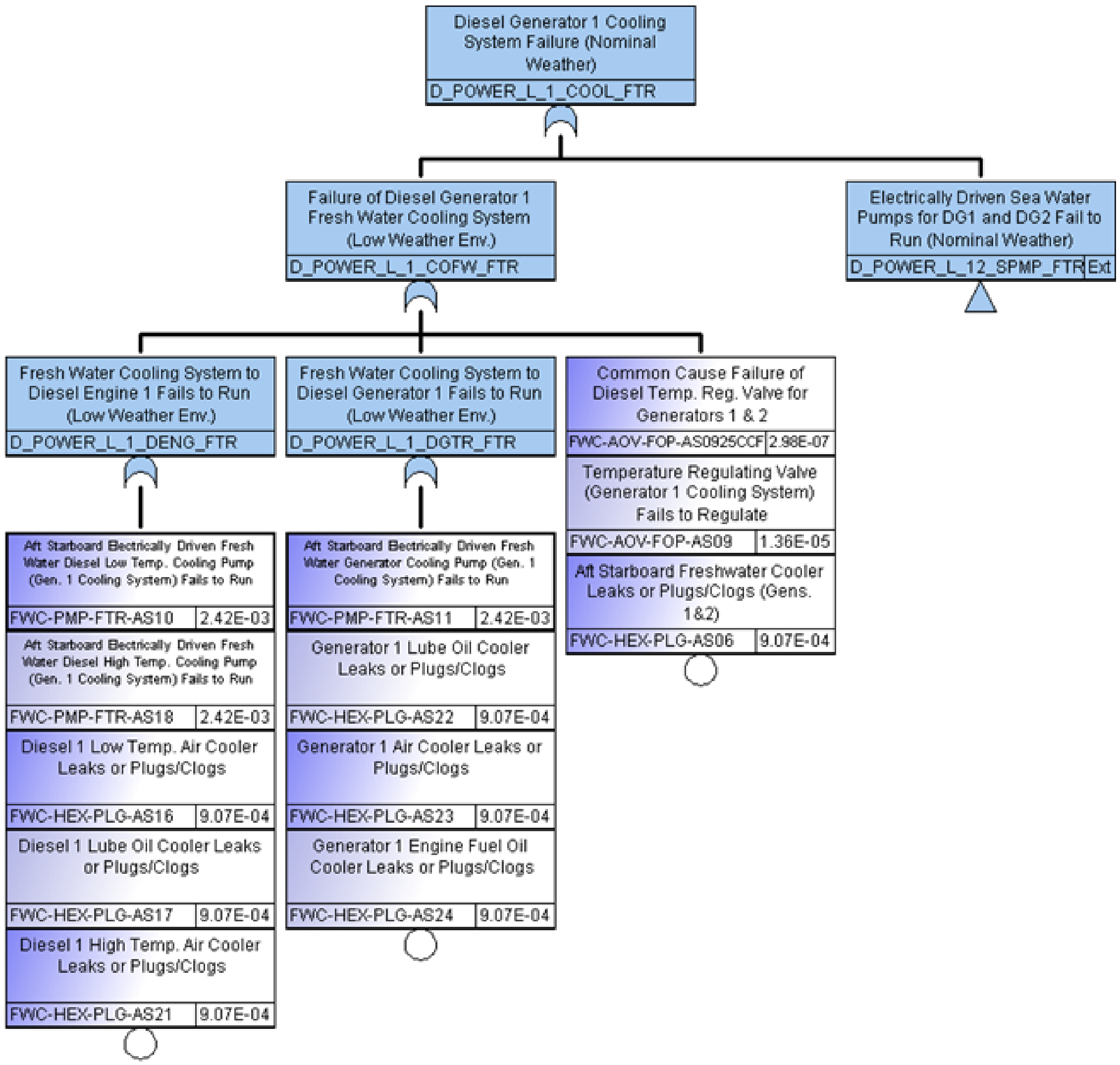


Figure C- 137: Initiating Events: Drift-off/Push-off (Continued)

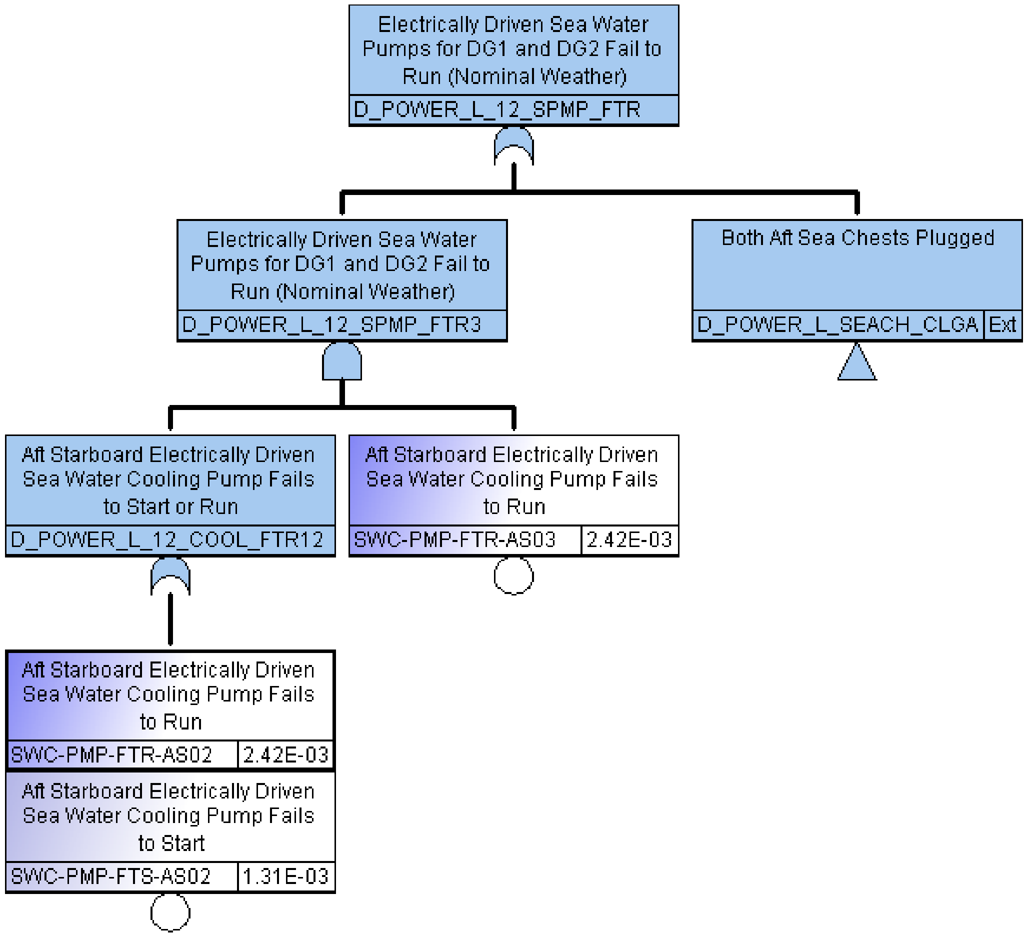


Figure C- 138: Initiating Events: Drift-off/Push-off (Continued)

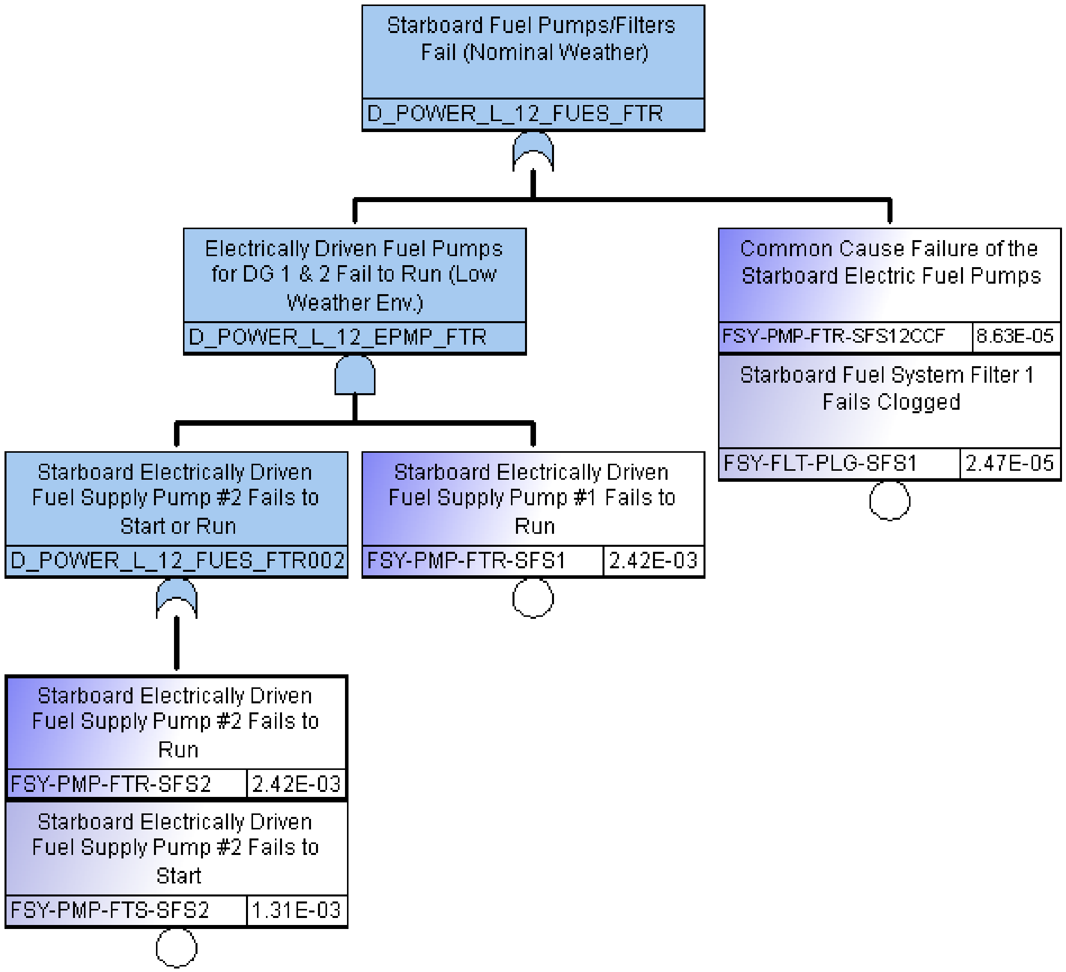


Figure C- 139: Initiating Events: Drift-off/Push-off (Continued)

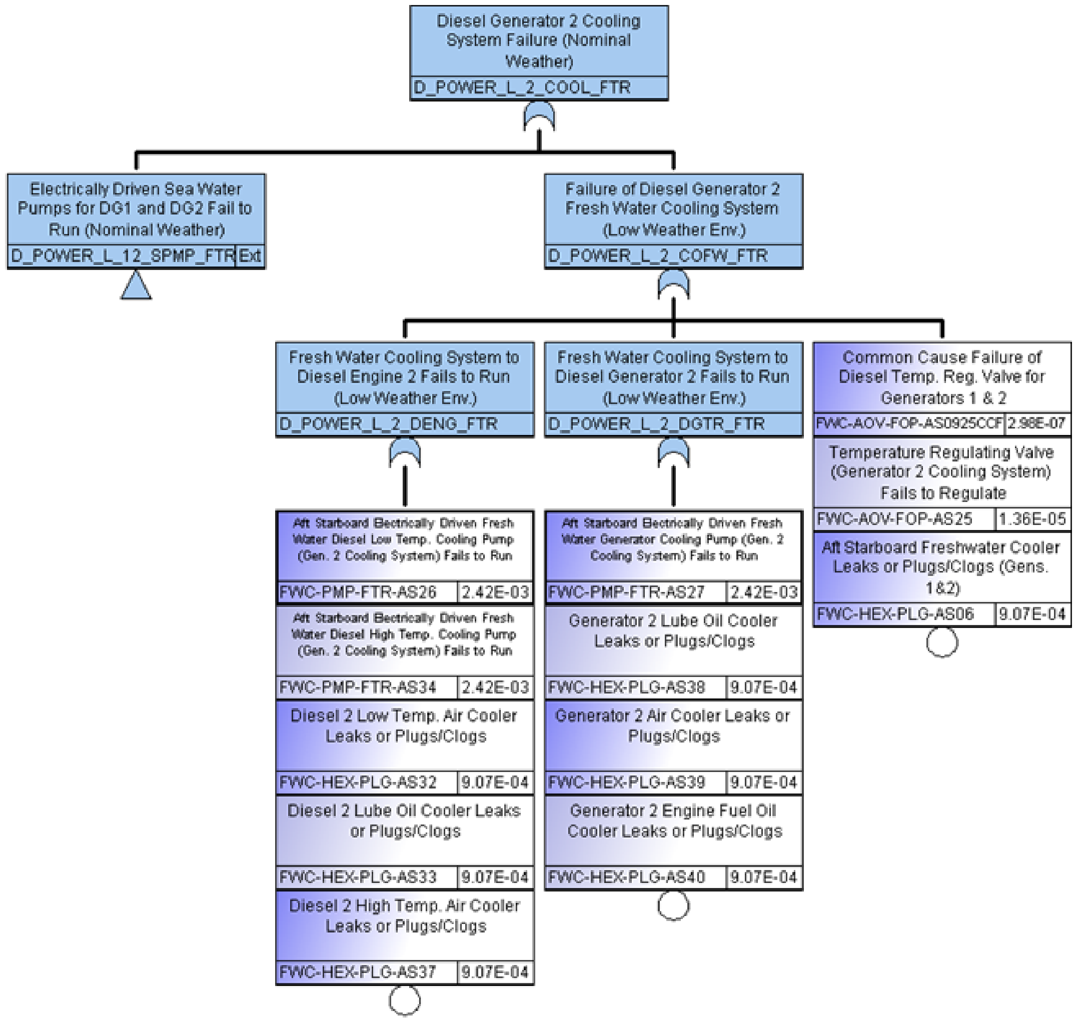


Figure C- 140: Initiating Events: Drift-off/Push-off (Continued)

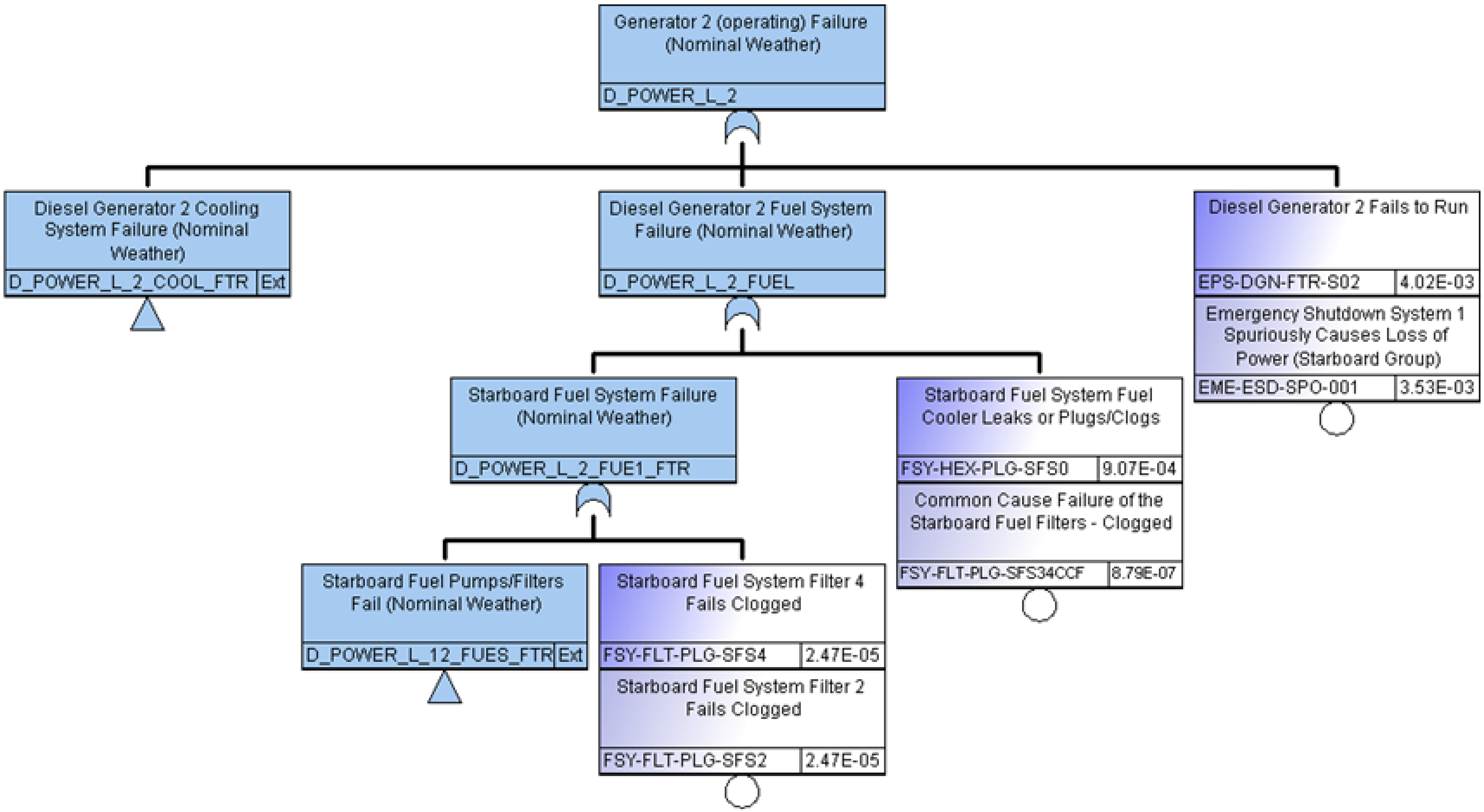


Figure C- 141: Initiating Events: Drift-off/Push-off (Continued)

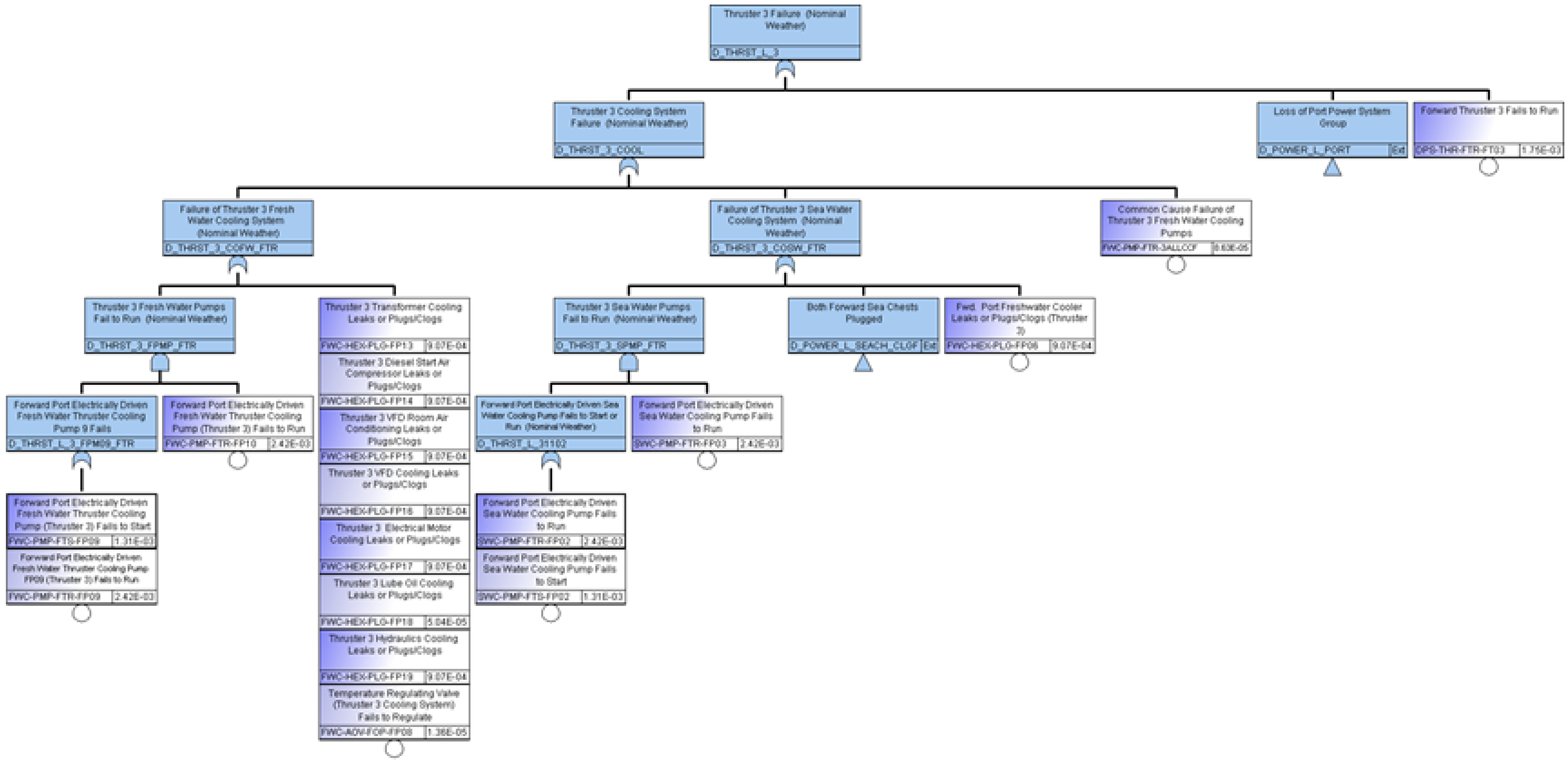


Figure C- 142: Initiating Events: Drift-off/Push-off (Continued)

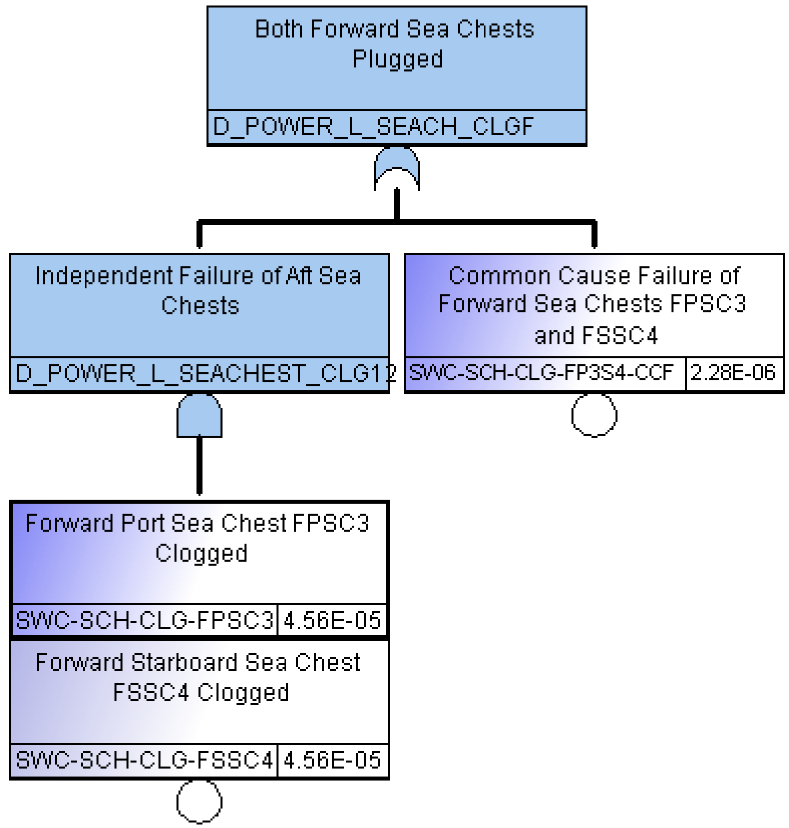


Figure C- 143: Initiating Events: Drift-off/Push-off (Continued)

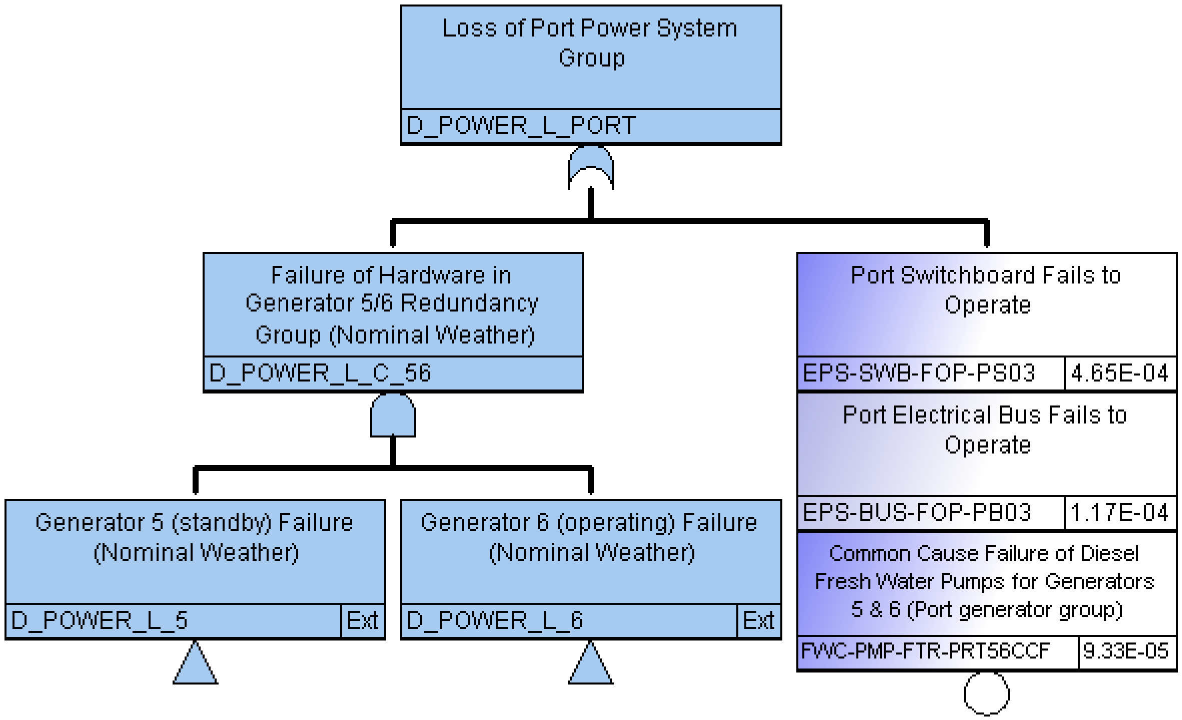


Figure C- 144: Initiating Events: Drift-off/Push-off (Continued)

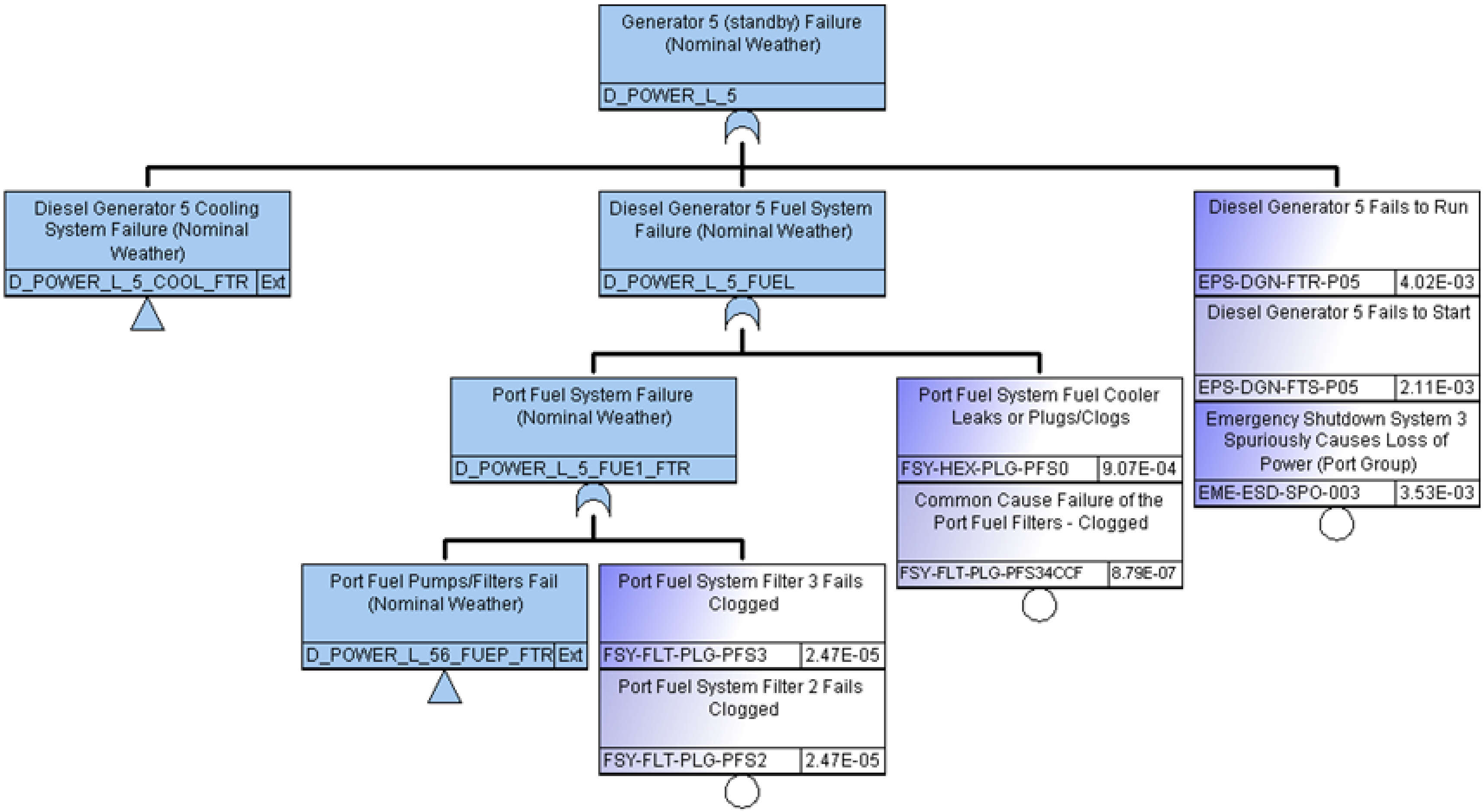


Figure C- 145: Initiating Events: Drift-off/Push-off (Continued)

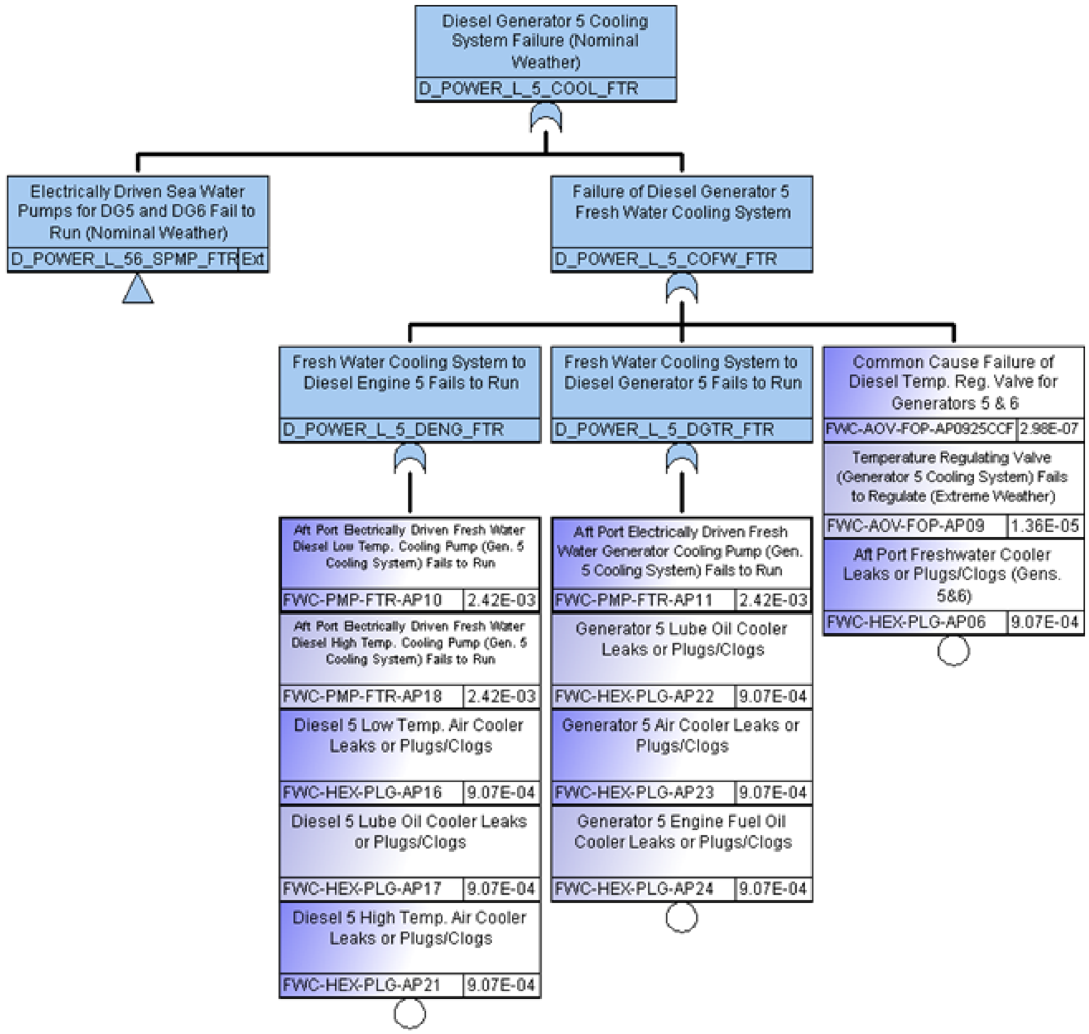


Figure C- 146: Initiating Events: Drift-off/Push-off (Continued)

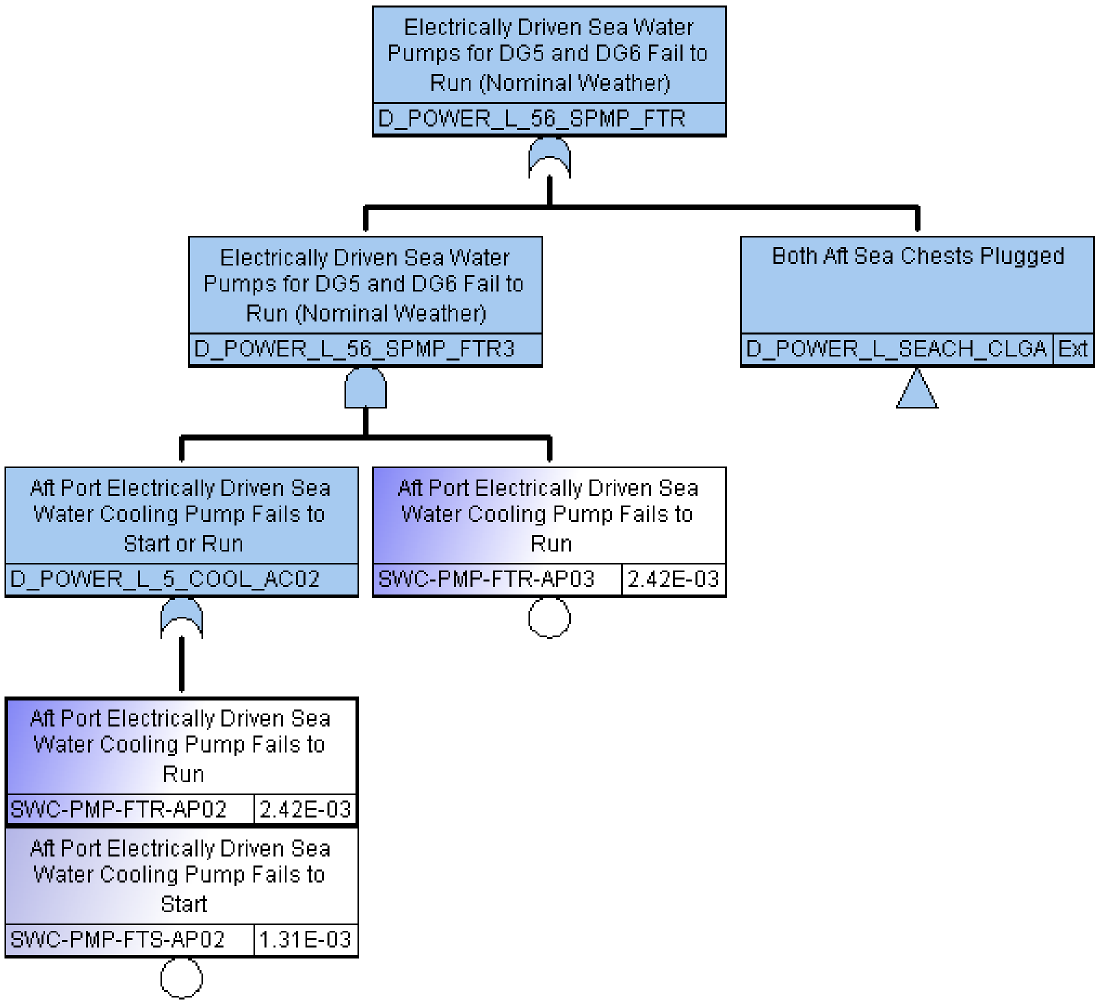


Figure C- 147: Initiating Events: Drift-off/Push-off (Continued)

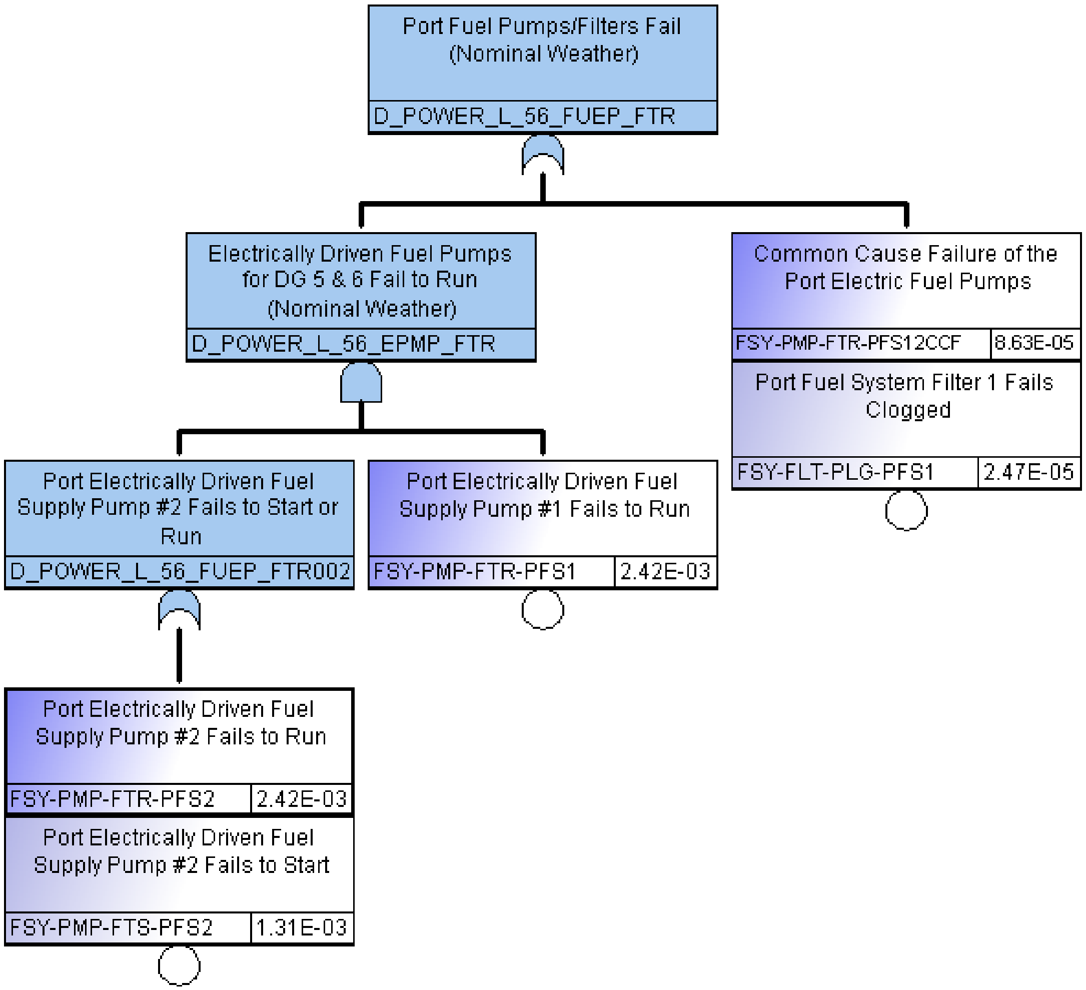


Figure C- 148: Initiating Events: Drift-off/Push-off (Continued)

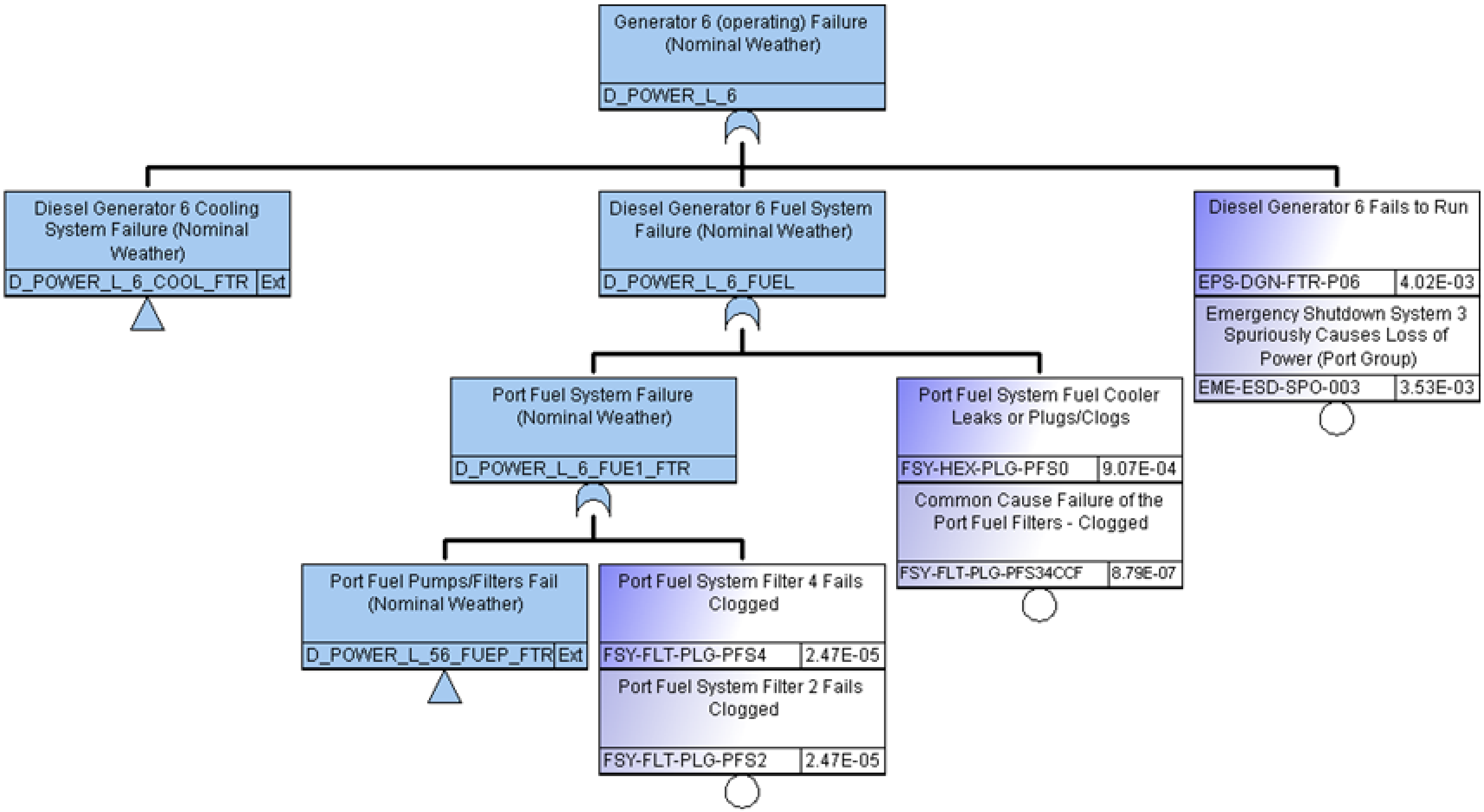


Figure C- 149: Initiating Events: Drift-off/Push-off (Continued)

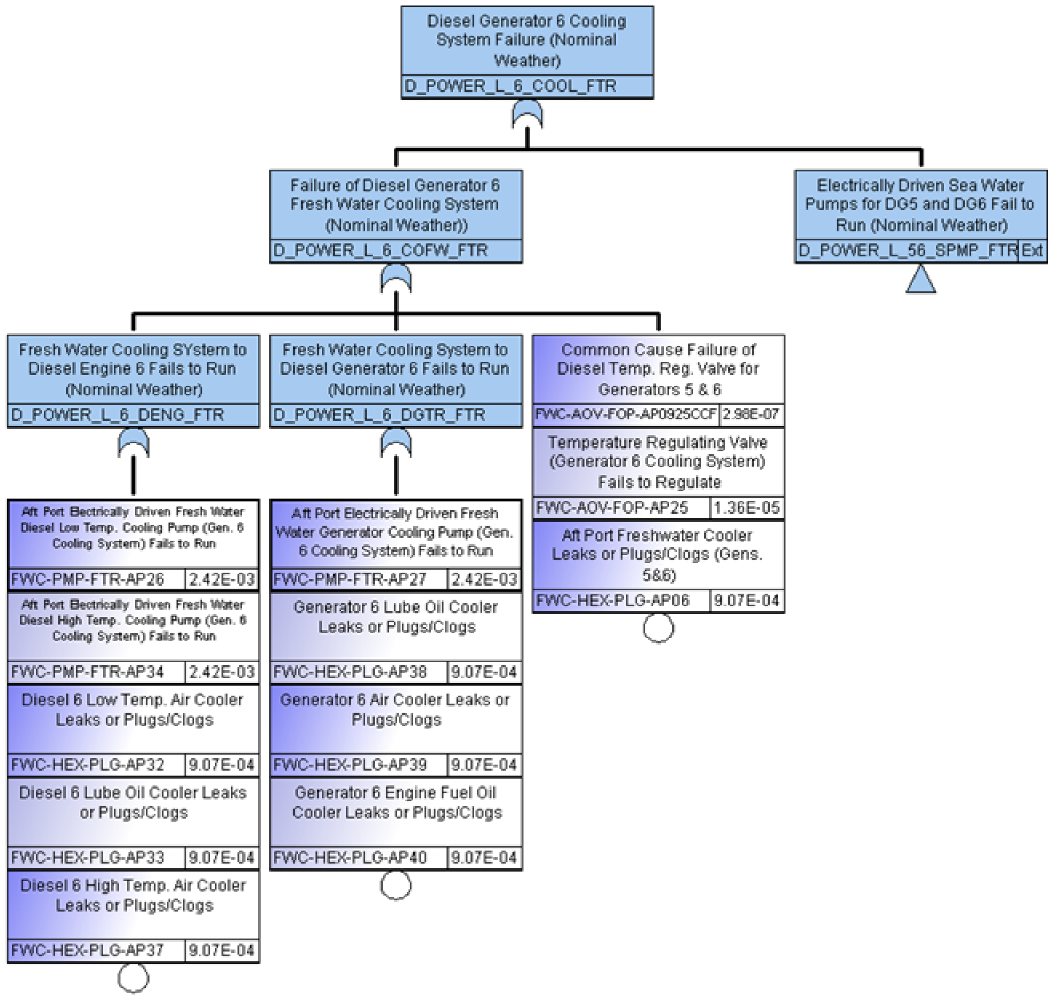


Figure C- 150: Initiating Events: Drift-off/Push-off (Continued)

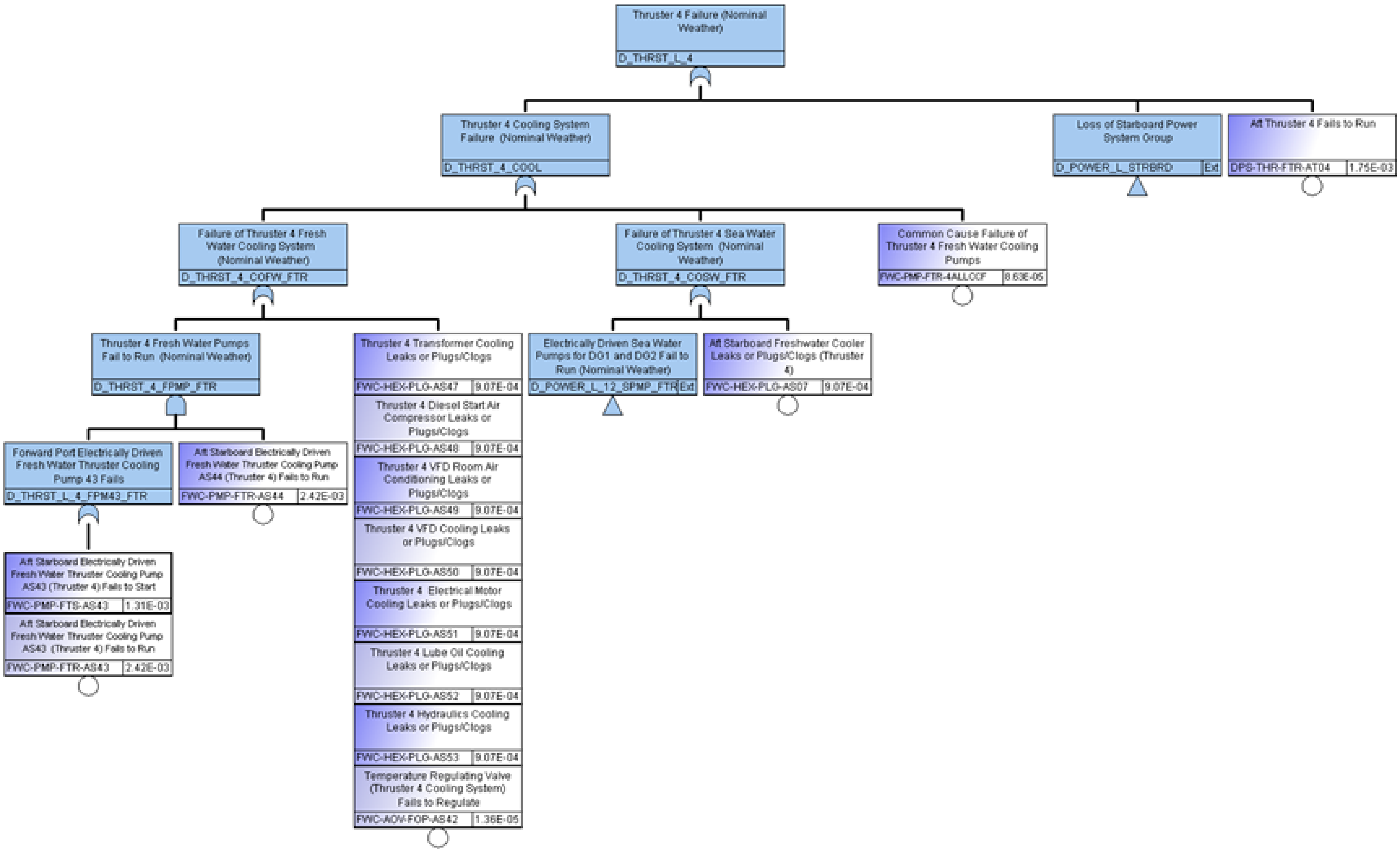


Figure C- 151: Initiating Events: Drift-off/Push-off (Continued)

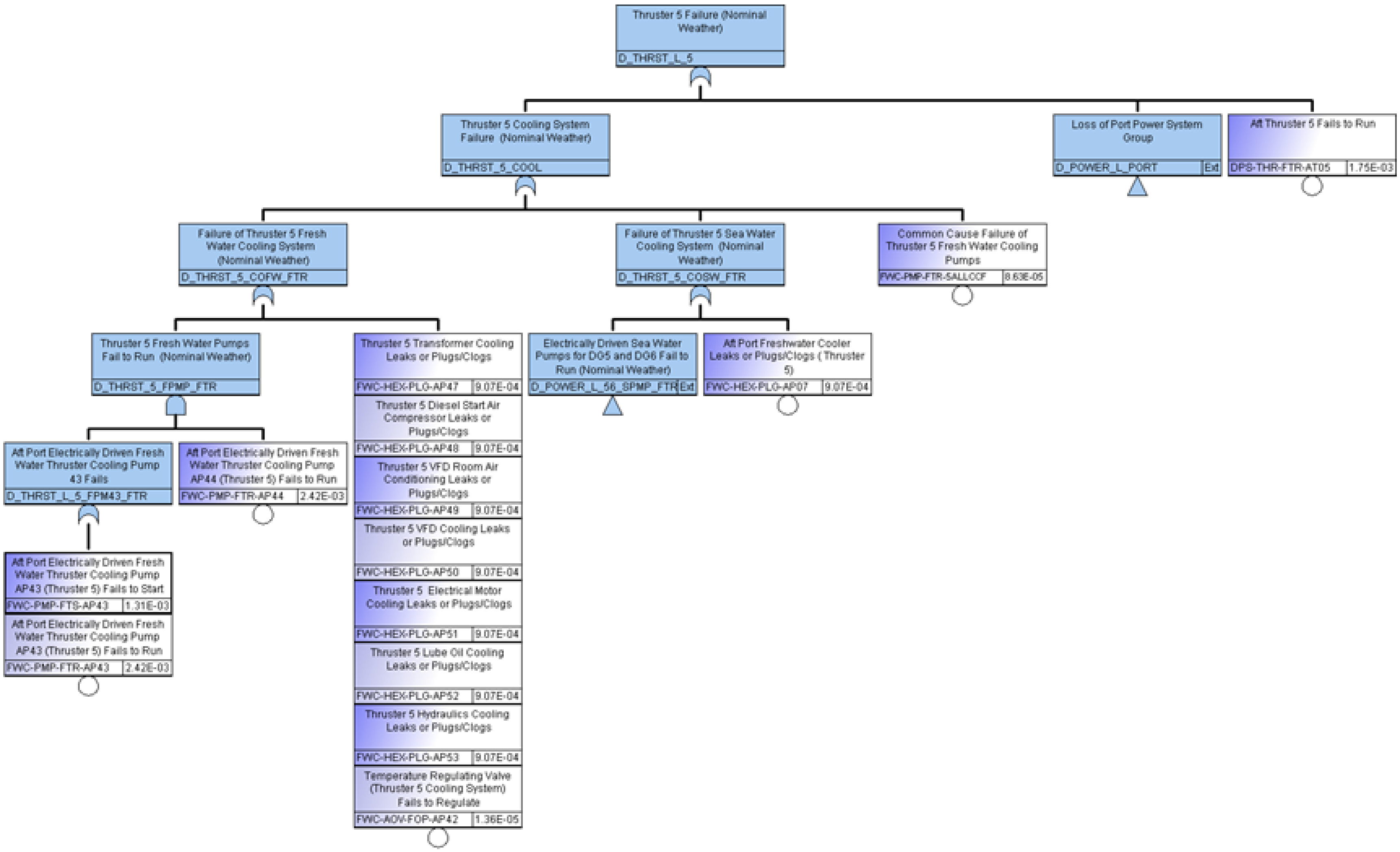


Figure C- 152: Initiating Events: Drift-off/Push-off (Continued)

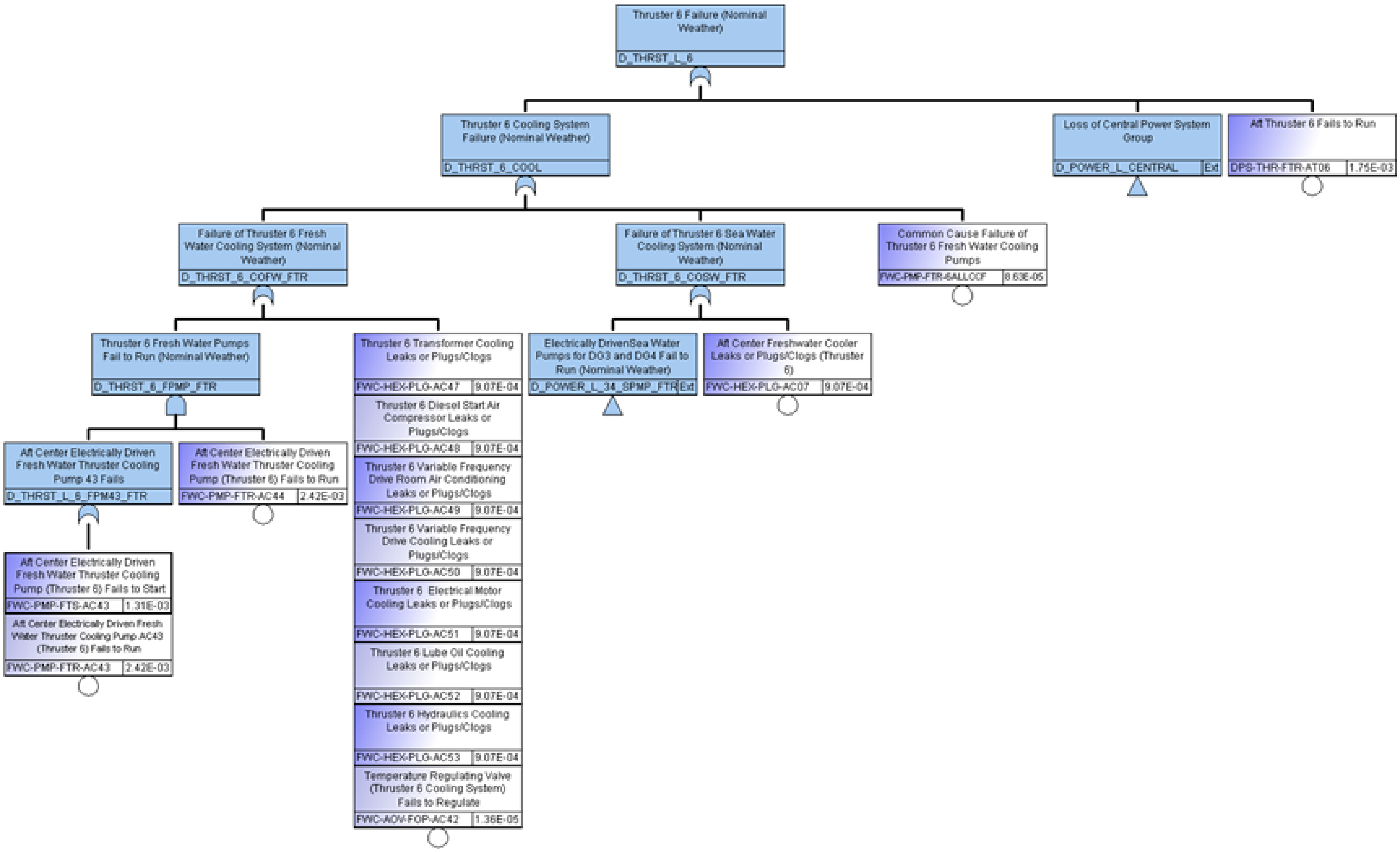


Figure C- 153: Initiating Events: Drift-off/Push-off (Continued)

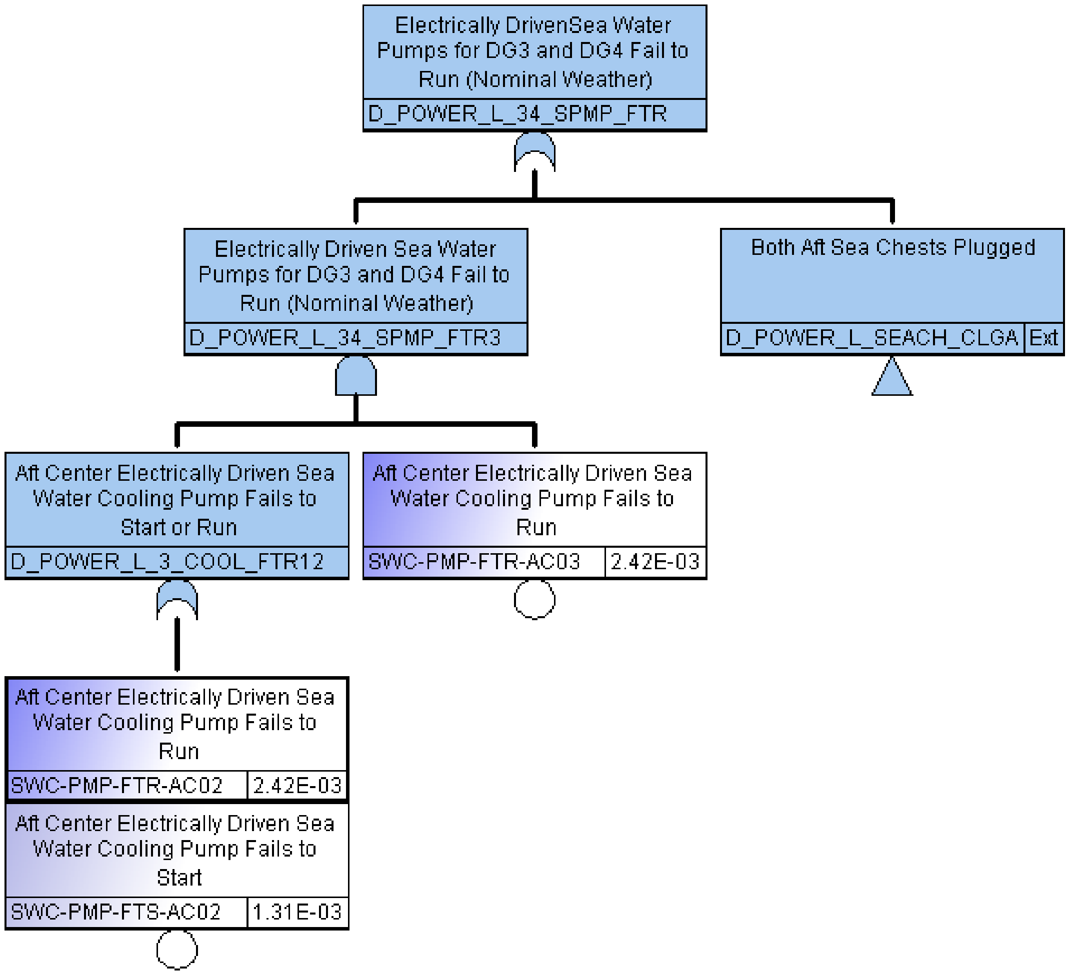


Figure C- 154: Initiating Events: Drift-off/Push-off (Continued)

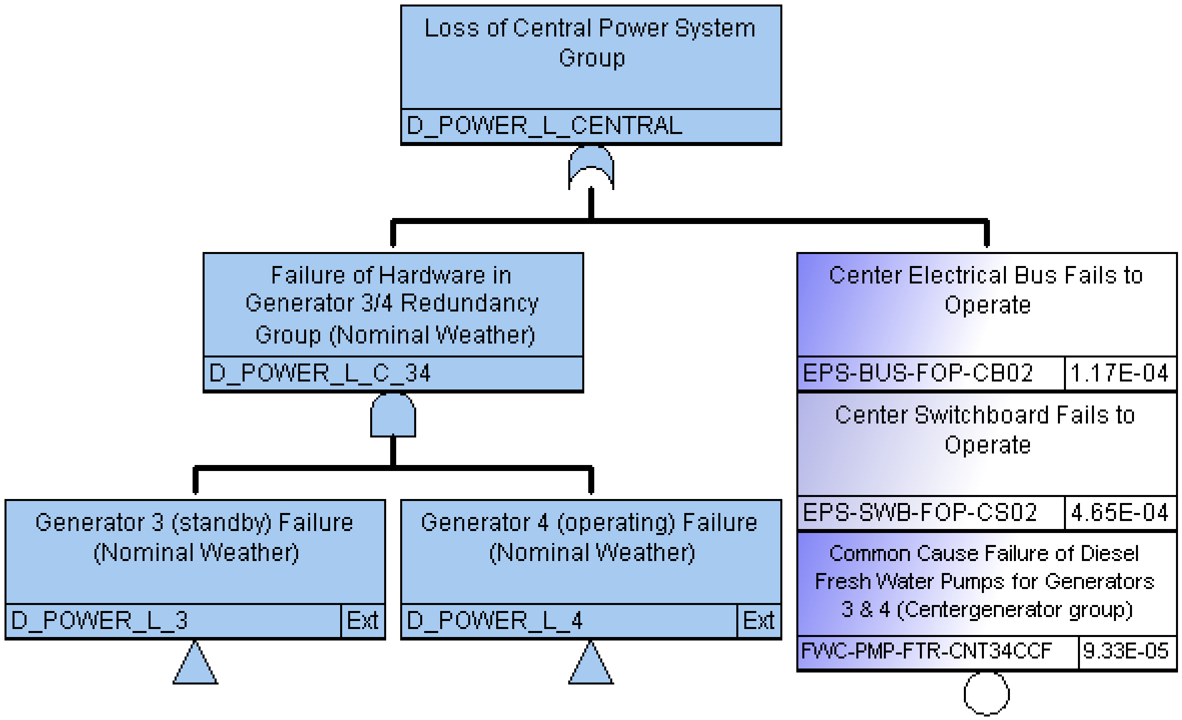


Figure C- 155: Initiating Events: Drift-off/Push-off (Continued)

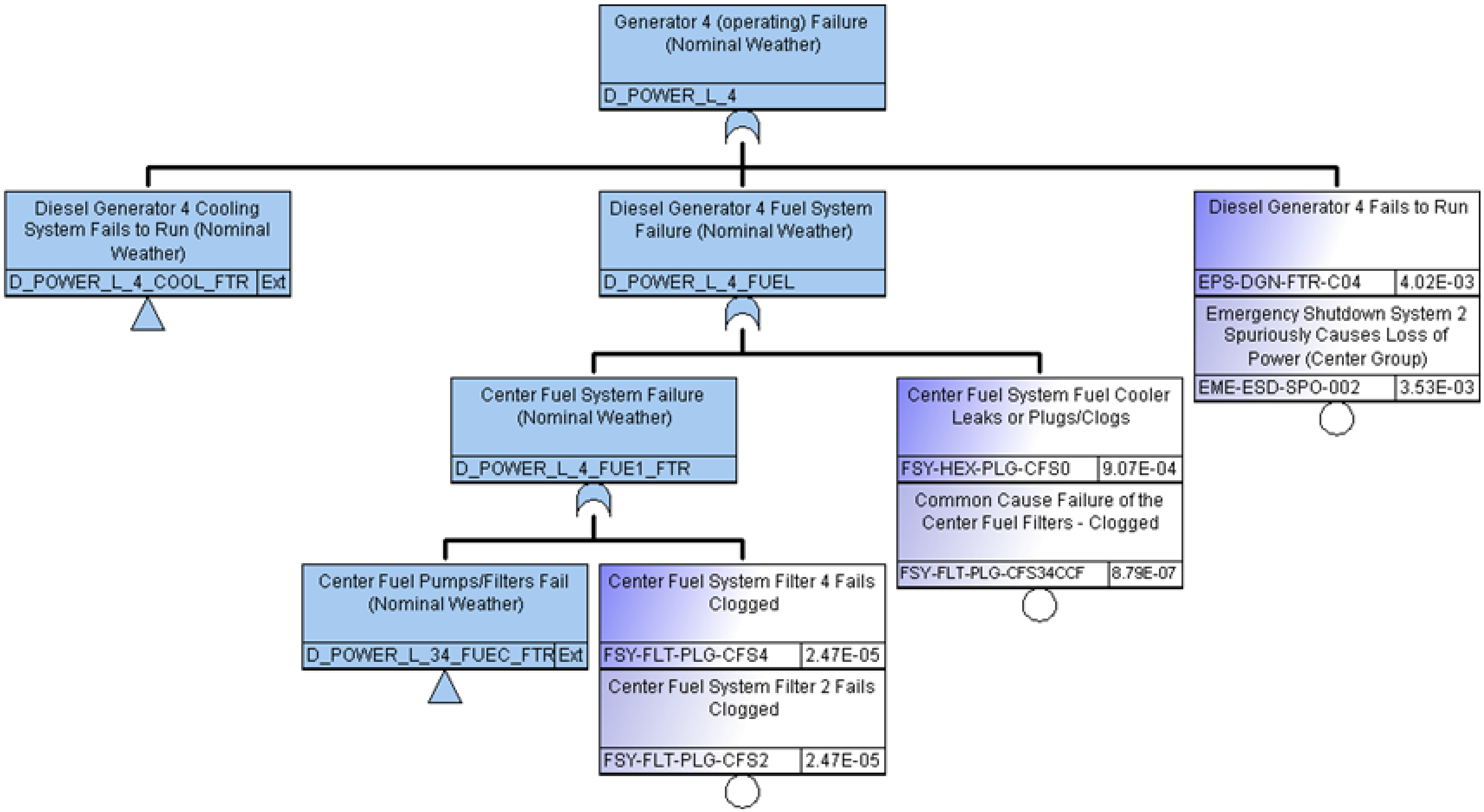


Figure C- 156: Initiating Events: Drift-off/Push-off (Continued)

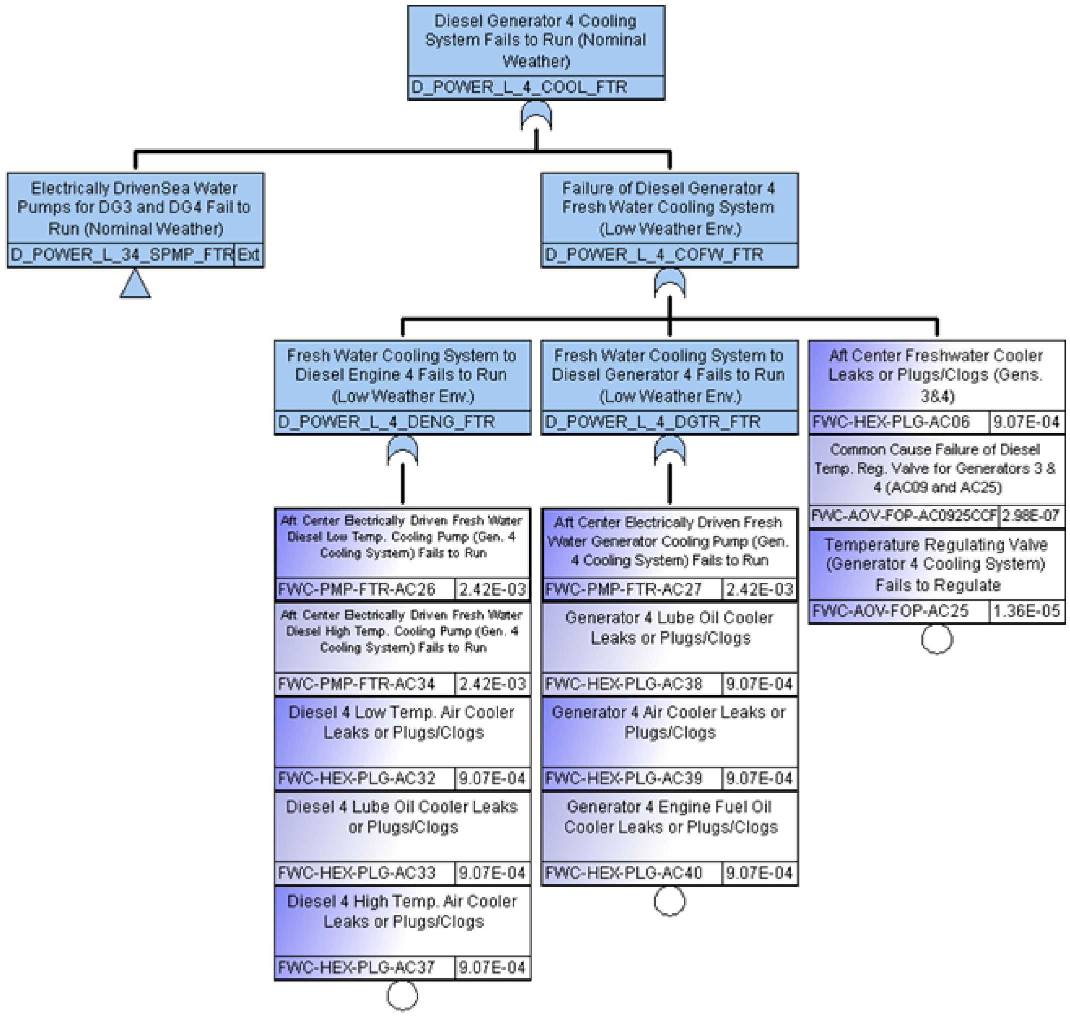


Figure C- 157: Initiating Events: Drift-off/Push-off (Continued)

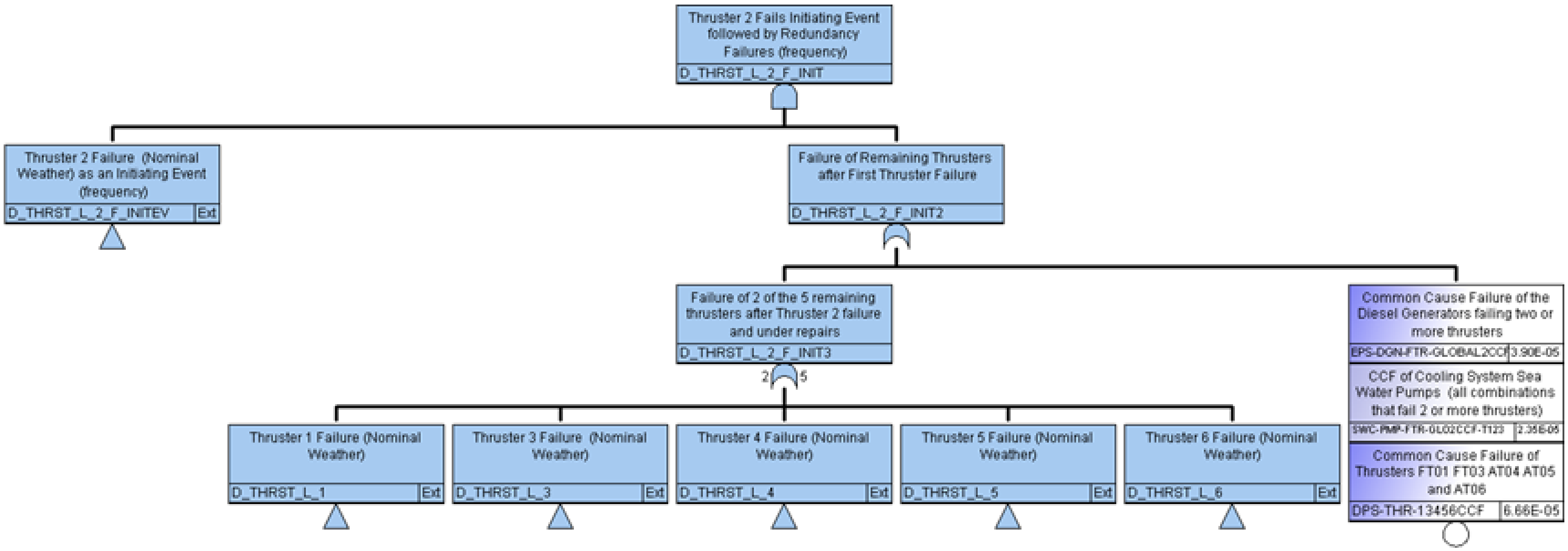


Figure C- 158: Initiating Events: Drift-off/Push-off (Continued)

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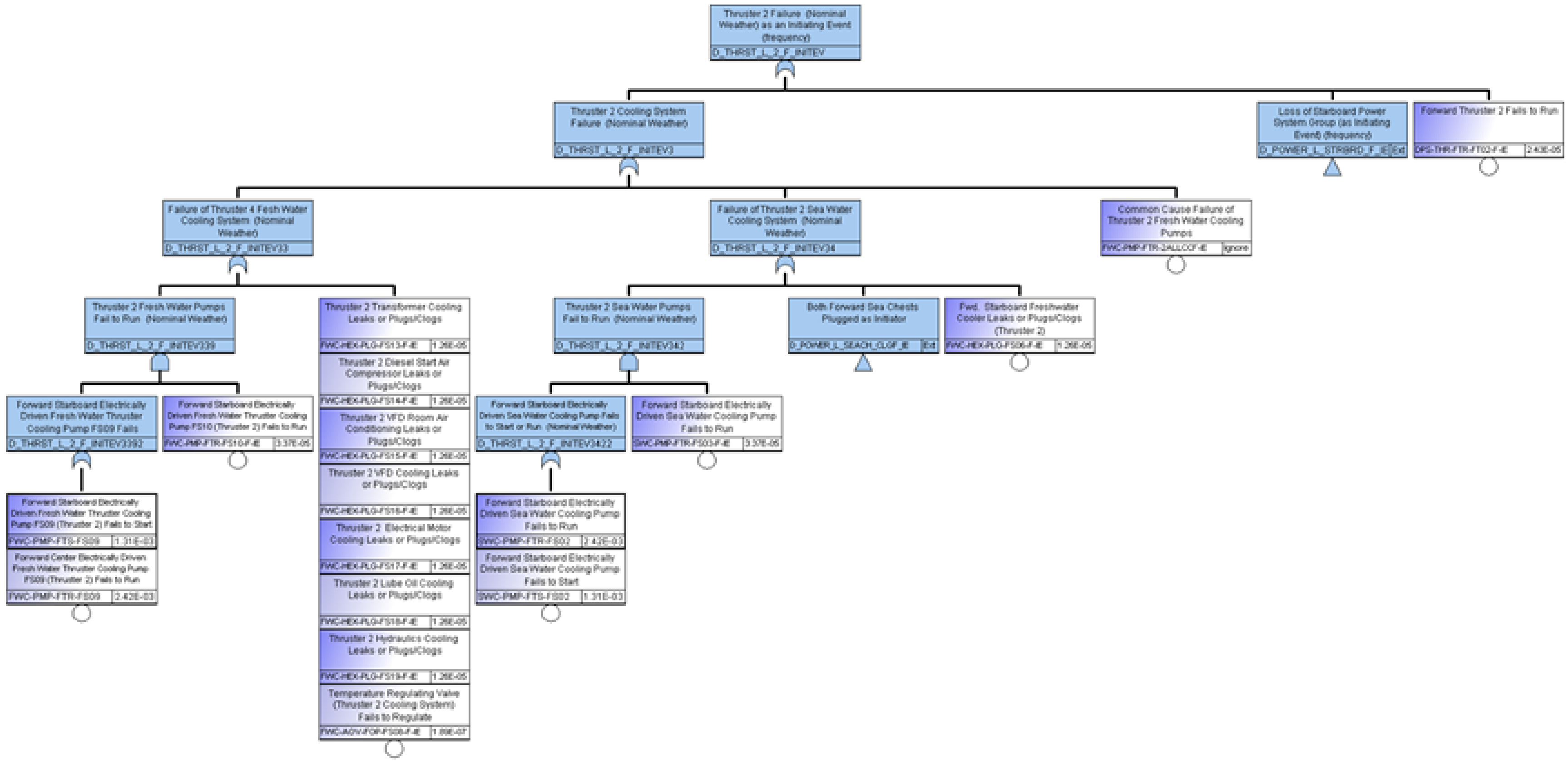

Figure C- 159: Initiating Events: Drift-off/Push-off (Continued)

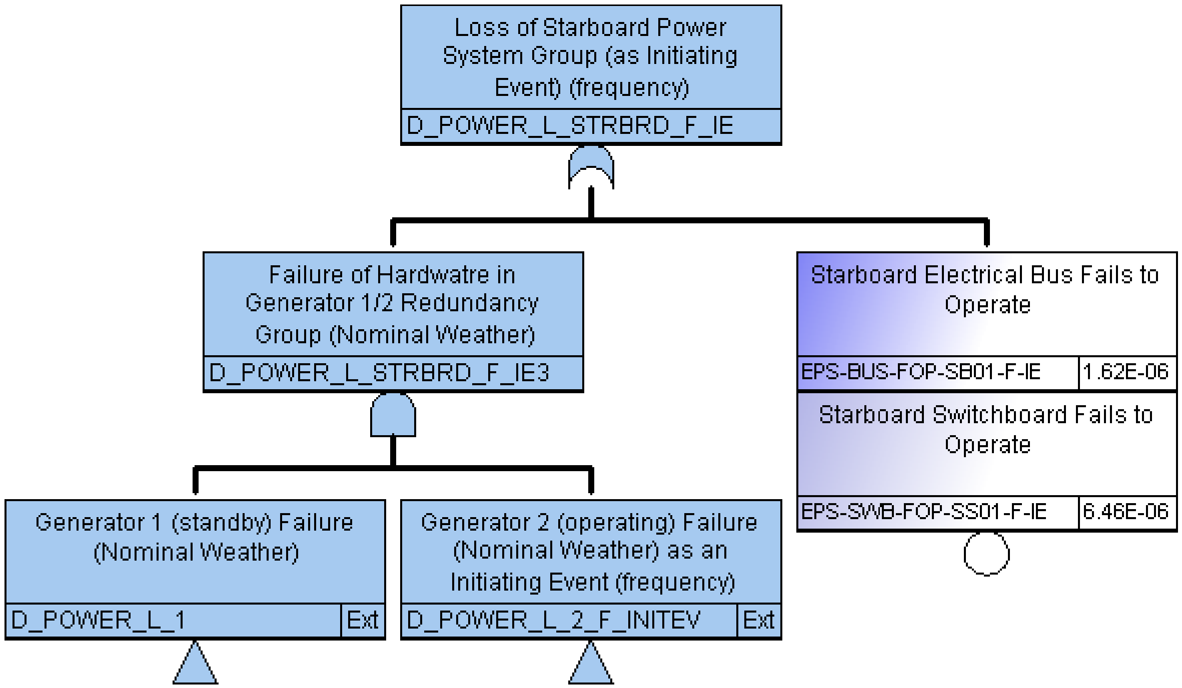

Figure C- 160: Initiating Events: Drift-off/Push-off (Continued)

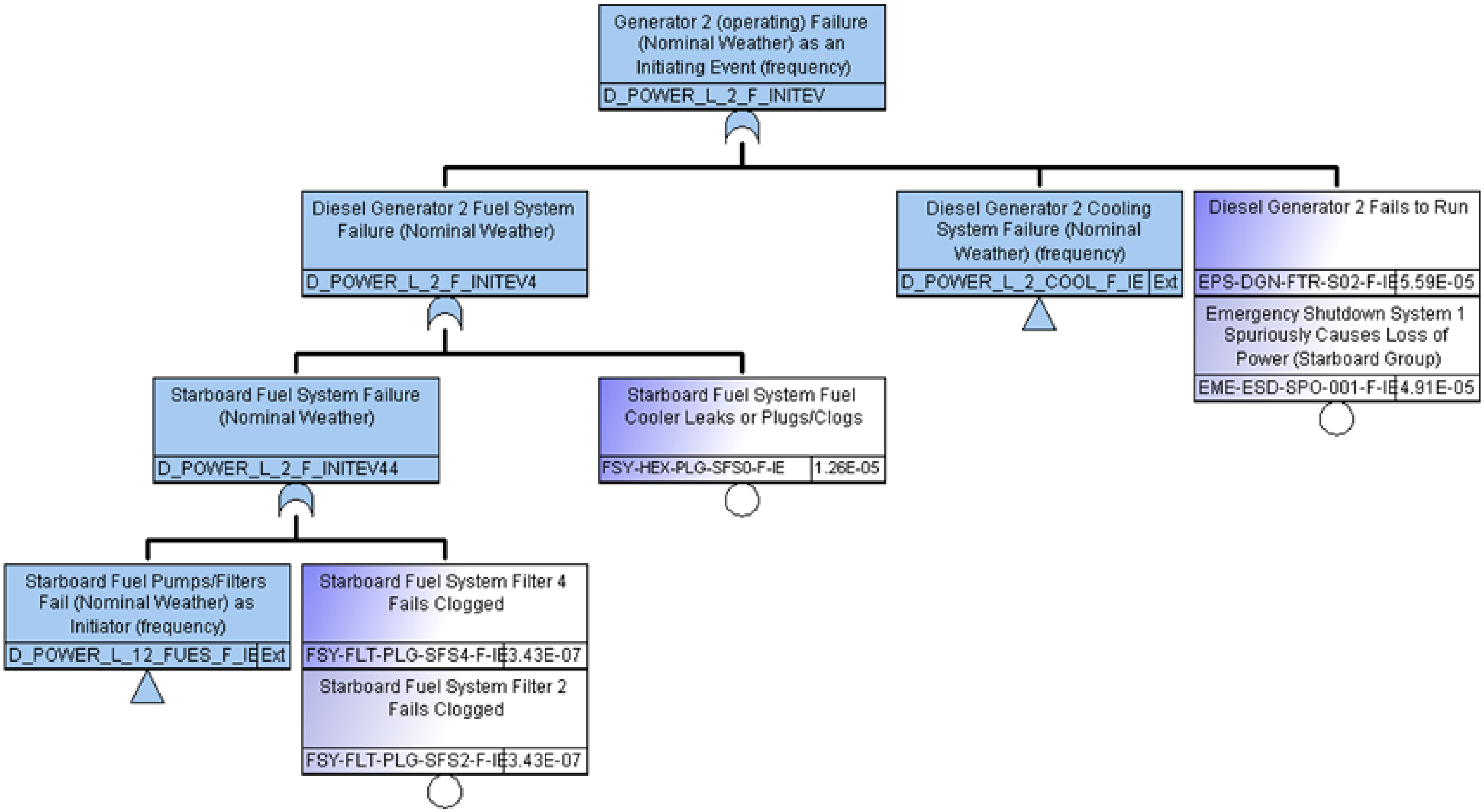

Figure C- 161: Initiating Events: Drift-off/Push-off (Continued)

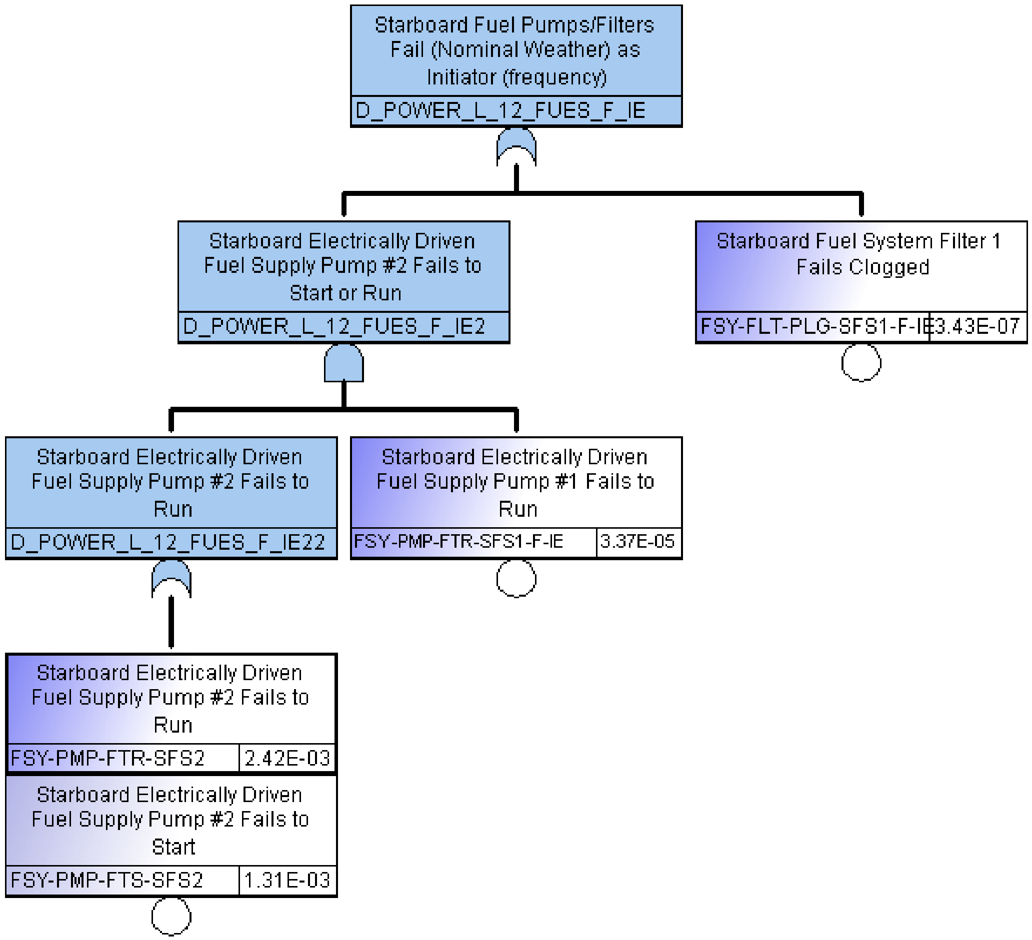

Figure C- 162: Initiating Events: Drift-off/Push-off (Continued)

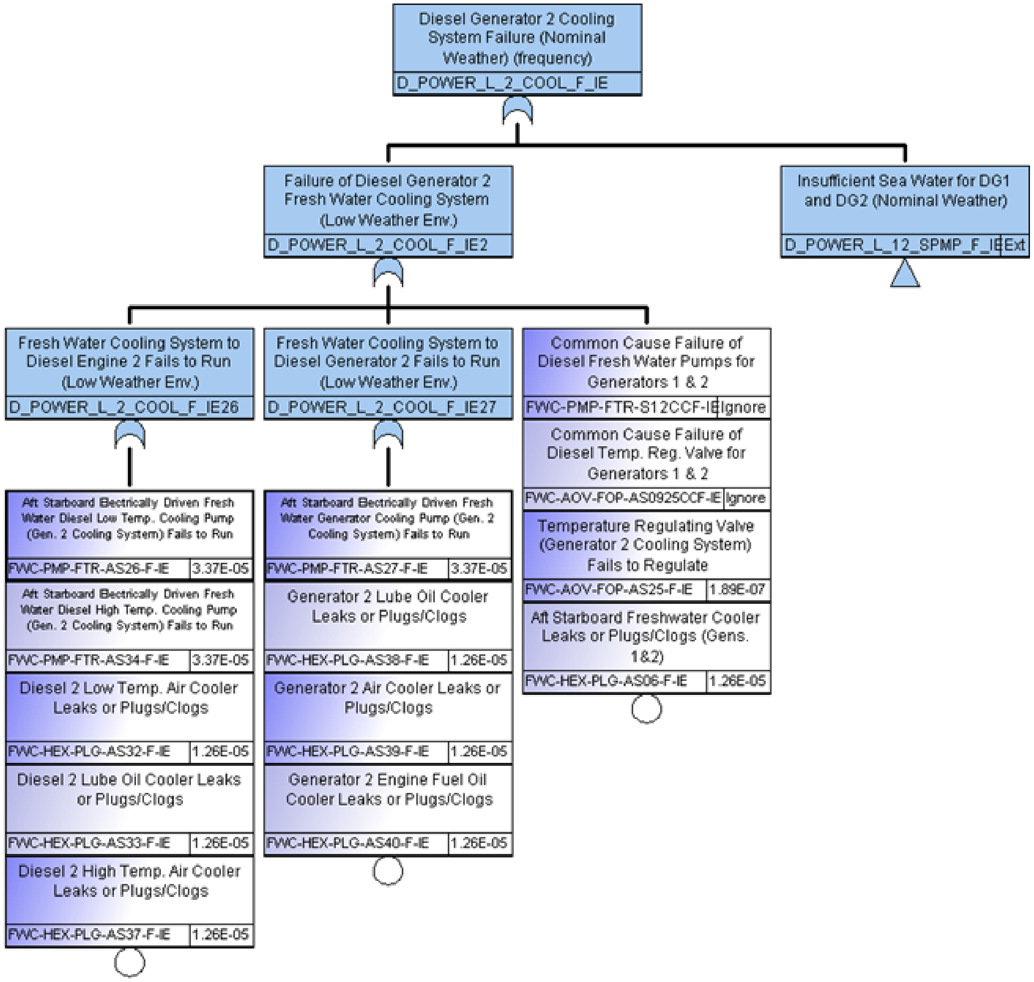

Figure C- 163: Initiating Events: Drift-off/Push-off (Continued)

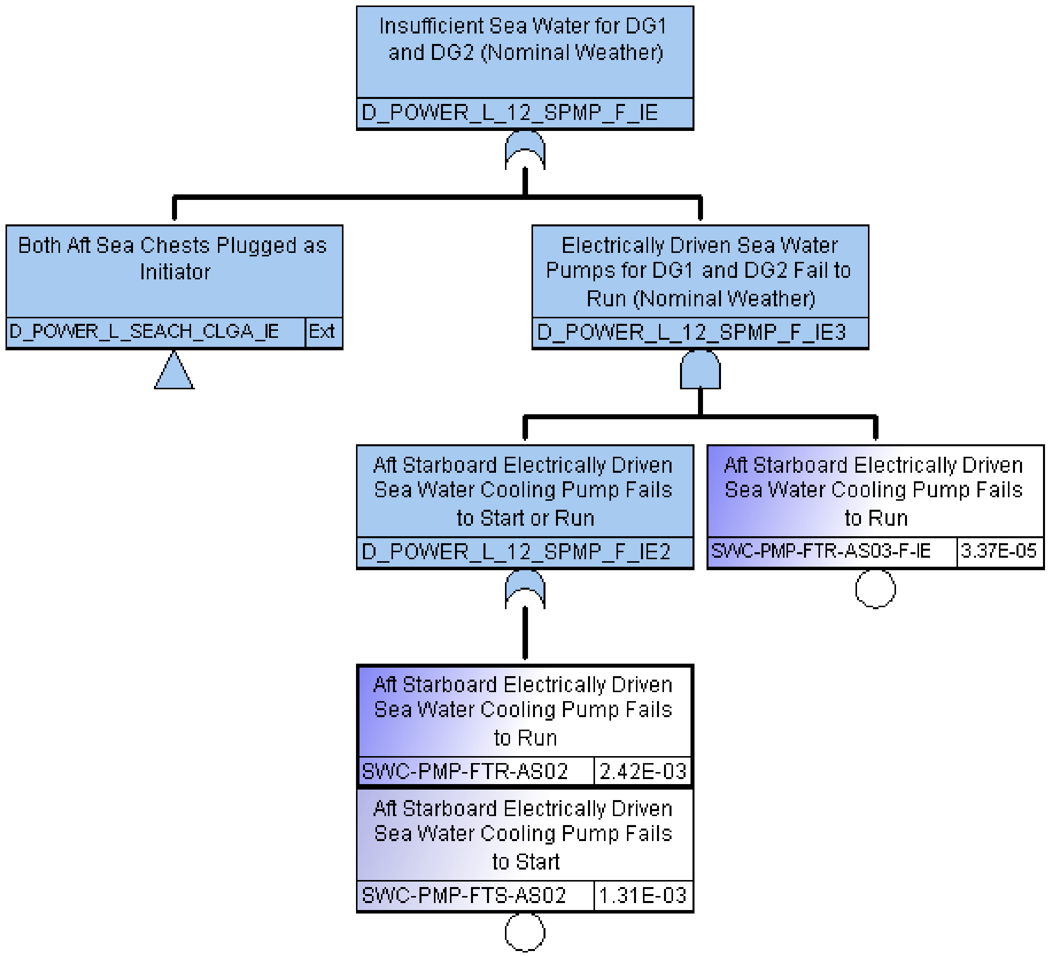

Figure C- 164: Initiating Events: Drift-off/Push-off (Continued)

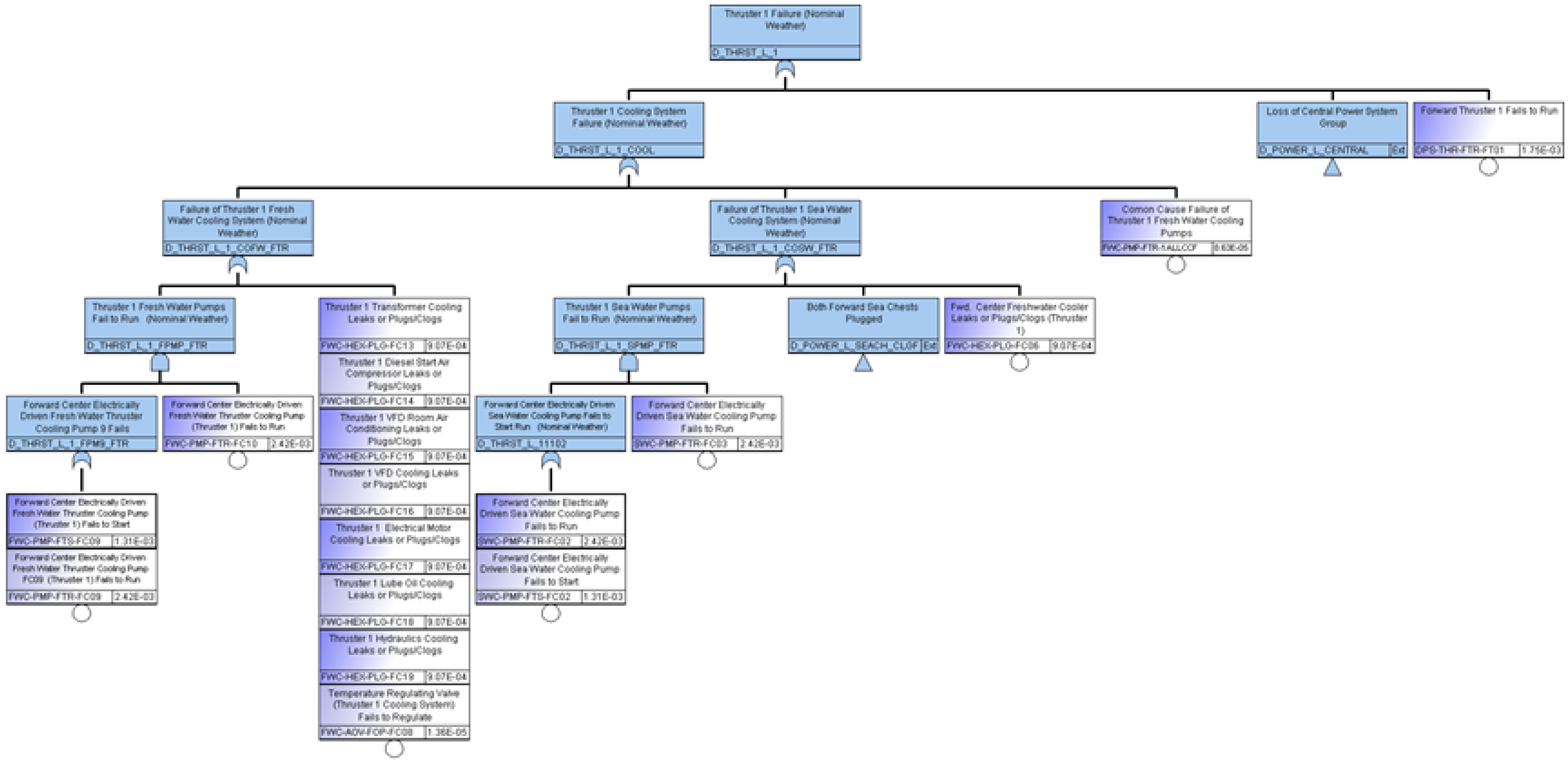

Figure C- 165: Initiating Events: Drift-off/Push-off (Continued)

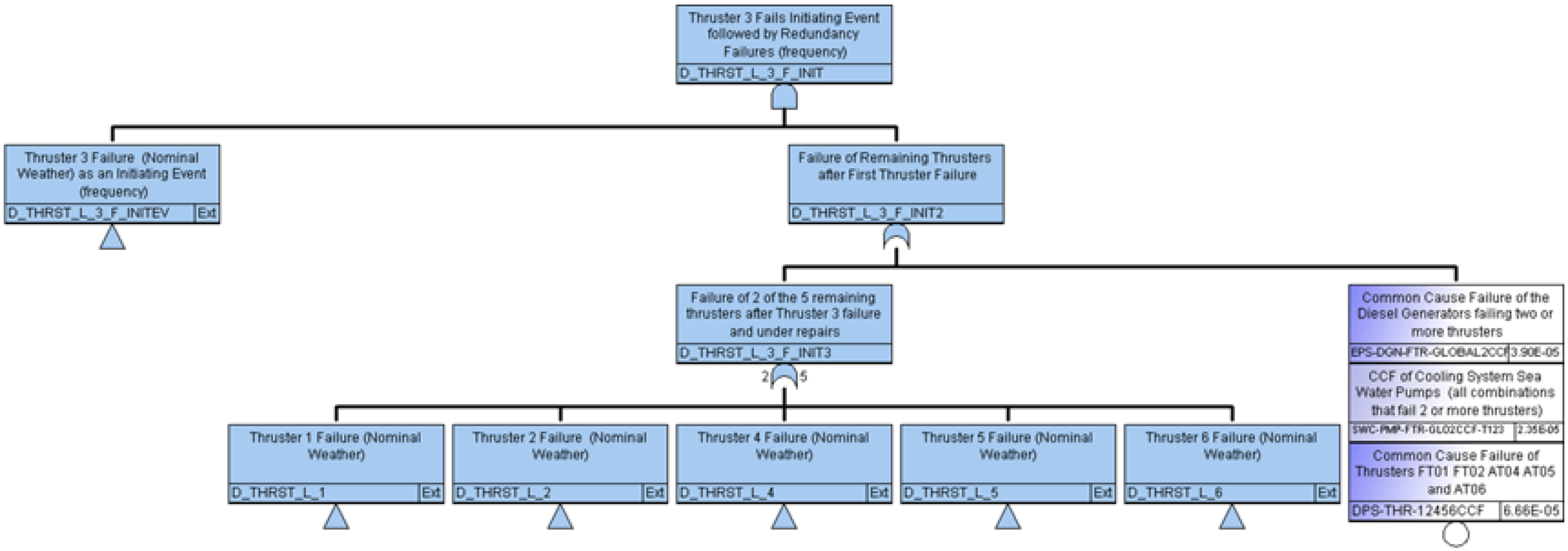

Figure C- 166: Initiating Events: Drift-off/Push-off (Continued)

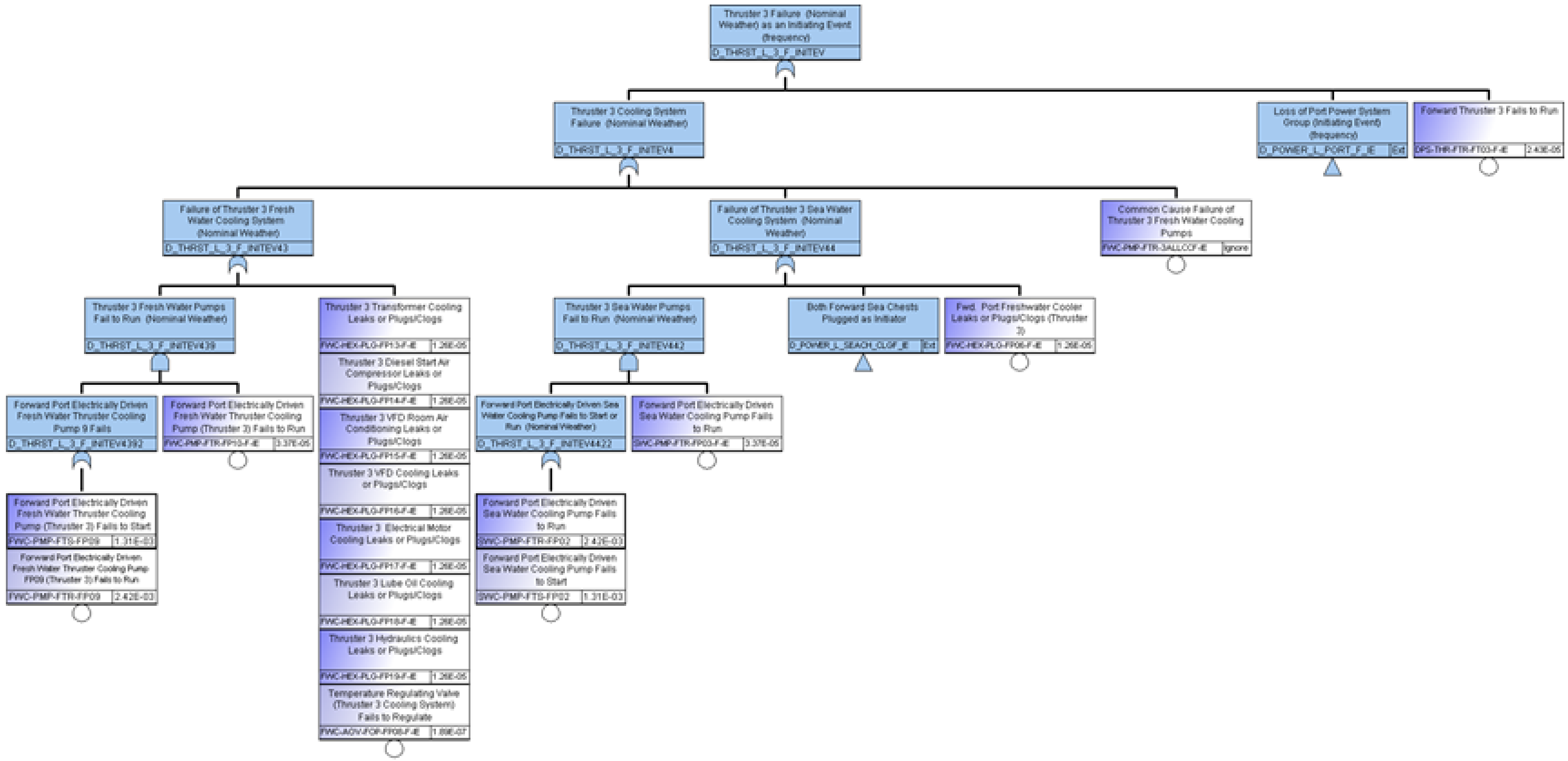

Figure C- 167: Initiating Events: Drift-off/Push-off (Continued)

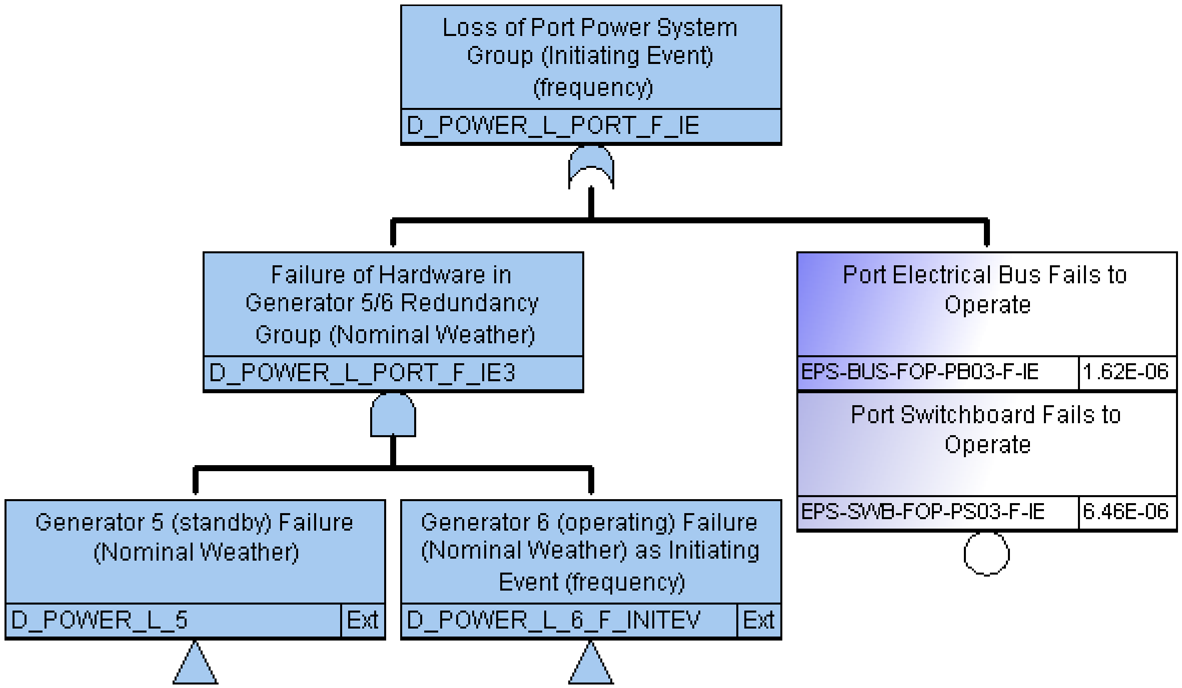

Figure C- 168: Initiating Events: Drift-off/Push-off (Continued)

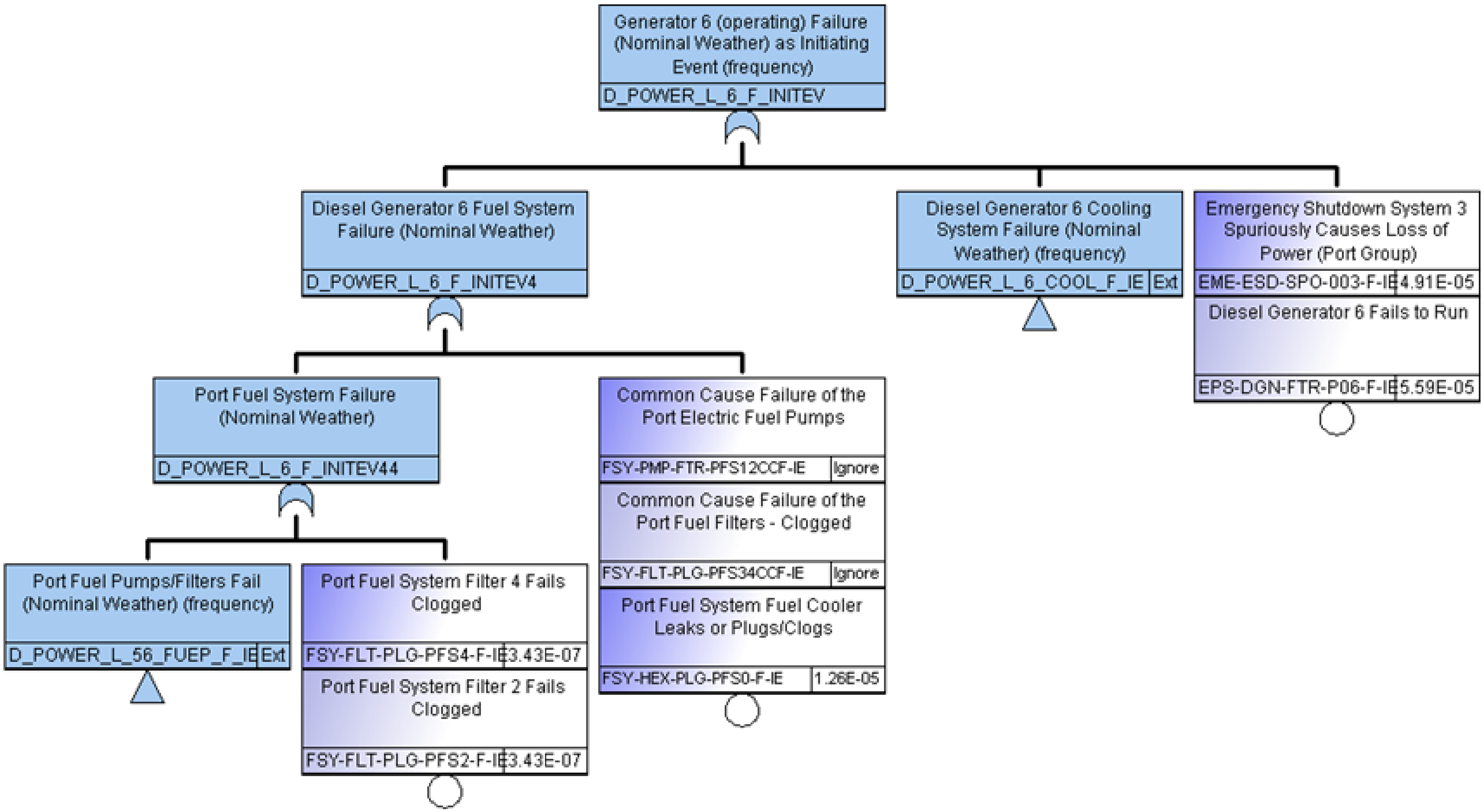

Figure C- 169: Initiating Events: Drift-off/Push-off (Continued)

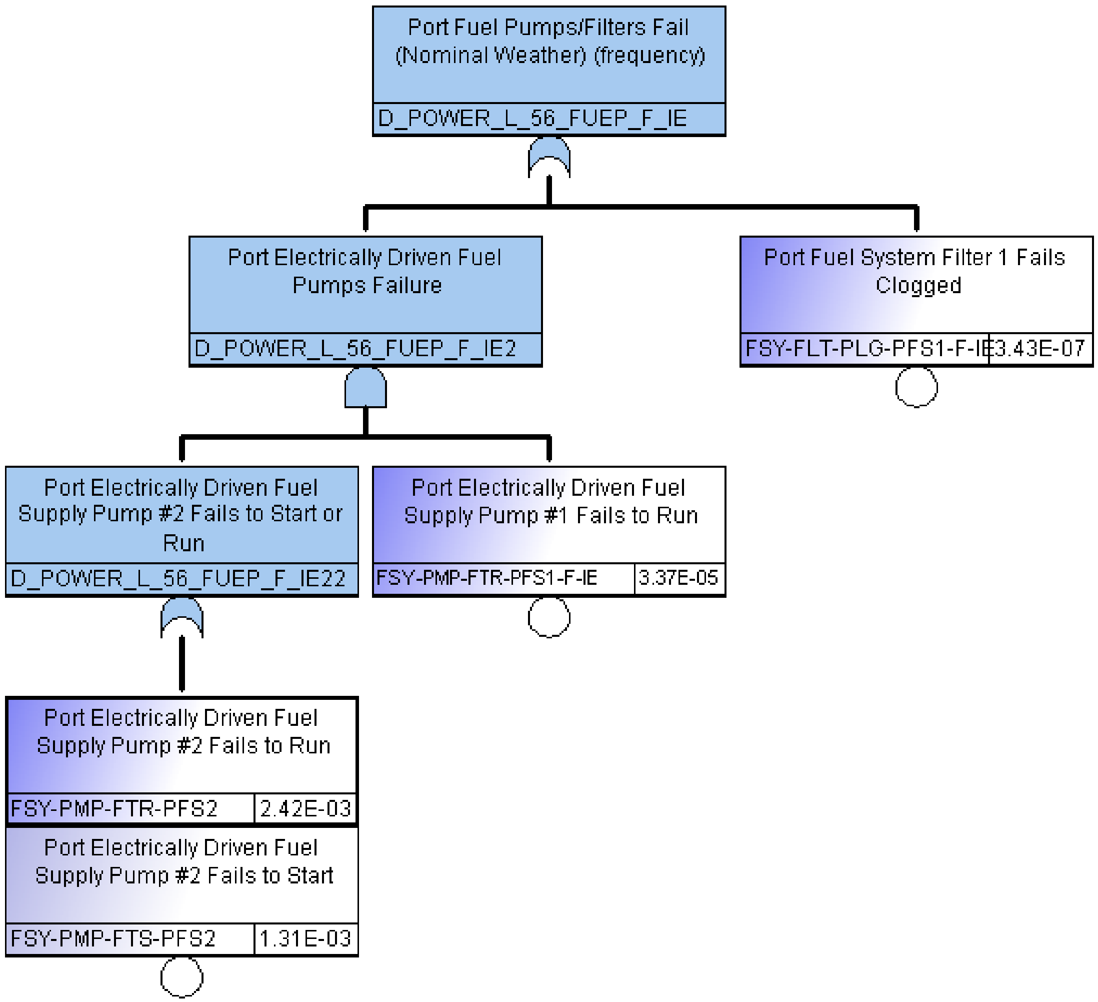

Figure C- 170: Initiating Events: Drift-off/Push-off (Continued)

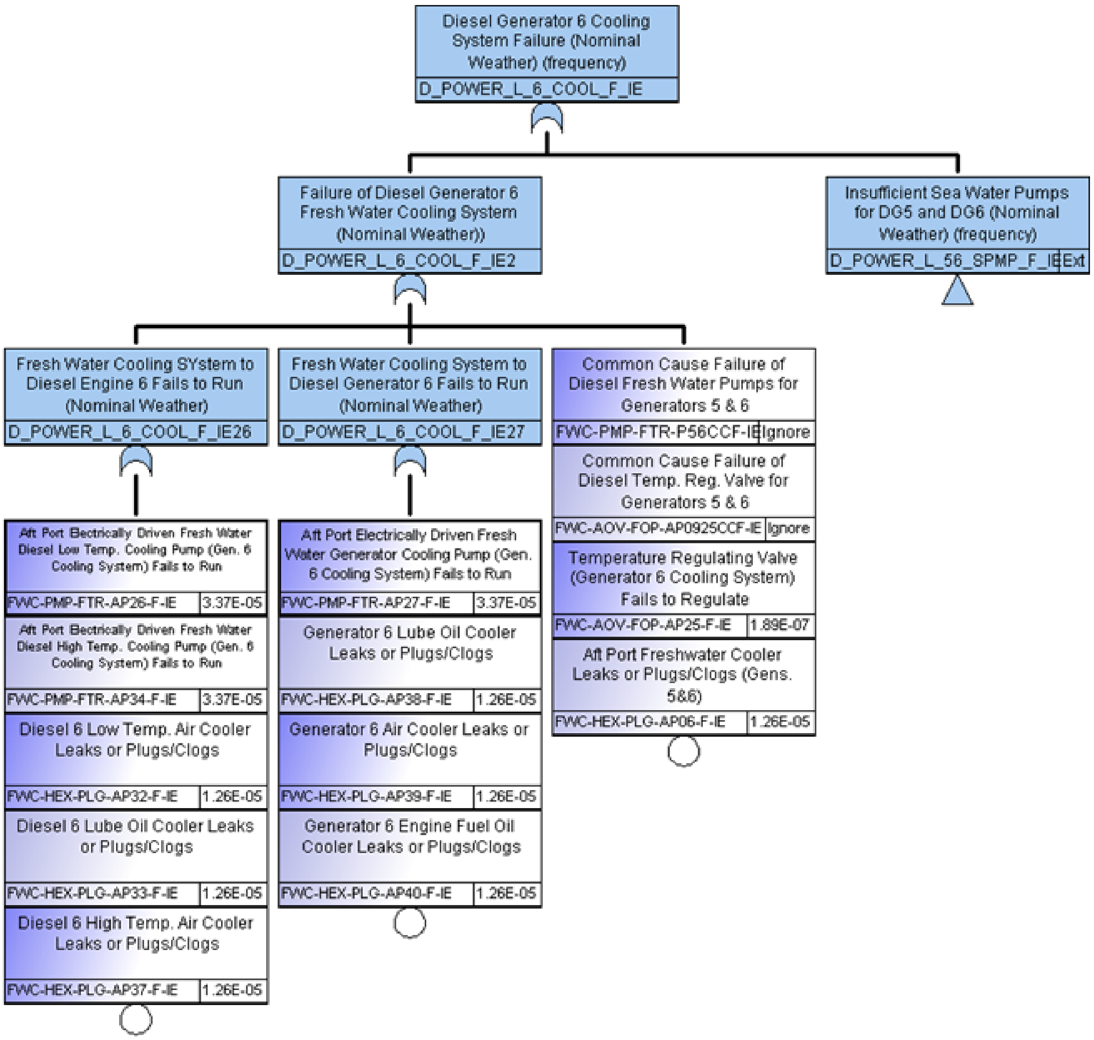

Figure C- 171: Initiating Events: Drift-off/Push-off (Continued)

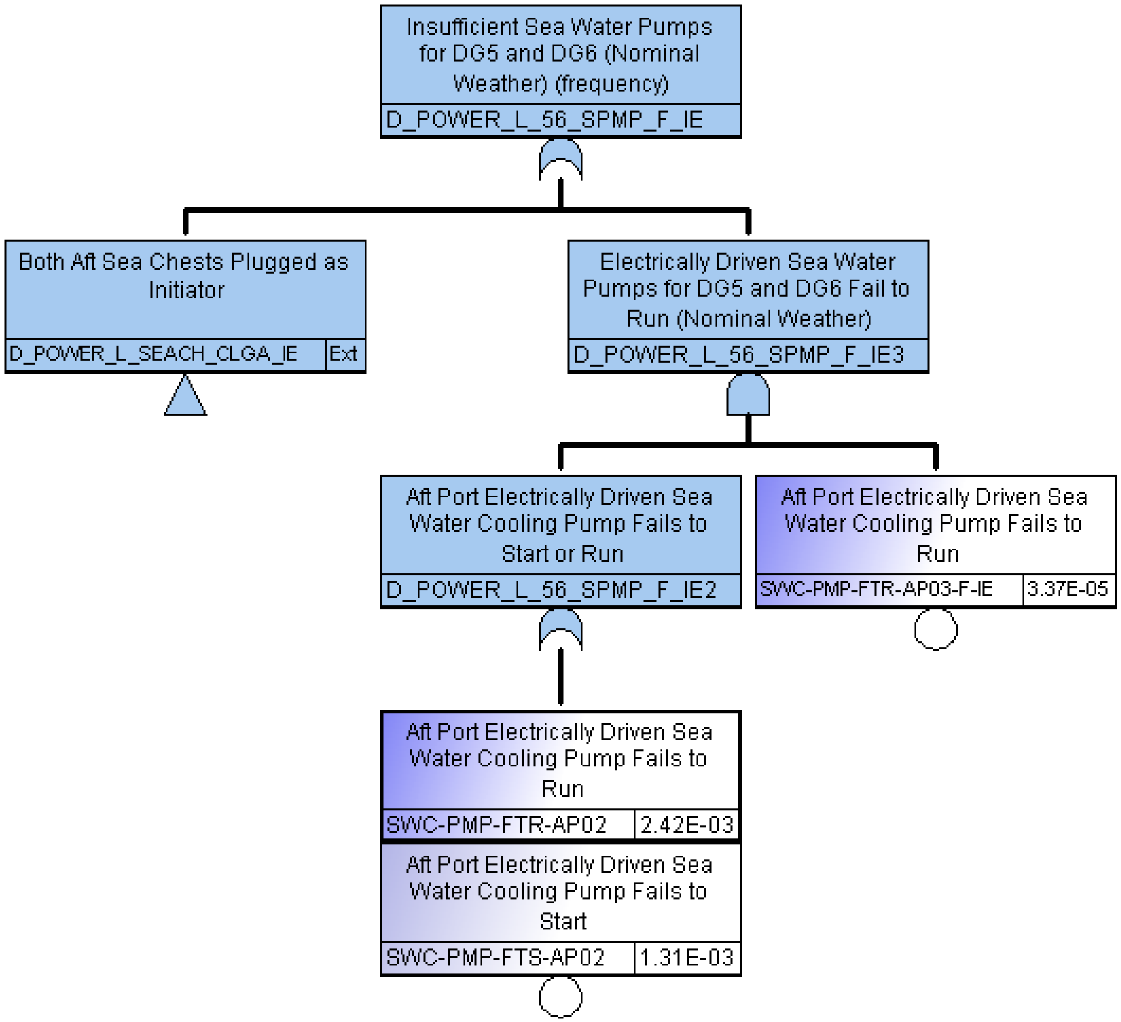

Figure C- 172: Initiating Events: Drift-off/Push-off (Continued)

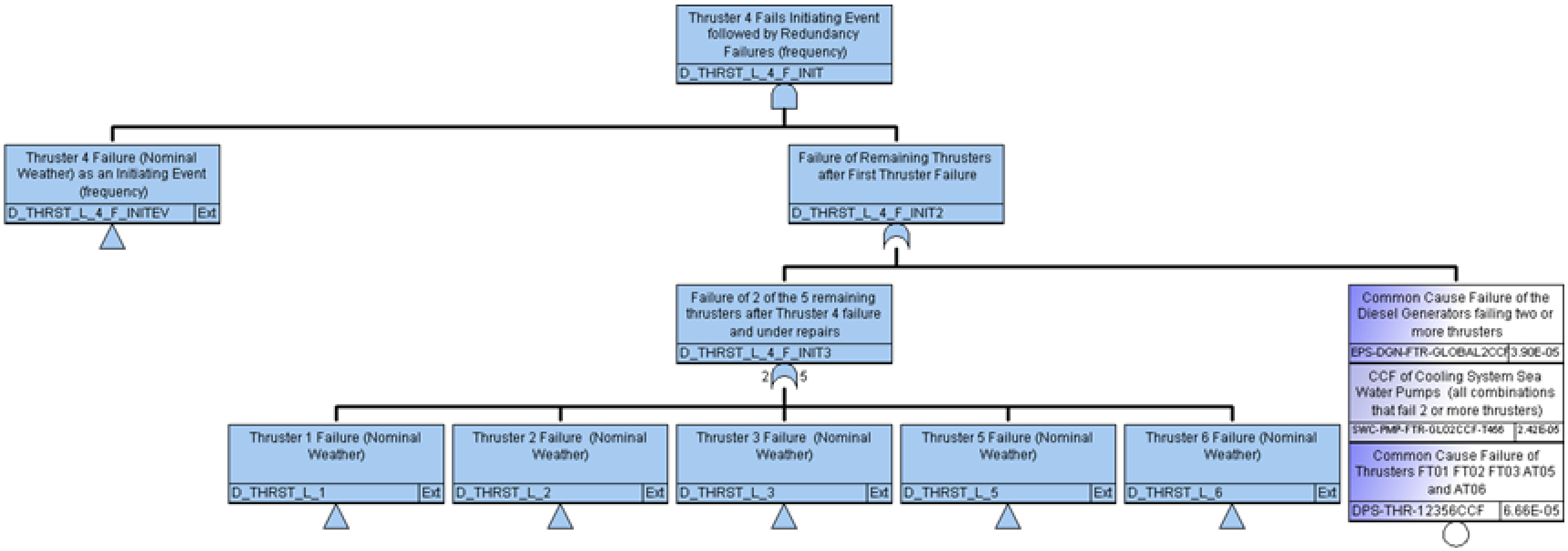

Figure C- 173: Initiating Events: Drift-off/Push-off (Continued)

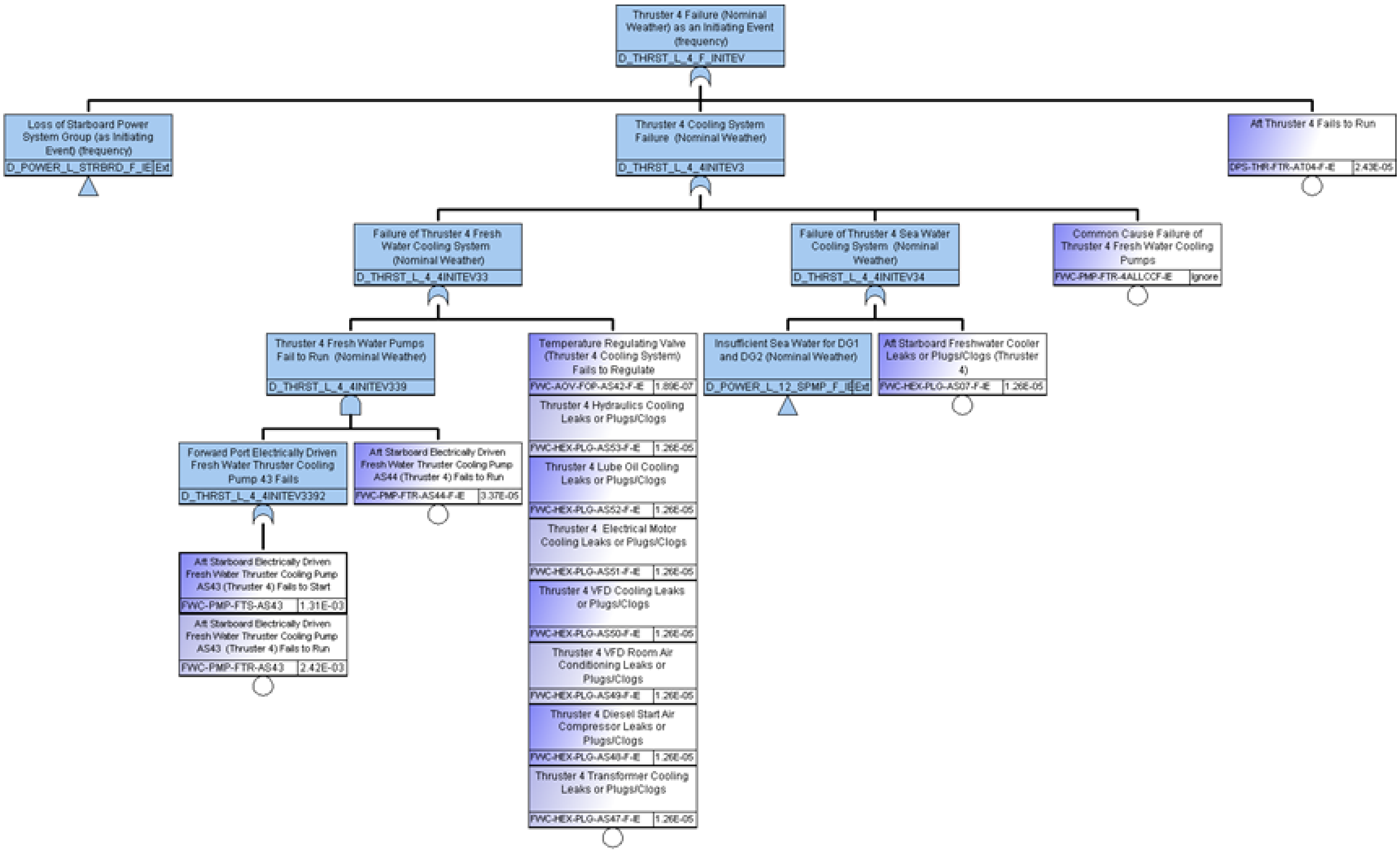

Figure C- 174: Initiating Events: Drift-off/Push-off (Continued)

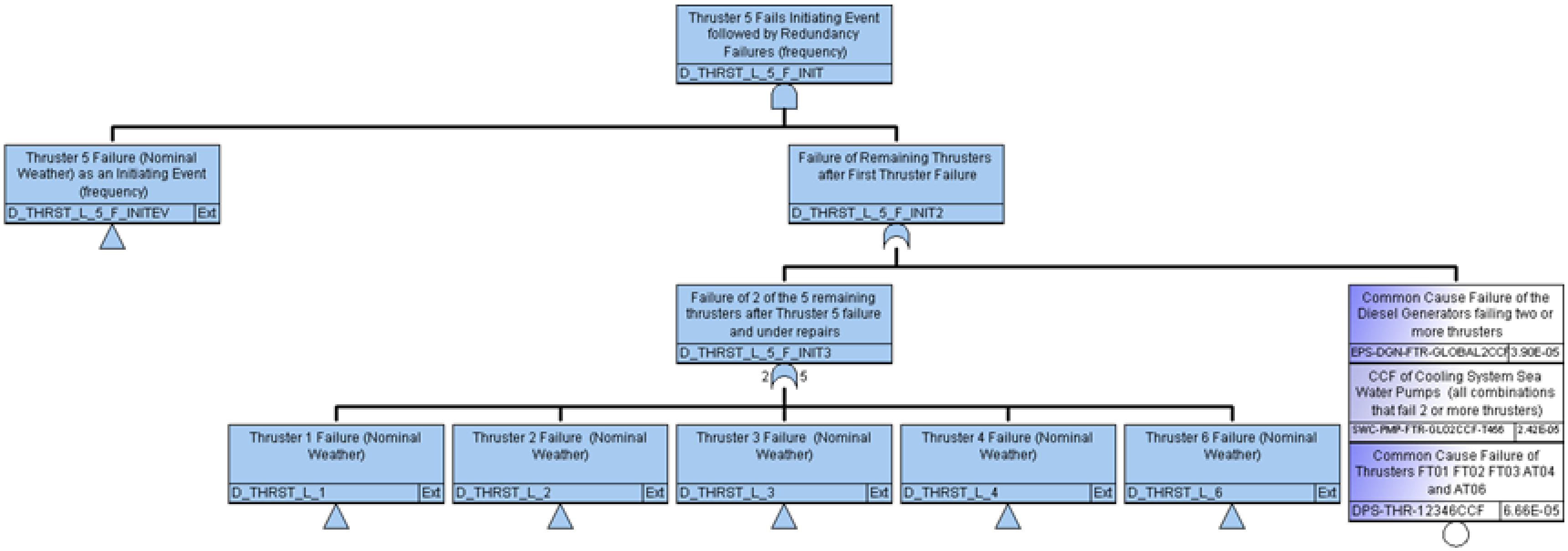

Figure C- 175: Initiating Events: Drift-off/Push-off (Continued)

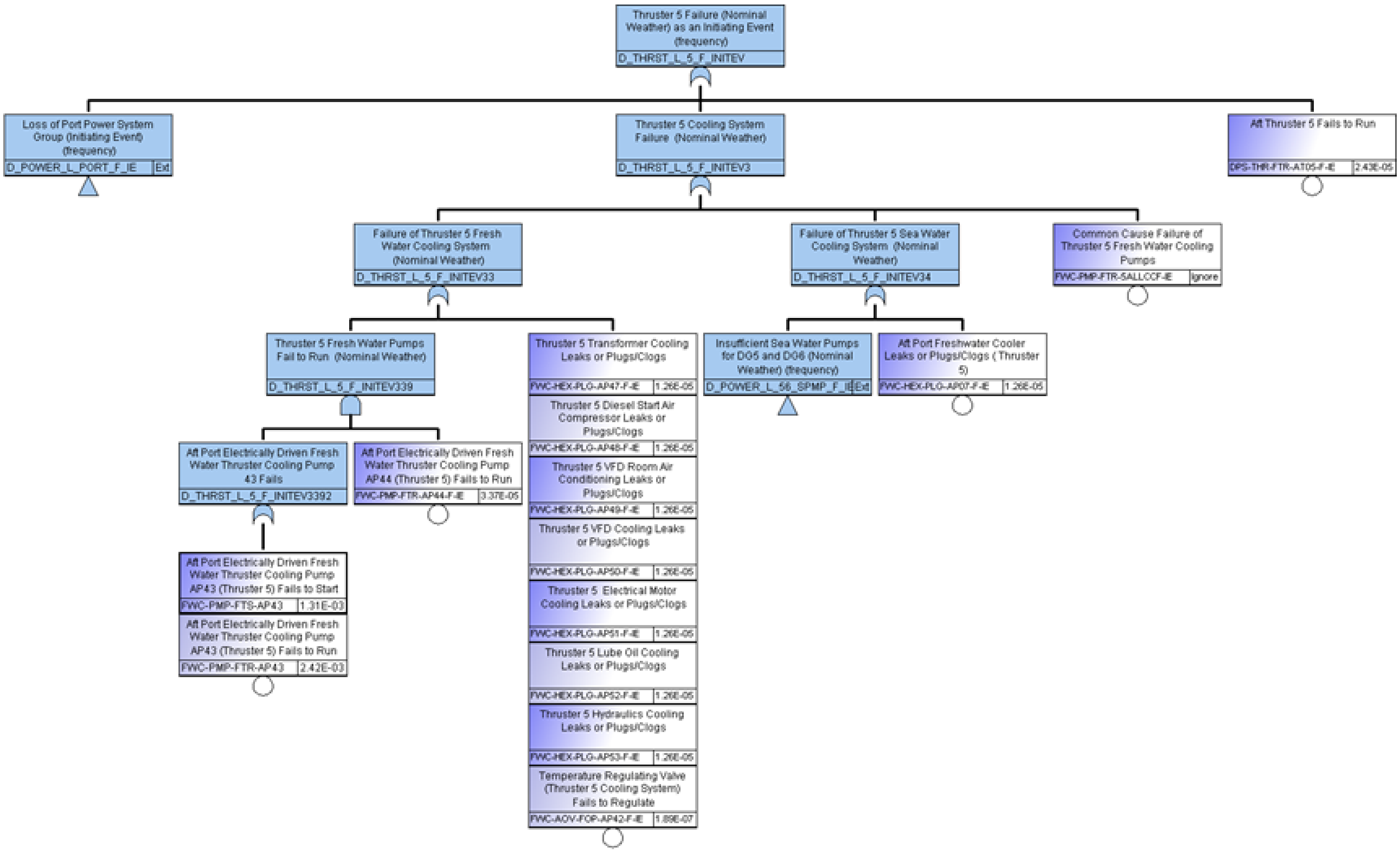

Figure C- 176: Initiating Events: Drift-off/Push-off (Continued)

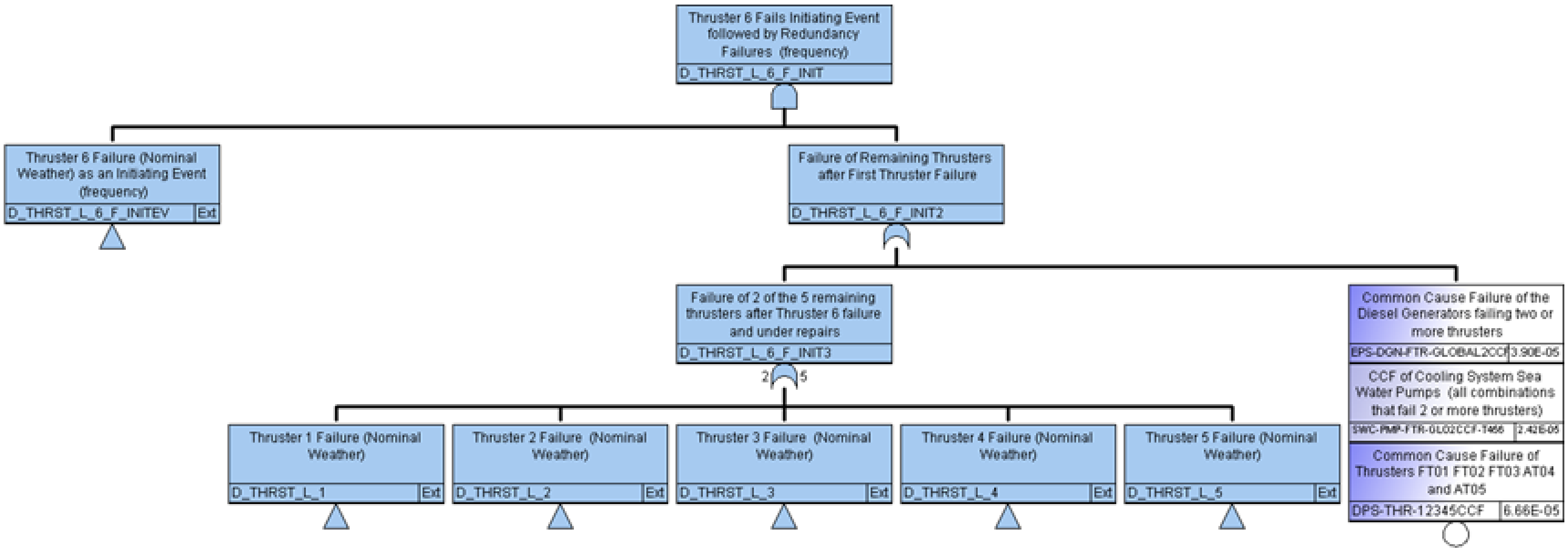

Figure C- 177: Initiating Events: Drift-off/Push-off (Continued)

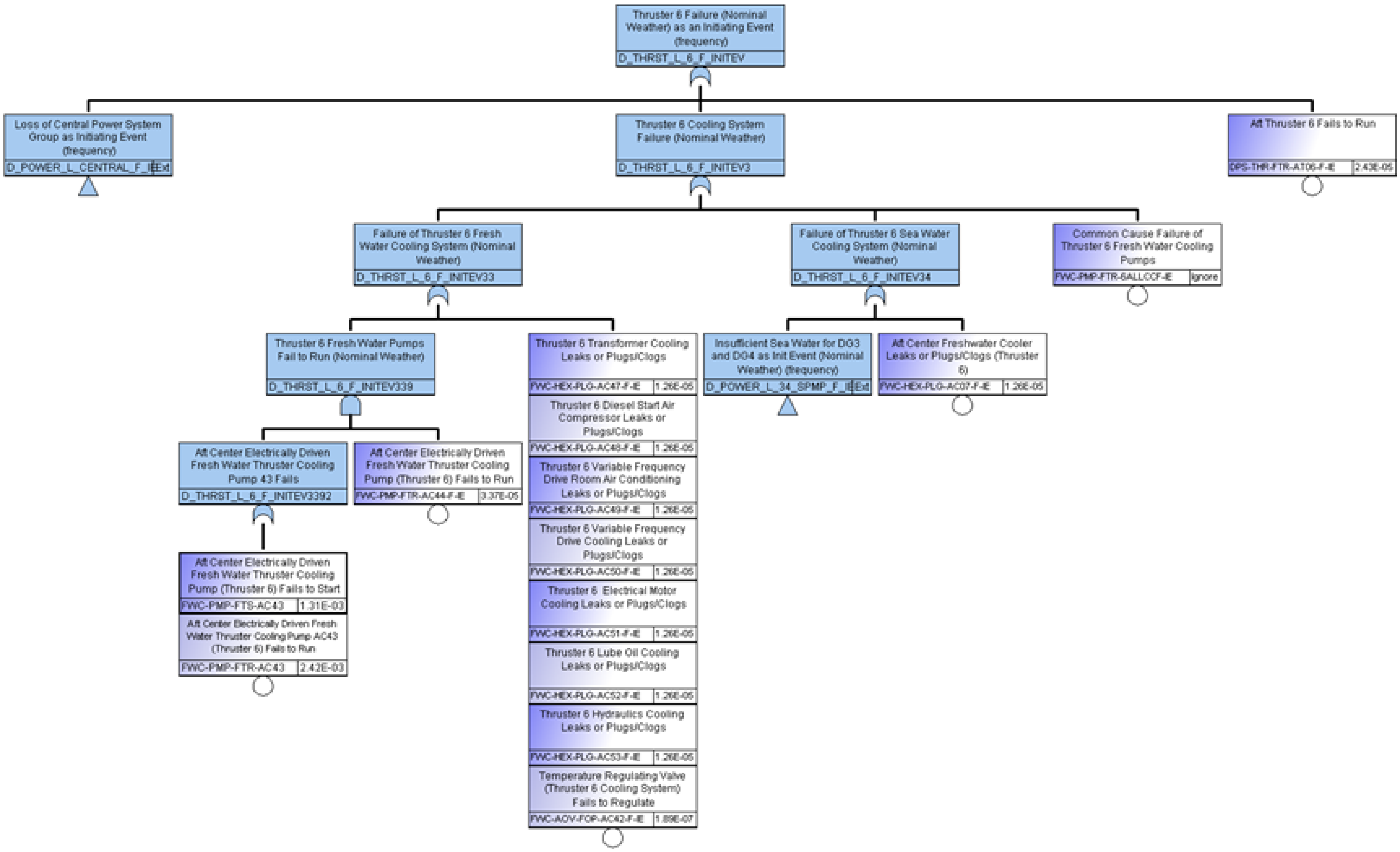

Figure C- 178: Initiating Events: Drift-off/Push-off (Continued)

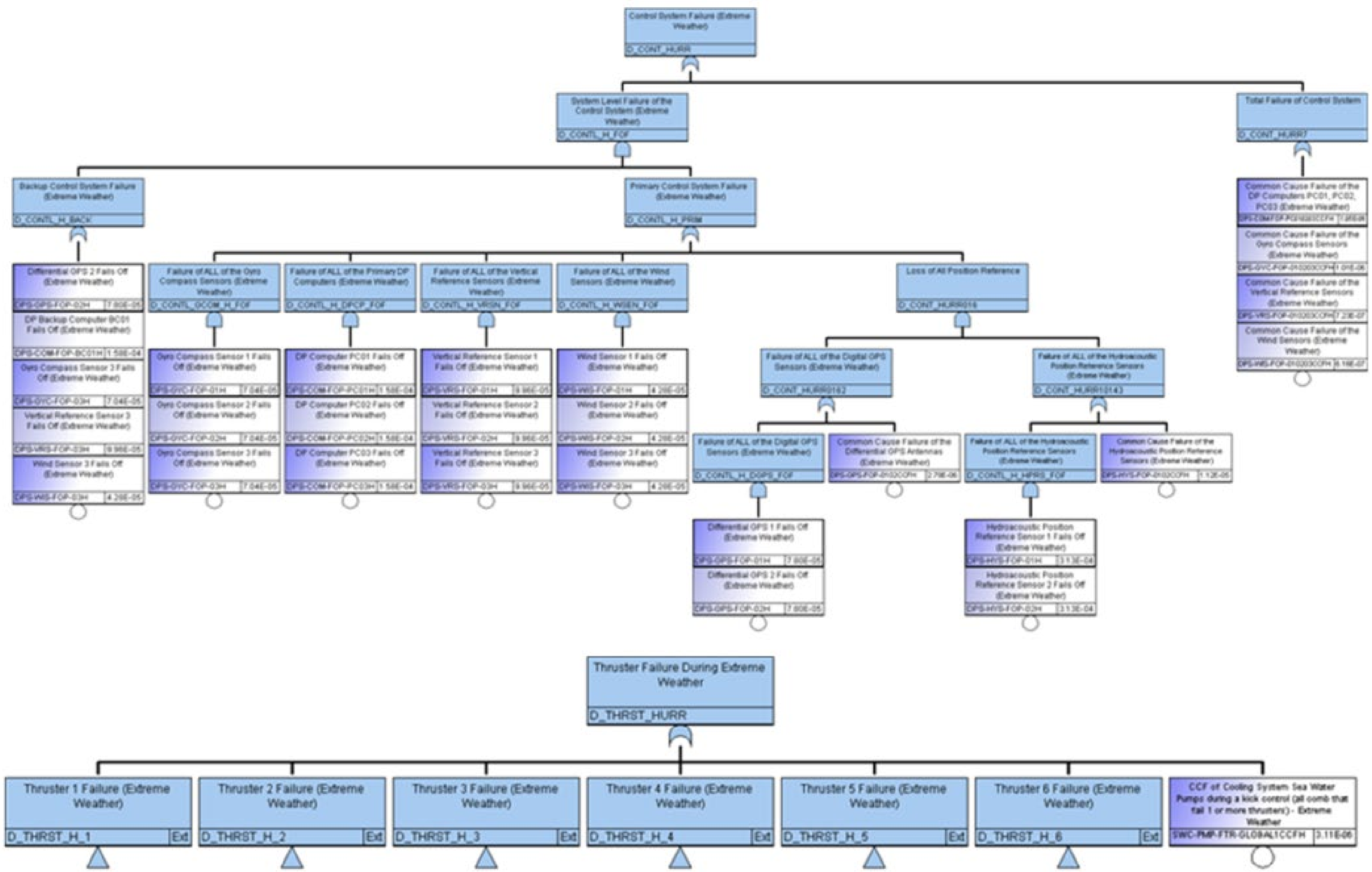

Figure C- 179: Initiating Events: Drift-off/Push-off (Continued)

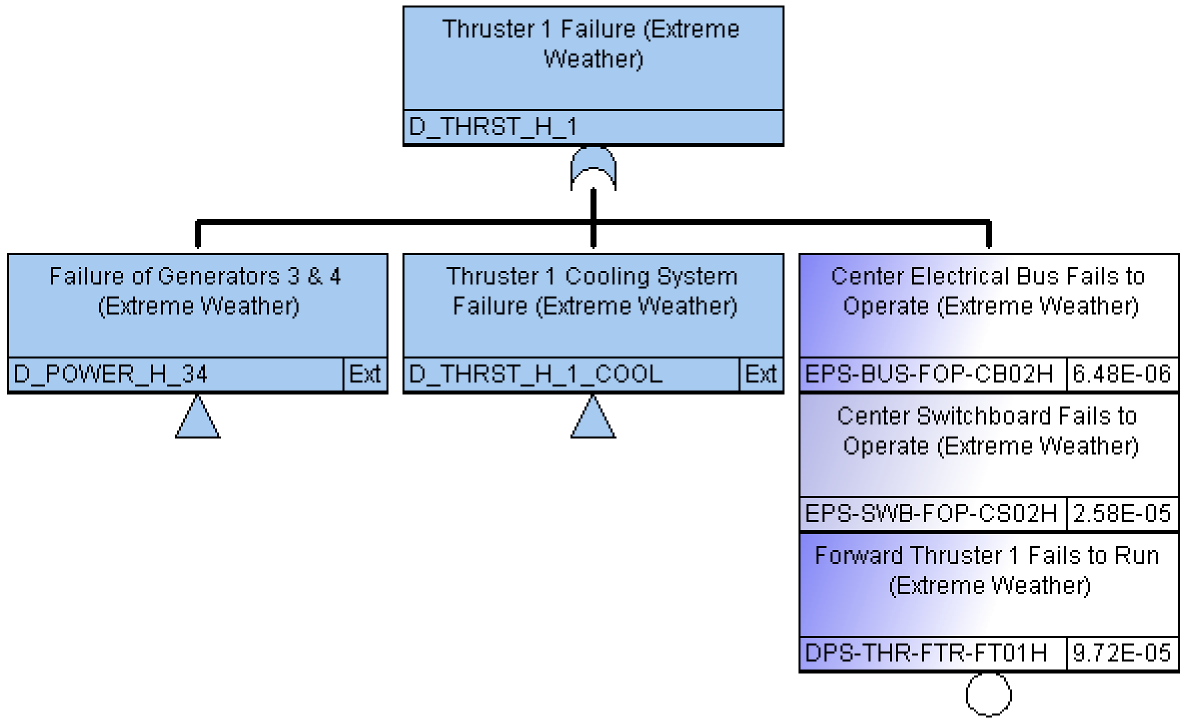

Figure C- 180: Initiating Events: Drift-off/Push-off (Continued)

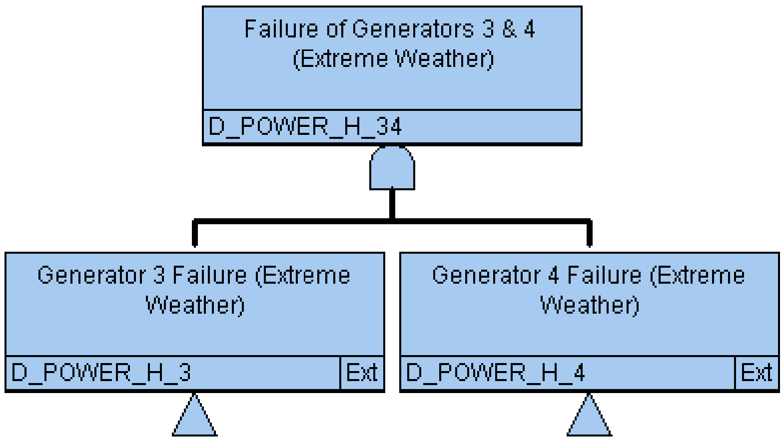

Figure C- 181: Initiating Events: Drift-off/Push-off (Continued)

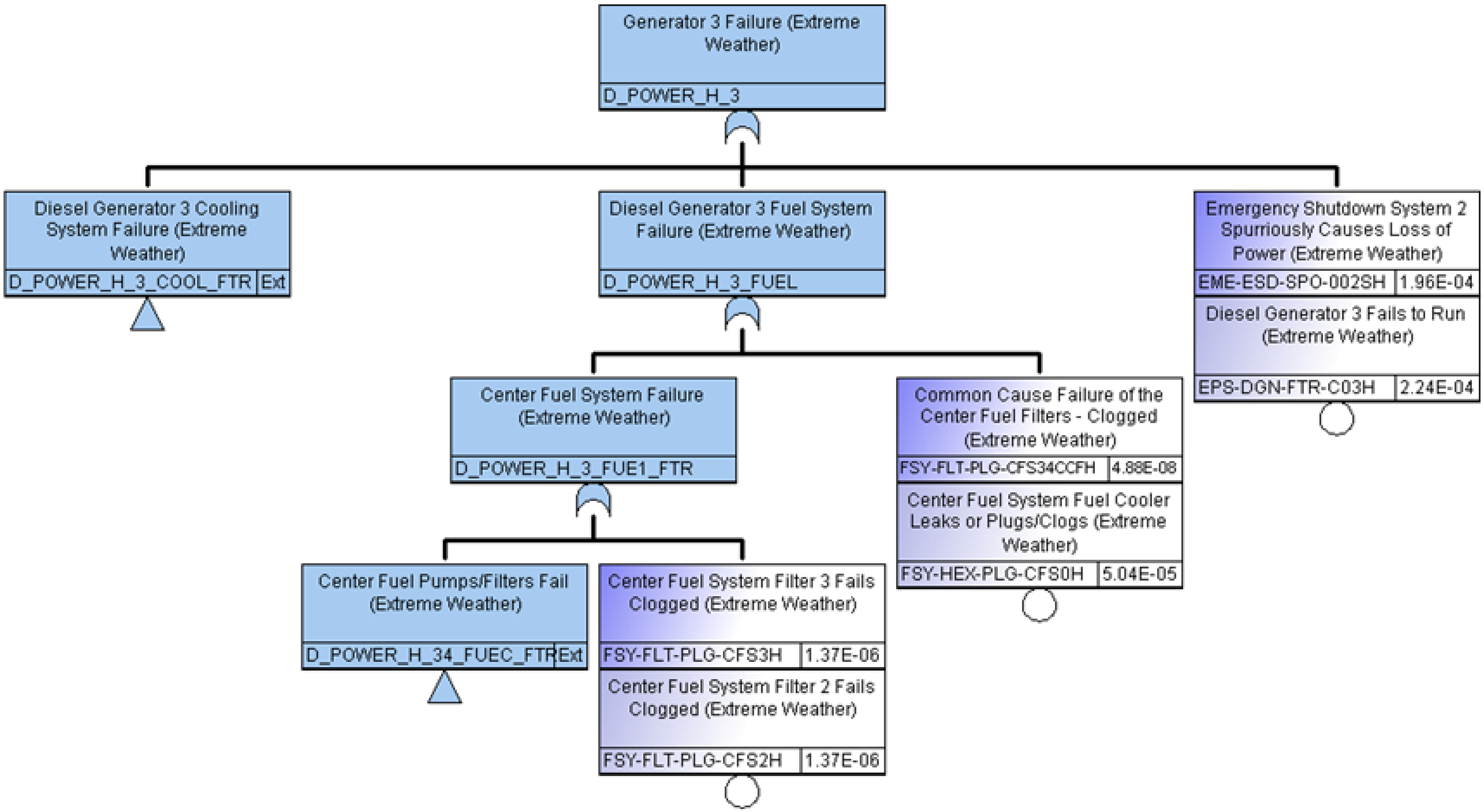

Figure C- 182: Initiating Events: Drift-off/Push-off (Continued)

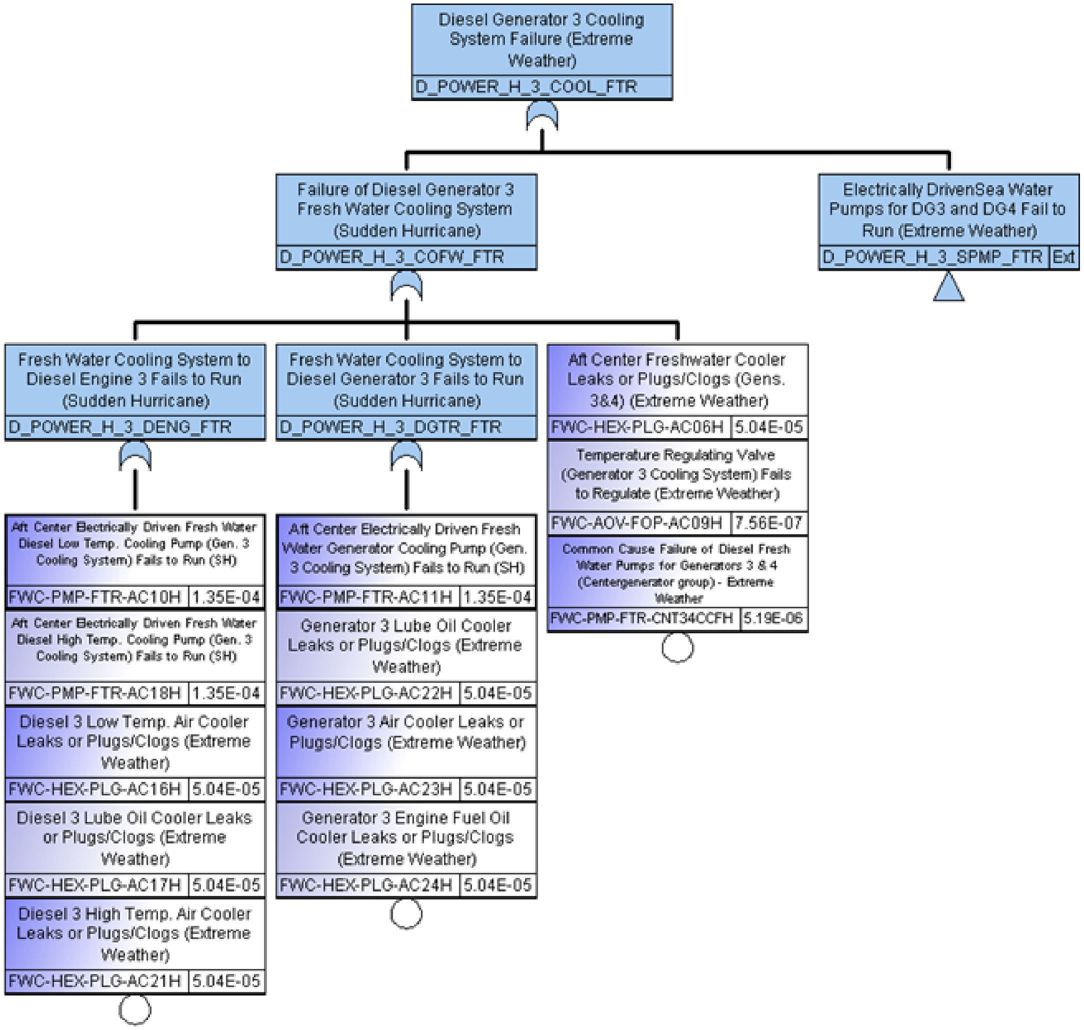

Figure C- 183: Initiating Events: Drift-off/Push-off (Continued)

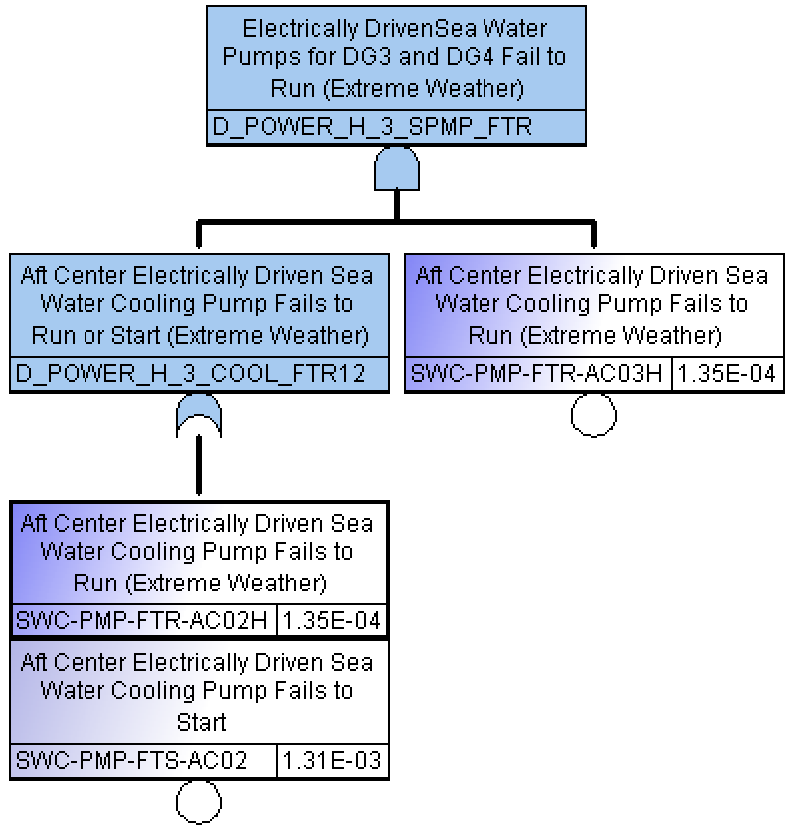

Figure C- 184: Initiating Events: Drift-off/Push-off (Continued)

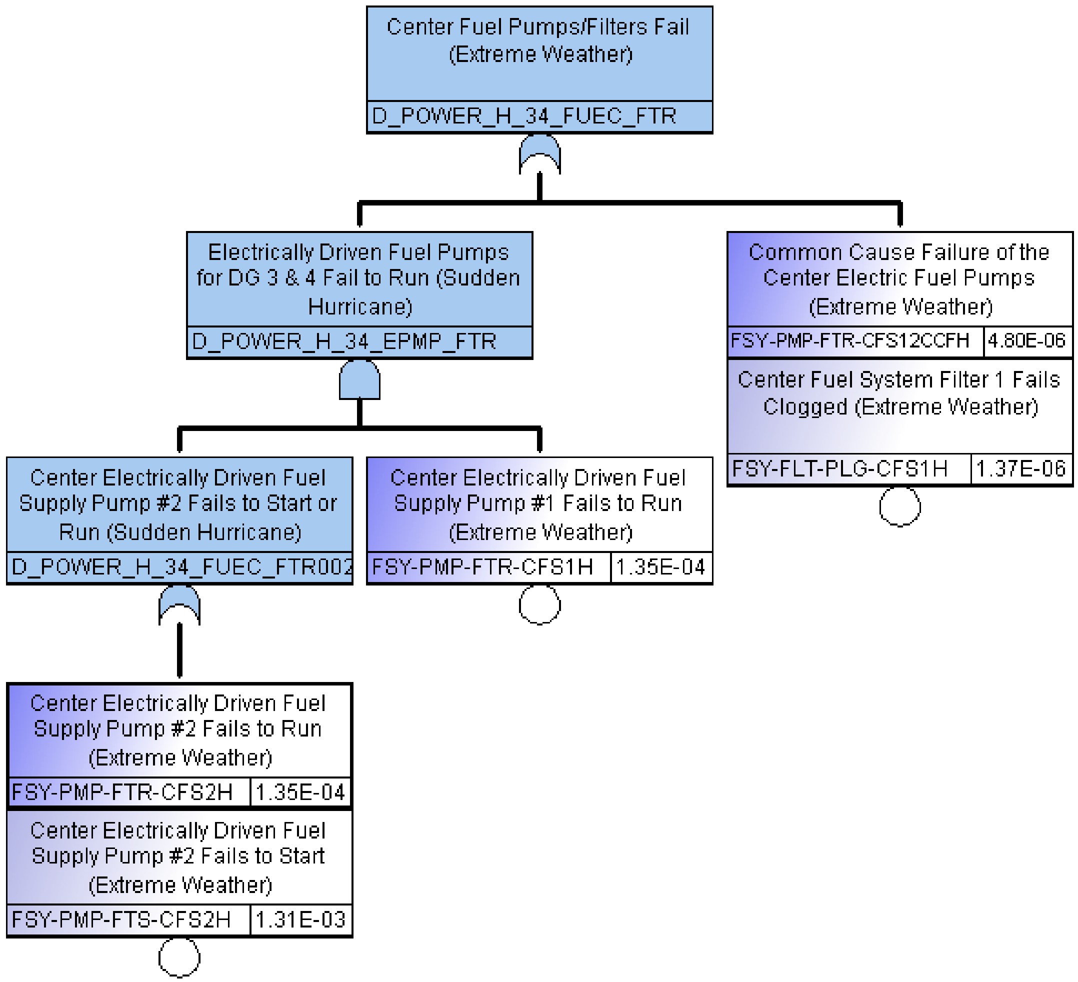

Figure C- 185: Initiating Events: Drift-off/Push-off (Continued)

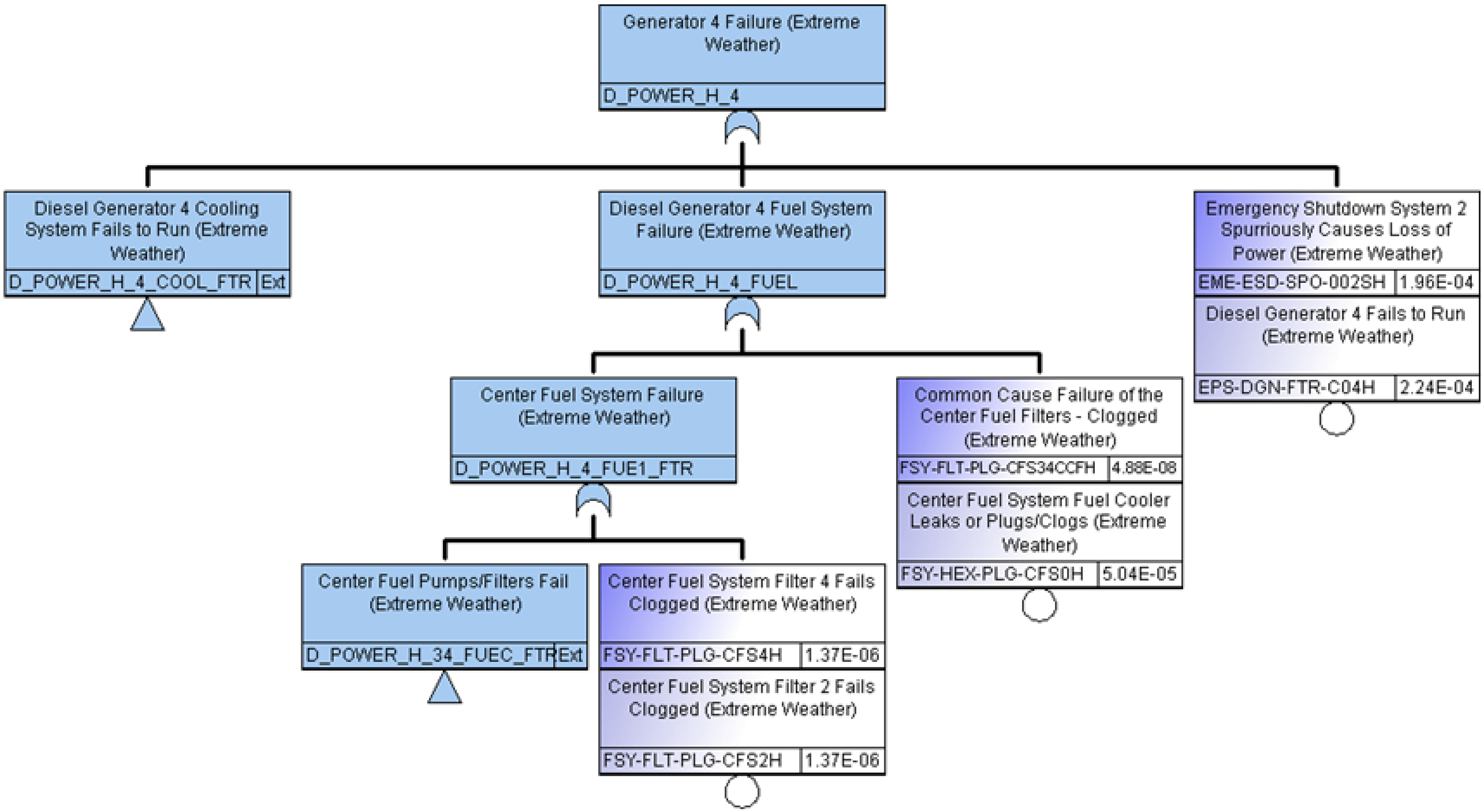

Figure C- 186: Initiating Events: Drift-off/Push-off (Continued)

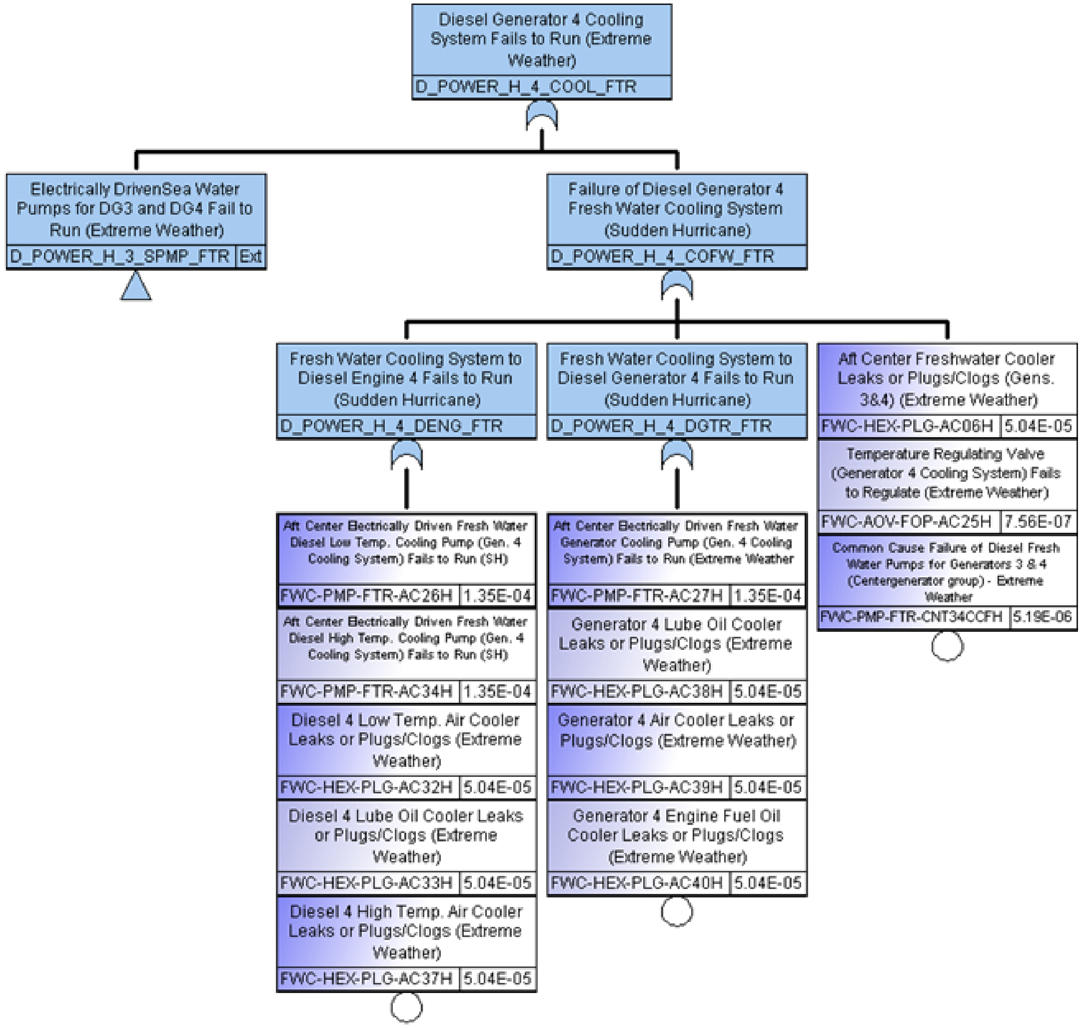

Figure C- 187: Initiating Events: Drift-off/Push-off (Continued)

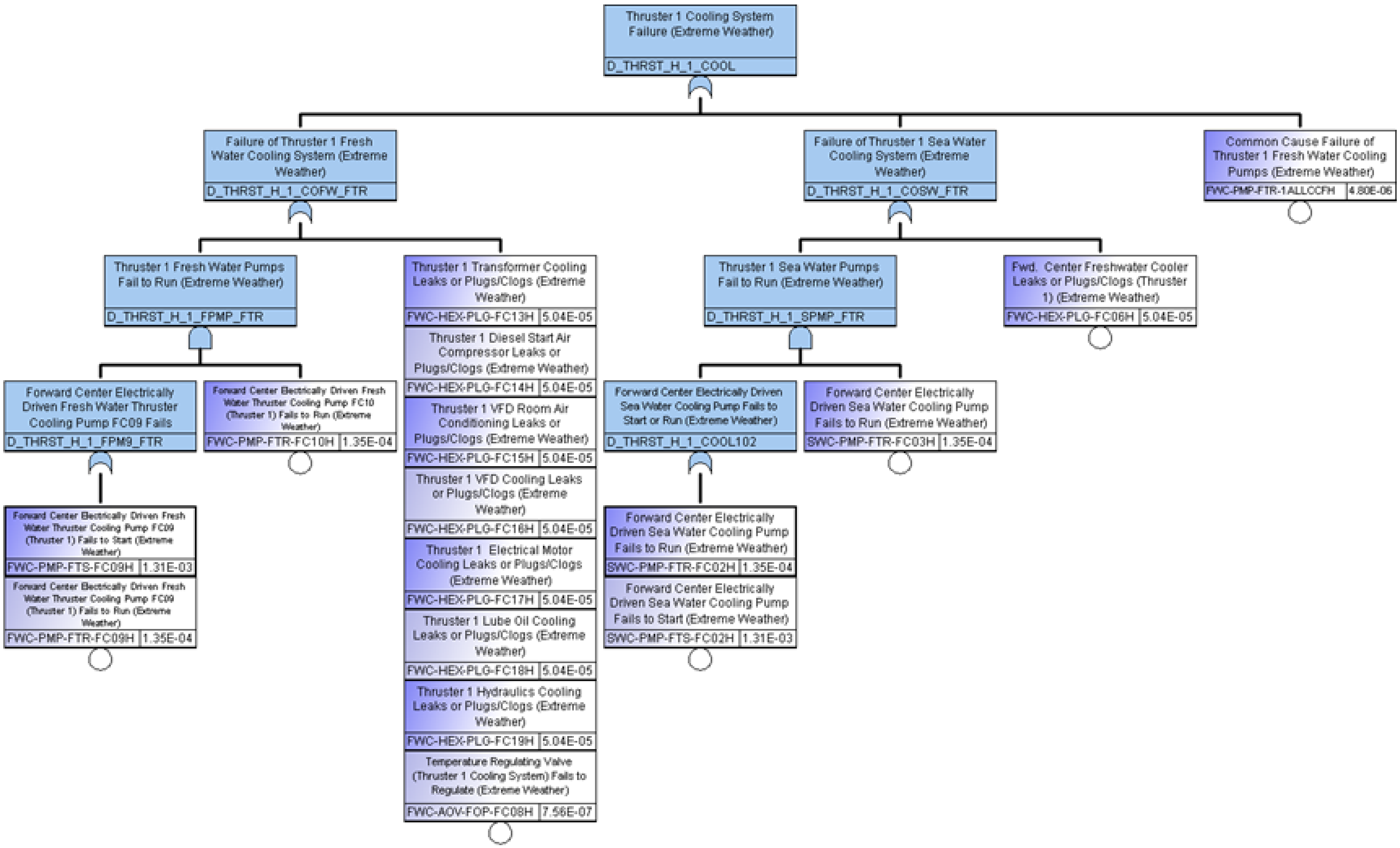

Figure C- 188: Initiating Events: Drift-off/Push-off (Continued)

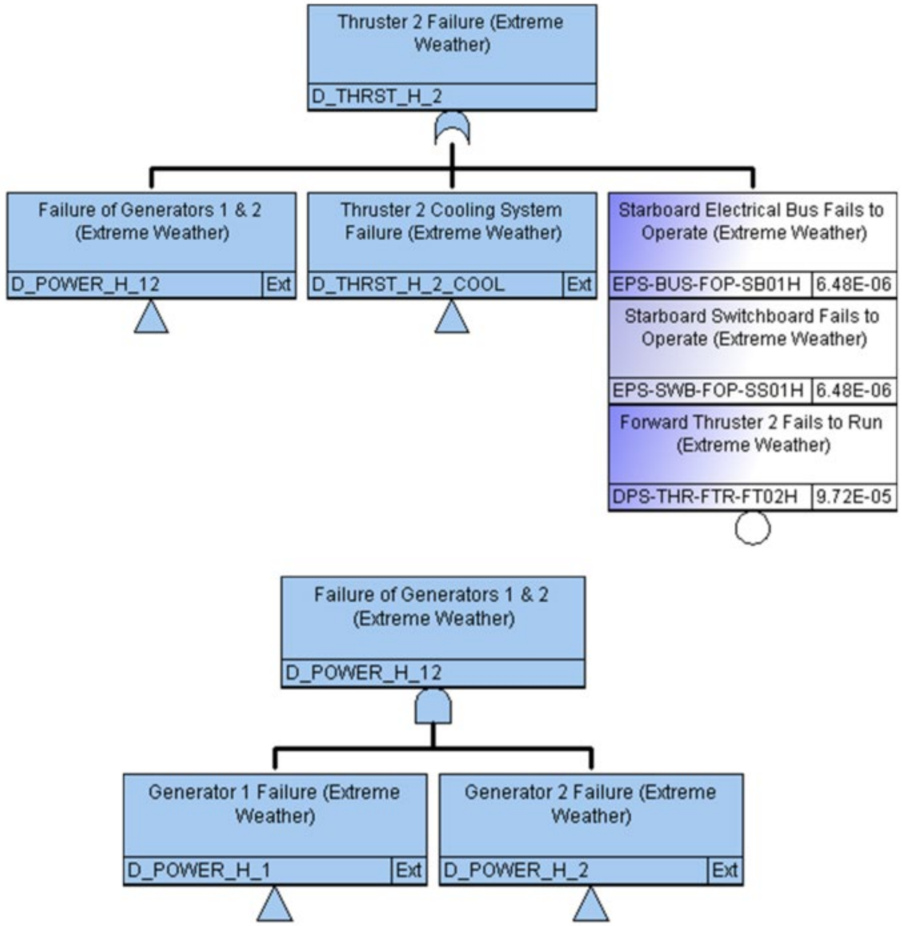

Figure C- 189: Initiating Events: Drift-off/Push-off (Continued)

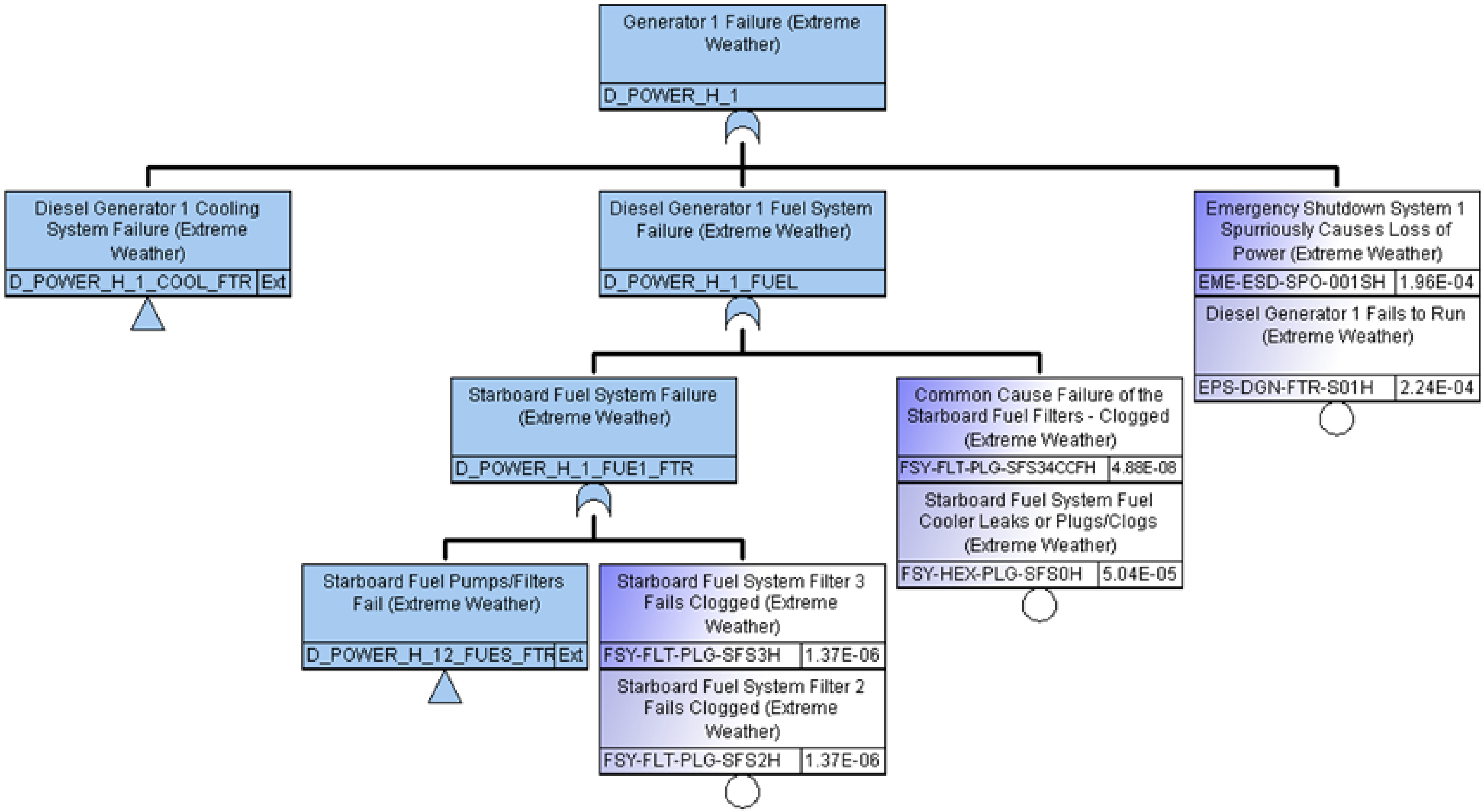

Figure C- 190: Initiating Events: Drift-off/Push-off (Continued)

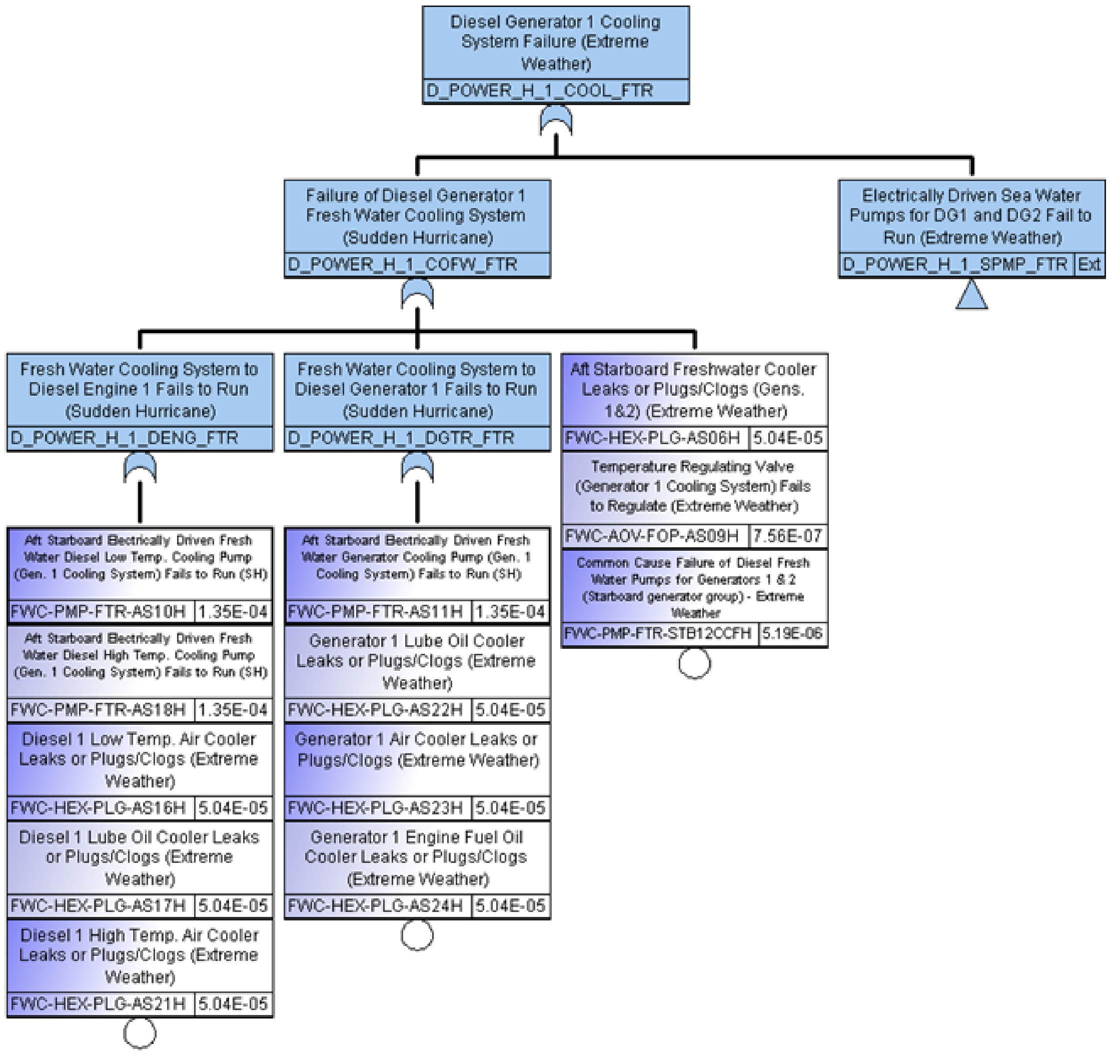

Figure C- 191: Initiating Events: Drift-off/Push-off (Continued)

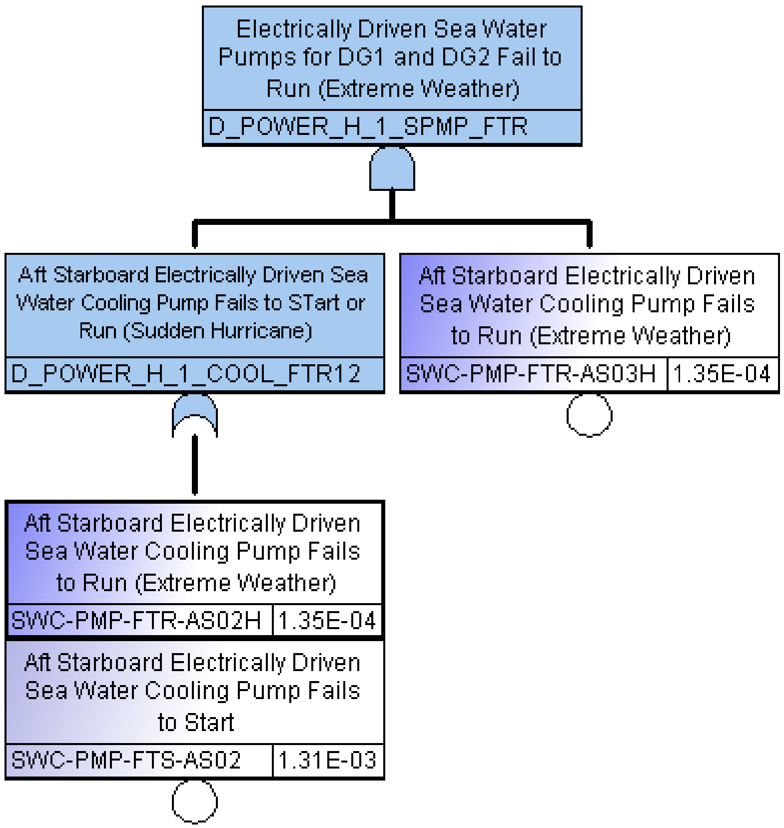

Figure C- 192: Initiating Events: Drift-off/Push-off (Continued)

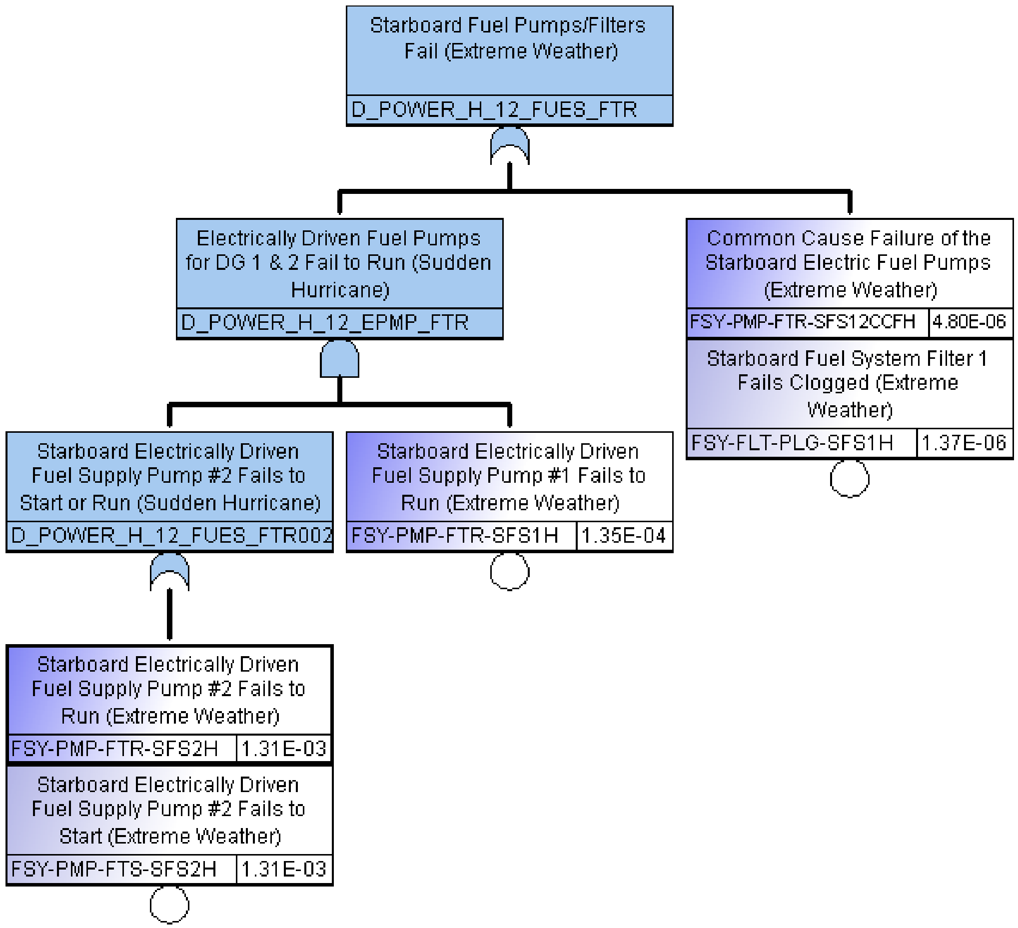

Figure C- 193: Initiating Events: Drift-off/Push-off (Continued)

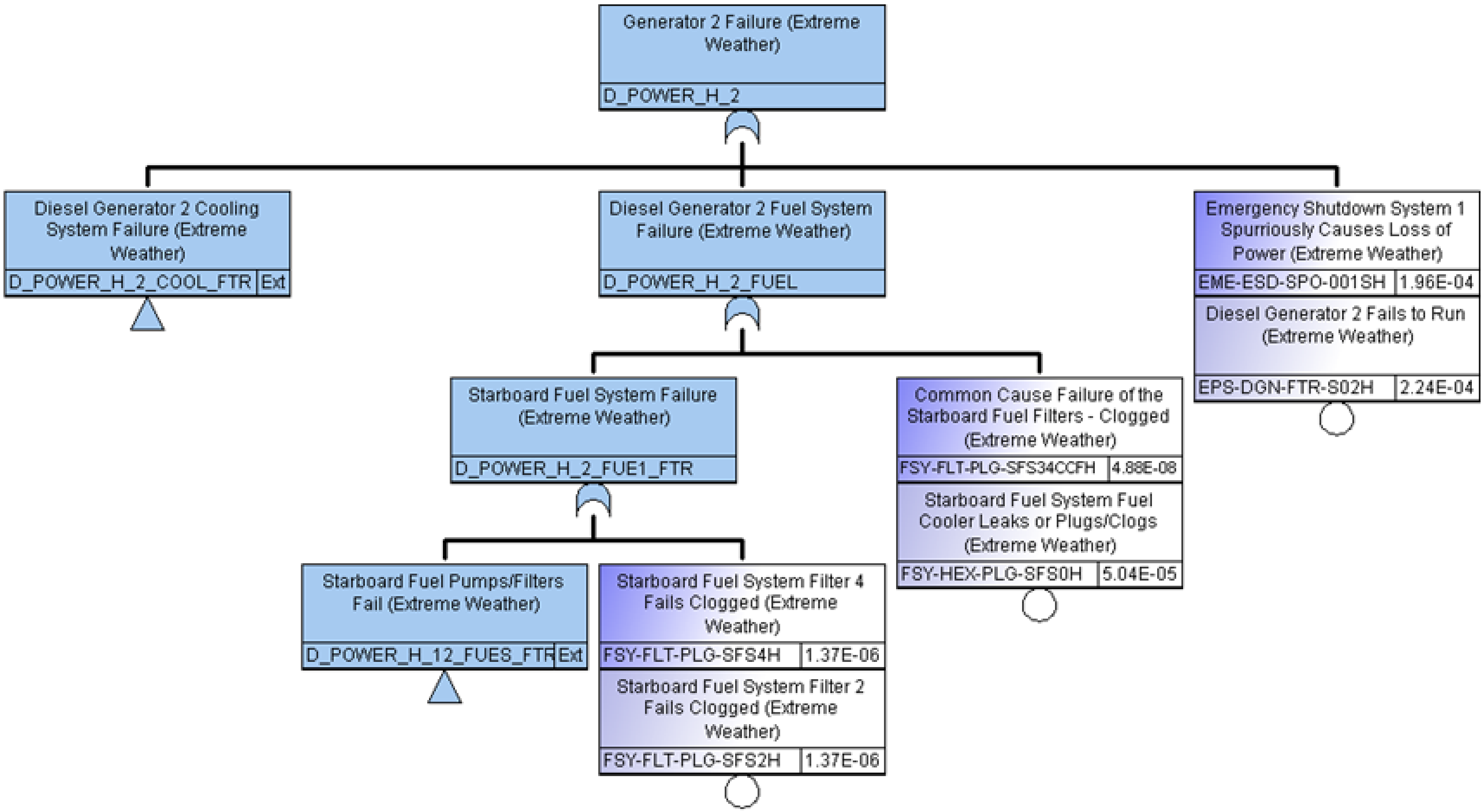

Figure C- 194: Initiating Events: Drift-off/Push-off (Continued)

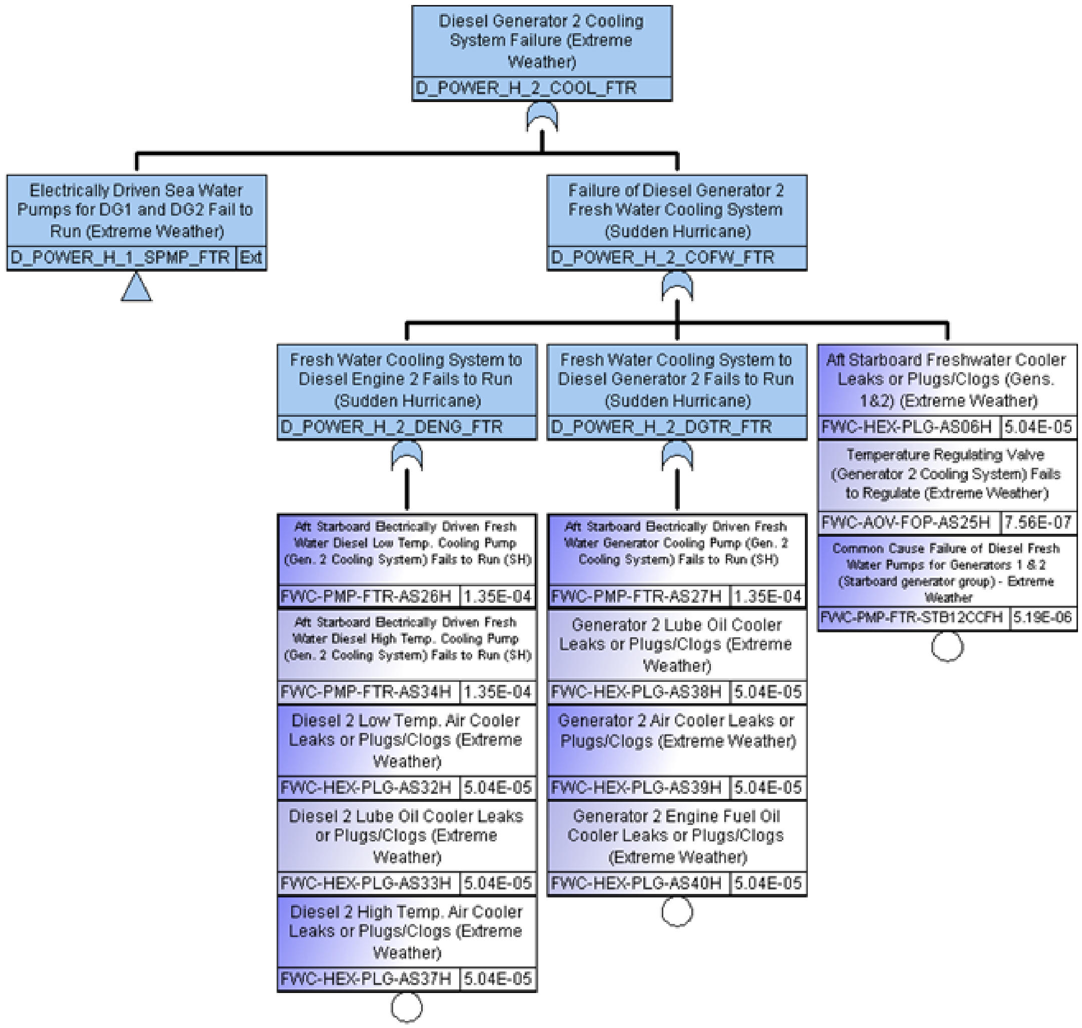

Figure C- 195: Initiating Events: Drift-off/Push-off (Continued)

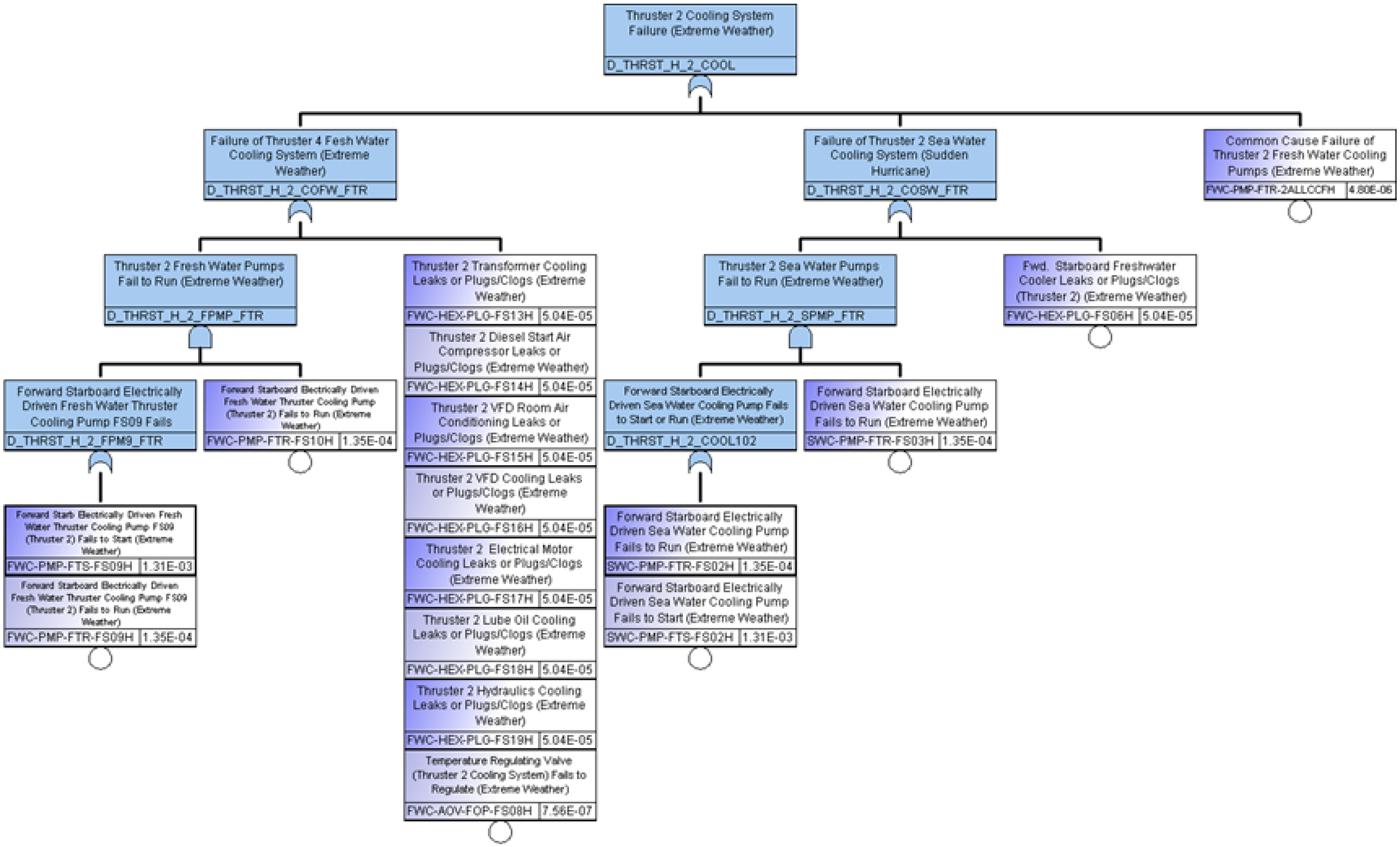

Figure C- 196: Initiating Events: Drift-off/Push-off (Continued)

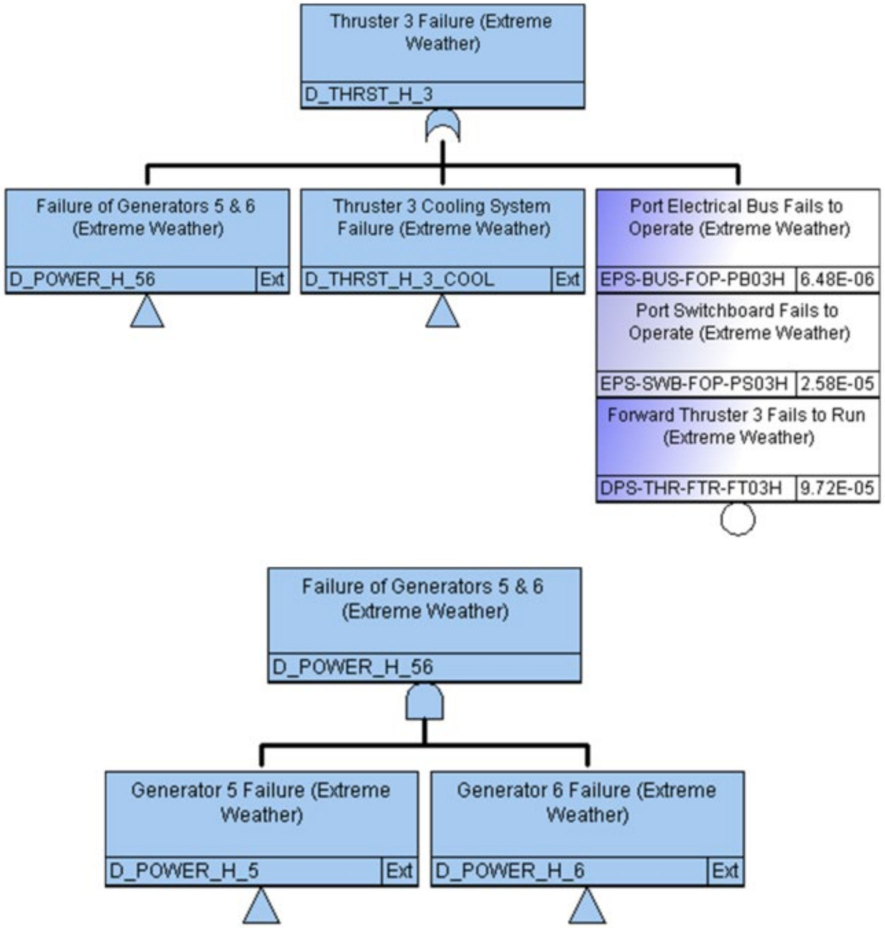

Figure C- 197: Initiating Events: Drift-off/Push-off (Continued)

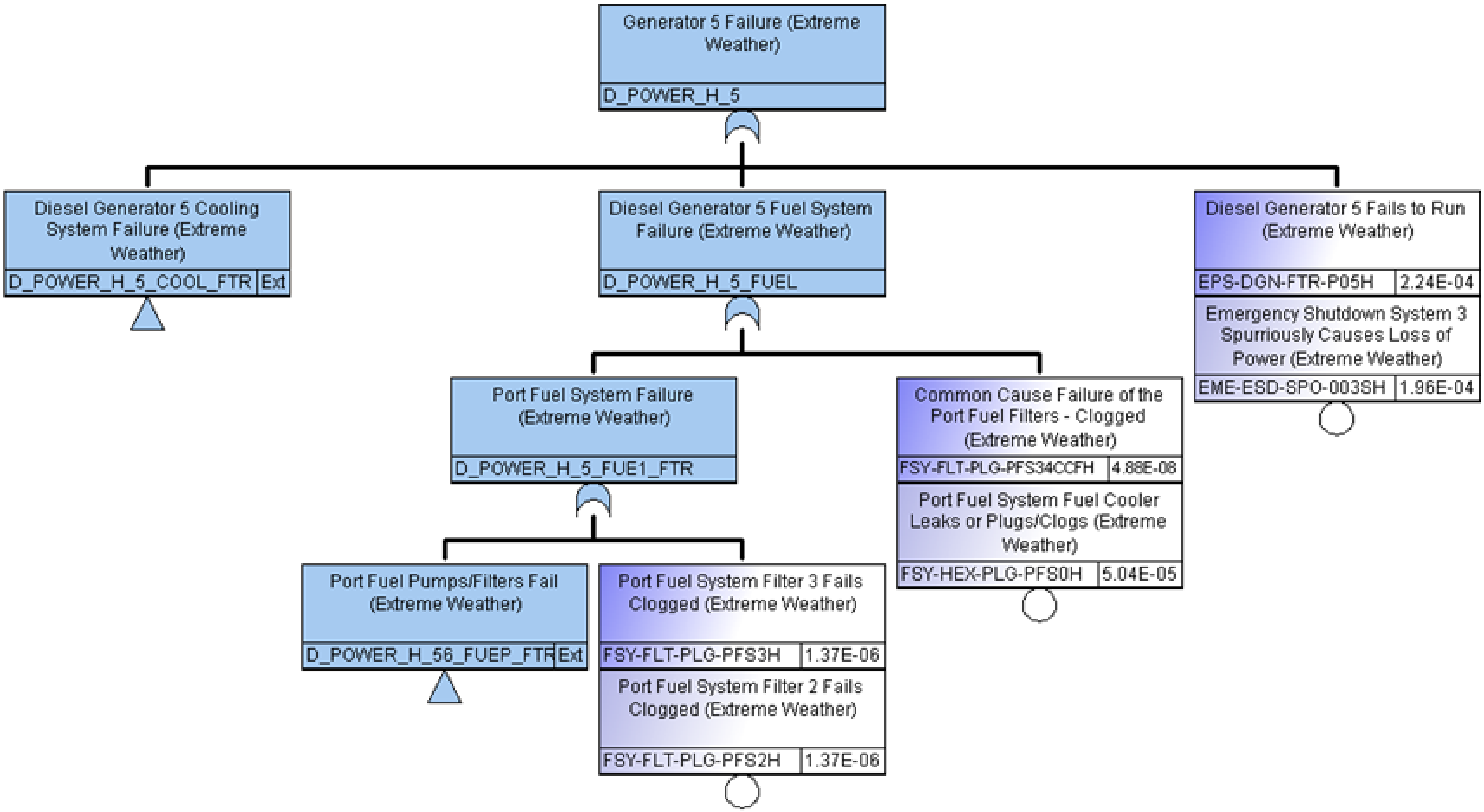

Figure C- 198: Initiating Events: Drift-off/Push-off (Continued)

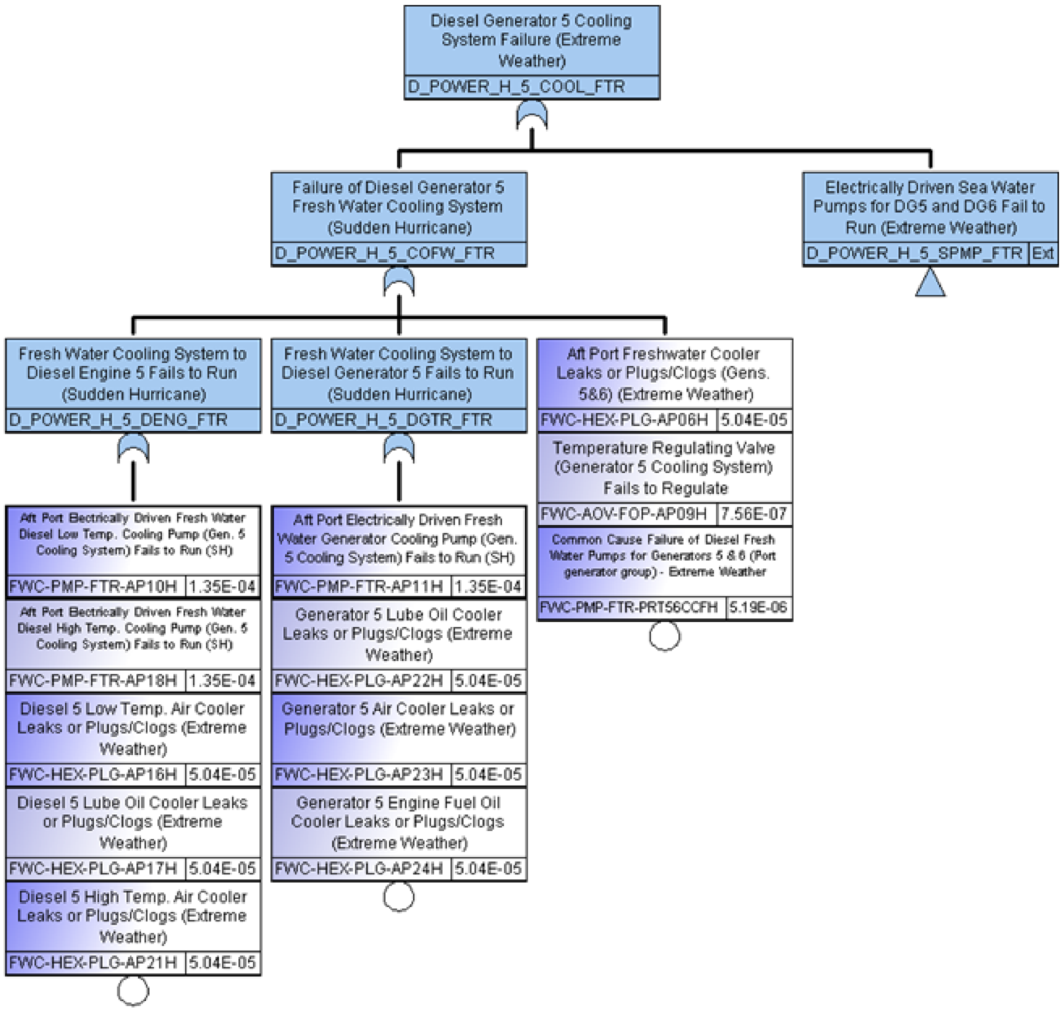

Figure C- 199: Initiating Events: Drift-off/Push-off (Continued)

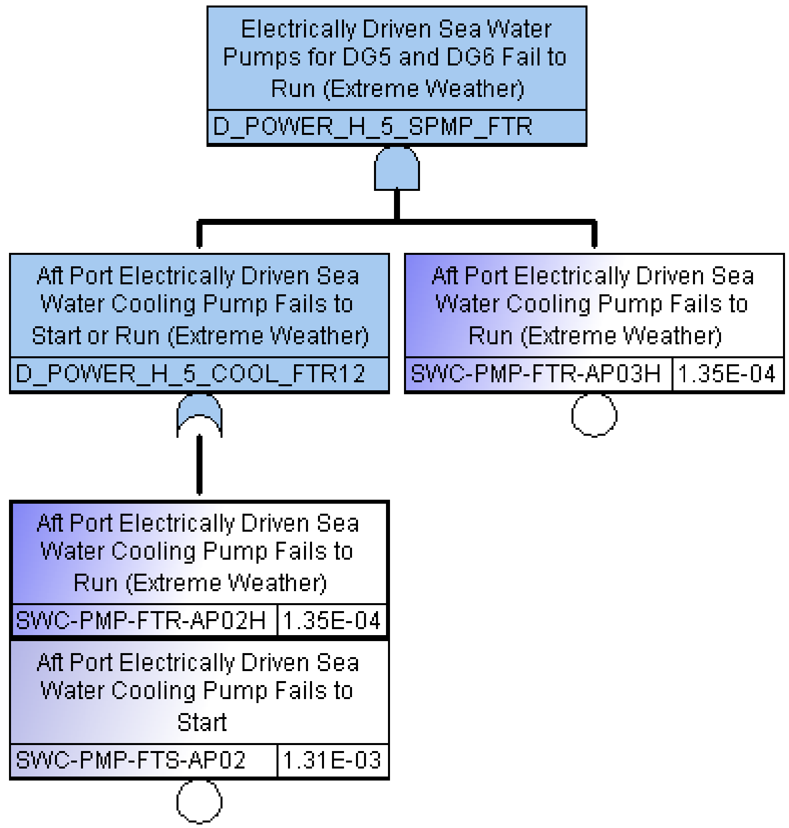

Figure C- 200: Initiating Events: Drift-off/Push-off (Continued)

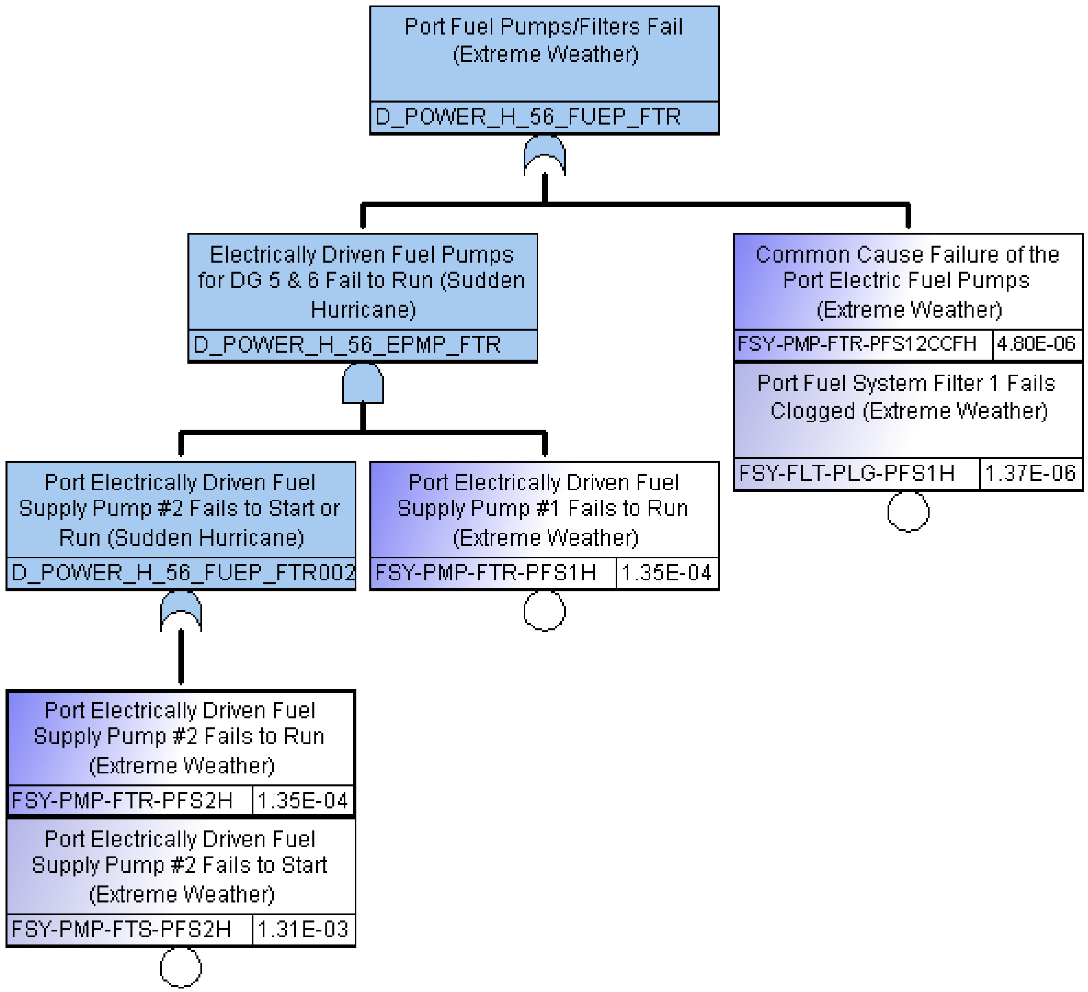

Figure C- 201: Initiating Events: Drift-off/Push-off (Continued)

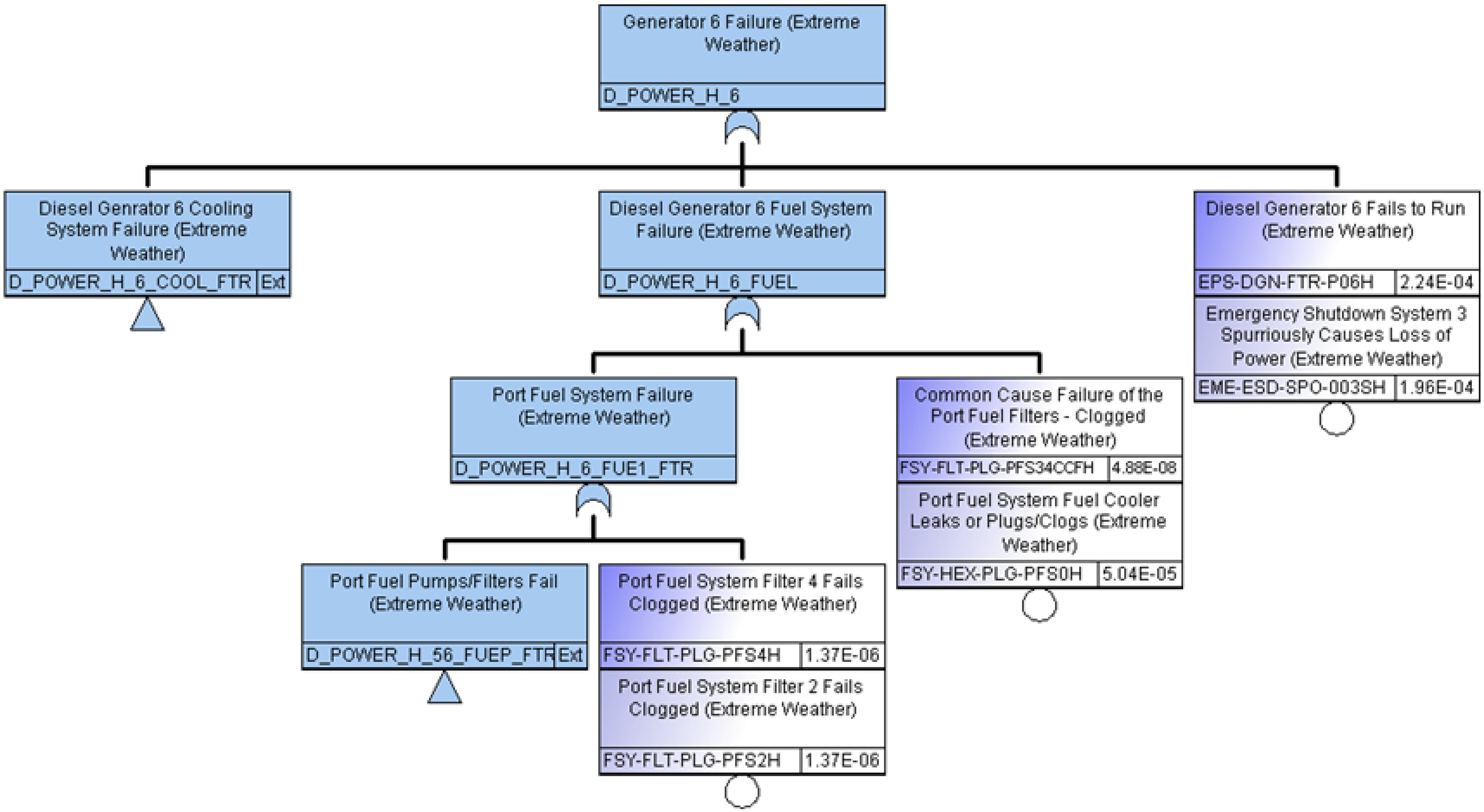

Figure C- 202: Initiating Events: Drift-off/Push-off (Continued)

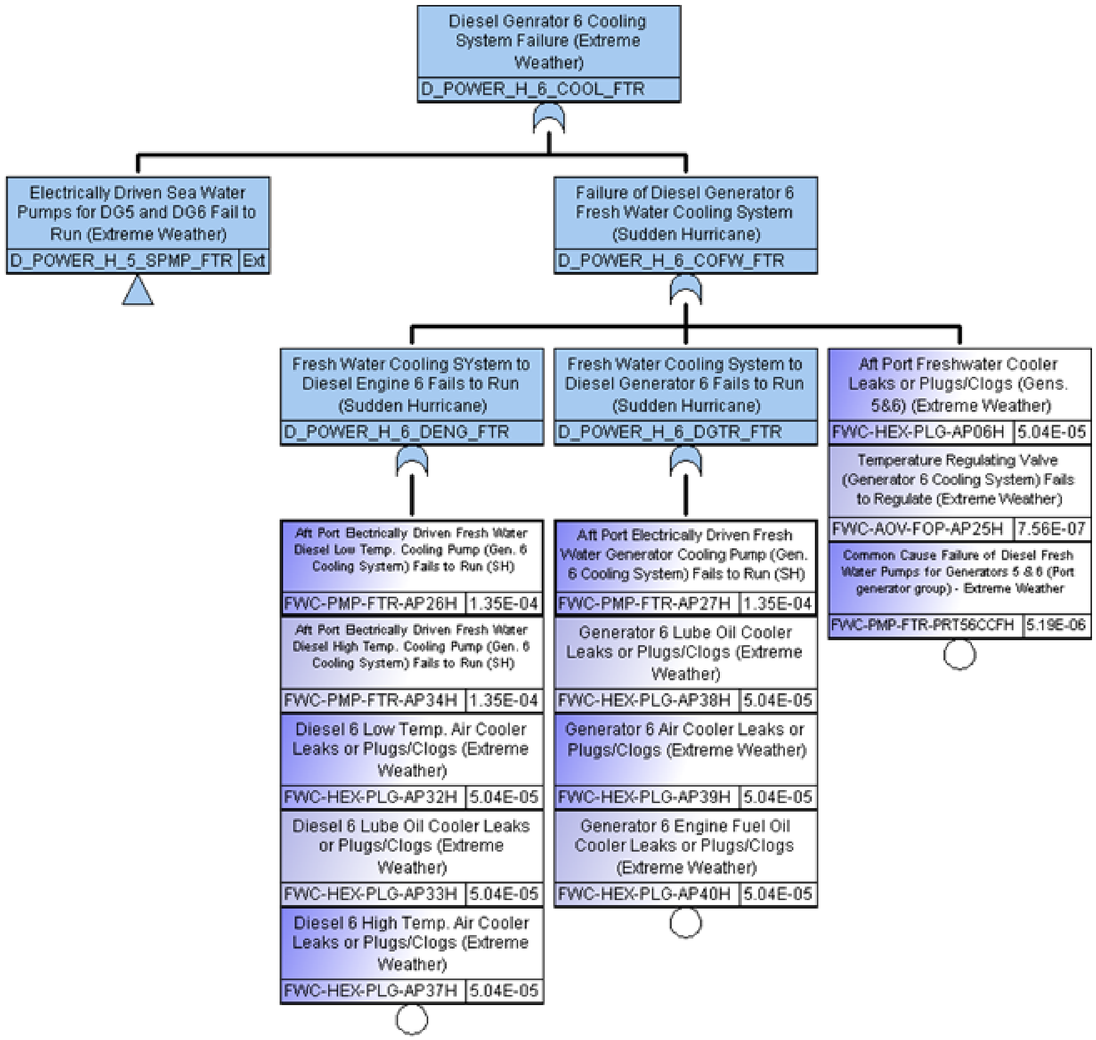

Figure C- 203: Initiating Events: Drift-off/Push-off (Continued)

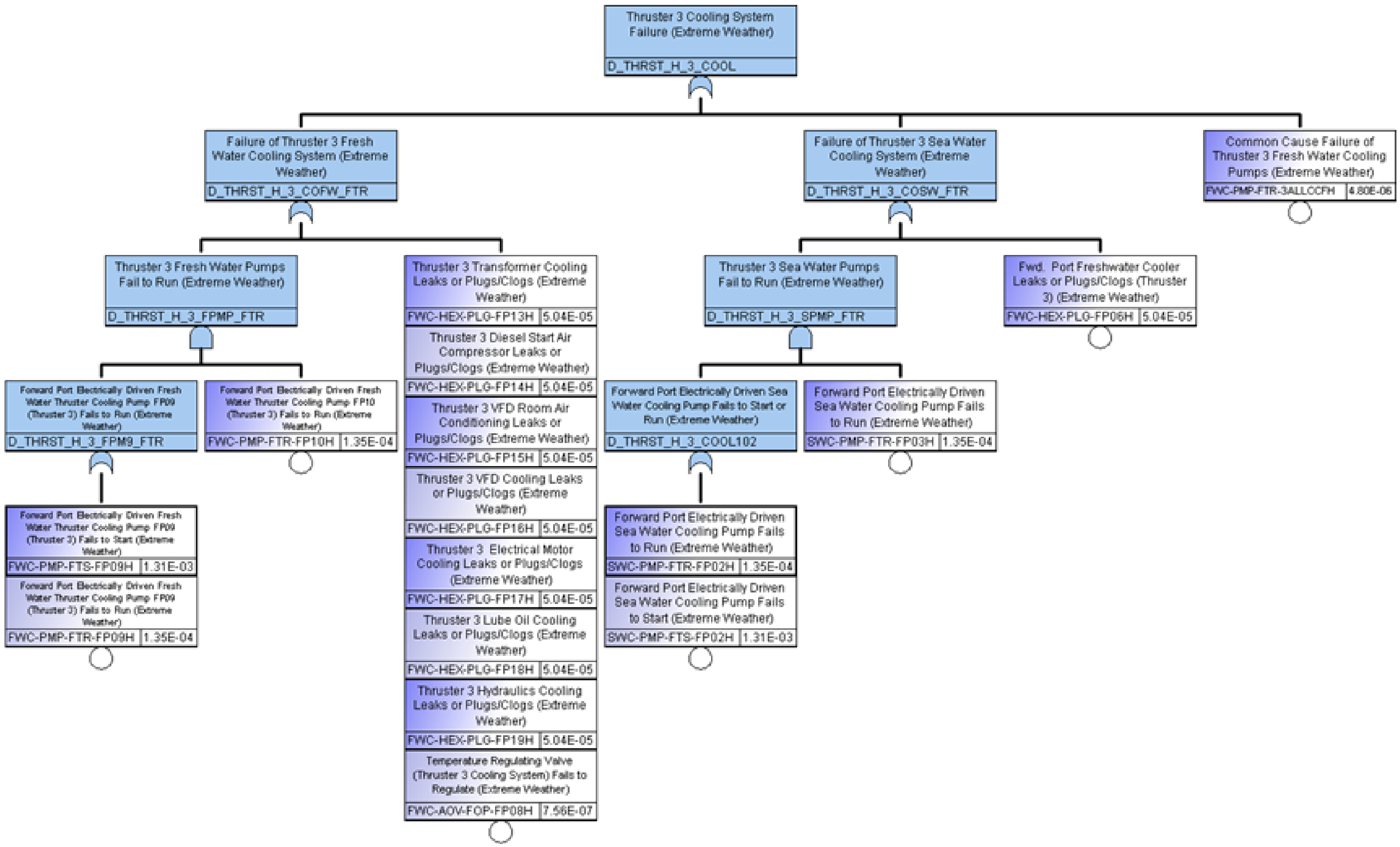

Figure C- 204: Initiating Events: Drift-off/Push-off (Continued)

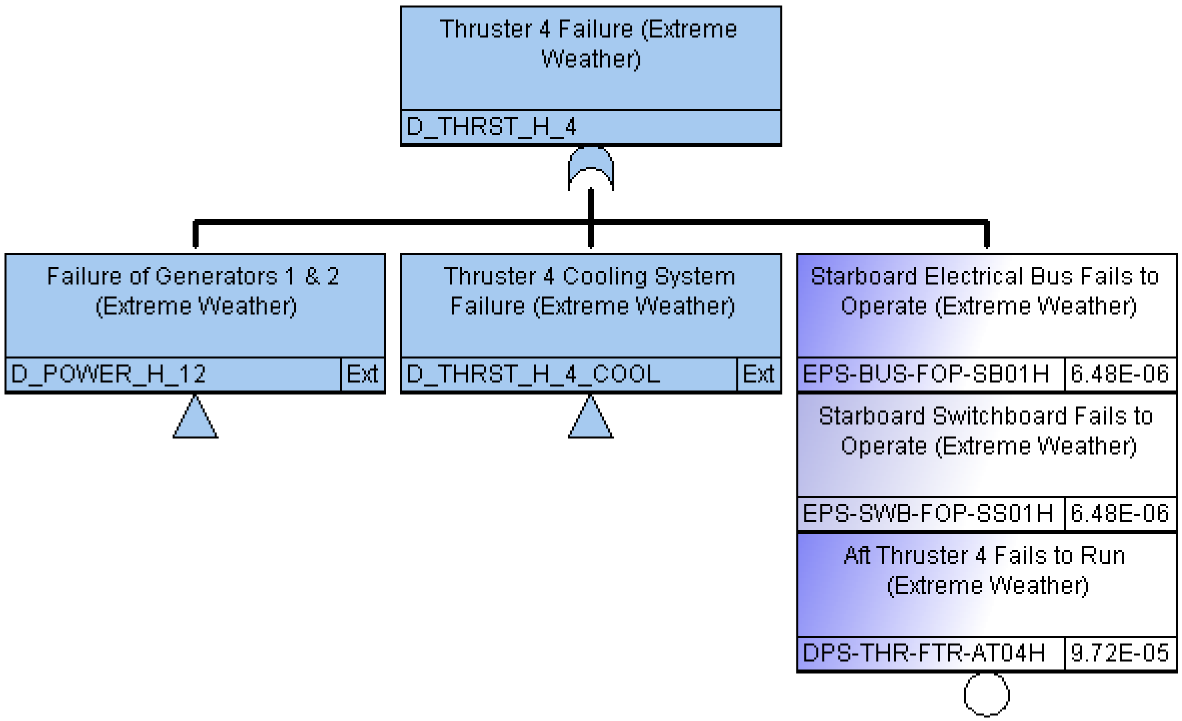

Figure C- 205: Initiating Events: Drift-off/Push-off (Continued)

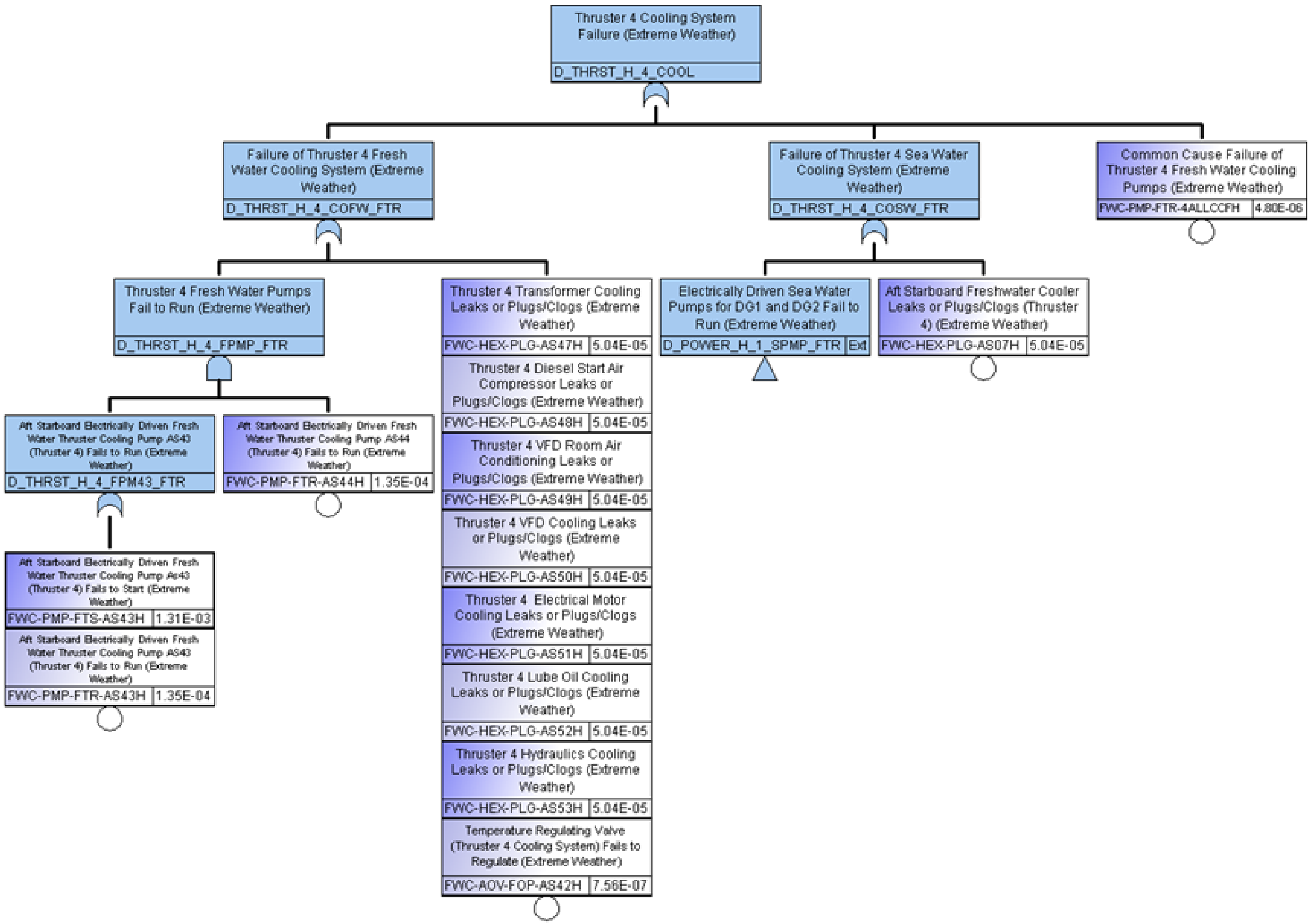

Figure C- 206: Initiating Events: Drift-off/Push-off (Continued)

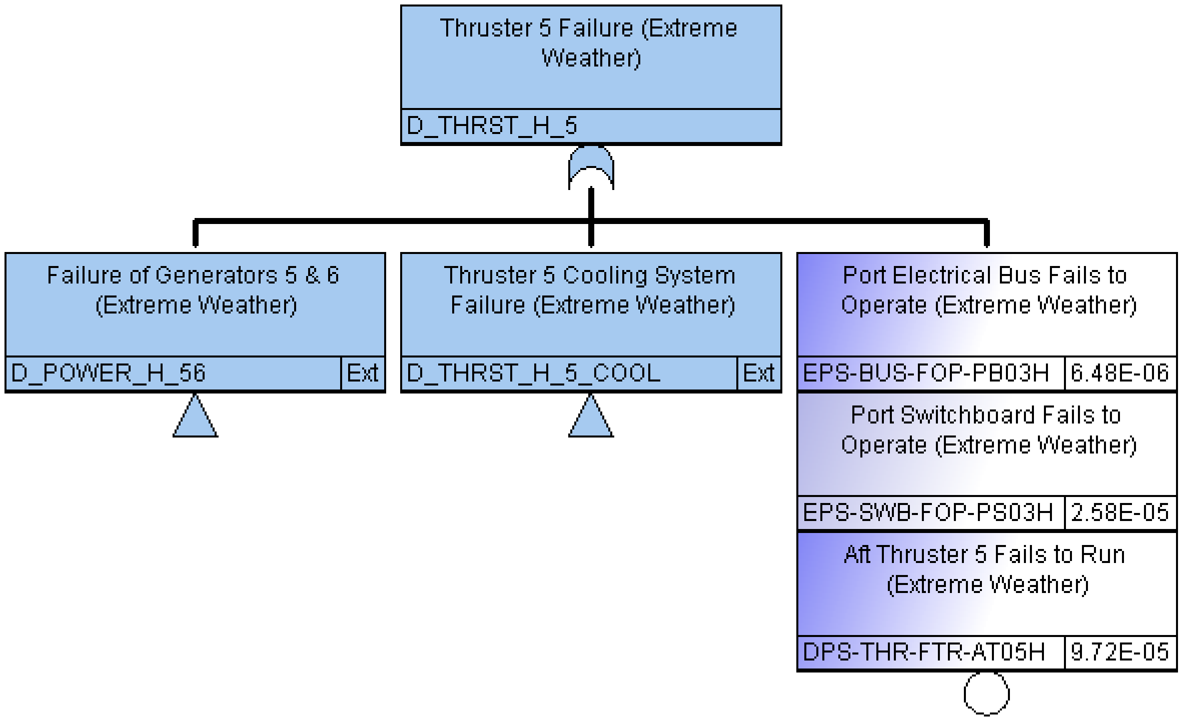

Figure C- 207: Initiating Events: Drift-off/Push-off (Continued)

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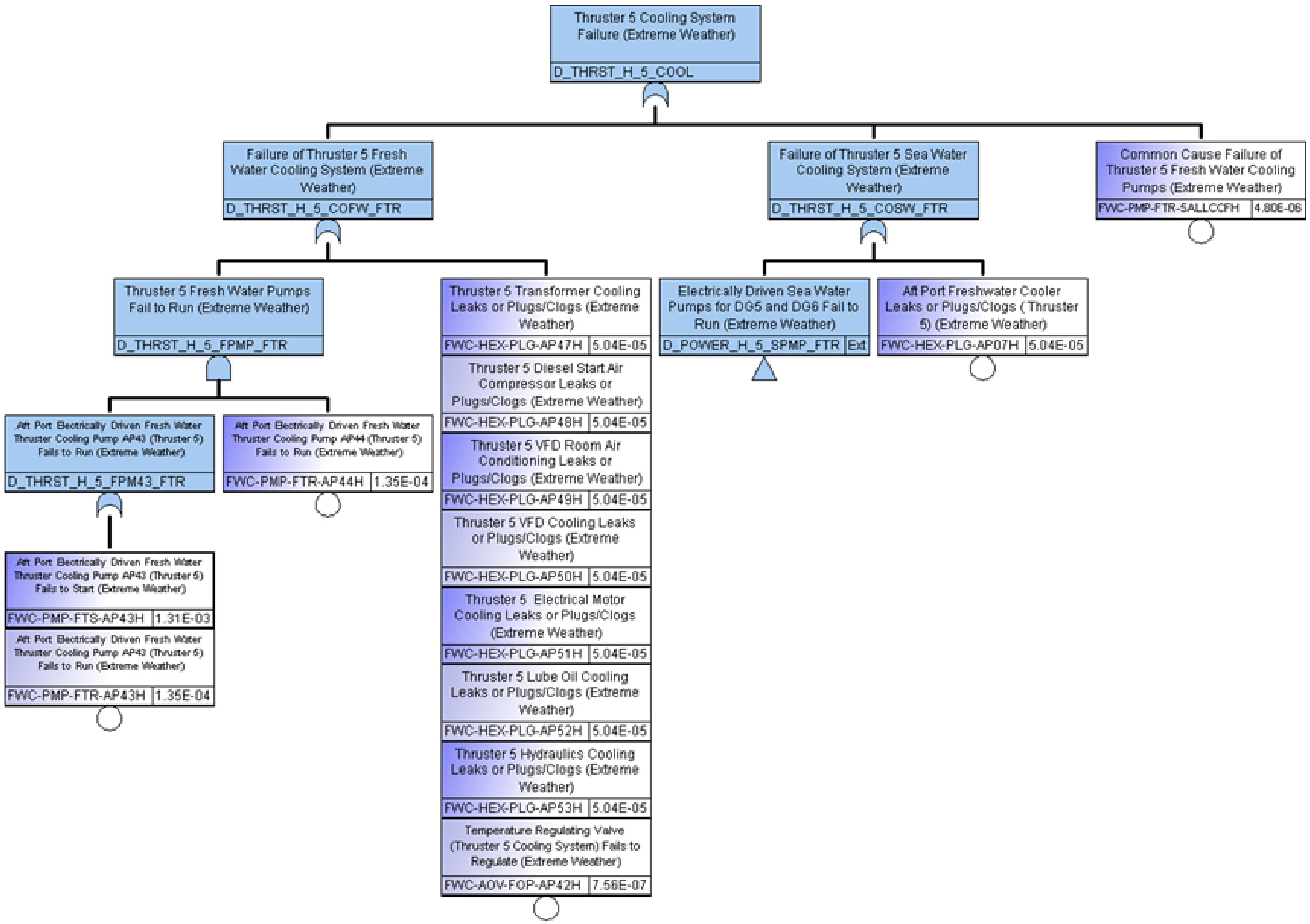


Figure C- 208: Initiating Events: Drift-off/Push-off (Continued)

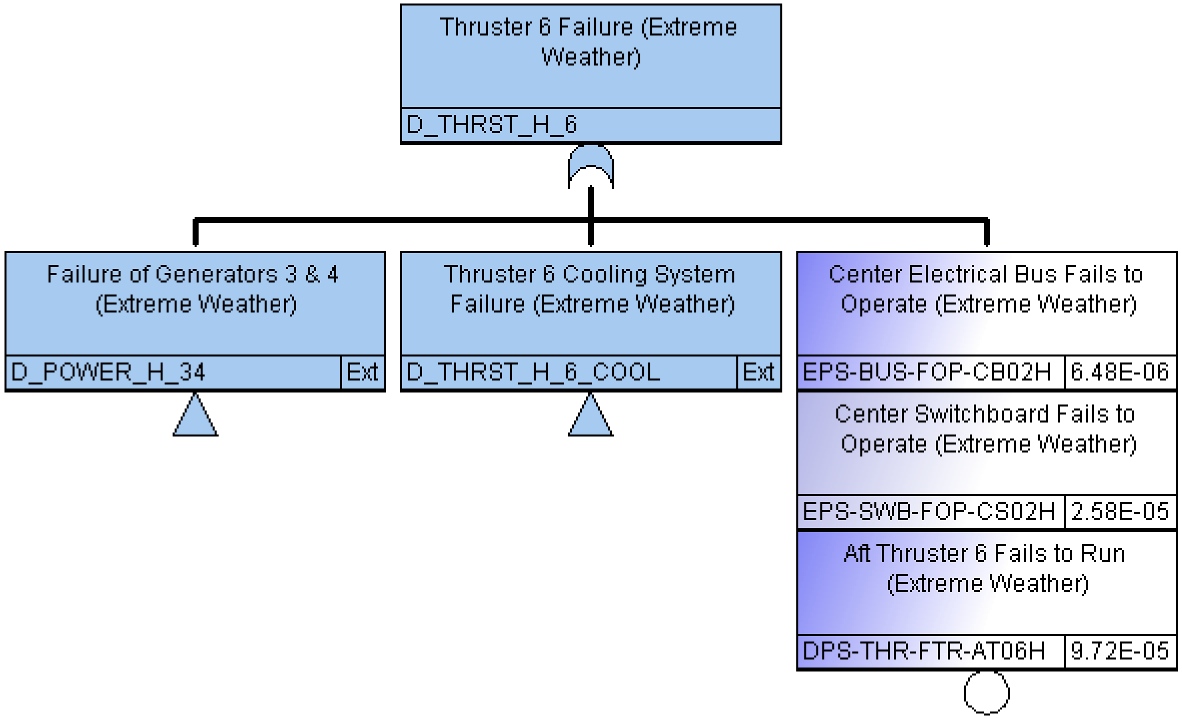


Figure C- 209: Initiating Events: Drift-off/Push-off (Continued)

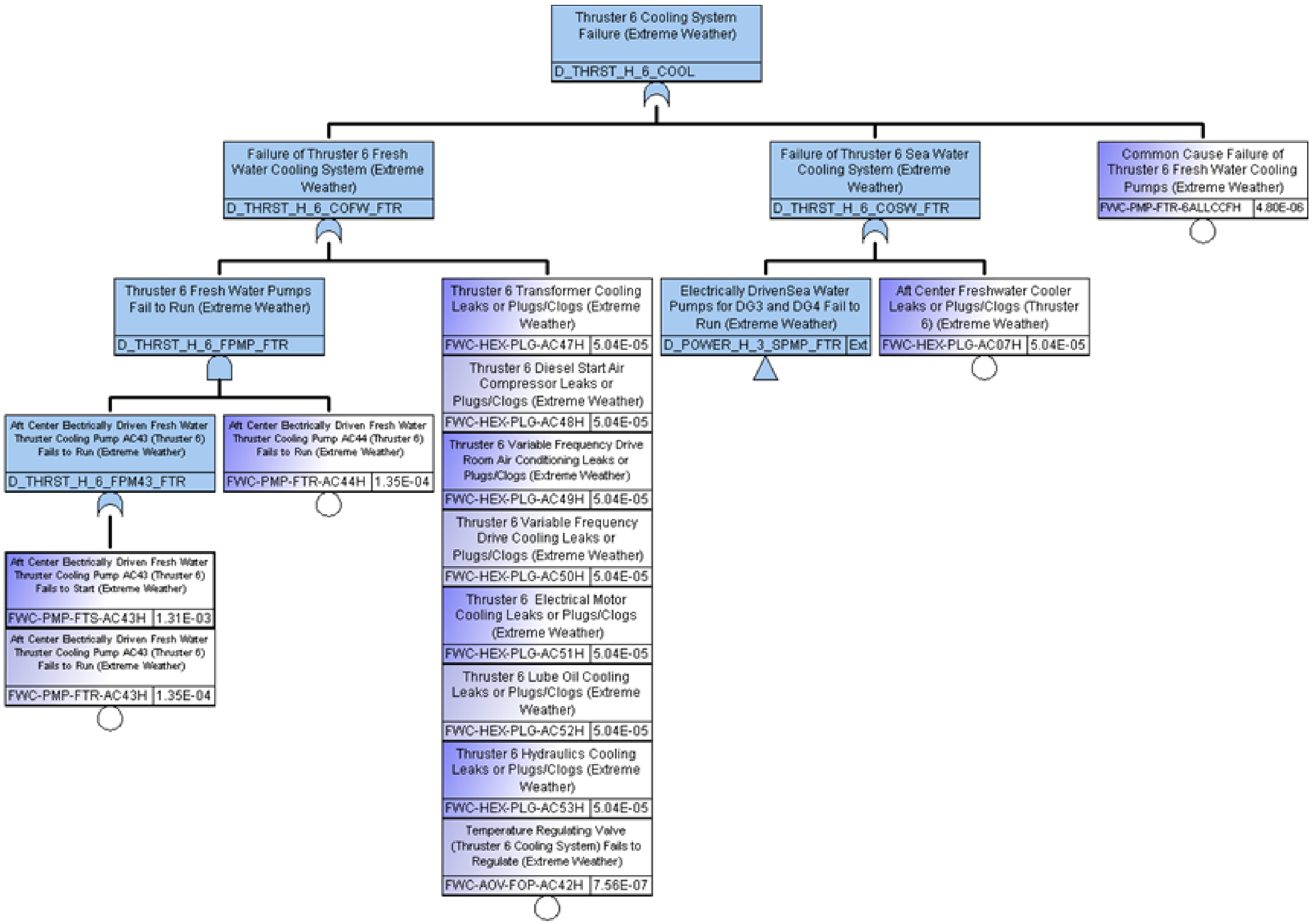


Figure C- 210: Initiating Events: Drift-off/Push-off (Continued)

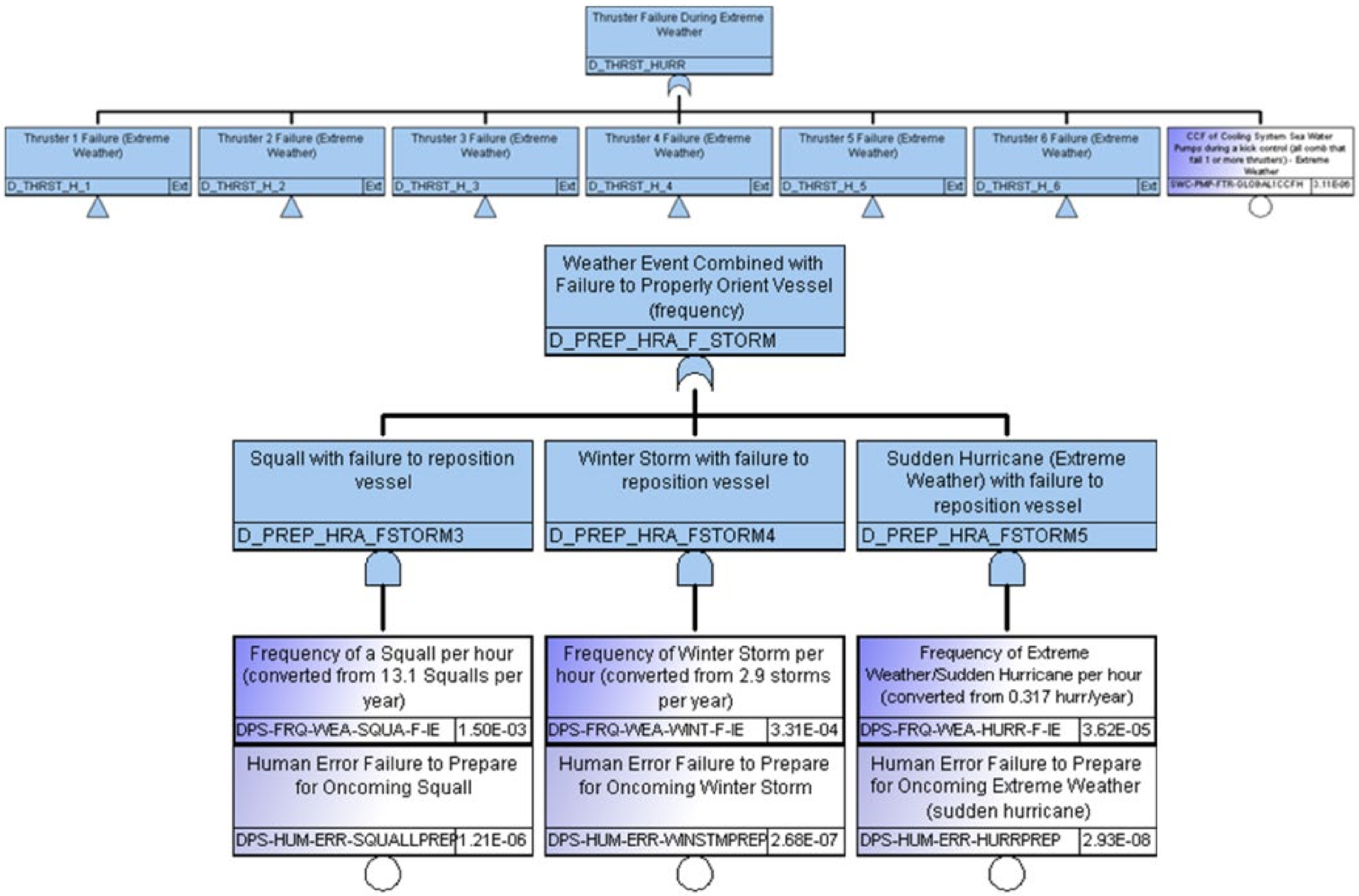


Figure C- 211: Initiating Events: Drift-off/Push-off (Continued)

C.29 DRIVE-OFF INITIATOR

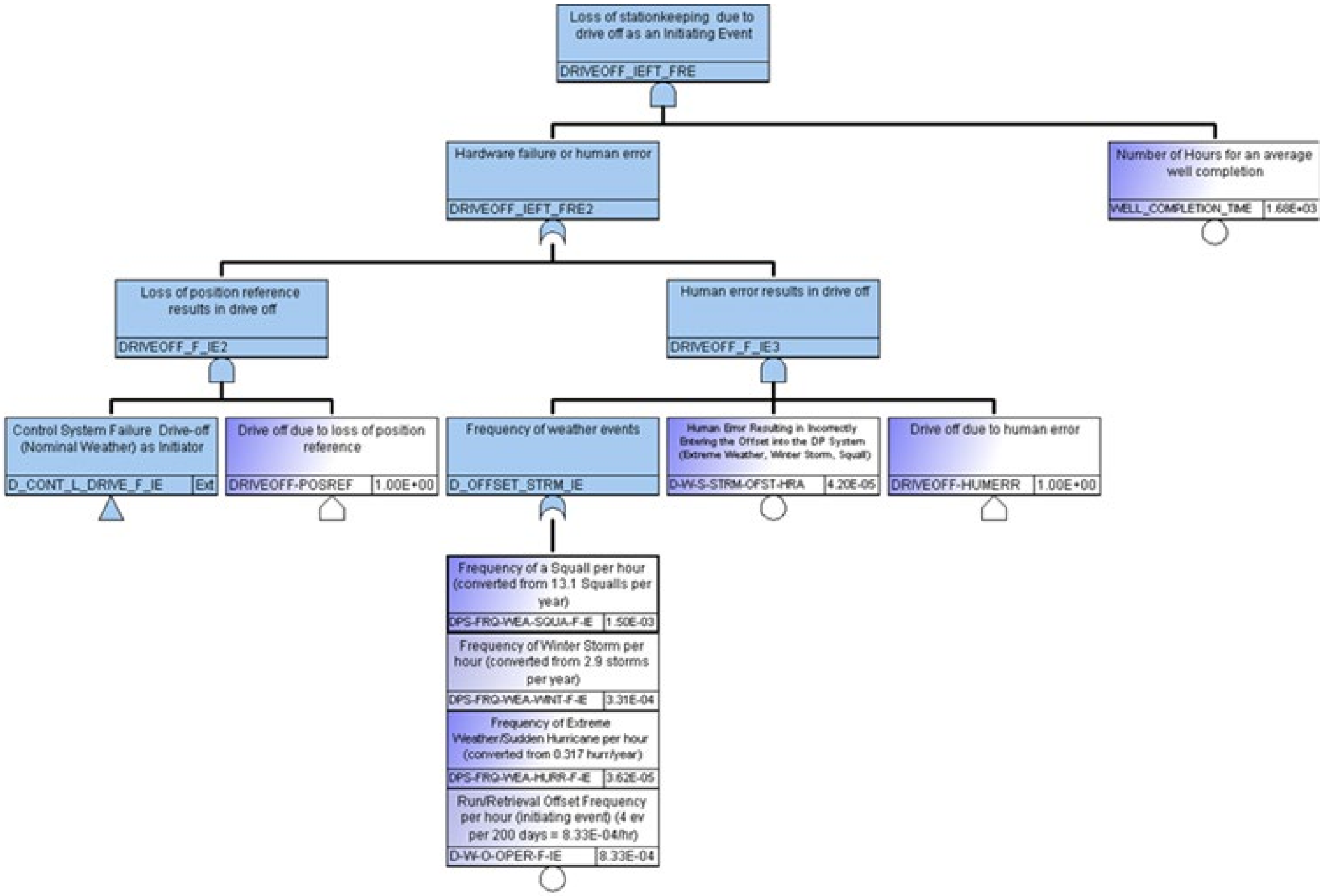


Figure C- 212: Initiating Events: Drive-off

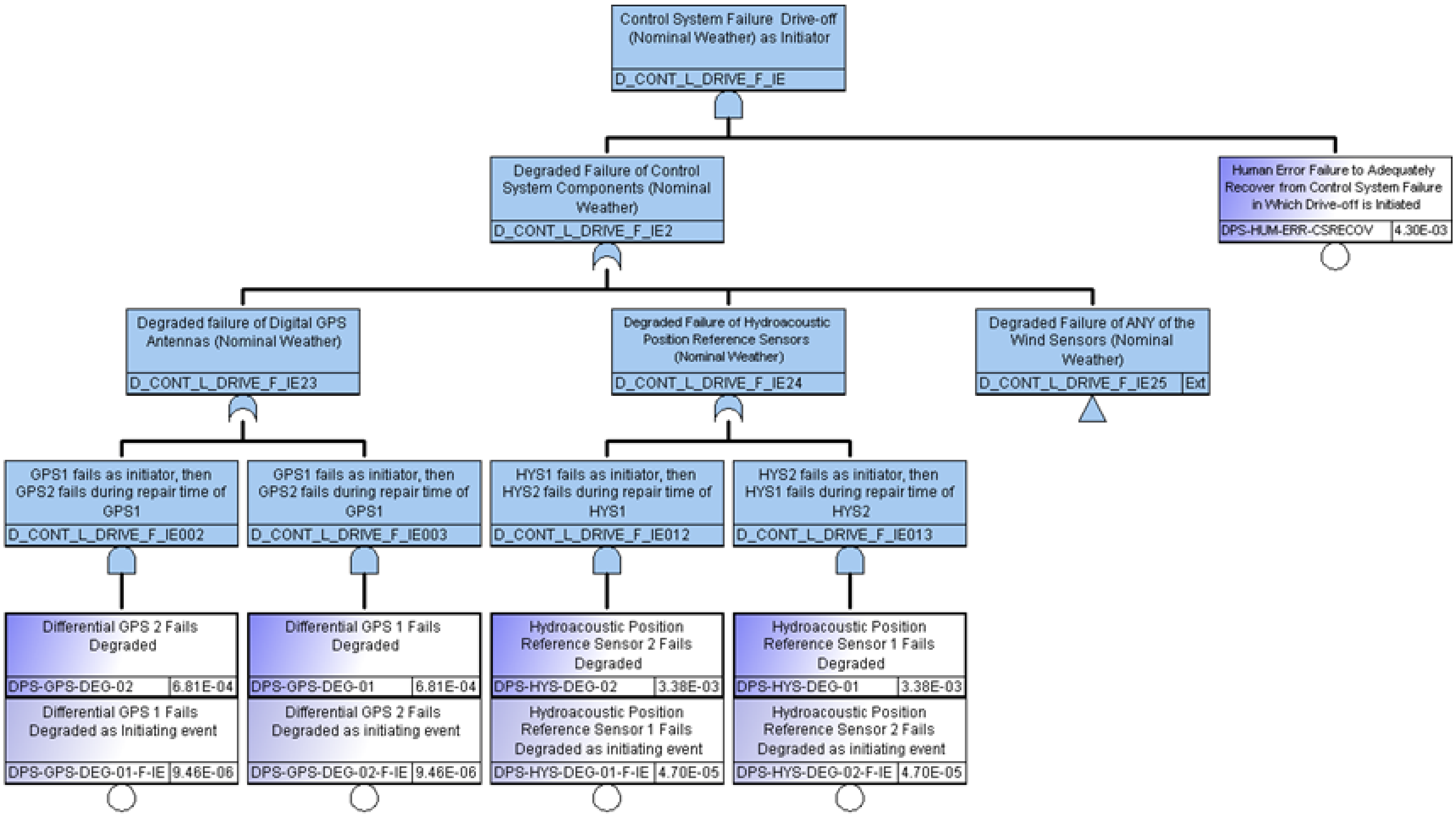


Figure C- 213: Initiating Events: Drive-off (Continued)

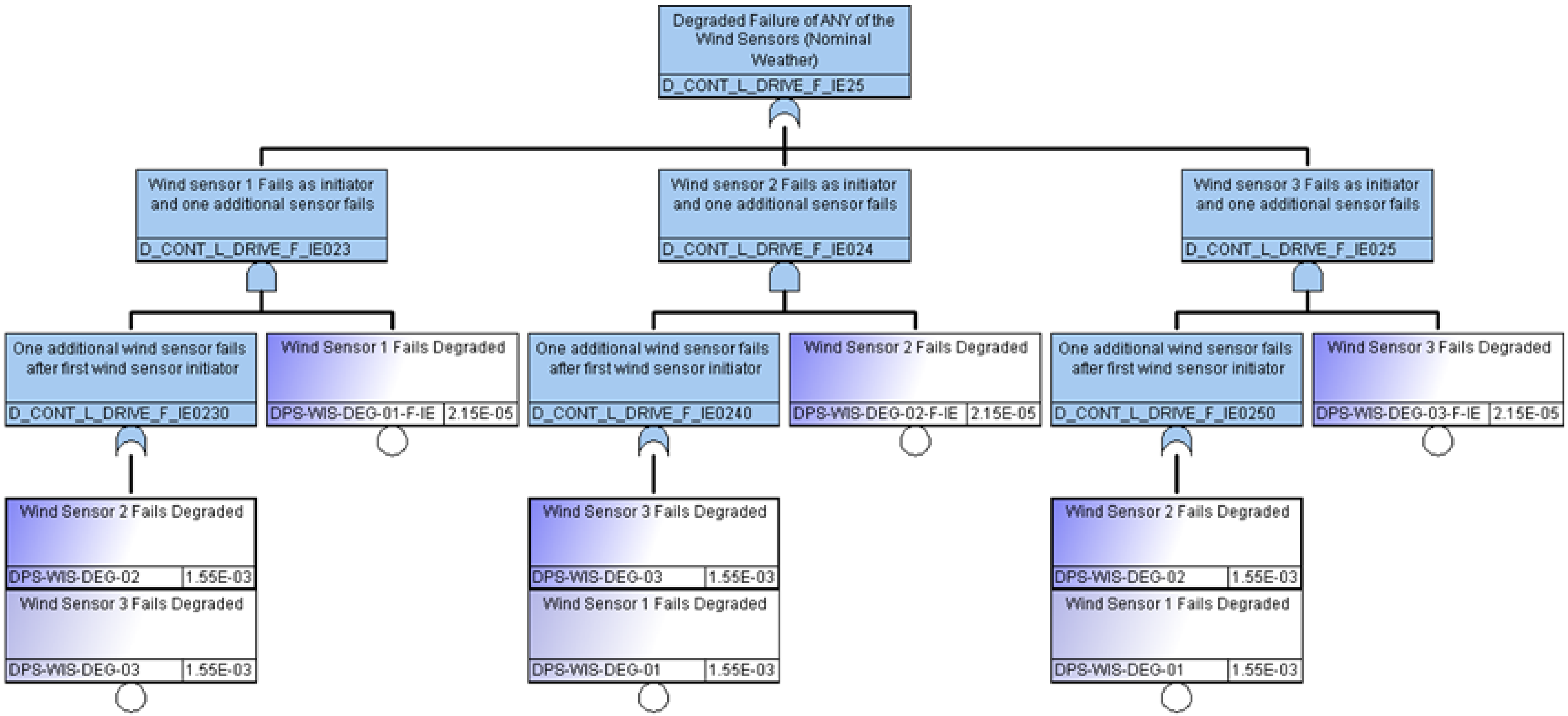


Figure C- 214: Initiating Events: Drive-off (Continued)

APPENDIX D- BASIC EVENT NAMING CONVENTION

D.1 BASIC EVENT NAMING SCHEME

In order for SAPHIRE to properly account for dependencies and common components between fault trees, it is very important to follow a detailed naming convention for basic events throughout the whole PRA project. In this study, the following naming scheme has been used for components:

Basic Event Name:

XXX-YYY-ZZZ-DDDDD. The different codes represent the following:

- XXX: The system the component belongs to (see Table D- 1)
- YYY: The component type (Table D- 2)
- ZZZ: The failure mode (see Table D- 3)
- DDDDD: the unique component identifier

Table D- 1: Naming Convention for Systems

Code	Description
BOP	Blowout Preventer
DPS	Dynamic Positioning System
ELS	Electric Power Distribution System
EME	Emergency Shutdown System
EPS	Electric Power Generation System
FSY	Fuel System
FWC	Fresh Water Cooling System
HYS	Topsides Hydraulic System
SWC	Seawater Cooling System

Table D- 2: Basic Event Naming Convention for Component Types

Code	Description
ACC	Accumulator
AOV	Temperature Regulating Valve
BUS	Bus (electrical)
CCU	Central Control Unit
COM	Dynamic Positioning Computer
CTL	Control Panel
CYL	Cylinder Ram
DGN	Diesel Generator
ESD	Emergency Shutdown System

Code	**Description**
FLT	Filter
GPS	Global Positioning System
GYC	Gyro Compass Sensor
HEX	Heat Exchanger
HOV	Choke Valve
HUM	Human
HYS	Hydroacoustic Position Reference Sensor
JBX	Junction Box
JOY	Joystick Control System
ORF	Orifice
PDP	Power Distribution Panel
PMP	Pump
PRG	Regulator
PVL	Pilot Operated Valve
SCV	Spring Check Valve
SCH	Sea Chest
SEA	Annular Elastomer
SEM	Control Pod SEM
SHV	Shuttle Valve
SVL	Solenoid Valve
SWB	Switchboard
THR	Thruster
TRF	Electrical Transformer
UMB	Umbilical
UPS	Uninterruptable Power Supply
VRS	Vertical Reference Sensor
WIS	Wind Sensor

The unique identifier is typically a component number from a drawing and each component basic event has a unique identifier so they are not listed here. For Common Cause Failure (CCF) basic events, a “CCF” label is appended to the end of the unique identifier. For components that are initiators, and “IE” is appended to the unique identifier.

Non-component basic events are also used in the model and do not follow the form above. Generally, these types of events are conditions such as a kick or a tool joint is present. These are more freeform input while trying to be as descriptive as possible to allow for easy identification.

Tag type basic events are used in a few areas. These basic events are represented graphically by a house event and have a value of 1.0. These tag events make sorting through the cut sets more convenient.

Table D- 3: Basic Event Naming Convention for Failure Modes

Code	Description
CLG	Clogged
DEG	Degraded
ERR	Error
FLO	Fails Low
FOF	Fails Off
FOP	Failure to Operate
FTC	Failure to Close
FTO	Failure to Open
FTR	Failure to Run
FTS	Failure to Start
JAM	Jammed
LKE	Leakage (External)
LKI	Leakage (Internal)
PLG	Plugged
SPO	Spurious Power Outage

APPENDIX E- SYSTEM ANALYSES

E.1 BLOW OUT PREVENTER (BOP)

This section describes the design of a generic BOP with two shear rams, two annulars, and three variable bore pipe rams.

E.2 BOP STACK DESCRIPTION

The BOP system is a large, specialized device attached to the wellhead on the sea floor, used to seal, control and monitor oil and gas wells to prevent the uncontrolled release of crude oil and/or natural gas from a well. The BOP stack include various types of rams and preventers used for well containment as well as choke and kill lines used after a kick to kill the well. Figure E- 1 shows the basic BOP layout, while Table E- 1 shows the subsystems that are part of a BOP system, their basic function, and whether they are included in the model.

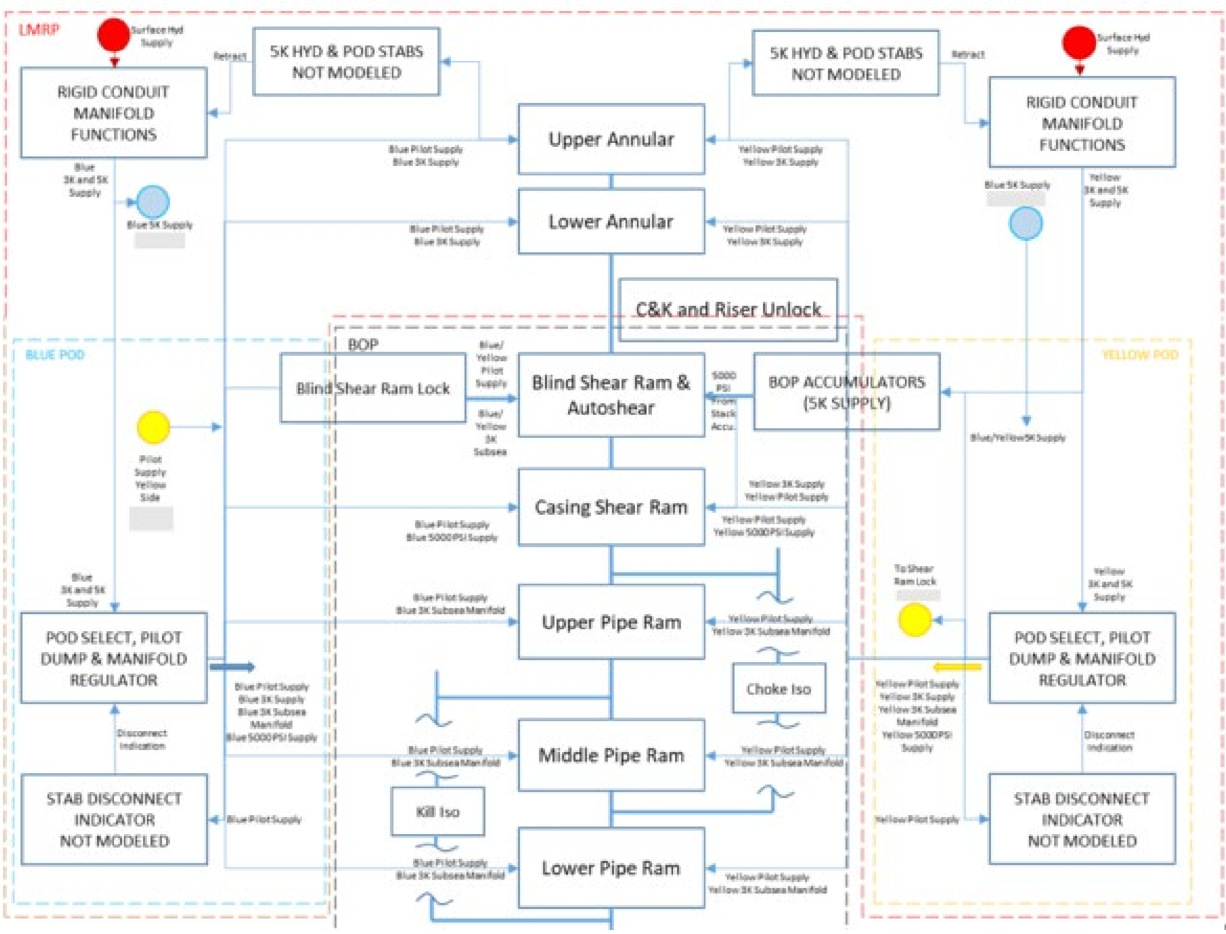


Figure E- 1: BOP Upper and Lower Stack

Table E- 1: BOP Systems

Subsystem	Basic Function	Modeled?	Comments
Annular preventers	Well Containment	Yes	Upper and lower
Pipe Rams	Well Containment	Yes	Upper, middle, and lower
Casing shear rams	Shearing pipe	Yes	
Blind shear rams	Shearing pip and sealing well	Yes	
Test rams	Well testing	No	
LMRP disconnect	Emergency disconnect	Yes	Only the riser connector and choke and kill connectors are modeled
Choke & Kill Lines	Well kill	Yes	
Autoshear/deadman	Well Containment	Yes	
Rigid conduit manifold	Support subsystem	Yes	Hydraulic supply from surface to all other support subsystems
Pilot hydraulics	Support subsystem	Yes	Hydraulic supply to pod controls
Subsea hydraulic manifold	Support subsystem	Yes	Hydraulic supply to various functions
3000 PSI hydraulic manifold	Support subsystem	Yes	Hydraulic supply to various functions
5000 PSI hydraulic manifold	Support subsystem	Yes	Hydraulic supply to various functions
Mud boost		No	
Wellhead connector	Secures BOP to wellhead	No	

All functions on the BOP system have redundant controls through the yellow and blue pods with the exception of the deadman hydraulic circuit. Only one side at a time is active, and should the active side fail, a manual action is required to shift the controls to the redundant pod. The alignment of commands on the active and inactive pods stay in sync so when a shift between pods occurs, the existing alignment is maintained. Two safety related functions are included in the PRA model, response to a loss of containment event, and response to an emergency disconnect. The annular preventers and pipe rams are the first choice when responding to a loss of containment event as they can provide containment and allow the normal well kill process to start. In situations where they fail to adequately contain the well, the shear rams need to function to provide containment. This is undesirable because any tubular across the BOP will be sheared and will require a longer recovery process. On an emergency disconnect, the topside hydraulics will provide a shear signal to the BOP and upper part of the BOP, the LMRP, will disconnect from the lower stack. Once this has occurred, the autoshear function will trigger and provides a backup function for closing the casing shear rams and blind shear rams to contain the well.

Table E- 2 shows the functions included in the BOP PRA model and their subsystem dependencies. Control electric power and pilot hydraulic pressure/flow are required by all functions. The subsea, 3000 PSI, and 5000 PSI hydraulic manifolds are used for different functions depending on the pressure required.

Table E- 3 shows the support subsystem dependencies. The topside hydraulics and the electronic control portion of the system are modeled at a high level.

Table E- 2: BOP Frontline System Dependency Matrix

Function -> Support Subsystem	Upper Annular	Lower Annular	Upper Pipe Ram	Middle Pipe Ram	Lower Pipe Ram	Casing Shear Ram	Blind Shear Ram	DMAS (BSR and CSR)	LMRP Disconnect	Choke & Kill Line Isolate
Yellow pod control power	X	X	X	X	X	X	X		X	X
Blue pod control power	X[1]	X[1]	X[1]	X[1]	X[1]	X[1]	X[1]		X[1]	X[1]
Yellow Pod hydraulic pilot	X	X	X	X	X	X	X		X	X
Blue Pod hydraulic pilot	X[1]	X[1]	X[1]	X[1]	X[1]	X[1]	X[1]		X[1]	X[1]
Yellow Pod subsea manifold			X	X	X	X[2]	X[4]		X[5]	X[5]
Blue Pod subsea manifold			X[1]	X[1]	X[1]	X[1,2]	X[1,4]		X[1,5]	X[1,5]
Yellow Pod 3000 PSI manifold	X	X							X[6]	X[6]
Blue Pod 3000 PSI manifold	X[1]	X[1]							X[1,6]	X[1,6]
Yellow Pod 5000 PSI manifold						X	X			
Blue Pod 5000 PSI manifold						X[1]	X[1]			
Subsea Accumulators							X[3]	X[3]		

Notes:

[1] - The blue pod is assumed to be in standby and would be manually activated on loss of the yellow pod function

[2] - The subsea manifold supplies hydraulic power for the open function of the casing shear ram (not modeled), the 5000 PSI manifold supplies the closing power

[3] - The DMAS circuit is a backup function if topside hydraulics is not available and draws hydraulic power from the subsea accumulators

[4] - The subsea manifold is used for a low pressure close and locks for the blind shear ram

[5]- Hydraulic power for primary unlock

[6] - Hydraulic power for secondary unlock (back up)

Table E- 3: Subsystem Support to Support Dependencies

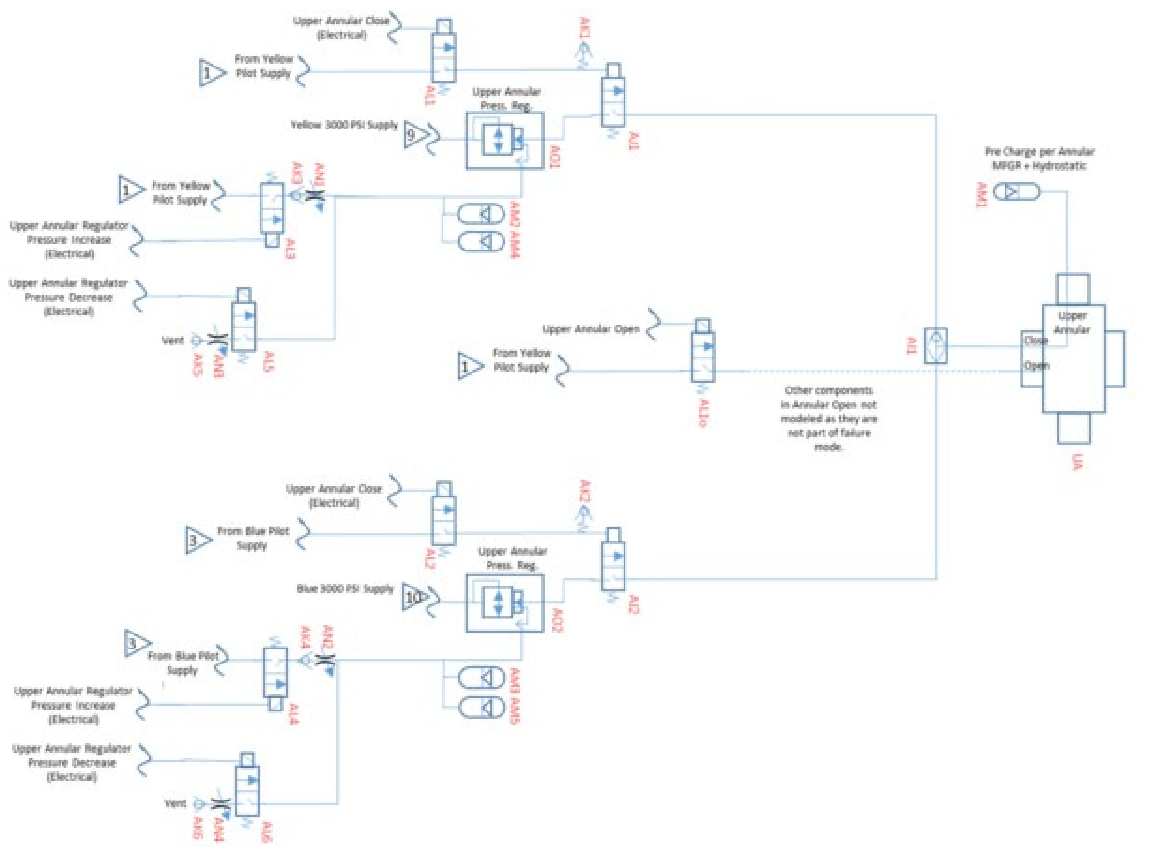
	Ship Electrical power	Topside hydraulics	Rigid Conduit Manifold	Yellow pod control power	Blue pod control power	Yellow Pod hydraulic pilot	Blue Pod hydraulic pilot	Yellow Pod subsea manifold	Blue Pod subsea manifold	Yellow Pod 3000 PSI manifold	Blue Pod 3000 PSI manifold	Yellow Pod 5000 PSI manifold	Blue Pod 5000 PSI manifold	Subsea Accumulators
Ship Electrical power				X	X									X[2]
Topside hydraulics			X											X[2]
Rigid Conduit Manifold										X	X	X	X	X[2]
Yellow pod control power														
Blue pod control power														
Yellow Pod hydraulic pilot														
Blue Pod hydraulic pilot														
Yellow Pod subsea manifold														
Blue Pod subsea manifold														
Yellow Pod 3000 PSI manifold						X[1]		X						
Blue Pod 3000 PSI manifold							X[1]		X					
Yellow Pod 5000 PSI manifold														
Blue Pod 5000 PSI manifold														
Subsea Accumulators														

[1] – There is a set of accumulators that can temporarily supply hydraulic power to the pilot system
[2] – For charging/recharging

E.3 BOP STACK SUBSYSTEM DESCRIPTIONS

Annular Preventers

The Annular preventer is a large valve used to control wellbore fluids. In this type of valve, the sealing element resembles a large rubber doughnut that is mechanically squeezed inward to seal on either pipe (drill collar, drillpipe, casing, or tubing) or the open hole. The ability to seal on a variety of pipe sizes is one advantage the annular preventer has over the ram BOP. While not considered as reliable in sealing over the open hole as around tubulars, the elastomeric sealing doughnut is required by American Petroleum Institute (API) specifications to seal adequately over the open hole as part of its certification process. The annular preventers may also be used to strip in drillpipe. This operation involves forcing the drillpipe through a closed annular preventer to drive it farther into the well. When a tool joint is at the preventer, forcing the tool joint through is allowed by a surge accumulator that absorbs the pressure increase when the larger diameter tool joint is forced into the annular. This PRA model includes two annulars; Upper Annular and Lower Annular. Each annular may be operated by either the yellow or blue pod controls although only one side is selected at any given time.



Upper Annular

Figure E- 2 and Figure E- 3 show schematics of the upper and lower annular preventers.

The boundaries for modeling the annular subsystem includes the solenoid activated control valves in the yellow and blue control pods through the annular preventer elastomer doughnut.

The annular preventers are end use functions for well containment and allowing stripping in drillpipe and do not have any subsystems dependent on their function. The annular preventers are dependent on:

- Electrical control power for both the yellow and blue pods
- The hydraulic fluid pilot supply for both the yellow and blue pods for activation of the control systems
- The 3000 psi supply manifold for the yellow and blue pods for closing the annular preventers.

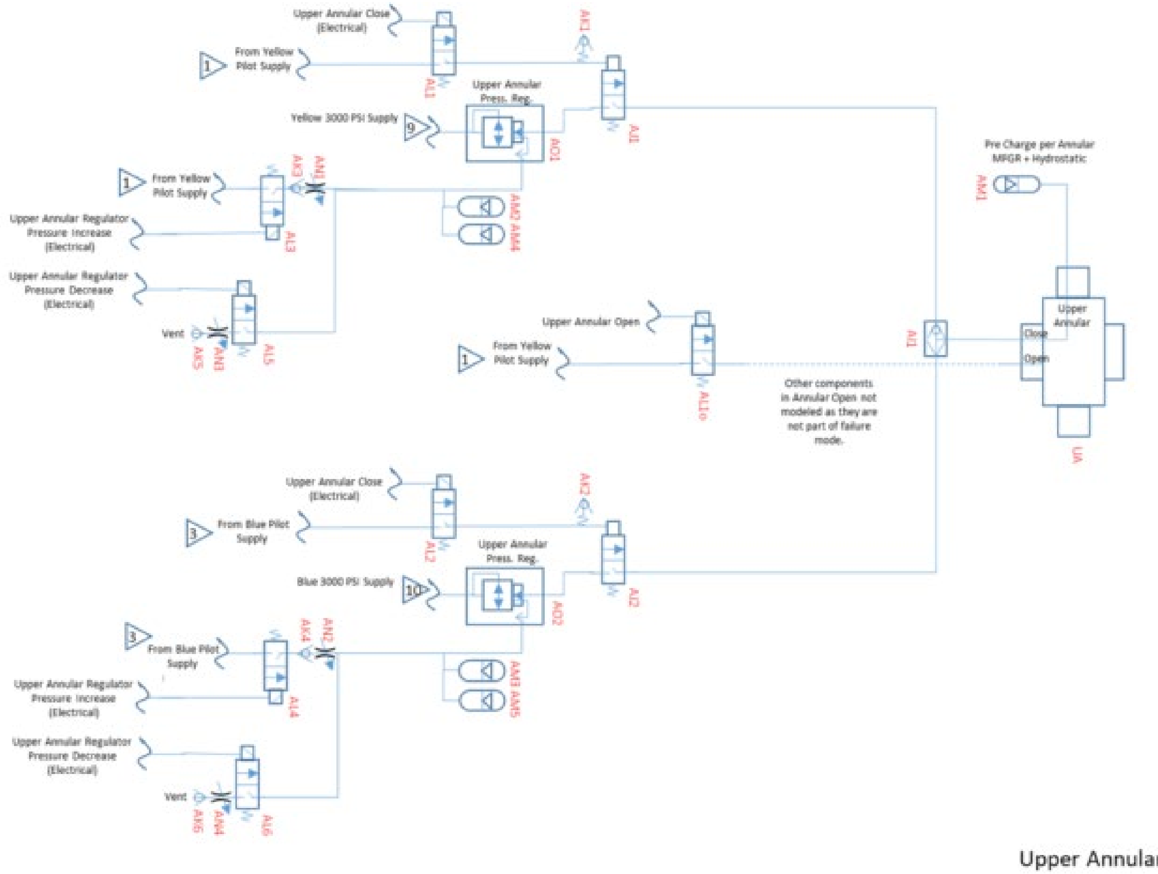


Figure E- 2: Upper Annular Preventer Schematic

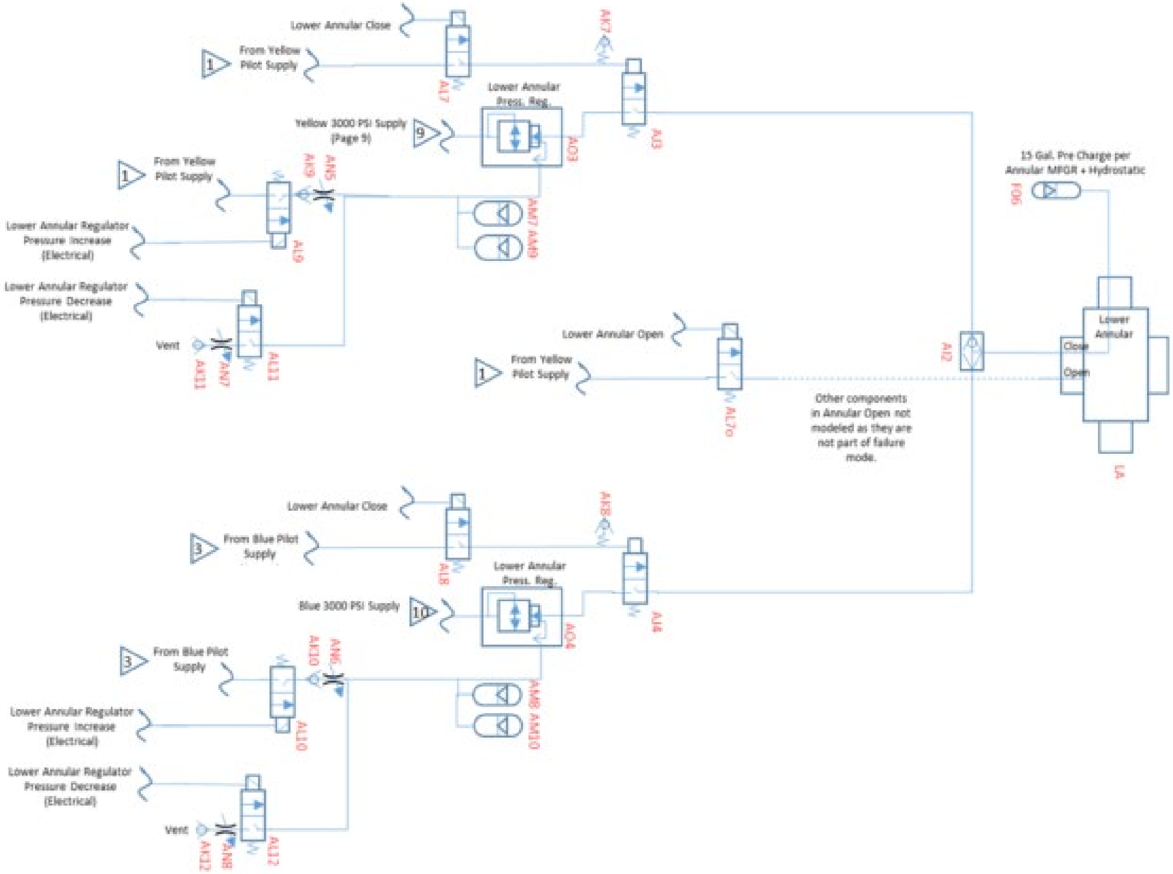


Figure E- 3: Lower Annular Preventer Schematic

Pipe Ram

The Pipe Ram is a type of sealing element in high-pressure split seal blowout preventers that is manufactured with a half-circle hole on the edge (to mate with another horizontally opposed pipe ram) sized to fit around drillpipe. Most pipe rams fit only one size or a small range of drillpipe sizes and do not close properly around drillpipe tool joints or drill collars. Pipe rams may also be used to strip in drillpipe. When stripping in pipe with the ripe rams, two pipe rams are required since the tool joint cannot be forced through the pipe rams so when a tool joint reaches a pipe ram it must be opened to allow the tool joint through. When this happens a second pipe ram is closed prior to opening the first for the tool joint. The pipe is the slid down until the next tool joint is reached. The pipe rams have locks to ensure the seal around the pipe is maintained. This PRA model includes three pipe rams; Upper, Middle, and Lower Rams.

Each pipe ram may be operated by either the yellow or blue pod controls although only one side is selected at any given time. Figure E- 4, Figure E- 5, and Figure E- 6 show schematics of the upper, middle, and lower pipe rams for the close function. Figure E- 7 shows a schematic of all of the pipe rams open function.

The boundaries for modeling the pipe ram subsystem includes the solenoid activated control valves in the yellow and blue control pods through the pipe rams.

The pipe rams are end use functions for well containment and allowing stripping in drillpipe and do not have any subsystems dependent on their function. The pipe rams are dependent on:

- Electrical control power for both the yellow and blue pods
- The hydraulic fluid pilot supply for both the yellow and blue pods for activation of the control systems
- The subsea supply manifold for the yellow and blue pods for opening and closing the pipe rams

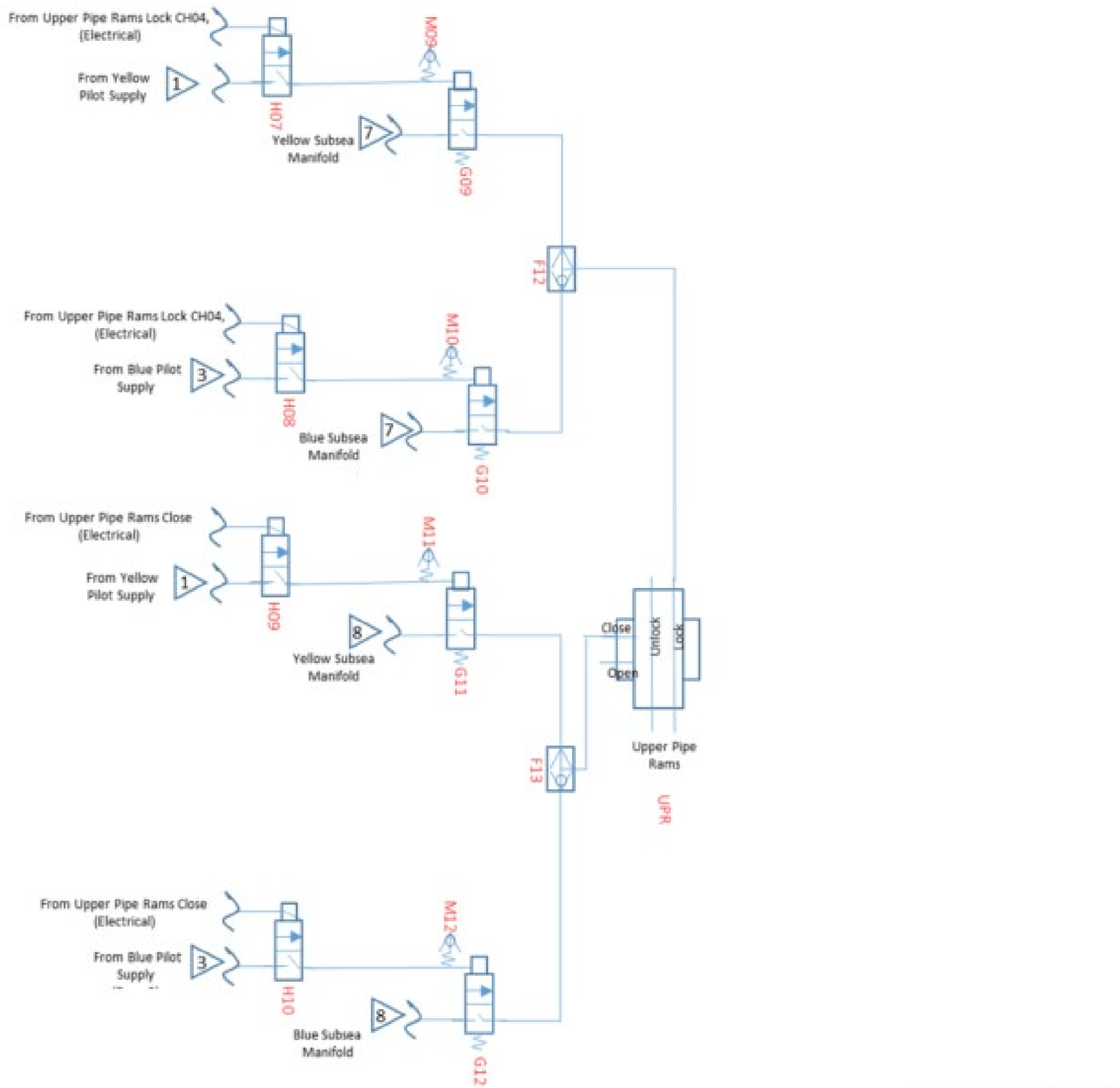


Figure E- 4: Upper Pipe Ram Close Schematic

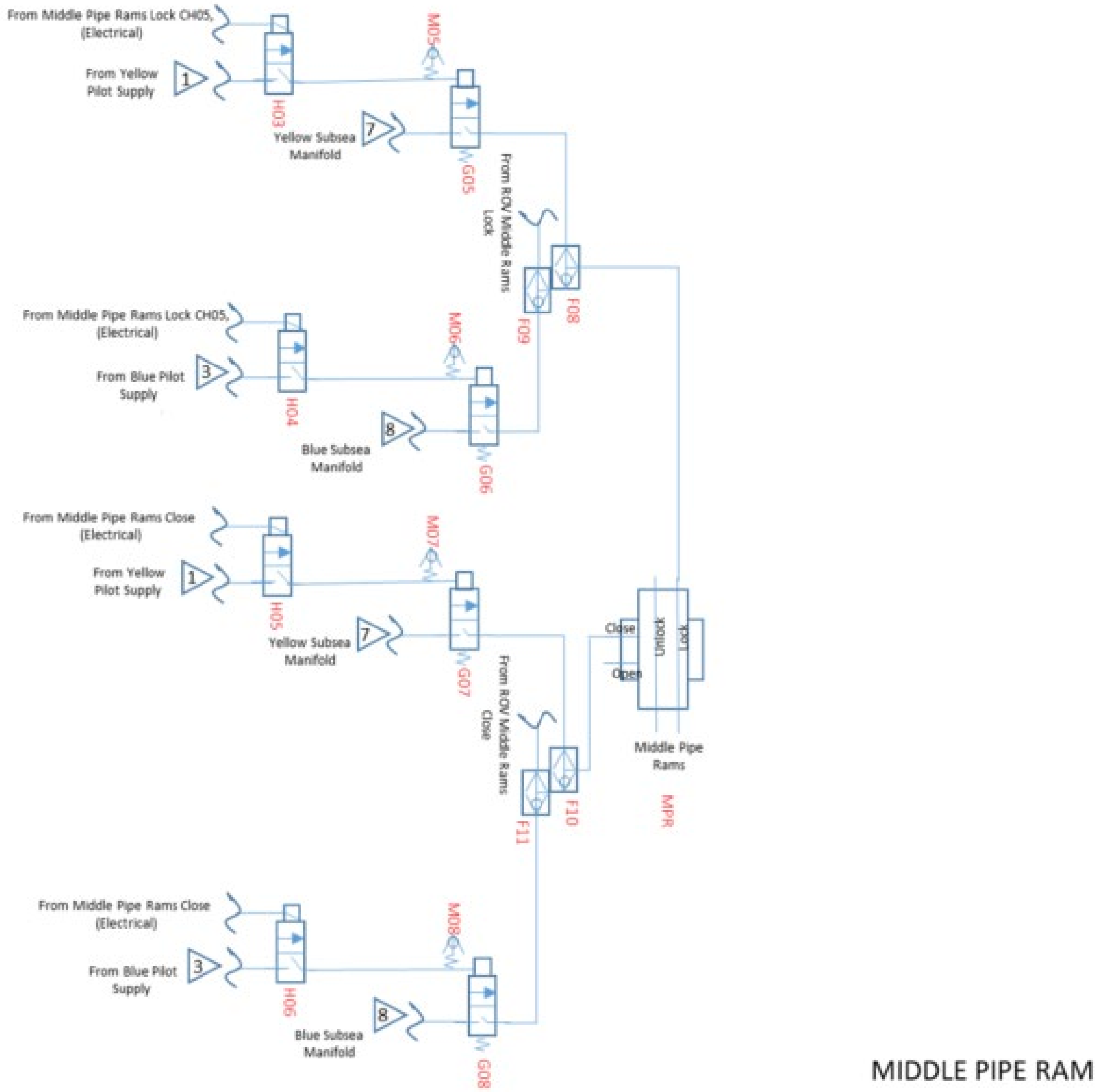


Figure E- 5: Middle Pipe Ram Close Schematic

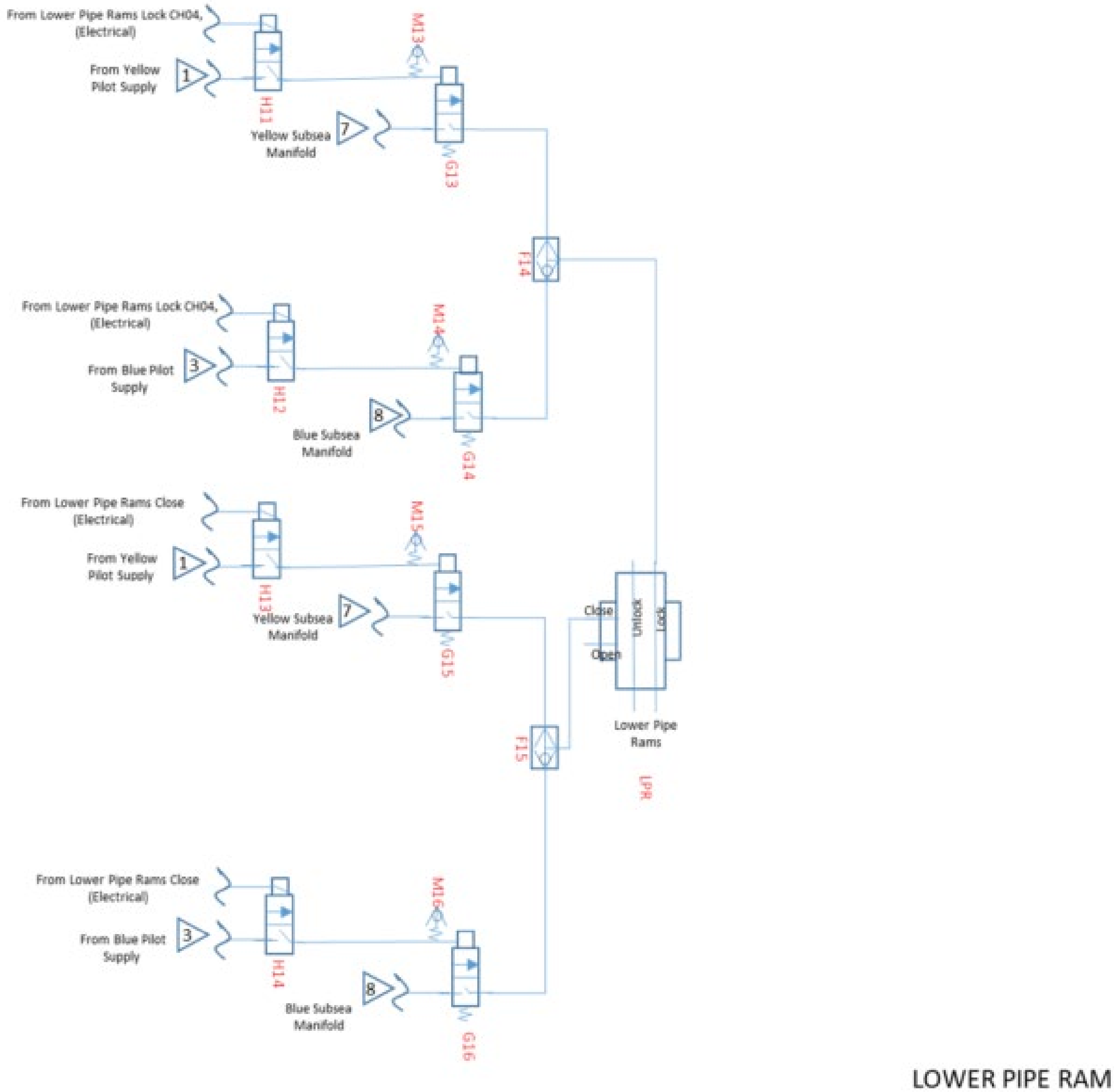


Figure E- 6: Lower Pipe Ram Close Schematic

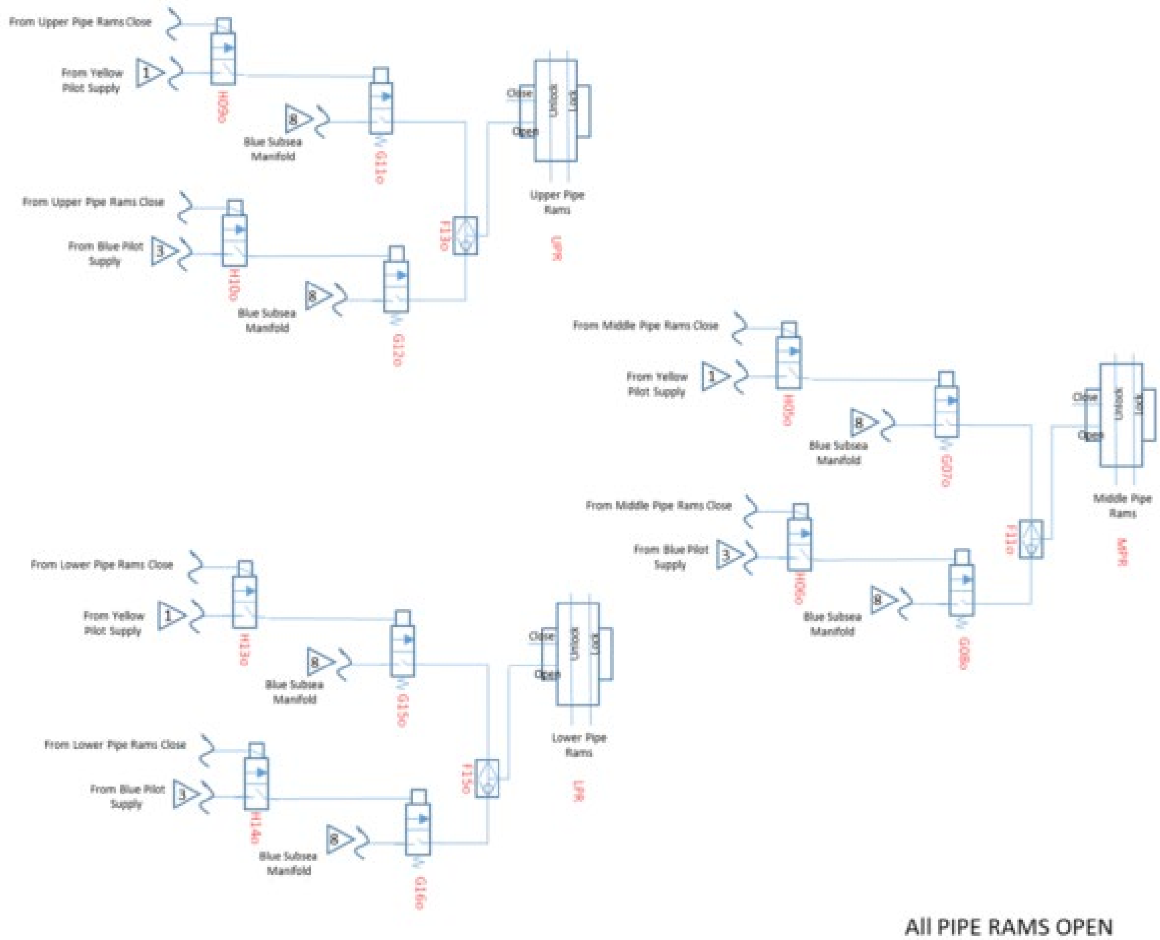


Figure E- 7: All Pipe Rams Open Schematic

Blind Shear Ram

Blind Shear Ram (BSR) is a BOP closing element fitted with hardened tool steel blades designed to cut the drillpipe or tubing when the BOP is closed, and then fully close to provide isolation or sealing of the wellbore. It is the only BOP certified to seal the well when it is closed. Once the BSR is closed, it can be locked in place to ensure the well remains sealed.

The BSR may be operated by either the yellow or blue pod controls although only one side is selected at any given time. The BSR is also automatically closed through the autoshear function when performing an emergency disconnect. Loss of both electrical and hydraulic communication between the rig and BOP will result in activation of the deadman function which includes closing of the BSR. Figure E- 8, and Figure E- 9 show schematics of the BSR and BSR lock.

The boundaries for modeling the BSR subsystem includes the solenoid activated control valves in the yellow and blue control pods through the BSR including the locks.

The BSR is an end use function for well containment and shearing drillpipe and does not have any subsystems dependent on its function. The BSR is dependent on:

- Electrical control power for both the yellow and blue pods
- The hydraulic fluid pilot supply for both the yellow and blue pods for activation of the control systems
- The subsea supply manifold for the yellow and blue pods for the BSR lock
- The 5000 psi hydraulic fluid supply for both the yellow and blue pods for high pressure closing of the BSR
- The deadman/autoshear function for activation of the BSR during emergency disconnects or loss of hydraulic and electrical communication between the rig and BOP

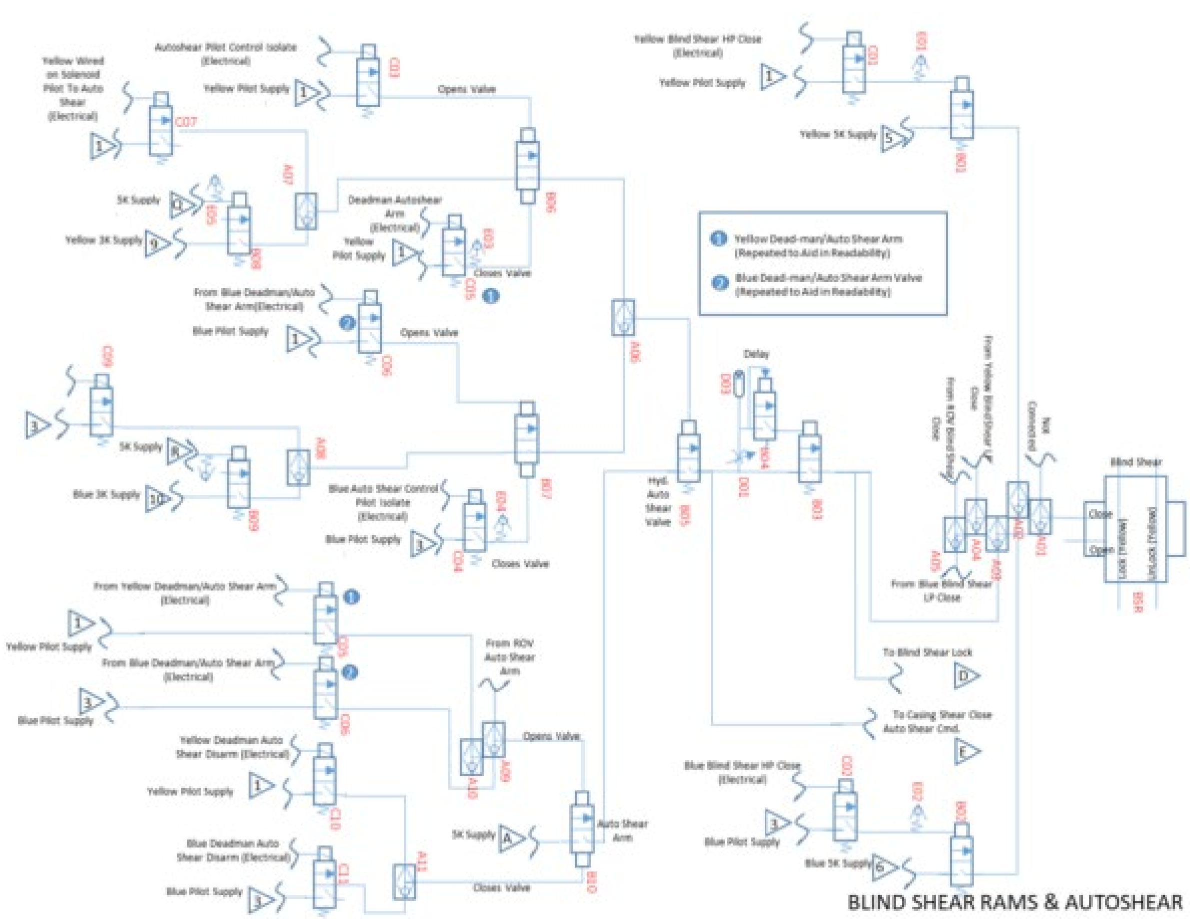


Figure E- 8: Blind Shear Ram Schematic

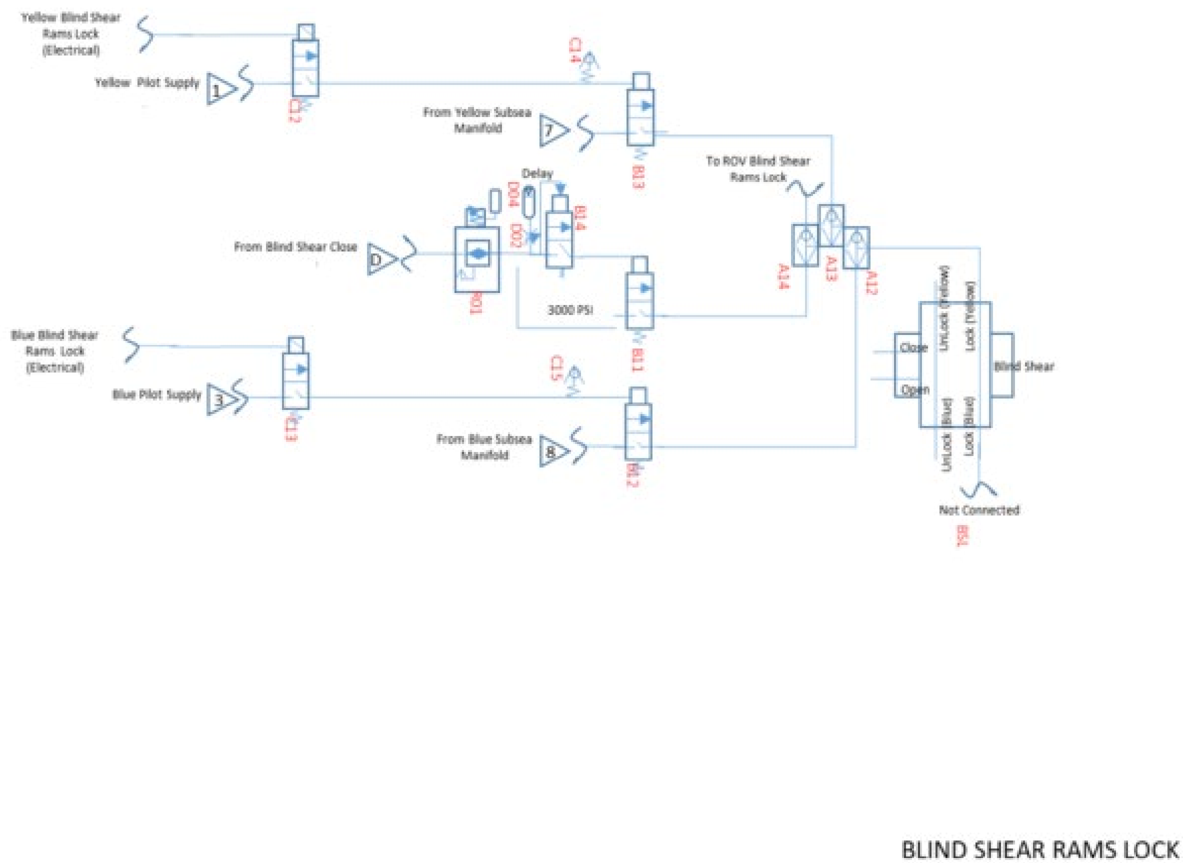


Figure E- 9: Blind Shear Ram Lock Schematic

Casing Shear Ram

The Casing Shear Ram (CSR) is a BOP closing element fitted with hardened tool steel blades designed specifically to shear casing and drillpipe, and is not designed to seal the well bore. It is located below the BSR, and activated prior to the BSR. If the CSR shears pipe, the pipe will rise above the BSR due to tension in the drill string being released.

The CSR may be operated by either the yellow or blue pod controls although only one side is selected at any given time. The CSR is also automatically closed before the BSR through the autoshear function when performing an emergency disconnect. Loss of both electrical and hydraulic communication between the rig and BOP will result in activation of the deadman function which includes closing of the CSR. Figure E- 10 shows the schematic of the CSR.

The boundaries for modeling the CSR subsystem includes the solenoid activated control valves in the yellow and blue control pods through the CSR.

The CSR is an end use function for shearing pipe and does not have any subsystems directly dependent on its function, however, the BSR is likely to be more successful if the CSR shears any pipe in across the BOP prior to the BSR closing. The CSR is dependent on:

- Electrical control power for both the yellow and blue pods

- The hydraulic fluid pilot supply for both the yellow and blue pods for activation of the control systems
- The subsea supply manifold for the yellow and blue pods for the opening and low pressure close functions
- The 5000 psi hydraulic fluid supply for both the yellow and blue pods for high pressure closing of the CSR
- The deadman/autoshear function for activation of the CSR during emergency disconnects or loss of hydraulic and electrical communication between the rig and BOP

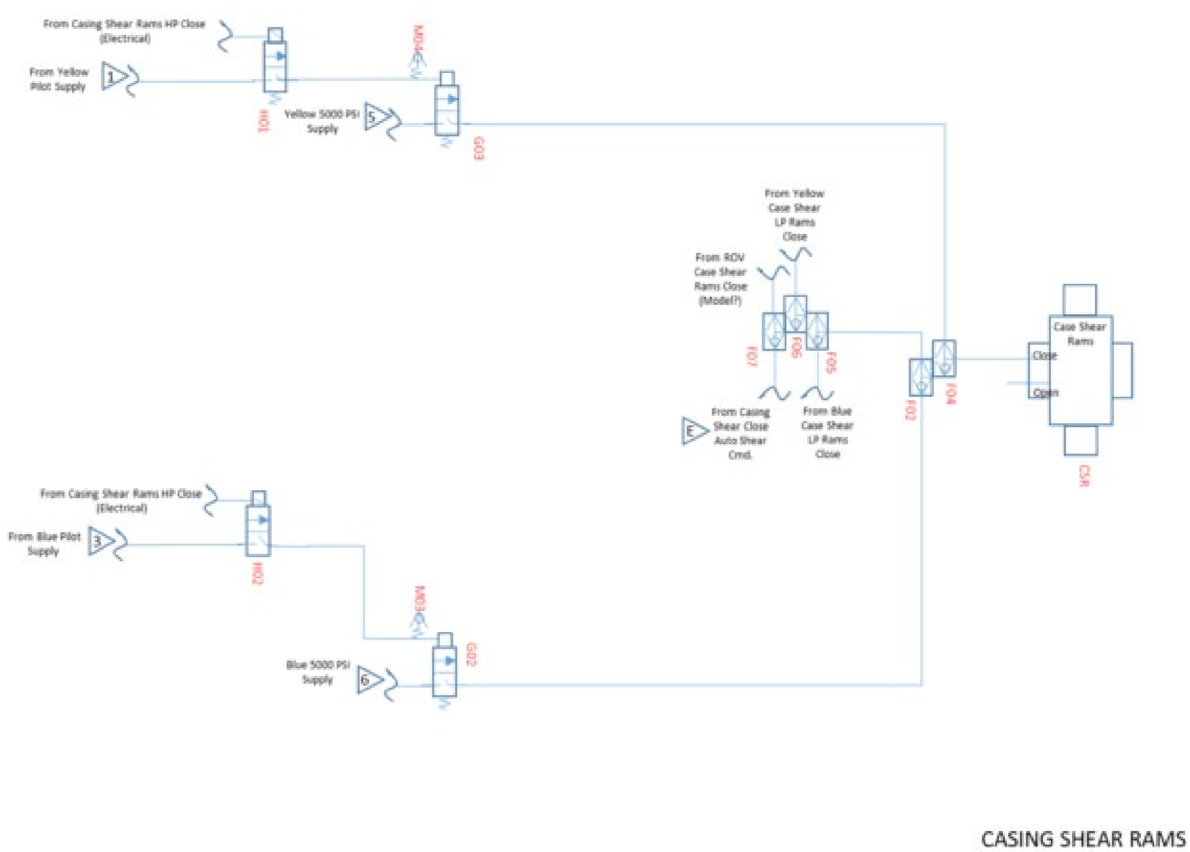


Figure E- 10: Casing Shear Ram Schematic

Choke/Kill lines

A choke line is a high-pressure pipe leading from an outlet on the BOP stack to the backpressure choke and associated manifolds. A kill line is a high-pressure pipe leading from the high-pressure rig pumps to an inlet on the BOP stack. During well-control operations, the well is sealed, usually with annulars or pipe rams, and kill fluid is pumped through the drill string and the fluid under pressure in the wellbore is taken out of the well through the choke line to the choke, thus reducing the fluid pressure to atmospheric pressure. If the drillpipe is not across the BOP, it may be necessary to pump heavy drilling fluid in the top of the well through the kill line, wait for the fluid to fall under the force of gravity, and then remove fluid from the annulus. In addition, this provides a measure of redundancy for the operation. In floating offshore operations, the choke and kill lines exit the subsea BOP stack and then run along the outside of the riser to the surface. The volumetric and frictional effects of these long choke and kill lines must be taken into account to properly control the well.

The choke and kill lines have fail safe isolation valves that automatically close when an emergency disconnect occurs and the LMRP lifts off. Each choke and kill line has redundant inner and outer isolation valves. The emergency disconnect also unlatches the choke and kill line connectors so the LMRP can be lifted off the lower stack.

Figure E- 11 and Figure E- 12 show schematics of the choke and kill isolation and connectors valves.

The boundaries for modeling the choke and kill subsystem includes the solenoid activated control valves in the yellow and blue control pods through the isolation and connector valves.

The choke and kill subsystem is an end use function for well control and does not have any subsystems directly dependent on its function. The choke and kill system is dependent on:

- Electrical control power for both the yellow and blue pods
- The hydraulic fluid pilot supply for both the yellow and blue pods for activation of the control systems
- The subsea supply manifold for the yellow and blue pods for the opening the primary connector locks
- The 3000 psi supply manifold for the yellow and blue pods for the opening the secondary connector locks
- The deadman/autoshear function for unlocking the choke and kill connectors during emergency disconnects

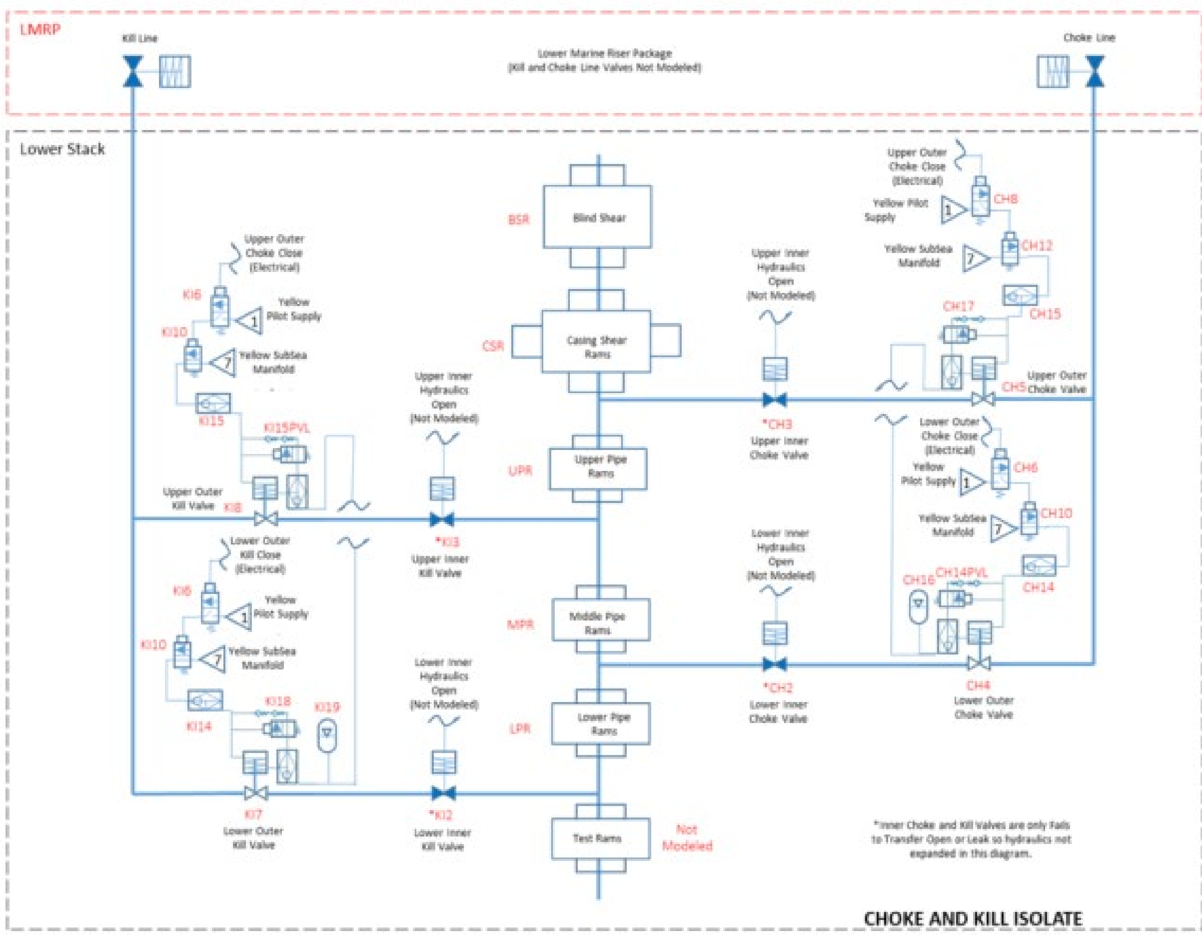


Figure E- 11: Choke and Kill Line Isolation Valves Schematic

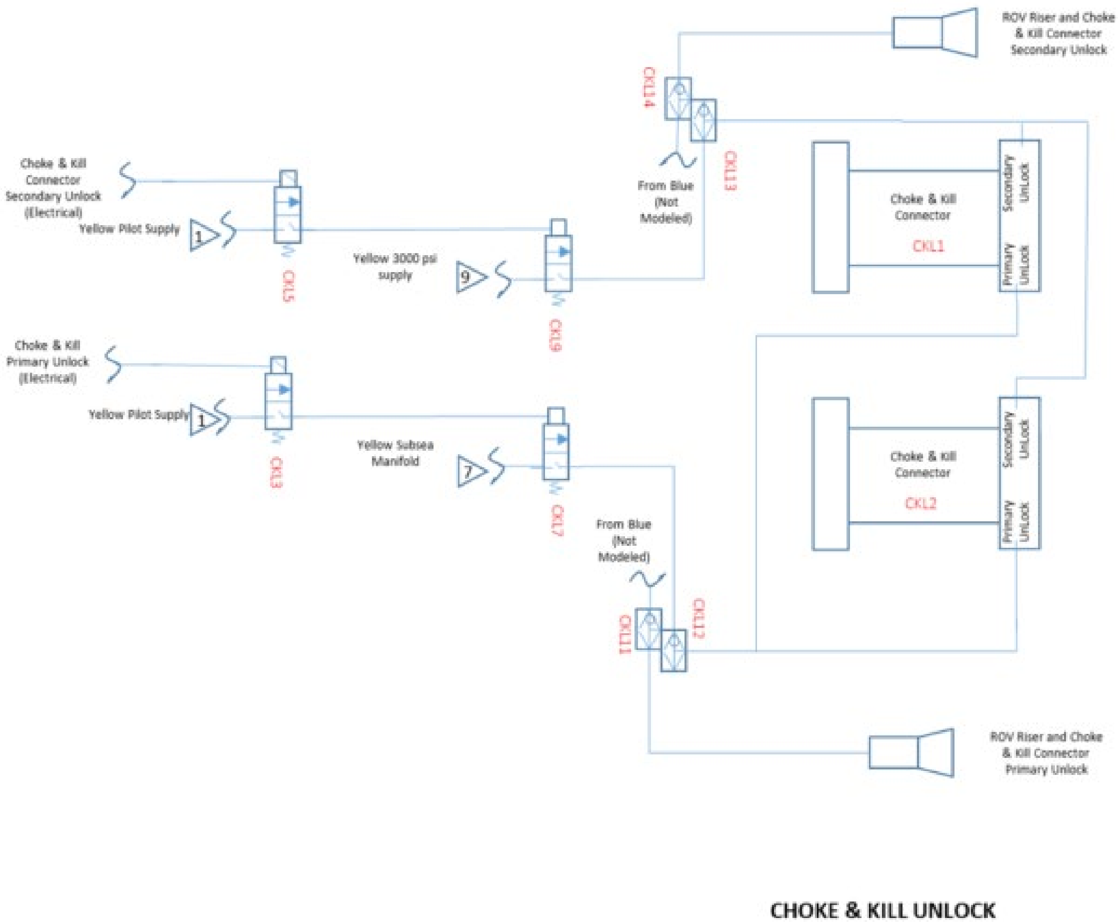


Figure E- 12: Choke and Kill Line Connector Valves Schematic

Lower Marine Riser Package (LMRP) Disconnect Function

The LMRP is the upper section of the two-section subsea BOP stack. It consists of a hydraulic connector, annular BOP, ball/flex joint, riser adapter, jumper hoses for the choke, kill, and auxiliary lines, and subsea control pods. The LMRP interfaces with the lower BOP stack. During an emergency disconnect, a programmed sequence of events that operates the functions to leave the BOP stack and controls in a desired state and then disconnect the LMRP from the lower stack. The three main connection points accounted for in the PRA are the riser connector and the choke and kill line connectors. All of these connectors have both a primary and secondary unlock function that are redundant to make sure the disconnect occurs.

Figure E- 13 shows a schematic of the riser disconnect. The choke and kill disconnect were covered earlier in this Appendix.

The boundaries for modeling the LMRP disconnect subsystem includes the solenoid activated control valves in the yellow and blue control pods through the riser and choke and kill connectors.

The LMRP disconnect subsystem is an end use function for emergency disconnects and no other functions depend on the disconnect function. The LMRP disconnect subsystem is dependent on:

- Electrical control power for both the yellow and blue pods
- The subsea supply manifold for the yellow and blue pods for the opening the primary connector locks
- The hydraulic fluid pilot supply for both the yellow and blue pods for activation of the control systems
- The 3000 psi supply manifold for the yellow and blue pods for the opening the secondary connector locks

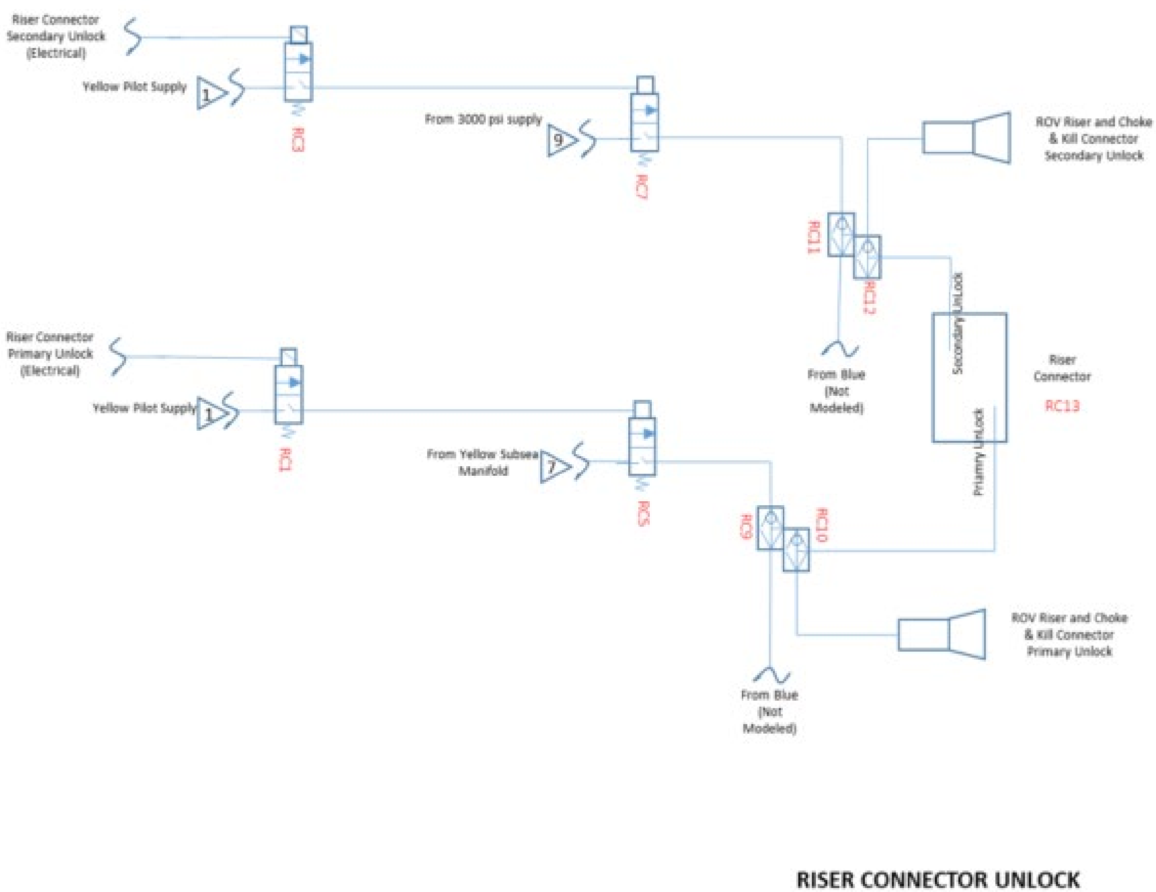


Figure E- 13: Riser Connector Unlock Schematic

Deadman/Autoshear Function

The DMAS subsystem contains two separate functions, the deadman function and autoshear function. The deadman function is designed to automatically shut in the wellbore in the event of a simultaneous absence of hydraulic supply and control of both subsea control pods. Autoshear is a safety function that is designed to automatically shut-in the wellbore in the event of a disconnect of the LMRP. The DMAS subsystem automatically closes the CSR followed by the BSR. There is a delay circuit installed so that the CSR will be able to cut through any pipe present before the BSR is actuated. The DMAS subsystem also locks the BSR in place following closure, and a delay circuit is used to ensure the BSR is closed prior to locking. The dedicated emergency accumulator system may be used for both the autoshear and deadman systems, and is supplied from the rig's main hydraulic system and pressure is maintained (e.g. check valves) if the main supply is lost.

Figure E- 8 shows the schematic of the DMAS connections to the BSR and CSR, primarily the arming mechanism and delay. Figure E- 14 shows the BOP subsea accumulator schematic for the DMAS subsystem.

The boundaries for modeling the DMAS subsystem includes the solenoid activated control valves in the yellow and blue control pods through the subsea accumulators to the autoshear valve and delay circuits.

The DMAS subsystem is a support function for well control and the BSR and CSR are dependent on its function for both emergency disconnect and deadman scenarios. For emergency disconnects, the choke and kill connectors and riser connector are also dependent to ensure the LMRP is able to lift off from the lower stack. The DMAS subsystem is dependent on:

- Electrical control power for both the yellow and blue pods
- The hydraulic fluid pilot supply for both the yellow and blue pods for activation of the control systems
- The 5000 psi supply manifold for the yellow and blue pods for the opening connector locks

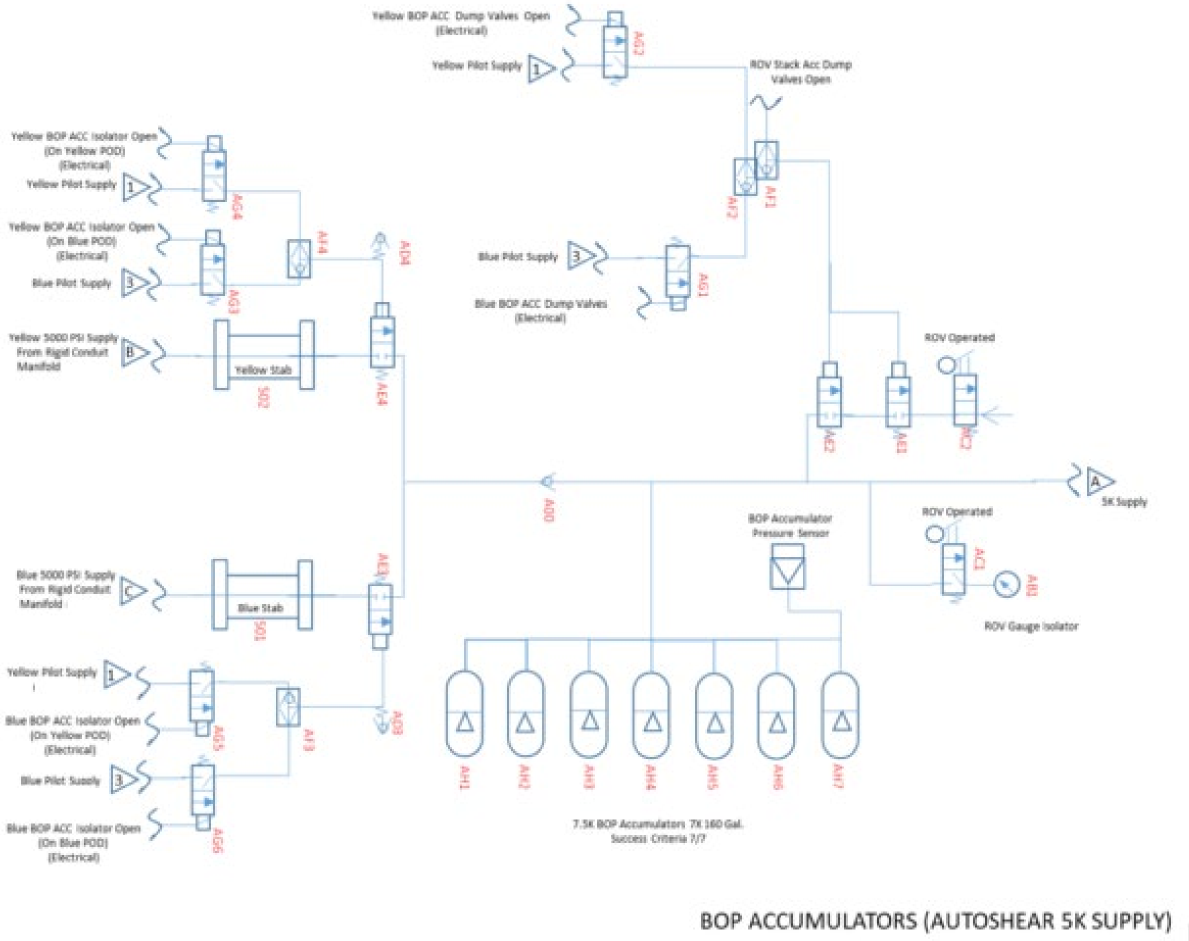


Figure E- 14: BOP Subsea Accumulators for Deadman/Autoshear Function Schematic

Subsea Manifold

The subsea manifold is composed of pipework, valves, structure framework, subsea connection equipment, and the control equipment that provide the system operating pressure to control a variety of BOP functions.

Figure E- 15 shows the schematic that contains the subsea manifold supply and regulator.

The boundaries for modeling the subsea manifold subsystem includes the solenoid activated control valves in the yellow and blue control pods through the subsea manifold regulators on the yellow and blue pods.

The subsea manifold subsystem is a support function for a variety of BOP functions including:

- Opening and closing of the upper, middle, and lower pipe rams
- Blind shear ram open, low pressure close, and opening/closing locks
- Casing shear open/ low pressure close
- Opening and closing of the choke & kill line isolation valves
- Riser connector secondary unlock

The subsea manifold subsystem is dependent on:

- Electrical control power for both the yellow and blue pods
- The hydraulic fluid pilot supply for both the yellow and blue pods for activation of the control systems
- The 3000 psi supply manifold for the yellow and blue pods

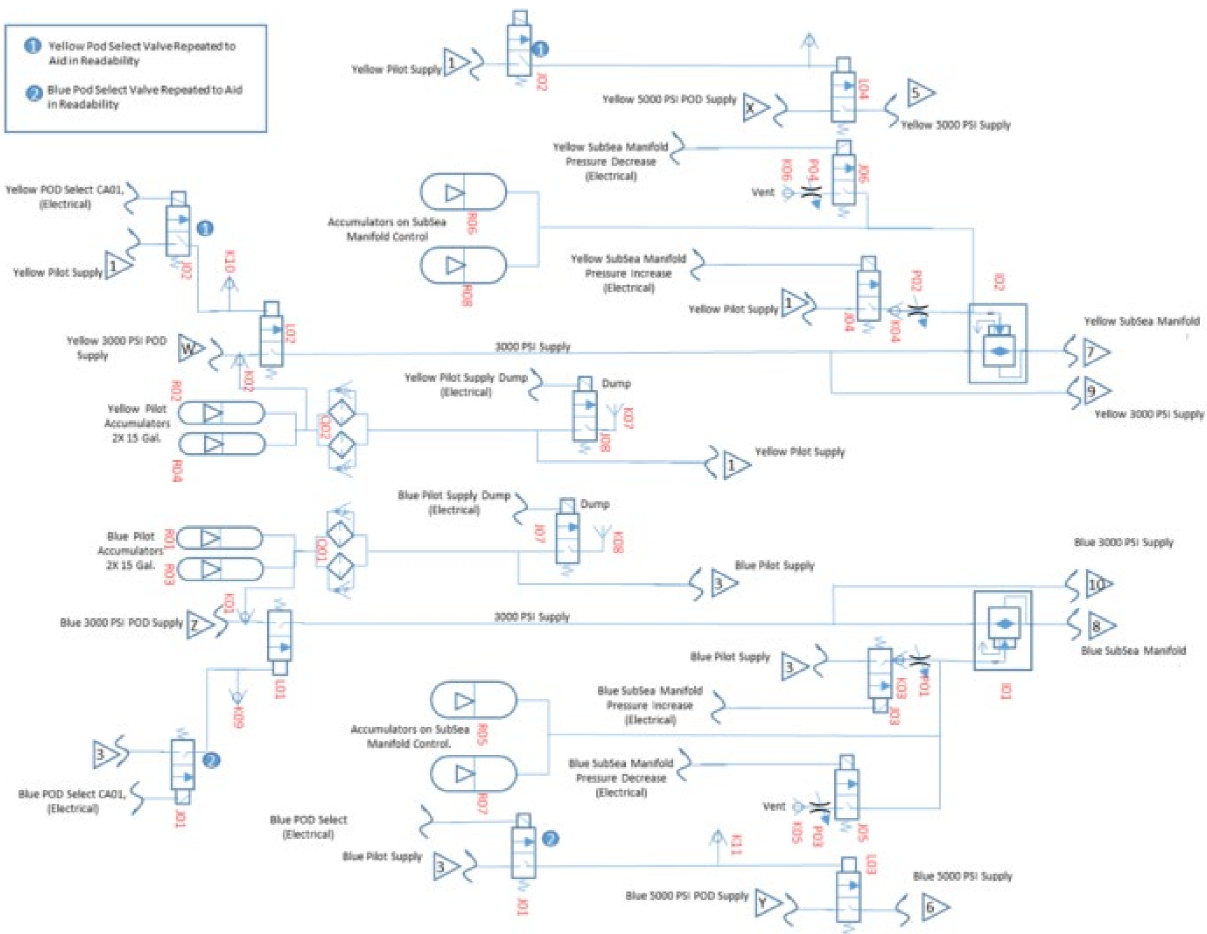


Figure E- 15: BOP Pod Select, Pilot, and Subsea Manifold Schematic

5000 PSI Manifold

The 5000 psi manifold is composed of pipework, valves, structure framework, subsea connection equipment, and the control equipment that provide high pressure to the shearing functions for the Casing Shear Ram, and the Blind Shear Ram.

Figure E- 16 shows the schematic that shows the rigid conduit manifold which provides the supply to the 5000 psi manifold. The rigs topside hydraulics provide the pressure regulation, so the subsea BOP does not have pressure regulators for the 5000 psi manifold.

The boundaries for modeling the 5000 psi manifold subsystem includes the solenoid activated control valves in the yellow and blue control pods controlling the 5000 psi supply and the 5000 psi dump valves.

The 5000 psi manifold subsystem is a support function for the high pressure close functions of the CSR and BSR.

The 5000 psi manifold subsystem is dependent on:

- Electrical control power for both the yellow and blue pods
- The hydraulic fluid pilot supply for both the yellow and blue pods for activation of the control systems
- The 5000 psi supply for the yellow and blue pods from the Rigid Conduit Manifold (RCM)/rig hydraulics

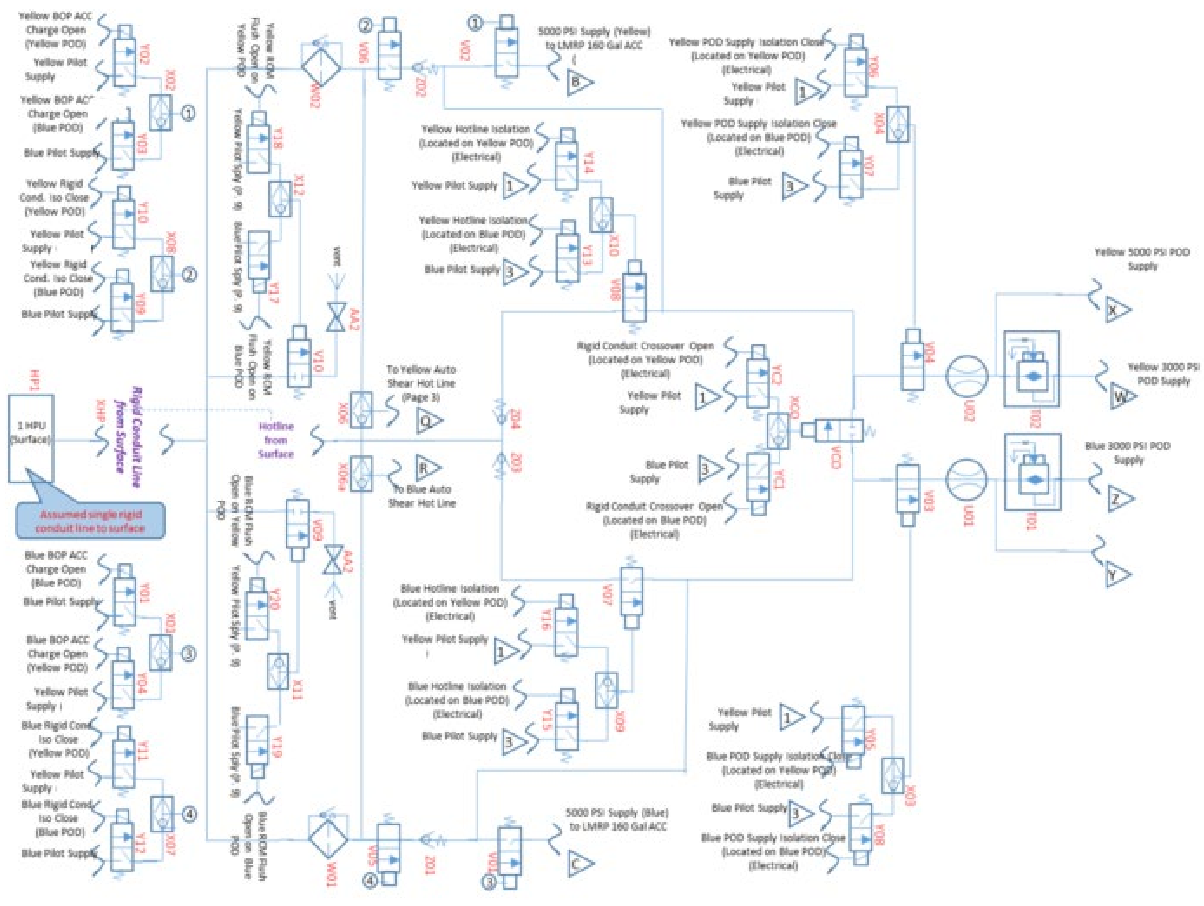


Figure E- 16: BOP Rigid Conduit Manifold Schematic

3000 PSI Manifold

The 3000 psi manifold is composed of pipework, valves, structure framework, subsea connection equipment, and the control equipment that provide the system operating pressure to control various BOP functions.

Figure E- 16 shows the schematic that contains the 3000 psi manifold supply and regulator.

The boundaries for modeling the 3000 psi manifold subsystem includes the solenoid activated control valves in the yellow and blue control pods through the 3000 psi manifold regulators on the yellow and blue pods.

The 3000 psi manifold subsystem is a support function for a variety of BOP functions including:

- Opening and closing of the upper and lower annular
- Riser connector primary unlock
- Choke and Kill secondary unlock

The subsea manifold subsystem is dependent on:

- Electrical control power for both the yellow and blue pods
- The hydraulic fluid pilot supply for both the yellow and blue pods for activation of the control systems
- The 5000 psi supply for the yellow and blue pods from the RCM/rig hydraulics

E.4 MODELING SCOPE

The fundamental objective of the BOP is to prevent the uncontrolled release of hydrocarbons. The BOP portion of the model in the Deepwater Drillship PRA is designed to capture the basic failure logic and produce an estimate of the probability of a loss of containment of hydrocarbons during drilling of an exploratory deepwater well. To that end, the BOP model captures all of the system hardware required to prevent an uncontrolled release of hydrocarbons subsea during all phases of drilling, and also during well kill operations. This includes both end effector hardware (e.g. blind shear rams, annular preventers), as well as electrical and hydraulic control hardware (e.g. yellow and blue pods, pilot control valves). Additionally, the BOP model also captures HRA risk occurring during human interaction with hardware related to control of the BOP.

E.5 SUCCESS CRITERIA

Annular Preventers

Successful scenarios for the annular preventer are:

In response to a kick:

When commanded, one of the two annular preventers successfully seals the well around the pipe inside the BOP and contains the well pressure/flow.

When commanded, one of the two annular preventers successfully seals the open hole well and contains the well pressure/flow when there is no pipe inside the BOP.

When needed to strip in drillpipe:

One of two annular preventers maintains containment of the well while allowing drillpipe to be forced through, and the surge accumulator allows tool joint passage.

Pipe Rams

Successful scenarios for the pipe rams are:

In response to a kick:

When commanded, one of the three pipe rams successfully seals the well around the drillpipe inside the BOP and contains the well pressure/flow.

When needed to strip in drillpipe:

Two of three pipe rams maintains containment of the well while allowing drillpipe to be fed through while maintaining a seal on the well, When a tool joint reaches a pipe ram, a second pipe ram is closed and the one with the tool joint adjacent is opened to let the tool joint pass. The pipe rams are a back up to the annulars for stripping in pipe.

Blind Shear Ram

Successful scenarios for the blind shear ram are:

In response to a kick:

When commanded, the blind shear ram successfully closes (including shearing the drillpipe if across the BOP) and seals the well and the locks engage after the well has sealed.

In response to an emergency disconnect or deadman actuation:

The blind shear ram is automatically actuated on a loss of position event or deadman event, and the blind shear ram successfully shears the drillpipe (if across the BOP) and seals the well and the locks engage after the well has sealed.

Casing Shear Ram

Successful scenarios for the casing shear ram are:

In response to a kick:

When commanded, the casing shear ram successfully shears the drillpipe or casing (if across the BOP) prior to activation of the blind shear ram.

In response to an emergency disconnect or deadman actuation:

The casing shear ram is automatically actuated on a loss of position event or deadman event, and the casing shear ram successfully shears the drillpipe or casing (if across the BOP) prior to activation of the blind shear ram.

Choke and Kill Lines

Successful scenarios for the choke and kill lines are:

During well kill:

At least one of two choke lines is available to circulate out a kick

In response to an emergency disconnect or deadman actuation:

At least one of two inner/outer choke and kill valves close on each choke and kill line to seal the well. The choke and kill isolation valves properly disconnect between the LMRP and the lower stack allowing the LMRP to be lifted off. Only the primary or secondary unlock mechanism is required, not both.

LMRP Disconnect

Successful scenarios for the LMRP disconnect are:

In response to an emergency disconnect or deadman actuation:

At least one of two inner/outer choke and kill valves close on each choke and kill line to seal the well. The choke and kill isolation valves properly disconnect between the LMRP and the lower stack allowing the LMRP to be lifted off. The riser connector properly disconnects and allows the LMRP to lift off from the lower stack. Only the primary or secondary unlock mechanism is required for the choke and kill and riser connector, not both.

Deadman/Autoshear

Successful scenarios for the deadman/autoshear subsystem are:

In response to an emergency disconnect or deadman actuation:

Following liftoff of the LMRP from the lower stack, or on a loss of electrical and hydraulic communication with the rig, the DMAS subsystem opens the autoshear valve and provides pressure flow to the casing shear ram and the blind shear ram. The casing shear ram is actuated first with a delay to the blind shear ram so the casing shear ram can shear any pipe across the BOP and clear it from the plane of the blind shear ram.

Subsea Manifold

Successful scenarios for the subsea manifold include providing hydraulic pressure/flow from the selected pod to the pipe rams, LMRP disconnect, BSR locks, and choke and kill line isolation valves when required.

5000 PSI Manifold

Successful scenarios for the 5000 psi manifold include providing hydraulic pressure/flow from the selected pod to the 3000 psi manifold, subsea manifold, BSR, CSR, and subsea accumulators when required.

3000 PSI Manifold

Successful scenarios for the 3000 psi manifold include providing hydraulic pressure/flow from the selected pod to the upper and lower annulars and the choke and kill, and riser unlock functions when required.

E.6 ASSUMPTIONS

General Assumptions

The BOP is operating on the yellow pod initially. Upon failure of yellow pod, the failure of switching to blue pod is considered (manual action plus mechanical failure).

Only those functions of closing rams, locks, etc., were generally modeled and not the openings with the exception of opening the pipe rams when required to strip in pipe.

The fault trees use both demand related failure rates (probability of failure per demand) and time related failure rates (frequency of failure per hour). For the time related failure rates, a time between tests of two weeks is assumed for all components in the BOP. Assuming that the demand (initiator) would happen, on average, halfway through the test interval, a time of 1 week (168 hours) is used to obtain failure probabilities for time related failure rates.

Annular Preventers

The annulars can seal the well with drillpipe or casing across the BOP and with an open hole.

Pipe Rams

All three pipe rams are variable pipe rams capable of sealing on drillpipe, but no credit is taken for casing.

Blind Shear Ram

The BSR cannot shear tool joints, the Bottom Hole Assembly (BHA), casing, or casing couplings.

The BSR lock is required to maintain the seal on the well after manual operation and after an emergency disconnect.

If drillpipe is across the BSR, a tool joint is assumed to be present 10 percent of the time across the BSR and CSR. Credit is given for the driller repositioning the drillpipe to clear the shear ram, except in a drive-off situation.

If casing is across the BOP, a casing coupling is assumed to be present 2 percent of the time across the BSR and CSR. No credit is taken for spacing out a casing string.

If the kick makes it past the BOP, the BSR can still be closed and seal with the same failure rates as used prior to the influx reaching the BOP.

Casing Shear Ram

The CSR is closed before the BSR during manual actuation.

The CSR cannot shear tool joints, the BHA, or casing couplings. Tool joints may be moved if the drillpipe is spaced out, but case couplings are assumed to not be known in terms of position relative to the shear rams so spacing out casing is not considered plausible.

Any pipe across the BOP will clear from the BSR is the CSR is successful. The lower pipe will fall and clear and the tension in the string will lift the pipe clear of the BSR.

Choke and Kill Lines

A single choke line can provide the capacity to maintain well pressure and circulate out a kick.

LMRP Disconnect

Only the choke and kill isolation valves and riser connector need to be unlocked to successfully lift off the LMRP from the lower stack.

The yellow and blue pod stabs do not need to be retracted for the LMRP liftoff to occur.

During an emergency disconnect there is little opportunity to diagnose a problem on the BOP and so it is assumed that if the active pod fails (yellow), there will not be enough time to switch to the blue pod.

In a drive-off event, there is not time to space out the string, so if a tool joint is present across the BSR, it will cause failure of the BSR to shear and seal. For other loss of position events it is assumed there is time to space out.

Deadman/Autoshear

After a successful disconnect, or if the riser parts, the electrical and hydraulic communication with the rig are lost and will trigger the deadman subsystem.

Subsea Manifold

No specific assumptions were made for the subsea manifold.

5000 PSI Manifold

Only the yellow side is active for maintaining the charge on the accumulators.

The ROV dump valve on the RCM is open.

3000 PSI Manifold

No specific assumptions were made for the 3000 psi manifold.

E.7 DYNAMIC POSITIONING SYSTEM (DPS)

DPS Description

The DPS is a computer-controlled system that automatically maintains a MODU's position and heading by using its own thrusters during well operations. In order to prevent potentially catastrophic mishaps, the MODU's position within the operations envelope is monitored. Watch circles are defined around the rig's desired position in order to set limits of operation. Green, yellow and red thresholds are specified to make sure that appropriate actions can be taken to prevent damaging the riser and/or BOP. Station keeping refers to the process whereby a vessel's surface position is maintained within the designated operational circle (the green operation area) for the purpose of well operations. If the vessel moves beyond the green operation area to the extent that it ultimately reaches the red watch circle, the driller and/or marine personnel would initiate an emergency disconnect of the LMRP from the BOP stack. Initiation of the emergency disconnect is also known as a red event.

Results of this study should be applied to specific Class 3 vessels with caution. General insights from this study may be broadly applicable, but specific design details can alter conclusions depending on specific DPS configurations. A design specific analysis should be conducted before implementation of design changes based on this study.

DPS Classification

The DP Class definitions were developed by the International Maritime Organization (IMO) in its Maritime Safety Committee (MSC) circulars MSC/Circ. 645 [E-1], and updated by MSC.1/Circ. 1580 [E-2]. A vessel normally obtains a DP class notation which is issued by Marine Classification Societies as an additional notation to main vessel class. Example class notations are DYNPOS-AUTRO and DPS3 per Det Norske Veritas (DNV), and DPS-3 per the American Bureau of Shipping (ABS). The DP classifications indicate worst case failure design goals. A listing of the various class notations and their requirements as well as a corresponding list of classification societies is provided in Table 1.

Table E- 4: DPS Equipment Class and Notations by Classification Societies

Description	International Maritime Organization Equipment Class	LR Class Notation	DNV Class Notation	ABS Class Notation	NK Class Notation	BV Class Notation
Manual position control and automatic heading control under specified maximum environmental conditions.	-	DP(CM)	-	DPS-0	-	
Automatic and manual position and heading control under specified maximum environmental conditions. No redundancy: loss of position may occur in the event of a single fault	Class 1	DP(AM)	DP 1	DPS-1	DPS A	DYNAPOS AM/AT
Automatic and manual position and heading control under specified maximum environmental conditions, during and following any single fault in an active component or system, excluding loss of a compartment. (Two independent computer systems).	Class 2	DP(AA)	DP 2	DPS-2	DPS B	DYNAPOS AM/AT R
Automatic and manual position and heading control under specified maximum environmental conditions, during and following any single fault in an active component or system, including loss of a compartment due to fire or flood. (At least two independent computer systems with a separate backup system separated by A60 class division).	Class 3	DP(AAA)	DP 3	DPS-3	DPS C	DYNAPOS AM/AT RS

Subsystem Descriptions

Fundamentally, the DPS is comprised of the following subsystems:

- Thrusters
- Power generation
- Fuel
- Cooling
- Control

For the purpose of this study, a generic DPS Class 3 configuration was selected, which is described in this section and based on the Generic DPS PRA [E-3]. The generic configuration represents a typical DPS system, and the schematics and drawings describing it (including component IDs) are included in Section 1.11.

The basic philosophy is to arrange the system into three independent redundancy groups: port, center and starboard. The following subsections describe each of the subsystems.

Thruster Subsystem

The thruster subsystem is critical for the performance of the rig's positioning system. Thrusters are typically electric driven. Their function is to provide the necessary thrust to enable station keeping of the rig under all expected operational conditions.

The vessel is equipped with six thrusters: three forward and three aft. Figure E-17 provides an illustration of the thruster arrangement and the layout of the redundancy groups. The thrusters are arranged so that each redundancy group includes two thrusters, one aft and one forward.

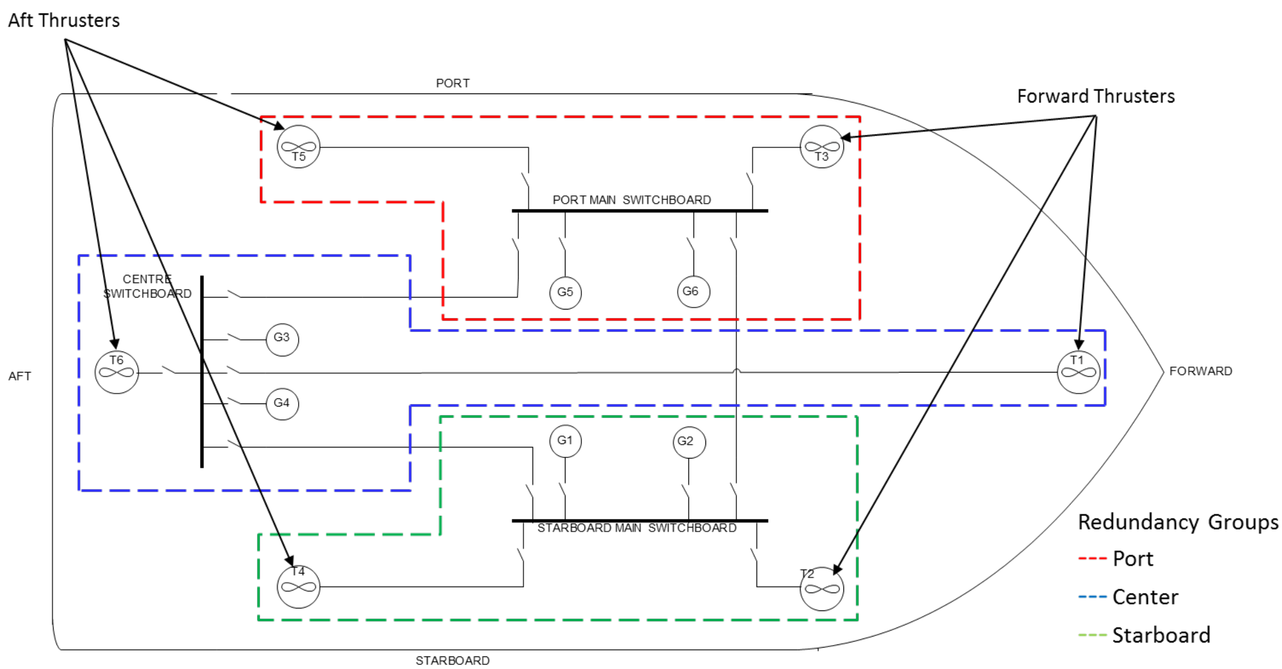


Figure E- 17: Thruster Layout

Power Generation Subsystem

Two diesel generators power each redundancy group: one operating and the other in hot standby. Both generators in a redundancy group are connected through a switchboard that allow them to be isolated, either individually or as a group, in the event of a failure. Each group powers two thrusters, as shown in Figure E-18.

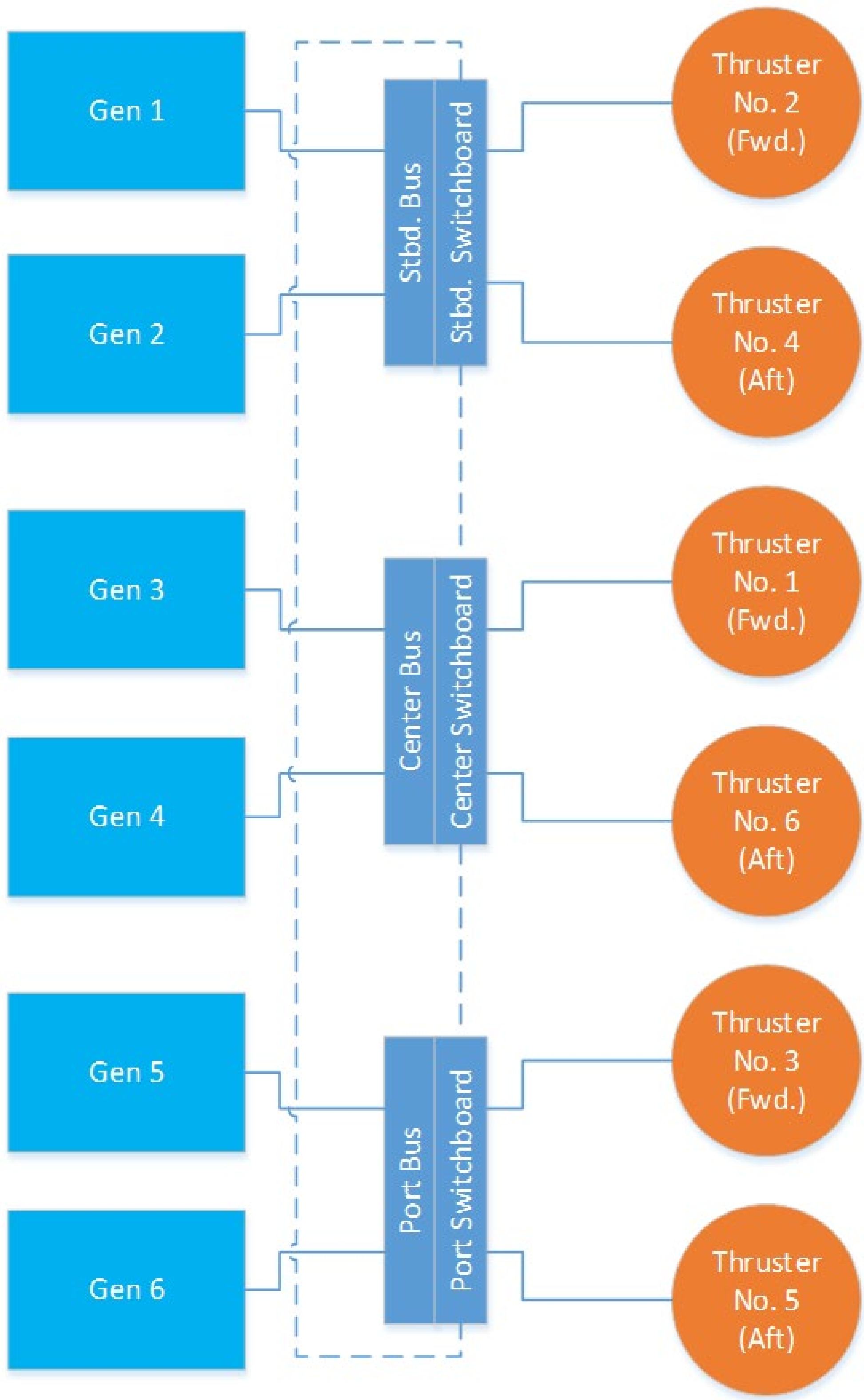


Figure E- 18: Power Generation System

Fuel Subsystem

Each redundancy groups is supplied by an independent fuel system. Each fuel system is equipped with redundant fuel pumps, a back-up or emergency pump, several fuel filters, and a heat exchanger for fuel cooling. Figure E-19 shows the fuel system architecture modeled in the analysis for the starboard fuel system. The emergency pumps are not used during normal station keeping operations, and are not modeled in this study.

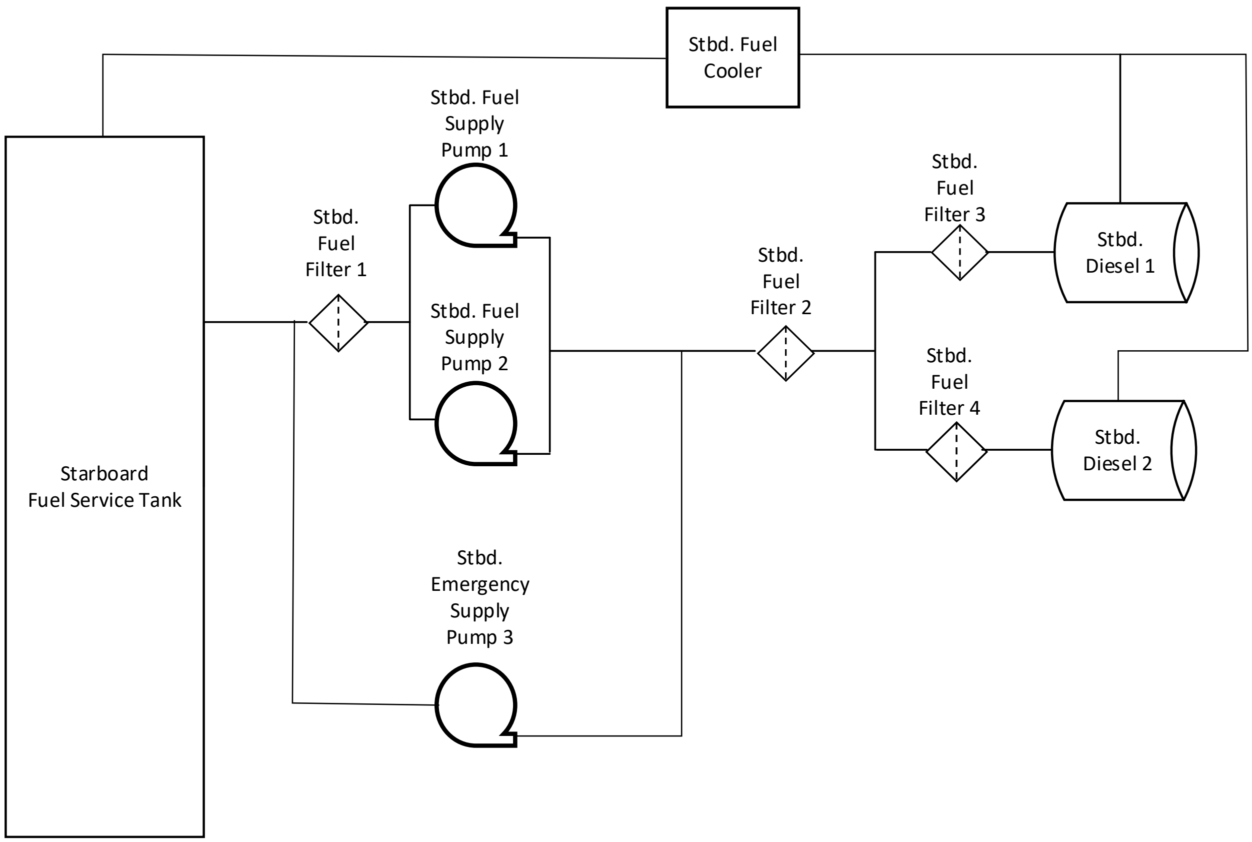


Figure E- 19: Starboard Fuel System

Cooling Subsystem

The cooling system is comprised of a closed loop fresh water cooling system, and an open loop sea water cooling system that provides cooling to the former.

The fresh water system provides direct cooling via heat exchangers to the generators, the diesel engines that power them, and the thrusters. Each fresh water cooling system has redundant pumps, various heat exchangers to provide cooling to specific system components, and temperature regulating valves.

The fresh water cooling system consists of two separate cooling loops: the Diesel Generator Fresh Water Cooling Systems and the Thruster Fresh Water Cooling System.

Figure E-20 shows the Diesel Generator Fresh Water Cooling Systems for a single redundancy group. The fresh water cooler is shared between the two diesel generators within that group. All fresh water cooling trains are shown in Section 1.11.

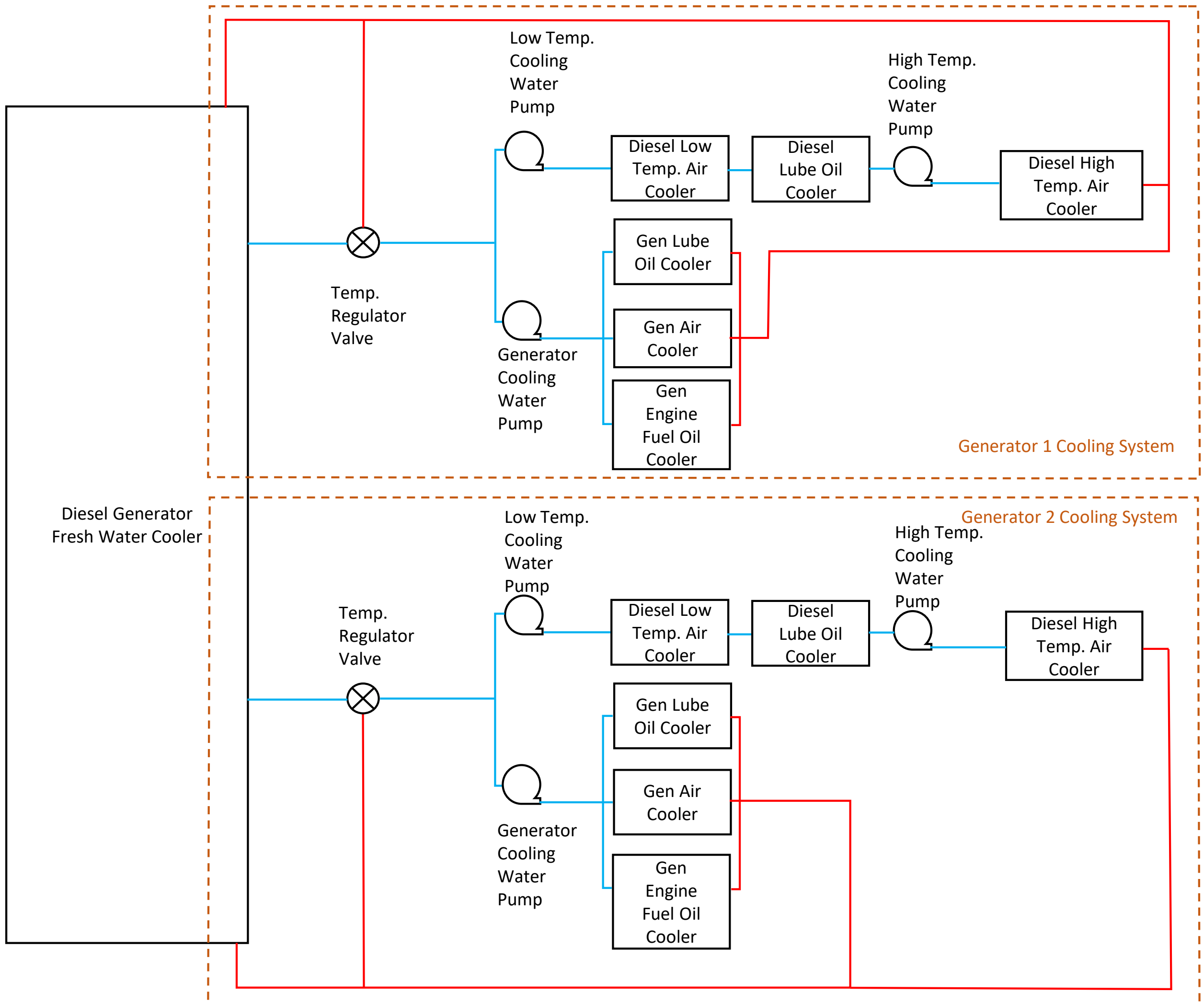


Figure E- 20: Diesel Generator Fresh Water Cooling System

Figure E-21 shows the fresh water cooling system for the thrusters. The same cooling system arrangement applies to all forward and aft thrusters. Each thruster (auxiliary) cooling loop is responsible for cooling the Diesel Start Air Compressor, and 6 thruster sub-systems (Transformer, Variable Frequency Drive (VFD) Room A/C, Electric Motor, Lube Oil, and Hydraulics).

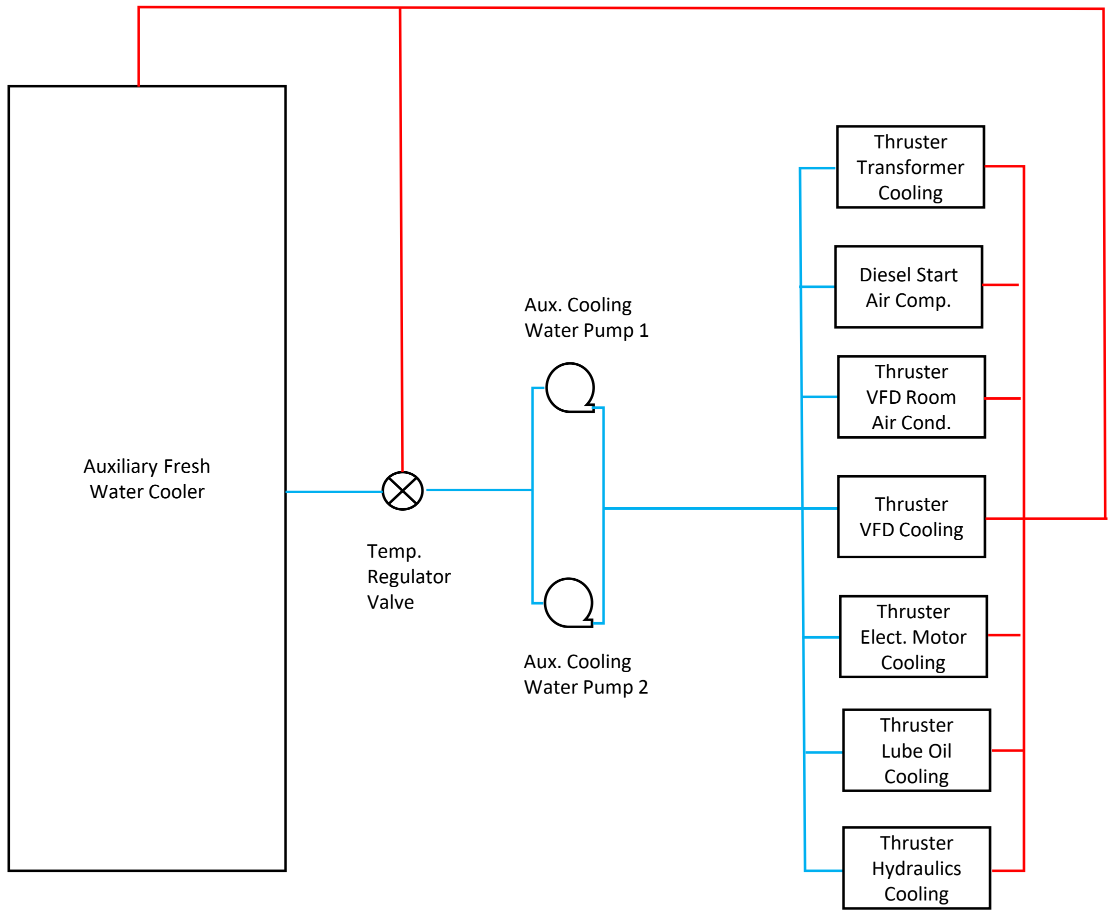


Figure E- 21: Thruster Fresh Water Cooling System

Figure E-22 shows the sea water cooling system for the entire vessel, arranged around the three redundancy groups. There are four sea chests, two aft and two forward. The two aft sea chests feed three sea water cooling trains, each including two redundant sea water pumps (one operating, one standby) and two coolers, one for two diesel generators, and the other for one aft thruster. The two forward sea chests feed three cooling trains, each including two sea water pumps and one cooler for the forward thrusters.

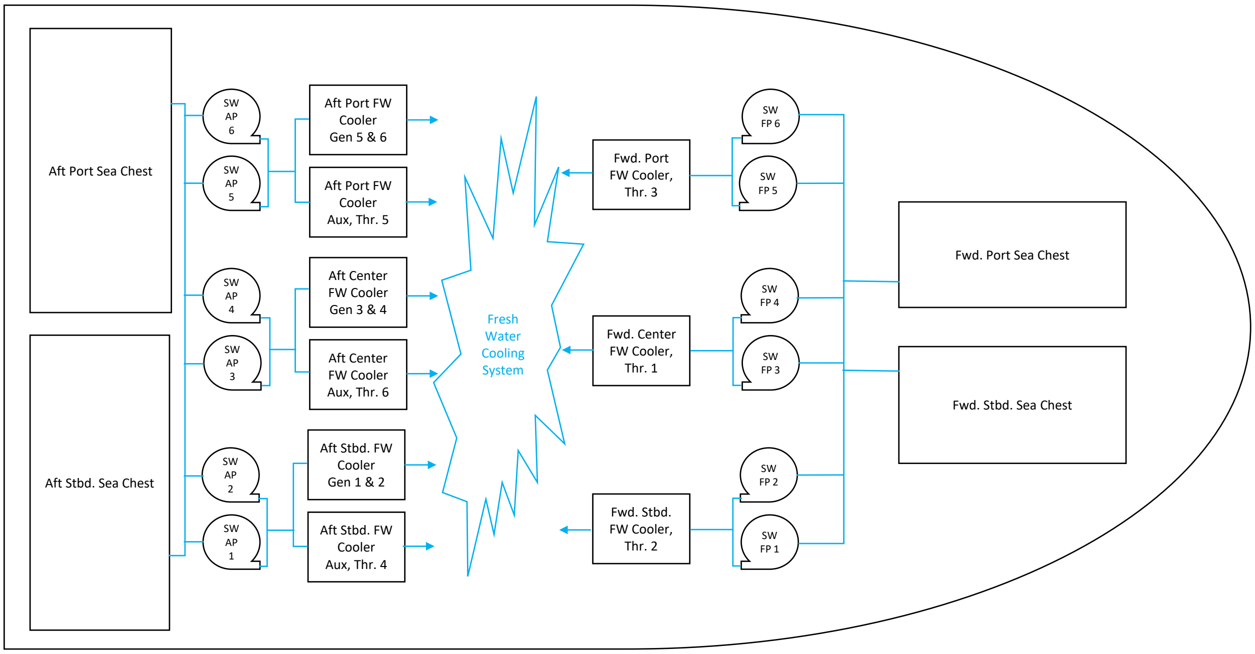


Figure E- 22: Sea Water Cooling System

Control Subsystem

The DP control system commands the diesel generators and thrusters to maintain position and heading. It also includes operator stations that provide information to the DPO about system condition, vessel performance, the operating environment, and provides for entry of operator commands. The Class 3 vessel is equipped with redundant Differential Global Positioning Systems (DGPS) and Hydroacoustic Position Reference (HPR) system that establish the position of the vessel. These systems satisfy class requirements for three position references. The DP control system includes Gyro Compasses (Gyros), Vertical Reference Sensors (VRSs), and wind sensors to provide information about the environment and the vessel to assist with maintaining position and heading. These systems are also redundant.

The control system has a primary system and a back-up system that provides station keeping capability in the event of a primary failure. All of the information gathered from the sensing portion of the control system is fed into a triple redundant primary processor, or Dynamic Position Controller (DPC), hence the DPC-3 designation, and based on the DPO's vessel location requirements, the DPC will send direction and speed commands to the thrusters to ensure that the vessel maintains position and heading. In the event that the control system is operating on the back-up control system, a single processor (noted as DPC-1) is used to perform control. The power generation system will also respond as necessary to meet the requirements of the thrusters. The primary control system computers can be controlled from any one of three DP Operating Stations (DPOS). The back-up control system is operated from its own single DPOS. There is also an independent joystick control to allow the DPO to manually maintain position and heading. It is important to note that the joystick is not frequently used and may be difficult to use depending on the weather so there exists the possibility for human error.

Figure E-23 is a representation of primary control system that shows the major components included in the PRA models. It should be reiterated that this DPS, including the control system, is a generic configuration. Other systems might have different configurations or different levels of control.

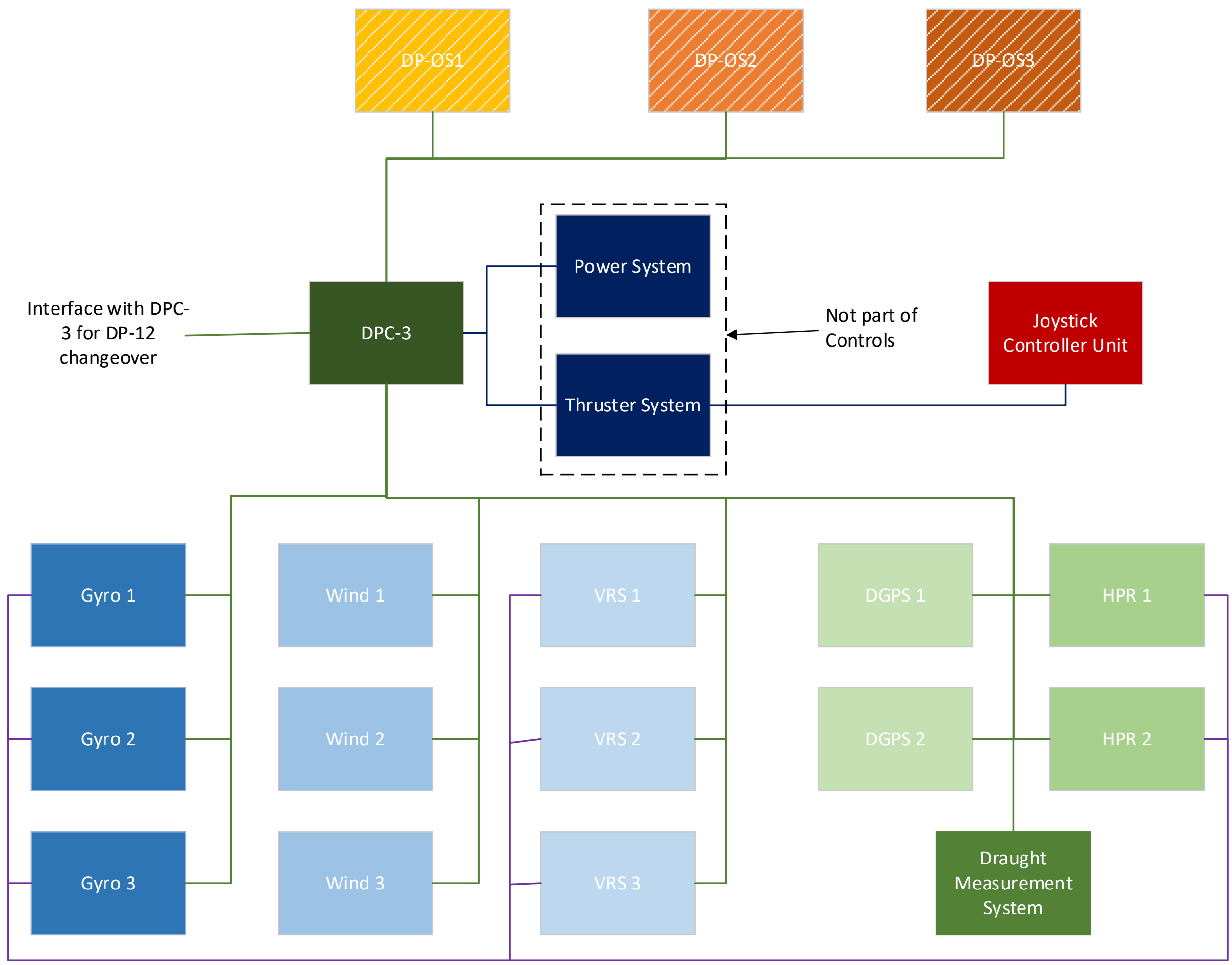


Figure E- 23: Primary Control System

Figure E-24 shows the back-up control system. The backup system is intended to replace the primary control system if there is an event that disables the primary control.

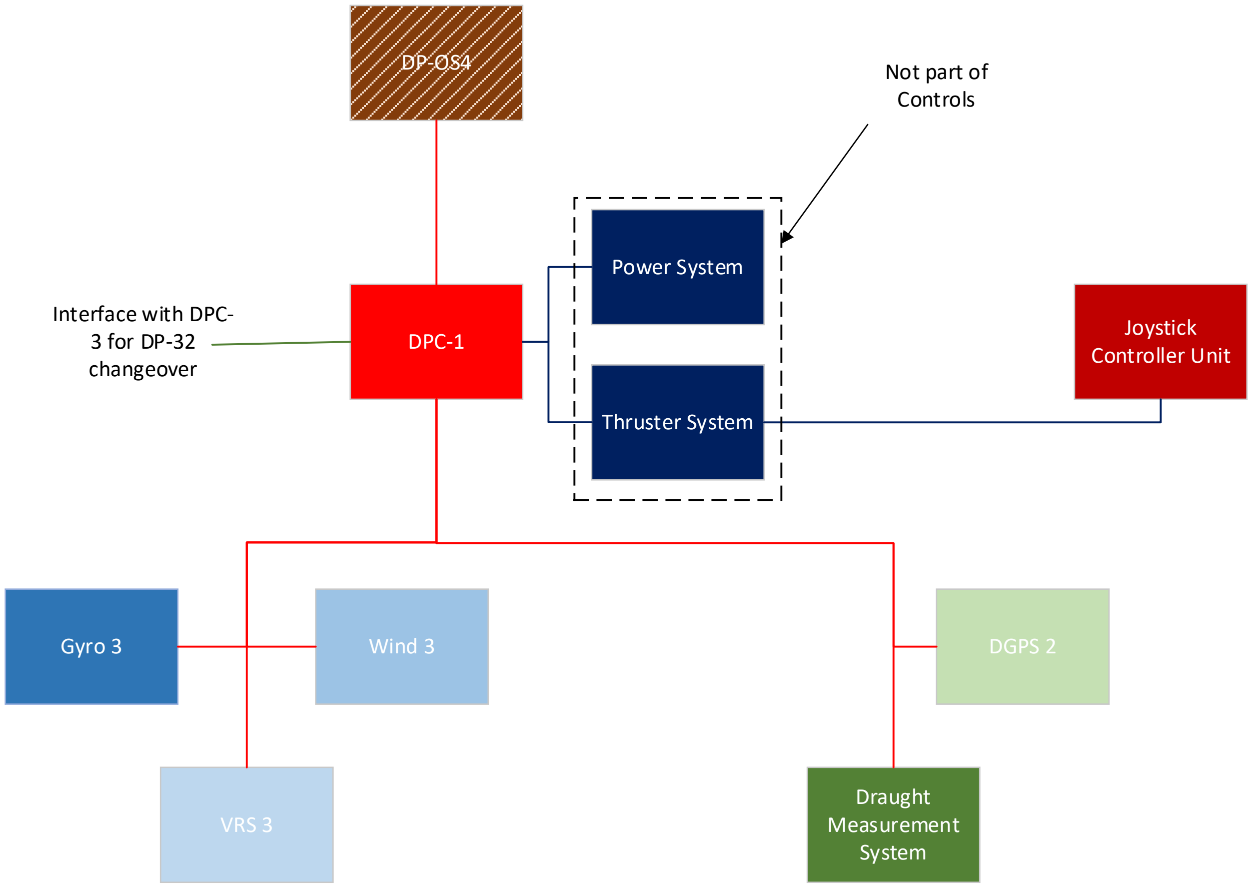


Figure E- 24: Back-up Control System

Detailed schematics including components' IDs are shown in Section 1.11.

System Dependencies

Table E- 5: Subsystem Dependencies for the DPS shows the subsystem dependencies in the dynamic positioning system. The columns list each one of the six diesel generators and six thrusters. The rows list the subsystems or components whose failure would cause the failure of a diesel generator or thruster. Some dependencies are direct (noted with a red X), and others indirect (noted with a blue X). For example, looking at Thruster #1, it is noted that it directly depends on the success operation of Diesel Engine 3 / 4 (Central Group), Fwd Center Cooler FC06 / Fresh Water Cooling FWT1, both Port and Stbd Forward Sea Chests and both Seawater Pumps FC02/FC03. At the same time Thruster #1 indirectly depends on the Center Fuel Supply subsystem, both Port and Stbd Aft Sea Chests, Emergency Shutdown System 2 and both Seawater Pumps AC02/AC03, since failure of any of them would cause failure of the Diesel Engine Central Group, which is a direct dependency for the Thruster #1. It is noted that the dependency on a subsystem includes all component failures within that subsystem that fail the subsystem function.

Electric power dependencies of the supporting subsystems are not modeled since failure of all the diesel generators directly causes the loss of all thrusters and hence loss of position.

Table E- 5: Subsystem Dependencies for the DPS

		Diesel Engine 1 (Stbd)	Diesel Engine 2 (Stbd)	Diesel Engine 3 (Ctr)	Diesel Engine 4 (Ctr)	Diesel Engine 5 (Port)	Diesel Engine 6 (Port)	Thruster 1 (Fwd,Ctr)	Thruster 2 (Fwd,Stbd)	Thruster 3 (Fwd,Port)	Thruster 4 (Aft,Stbd)	Thruster 5 (Aft,Port)	Thruster 6 (Aft,Ctr)
Support Subsystems	Diesel Engine 1 / 2 (Starboard Group)								**X**		**X**		
	Diesel Engine 3 / 4 (Central Group)							**X**					**X**
	Diesel Engine 5 / 6 (Port Group)									**X**		**X**	
	Aft Port Cooler AP06 / Fresh Water Cooling FWG5					**X**							
	Aft Port Cooler AP06 / Fresh Water Cooling FWG6						**X**						
	Aft Port Cooler AP07 / Fresh Water Cooling FWT5											**X**	
	Aft Center Cooler AC06 / Fresh Water Cooling FWG3			**X**									
	Aft Center Cooler AC06 / Fresh Water Cooling FWG4				**X**								
	Aft Center Cooler AC07 / Fresh Water Cooling FWT6												**X**
	Aft Stbd Cooler AS06 / Fresh Water Cooling FWG1	**X**											
	Aft Stbd Cooler AS06 / Fresh Water Cooling FWG2		**X**										
	Aft Stbd Cooler AS07 / Fresh Water Cooling FWT4										**X**		
	Fwd Port Cooler FP06 / Fresh Water Cooling FWT3									**X**			
	Fwd Center Cooler FC06 / Fresh Water Cooling FWT1							**X**					
	Fwd Stbd Cooler FS06 / Fresh Water Cooling FWT2								**X**				
	Starboard Fuel Supply	**X**	**X**						*X*		*X*		
	Center Fuel Supply			**X**	**X**			*X*					*X*
	Port Fuel Supply					**X**	**X**			*X*		*X*	
	Both Port & Stbd Aft Sea Chests	**X**	**X**	**X**	**X**	**X**	**X**	*X*	*X*	*X*	**X**	**X**	**X**
	Both Port & Stbd Fwd Sea Chests							**X**	**X**	**X**			
	Emergency S/D System 1	**X**	**X**						*X*		*X*		
	Emergency S/D System 2			**X**	**X**			*X*					*X*
	Emergency S/D System 3					**X**	**X**			*X*		*X*	
	Both Sea Water Pumps AP02 & AP03					**X**	**X**			*X*		**X**	
	Both Sea Water Pump AC02 & AC03			**X**	**X**			*X*					**X**
	Both Sea Water Pump AS02 & AS03	**X**	**X**						*X*		**X**		
	Both Sea Water Pump FP02 & FP03									**X**			
	Both Sea Water Pump FC02 & FC03							**X**					
	Both Sea Water Pump FS02 & FS03								**X**				

X Direct Dependency

X Indirect Dependency

Modeling Scope

The objective of the DPS model is to estimate the risk of loss of position and initiation of an emergency disconnect. Other events that might result in loss of position such as a full vessel blackout, collision with another vessel, loss of vessel stability, crew incapacitation, drilling or other shipboard operations mishaps are considered beyond the scope of this analysis. Additionally phenomenological events, (e.g. fire, impact with another vessel resulting in flooding of the hull) are considered to be out of scope because these would compromise the vessel to the extent that loss of position might be a secondary concern. This analysis only includes operations when the BOP is connected to the wellhead. Other operations, such as deploying or retrieving the BOP, top-hole drilling, and running and cementing surface casing are outside of scope of this analysis.

The DPS model accounts for loss of control, power, and support systems, as well as human error. In general, the DPS is modeled at the system level which includes all major components of a particular system. Given that the model is approximating a generic system, it has been constructed modularly so that a more vessel specific system can be easily incorporated at a future date, if required. Components that are not part of the DPS but whose proximal location might jeopardize function in the event of a violent failure are not captured in the models for the same reason that phenomenological events are not addressed.

Loss of Position Scenarios

There are three scenarios modeled by which the MODU can lose location: drift-off, drive-off, and push-off.

- **Drift-off -** The drift-off scenario occurs when a DPS failure causes the drilling vessel to lose the DPS capability required to maintain position and the vessel begins to drift. As the vessel drifts beyond the green operation area into the yellow watch circle, the DPO notifies the driller to prepare for a potential emergency disconnect. The DPO, driller, and vessel captain remain in communication as the vessel continues to drift. At the point where the vessel reaches the red watch circle a red event is declared and an emergency disconnect sequence is initiated.
- **Drive-off** - The drive-off scenario results from an unintended movement of a dynamically positioned vessel to a position off location caused by the vessel's main propulsion or station-keeping thrusters. This can be the result of system failure or human error. In either case, once the vessel gains momentum, there will be little time for recovery. An emergency disconnect will be initiated, regardless of where the vessel is located relative to the red watch circle.
- **Push-off -** The push-off scenario arises when the weather conditions are such that, even with a fully operational DPS, the vessel is incapable of maintaining its position. If the vessel begins to be pushed to the point where it loses location, a red event may be declared prior to the vessel reaching the red watch circle.

Loss of Position as an Initiator or Post-Initiating Event

The loss of position scenarios above can occur as an initiator, or during the response to a well kick (post-initiator). Each of these two alternatives require a different type of fault tree model:

- **Loss of position as an initiating event:** In this case, everything is working normally, until one or more hardware/software failures, human errors or environmental condition occur causing loss of position of the drilling rig. This case requires the use of a so called "initiating event" fault tree. The main difference between this tree and a standard fault tree is that the initiating event fault tree models frequency of events per unit time (e.g. failures per hour), as opposed to probability of failure (a number between 0 and 1) for a standard fault tree. An initiating event fault tree models all potential failures that can initiate a loss of position, when combined with additional failures. For example if we assume that all six thrusters are normally running, the failure to run of any of these thrusters can potentially initiate a loss of position event. Since we have assumed that four operating thrusters are sufficient to maintain position under nominal weather conditions, three thrusters have to fail before a loss of position can occur. So, in addition to the first thruster failure (initiating event), two additional thrusters (2 out of the remaining 5 thrusters) have to fail in between the time of the first thruster failure, and its repair time (time to repair the thruster and place it back in operation) to cause loss of position. It should be noted that each cut set of an initiating event fault tree has to contain one and only one initiator (first failure), and the remaining failures in that cut set are failures that occur after the first failure, and within a time equal to the repair time of the first failure. In order to easily recognize these initiator failures, the basic event names are identified with "-IE" ending.
- **Loss of position as post initiator:** In this case, the loss of position occurs after an unrelated initiating event occurs. In this model an initiating event would be a kick or an inadvertent LMRP disconnect. As discussed in the well kick section of this report, after a kick, the BOP has to close and seal the well, and then the kick has to be circulated out. This is called killing the well, and it can take a couple of days to complete. It is possible that a loss of position could occur during this time and further complicate the well kill operation. A standard fault tree is constructed for this situation. The standard fault tree is similar to the initiating event fault tree as far as it models the same combination of failures. However the standard fault tree quantifies the probability that the position can be lost within the well kill time. The standard fault tree does not contain any initiator failures since the initiator has occurred before and is unrelated to the positioning system. For example, going back to thruster failures, since six thrusters are normally operating, the standard fault tree models the probability that three out of six thrusters fail within the well kill time.

DPS System Success Criteria

The DPS is successful when the MODU can hold against the forces of wind, current and waves and stay on station. The MODU must maintain its surface position within a designated region (the green operation area) for well operations and the watch circles (yellow and red) are designated by the DPO based on specific weather or well operations that may be planned.

The following success criteria are considered in the DPS model:

During Nominal Weather: Nominal weather is defined as all weather conditions in which four working thrusters are sufficient to maintain position regardless of the orientation of the rig. This success criteria of four thrusters is determined by the design requirements for a Class 3 DP drilling rig, in which any single failure (including fire of flooding in a single compartment) should not cause a loss of position under normal environmental conditions. The drilling rig design for this study includes six thrusters, and no single failure results in more than two thruster failures, hence the success criteria of a minimum of four operating thrusters.

During Extreme Weather: Extreme weather is defined as weather above nominal conditions. In extreme weather, the drilling rig can still maintain position but only if the DPO properly orients the rig in order to minimize the drag on the vessel created by the weather. Three different weather conditions were identified in this scenario:

- Squalls
- Winter storms
- Hurricanes

The success criteria for squalls and winter storms for which the DPO has successfully oriented the vessel to minimize the drag is the same as nominal weather, i.e. four operating thrusters. In the case of hurricanes, it is assumed that even if the DPO properly orients the drilling rig, the successful operation of six thrusters during the duration of the hurricane are needed in order to maintain rig position. In the GoM, remaining on location during a hurricane is rare because there are established procedures for planned disconnect and evacuation prior to its arrival.

Above Extreme Weather: Above extreme weather conditions are defined as those weather states for which even all six thruster successfully operating are not sufficient to maintain vessel position. Hence the positioning system will not maintain location.

DPS Model Assumptions

General Assumptions

- It is assumed that the DP system being analyzed is consistent with the general configuration used aboard a sixth generation deep water drillship operating in the GoM. The analysis assumes a generic vessel [E-3].
- It is assumed that the vessel has gone through the appropriate surveys, at the specified intervals, according to regulatory requirements.
- Correct set-up and initiation of the DPS upon arrival at the drill site is assumed. Latent failure modes resulting from incorrect set-up are not considered.
- All DP trials have been conducted and equipment has been verified to be in good working condition to the extent that system failure due to wear out or other non-random failure modes can be ruled out. Additionally, the DP trials have also ensured that the DP system as configured is fit for purpose and all components meet their specified requirements.
- System operations and human interactions with the system are assumed to be normal.
- Humans interacting with the DPS are trained in accordance with industry accepted practices and will be able to follow generally accepted procedures; however this does not eliminate the possibility of human error resulting in a loss of station-keeping.
- System operations and human interactions with the system are assumed to be normal. Worst case conditions consistent with identified success criteria are modeled; however, rare events, natural disasters, or heroic actions on the part of humans interacting with the system are not modeled.

- Scheduled maintenance is not considered with respect to loss of redundancy because it is assumed to occur during periods when success criteria are less likely to be challenged (e.g. nominal weather conditions).
- The service air system is not modeled because it is equipped with multiple system redundancies and in the event of a total system failure it is assumed that normal repair times are sufficiently short such that DPS operations will remain unaffected.
- Passive elements of the DPS, such as cables and piping, are assumed to be highly reliable. Issues, such as wear and environmental impact on these elements are assumed to be negligible. As a result, these elements are not considered in the model.
- Catch tanks and overflow reservoirs are assumed to be passive elements as well so their failures are not modeled.
- For normally operating components, common cause failures as initiators were not modeled. The only exception is for the sea chests, where clogging could potentially impact the two aft sea chests, or the two forward sea chests initiators. However, after the initiator, i.e. post-initiator, common cause failures are included for all applicable components.

Thruster Subsystem Assumptions

- It is assumed that all thrusters are operating during normal operations. Per previously stated success criteria, a minimum of four thrusters are needed during nominal weather, squalls and winter storms, and all six are needed during a hurricane event.

Power Generation Subsystem Assumptions

- Each of the three power generation systems is equipped with two generators, both of which have the same power rating.
- One generator in each power generating system is on-line to meet normal the power requirements. The other is off-line but maintained as a hot standby to meet power requirements should they be needed. The model assumes generators 2, 4 and 6 as operating and 1, 3 and 5 as stand by.
- Regarding the generators held in standby mode, any lag between increased power requirements and the generator being brought on line is assumed to not result in a loss of station keeping.
- Bringing electrical systems back on line following a spurious trip of the emergency shutdown system requires an extended period of time. As a result, no credit is given to any human recovery action to prevent a loss of position under these circumstances. Therefore, no human error associated with failure to recover following a blackout is modeled.
- Auxiliary or support systems for the generators and thrusters (e.g. fuel system, cooling system) are assumed to be operational for the entire well completion operation since at least one generator in each of the redundancy groups they support will be operational during that time.
- The air start system for the diesel generators is not being modeled explicitly because it is assumed that all of the potential failures of this system will be are captured in the data used to produce the "Diesel Generator, "Fail to Start" failure rate.

Fuel Subsystem Assumptions

- The fuel system is aligned to support the higher level power generation systems in the following manner;

  - Starboard Train consist of Starboard Diesel 1&2, Starboard Fuel Supply Pumps 1&2 as primary and 3 as backup, and the starboard fuel tank.
  - Center consist of Center Diesel 1&2, Center Pumps 1&2 as primary and Center Pump 3 as backup, and the Center fuel tank.
  - Portside consist of Port Diesel 1&2, Port Pumps 1&2 as primary and Port Pump 3 as backup, and the Port fuel tank.

- For each fuel system train, one pump is assumed operating (pump #1), and one in standby (pump #2).
- The diesel fuel supplied to the engines is assumed to be the proper type and free of major contaminants. As a result, the settling tank, etc. is not modeled. However, due to cumulative effects of minor contamination over time, the plugging failure mode for filters are included in the fuel system models.
- Onboarding fuel is a carefully observed process. As a result, the probability of contaminated fuel resulting in a common cause failure that would take out all fuel systems is low. Therefore, common cause failure of fuel system components is addressed at the single train level.
- Fuel leakage above a level necessary to create a fire hazard is assumed to be detectable and is not included in the model.

Cooling Subsystem Assumptions

- The Cooling System is successful when at least two fresh water cooling pumps are operating, providing 100% of nominal cooling flow to the heat loads serviced by the system during low weather conditions, during sudden hurricane conditions all cooling pumps must operate.
- Auxiliary or support systems for the generators and thrusters (cooling system) are assumed to be operational for the entire drilling and completion period since at least one generator in each of the redundancy groups they support will be operational during that time.
- No cross-connecting capability is assumed for the cooling systems.
- The loss of two port or two starboard fresh water cooling pumps only results in a decrease in rated speeds or loads.
- Common cause failure of the fresh water cooling system components is addressed only within each train for both the normal operating environment and extreme weather. Common cause failure across trains is assumed very unlikely.
- Inlet strainers to the sea chest are considered high reliability items and given the redundant inputs, the probability of them contributing significantly to the overall failure probability is low; therefore they are not included in the model.

Control Subsystem Assumptions

- In the case where the primary control system has been lost due to a hardware failure, it is assumed that the MODU can maintain position using the back-up (or emergency) control system as long as sensors directly connected to the backup system: for example gyro compass sensor #3, VRS #3, and DGPS #2 are operational.
- The joystick controller, while critical as a last resort for maintaining DP, is assumed to be somewhat difficult to operate for long periods of time. As a result, a human error component is included in the model.

- The level of redundancy in the control system and the ability of the system to be re-configured leads to the assumption that combinations of independent failures will not be significant risk drivers.
- For the control system, the most critical failure mode for the hardware is assumed to be failure to function or "fails off" and will result in the vessel losing location by drifting off station. Failure of a sensor in a degraded state (e.g. dithering sensor) can occur but is assumed to require human intervention and it is modeled in the drive-off scenario.
- The Joy Stick back-up option can only be used during nominal weather environments.
- The draught measurement system will not immediately result in a loss of position unless the Dynamic Positioning Operator (DPO) fails to take action to switch to manual input of draught in the Dynamic Positioning (DP) controls. Given the low likelihood of this scenario it is not included in the models.
- The HPR sensors receive inputs from both the gyro compass and VRS sensors. A complete failure of either type of sensor could result in erroneous outputs from the HPR sensors; however, modeling this relationship would produce the same cut sets given the assumption that a complete loss of either group of sensors already constitutes control system failure. Therefore, the relationship between the gyro compass, VRS, and HPR sensors is not captured in the control system models.
- The acoustic riser angle sensor, Doppler log sensor, water depth sensor, and riser tensioner stroke measurement are not used by the DPS to control the vessel and are assumed not to directly impact station keeping. As a result, none of these sensors are included in the models.
- Ballast control is not used by the DPS for station keeping; therefore, none of the components used strictly for ballast control are included in the models.
- The level of redundancy in the control system and the ability of the system to be re-configured leads to the assumption that combinations of independent failures will not be significant risk drivers. However, common cause failure is included in the models.
- Pressure sensors in the auxiliary systems are not used by the DP system to maintain position; therefore, their respective failures are not included in the models.
- With respect to drift-off, it is assumed that the DPS is operating in automatic mode so human interaction is only a reaction to a fault generated within the system or weather; therefore, human error is not an initiating event.

Weather Model Assumptions

Table E-6 provides the success criteria for the DPS to maintain location in the normal operating environment and extreme weather situations.

Table E- 6: Weather Modeling Success Criteria

Operating Environment	Power Generation	Thrusters	Controls
Normal Operating Environment	As many generators as needed to supply the thrusters required as per thruster success criteria	4 of 6 thrusters required	At least one Gyro Compass Sensor, one DP computer, one Vertical Reference Sensor, and one Differential GPS
Squalls and Winter Storms	As many generators as needed to supply the thrusters required as per thruster success criteria	4 of 6 thrusters required	At least one Gyro Compass Sensor, one DP computer, one Vertical Reference Sensor, and one Differential GPS
Sudden Hurricane	Three generators required. It is assumed that three generators can provide all required power to supply the six thrusters during extreme weather	All thrusters required for the average hurricane duration time of 4 hours	At least one Gyro Compass Sensor, one DP computer, one Vertical Reference Sensor, and one Differential GPS

- In a sudden hurricane, three generators and all six thrusters are assumed to be operational at the onset of the weather system.
- In the event that critical hardware needed for station keeping is unavailable due to maintenance or failure, it is assumed that the vessel will disconnect prior to onset of the extreme weather condition.
- Maintaining vessel heading during extreme weather is considered part of the original task of orienting the vessel into the wind prior to the onset of extreme weather and it is included in the human error probability used.
- Controlling the vessel using the joystick is difficult; therefore, it is not viewed as an option for maintaining position in an extreme environment and it is not modeled.
- During squalls and winter storms, it is assumed that the vessel will be oriented into the wind. Failure to do so is assumed to result in a loss of position and it is captured in the form of a human error in the model.

Drive-off Model Assumptions

- Drive-off is assumed to be the result of two scenarios:
  a. The control system experiences some type of degradation that requires human intervention. The human intervention may result in an error causing the vessel to move off location.
  b. In preparing for a storm or when simply attempting to reposition the vessel for normal activities, the DPO attempts to reposition the vessel in the green operation area. During this process, the operator may incorrectly enter new position information resulting in the vessel powering itself to an unintended location requiring the initiation of an emergency disconnect.
- During a drive-off situation, it is assumed that the driller does not have any time to reposition the drillpipe to clear the shear ram should there be a non-shearable across it.

Push-off Model Assumptions

- Extreme weather may only be present for a short time but the conditions are sufficiently severe that the vessel cannot maintain position.
- The weather system that creates the elevated environment is predictable and is being tracked prior to its arrival.

Data Assumptions

- The average time during which the DPS must be operational on a well site, while the BOP is connected to the wellhead, is 70 days and, as such, is the period of exposure for this analysis.
- Repair times on location for each component varies. For model simplicity, an average repair time for most components has been set to 72 hours. This assumed repair time is conservative for all components with the possible exception of thruster repair time. This should be kept in mind when considering the results involving thruster failures.
- For simplicity, the average well kill time has also been set to 72 hours. The historical data analyzed for well kill times is in line with this assumption. Setting both the average repair time and average well kill time to the same estimate results in a simplification of fault tree modelling.

Note: In order to remove incorrect cut sets arising from the fact that components can fail either as an initiator, or as a post-initiator (but not both), there is a need to run fault tree post-processing rules. For example, an operating diesel generator can fail to run (as initiator) and it can also fail to run post initiator. Being that these two different basic events have different names in SAPHIRE, quantification will produce cut sets that include the diesel generator failure to run as initiator and the same diesel generator failure to run post-initiator within the same cut set. Obviously this combination is not a correct cut set, since if the diesel failed as initiator, then it is failed throughout the accident sequence (no recoveries are modeled in the BSEE model at the current time). Basically, the post processing rules look for these incorrect combinations and delete the post initiator basic event, leaving the rest of the basic events in that cut set intact. This correction will therefore increase the frequency of those affected cut sets, typically by three or four orders of magnitude. At this time, these rules are located in the Project level (as opposed to the individual fault trees).

E.8 REFERENCES

E-1 MSC/Circ.645, "Guidelines for Vessels with Dynamic Positioning Systems"

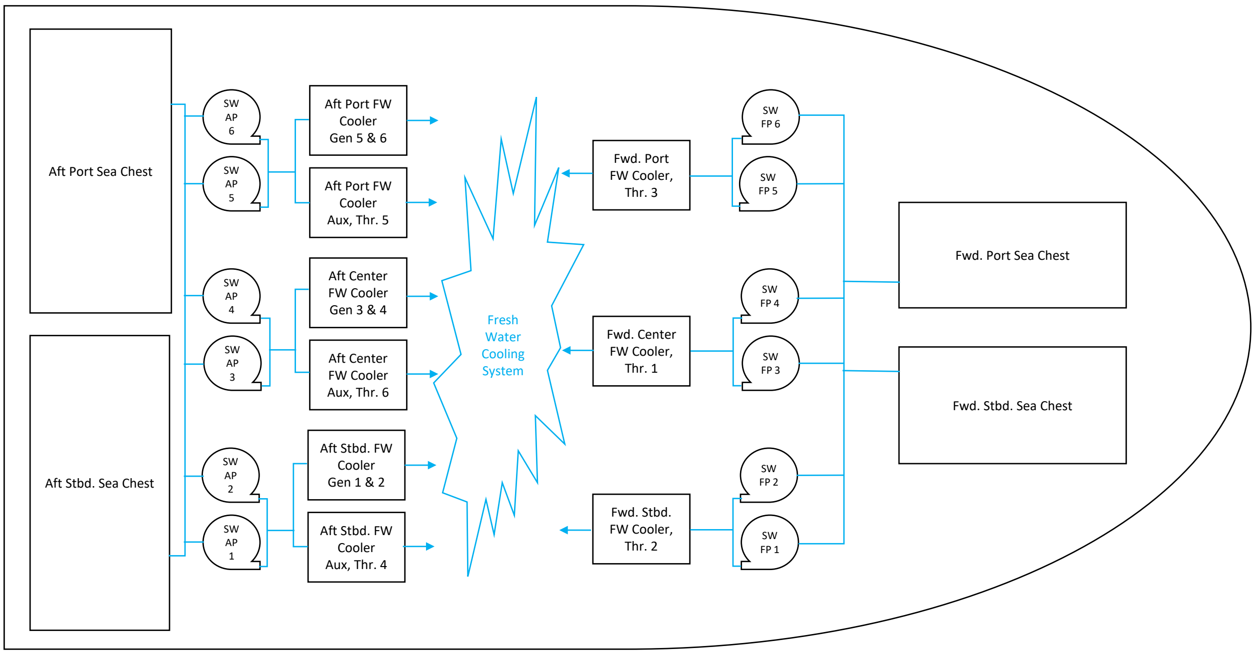
E-2 MSC.1/Circ.1580, "Guidelines for Vessels and Units with Dynamic Positioning (DP) Systems", 16 June 2017

E-3 Generic Dynamic Positioning System (DPS) Probabilistic Risk Assessment (PRA), Prepared By: Michael A. Stewart (NASA-JSC), Eric Thigpen (SAIC-JSC), Bruce Reistle, (NASA-JSC), Pete Fougere (Consultant)

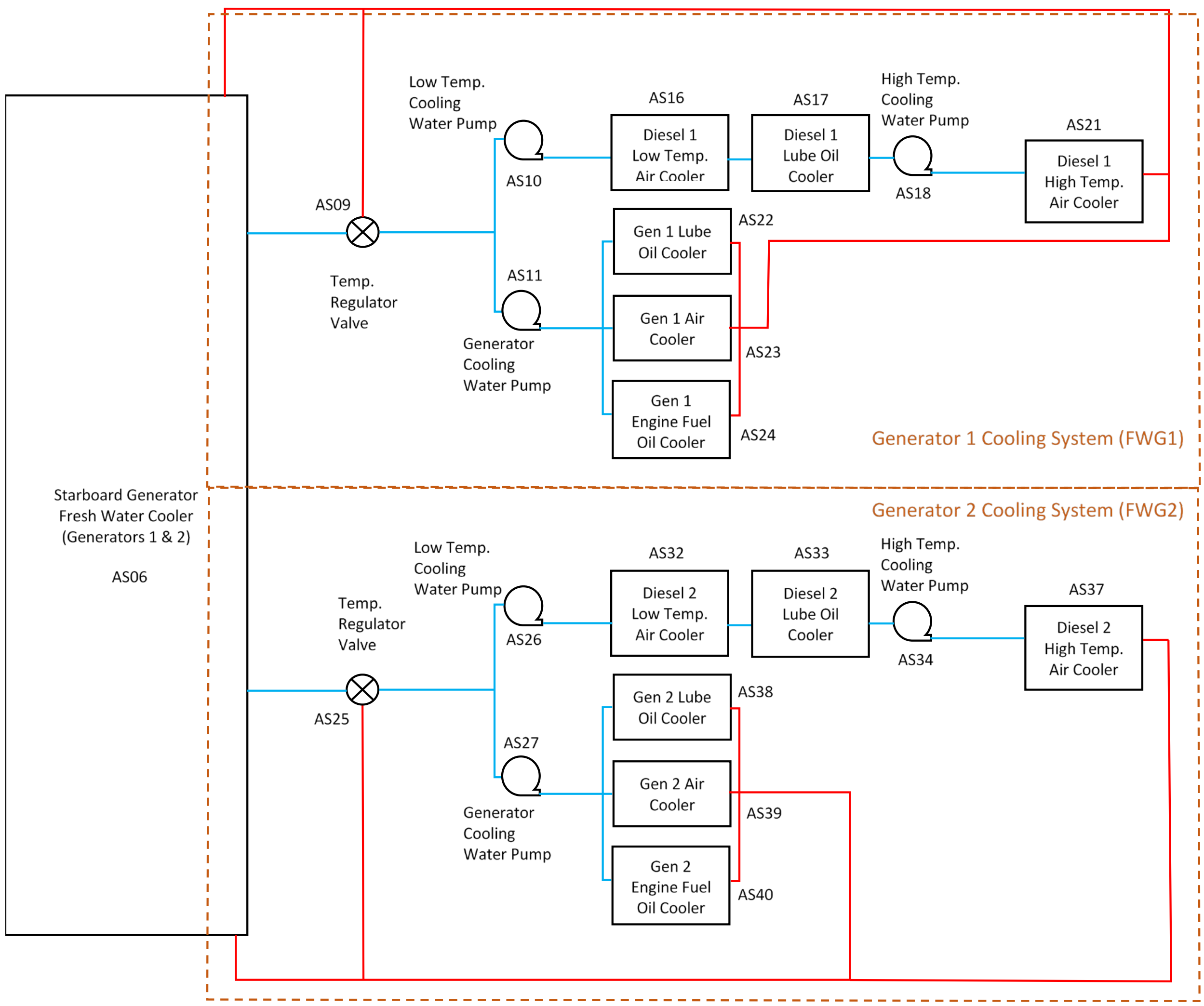
E.9 SCHEMATICS

DPS Subsystem Diagrams

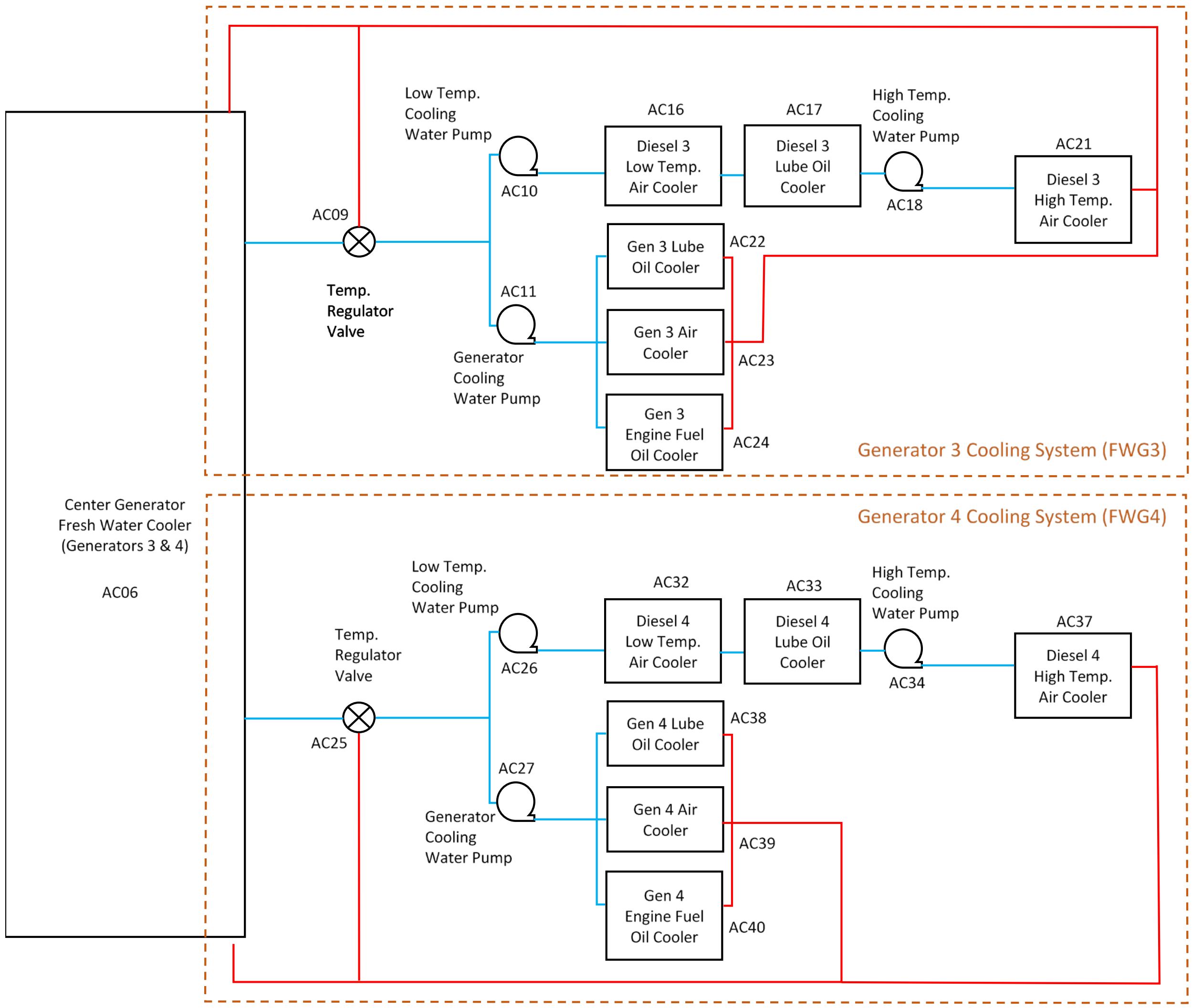
Sea Water Cooling System



Aft Starboard Generators Fresh Water Cooling System (Generators 1 & 2)



Aft Center Generators Fresh Water Cooling System (Generators 3 & 4)



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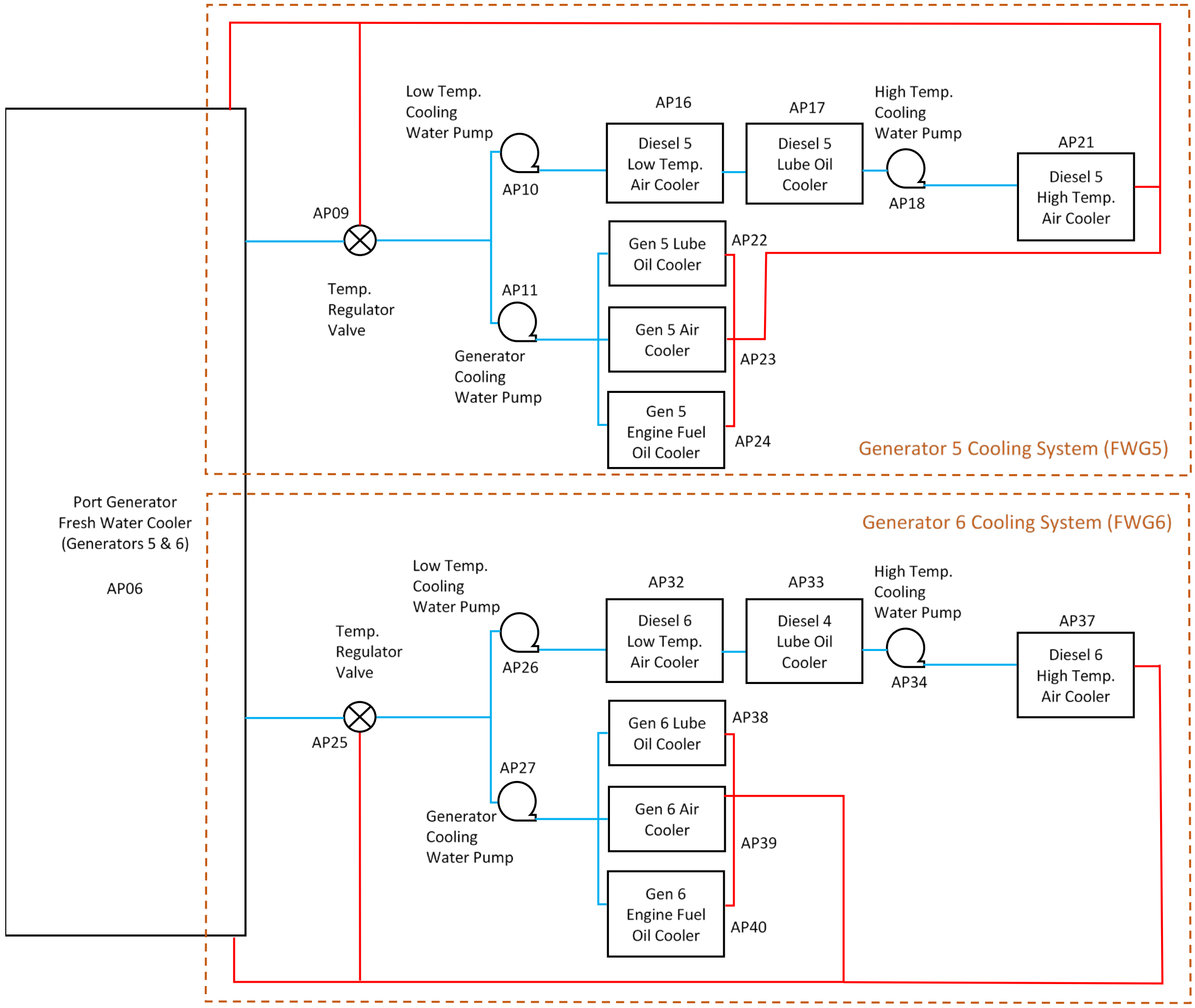
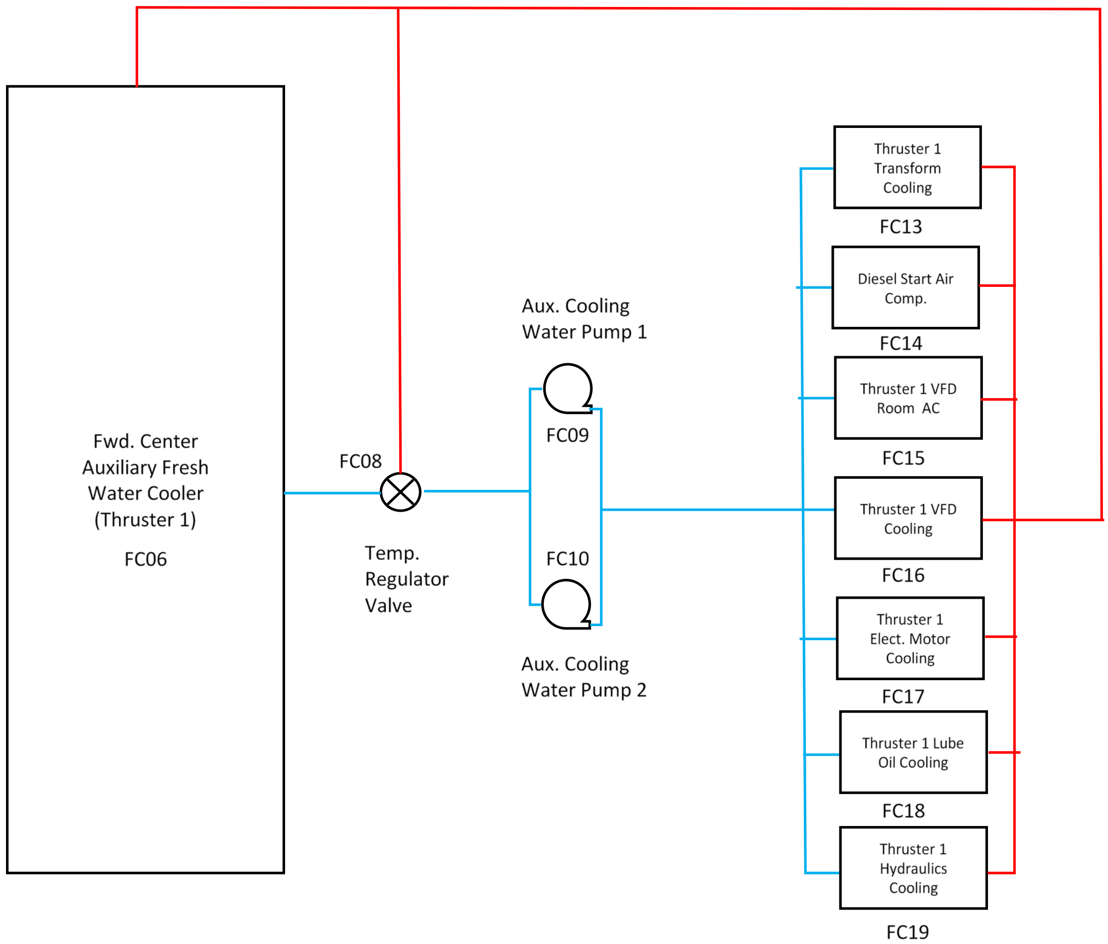
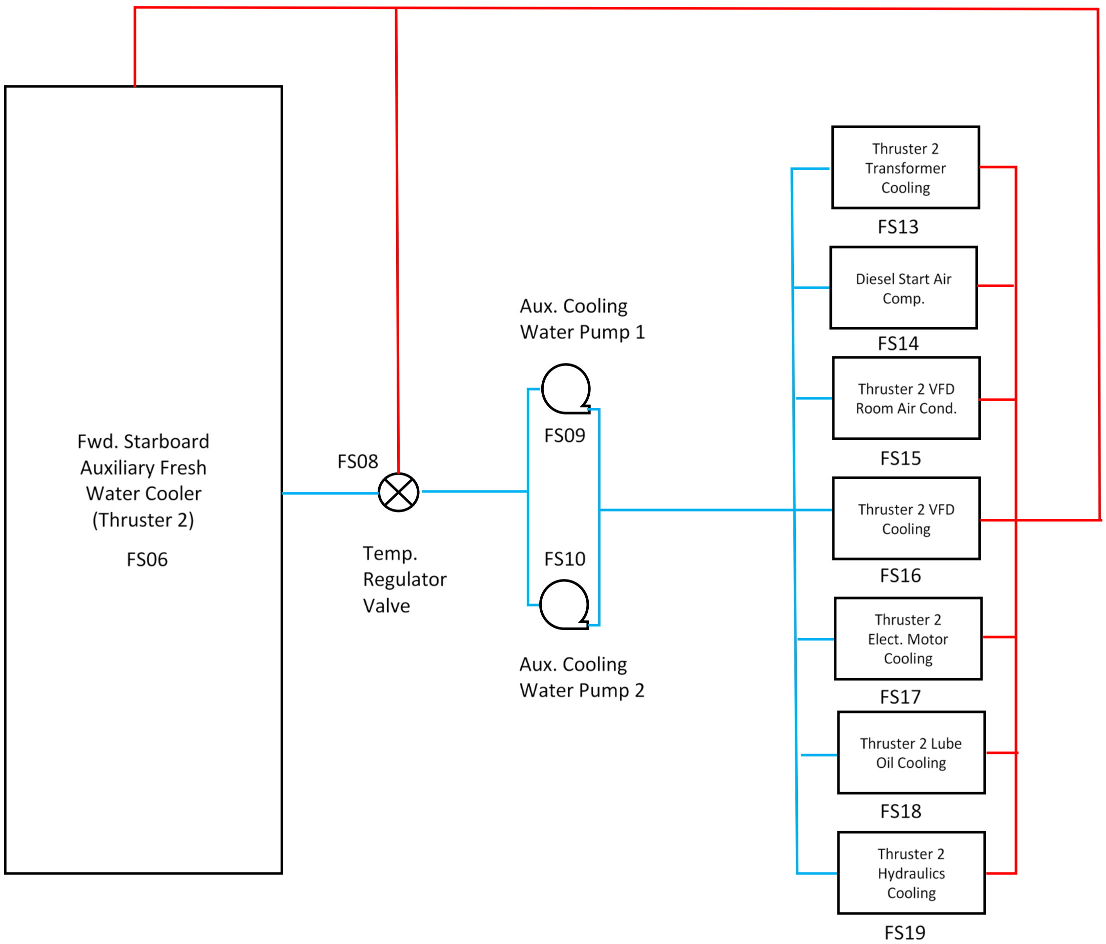


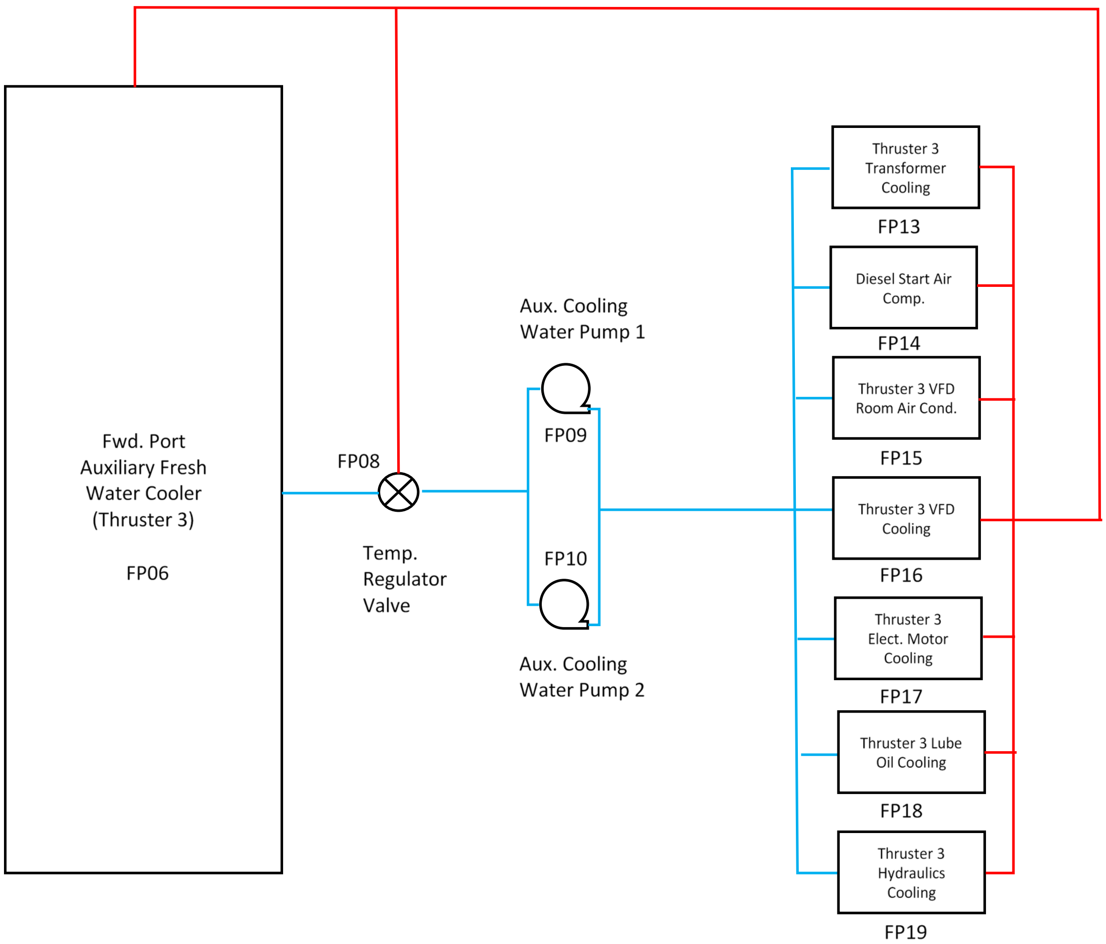
Forward Center Auxiliary Fresh Water Cooling System (Thruster 1)
FWT1



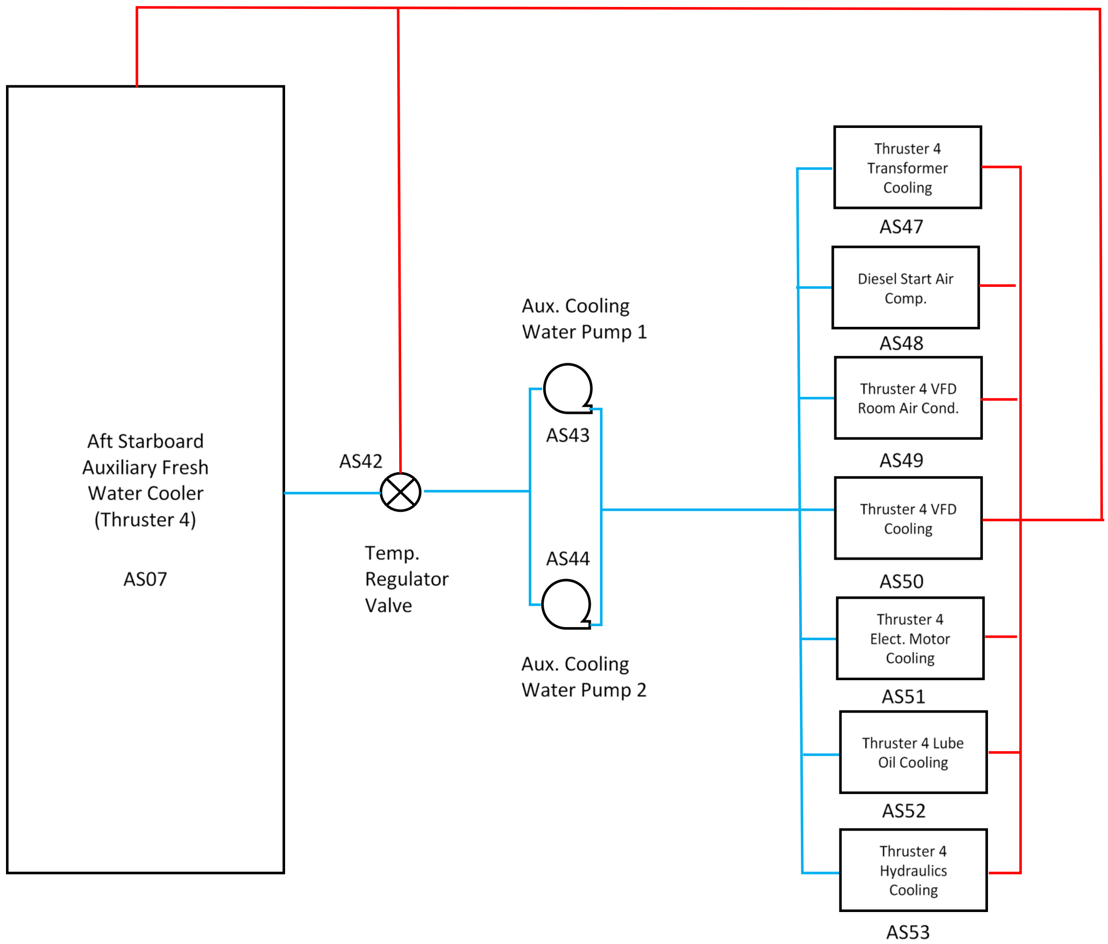
Forward Starboard Auxiliary Fresh Water Cooling System (Thruster 2)
FWT2



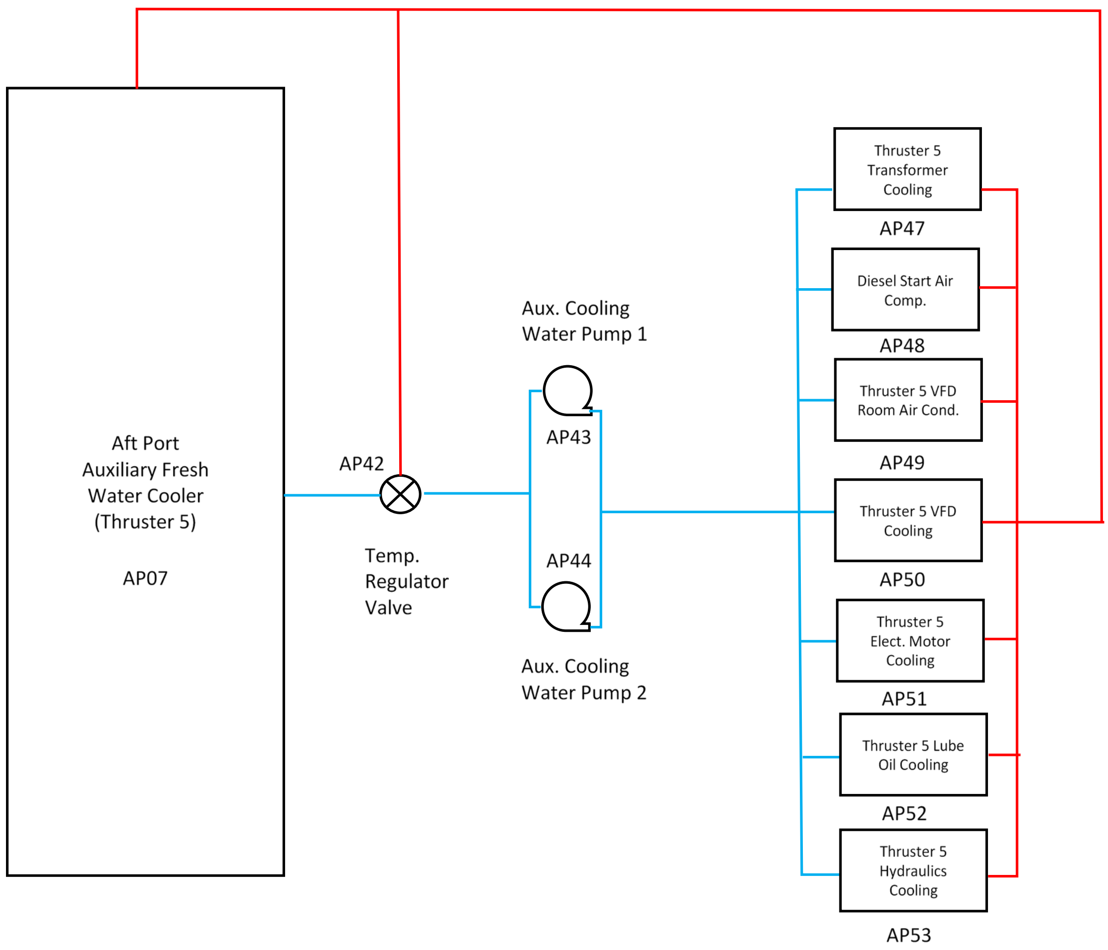
Forward Port Auxiliary Fresh Water Cooling System (Thruster 3)
FWT3



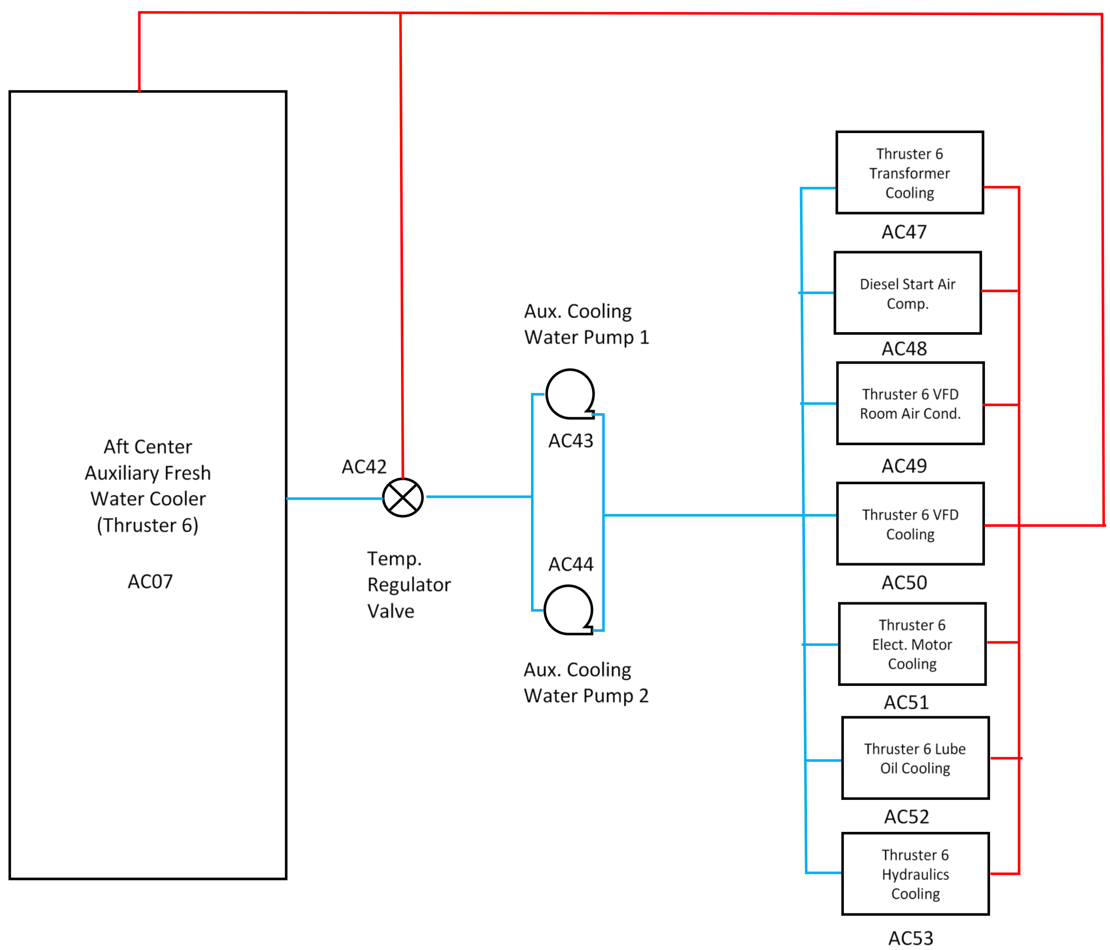
Aft Starboard Auxiliary Fresh Water Cooling System (Thruster 4)
FWT4



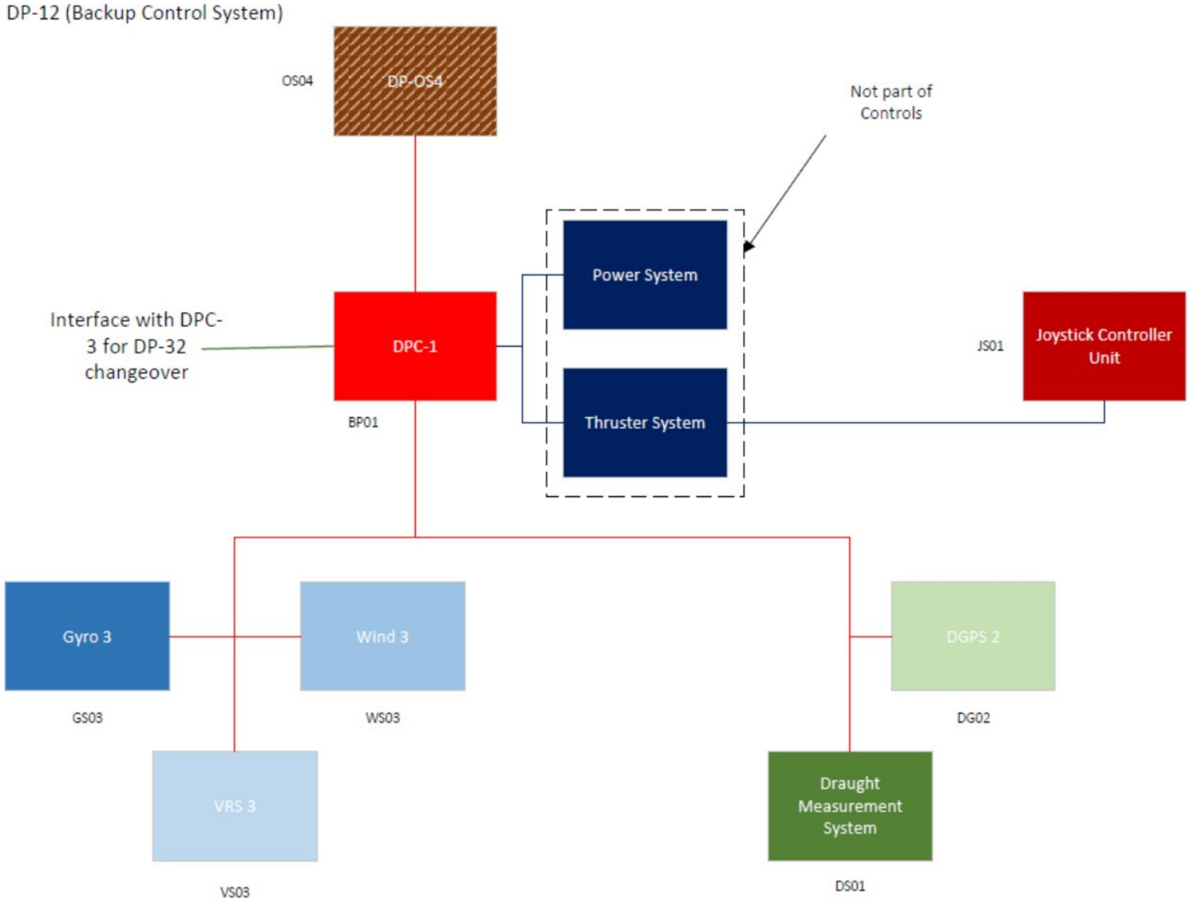
Aft Port Auxiliary Fresh Water Cooling System (Thruster 5)
FWT5

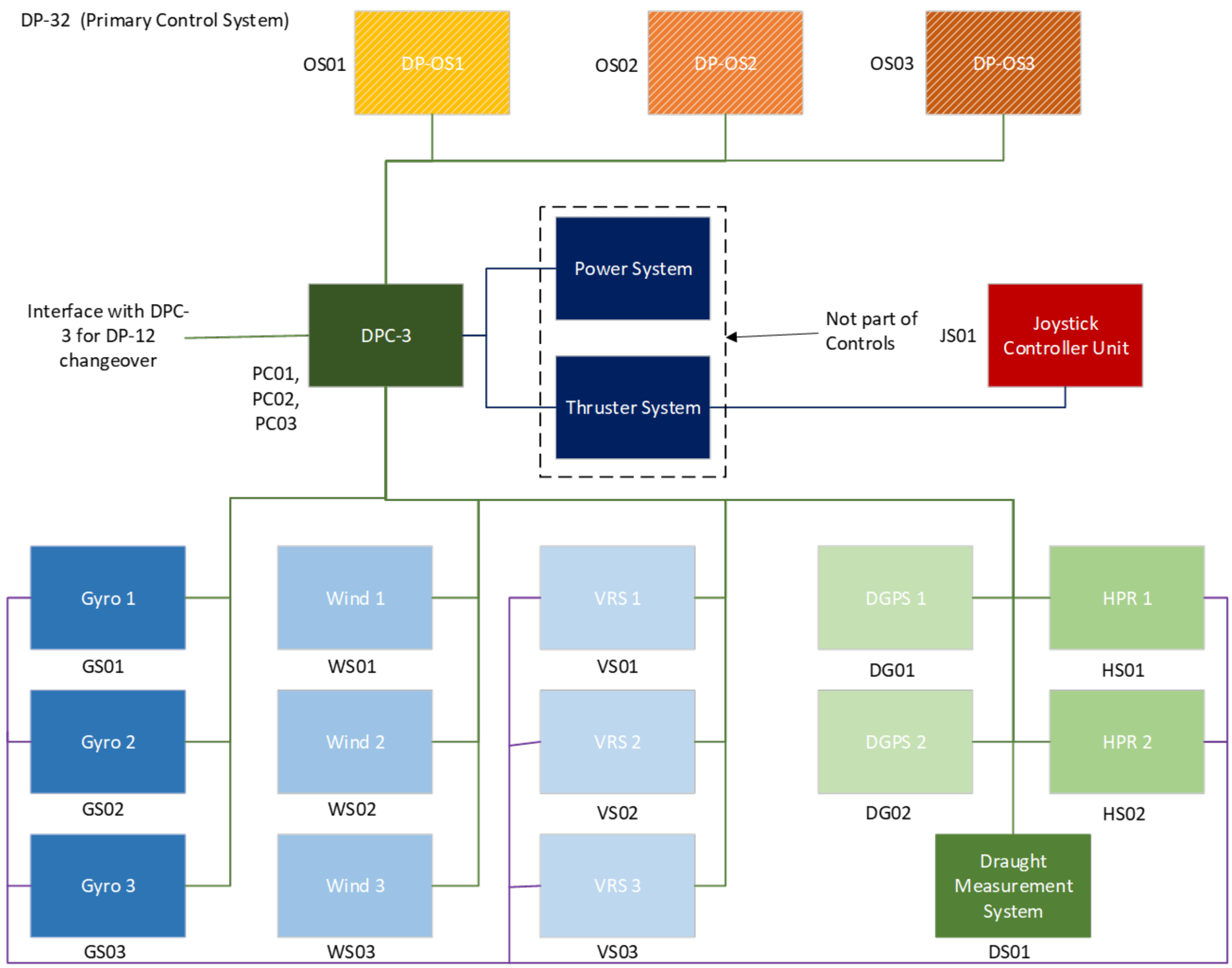


Aft Center Auxiliary Fresh Water Cooling System (Thruster 6)
FWT6

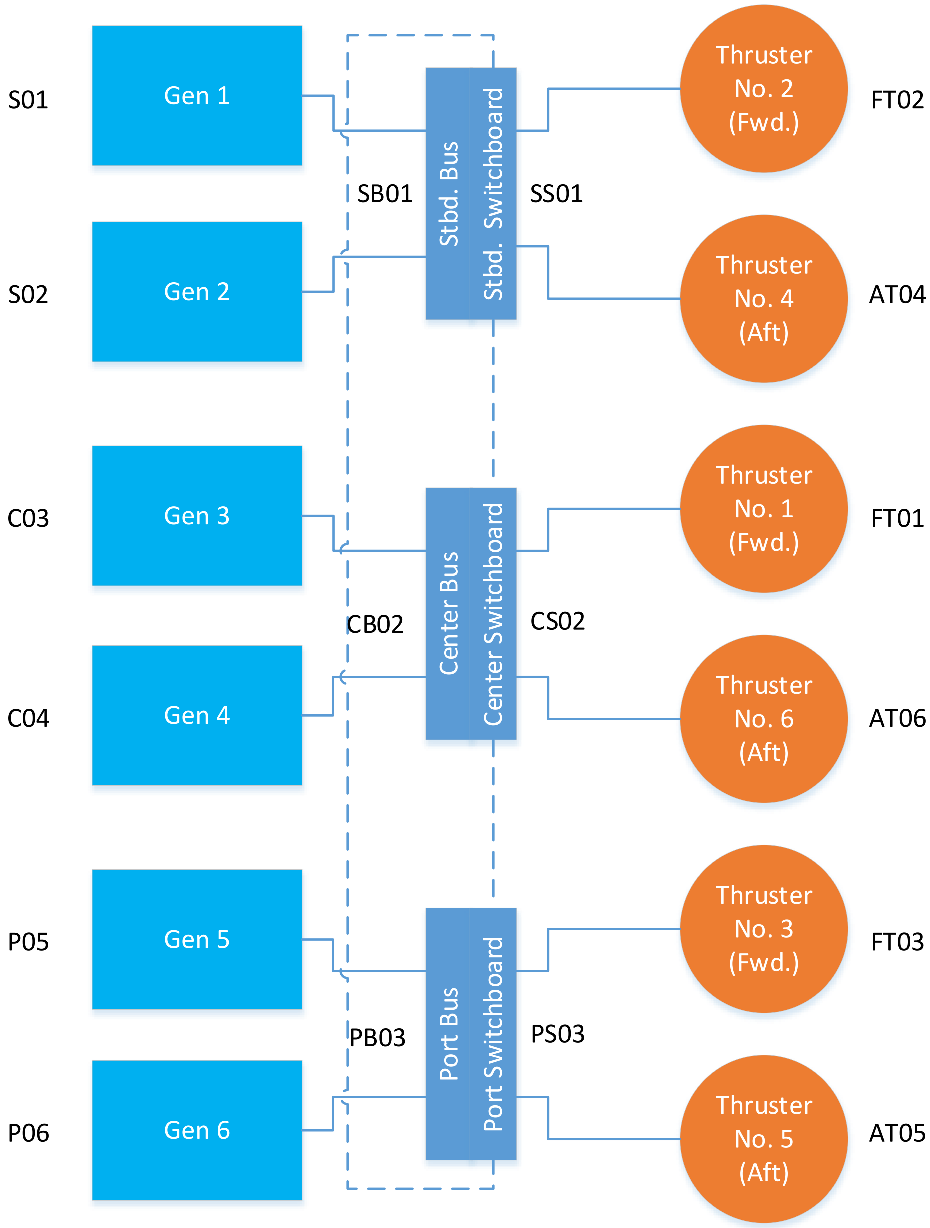


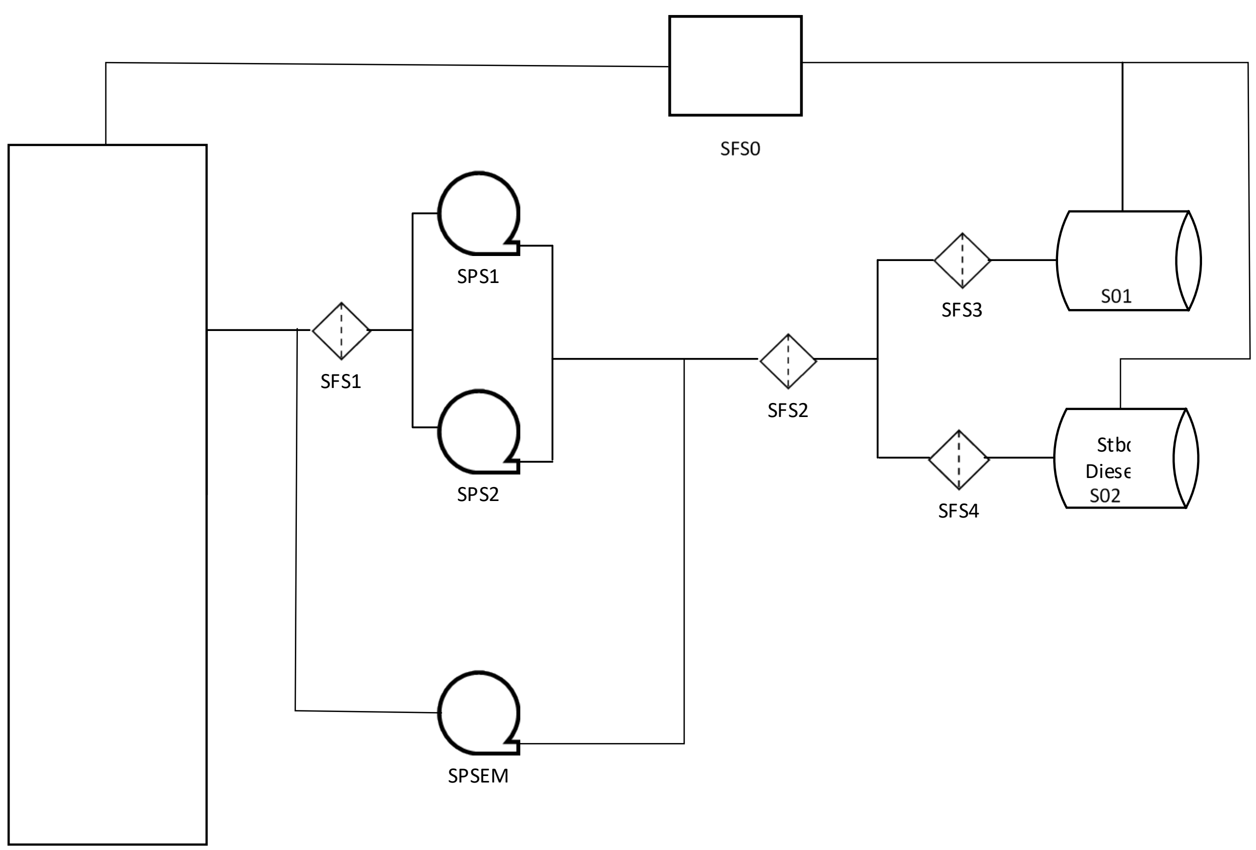
DP-12 (Backup Control System)




DP-32 (Primary Control System)
OS01
DP-OS1
OS02
DP-OS2
OS03
DP-OS3
Power System
Interface with DPC-3 for DP-12 changeover
DPC-3
Not part of Controls
JS01
Joystick Controller Unit
PC01, PC02, PC03
Thruster System
Gyro 1
GS01
Wind 1
WS01
VRS 1
VS01
DGPS 1
DG01
HPR 1
HS01
Gyro 2
GS02
Wind 2
WS02
VRS 2
VS02
DGPS 2
DG02
HPR 2
HS02
Gyro 3
GS03
Wind 3
WS03
VRS 3
VS03
Draught Measurement System
DS01

Power Generation Diagram

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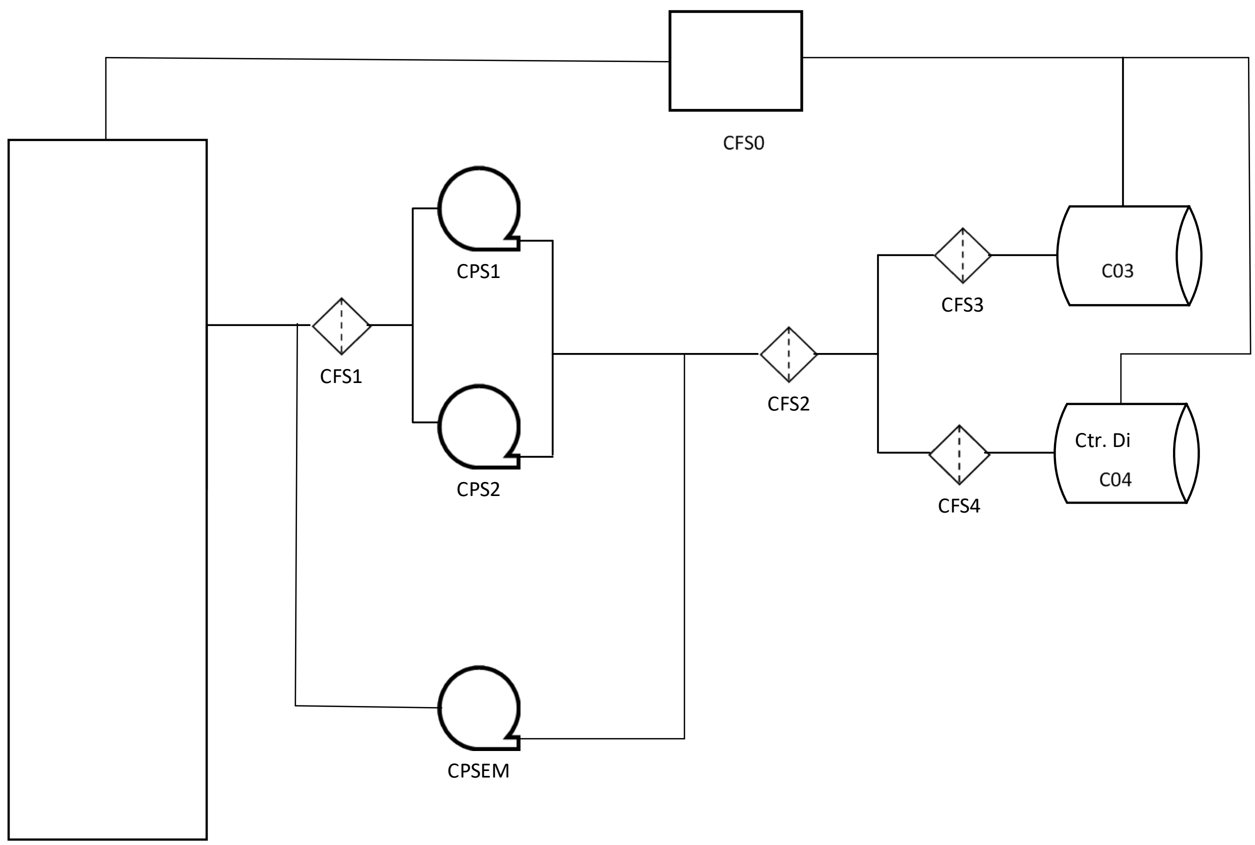
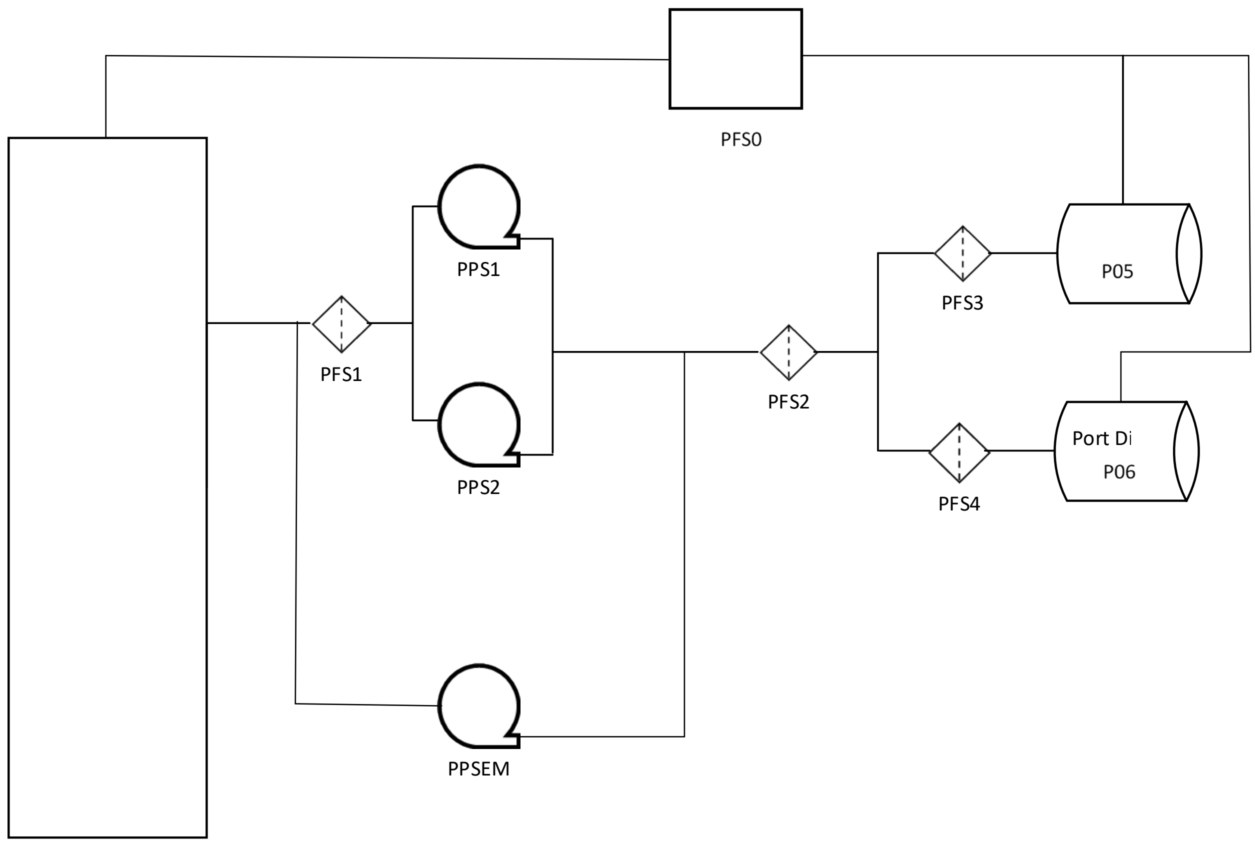
SPS1
SPS2
SPSEM
SFS1
SFS2
SFS3
SFS4
S01
Stbd
Diese
S02


CFS0
CPS1
CFS1
CPS2
CFS2
CFS3
C03
CFS4
Ctr. Di
C04
CPSEM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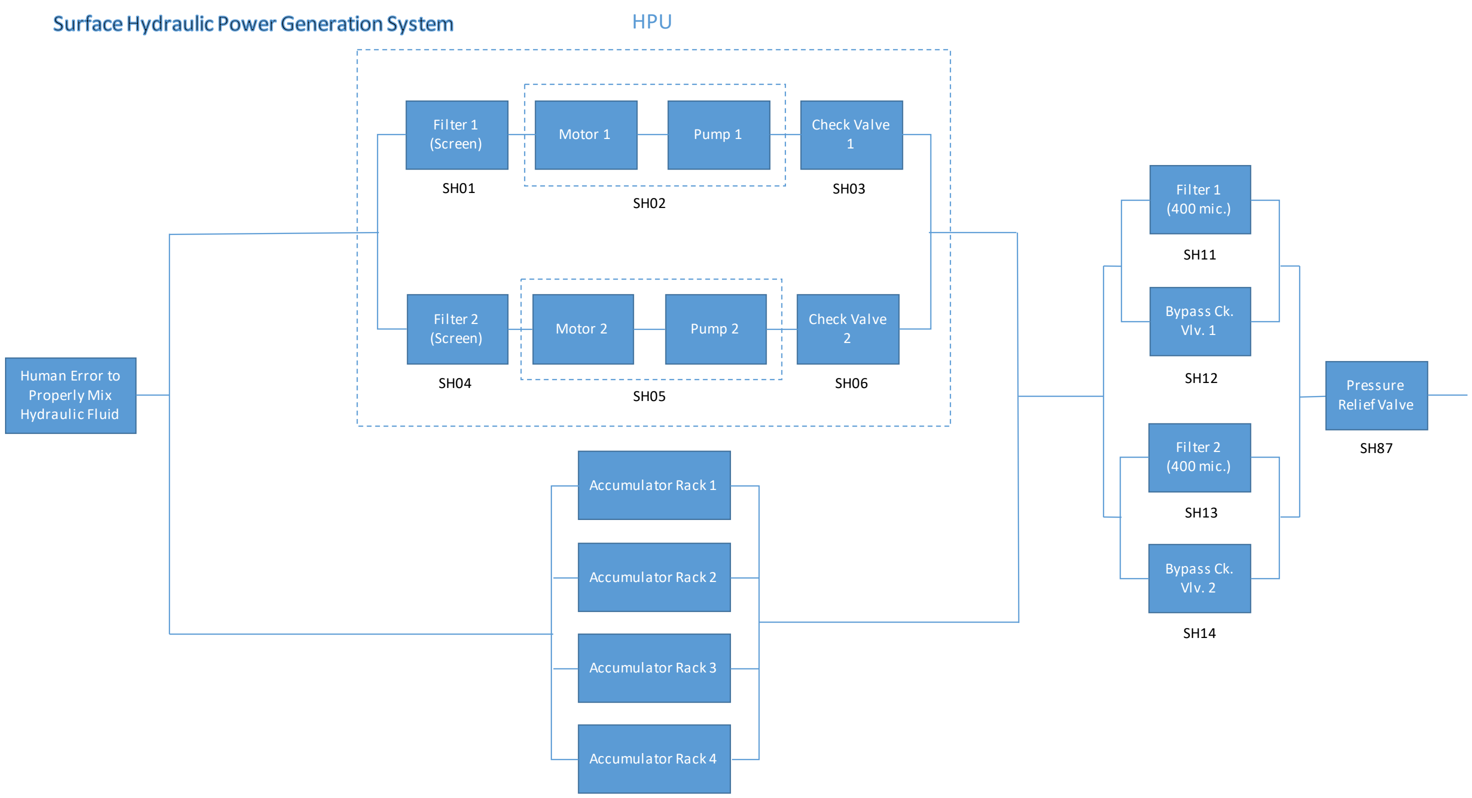
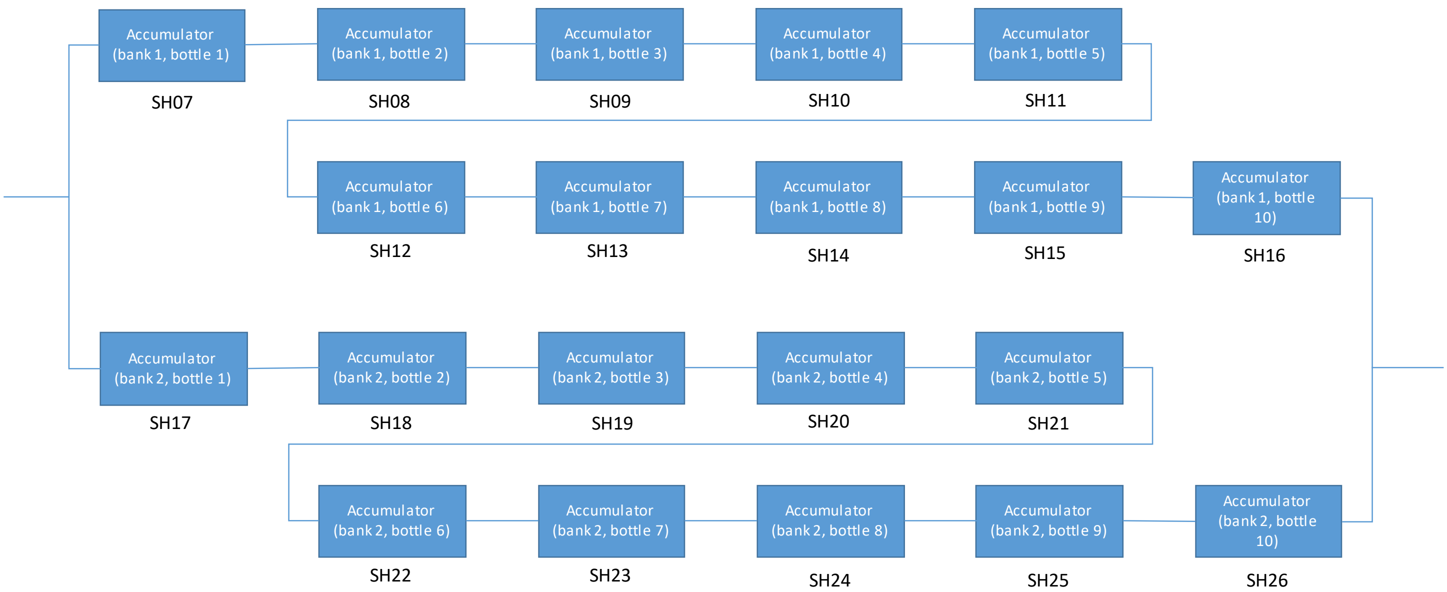
PFS1
PPS2
PFS2
PFS3
P05
Port Di
P06
PFS4
PPSEM

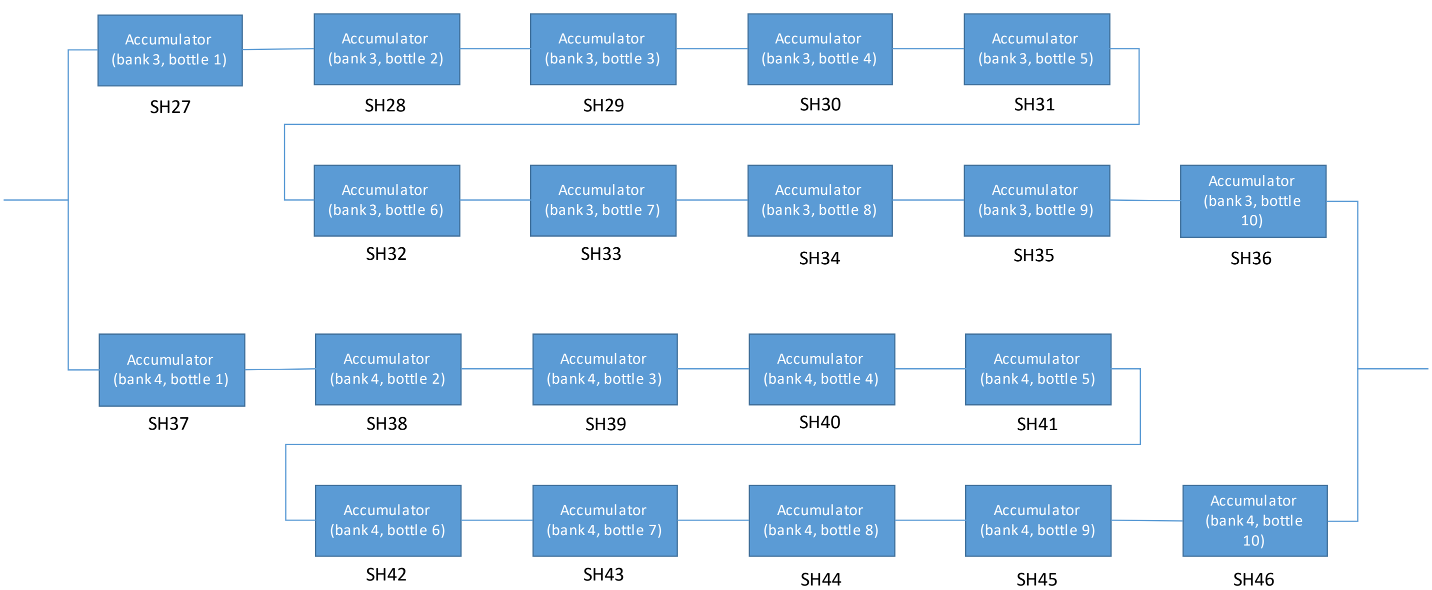
Surface Power Supply



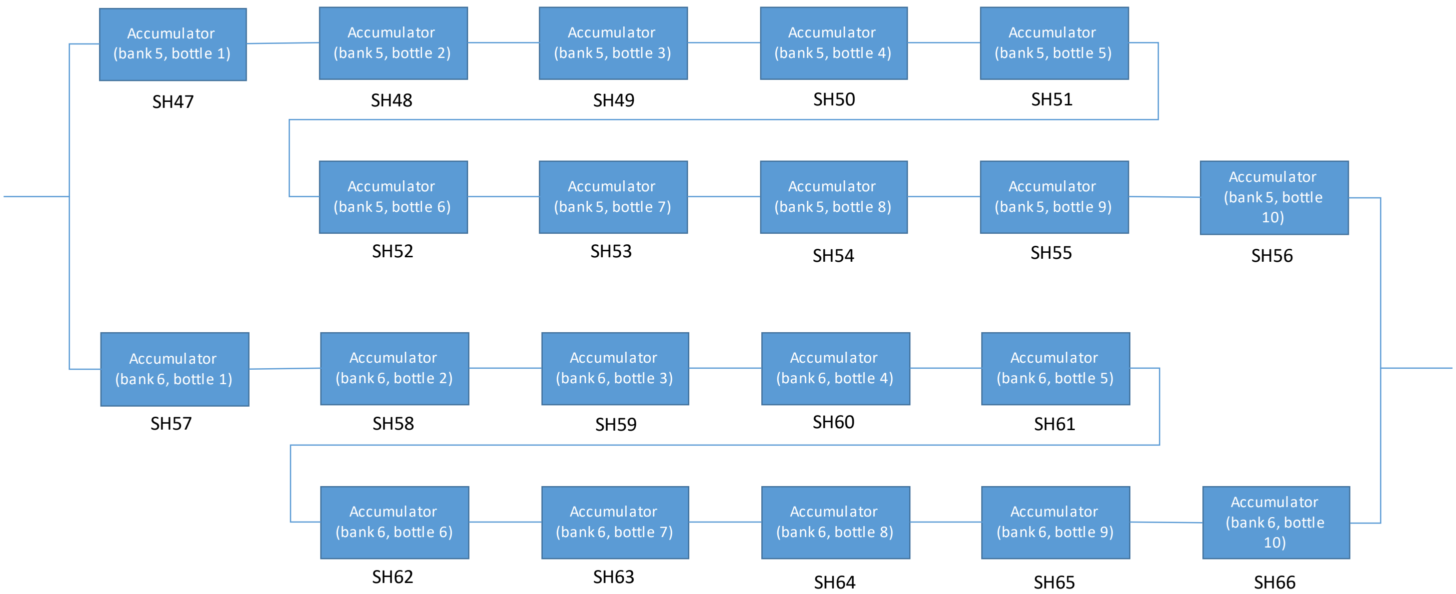
Accumulator Rack 1



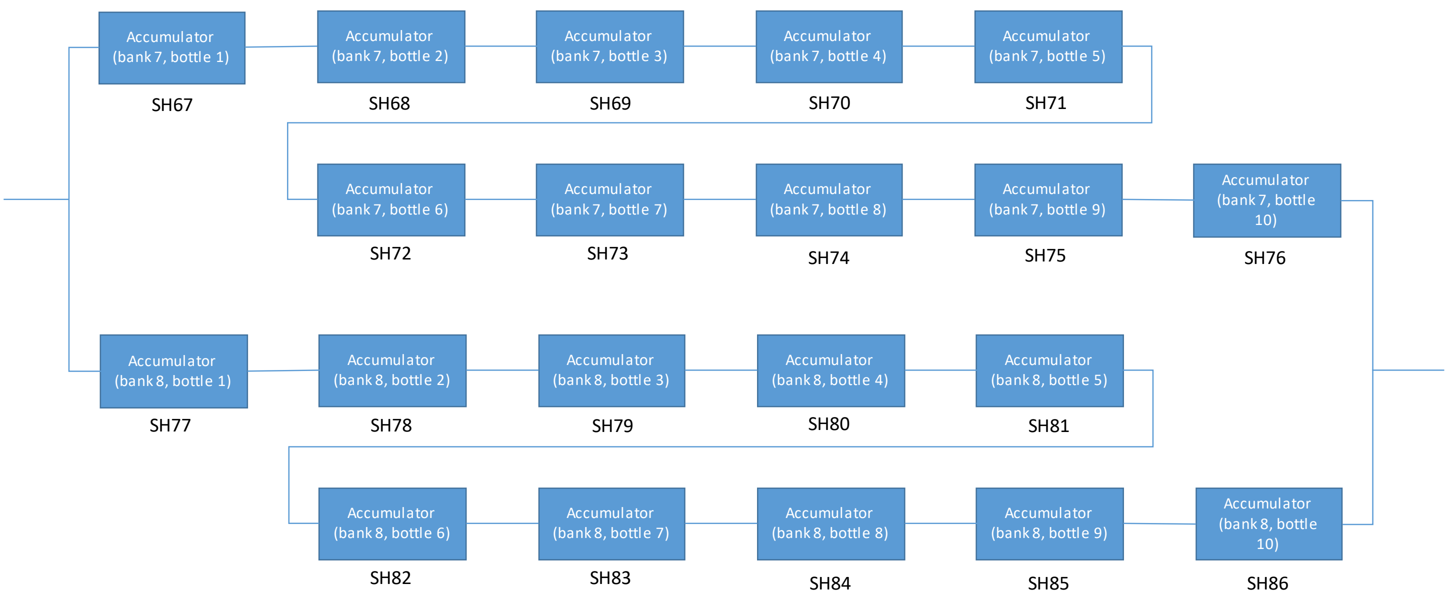
Accumulator Rack 2



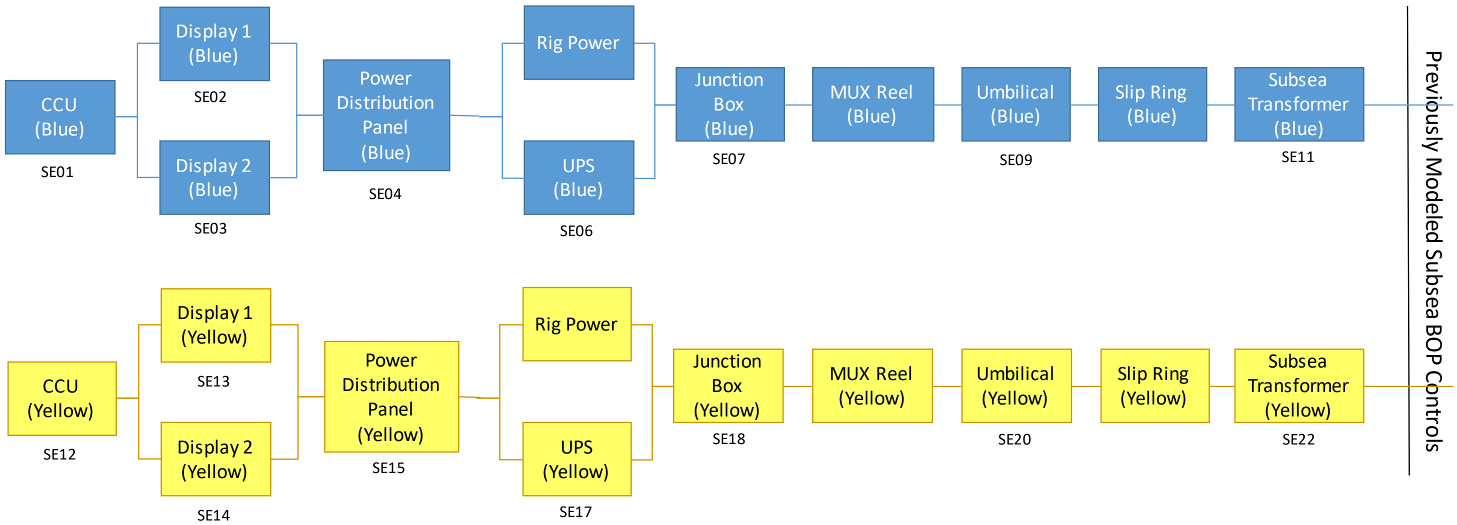
Accumulator Rack 3



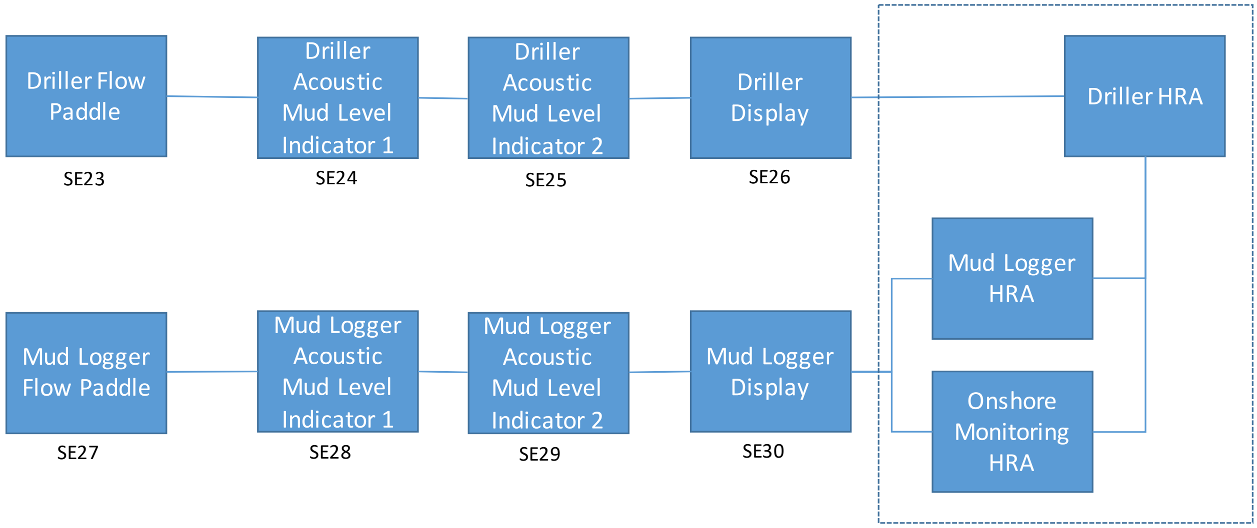
Accumulator Rack 4



Surface Electrical Power Generation/Control System



Well Kick Detection System



APPENDIX F- MODEL DATA DEVELOPMENT

F-1. FAILURE DATA DEVELOPMENT

The methodology used to generate the data for the components modeled in the Integrated PRA has evolved over time and has been applied previously to numerous projects at NASA. The data sources and calculated failure rates for all of the components modeled in this analysis are provided in the D-RAD database [F-1]. The data worksheets produced by the D-RAD database showing failure rate for each of the failure modes captured in the models is provided in this appendix.

Notes:

1. Time-based events have a failure *rate* per unit of time (per hour in this model) whereas demand-based events have a failure *probability* per demand. However, in general the term “failure rate” will refer to either failure rate or failure probability.
2. The details in this section describe the methods used to obtain the failure rates and failure modes.

It is important to differentiate between reliability analysis and PRA. Reliability analysis is a detailed failure rate assessment of a single component or a relatively small group of components. If data is not available, a reliability analysis might include a test plan where the item under study is subjected to accelerated life tests, non-destructive evaluation, etc. In a PRA, an entire system is typically modeled (usually hundreds or thousands of components) and it would be prohibitive to develop and implement a test plan to more accurately obtain the failure rates for every item in a system. To be clear, a PRA will use the best data available. Sometimes the best data available comes directly from the item being modeled, and sometimes it comes from a surrogate source. Most often, surrogate data is the best data available.

The underlying philosophy when using surrogate data is that all items of a certain type will operate similarly and have similar failure modes. For example, a hydraulic valve will regulate flow with potential failure modes being failure to open, failure to close, internal leaking, external leaking, etc. This will be true whether the valve was designed for use in naval applications or whether the valve was designed for use in subsea drilling. This is not to say that a component designed for an aircraft would work just as well in a subsea environment. But rather, that the same types of components will have similar failure modes and similar failure rates (within the same order of magnitude) for the respective environment that they were designed for.

When using surrogate data, uncertainty comes from many sources including:

- Representativeness of the surrogate
- Environmental differences
- Data collection accuracy

To account for uncertainty, as many surrogate sources as possible are used in order to capture a range of failure rate values. The surrogates for a given item are combined to arrive at a continuous range of failure rates that is modeled by a mean value as well as a measure of variance by using a probability distribution (e.g., the lognormal distribution).

In addition to the overall mean and variance of the combined surrogates, failure modes are also considered (e.g., failure to open, failure to close, etc.).

Surrogate Data Sources

The primary data sources used to obtain surrogate data in this analysis are:

1. Offshore and Onshore Reliability Data (OREDA) 6th Edition [F-2]
2. The Foundation for Scientific and Industrial Research (SINTEF) Reliability Data for Safety Instrumented Systems 2013 Edition [F-3]
3. Non-electronic Parts Reliability Data (NPRD)-2016 from Quanterion Solutions [F-4]

The first two are the preferred sources since they contain data specific to oil industry applications.

In general, surrogates are not rejected because of their failure rates. Selecting only those surrogates whose failure rates are pleasing would bias the results. However, a “sanity check” can be used to eliminate surrogates whose failure rates are orders of magnitude different from reasonable expectations.

Three basic steps are required to combine surrogate data:

1. For each data source, determine the mean and variance.
2. Combine the individual data sources to obtain the overall mean and variance.
3. Partition the overall failure rate to determine the distributions for each failure mode.

Table F- 1 presents the mathematical terms used in this study.

Table F- 1: Data Development Nomenclature

Term	Definition
n	Number of Failures for a Given Source
T	Time
D	Demands
f	Failure Mode Proportion
μ	Mean
σ^2	Variance
α	First Gamma or Beta Parameter
β	Second Gamma or Beta Parameter
N	Total Failures (actual or implied)

For clarification, the above terms may contain subscripts, e.g., σ_i^2 refers to the variance of the i^{th} data source.

Step 1–Get the Statistics for Each Data Source

For each data source, the number of failures and the total time (or demands) is given. (The zero failure case will be discussed later.) From these, the mean and variance are calculated. The equations for these items depend on whether the information is given in terms of time or demands.

Table F- 2 presents the formulas used to find the mean and variance for each data source.

Table F- 2: Equations for Individual Data Sources

Data Type	Distribution	Parameters	Mean	Variance
Demand Based	Beta	$\alpha = n$ $\alpha + \beta = D$	$\mu = \frac{\alpha}{\alpha + \beta}$	$\sigma^2 = \frac{\alpha\beta}{(\alpha + \beta)^3}$
Time Based	Gamma	$\alpha = n$ $\beta = T$	$\frac{\alpha}{\beta}$	$\frac{\alpha}{\beta^2}$

Consider the case where one or more data sources show zero failures and a positive operating time or demands. In these cases, a Jeffreys non-informative prior will be used and will be updated by the time or demands. More specifically, a zero-failure time-based source will have a posterior Gamma (0.5, T_i). The demand-based case will have a posterior Beta (0.5, D_i + 0.5).

Time-based failures use a gamma distribution with shape parameter α and scale parameter β. Demand-based failures use a beta distribution with two shape parameters, α and β.

Step 2–Combine the Data Sources to Obtain the Overall Failure Rate

Assume that after completing Step 1 there are k data sources with means $\mu_1, \mu_2, \ldots \mu_k$ and variances $\sigma_1^2, \sigma_2^2 \ldots \sigma_k^2$. At this point any zero-failure sources will have been updated to form non-zero failure posteriors. Table F- 3 presents the equations used to determine the overall statistics.

Table F- 3: Equations for the Overall Failure Rate

Term	Expression
$\mu_{Overall}$	$\frac{1}{k} \sum_{i=1}^{k} \mu_i$
$\sigma_{Overall}^2$	$\frac{1}{k} \sum_{i=1}^{k} \sigma_i^2 + \frac{1}{k-1} \sum_{i=1}^{k} (\mu_i - \mu_{Overall})^2$

The two components of $\sigma_{Overall}^2$ account for within-source and between-source variation.

Step 3–Obtain the Failure Modes

Let f_i denote the proportion of failures attributable to the *i*th failure mode. Table F- 4 presents the equations used to obtain the parameters that characterize the failure mode.

Table F- 4: Failure Mode Equations

Term	Expression
μ_i	$f_i \cdot \mu_{Overall}$
σ_i^2	$\sigma_{f_i}^2 \mu_{Overall}^2 + \sigma_{Overall}^2 f_i^2 + \sigma_{f_i}^2 \sigma_{Overall}^2$, where $\sigma_{f_i}^2 = \frac{f_i(1-f_i)}{N}$
Beta α_i ,β_i	$\alpha_i = \frac{\mu_i^2 - \mu_i^3 - \mu_i \sigma_i^2}{\sigma_i^2}$, $\beta_i = \frac{(\mu_i - \mu_i^2 - \sigma_i^2)(1-\mu_i)}{\sigma_i^2}$

The term *N* (used above) is the sum of all failures from the individual sources.

In cases where $\alpha_f < 1.0$, the distribution can be extremely broad. To avoid this, this analysis will use lognormal distributions with the given mean and Error Factor (EF). In general, an EF near 1.0 (the theoretical minimum) suggests a narrow distribution, an EF near 5.0 is a medium spread, and an EF greater than 10.0 suggests a large spread.

Once a failure rate and its variance is determined, a lognormal distribution is used for failure rates and a beta distribution is used for failures on demand. The shapes of those distributions are shown in Figure F-1 and Figure F- 2 below. Note that the lognormal distribution goes from zero to infinity whereas the beta distribution is constrained between zero and one.

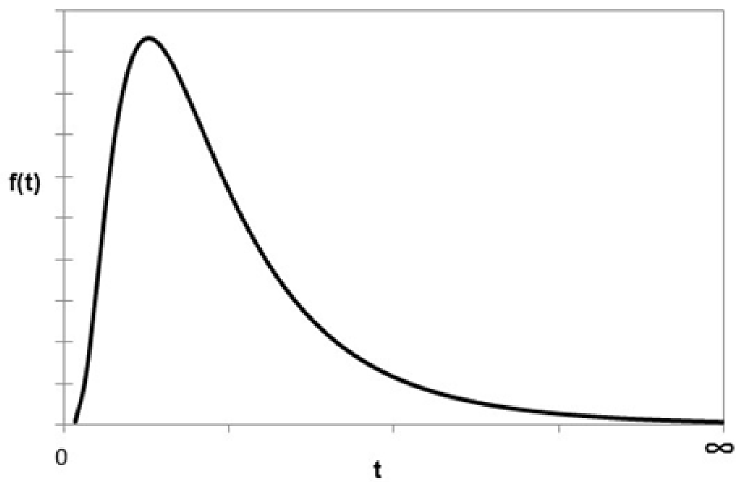


Figure F- 1: Lognormal Distribution

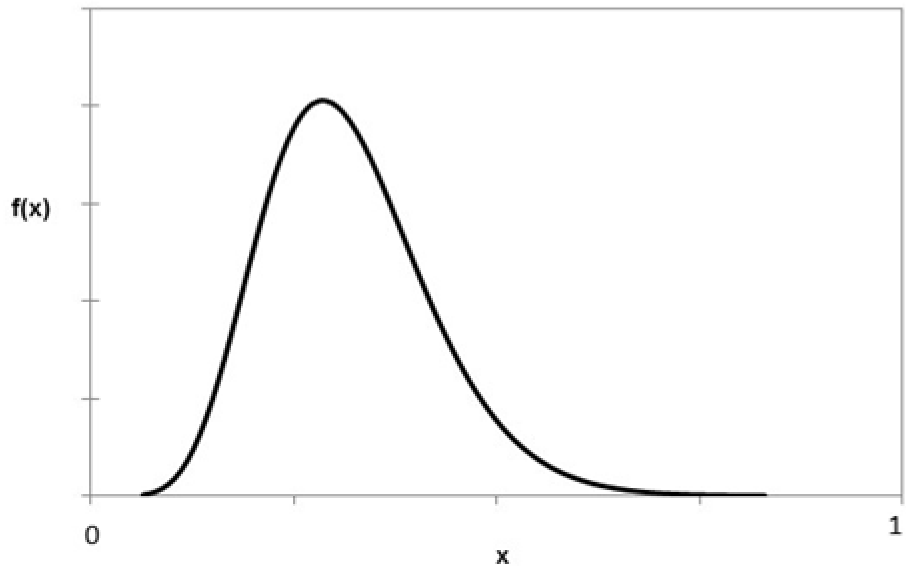


Figure F- 2: Beta Distribution

In SAPHIRE, most basic events represent a probability of failure (with the exception of initiating events) and this probability is calculated in any of the following ways:

1) If the failure data is given as a failure probability (e.g. probability of failure to open per demand), then this probability is directly used in SAPHIRE, using the "Failure Model" (Calculation Type) 1. Demand-based failure probabilities are typically sampled directly from a beta distribution. There is no time dependency in a demand-based event.
2) If the failure data is given as a failure rate per unit time λ (i.e. failures per hour), and the component is operating, SAPHIRE "Failure Model" 3 is used. A further assumption is that failures are expected to occur randomly at any time during operation, so the exponential distribution is used to obtain a probability of failure $F(t)$. The sample λ is then combined with the operating time *t* (also called the mission time) as shown in Equation (1).

$$F(t) = 1 - e^{-\lambda t} \quad (1)$$

λ is usually sampled from a lognormal distribution. It is noted that if λ t is small, the above equation is approximately equal to λ t.

If the failure data is given as a failure rate per unit time λ (i.e. failures per hour), and the component is in standby before the initiator, SAPHIRE "Failure Model" 7 is used. It is further assumed that failures can occur randomly at any time while in standby, the component is tested periodically (every T hours) and that if it fails, such failure is a "hidden failure" (i.e. there is no indication to the operators that the failure occurred until the following testing occurs). The sample λ is then combined with the time between tests T as shown in Equation (2).

$$F(t) = 1 + (e^{-\lambda T} - 1)/(\lambda T) \qquad (2)$$

It is noted that if λ T is small, the above equation is approximately equal to λ T/2. If we compare this approximation with the approximation for Failure Model 3, it is noted that both calculation types would give approximately the same estimate if the time t is replaced by half the time between tests. Another way of visualizing this approximation is by noting that the standby component can fail at any time between the last test and the following one, so, on average, it would be equivalent to assume that the failure occur at half the time between tests (T/2). It is due to this observation that the BSEE baseline models is using Failure Model 3 for both operating components and standby components in almost all cases, but replacing the time between tests by half that time (T/2) for the latter.

3) If the failure data is given as a failure rate per unit time λ (i.e. failures per hour), and the component failure is an initiator of an accident sequence, SAPHIRE "Failure Model" N is used. This Failure Model keeps the failure as a frequency (failures per hour in the BSEE model), so no time is needed in SAPHIRE. The failure rate λ is used in the basic event estimation.

Template Listing

SAPHIRE allows for the use of templates in order to simplify the creation and maintenance of basic events. For example, if the design to be modeled includes a large number of Solenoid Operated Valves, it would be necessary to input the component data (i.e. failure rate, mission time, error factor, correlation) every time each solenoid valve is modeled. Since all the Solenoid Operated Valves would generally share the exactly same failure rate, mission time, error factor, correlation factor, it is possible to define a "Solenoid Operated Valve" template and then each basic event for each solenoid valve can refer to that template and automatically link the desired information from that template. An added advantage on the use of templates is that if for any reason a failure rate wants to be modified, just by changing this information in the corresponding template once, SAPHIRE will automatically modify the corresponding information in all basic events that are linked to that template.

The templates events listed below in Table F- 5 are found under the Basic Events section in SAPHIRE.

Table F- 5: Template Event List

Name	Description	Failure Type	Unit	Lambda	Error Factor	Probability/ Frequency	Error Factor	Correlation Class
ABOV-EXT-WEATHER-IE	Above Extreme Weather (Initiating Event)	N	Y			5.71E-10	3.17	EXT-WEA
ACC-RECHARGE-FREQ	Subsea stack accumulators need to be recharged (Assume once per well)	1	Y			1.00E+0		
BOP-ACC-LKI	Subsea BOP accumulator fails due to internal leak	3	Y	2.80E-7	9.57			ACC-LKI
BOP-BSRCYL-FTC-DP	Blind shear rams fail to close and seal when drill string is in the hole	1	Y			1.00E-1	9.00	
BOP-BSRCYL-JAM-NABOP	Blind shear rams fail to close and seal when nothing is across the BOP	3	Y	2.20E-5	13.50			
BOP-CYL-FTC-ANN	Annular fails to close due to sticking, jamming etc.	3	Y	7.80E-5	9.81			ANN-FTC
BOP-CYL-FTC-CSR	Casing shear ram binds and fails to close and shear properly (both on drillpipe or casing)	3	Y	2.20E-5	13.50			
BOP-CYL-FTC-PR	Pipe ram fails to close and seal properly	3	Y	1.46E-5	7.52			PRA-FTC
BOP-CYL-FTO-CKL	Choke and Kill Line Lock Fails to Unlock	1	Y			2.03E-3	6.46	CKL-FTO
BOP-CYL-FTO-PR	Pipe ram fails to open	3	Y	1.46E-5	7.52			PRA-FTO
BOP-CYL-FTO-RCLK	Riser Connector Lock Fails to Unlock	1	Y			2.03E-3	6.46	
BOP-FLT-PLG	Filter fails plugged	3	Y	3.43E-7	9.51			FIL-PLG
BOP-HOV-FTO	Choke Valve Fails to Open	1	Y			5.89E-4	5.67	HOV-FTO
BOP-HOV-LKI	Choke Valve Internal Leakage	3	Y	5.12E-6	9.11			HOV-LKI
BOP-LOCK-FTC	Pipe ram Lock fails to close and seal properly	3	Y	2.74E-6	6.10			LCK-FTC
BOP-ORF-PLG	BOP timing circuit orifice plugged	3	Y	5.81E-7	4.54			ORF-PLG
BOP-PRG-FLO	Pressure regulator fails low	3	Y	1.45E-5	8.33			PRG-FLO
BOP-PVL-FTO	Pilot operated valve fails to open on demand	1	Y			2.27E-5	7.13	PVL-FTO

Name	Description	Failure Type	Unit	Lambda	Error Factor	Probability/ Frequency	Error Factor	Correlation Class
BOP-PVL-LKE	Pilot operated valve, External leak	3	Y	2.69E-6	3.97			PVL-LKE
BOP-PVL-LKI	Pilot operated hydraulic valve, Internal leakage	3	Y	1.34E-6	4.25			PVL-LKI
BOP-SCV-FTC	Pilot supply check valve fails to close	1	Y			8.66E-5	7.99	CHV-FTC
BOP-SCV-FTO	BOP Check valve Fails to open	1	Y			1.07E-4	7.99	CHV-FTO
BOP-SEA-DEG	Annular elastomer damaged while stripping in pipe	1	H			1.00E-1		
BOP-SEM-FOP	Control pod SEM fails off	3	Y	4.79E-5	10.50			MODELE-FOP
BOP-SHV-LKE	Shuttle valve jams/external leak	3	Y	9.17E-6	9.70			SHV-LKE
BOP-SVL-FTO	Solenoid valve fails to open on demand	1	Y			2.62E-4	7.51	SVL-FTO
BOP-SVL-LKE	Solenoid operated valve, external leak	3	Y	1.25E-7	5.88			SVL-LKE
BOP-SVL-LKI	Solenoid operated valve, internal leak	3	Y	9.71E-8	6.13			SVL-LKI
CASE-COUPLING-PRESENT	Casing Coupling prevents casing shear from cutting pipe	1	Y			2.00E-2		
D-W-O-OPER	Run/Retrieval Offset Frequency per hour	3	H	2.38E-3	3.93			OFFSET
D-W-O-OPER-IE	Run/Retrieval Offset Frequency per hour (initiating event)	N	H			2.38E-3	3.93	OFFSET
DP-TOOLJOINT	Drillpipe tool joint is present	1	Y			1.00E-1		
DPS-COM-FOP	DP Computer Fails Off	3	Y	3.96E-5	8.00			COMP-FOP
DPS-COM-FOP-F-IE	DP Computer PC02 Fails Off	N	H			3.96E-5	8.00	COMP-FOP
DPS-COM-FOP-RT	DP Computer Fails Off During Repair Time	3	Y	3.96E-5	8.00			COMP-FOP
DPS-GPS-DEG	Differential GPS Fails Degraded	3		9.46E-6	9.90			GPS-DEG
DPS-GPS-DEG-F-IE	Differential GPS Fails Degraded, as Initiator	N	H			9.46E-6	9.90	GPS-DEG
DPS-GPS-FOP	Differential GPS Fails Off	3		1.95E-5	9.25			GPS-FOP

Name	Description	Failure Type	Unit	Lambda	Error Factor	Probability/ Frequency	Error Factor	Correlation Class
DPS-GPS-FOP-F-IE	Differential GPS 2 Fails Off as initiator (frequency)	N	H			1.95E-5	9.25	GPS-FOP
DPS-GPS-FOP-RT	Differential GPS Fails Off during Repair Time	3		1.95E-5	9.25			GPS-FOP
DPS-GYC-FOP	Gyro Compass Sensor 1 Fails Off	3		1.76E-5	4.99			GYRO-FOP
DPS-GYC-FOP-F-IE	Gyro Compass Sensor Fails Off as initiator (frequency)	N	H			1.76E-5	4.99	GYRO-FOP
DPS-GYC-FOP-RT	Gyro Compass Sensor Fails Off during Repair Time	3		1.76E-5	4.99			GYRO-FOP
DPS-HYS-DEG	Hydroacoustic Position Reference Sensor Fails Degraded	3		4.70E-5	9.61			ACOU_DEG
DPS-HYS-DEG-F-IE	Hydroacoustic Position Reference Sensor Fails Degraded as initiating event	N	H			4.70E-5	9.61	ACOU-DEG
DPS-HYS-FOP	Hydroacoustic Position Reference Sensor 1 Fails Off	3		7.83E-5	8.76			ACOU-FOP
DPS-HYS-FOP-F-IE	Hydroacoustic Position Reference Sensor 2 Fails Off	N	H			7.83E-5	8.76	ACOU-FOP
DPS-HYS-FOP-RT	Hydroacoustic Position Reference Sensor Fails Off	3		7.83E-5	8.76			ACOU-FOP
DPS-JOY-FOP	Failure of the Joystick Control System	7	Y	1.30E-5	7.09			JOY-FOP
DPS-THR-FTR	Thruster Fails to Run	3		2.43E-5	13.00			THR-FTR
DPS-THR-FTR-F-IE	Thruster Fails to Run as initiator (frequency)	N	H			2.43E-5	13.00	THR-FTR
DPS-VRS-FOP	Vertical Reference Sensor Fails Off	3		2.49E-5	12.80			MOTSENS-FOP
DPS-VRS-FOP-F-IE	Vertical Reference Sensor Fails Off as initiator (frequency)	N	H			2.49E-5	12.80	MOTSENS-FOP
DPS-VRS-FOP-RT	Vertical Reference Sensor Fails Off during Repair Time	3		2.49E-5	12.80			MOTSENS-FOP
DPS-WEA-HURR	Probability of Extreme Weather/Hurricane	3	Y	3.62E-5	1.50			WEA-HURR
DPS-WEA-HURR-F-IE	Frequency of Extreme Weather/Hurricane per hour	N	H			3.62E-5	1.50	WEA-HURR

Name	Description	Failure Type	Unit	Lambda	Error Factor	Probability/ Frequency	Error Factor	Correlation Class
DPS-WEA-SQUA	Probability of a Squall	3	Y	1.61E-3	2.50			WEA-SQUA
DPS-WEA-SQUA-F-IE	Frequency of a Squall per hour	N	H			1.61E-3	2.50	WEA-SQUA
DPS-WEA-WINT	Probability of Winter Storm	3	Y	3.31E-4	3.93			WEA-WINT
DPS-WEA-WINT-F-IE	Frequency of Winter Storm per hour	N	H			3.31E-4	3.93	WEA-WINT
DPS-WIS-DEG	Wind Sensor Fails Degraded	3		2.15E-5	7.38			WINDSEN S-DEG
DPS-WIS-DEG-F-IE	Wind Sensor Fails Degraded as Initiating Event	N	H			2.15E-5	7.38	WINDSEN S-DEG
DPS-WIS-FOP-H	Wind Sensor Fails Off (Extreme Weather/Hurricane)	3		1.07E-5	9.28			WINDSEN S-FOF
ELS-CCU-FOF	Central Control Unit Fails Off	3	Y	3.96E-5	8.00			COMP-FOF
ELS-CTL-FOF	Control panel Fails off	3	Y	1.72E-5	15.20			CTRLPNL -FOP
ELS-JBX-FOF	Junction box fails to operate	3	Y	6.46E-6	9.20			SWB-FOP
ELS-PDP-FOF	Power distribution panel fails off	3	Y	1.62E-6	7.56			ELECBUS -FOP
ELS-TRF-FOF	Subsea transformer fails to operate	3	Y	7.20E-6	6.05			TRF-FOF
ELS-UMB-FOF	Umbilical breaks or is sheared and fails to provide electrical signal subsea	3	Y	2.47E-6	17.60			UMB-FOF
ELS-UPS-FOF	UPS fails to operate	3	Y	1.41E-5	9.90			UPS-FOF
EME-ESD-SPO	Emergency Shutdown System Spuriously Causes Loss of Power	3	Y	4.91E-5	8.00			COMP-SPO
EME-ESD-SPO-F-IE	Emergency Shutdown System Spuriously Causes Loss of Power as initiator (frequency)	N	H			4.91E-5	8.00	COMP-SPO
EME-ESD-SPO-H	Emergency Shutdown System Spuriously Causes Loss of Power (Extreme Weather)	3	Y	4.91E-5	8.00			COMP-SPO
EPS-BUS-FOP	Electrical Bus Fails to Operate	3		1.62E-6	7.56			ELECBUS -FOP

Name	Description	Failure Type	Unit	Lambda	Error Factor	Probability/ Frequency	Error Factor	Correlation Class
EPS-BUS-FOP-F-IE	Electrical Bus Fails to Operate as initiator (frequency)	N	H			1.62E-6	7.56	ELECBUS -FOP
EPS-BUS-FOP-H	Electrical Bus Fails to Operate (Extreme Weather)	3		1.62E-6	7.56			ELECBUS -FOP
EPS-DGN-FTR	Diesel Generator Fails to Run	3		5.59E-5	7.39			DGN-FTR
EPS-DGN-FTR-F-IE	Diesel Generator Fails to Run as initiator (frequency)	N	H			5.59E-5	7.39	DGN-FTR
EPS-DGN-FTR-H	Diesel Generator Fails to Run (Extreme Weather)	3		5.59E-5	7.39			DGN-FTR
EPS-DGN-FTS	Diesel Generator Fails to Start	1	Y			2.11E-3	3.54	DGN-FTS
EPS-SWB-FOP	Switchboard Fails to Operate	3		6.46E-6	9.20			SWB-FOP
EPS-SWB-FOP-F-IE	Switchboard Fails to Operate as Initiator (frequency)	N	H			6.46E-6	9.20	SWB-FOP
EPS-SWB-FOP-H	Switchboard Fails to Operate (Extreme Weather)	3		6.46E-6	9.20			SWB-FOP
FORM-PRE-HIGH	Formation pressure/flow is high (placeholder)	1	Y			1.00E-2		
FORMFRACTURE_BH	Bullheading leads to fracturing the formation (placeholder)	1	Y			5.00E-1		
FORM_PRESS_ANN	Formation pressure above annular design pressure (placeholder)	1	Y			5.00E-2		
FSY-FLT-PLG	Fuel System Filter Fails Clogged	3		3.43E-7	9.51			FLT-PLG
FSY-FLT-PLG-F-IE	Fuel System Filter Fails Clogged as initiator (frequency)	N	H			3.43E-7	9.51	FLT-PLG
FSY-FLT-PLG-H	Fuel System Filter Fails Clogged (Extreme Weather)	3		3.43E-7	9.51			FLT-PLG
FSY-HEX-PLG	Fuel System Fuel Cooler Leaks or Plugs/Clogs	3		1.26E-5	5.01			HEATEXC H-PLG
FSY-HEX-PLG-F-IE	Fuel System Fuel Cooler Leaks or Plugs/Clogs as initiator (frequency)	N	H			1.26E-5	5.01	HEATEXC H-PLG
FSY-HEX-PLG-H	Fuel System Fuel Cooler Leaks or Plugs/Clogs (Extreme Weather)	3		1.26E-5	5.01			HEATEXC H-PLG
FSY-PMP-FTR	Electrically Driven Fuel Supply Pump, Fails to Run	3		3.37E-5	9.12			ELECPMP-FTR

Name	Description	Failure Type	Unit	Lambda	Error Factor	Probability/ Frequency	Error Factor	Correlation Class
FSY-PMP-FTR-F-IE	Electrically Driven Fuel Supply Pump Fails to Run as initiator (frequency)	N	H			3.37E-5	9.12	ELECPMP-FTR
FSY-PMP-FTR-H	Center Electrically Driven Fuel Supply Pump Fails to Run (Extreme Weather)	3		3.37E-5	9.12			ELECPMP-FTR
FSY-PMP-FTS	Electrically Driven Fuel Supply Pump, Fails to Start	1	Y			1.31E-3	1.14	ELECPMP-FTS
FSY-PMP-FTS-H	Center Electrically Driven Fuel Supply Pump Fails to Start (Extreme Weather)	1	Y			1.31E-3	1.14	ELECPMP-FTS
FWC-AOV-FOP	Temperature Regulating Valve Fails to Regulate	3		1.89E-7	5.57			TEMPREG VLV-FOP
FWC-AOV-FOP-F-IE	Temperature Regulating Valve Fails to Regulate as initiator (frequency)	N	H			1.89E-7	5.57	TEMPREG VLV-FOP
FWC-AOV-FOP-H	Temperature Regulating Valve Fails to Regulate (Extreme Weather)	3		1.89E-7	5.57			TEMPREG VLV-FOP
FWC-HEX-PLG	Freshwater Cooler Leaks or Plugs/Clogs	3		1.26E-5	5.01			HEATEXC H-PLG
FWC-HEX-PLG-F-IE	Freshwater Cooler Leaks or Plugs/Clogs as initiator (frequency)	N	H			1.26E-5	5.01	HEATEXC H-PLG
FWC-HEX-PLG-H	Thruster Hydraulics Cooling Leaks or Plugs/Clogs (Extreme Weather)	3		1.26E-5	5.01			HEATEXC H-PLG
FWC-PMP-FTR	Electrically Driven Fresh Water Thruster Cooling Pump, Fails to Run	3		3.37E-5	9.12			ELECPMP -FTR
FWC-PMP-FTR-F-IE	Electrically Driven Fresh Water Generator Cooling Pump Fails to Run as initiator (frequency)	N	H			3.37E-5	9.12	ELECPMP -FTR
FWC-PMP-FTR-H	Electrically Driven Fresh Water Thruster Cooling Pump, Fails to Run (Extreme Weather)	3		3.37E-5	9.12			ELECPMP -FTR
FWC-PMP-FTS	Electrically Driven Fresh Water Thruster Cooling Pump Fails to Start	1				1.31E-3	1.14	ELECPMP -FTS
HUM-ERR-CSRECOV	Human Error Failure to Adequately Recover from Control System Failure in Which Drive-off is Initiated	1	Y			4.30E-3	7.20	
HUM-ERR-EMERGDIS	Operator fails to initiate emergency disconnect successfully	1	Y			4.90E-4	13.80	

Name	Description	Failure Type	Unit	Lambda	Error Factor	Probability/ Frequency	Error Factor	Correlation Class
HUM-ERR-HANGOFF	Driller fails to position drillpipe/casing properly before activating shear ram	1	Y			1.60E-1	5.00	
HUM-ERR-IBOP-INSTALL	Human error - failure to install IBOP	1	Y			1.60E-1	5.00	
HUM-ERR-JOYSTICK	Human Error Failure to Control Vessel Using the Independent Joystick	1	Y			8.00E-2	10.00	
HUM-ERR-KICKDET	Operator fails to realize a kick has occurred or does not take timely action	1	Y			3.70E-4	7.70	
HUM-ERR-PODSEL	Operator failure to manually shift to the blue pod after yellow pod failure	1	Y			1.24E-4	5.30	
HYS-ACC-LKE	Accumulator fails leaking	3	Y	2.12E-7	9.99			ACC-LKE
HYS-FLT-PLG	HPU screen filter Fails clogged	3	Y	3.43E-7	9.51			FLT-PLG
HYS-PMP-FTR	HPU pump Fails to run	3	Y	3.37E-5	9.12			ELECPMP -FTR
HYS-SCV-FTC	HPU pressure relief valve leaks in the closed position	3	Y	1.14E-7	9.66			CHV-R-FTC
HYS-SCV-FTO	HPU check valve Fails to open	3	Y	5.30E-9	18.20			CHV-R-FTO
LOW-MUD-DEN-D-IC	Low mud density/volume leads to kick while drilling, intermediate casing ops	1	Y			6.68E-2		
LOW-MUD-DEN-D-PZ	Low mud density/volume leads to kick while drilling, reservoir ops	1	Y			6.44E-2		
LOW-MUD-DEN-D-SC	Low mud density/volume leads to kick while drilling during surface casing operations	1	Y			0.00E+0		
LOW-MUD-DEN-NABOP-IC	Low mud density causes kick with nothing across the BOP, intermediate casing ops	1	Y			9.45E-3		
LOW-MUD-DEN-NABOP-PZ	Low mud density causes kick with nothing across the BOP, reservoir ops	1	Y			7.16E-3		
LOW-MUD-DEN-NABOP-SC	Low mud density/volume leads to kick nothing in the hole, surface casing ops	1	Y			3.53E-4		
LOW-MUD-DEN-RC-IC	Low mud density/volume leads to kick while running casing, intermediate casing ops	1	Y			1.91E-2		

Name	Description	Failure Type	Unit	Lambda	Error Factor	Probability/ Frequency	Error Factor	Correlation Class
LOW-MUD-DEN-RC-PZ	Low mud density/volume leads to kick while running casing, reservoir ops	1	Y			0.00E+0		
LOW-MUD-DEN-RC-SC	Low mud density/volume leads to kick while running casing during surface casing operation	1	Y			9.71E-4		
OTHER-KICK-D-IC	Kick from undefined caused while drilling, intermediate casing op	1	Y			2.30E-2		
OTHER-KICK-D-PZ	Kick from undefined caused while drilling, reservoir ops	1	Y			2.22E-2		
OTHER-KICK-NABOP-IC	Kick from undefined caused with nothing across the BOP intermediate casing ops	1	Y			3.28E-3		
OTHER-KICK-NABOP-PZ	Kick from undefined caused with nothing across the BOP reservoir ops	1	Y			2.46E-3		
OTHER-KICK-RC-IC	Kick from undefined caused while running casing intermediate casing ops	1	Y			6.57E-3		
OTHER-KICK-RC-PZ	Kick from undefined caused while running casing reservoir ops	1	Y			0.00E+0		
RIS-PARTS	Riser parts following a failed disconnect	1	Y			5.00E-1		
RIS-PARTS-DRIVE	Riser parts following a loss of location due to drive-off	1	Y			1.00E+0		
RIS-PARTS-KICK	Ensure that riser doesn't part during a well kick	1	Y			0.00E+0		
STRM-OFST-HRA	Human Error Resulting in Incorrectly Entering the Offset into the DP System (Extreme Weather, Winter Storm, Squall)	1	Y			4.20E-5	4.90	
SURG-D-IC	Surge effect causes well kick while drilling, intermediate casing ops	1	Y			0.00E+0		
SURG-D-PZ	Surge effect causes well kick while drilling, reservoir ops	1	Y			0.00E+0		
SURG-RC-IC	Surge effect causes well kick while running casing, intermediate casing ops	1	Y			2.93E-3		
SURG-RC-PZ	Surge effect causes well kick while running casing reservoir ops	1	Y			0.00E+0		

Name	Description	Failure Type	Unit	Lambda	Error Factor	Probability/ Frequency	Error Factor	Correlation Class
SWAB-D-PZ	Swab effect causes well kick while drilling, reservoir ops	1	Y			2.48E-2		
SWABB-D-IC	Swab effect causes well kick while drilling, intermediate casing ops	1	Y			3.31E-2		
SWC-PMP-FTR	Electrically Driven Sea Water Cooling Pump Fails to Run	3		3.37E-5	9.12			ELECPMP-FTR
SWC-PMP-FTR-F-IE	Electrically Driven Sea Water Cooling Pump Fails to Run as initiator (frequency)	N	H			3.37E-5	9.12	ELECPMP-FTR
SWC-PMP-FTR-H	Electrically Driven Sea Water Cooling Pump Fails to Run (Extreme Weather)	3		3.37E-5	9.12			ELECPMP-FTR
SWC-PMP-FTS	Electrically Driven Sea Water Cooling Pump Fails to Start	1	Y			1.31E-3	1.14	ELECPMP-FTS
SWC-SCH-CLG	Sea Chest Clogged (Nominal Weather)	3	Y	6.34E-7	3.71			HULLINT-CLG
SWC-SCH-CLG-F-IE	Sea Chest Clogged (Nominal Weather) as an Initiating Event (Frequency)	N	H			6.34E-7	3.71	HULLINT-CLG
UNDER_GROUND_BO	Underground blowout after formation fractures (placeholder)	1	Y			1.00E-2		
UNEXP-OVERP-D-IC	Unexpected Overpressure zone while drilling, intermediate casing ops	1	Y			9.54E-2		
UNEXP-OVERP-D-PZ	Unexpected Overpressure zone while drilling, reservoir ops	1	Y			7.16E-2		
UNEXP-OVERP-D-SC	Unexpected Overpressure zone while drilling during surface casing operations	1	Y			1.68E-3		
UNEXP-OVERP-RC-SC	Unexpected Overpressure zone while drilling during surface casing operations	1	Y			0.00E+0		
WEA-HRA-PREP	Human Error Failure to Orient the Vessel for the Onset of Elevated Weather	1	Y			8.10E-4	3.20	
WEAK-FORM-D-IC	Weak formation / incorrect fracture pressure data lead to kick while drilling, intermediate casing ops	1	Y			1.17E-2		
WEAK-FORM-D-PZ	Weak formation / incorrect fracture pressure data lead to kick while drilling, reservoir ops	1	Y			1.10E-2		

Name	Description	Failure Type	Unit	Lambda	Error Factor	Probability/ Frequency	Error Factor	Correlation Class
WEAK-FORM-D-SC	Weak formation / incorrect fracture pressure data lead to kick while drilling during surface casing operations	1	Y			0.00E+0		
WEAK-FORM-RC-IC	Weak formation / incorrect fracture pressure data lead to kick while running casing, intermediate casing ops	1	Y			0.00E+0		
WEAK-FORM-RC-PZ	Weak formation / incorrect fracture pressure data lead to kick while running casing, reservoir ops	1	Y			0.00E+0		

PRA Template Data Worksheets

Figure F- 3 to Figure F- 41 contain the data tables used to generate the failure rates/probabilities for the hardware components included in the PRA model. All of the tables provided in this Appendix are contained in NASA's Oil and Gas Industry database (D-RAD).

Accumulator **D-RAD Rate Based Data Sheet (per hour)**

Accumulator, Pressurized, Hydraulic FMD-2013 ← Mode Source		Parameters for Lognormal(Mean, EF) and Gamma(α, β)					
Failure Mode	**Percent**	**Mean**	**Error Factor**	**α**	**β**	**SD**	**Variance**
Overall Critical Rate (ACC-LKI)	100%	2.80E-07	9.59	1.8E-01	6.4E+05	6.6E-07	4.4E-13
Leaking (ACC-LKE)	75.9%	2.12E-07	9.99	1.6E-01	7.7E+05	5.2E-07	2.7E-13
No Operation	10.3%	2.9E-08	17.1	5.4E-02	1.9E+06	1.2E-07	1.5E-14
Mechanical Failure	6.9%	1.9E-08	19.7	3.9E-02	2.0E+06	9.8E-08	9.6E-15
Breach	3.4%	9.5E-09	25.6	2.1E-02	2.2E+06	6.6E-08	4.3E-15
Out of Specification	3.4%	9.5E-09	25.6	2.1E-02	2.2E+06	6.6E-08	4.3E-15
		Records Used		7	Failures Used		3.4

Name	Field 1	Field 2	Location	Source	Data Type	A	B	Implicit Failures	Mean	EF	Variance	Data Selector	Comment
Accumulator	Overall Critical Rate	5.1	p60	OREDA-2015	2. A: Mean B: SD	**1.1E-08**	**1.6E-08**	0.5	1.1E-08	5.6	2.6E-16	1	
Accumulator	Overall Critical Rate	5.1.1	p80	OREDA-2015	2. A: Mean B: SD	6.8E-07	9.7E-07	0.5	6.8E-07	5.7	9.4E-13	1	
Accumulator	Overall Critical Rate	5.1.2	p86	OREDA-2015	2. A: Mean B: SD	4.0E-08	6.0E-08	0.4	4.0E-08	6.0	3.6E-15	1	
Accumulator	Overall Critical Rate	5.1.4	p93	OREDA-2015	2. A: Mean B: SD	7.8E-07	1.1E-06	0.5	7.8E-07	5.6	1.2E-12	1	
Accumulator	Overall Critical Rate	5.1.5	p97	OREDA-2015	2. A: Mean B: SD	**2.4E-08**	**3.4E-08**	0.5	2.4E-08	5.6	1.2E-15	1	
Accumulator	Overall Critical Rate	5.1.6	p102	OREDA-2015	2. A: Mean B: SD	2.7E-07	3.8E-07	0.5	2.7E-07	5.6	1.4E-13	1	
Accumulator	Overall Critical Rate	5.1.7	p108	OREDA-2015	2. A: Mean B: SD	1.5E-07	2.1E-07	0.5	1.5E-07	5.6	4.6E-14	1	

Figure F- 3: D-RAD Rate Based Data Sheet for Accumulators

Acoustic Control **D-RAD Rate Based Data Sheet (per hour)**

Beacon,Acoustic FMD-2016 ← Mode Source		Parameters for Lognormal(Mean, EF) and Gamma(α, β)								
Failure Mode	**Percent**	**Mean**	**Error Factor**	**α**	**β**	**SD**	**Variance**			
Overall Critical Rate	100%	1.3E-04	8.2	2.4E-01	1.9E+03	2.6E-04	6.6E-08			
Electrical Failure	50.0%	6.3E-05	9.1	2.0E-01	3.2E+03	1.4E-04	2.0E-08			
Erratic Operation	25.0%	3.1E-05	10.6	1.5E-01	4.7E+03	8.2E-05	6.7E-09			
Improper Output	25.0%	3.1E-05	10.6	1.5E-01	4.7E+03	8.2E-05	6.7E-09			
Fails Off* (DPS-HYS-FOP)	62.500%	7.83E-05	8.76	2.1E-01	2.7E+03	1.7E-04	2.9E-08	B5+B7/2	x Overall	Electrical Failure and half of Improper Output
Degraded Failure* (DPS-HYS-DEG)	37.500%	4.70E-05	9.61	1.8E-01	3.8E+03	1.1E-04	1.2E-08	B6+B7/2	x Overall	Erratic Operation and half of Improper Output
		Records Used		2	Failures Used		4.9			

Name	Field 1	Field 2	Location	Source	Data Type	A	B	Implicit Failures	Mean	EF	Variance	Data Selector	Comment
Acoustic Position Ref (HIPAP)	Overall Critical Rate	Table 5-2	Master's Thesis	KTH2010	2. A: Mean B: SD	2.5E-04	2.6E-04	0.9	2.5E-04	4.1	6.9E-08	1	
Beacon,Acoustic	Military	AC	800109-000	NPRD-2016	1. A: Failures B: Time	4.0	8613744.0	4.0	4.6E-07	2.2	5.4E-14	1	Overall
Beacon,Acoustic	Military	AC	800109-000	NPRD-2016	1. A: Failures B: Time	3.0	802056.0	3.0	3.7E-06	2.4	4.7E-12	0	Included in Overall
Beacon,Acoustic	Military	AC	800110-000	NPRD-2016	1. A: Failures B: Time	0	862278.0	0.5	5.8E-07	5.6	6.7E-13	0	Included in Overall
Beacon,Acoustic	Military	AC	800111-000	NPRD-2016	1. A: Failures B: Time	0	951456.0	0.5	5.3E-07	5.6	5.5E-13	0	Included in Overall
Beacon,Acoustic	Military	AC	800112-000	NPRD-2016	1. A: Failures B: Time	0	1037868.0	0.5	4.8E-07	5.6	4.6E-13	0	Included in Overall
Beacon,Acoustic	Military	AC	800113-000	NPRD-2016	1. A: Failures B: Time	1.0	957360.0	1.0	1.0E-06	3.9	1.1E-12	0	Included in Overall
Beacon,Acoustic	Military	AC	800114-000	NPRD-2016	1. A: Failures B: Time	0	903510.0	0.5	5.5E-07	5.6	6.1E-13	0	Included in Overall
Beacon,Acoustic	Military	AC	800115-000	NPRD-2016	1. A: Failures B: Time	0	818952.0	0.5	6.1E-07	5.6	7.5E-13	0	Included in Overall
Beacon,Acoustic	Military	AC	800116-000	NPRD-2016	1. A: Failures B: Time	0	794595.0	0.5	6.3E-07	5.6	7.9E-13	0	Included in Overall
Beacon,Acoustic	Military	AC	800117-000	NPRD-2016	1. A: Failures B: Time	0	751710.0	0.5	6.7E-07	5.6	8.8E-13	0	Included in Overall
Beacon,Acoustic	Military	AC	800118-000	NPRD-2016	1. A: Failures B: Time	0	733959.0	0.5	6.8E-07	5.6	9.3E-13	0	Included in Overall

Figure F- 4: D-RAD Rate Based Data Sheet for Acoustic Controls

Annular Preventer — **D-RAD Rate Based Data Sheet (per hour)**

← Mode Source		Parameters for Lognormal(Mean, EF) and Gamma(α, β)					
Failure Mode	Percent	Mean	Error Factor	α	β	SD	Variance
Overall Critical Rate	100%	1.1E-04	9.6	1.8E-01	1.6E+03	2.7E-04	7.2E-08
Fail to Open	12%	1.3E-05	12.1	1.1E-01	8.3E+03	4.0E-05	1.6E-09
Leakage, Hydraulic	2%	2.7E-06	19.1	4.2E-02	1.6E+04	1.3E-05	1.7E-10
Unknown/Other	5%	5.4E-06	15.3	6.9E-02	1.3E+04	2.1E-05	4.2E-10
Leakage in Closed Position	2%	2.7E-06	19.1	4.2E-02	1.6E+04	1.3E-05	1.7E-10
Internal Leakage	62%	7.0E-05	9.9	1.7E-01	2.4E+03	1.7E-04	2.9E-08
External Leakage	2%	2.7E-06	19.1	4.2E-02	1.6E+04	1.3E-05	1.7E-10
Failed to Close	2%	2.7E-06	19.1	4.2E-02	1.6E+04	1.3E-05	1.7E-10
Fail to Close* (CYL-FTC-ANN)	69%	7.80E-05	9.81	1.7E-01	2.2E+03	1.9E-04	3.6E-08
		Records Used		5	Failures Used		14.0

Name	Field 1	Field 2	ID	Source	Data Type	A	B	Implicit Failures	Mean	EF	Variance	Data Selector	Comment
Annular Preventer	Total	Table IV.2		434-A1, OGP	3. A: Mean Only	7.2E-05		0.5	7.2E-05	5.6	1.0E-08	1	Overall
Annular Preventer	Fail to Open	Table IV.2		434-A1, OGP	3. A: Mean Only	5.4E-05		0.5	5.4E-05	5.6	5.9E-09	0	Included in Overall
Annular Preventer	Leakage, Hydraulic	Table IV.2		434-A1, OGP	3. A: Mean Only	9.0E-06		0.5	9.0E-06	5.6	1.6E-10	0	Included in Overall
Annular Preventer	Unknown/Other	Table IV.2		434-A1, OGP	3. A: Mean Only	9.0E-06		0.5	9.0E-06	5.6	1.6E-10	0	Included in Overall
Annular Preventer	Total	Table IV.5		434-A1, OGP	3. A: Mean Only	3.5E-04		0.5	3.5E-04	5.6	2.5E-07	1	Overall
Annular Preventer	Fail to Open	Table IV.5		434-A1, OGP	3. A: Mean Only	2.5E-04		0.5	2.5E-04	5.6	1.2E-07	0	Included in Overall
Annular Preventer	Leakage in Closed Position	Table IV.5		434-A1, OGP	3. A: Mean Only	1.1E-04		0.5	1.1E-04	5.6	2.2E-08	0	Included in Overall
Annular Preventer	Internal Leakage	Table 1.2		STF38 A99426	1. A: Failures B: Time	12.0	96216.0	12.0	1.2E-04	1.6	1.3E-09	1	Overall
Annular Preventer	Total	Table 4.1		STF38 A99426	3. A: Mean Only	1.2E-05		0.5	1.2E-05	5.6	2.9E-10	1	Overall
Annular Preventer	Internal Leakage	Table 4.1		STF38 A99426	3. A: Mean Only	2.3E-06		0.5	2.3E-06	5.6	1.0E-11	0	Included in Overall
Annular Preventer	External Leakage	Table 4.1		STF38 A99426	3. A: Mean Only	8.7E-07		0.5	8.7E-07	5.6	1.5E-12	0	Included in Overall
Annular Preventer	Fail to Open	Table 4.1		STF38 A99426	3. A: Mean Only	4.5E-06		0.5	4.5E-06	5.6	4.0E-11	0	Included in Overall
Annular Preventer	Fail to Open	Table 4.1		STF38 A99426	3. A: Mean Only	8.7E-07		0.5	8.7E-07	5.6	1.5E-12	0	Included in Overall
Annular Preventer	Failed to Close	Table 4.1		STF38 A99426	3. A: Mean Only	8.7E-07		0.5	8.7E-07	5.6	1.5E-12	0	Included in Overall
Annular Preventer	Internal Leakage	Table 4.1		STF38 A99426	3. A: Mean Only	8.7E-07		0.5	8.7E-07	5.6	1.5E-12	0	Included in Overall
Annular Preventer	Unknown/Other	Table 4.1		STF38 A99426	3. A: Mean Only	1.7E-06		0.5	1.7E-06	5.6	6.1E-12	0	Included in Overall
Annular Preventer	Total	Table 5.3		STF38 A99426	3. A: Mean Only	3.8E-06		0.5	3.8E-06	5.6	2.9E-11	1	Overall
Annular Preventer	Fail to Open	Table 5.3		STF38 A99426	3. A: Mean Only	2.3E-06		0.5	2.3E-06	5.6	1.0E-11	0	Included in Overall
Annular Preventer	Internal Leakage	Table 5.3		STF38 A99426	3. A: Mean Only	1.5E-06		0.5	1.5E-06	5.6	4.6E-12	0	Included in Overall

Figure F- 5: D-RAD Rate Based Data Sheet for Annular Preventers

Bus, Electric — **D-RAD Rate Based Data Sheet (per hour)**

Connection, Busbar	← Mode Source FMD-97	Parameters for Lognormal(Mean, EF) and Gamma(α, β)					
Failure Mode	Percent	Mean	Error Factor	α	β	SD	Variance
Overall Critical Rate (ELS-PDP-FOF, EPS-BUS-FOP)	100%	1.62E-06	7.56	2.8E-01	1.7E+05	3.1E-06	9.3E-12
Voids	60%	9.7E-07	7.6	2.8E-01	2.8E+05	1.8E-06	3.4E-12
Electrical Overstress	20%	3.2E-07	8.0	2.5E-01	7.8E+05	6.4E-07	4.1E-13
Short	20%	3.2E-07	8.0	2.5E-01	7.8E+05	6.4E-07	4.1E-13
		Records Used	33	Failures Used	45.0		

Name	Field 1	Field 2	Location	Source	Data Type	A	B	Implicit Failures	Mean	EF	Variance	Data Selector	Comment
Buss Bar	Commercial	GF	23047-053	NPRD-2011	1. A: Failures B: Time	0	459936.0	0.5	1.1E-06	5.6	2.4E-12	1	
Buss Bar	Commercial	GF	23047-063	NPRD-2011	1. A: Failures B: Time	0	1368480.0	0.5	3.7E-07	5.6	2.7E-13	1	
Buss Bar	Commercial	GF	23047-072	NPRD-2011	1. A: Failures B: Time	4.0	25819168.0	4.0	1.5E-07	2.2	6.0E-15	1	
Relay,Bus Tie Contactor,External Power/APU	Military	AA	221001-000	NPRD-2011	1. A: Failures B: Time	0	730928.0	0.5	6.8E-07	5.6	9.4E-13	0	Aggregate
Relay,Bus Tie Contactor,External Power/APU	Military	AA	221001-000	NPRD-2011	1. A: Failures B: Time	0	160846.0	0.5	3.1E-06	5.6	1.9E-11	0	Included in Aggregate
Relay,Bus Tie Contactor,External Power/APU	Military	AA	221002-000	NPRD-2011	1. A: Failures B: Time	0	153954.0	0.5	3.2E-06	5.6	2.1E-11	0	Included in Aggregate
Relay,Bus Tie Contactor,External Power/APU	Military	AA	221003-000	NPRD-2011	1. A: Failures B: Time	0	151738.0	0.5	3.3E-06	5.6	2.2E-11	0	Included in Aggregate
Relay,Bus Tie Contactor,External Power/APU	Military	AA	221004-000	NPRD-2011	1. A: Failures B: Time	0	152930.0	0.5	3.3E-06	5.6	2.1E-11	0	Included in Aggregate
Relay,Bus Tie Contactor,External Power/APU	Military	AA	221005-000	NPRD-2011	1. A: Failures B: Time	0	111460.0	0.5	4.5E-06	5.6	4.0E-11	0	Included in Aggregate
Switchgear,Bare Bus	Commercial	GF	23047-005	NPRD-2011	1. A: Failures B: Time	0	107664.0	0.5	4.6E-06	5.6	4.3E-11	1	
Switchgear,Bare Bus	Commercial	GF	23047-016	NPRD-2011	1. A: Failures B: Time	0	107472.0	0.5	4.7E-06	5.6	4.3E-11	1	
Switchgear,Bare Bus	Commercial	GF	23047-020	NPRD-2011	1. A: Failures B: Time	0	7774848.0	0.5	6.4E-08	5.6	8.3E-15	1	
Switchgear,Bare Bus	Commercial	GF	23047-025	NPRD-2011	1. A: Failures B: Time	0	1106172.0	0.5	4.5E-07	5.6	4.1E-13	1	
Switchgear,Bare Bus	Commercial	GF	23047-027	NPRD-2011	1. A: Failures B: Time	0	203641.0	0.5	2.5E-06	5.6	1.2E-11	1	
Switchgear,Bare Bus	Commercial	GF	23047-038	NPRD-2011	1. A: Failures B: Time	15.0	5161920.0	15.0	2.9E-06	1.5	5.6E-13	1	
Switchgear,Bare Bus	Commercial	GF	23047-041	NPRD-2011	1. A: Failures B: Time	0	105840.0	0.5	4.7E-06	5.6	4.5E-11	1	
Switchgear,Bare Bus	Commercial	GF	23047-050	NPRD-2011	1. A: Failures B: Time	0	19831600.0	0.5	2.5E-08	5.6	1.3E-15	1	
Switchgear,Bare Bus	Commercial	GF	23047-051	NPRD-2011	1. A: Failures B: Time	0	520350.0	0.5	9.6E-07	5.6	1.8E-12	1	
Switchgear,Bare Bus	Commercial	GF	23047-062	NPRD-2011	1. A: Failures B: Time	0	2084616.0	0.5	2.4E-07	5.6	1.2E-13	1	
Switchgear,Bare Bus	Commercial	GF	23047-063	NPRD-2011	1. A: Failures B: Time	2.0	4105436.0	2.0	4.9E-07	2.9	1.2E-13	1	
Switchgear,Bare Bus	Commercial	GF	23047-067	NPRD-2011	1. A: Failures B: Time	0	43392.0	0.5	1.2E-05	5.6	2.7E-10	0	Out of Expected Range
Switchgear,Bare Bus	Commercial	GF	23047-069	NPRD-2011	1. A: Failures B: Time	0	639360.0	0.5	7.8E-07	5.6	1.2E-12	1	
Switchgear,Bare Bus	Commercial	GF	23047-071	NPRD-2011	1. A: Failures B: Time	1.0	256176.0	1.0	3.9E-06	3.9	1.5E-11	1	
Switchgear,Bare Bus	Commercial	GF	23047-084	NPRD-2011	1. A: Failures B: Time	2.0	2666160.0	2.0	7.5E-07	2.9	2.8E-13	1	
Switchgear,Insulated Bus	Commercial	GF	23047-014	NPRD-2011	1. A: Failures B: Time	0	699216.0	0.5	7.2E-07	5.6	1.0E-12	1	
Switchgear,Insulated Bus	Commercial	GF	23047-025	NPRD-2011	1. A: Failures B: Time	1.0	736852.0	1.0	1.4E-06	3.9	1.8E-12	1	
Switchgear,Insulated Bus	Commercial	GF	23047-028	NPRD-2011	1. A: Failures B: Time	3.0	1009600.0	3.0	3.0E-06	2.4	2.9E-12	1	
Switchgear,Insulated Bus	Commercial	GF	23047-033	NPRD-2011	1. A: Failures B: Time	1.0	1048872.0	1.0	9.5E-07	3.9	9.1E-13	1	
Switchgear,Insulated Bus	Commercial	GF	23047-038	NPRD-2011	1. A: Failures B: Time	1.0	687160.0	1.0	1.5E-06	3.9	2.1E-12	1	
Switchgear,Insulated Bus	Commercial	GF	23047-043	NPRD-2011	1. A: Failures B: Time	1.0	3348296.0	1.0	3.0E-07	3.9	8.9E-14	1	
Switchgear,Insulated Bus	Commercial	GF	23047-044	NPRD-2011	1. A: Failures B: Time	0	800016.0	0.5	6.2E-07	5.6	7.8E-13	1	
Switchgear,Insulated Bus	Commercial	GF	23047-052	NPRD-2011	1. A: Failures B: Time	0	1111392.0	0.5	4.5E-07	5.6	4.0E-13	1	
Switchgear,Insulated Bus	Commercial	GF	23047-062	NPRD-2011	1. A: Failures B: Time	0	2007408.0	0.5	2.5E-07	5.6	1.2E-13	1	
Switchgear,Insulated Bus	Commercial	GF	23047-072	NPRD-2011	1. A: Failures B: Time	0	2407664.0	0.5	2.1E-07	5.6	8.6E-14	1	
Switchgear,Insulated Bus	Commercial	GF	23047-075	NPRD-2011	1. A: Failures B: Time	0	375408.0	0.5	1.3E-06	5.6	3.5E-12	1	
Switchgear,Insulated Bus	Commercial	GF	23047-084	NPRD-2011	1. A: Failures B: Time	0	187704.0	0.5	2.7E-06	5.6	1.4E-11	1	
Switchgear,Insulated Bus	Commercial	GF	23047-095	NPRD-2011	1. A: Failures B: Time	1.0	576144.0	1.0	1.7E-06	3.9	3.0E-12	1	
Switchgear,Insulated Bus	Commercial	GF	23047-097	NPRD-2011	1. A: Failures B: Time	0	192816.0	0.5	2.6E-06	5.6	1.3E-11	1	
Switchgear,Insulated Bus	Commercial	GF	23047-099	NPRD-2011	1. A: Failures B: Time	1.0	481320.0	1.0	2.1E-06	3.9	4.3E-12	1	
Switchgear,Insulated Bus	Commercial	GF	23047-100	NPRD-2011	1. A: Failures B: Time	2.0	384960.0	2.0	5.2E-06	2.9	1.3E-11	1	

Figure F- 6: D-RAD Rate Based Data Sheet for Electric Buses

Computer — **D-RAD Rate Based Data Sheet (per hour)**

Computer,Digital	← Mode Source FMD-2016	Parameters for Lognormal(Mean, EF) and Gamma(α, β)								
Failure Mode	**Percent**	**Mean**	**Error Factor**	**α**	**β**	**SD**	**Variance**			
Overall Critical Rate	100%	9.5E-05	8.0	2.5E-01	2.7E+03	1.9E-04	3.5E-08			
Improper Output	50%	4.7E-05	8.0	2.5E-01	5.3E+03	9.4E-05	8.9E-09			
Electrical Failure	16.7%	1.6E-05	8.0	2.5E-01	1.6E+04	3.2E-05	9.9E-10			
Erratic Operation	16.7%	1.6E-05	8.0	2.5E-01	1.6E+04	3.2E-05	9.9E-10			
Intermittent	16.7%	1.6E-05	8.0	2.5E-01	1.6E+04	3.2E-05	9.9E-10			
Spurious Operation (EME-ESD-SPO)	51.7%	4.91E-05	8.00	2.5E-01	5.2E+03	9.7E-05	9.5E-09			
Degraded	83%	3.6E-05	17.3	5.2E-02	1.5E+03	1.6E-04	2.5E-08			
Fails Off* (DPS-COM-FOP, ELS-CCU-FOF)	41.700%	3.96E-05	8.00	2.5E-01	6.4E+03	7.9E-05	6.2E-09	B5/2+B6	x Overall	Half of Improper Output and Electrical failure
		Records Used		**20**	**Failures Used**		**1,138.1**			

Data Sources Name	Field 1	Field 2	Location	Source	Data Type	A	B	Implicit Failures	Mean	EF	Variance	Data Selector	Comment
Computer	Fails to trip Safety Shutoff Valve	Paragraph 8.3.1 Basic Events		BSEE 398AA	3. A: Mean Only	1.2E-04		0.5	1.2E-04	5.6	2.9E-08	1	
Processor & Equipment Cabinets (CCU)	Table C-1		IEEE Std 493-2008	2650788-RAM-1-F1	3. A: Mean Only	9.7E-05		0.5	9.7E-05	5.6	1.9E-08	1	
Control Logic Unit	All Modes		Taxonomy 4.3	OREDA-2015	2. A: Mean B: SD	2.5E-05	1.5E-05	2.6	2.5E-05	2.6	2.4E-10	1	
Control Logic Unit	Spurious Operation		Taxonomy 4.3	OREDA-2015	2. A: Mean B: SD	1.7E-05	2.4E-05	0.5	1.7E-05	5.4	5.7E-10	0	Included in Mode
CLU Control Logic Unit, F & G detection	Spurious Operation		Taxonomy 4.3.2	OREDA-2015	2. A: Mean B: SD	5.7E-05	5.7E-05	1.0	5.7E-05	3.9	3.2E-09	0	Included in Mode
CLU Control Logic Unit, F & G detection	Spurious Operation		Taxonomy 4.3.2.1	OREDA-2015	2. A: Mean B: SD	5.7E-05	5.7E-05	1.0	5.7E-05	3.9	3.2E-09	0	Included in Mode
CLU Control Logic Unit, Process Control Computer	All Modes		Taxonomy 4.3.3.1	OREDA-2015	2. A: Mean B: SD	3.1E-06	4.4E-06	0.5	3.1E-06	5.6	1.9E-11	1	
CLU Control Logic Unit, Process Shutdown	All Modes		Taxonomy 4.3.4	OREDA-2015	2. A: Mean B: SD	2.9E-05	2.9E-05	1.0	2.9E-05	3.9	8.1E-10	1	
CLU Control Logic Unit, Process Computer	All Modes		Taxonomy 4.3.4.1	OREDA-2015	2. A: Mean B: SD	2.9E-05	2.9E-05	1.0	2.9E-05	3.9	8.1E-10	1	
CLU Control Logic Unit, Process shutdown and ESD	All Modes		Taxonomy 4.3.5	OREDA-2015	2. A: Mean B: SD	5.7E-05	5.7E-05	1.0	5.7E-05	3.9	3.2E-09	1	
CLU Control Logic Unit, Process shutdown and ESD	Spurious Operation		Taxonomy 4.3.5	OREDA-2015	2. A: Mean B: SD	5.7E-05	5.7E-05	1.0	5.7E-05	3.9	3.2E-09	0	Included in Mode
CLU Control Logic Unit, Process shutdown and ESD computer	All Modes		Taxonomy 4.3.5.1	OREDA-2015	2. A: Mean B: SD	5.7E-05	5.7E-05	1.0	5.7E-05	3.9	3.2E-09	1	
CLU Control Logic Unit, Process shutdown and ESD computer	Spurious Operation		Taxonomy 4.3.5.1	OREDA-2015	2. A: Mean B: SD	5.7E-05	5.7E-05	1.0	5.7E-05	3.9	3.2E-09	0	Included in Mode
CLU Control Logic Unit Process Control	All Modes		Taxonomy 4.2.3	OREDA-2015	2. A: Mean B: SD	5.5E-06	7.8E-06	0.5	5.5E-06	5.6	6.1E-11	1	
PLC, Processor	2.3.1	Exida	3rd Ed	Vol 2	3. A: Mean Only	1.0E-05		0.5	1.0E-05	5.6	2.0E-10	0	
PLC,Processor,Hot-Standby	2.3.2	Exida	3rd Ed	Vol 2	3. A: Mean Only	1.3E-05		0.5	1.3E-05	5.6	3.1E-10	0	
PLC, SIL2 Certified, Processor	2.3.3	Exida	3rd Ed	Vol 2	3. A: Mean Only	1.0E-05		0.5	1.0E-05	5.6	2.0E-10	0	
PLC, SIL3 Certified, Processor	2.3.4	Exida	3rd Ed	Vol 2	3. A: Mean Only	1.0E-05		0.5	1.0E-05	5.6	2.0E-10	0	
PLC, Industrial, Processor	2.3.5	Exida	3rd Ed	Vol 2	3. A: Mean Only	1.6E-06		0.5	1.6E-06	5.6	5.3E-12	0	
Control Computer Console, Dual	Overall Critical Rate	Table 5-2	Master's Thesis	KTH2010	3. A: Mean Only	1.1E-05		0.5	1.1E-05	5.6	2.4E-10	1	
Computer Processor	Military	AA	221001-000	NPRD-2011	1. A: Failures B: Time	0	365464.0	0.5	1.4E-06	5.6	3.7E-12	1	Overall
Computer Processor	Military	AA	221001-000	NPRD-2011	1. A: Failures B: Time	0	80423.0	0.5	6.2E-06	5.6	7.7E-11	0	Included in Overall
Computer Processor	Military	AA	221002-000	NPRD-2011	1. A: Failures B: Time	0	76977.0	0.5	6.5E-06	5.6	8.4E-11	0	Included in Overall
Computer Processor	Military	AA	221003-000	NPRD-2011	1. A: Failures B: Time	0	75869.0	0.5	6.6E-06	5.6	8.7E-11	0	Included in Overall
Computer Processor	Military	AA	221004-000	NPRD-2011	1. A: Failures B: Time	0	76465.0	0.5	6.5E-06	5.6	8.6E-11	0	Included in Overall
Computer Processor	Military	AA	221005-000	NPRD-2011	1. A: Failures B: Time	0	55730.0	0.5	9.0E-06	5.6	1.6E-10	0	Included in Overall
Computer Subassembly	Military	AUA	221001-000	NPRD-2011	1. A: Failures B: Time	17.0	365464.0	17.0	4.7E-05	1.5	1.3E-10	1	Overall
Computer Subassembly	Military	AUA	221001-000	NPRD-2011	1. A: Failures B: Time	4.0	80423.0	4.0	5.0E-05	2.2	6.2E-10	0	Included in Overall
Computer Subassembly	Military	AUA	221002-000	NPRD-2011	1. A: Failures B: Time	1.0	76977.0	1.0	1.3E-05	3.9	1.7E-10	0	Included in Overall
Computer Subassembly	Military	AUA	221003-000	NPRD-2011	1. A: Failures B: Time	10.0	75869.0	10.0	1.3E-04	1.7	1.7E-09	0	Included in Overall
Computer Subassembly	Military	AUA	221004-000	NPRD-2011	1. A: Failures B: Time	1.0	76465.0	1.0	1.3E-05	3.9	1.7E-10	0	Included in Overall
Computer Subassembly	Military	AUA	221005-000	NPRD-2011	1. A: Failures B: Time	1.0	55730.0	1.0	1.8E-05	3.9	3.2E-10	0	Included in Overall
Computer Subassembly	Military	N	221015-000	NPRD-2011	1. A: Failures B: Time	0	192618.0	0.5	2.6E-06	5.6	1.3E-11	1	Overall
Computer Subassembly	Military	N	221015-000	NPRD-2011	1. A: Failures B: Time	0	40278.0	0.5	1.2E-05	5.6	3.1E-10	0	Included in Overall
Computer Subassembly	Military	N	221016-000	NPRD-2011	1. A: Failures B: Time	0	28560.0	0.5	1.8E-05	5.6	6.1E-10	0	Included in Overall
Computer Subassembly	Military	N	221017-000	NPRD-2011	1. A: Failures B: Time	0	23688.0	0.5	2.1E-05	5.6	8.9E-10	0	Included in Overall
Computer Subassembly	Military	N	221018-000	NPRD-2011	1. A: Failures B: Time	0	33768.0	0.5	1.5E-05	5.6	4.4E-10	0	Included in Overall
Computer Subassembly	Military	N	221019-000	NPRD-2011	1. A: Failures B: Time	0	20328.0	0.5	2.5E-05	5.6	1.2E-09	0	Included in Overall
Computer Subassembly	Military	N	221020-000	NPRD-2011	1. A: Failures B: Time	0	3192.0	0.5	1.6E-04	5.6	4.9E-08	0	Included in Overall
Computer System,Digital	Military	N	221015-000	NPRD-2011	1. A: Failures B: Time	0	42804.0	0.5	1.2E-05	5.6	2.7E-10	1	Overall
Computer System,Digital	Military	N	221015-000	NPRD-2011	1. A: Failures B: Time	0	11508.0	0.5	4.3E-05	5.6	3.8E-09	0	Included in Overall
Computer System,Digital	Military	N	221016-000	NPRD-2011	1. A: Failures B: Time	0	8160.0	0.5	6.1E-05	5.6	7.5E-09	0	Included in Overall
Computer System,Digital	Military	N	221017-000	NPRD-2011	1. A: Failures B: Time	0	6768.0	0.5	7.4E-05	5.6	1.1E-08	0	Included in Overall
Computer System,Digital	Military	N	221018-000	NPRD-2011	1. A: Failures B: Time	0	9648.0	0.5	5.2E-05	5.6	5.4E-09	0	Included in Overall
Computer System,Digital	Military	N	221019-000	NPRD-2011	1. A: Failures B: Time	0	5808.0	0.5	8.6E-05	5.6	1.5E-08	0	Included in Overall
Computer System,Digital	Military	N	221020-000	NPRD-2011	1. A: Failures B: Time	0	912.0	0.5	5.5E-04	5.6	6.0E-07	0	Included in Overall

Figure F- 7: D-RAD Rate Based Data Sheet for Computers

Computer,Air Data	Military	AA	221001-000	NPRD-2011	1. A: Failures B: Time	0	1461856.0	0.5	3.4E-07	5.6	2.3E-13	1	Overall
Computer,Air Data	Military	AA	221001-000	NPRD-2011	1. A: Failures B: Time	0	321692.0	0.5	1.6E-06	5.6	4.8E-12	0	Included in Overall
Computer,Air Data	Military	AA	221002-000	NPRD-2011	1. A: Failures B: Time	0	307908.0	0.5	1.6E-06	5.6	5.3E-12	0	Included in Overall
Computer,Air Data	Military	AA	221003-000	NPRD-2011	1. A: Failures B: Time	0	303476.0	0.5	1.6E-06	5.6	5.4E-12	0	Included in Overall
Computer,Air Data	Military	AA	221004-000	NPRD-2011	1. A: Failures B: Time	0	305860.0	0.5	1.6E-06	5.6	5.3E-12	0	Included in Overall
Computer,Air Data	Military	AA	221005-000	NPRD-2011	1. A: Failures B: Time	0	222920.0	0.5	2.2E-06	5.6	1.0E-11	0	Included in Overall
Computer,Air Data	Military	AUA	221001-000	NPRD-2011	1. A: Failures B: Time	314.0	730928.0	314.0	4.3E-04	1.1	5.9E-10	1	Overall
Computer,Air Data	Military	AUA	221001-000	NPRD-2011	1. A: Failures B: Time	162.0	160846.0	162.0	1.0E-03	1.1	6.3E-09	0	Included in Overall
Computer,Air Data	Military	AUA	221002-000	NPRD-2011	1. A: Failures B: Time	102.0	153954.0	102.0	6.6E-04	1.2	4.3E-09	0	Included in Overall
Computer,Air Data	Military	AUA	221003-000	NPRD-2011	1. A: Failures B: Time	21.0	151738.0	21.0	1.4E-04	1.4	9.1E-10	0	Included in Overall
Computer,Air Data	Military	AUA	221004-000	NPRD-2011	1. A: Failures B: Time	17.0	152930.0	17.0	1.1E-04	1.5	7.3E-10	0	Included in Overall
Computer,Air Data	Military	AUA	221005-000	NPRD-2011	1. A: Failures B: Time	12.0	111460.0	12.0	1.1E-04	1.6	9.7E-10	0	Included in Overall
Computer,Digital	Military	N	221015-000	NPRD-2011	1. A: Failures B: Time	0	64206.0	0.5	7.8E-06	5.6	1.2E-10	1	Overall
Computer,Digital	Military	N	221015-000	NPRD-2011	1. A: Failures B: Time	0	17262.0	0.5	2.9E-05	5.6	1.7E-09	0	Included in Overall
Computer,Digital	Military	N	221016-000	NPRD-2011	1. A: Failures B: Time	0	12240.0	0.5	4.1E-05	5.6	3.3E-09	0	Included in Overall
Computer,Digital	Military	N	221017-000	NPRD-2011	1. A: Failures B: Time	0	10152.0	0.5	4.9E-05	5.6	4.9E-09	0	Included in Overall
Computer,Digital	Military	N	221018-000	NPRD-2011	1. A: Failures B: Time	0	14472.0	0.5	3.5E-05	5.6	2.4E-09	0	Included in Overall
Computer,Digital	Military	N	221019-000	NPRD-2011	1. A: Failures B: Time	0	8712.0	0.5	5.7E-05	5.6	6.6E-09	0	Included in Overall
Computer,Digital	Military	N	221020-000	NPRD-2011	1. A: Failures B: Time	0	1368.0	0.5	3.7E-04	5.6	2.7E-07	0	Included in Overall
Computer,Engine	Military	AUA	221001-000	NPRD-2011	1. A: Failures B: Time	526.0	730928.0	526.0	7.2E-04	1.1	9.8E-10	1	Overall
Computer,Engine	Military	AUA	221001-000	NPRD-2011	1. A: Failures B: Time	198.0	160846.0	198.0	1.2E-03	1.1	7.7E-09	0	Included in Overall
Computer,Engine	Military	AUA	221002-000	NPRD-2011	1. A: Failures B: Time	114.0	153954.0	114.0	7.4E-04	1.2	4.8E-09	0	Included in Overall
Computer,Engine	Military	AUA	221003-000	NPRD-2011	1. A: Failures B: Time	95.0	151738.0	95.0	6.3E-04	1.2	4.1E-09	0	Included in Overall
Computer,Engine	Military	AUA	221004-000	NPRD-2011	1. A: Failures B: Time	79.0	152930.0	79.0	5.2E-04	1.2	3.4E-09	0	Included in Overall
Computer,Engine	Military	AUA	221005-000	NPRD-2011	1. A: Failures B: Time	40.0	111460.0	40.0	3.6E-04	1.3	3.2E-09	0	Included in Overall
Computer,Fire Control	Military	AUA	221001-000	NPRD-2011	1. A: Failures B: Time	269.0	1096392.0	269.0	2.5E-04	1.1	2.2E-10	1	Overall
Computer,Fire Control	Military	AUA	221001-000	NPRD-2011	1. A: Failures B: Time	150.0	241269.0	150.0	6.2E-04	1.1	2.6E-09	0	Included in Overall
Computer,Fire Control	Military	AUA	221002-000	NPRD-2011	1. A: Failures B: Time	39.0	230931.0	39.0	1.7E-04	1.3	7.3E-10	0	Included in Overall
Computer,Fire Control	Military	AUA	221003-000	NPRD-2011	1. A: Failures B: Time	30.0	227607.0	30.0	1.3E-04	1.3	5.8E-10	0	Included in Overall
Computer,Fire Control	Military	AUA	221004-000	NPRD-2011	1. A: Failures B: Time	34.0	229395.0	34.0	1.5E-04	1.3	6.5E-10	0	Included in Overall
Computer,Fire Control	Military	AUA	221005-000	NPRD-2011	1. A: Failures B: Time	16.0	167190.0	16.0	9.6E-05	1.5	5.7E-10	0	Included in Overall
Computer,Integrated Flight And Fire Control	Military	AA	221001-000	NPRD-2011	1. A: Failures B: Time	0	730928.0	0.5	6.8E-07	5.6	9.4E-13	1	Overall
Computer,Integrated Flight And Fire Control	Military	AA	221001-000	NPRD-2011	1. A: Failures B: Time	0	160846.0	0.5	3.1E-06	5.6	1.9E-11	0	Included in Overall
Computer,Integrated Flight And Fire Control	Military	AA	221002-000	NPRD-2011	1. A: Failures B: Time	0	153954.0	0.5	3.2E-06	5.6	2.1E-11	0	Included in Overall
Computer,Integrated Flight And Fire Control	Military	AA	221003-000	NPRD-2011	1. A: Failures B: Time	0	151738.0	0.5	3.3E-06	5.6	2.2E-11	0	Included in Overall
Computer,Integrated Flight And Fire Control	Military	AA	221004-000	NPRD-2011	1. A: Failures B: Time	0	152930.0	0.5	3.3E-06	5.6	2.1E-11	0	Included in Overall
Computer,Integrated Flight And Fire Control	Military	AA	221005-000	NPRD-2011	1. A: Failures B: Time	0	111460.0	0.5	4.5E-06	5.6	4.0E-11	0	Included in Overall
Processor,Central,Computer	Military	ARW	221006-000	NPRD-2011	1. A: Failures B: Time	0	79401.0	0.5	6.3E-06	5.6	7.9E-11	0	Environment
Processor,Central,Computer	Military	ARW	221007-000	NPRD-2011	1. A: Failures B: Time	0	80658.0	0.5	6.2E-06	5.6	7.7E-11	0	Environment
Processor,Central,Computer	Military	ARW	221008-000	NPRD-2011	1. A: Failures B: Time	0	80709.0	0.5	6.2E-06	5.6	7.7E-11	0	Environment
Processor,Central,Computer	Military	ARW	221009-000	NPRD-2011	1. A: Failures B: Time	0	76500.0	0.5	6.5E-06	5.6	8.5E-11	0	Environment
Processor,Central,Computer	Military	ARW	221010-000	NPRD-2011	1. A: Failures B: Time	0	81258.0	0.5	6.2E-06	5.6	7.6E-11	0	Environment
Processor,Central,Computer	Military	ARW	221011-000	NPRD-2011	1. A: Failures B: Time	0	84441.0	0.5	5.9E-06	5.6	7.0E-11	0	Environment
Processor,Central,Computer	Military	ARW	221012-000	NPRD-2011	1. A: Failures B: Time	0	79428.0	0.5	6.3E-06	5.6	7.9E-11	0	Environment
Processor,Central,Computer	Military	ARW	221013-000	NPRD-2011	1. A: Failures B: Time	0	73707.0	0.5	6.8E-06	5.6	9.2E-11	0	Environment
Processor,Central,Computer	Military	ARW	221014-000	NPRD-2011	1. A: Failures B: Time	0	63267.0	0.5	7.9E-06	5.6	1.2E-10	0	Environment
Processor,Computer	Military	ARW	221006-000	NPRD-2011	1. A: Failures B: Time	0	423472.0	0.5	1.2E-06	5.6	2.8E-12	0	Environment
Processor,Computer	Military	ARW	221007-000	NPRD-2011	1. A: Failures B: Time	0	430176.0	0.5	1.2E-06	5.6	2.7E-12	0	Environment
Processor,Computer	Military	ARW	221008-000	NPRD-2011	1. A: Failures B: Time	0	430448.0	0.5	1.2E-06	5.6	2.7E-12	0	Environment
Processor,Computer	Military	ARW	221009-000	NPRD-2011	1. A: Failures B: Time	0	408000.0	0.5	1.2E-06	5.6	3.0E-12	0	Environment
Processor,Computer	Military	ARW	221010-000	NPRD-2011	1. A: Failures B: Time	0	433376.0	0.5	1.2E-06	5.6	2.7E-12	0	Environment
Processor,Computer	Military	ARW	221011-000	NPRD-2011	1. A: Failures B: Time	0	450352.0	0.5	1.1E-06	5.6	2.5E-12	0	Environment
Processor,Computer	Military	ARW	221012-000	NPRD-2011	1. A: Failures B: Time	0	423616.0	0.5	1.2E-06	5.6	2.8E-12	0	Environment
Processor,Computer	Military	ARW	221013-000	NPRD-2011	1. A: Failures B: Time	0	393104.0	0.5	1.3E-06	5.6	3.2E-12	0	Environment
Processor,Computer	Military	ARW	221014-000	NPRD-2011	1. A: Failures B: Time	0	337424.0	0.5	1.5E-06	5.6	4.4E-12	0	Environment

Figure F- 8: D-RAD Rate Based Data Sheet for Computers (Cont.)

Control Panel **D-RAD Rate Based Data Sheet (per hour)**

Control Panel	← Mode Source FMD-2016	Parameters for Lognormal(Mean, EF) and Gamma(α, β)						
Failure Mode	**Percent**	**Mean**	**Error Factor**	**α**	**β**	**SD**	**Variance**	
Overall Critical Rate	100%	2.2E-05	15.1	7.0E-02	3.2E+03	8.2E-05	6.8E-09	
Failed To Operate	57.1%	1.3E-05	15.3	6.8E-02	5.4E+03	4.8E-05	2.3E-09	
Improper Output	42.9%	9.4E-06	15.5	6.6E-02	7.0E+03	3.7E-05	1.3E-09	
Fails to Operate* (ELS-CTL-FOF)	78.6%	1.72E-05	15.17	7.0E-02	4.0E+03	6.5E-05	4.3E-09	Fails To Operate and half of Improper Output
		Records Used	23		**Failures Used**	21.0		

Name	Field 1	Field 2	Location	Source	Data Type	A	B	Implicit Failures	Mean	EF	Variance	Data Selector	Comment
Panel. Driller	BSEE Data	Table C-1	BSEE MIT	2650788-RAM-1-F1	3. A: Mean Only	8.9E-06		0.5	8.9E-06	5.6	1.6E-10	1	
Control Panel	BSEE Data	Table C-1	BSEE MIT	2650788-RAM-1-F1	3. A: Mean Only	1.0E-05		0.5	1.0E-05	5.6	2.1E-10	1	
Central Control Console	BSEE Data	Table C-1	BSEE MIT	2650788-RAM-1-F1	3. A: Mean Only	9.7E-05		0.5	9.7E-05	5.6	1.9E-08	1	
Panel, Bypass	Taxonomy 5.1, Control System	5.1.0.7.10	p63	OREDA-2015	3. A: Mean Only	2.7E-06		0.5	2.7E-06	5.6	1.5E-11	1	
Panel, Bypass	Taxonomy 5.2, Control System	5.1.2	p88	OREDA-2015	3. A: Mean Only	6.3E-06		0.5	6.3E-06	5.6	7.8E-11	1	
Panel, Bypass	Taxonomy 5.6, Control System	5.1.6	p104	OREDA-2015	3. A: Mean Only	4.9E-06		0.5	4.9E-06	5.6	4.7E-11	1	
Controller, Panelboard	Controller, Electronic Panelboard	2.2.1.1		PERD	3. A: Mean Only	2.1E-04		0.5	2.1E-04	5.6	8.4E-08	1	
Controller, Panelboard	Controller, Pneumatic Panelboard	2.2.1.2		PERD	3. A: Mean Only	4.3E-05		0.5	4.3E-05	5.6	3.8E-09	1	
Master Control Panel	Station 1		p57	OREDA-2015	3. A: Mean Only	1.2E-05		0.5	1.2E-05	5.6	2.7E-10	1	
Control Panel	221001-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	6.0	730928.0	6.0	8.2E-06	1.9	1.1E-11	0	Environment
Control Panel	221001-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	3.0	365464.0	3.0	8.2E-06	2.4	2.2E-11	0	Included in Overall
Control Panel	221001-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	0	80423.0	0.5	6.2E-06	5.6	7.7E-11	0	Included in Overall
Control Panel	221002-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	2.0	76977.0	2.0	2.6E-05	2.9	3.4E-10	0	Included in Overall
Control Panel	221003-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	0	75869.0	0.5	6.6E-06	5.6	8.7E-11	0	Included in Overall
Control Panel	221004-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	0	76465.0	0.5	6.5E-06	5.6	8.6E-11	0	Included in Overall
Control Panel	221005-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	1.0	55730.0	1.0	1.8E-05	3.9	3.2E-10	0	Included in Overall
Control Panel	221021-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	71472.0	0.5	7.0E-06	5.6	9.8E-11	1	Overall
Control Panel	221021-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	3672.0	0.5	1.4E-04	5.6	3.7E-08	0	Included in Overall
Control Panel	221022-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	11064.0	0.5	4.5E-05	5.6	4.1E-09	0	Included in Overall
Control Panel	221023-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	8736.0	0.5	5.7E-05	5.6	6.6E-09	0	Included in Overall
Control Panel	221024-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	5832.0	0.5	8.6E-05	5.6	1.5E-08	0	Included in Overall
Control Panel	221025-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	7776.0	0.5	6.4E-05	5.6	8.3E-09	0	Included in Overall
Control Panel	221026-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	5112.0	0.5	9.8E-05	5.6	1.9E-08	0	Included in Overall
Control Panel	221027-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	4224.0	0.5	1.2E-04	5.6	2.8E-08	0	Included in Overall
Control Panel	221028-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	8304.0	0.5	6.0E-05	5.6	7.3E-09	0	Included in Overall
Control Panel	221029-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	3600.0	0.5	1.4E-04	5.6	3.9E-08	0	Included in Overall
Control Panel	221030-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	8016.0	0.5	6.2E-05	5.6	7.8E-09	0	Included in Overall
Control Panel	221031-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	5136.0	0.5	9.7E-05	5.6	1.9E-08	0	Included in Overall
Control Panel Assembly	221015-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	92874.0	0.5	5.4E-06	5.6	5.8E-11	1	Overall
Control Panel Assembly	221015-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	5754.0	0.5	8.7E-05	5.6	1.5E-08	0	Included in Overall
Control Panel Assembly	221016-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	4080.0	0.5	1.2E-04	5.6	3.0E-08	0	Included in Overall
Control Panel Assembly	221017-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	3384.0	0.5	1.5E-04	5.6	4.4E-08	0	Included in Overall
Control Panel Assembly	221018-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	4824.0	0.5	1.0E-04	5.6	2.1E-08	0	Included in Overall
Control Panel Assembly	221019-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	2904.0	0.5	1.7E-04	5.6	5.9E-08	0	Included in Overall
Control Panel Assembly	221020-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	456.0	0.5	1.1E-03	5.6	2.4E-06	0	Included in Overall
Control Panel Assembly	221021-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	3672.0	0.5	1.4E-04	5.6	3.7E-08	0	Included in Overall
Control Panel Assembly	221022-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	11064.0	0.5	4.5E-05	5.6	4.1E-09	0	Included in Overall
Control Panel Assembly	221023-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	8736.0	0.5	5.7E-05	5.6	6.6E-09	0	Included in Overall
Control Panel Assembly	221024-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	5832.0	0.5	8.6E-05	5.6	1.5E-08	0	Included in Overall
Control Panel Assembly	221025-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	7776.0	0.5	6.4E-05	5.6	8.3E-09	0	Included in Overall
Control Panel Assembly	221026-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	5112.0	0.5	9.8E-05	5.6	1.9E-08	0	Included in Overall
Control Panel Assembly	221027-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	4224.0	0.5	1.2E-04	5.6	2.8E-08	0	Included in Overall
Control Panel Assembly	221028-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	8304.0	0.5	6.0E-05	5.6	7.3E-09	0	Included in Overall
Control Panel Assembly	221029-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	3600.0	0.5	1.4E-04	5.6	3.9E-08	0	Included in Overall
Control Panel Assembly	221030-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	8016.0	0.5	6.2E-05	5.6	7.8E-09	0	Included in Overall
Control Panel Assembly	221031-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	5136.0	0.5	9.7E-05	5.6	1.9E-08	0	Included in Overall

Figure F- 8: D-RAD Rate Based Data Sheet for Control Panels

Control Panel,Generator	23047-016	Commercial	GF	NPRD-2011	1. A: Failures B: Time	0	53880.0	0.5	9.3E-06	5.6	1.7E-10	1	
Control Panel,Generator	23047-030	Commercial	GF	NPRD-2011	1. A: Failures B: Time	0	311214.0	0.5	1.6E-06	5.6	5.2E-12	1	
Control Panel,Generator	23047-062	Commercial	GF	NPRD-2011	1. A: Failures B: Time	0	77076.0	0.5	6.5E-06	5.6	8.4E-11	1	
Control Panel,Generator	23047-063	Commercial	GF	NPRD-2011	1. A: Failures B: Time	10.0	821022.0	10.0	1.2E-05	1.7	1.5E-11	1	
Control Panel,Generator	23047-065	Commercial	GF	NPRD-2011	1. A: Failures B: Time	0	62520.0	0.5	8.0E-06	5.6	1.3E-10	1	
Control Panel,Generator	23047-069	Commercial	GF	NPRD-2011	1. A: Failures B: Time	0	215796.0	0.5	2.3E-06	5.6	1.1E-11	1	
Control Panel,Generator	23047-071	Commercial	GF	NPRD-2011	1. A: Failures B: Time	0	20332560.0	0.5	2.5E-08	5.6	1.2E-15	1	
Control Panel,Generator	23047-072	Commercial	GF	NPRD-2011	1. A: Failures B: Time	0	344256.0	0.5	1.5E-06	5.6	4.2E-12	1	
Electrical/Electronic Equipment Control Panel	221001-000	Military	AA	NPRD-2011	1. A: Failures B: Time	0	1461856.0	0.5	3.4E-07	5.6	2.3E-13	0	Environment
Electrical/Electronic Equipment Control Panel	221001-000	Military	AA	NPRD-2011	1. A: Failures B: Time	0	321692.0	0.5	1.6E-06	5.6	4.8E-12	0	Included in Overall
Electrical/Electronic Equipment Control Panel	221002-000	Military	AA	NPRD-2011	1. A: Failures B: Time	0	307908.0	0.5	1.6E-06	5.6	5.3E-12	0	Included in Overall
Electrical/Electronic Equipment Control Panel	221003-000	Military	AA	NPRD-2011	1. A: Failures B: Time	0	303476.0	0.5	1.6E-06	5.6	5.4E-12	0	Included in Overall
Electrical/Electronic Equipment Control Panel	221004-000	Military	AA	NPRD-2011	1. A: Failures B: Time	0	305860.0	0.5	1.6E-06	5.6	5.3E-12	0	Included in Overall
Electrical/Electronic Equipment Control Panel	221005-000	Military	AA	NPRD-2011	1. A: Failures B: Time	0	222920.0	0.5	2.2E-06	5.6	1.0E-11	0	Included in Overall
Panel	221001-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	13.0	730928.0	13.0	1.8E-05	1.6	2.4E-11	0	Environment
Panel	221001-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	0	160846.0	0.5	3.1E-06	5.6	1.9E-11	0	Included in Overall
Panel	221002-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	0	153954.0	0.5	3.2E-06	5.6	2.1E-11	0	Included in Overall
Panel	221003-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	8.0	151738.0	8.0	5.3E-05	1.8	3.5E-10	0	Included in Overall
Panel	221004-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	5.0	152930.0	5.0	3.3E-05	2.0	2.1E-10	0	Included in Overall
Panel	221005-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	0	111460.0	0.5	4.5E-06	5.6	4.0E-11	0	Included in Overall
Panel Assembly	221001-000	Military	AA	NPRD-2011	1. A: Failures B: Time	0	365464.0	0.5	1.4E-06	5.6	3.7E-12	0	Environment
Panel Assembly	221001-000	Military	AA	NPRD-2011	1. A: Failures B: Time	0	80423.0	0.5	6.2E-06	5.6	7.7E-11	0	Included in Overall
Panel Assembly	221002-000	Military	AA	NPRD-2011	1. A: Failures B: Time	0	76977.0	0.5	6.5E-06	5.6	8.4E-11	0	Included in Overall
Panel Assembly	221003-000	Military	AA	NPRD-2011	1. A: Failures B: Time	0	75869.0	0.5	6.6E-06	5.6	8.7E-11	0	Included in Overall
Panel Assembly	221004-000	Military	AA	NPRD-2011	1. A: Failures B: Time	0	76465.0	0.5	6.5E-06	5.6	8.6E-11	0	Included in Overall
Panel Assembly	221005-000	Military	AA	NPRD-2011	1. A: Failures B: Time	0	55730.0	0.5	9.0E-06	5.6	1.6E-10	0	Included in Overall
Panel Assembly	221001-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	218.0	8771136.0	218.0	2.5E-05	1.1	2.8E-12	0	Environment
Panel Assembly	221001-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	72.0	1930152.0	72.0	3.7E-05	1.2	1.9E-11	0	Included in Overall
Panel Assembly	221002-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	106.0	1847448.0	106.0	5.7E-05	1.2	3.1E-11	0	Included in Overall
Panel Assembly	221003-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	14.0	1820856.0	14.0	7.7E-06	1.5	4.2E-12	0	Included in Overall
Panel Assembly	221004-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	14.0	1835160.0	14.0	7.6E-06	1.5	4.2E-12	0	Included in Overall
Panel Assembly	221005-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	12.0	1337520.0	12.0	9.0E-06	1.6	6.7E-12	0	Included in Overall
Panel Assembly,Circuit	221001-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	4.0	365464.0	4.0	1.1E-05	2.2	3.0E-11	0	Environment
Panel Assembly,Circuit	221001-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	1.0	80423.0	1.0	1.2E-05	3.9	1.5E-10	0	Included in Overall
Panel Assembly,Circuit	221002-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	1.0	76977.0	1.0	1.3E-05	3.9	1.7E-10	0	Included in Overall
Panel Assembly,Circuit	221003-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	1.0	75869.0	1.0	1.3E-05	3.9	1.7E-10	0	Included in Overall
Panel Assembly,Circuit	221004-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	1.0	76465.0	1.0	1.3E-05	3.9	1.7E-10	0	Included in Overall
Panel Assembly,Circuit	221005-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	0	55730.0	0.5	9.0E-06	5.6	1.6E-10	0	Included in Overall
Panel,Control	221001-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	34.0	365464.0	34.0	9.3E-05	1.3	2.5E-10	0	Environment
Panel,Control	221001-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	7.0	80423.0	7.0	8.7E-05	1.8	1.1E-09	0	Included in Overall
Panel,Control	221002-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	9.0	76977.0	9.0	1.2E-04	1.7	1.5E-09	0	Included in Overall
Panel,Control	221003-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	9.0	75869.0	9.0	1.2E-04	1.7	1.6E-09	0	Included in Overall
Panel,Control	221004-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	5.0	76465.0	5.0	6.5E-05	2.0	8.6E-10	0	Included in Overall
Panel,Control	221005-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	4.0	55730.0	4.0	7.2E-05	2.2	1.3E-09	0	Included in Overall
Panel,Control,Electrical	221001-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	8.0	795134.0	8.0	1.0E-05	1.8	1.3E-11	0	Environment
Panel,Control,Electrical	221001-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	0	160846.0	0.5	3.1E-06	5.6	1.9E-11	0	Included in Overall
Panel,Control,Electrical	221002-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	1.0	153954.0	1.0	6.5E-06	3.9	4.2E-11	0	Included in Overall
Panel,Control,Electrical	221003-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	2.0	151738.0	2.0	1.3E-05	2.9	8.7E-11	0	Included in Overall
Panel,Control,Electrical	221004-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	5.0	152930.0	5.0	3.3E-05	2.0	2.1E-10	0	Included in Overall
Panel,Control,Electrical	221005-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	0	111460.0	0.5	4.5E-06	5.6	4.0E-11	0	Included in Overall

Figure F- 9: D-RAD Rate Based Data Sheet for Control Panels (Cont.)

Panel,Control,Electrical	221015-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	17262.0	0.5	2.9E-05	5.6	1.7E-09	1	Overall
Panel,Control,Electrical	221016-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	12240.0	0.5	4.1E-05	5.6	3.3E-09	0	Included in Overall
Panel,Control,Electrical	221017-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	10152.0	0.5	4.9E-05	5.6	4.9E-09	0	Included in Overall
Panel,Control,Electrical	221018-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	14472.0	0.5	3.5E-05	5.6	2.4E-09	0	Included in Overall
Panel,Control,Electrical	221019-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	8712.0	0.5	5.7E-05	5.6	6.6E-09	0	Included in Overall
Panel,Control,Electrical	221020-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	1368.0	0.5	3.7E-04	5.6	2.7E-07	0	Included in Overall
Panel,Control,Electrical-Electronic	221001-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	6.0	365464.0	6.0	1.6E-05	1.9	4.5E-11	0	Environment
Panel,Control,Electrical-Electronic	221001-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	6.0	80423.0	6.0	7.5E-05	1.9	9.3E-10	0	Included in Overall
Panel,Control,Electrical-Electronic	221002-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	0	76977.0	0.5	6.5E-06	5.6	8.4E-11	0	Included in Overall
Panel,Control,Electrical-Electronic	221003-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	0	75869.0	0.5	6.6E-06	5.6	8.7E-11	0	Included in Overall
Panel,Control,Electrical-Electronic	221004-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	0	76465.0	0.5	6.5E-06	5.6	8.6E-11	0	Included in Overall
Panel,Control,Electrical-Electronic	221005-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	0	55730.0	0.5	9.0E-06	5.6	1.6E-10	0	Included in Overall
Panel,Control,Electrical-Electronic	221001-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	6.0	365464.0	6.0	1.6E-05	1.9	4.5E-11	0	Environment
Panel,Control,Electrical-Electronic	221001-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	6.0	80423.0	6.0	7.5E-05	1.9	9.3E-10	0	Included in Overall
Panel,Control,Electrical-Electronic	221002-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	0	76977.0	0.5	6.5E-06	5.6	8.4E-11	0	Included in Overall
Panel,Control,Electrical-Electronic	221003-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	0	75869.0	0.5	6.6E-06	5.6	8.7E-11	0	Included in Overall
Panel,Control,Electrical-Electronic	221004-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	0	76465.0	0.5	6.5E-06	5.6	8.6E-11	0	Included in Overall
Panel,Control,Electrical-Electronic	221005-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	0	55730.0	0.5	9.0E-06	5.6	1.6E-10	0	Included in Overall
Panel,Control,Electrical-Electronic Equipment	221001-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	613.0	4020104.0	613.0	1.5E-04	1.1	3.8E-11	0	Environment
Panel,Control,Electrical-Electronic Equipment	221001-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	174.0	884653.0	174.0	2.0E-04	1.1	2.2E-10	0	Included in Overall
Panel,Control,Electrical-Electronic Equipment	221002-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	132.0	846747.0	132.0	1.6E-04	1.2	1.8E-10	0	Included in Overall
Panel,Control,Electrical-Electronic Equipment	221003-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	115.0	834559.0	115.0	1.4E-04	1.2	1.7E-10	0	Included in Overall
Panel,Control,Electrical-Electronic Equipment	221004-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	105.0	841115.0	105.0	1.2E-04	1.2	1.5E-10	0	Included in Overall
Panel,Control,Electrical-Electronic Equipment	221005-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	87.0	613030.0	87.0	1.4E-04	1.2	2.3E-10	0	Included in Overall
Panel,Control,Electrical-Electronic Equipment	221015-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	42804.0	0.5	1.2E-05	5.6	2.7E-10	1	Overall
Panel,Control,Electrical-Electronic Equipment	221015-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	11508.0	0.5	4.3E-05	5.6	3.8E-09	0	Included in Overall
Panel,Control,Electrical-Electronic Equipment	221016-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	8160.0	0.5	6.1E-05	5.6	7.5E-09	0	Included in Overall
Panel,Control,Electrical-Electronic Equipment	221017-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	6768.0	0.5	7.4E-05	5.6	1.1E-08	0	Included in Overall
Panel,Control,Electrical-Electronic Equipment	221018-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	9648.0	0.5	5.2E-05	5.6	5.4E-09	0	Included in Overall
Panel,Control,Electrical-Electronic Equipment	221019-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	5808.0	0.5	8.6E-05	5.6	1.5E-08	0	Included in Overall
Panel,Control,Electrical-Electronic Equipment	221020-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	912.0	0.5	5.5E-04	5.6	6.0E-07	0	Included in Overall
Panel,Control,Electronic	221001-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	2.0	730928.0	2.0	2.7E-06	2.9	3.7E-12	0	Environment
Panel,Control,Electronic	221001-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	0	160846.0	0.5	3.1E-06	5.6	1.9E-11	0	Included in Overall
Panel,Control,Electronic	221002-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	0	153954.0	0.5	3.2E-06	5.6	2.1E-11	0	Included in Overall
Panel,Control,Electronic	221003-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	1.0	151738.0	1.0	6.6E-06	3.9	4.3E-11	0	Included in Overall
Panel,Control,Electronic	221004-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	0	152930.0	0.5	3.3E-06	5.6	2.1E-11	0	Included in Overall
Panel,Control,Electronic	221005-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	1.0	111460.0	1.0	9.0E-06	3.9	8.0E-11	0	Included in Overall
Panel,Control,Electrical-Electronic Equipment	221001-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	613.0	4020104.0	613.0	1.5E-04	1.1	3.8E-11	0	Environment
Panel,Control,Electrical-Electronic Equipment	221001-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	174.0	884653.0	174.0	2.0E-04	1.1	2.2E-10	0	Included in Overall
Panel,Control,Electrical-Electronic Equipment	221002-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	132.0	846747.0	132.0	1.6E-04	1.2	1.8E-10	0	Included in Overall
Panel,Control,Electrical-Electronic Equipment	221003-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	115.0	834559.0	115.0	1.4E-04	1.2	1.7E-10	0	Included in Overall
Panel,Control,Electrical-Electronic Equipment	221004-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	105.0	841115.0	105.0	1.2E-04	1.2	1.5E-10	0	Included in Overall
Panel,Control,Electrical-Electronic Equipment	221005-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	87.0	613030.0	87.0	1.4E-04	1.2	2.3E-10	0	Included in Overall

Figure F- 9: D-RAD Rate Based Data Sheet for Control Panels (Cont.)

Panel,Control,Electrical-Electronic Equipment	221015-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	42804.0	0.5	1.2E-05	5.6	2.7E-10	1	Overall
Panel,Control,Electrical-Electronic Equipment	221015-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	11508.0	0.5	4.3E-05	5.6	3.8E-09	0	Included in Overall
Panel,Control,Electrical-Electronic Equipment	221016-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	8160.0	0.5	6.1E-05	5.6	7.5E-09	0	Included in Overall
Panel,Control,Electrical-Electronic Equipment	221017-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	6768.0	0.5	7.4E-05	5.6	1.1E-08	0	Included in Overall
Panel,Control,Electrical-Electronic Equipment	221018-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	9648.0	0.5	5.2E-05	5.6	5.4E-09	0	Included in Overall
Panel,Control,Electrical-Electronic Equipment	221019-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	5808.0	0.5	8.6E-05	5.6	1.5E-08	0	Included in Overall
Panel,Control,Electrical-Electronic Equipment	221020-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	912.0	0.5	5.5E-04	5.6	6.0E-07	0	Included in Overall
Panel,Control,Electronic	221001-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	2.0	730928.0	2.0	2.7E-06	2.9	3.7E-12	0	Environment
Panel,Control,Electronic	221001-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	0	160846.0	0.5	3.1E-06	5.6	1.9E-11	0	Included in Overall
Panel,Control,Electronic	221002-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	0	153954.0	0.5	3.2E-06	5.6	2.1E-11	0	Included in Overall
Panel,Control,Electronic	221003-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	1.0	151738.0	1.0	6.6E-06	3.9	4.3E-11	0	Included in Overall
Panel,Control,Electronic	221004-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	0	152930.0	0.5	3.3E-06	5.6	2.1E-11	0	Included in Overall
Panel,Control,Electronic	221005-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	1.0	111460.0	1.0	9.0E-06	3.9	8.0E-11	0	Included in Overall
Panel,Control	221001-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	34.0	365464.0	34.0	9.3E-05	1.3	2.5E-10	0	Environment
Panel,Control	221001-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	7.0	80423.0	7.0	8.7E-05	1.8	1.1E-09	0	Included in Overall
Panel,Control	221002-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	9.0	76977.0	9.0	1.2E-04	1.7	1.5E-09	0	Included in Overall
Panel,Control	221003-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	9.0	75869.0	9.0	1.2E-04	1.7	1.6E-09	0	Included in Overall
Panel,Control	221004-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	5.0	76465.0	5.0	6.5E-05	2.0	8.6E-10	0	Included in Overall
Panel,Control	221005-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	4.0	55730.0	4.0	7.2E-05	2.2	1.3E-09	0	Included in Overall
Panel,Control,Electrical	221001-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	8.0	730928.0	8.0	1.1E-05	1.8	1.5E-11	0	Environment
Panel,Control,Electrical	221001-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	0	160846.0	0.5	3.1E-06	5.6	1.9E-11	0	Included in Overall
Panel,Control,Electrical	221002-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	1.0	153954.0	1.0	6.5E-06	3.9	4.2E-11	0	Included in Overall
Panel,Control,Electrical	221003-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	2.0	151738.0	2.0	1.3E-05	2.9	8.7E-11	0	Included in Overall
Panel,Control,Electrical	221004-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	5.0	152930.0	5.0	3.3E-05	2.0	2.1E-10	0	Included in Overall
Panel,Control,Electrical	221005-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	0	111460.0	0.5	4.5E-06	5.6	4.0E-11	0	Included in Overall
Panel,Control,Electrical	221015-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	64206.0	0.5	7.8E-06	5.6	1.2E-10	1	Overall
Panel,Control,Electrical	221015-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	17262.0	0.5	2.9E-05	5.6	1.7E-09	0	Included in Overall
Panel,Control,Electrical	221016-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	12240.0	0.5	4.1E-05	5.6	3.3E-09	0	Included in Overall
Panel,Control,Electrical	221017-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	10152.0	0.5	4.9E-05	5.6	4.9E-09	0	Included in Overall
Panel,Control,Electrical	221018-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	14472.0	0.5	3.5E-05	5.6	2.4E-09	0	Included in Overall
Panel,Control,Electrical	221019-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	8712.0	0.5	5.7E-05	5.6	6.6E-09	0	Included in Overall
Panel,Control,Electrical	221020-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	1368.0	0.5	3.7E-04	5.6	2.7E-07	0	Included in Overall
Panel,Control,Electrical-Electronic	221001-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	6.0	365464.0	6.0	1.6E-05	1.9	4.5E-11	0	Environment
Panel,Control,Electrical-Electronic	221001-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	6.0	80423.0	6.0	7.5E-05	1.9	9.3E-10	0	Included in Overall
Panel,Control,Electrical-Electronic	221002-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	0	76977.0	0.5	6.5E-06	5.6	8.4E-11	0	Included in Overall
Panel,Control,Electrical-Electronic	221003-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	0	75869.0	0.5	6.6E-06	5.6	8.7E-11	0	Included in Overall
Panel,Control,Electrical-Electronic	221004-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	0	76465.0	0.5	6.5E-06	5.6	8.6E-11	0	Included in Overall
Panel,Control,Electrical-Electronic	221005-000	Military	AUA	NPRD-2011	1. A: Failures B: Time	0	55730.0	0.5	9.0E-06	5.6	1.6E-10	0	Included in Overall

Figure F- 9: D-RAD Rate Based Data Sheet for Control Panels (Cont.)

Detector, Wind — **D-RAD Rate Based Data Sheet (per hour)**

Indicator,Airspeed	← Mode Source FMD-2016	Parameters for Lognormal(Mean, EF) and Gamma(α, β)					
Failure Mode	**Percent**	**Mean**	**Error Factor**	**α**	**β**	**SD**	**Variance**
Overall Critical Rate	100%	3.2E-05	6.6	3.6E-01	1.1E+04	5.4E-05	2.9E-09
Erratic Operation (DPS-WIS-DEG)	66.7%	2.15E-05	7.38	3.0E-01	1.4E+04	4.0E-05	1.6E-09
Improper Response To Electrical Input (DPS-WIS-FOP)	33.3%	1.07E-05	9.28	1.9E-01	1.8E+04	2.5E-05	6.1E-10
		Records Used	4		Failures Used	2.0	

Name	Field 1	Field 2	Location	Source	Data Type	A	B	Implicit Failures	Mean	EF	Variance	Data Selector	Comment
Sensor, Wind	Overall Critical Rate	Table 5-1	Master's Thesis	KTH2010	3. A: Mean Only	5.9E-05		0.5	5.9E-05	5.6	6.9E-09	1	
Detector,Wind Direction	Military	N	221015-000	NPRD-2011	1. A: Failures B: Time	0	21402.0	0.5	2.3E-05	5.6	1.1E-09	1	Overall
Detector,Wind Direction	Military	N	221015-000	NPRD-2011	1. A: Failures B: Time	0	5754.0	0.5	8.7E-05	5.6	1.5E-08	0	Included in Overall
Detector,Wind Direction	Military	N	221016-000	NPRD-2011	1. A: Failures B: Time	0	4080.0	0.5	1.2E-04	5.6	3.0E-08	0	Included in Overall
Detector,Wind Direction	Military	N	221017-000	NPRD-2011	1. A: Failures B: Time	0	3384.0	0.5	1.5E-04	5.6	4.4E-08	0	Included in Overall
Detector,Wind Direction	Military	N	221018-000	NPRD-2011	1. A: Failures B: Time	0	4824.0	0.5	1.0E-04	5.6	2.1E-08	0	Included in Overall
Detector,Wind Direction	Military	N	221019-000	NPRD-2011	1. A: Failures B: Time	0	2904.0	0.5	1.7E-04	5.6	5.9E-08	0	Included in Overall
Detector,Wind Direction	Military	N	221020-000	NPRD-2011	1. A: Failures B: Time	0	456.0	0.5	1.1E-03	5.6	2.4E-06	0	Included in Overall
Indicator,Wind Direction	Military	N	221015-000	NPRD-2011	1. A: Failures B: Time	0	21402.0	0.5	2.3E-05	5.6	1.1E-09	1	Overall
Indicator,Wind Direction	Military	N	221015-000	NPRD-2011	1. A: Failures B: Time	0	5754.0	0.5	8.7E-05	5.6	1.5E-08	0	Included in Overall
Indicator,Wind Direction	Military	N	221016-000	NPRD-2011	1. A: Failures B: Time	0	4080.0	0.5	1.2E-04	5.6	3.0E-08	0	Included in Overall
Indicator,Wind Direction	Military	N	221017-000	NPRD-2011	1. A: Failures B: Time	0	3384.0	0.5	1.5E-04	5.6	4.4E-08	0	Included in Overall
Indicator,Wind Direction	Military	N	221018-000	NPRD-2011	1. A: Failures B: Time	0	4824.0	0.5	1.0E-04	5.6	2.1E-08	0	Included in Overall
Indicator,Wind Direction	Military	N	221019-000	NPRD-2011	1. A: Failures B: Time	0	2904.0	0.5	1.7E-04	5.6	5.9E-08	0	Included in Overall
Indicator,Wind Direction	Military	N	221020-000	NPRD-2011	1. A: Failures B: Time	0	456.0	0.5	1.1E-03	5.6	2.4E-06	0	Included in Overall
Wind Sensing Unit	Military	N	221015-000	NPRD-2011	1. A: Failures B: Time	0	21402.0	0.5	2.3E-05	5.6	1.1E-09	1	Overall
Wind Sensing Unit	Military	N	221015-000	NPRD-2011	1. A: Failures B: Time	0	5754.0	0.5	8.7E-05	5.6	1.5E-08	0	Included in Overall
Wind Sensing Unit	Military	N	221016-000	NPRD-2011	1. A: Failures B: Time	0	4080.0	0.5	1.2E-04	5.6	3.0E-08	0	Included in Overall
Wind Sensing Unit	Military	N	221017-000	NPRD-2011	1. A: Failures B: Time	0	3384.0	0.5	1.5E-04	5.6	4.4E-08	0	Included in Overall
Wind Sensing Unit	Military	N	221018-000	NPRD-2011	1. A: Failures B: Time	0	4824.0	0.5	1.0E-04	5.6	2.1E-08	0	Included in Overall
Wind Sensing Unit	Military	N	221019-000	NPRD-2011	1. A: Failures B: Time	0	2904.0	0.5	1.7E-04	5.6	5.9E-08	0	Included in Overall
Wind Sensing Unit	Military	N	221020-000	NPRD-2011	1. A: Failures B: Time	0	456.0	0.5	1.1E-03	5.6	2.4E-06	0	Included in Overall

Figure F- 9: D-RAD Rate Based Data Sheet for Wind Detectors

Filter — **D-RAD Rate Based Data Sheet (per hour)**

OREDA-2015	← Mode Source	Parameters for Lognormal(Mean, EF) and Gamma(α, β)					
Failure Mode	**Percent**	**Mean**	**Error Factor**	**α**	**β**	**SD**	**Variance**
Overall Critical Rate (FLT-PLG)	100%	3.43E-07	9.51	1.8E-01	5.3E+05	8.1E-07	6.5E-13
Plugged/Choked	1%	4.9E-09	34.4	9.9E-03	2.0E+06	5.0E-08	2.5E-15
Plugged/Choked*	1%	4.9E-09	34.4	9.9E-03	2.0E+06	5.0E-08	2.5E-15
		Records Used	9		Failures Used	3.7	

Name	Field 1 (Data Sources)	Field 2	Location	Source	Data Type	A	B	Implicit Failures	Mean	EF	Variance	Data Selector	Comment
Filter	Overall Critical Rate	5.1	p60	OREDA-2015	2. A: Mean B: SD	2.0E-08	1.0E-07	0.04	2.0E-08	19.5	1.0E-14	1	Overall
Filter	Plugged/Choked	5.1	p60	OREDA-2015	2. A: Mean B: SD	2.0E-08	1.0E-07	0.0	2.0E-08	19.5	1.0E-14	0	Included in Overall
Filter	Overall Critical Rate	5.1.1	p80	OREDA-2015	2. A: Mean B: SD	3.6E-07	5.2E-07	0.5	3.6E-07	5.7	2.7E-13	1	
Filter	Overall Critical Rate	5.1.2	p86	OREDA-2015	2. A: Mean B: SD	6.0E-08	1.5E-07	0.2	6.0E-08	10.1	2.3E-14	1	Overall
Filter	Plugged/Choked	5.1.2	p86	OREDA-2015	2. A: Mean B: SD	6.0E-08	1.5E-07	0.2	6.0E-08	10.1	2.3E-14	0	Included in Overall
Filter	Overall Critical Rate	5.1.4	p93	OREDA-2015	2. A: Mean B: SD	1.2E-06	1.7E-06	0.5	1.2E-06	5.6	2.8E-12	1	
Filter	Overall Critical Rate	5.1.5	p97	OREDA-2015	2. A: Mean B: SD	3.0E-08	4.0E-08	0.6	3.0E-08	5.3	1.6E-15	1	
Filter	Overall Critical Rate	5.1.6	p102	OREDA-2015	2. A: Mean B: SD	6.0E-08	9.0E-08	0.4	6.0E-08	6.0	8.1E-15	1	
Filter	Overall Critical Rate	5.1.7	p108	OREDA-2015	2. A: Mean B: SD	4.3E-07	6.1E-07	0.5	4.3E-07	5.6	3.7E-13	1	
Filter,Fuel	Military	AA	221001-000	NPRD-2011	1. A: Failures B: Time	0	1827320.0	0.5	2.7E-07	5.6	1.5E-13	1	Overall
Filter,Fuel	Military	AA	221001-000	NPRD-2011	1. A: Failures B: Time	0	402115.0	0.5	1.2E-06	5.6	3.1E-12	0	Included in Overall
Filter,Fuel	Military	AA	221002-000	NPRD-2011	1. A: Failures B: Time	0	384885.0	0.5	1.3E-06	5.6	3.4E-12	0	Included in Overall
Filter,Fuel	Military	AA	221003-000	NPRD-2011	1. A: Failures B: Time	0	379345.0	0.5	1.3E-06	5.6	3.5E-12	0	Included in Overall
Filter,Fuel	Military	AA	221004-000	NPRD-2011	1. A: Failures B: Time	0	382325.0	0.5	1.3E-06	5.6	3.4E-12	0	Included in Overall
Filter,Fuel	Military	AA	221005-000	NPRD-2011	1. A: Failures B: Time	0	278650.0	0.5	1.8E-06	5.6	6.4E-12	0	Included in Overall
Filter,Fuel	Military	ARW	221006-000	NPRD-2011	1. A: Failures B: Time	0	233123.0	0.5	2.1E-06	5.6	9.2E-12	0	Environment
Filter,Fuel	Military	ARW	221006-000	NPRD-2011	1. A: Failures B: Time	0	26467.0	0.5	1.9E-05	5.6	7.1E-10	0	Environment
Filter,Fuel	Military	ARW	221007-000	NPRD-2011	1. A: Failures B: Time	0	26886.0	0.5	1.9E-05	5.6	6.9E-10	0	Environment
Filter,Fuel	Military	ARW	221008-000	NPRD-2011	1. A: Failures B: Time	0	26903.0	0.5	1.9E-05	5.6	6.9E-10	0	Environment
Filter,Fuel	Military	ARW	221009-000	NPRD-2011	1. A: Failures B: Time	0	25500.0	0.5	2.0E-05	5.6	7.7E-10	0	Environment
Filter,Fuel	Military	ARW	221010-000	NPRD-2011	1. A: Failures B: Time	0	27086.0	0.5	1.8E-05	5.6	6.8E-10	0	Environment
Filter,Fuel	Military	ARW	221011-000	NPRD-2011	1. A: Failures B: Time	0	28147.0	0.5	1.8E-05	5.6	6.3E-10	0	Environment
Filter,Fuel	Military	ARW	221012-000	NPRD-2011	1. A: Failures B: Time	0	26476.0	0.5	1.9E-05	5.6	7.1E-10	0	Environment
Filter,Fuel	Military	ARW	221013-000	NPRD-2011	1. A: Failures B: Time	0	24569.0	0.5	2.0E-05	5.6	8.3E-10	0	Environment
Filter,Fuel	Military	ARW	221014-000	NPRD-2011	1. A: Failures B: Time	0	21089.0	0.5	2.4E-05	5.6	1.1E-09	0	Environment
Filter,Fuel,Main	Military	AA	221001-000	NPRD-2011	1. A: Failures B: Time	0	730928.0	0.5	6.8E-07	5.6	9.4E-13	1	Overall
Filter,Fuel,Main	Military	AA	221001-000	NPRD-2011	1. A: Failures B: Time	0	160846.0	0.5	3.1E-06	5.6	1.9E-11	0	Included in Overall
Filter,Fuel,Main	Military	AA	221002-000	NPRD-2011	1. A: Failures B: Time	0	153954.0	0.5	3.2E-06	5.6	2.1E-11	0	Included in Overall
Filter,Fuel,Main	Military	AA	221003-000	NPRD-2011	1. A: Failures B: Time	0	151738.0	0.5	3.3E-06	5.6	2.2E-11	0	Included in Overall
Filter,Fuel,Main	Military	AA	221004-000	NPRD-2011	1. A: Failures B: Time	0	152930.0	0.5	3.3E-06	5.6	2.1E-11	0	Included in Overall
Filter,Fuel,Main	Military	AA	221005-000	NPRD-2011	1. A: Failures B: Time	0	111460.0	0.5	4.5E-06	5.6	4.0E-11	0	Included in Overall

Figure F- 10: D-RAD Rate Based Data Sheet for Filters

Generator, Diesel — **D-RAD Rate Based Data Sheet (per hour)**

Generator,Diesel Engine	← Mode Source FMD-2016	Parameters for Lognormal(Mean, EF) and Gamma(α, β)					
Failure Mode	**Percent**	**Mean**	**Error Factor**	**α**	**β**	**SD**	**Variance**
Overall Critical Rate	100%	1.0E-04	7.4	3.0E-01	2.9E+03	1.9E-04	3.5E-08
No Operation (EPS-DGN-FTR)	54.9%	5.59E-05	7.39	3.0E-01	5.3E+03	1.0E-04	1.1E-08
Degraded Operation	26.0%	2.6E-05	7.4	2.9E-01	1.1E+04	4.9E-05	2.4E-09
Excessive Vibration	12.2%	1.2E-05	7.4	2.9E-01	2.4E+04	2.3E-05	5.2E-10
Induced Failure	6.9%	7.0E-06	7.4	2.9E-01	4.2E+04	1.3E-05	1.7E-10
		Records Used	38		Failures Used	1,263.5	

Data Sources

Name	Field 1	Field 2	Location	Source	Data Type	A	B	Implicit Failures	Mean	EF	Variance	Data Selector	Comment
Power Supply System, Engine, Diesel	Overall Critical Rate	Table 5-1	Master's Thesis	KTH2010	3. A: Mean Only	1.0E-04		0.5	1.0E-04	5.6	2.0E-08	1	
Electric Generator	Overall Critical Rate	2.1	p211	OREDA-2015	2. A: Mean B: SD	2.2E-05	2.6E-05	0.7	2.2E-05	4.7	7.0E-10	1	
Electric Generator	Overall Critical Rate	2.1.1	p215	OREDA-2015	2. A: Mean B: SD	1.8E-05	1.6E-05	1.3	1.8E-05	3.4	2.5E-10	1	
Electric Generator, Motor Driven (diesel, gas motor)	Overall Critical Rate	2.1.1.2	p223	OREDA-2015	2. A: Mean B: SD	3.8E-05	2.7E-05	2.0	3.8E-05	2.8	7.2E-10	1	
Electric Generator, Motor Driven (diesel, gas motor)	Overall Critical Rate	2.1.1.2.1	p224	OREDA-2015	2. A: Mean B: SD	3.8E-05	2.7E-05	2.0	3.8E-05	2.8	7.2E-10	1	
Generator,Diesel Engine,Packaged	Commercial	GF	23047-004	NPRD-2011	1. A: Failures B: Time	41.0	2733.0	41.0	1.5E-02	1.3	5.5E-06	0	Out of Expected Range
Generator,Diesel Engine,Packaged	Commercial	GF	23047-006	NPRD-2011	1. A: Failures B: Time	1.0	728.0	1.0	1.4E-03	3.9	1.9E-06	0	Out of Expected Range
Generator,Diesel Engine,Packaged	Commercial	GF	23047-010	NPRD-2011	1. A: Failures B: Time	0	75576.0	0.5	6.6E-06	5.6	8.8E-11	1	
Generator,Diesel Engine,Packaged	Commercial	GF	23047-028	NPRD-2011	1. A: Failures B: Time	60.0	1826880.0	60.0	3.3E-05	1.2	1.8E-11	1	
Generator,Diesel Engine,Packaged	Commercial	GF	23047-030	NPRD-2011	1. A: Failures B: Time	48.0	903.0	48.0	5.3E-02	1.3	5.9E-05	0	Out of Expected Range
Generator,Diesel Engine,Packaged	Commercial	GF	23047-031	NPRD-2011	1. A: Failures B: Time	0	2326.0	0.5	2.1E-04	5.6	9.2E-08	1	
Generator,Diesel Engine,Packaged	Commercial	GF	23047-033	NPRD-2011	1. A: Failures B: Time	432.0	286320.0	432.0	1.5E-03	1.1	5.3E-09	0	Out of Expected Range
Generator,Diesel Engine,Packaged	Commercial	GF	23047-040	NPRD-2011	1. A: Failures B: Time	1.0	87464.0	1.0	1.1E-05	3.9	1.3E-10	1	
Generator,Diesel Engine,Packaged	Commercial	GF	23047-046	NPRD-2011	1. A: Failures B: Time	2.0	1046264.0	2.0	1.9E-06	2.9	1.8E-12	1	
Generator,Diesel Engine,Packaged	Commercial	GF	23047-058	NPRD-2011	1. A: Failures B: Time	0	43536.0	0.5	1.1E-05	5.6	2.6E-10	1	
Generator,Diesel Engine,Packaged	Commercial	GF	23047-060	NPRD-2011	1. A: Failures B: Time	0	251250.0	0.5	2.0E-06	5.6	7.9E-12	1	
Generator,Diesel Engine,Packaged	Commercial	GF	23047-076	NPRD-2011	1. A: Failures B: Time	120.0	1329696.0	120.0	9.0E-05	1.2	6.8E-11	1	
Generator,Diesel Engine,Packaged,Continuous Operation	Commercial	GF	23047-003	NPRD-2011	1. A: Failures B: Time	197.0	1146255.0	197.0	1.7E-04	1.1	1.5E-10	1	
Generator,Diesel Engine,Unpackaged	Commercial	GF	23047-010	NPRD-2011	1. A: Failures B: Time	1.0	75576.0	1.0	1.3E-05	3.9	1.8E-10	1	
Generator,Diesel Engine,Unpackaged	Commercial	GF	23047-012	NPRD-2011	1. A: Failures B: Time	93.0	568296.0	93.0	1.6E-04	1.2	2.9E-10	1	
Generator,Diesel Engine,Unpackaged	Commercial	GF	23047-028	NPRD-2011	1. A: Failures B: Time	59.0	498240.0	59.0	1.2E-04	1.2	2.4E-10	1	
Generator,Diesel Engine,Unpackaged	Commercial	GF	23047-038	NPRD-2011	1. A: Failures B: Time	5.0	68160.0	5.0	7.3E-05	2.0	1.1E-09	1	
Generator,Diesel Engine,Unpackaged	Commercial	GF	23047-046	NPRD-2011	1. A: Failures B: Time	61.0	25944.0	61.0	2.4E-03	1.2	9.1E-08	0	Out of Expected Range
Generator,Diesel Engine,Unpackaged	Commercial	GF	23047-048	NPRD-2011	1. A: Failures B: Time	2.0	105216.0	2.0	1.9E-05	2.9	1.8E-10	1	
Generator,Diesel Engine,Unpackaged	Commercial	GF	23047-049	NPRD-2011	1. A: Failures B: Time	21.0	751536.0	21.0	2.8E-05	1.4	3.7E-11	1	
Generator,Diesel Engine,Unpackaged	Commercial	GF	23047-051	NPRD-2011	1. A: Failures B: Time	52.0	182582.0	52.0	2.8E-04	1.3	1.6E-09	1	
Generator,Diesel Engine,Unpackaged	Commercial	GF	23047-052	NPRD-2011	1. A: Failures B: Time	54.0	434280.0	54.0	1.2E-04	1.2	2.9E-10	1	
Generator,Diesel Engine,Unpackaged	Commercial	GF	23047-068	NPRD-2011	1. A: Failures B: Time	20.0	46875.0	20.0	4.3E-04	1.4	9.1E-09	1	
Generator,Diesel Engine,Unpackaged	Commercial	GF	23047-069	NPRD-2011	1. A: Failures B: Time	4.0	211044.0	4.0	1.9E-05	2.2	9.0E-11	1	
Generator,Diesel Engine,Unpackaged	Commercial	GF	23047-079	NPRD-2011	1. A: Failures B: Time	4.0	67424.0	4.0	5.9E-05	2.2	8.8E-10	1	
Generator,Diesel Engine,Unpackaged	Commercial	GF	23047-080	NPRD-2011	1. A: Failures B: Time	9.0	256027.0	9.0	3.5E-05	1.7	1.4E-10	1	
Generator,Diesel Engine,Unpackaged	Commercial	GF	23047-081	NPRD-2011	1. A: Failures B: Time	5.0	219024.0	5.0	2.3E-05	2.0	1.0E-10	1	
Generator,Diesel Engine,Unpackaged	Commercial	GF	23047-082	NPRD-2011	1. A: Failures B: Time	1.0	253200.0	1.0	3.9E-06	3.9	1.6E-11	1	
Generator,Diesel Engine,Unpackaged	Commercial	GF	23047-083	NPRD-2011	1. A: Failures B: Time	56.0	223785.0	56.0	2.5E-04	1.2	1.1E-09	1	
Generator,Diesel Engine,Unpackaged	Commercial	GF	23047-089	NPRD-2011	1. A: Failures B: Time	40.0	3591.0	40.0	1.1E-02	1.3	3.1E-06	0	Out of Expected Range
Generator,Diesel Engine,Unpackaged	Commercial	GF	23047-098	NPRD-2011	1. A: Failures B: Time	15.0	4400.0	15.0	3.4E-03	1.5	7.7E-07	0	Out of Expected Range
Generator,Diesel Engine,Unpackaged	Commercial	GF	23047-099	NPRD-2011	1. A: Failures B: Time	3.0	192528.0	3.0	1.6E-05	2.4	8.1E-11	1	
Generator,Diesel Engine,Unpackaged	Commercial	GF	23047-102	NPRD-2011	1. A: Failures B: Time	0	94152.0	0.5	5.3E-06	5.6	5.6E-11	1	
Generator,Diesel Engine,Unpackaged	Commercial	GF	23047-103	NPRD-2011	1. A: Failures B: Time	0	96264.0	0.5	5.2E-06	5.6	5.4E-11	1	
Generator,Diesel Engine,Unpackaged	Commercial	GF	23047-104	NPRD-2011	1. A: Failures B: Time	24.0	1097472.0	24.0	2.2E-05	1.4	2.0E-11	1	
Generator,Diesel Engine,Unpackaged	Commercial	GF	23047-106	NPRD-2011	1. A: Failures B: Time	50.0	875889.0	50.0	5.7E-05	1.3	6.5E-11	1	
Generator,Diesel Engine,Unpackaged	Commercial	GF	23047-112	NPRD-2011	1. A: Failures B: Time	6.0	96240.0	6.0	6.2E-05	1.9	6.5E-10	1	
Generator,Diesel Engine,Unpackaged,Continuous Operation	Commercial	GF	23047-013	NPRD-2011	1. A: Failures B: Time	63.0	641333.0	63.0	9.8E-05	1.2	1.5E-10	1	
Generator,Diesel Engine,Unpackaged,Continuous Operation	Commercial	GF	23047-014	NPRD-2011	1. A: Failures B: Time	6.0	30202.0	6.0	2.0E-04	1.9	6.6E-09	1	
Generator,Diesel Engine,Unpackaged,Continuous Operation	Commercial	GF	23047-040	NPRD-2011	1. A: Failures B: Time	336.0	335903.0	336.0	1.0E-03	1.1	3.0E-09	1	

Figure F- 11: D-RAD Rate Based Data Sheet for Diesel Generators

GPS — **D-RAD Rate Based Data Sheet (per hour)**

Antenna,GPS	← Mode Source FMD-2016	Parameters for Lognormal(Mean, EF) and Gamma(α, β)								
Failure Mode	**Percent**	**Mean**	**Error Factor**	**α**	**β**	**SD**	**Variance**			
Overall Critical Rate	100%	2.9E-05	9.0	2.0E-01	6.9E+03	6.5E-05	4.2E-09			
Improper Output	54.1%	1.6E-05	9.4	1.9E-01	1.2E+04	3.6E-05	1.3E-09			
Broken	13.3%	3.8E-06	11.5	1.2E-01	3.2E+04	1.1E-05	1.2E-10			
Leakage	12.7%	3.7E-06	11.7	1.2E-01	3.3E+04	1.1E-05	1.1E-10			
Electrical Failure	7.7%	2.2E-06	13.2	9.3E-02	4.2E+04	7.3E-06	5.3E-11			
Loose	7.6%	2.2E-06	13.3	9.2E-02	4.2E+04	7.2E-06	5.2E-11			
Delamination	4.7%	1.4E-06	15.3	6.8E-02	5.0E+04	5.2E-06	2.7E-11	These two items are different from DPS model		
Fails Off (GPS-FOP)	67.40%	1.95E-05	9.25	1.9E-01	9.8E+03	4.5E-05	2.0E-09	B5+B6	x Overall	Improper Output + Broken
Degraded (GPS-DEG)	32.70%	9.46E-06	9.90	1.7E-01	1.8E+04	2.3E-05	5.4E-10	B7+B8+B9 +B10	x Overall	Leakge+Elec Failure+Loose+Delamination
		Records Used		**2**	**Failures Used**		**11.5**			

Data Sources													
Name	**Field 1**	**Field 2**	**Location**	**Source**	**Data Type**	**A**	**B**	**Implicit Failures**	**Mean**	**EF**	**Variance**	**Data Selector**	**Comment**
GPS, Differential	Overall Critical Rate	Table 5-1	Master's Thesis	KTH2010	3. A: Mean Only	5.4E-05		0.5	5.4E-05	5.6	5.8E-09	1	
Assembly,GPS	Military	AC	800109-000	NPRD-2016	1. A: Failures B: Time	11.0	2871248.0	11.0	3.8E-06	1.6	1.3E-12	1	Overall
Assembly,GPS	Military	AC	800109-000	NPRD-2016	1. A: Failures B: Time	0	267352.0	0.5	1.9E-06	5.6	7.0E-12	0	Included in Overall
Assembly,GPS	Military	AC	800110-000	NPRD-2016	1. A: Failures B: Time	0	287426.0	0.5	1.7E-06	5.6	6.1E-12	0	Included in Overall
Assembly,GPS	Military	AC	800111-000	NPRD-2016	1. A: Failures B: Time	0	317152.0	0.5	1.6E-06	5.6	5.0E-12	0	Included in Overall
Assembly,GPS	Military	AC	800112-000	NPRD-2016	1. A: Failures B: Time	0	345956.0	0.5	1.4E-06	5.6	4.2E-12	0	Included in Overall
Assembly,GPS	Military	AC	800113-000	NPRD-2016	1. A: Failures B: Time	1.0	319120.0	1.0	3.1E-06	3.9	9.8E-12	0	Included in Overall
Assembly,GPS	Military	AC	800114-000	NPRD-2016	1. A: Failures B: Time	0	301170.0	0.5	1.7E-06	5.6	5.5E-12	0	Included in Overall
Assembly,GPS	Military	AC	800115-000	NPRD-2016	1. A: Failures B: Time	1.0	272984.0	1.0	3.7E-06	3.9	1.3E-11	0	Included in Overall
Assembly,GPS	Military	AC	800116-000	NPRD-2016	1. A: Failures B: Time	3.0	264865.0	3.0	1.1E-05	2.4	4.3E-11	0	Included in Overall
Assembly,GPS	Military	AC	800117-000	NPRD-2016	1. A: Failures B: Time	6.0	250570.0	6.0	2.4E-05	1.9	9.6E-11	0	Included in Overall
Assembly,GPS	Military	AC	800118-000	NPRD-2016	1. A: Failures B: Time	0	244653.0	0.5	2.0E-06	5.6	8.4E-12	0	Included in Overall
Antenna,GPS	Military	AC	800109-000	NPRD-2016	1. A: Failures B: Time	28.0	14356240.0	28.0	2.0E-06	1.4	1.4E-13	0	Overall
Antenna,GPS	Military	AC	800109-000	NPRD-2016	1. A: Failures B: Time	0	1336760.0	0.5	3.7E-07	5.6	2.8E-13	0	Included in Overall
Antenna,GPS	Military	AC	800110-000	NPRD-2016	1. A: Failures B: Time	1.0	1437130.0	1.0	7.0E-07	3.9	4.8E-13	0	Included in Overall
Antenna,GPS	Military	AC	800111-000	NPRD-2016	1. A: Failures B: Time	0	1585760.0	0.5	3.2E-07	5.6	2.0E-13	0	Included in Overall
Antenna,GPS	Military	AC	800112-000	NPRD-2016	1. A: Failures B: Time	0	1729780.0	0.5	2.9E-07	5.6	1.7E-13	0	Included in Overall
Antenna,GPS	Military	AC	800113-000	NPRD-2016	1. A: Failures B: Time	7.0	1595600.0	7.0	4.4E-06	1.8	2.7E-12	0	Included in Overall
Antenna,GPS	Military	AC	800114-000	NPRD-2016	1. A: Failures B: Time	1.0	1505850.0	1.0	6.6E-07	3.9	4.4E-13	0	Included in Overall
Antenna,GPS	Military	AC	800115-000	NPRD-2016	1. A: Failures B: Time	6.0	1364920.0	6.0	4.4E-06	1.9	3.2E-12	0	Included in Overall
Antenna,GPS	Military	AC	800116-000	NPRD-2016	1. A: Failures B: Time	3.0	1324325.0	3.0	2.3E-06	2.4	1.7E-12	0	Included in Overall
Antenna,GPS	Military	AC	800117-000	NPRD-2016	1. A: Failures B: Time	8.0	1252850.0	8.0	6.4E-06	1.8	5.1E-12	0	Included in Overall
Antenna,GPS	Military	AC	800118-000	NPRD-2016	1. A: Failures B: Time	2.0	1223265.0	2.0	1.6E-06	2.9	1.3E-12	0	Included in Overall

Figure F- 12: D-RAD Rate Based Data Sheet for GPS

Gyroscope

D-RAD Rate Based Data Sheet (per hour)

Gyroscope	← Mode Source FMD-2016	Parameters for Lognormal(Mean, EF) and Gamma(α, β)							
Failure Mode	**Percent**	**Mean**	**Error Factor**	**α**	**β**	**SD**	**Variance**		
Overall Critical Rate	100%	3.1E-05	5.0	6.3E-01	2.0E+04	3.9E-05	1.6E-09		
Out Of Specification	87.4%	2.7E-05	5.0	6.3E-01	2.3E+04	3.5E-05	1.2E-09		
Binding/Sticking	11.9%	3.7E-06	5.0	6.1E-01	1.7E+05	4.7E-06	2.3E-11		
Opened	0.3%	9.4E-08	7.0	3.3E-01	3.5E+06	1.6E-07	2.7E-14		
Shorted	0.2%	6.3E-08	7.8	2.7E-01	4.3E+06	1.2E-07	1.5E-14		
No Operation	0.1%	3.1E-08	9.8	1.7E-01	5.4E+06	7.6E-08	5.8E-15		
Fail Off (DPS-GYC-FOP)	56.2%	1.76E-05	4.99	6.3E-01	3.6E+04	2.2E-05	4.9E-10	x Overall	Out of Spec/2 + Binding + Opened + Shorted + No Op
Degraded (DPS-GYC-DEG)	43.7%	1.37E-05	4.99	6.2E-01	4.6E+04	1.7E-05	3.0E-10	x Overall	Out of Spec/2
		Records Used	5	**Failures Used**	599.7				

Name	Field 1	Field 2	Location	Source	Data Type	A	B	Implicit Failures	Mean	EF	Variance	Data Selector	Comment
Gyroscope	Overall Critical Rate	Table 5-1	Master's Thesis	KTH2010	3. A: Mean Only	4.0E-05		0.5	4.0E-05	5.6	3.2E-09	1	
Gyroscope	Overall Critical Rate	Failure Rate Data	FARADIP	Version 8.0	2. A: Mean B: SD	1.5E-05	1.4E-05	1.2	1.5E-05	3.6	1.9E-10	1	
Gyro	Military	AA	221001-000	NPRD-2011	1. A: Failures B: Time	0	730928.0	0.5	6.8E-07	5.6	9.4E-13	0	Environment
Gyro	Military	AA	221001-000	NPRD-2011	1. A: Failures B: Time	0	160846.0	0.5	3.1E-06	5.6	1.9E-11	0	Included in Overall
Gyro	Military	AA	221002-000	NPRD-2011	1. A: Failures B: Time	0	153954.0	0.5	3.2E-06	5.6	2.1E-11	0	Included in Overall
Gyro	Military	AA	221003-000	NPRD-2011	1. A: Failures B: Time	0	151738.0	0.5	3.3E-06	5.6	2.2E-11	0	Included in Overall
Gyro	Military	AA	221004-000	NPRD-2011	1. A: Failures B: Time	0	152930.0	0.5	3.3E-06	5.6	2.1E-11	0	Included in Overall
Gyro	Military	AA	221005-000	NPRD-2011	1. A: Failures B: Time	0	111460.0	0.5	4.5E-06	5.6	4.0E-11	0	Included in Overall
Gyro Assembly,Rate	Military	N	221021-000	NPRD-2011	1. A: Failures B: Time	0	71472.0	0.5	7.0E-06	5.6	9.8E-11	1	Overall
Gyro Assembly,Rate	Military	N	221021-000	NPRD-2011	1. A: Failures B: Time	0	3672.0	0.5	1.4E-04	5.6	3.7E-08	0	Included in Overall
Gyro Assembly,Rate	Military	N	221022-000	NPRD-2011	1. A: Failures B: Time	0	11064.0	0.5	4.5E-05	5.6	4.1E-09	0	Included in Overall
Gyro Assembly,Rate	Military	N	221023-000	NPRD-2011	1. A: Failures B: Time	0	8736.0	0.5	5.7E-05	5.6	6.6E-09	0	Included in Overall
Gyro Assembly,Rate	Military	N	221024-000	NPRD-2011	1. A: Failures B: Time	0	5832.0	0.5	8.6E-05	5.6	1.5E-08	0	Included in Overall
Gyro Assembly,Rate	Military	N	221025-000	NPRD-2011	1. A: Failures B: Time	0	7776.0	0.5	6.4E-05	5.6	8.3E-09	0	Included in Overall
Gyro Assembly,Rate	Military	N	221026-000	NPRD-2011	1. A: Failures B: Time	0	5112.0	0.5	9.8E-05	5.6	1.9E-08	0	Included in Overall
Gyro Assembly,Rate	Military	N	221027-000	NPRD-2011	1. A: Failures B: Time	0	4224.0	0.5	1.2E-04	5.6	2.8E-08	0	Included in Overall
Gyro Assembly,Rate	Military	N	221028-000	NPRD-2011	1. A: Failures B: Time	0	8304.0	0.5	6.0E-05	5.6	7.3E-09	0	Included in Overall
Gyro Assembly,Rate	Military	N	221029-000	NPRD-2011	1. A: Failures B: Time	0	3600.0	0.5	1.4E-04	5.6	3.9E-08	0	Included in Overall
Gyro Assembly,Rate	Military	N	221030-000	NPRD-2011	1. A: Failures B: Time	0	8016.0	0.5	6.2E-05	5.6	7.8E-09	0	Included in Overall
Gyro Assembly,Rate	Military	N	221031-000	NPRD-2011	1. A: Failures B: Time	0	5136.0	0.5	9.7E-05	5.6	1.9E-08	0	Included in Overall
Gyro,Rate	Military	ARW	221006-000	NPRD-2011	1. A: Failures B: Time	0	23778546.0	0.5	2.1E-08	5.6	8.8E-16	0	Environment
Gyro,Rate	Military	ARW	221006-000	NPRD-2011	1. A: Failures B: Time	0	2699634.0	0.5	1.9E-07	5.6	6.9E-14	0	Included in Overall
Gyro,Rate	Military	ARW	221007-000	NPRD-2011	1. A: Failures B: Time	0	2742372.0	0.5	1.8E-07	5.6	6.6E-14	0	Included in Overall
Gyro,Rate	Military	ARW	221008-000	NPRD-2011	1. A: Failures B: Time	0	2744106.0	0.5	1.8E-07	5.6	6.6E-14	0	Included in Overall
Gyro,Rate	Military	ARW	221009-000	NPRD-2011	1. A: Failures B: Time	0	2601000.0	0.5	1.9E-07	5.6	7.4E-14	0	Included in Overall
Gyro,Rate	Military	ARW	221010-000	NPRD-2011	1. A: Failures B: Time	0	2762772.0	0.5	1.8E-07	5.6	6.6E-14	0	Included in Overall
Gyro,Rate	Military	ARW	221011-000	NPRD-2011	1. A: Failures B: Time	0	2870994.0	0.5	1.7E-07	5.6	6.1E-14	0	Included in Overall
Gyro,Rate	Military	ARW	221012-000	NPRD-2011	1. A: Failures B: Time	0	2700552.0	0.5	1.9E-07	5.6	6.9E-14	0	Included in Overall
Gyro,Rate	Military	ARW	221013-000	NPRD-2011	1. A: Failures B: Time	0	2506038.0	0.5	2.0E-07	5.6	8.0E-14	0	Included in Overall
Gyro,Rate	Military	ARW	221014-000	NPRD-2011	1. A: Failures B: Time	0	2151078.0	0.5	2.3E-07	5.6	1.1E-13	0	Included in Overall
Gyroscope	Military	ARW	NPRD-091	NPRD-2011	1. A: Failures B: Time	1.0	10000.0	1.0	1.0E-04	3.9	1.0E-08	0	Sparse
Gyroscope	Military	AUF	16953-000	NPRD-2011	1. A: Failures B: Time	0	117000.0	0.5	4.3E-06	5.6	3.7E-11	0	Environment
Gyroscope	Military	GF	NPRD-061	NPRD-2011	1. A: Failures B: Time	3.0	164000.0	3.0	1.8E-05	2.4	1.1E-10	0	Environment
Gyroscope	Military	SF	10219-034	NPRD-2011	1. A: Failures B: Time	2.0	508000.0	2.0	3.9E-06	2.9	7.8E-12	0	Environment
Gyroscope	Military	SF	NPRD-077	NPRD-2011	1. A: Failures B: Time	0	63000.0	0.5	7.9E-06	5.6	1.3E-10	0	Environment
Gyroscope,Rate	Commercial	AI	NPRD-079	NPRD-2011	1. A: Failures B: Time	1.0	270000.0	1.0	3.7E-06	3.9	1.4E-11	0	Environment
Gyroscope,Rate	Commercial	AUT	NPRD-081	NPRD-2011	1. A: Failures B: Time	2.0	7000.0	2.0	2.9E-04	2.9	4.1E-08	0	Environment
Gyroscope,Rate	Commercial	GMW	NPRD-085	NPRD-2011	1. A: Failures B: Time	26.0	1069000.0	26.0	2.4E-05	1.4	2.3E-11	0	Environment
Gyroscope,Rate	Military	AA	221001-000	NPRD-2011	1. A: Failures B: Time	0	365464.0	0.5	1.4E-06	5.6	3.7E-12	0	Environment
Gyroscope,Rate	Military	AA	221001-000	NPRD-2011	1. A: Failures B: Time	0	80423.0	0.5	6.2E-06	5.6	7.7E-11	0	Included in Overall
Gyroscope,Rate	Military	AA	221002-000	NPRD-2011	1. A: Failures B: Time	0	76977.0	0.5	6.5E-06	5.6	8.4E-11	0	Included in Overall
Gyroscope,Rate	Military	AA	221003-000	NPRD-2011	1. A: Failures B: Time	0	75869.0	0.5	6.6E-06	5.6	8.7E-11	0	Included in Overall
Gyroscope,Rate	Military	AA	221004-000	NPRD-2011	1. A: Failures B: Time	0	76465.0	0.5	6.5E-06	5.6	8.6E-11	0	Included in Overall
Gyroscope,Rate	Military	AA	221005-000	NPRD-2011	1. A: Failures B: Time	0	55730.0	0.5	9.0E-06	5.6	1.6E-10	0	Included in Overall

Figure F- 13: D-RAD Rate Based Data Sheet for Gyroscopes

Gyroscope,Rate	Military	AI	25199-000	NPRD-2011	1. A: Failures B: Time	1593.0	5937000.0	1,593.0	2.7E-04	1.0	4.5E-11	0	Environment
Gyroscope,Rate	Military	AI	NPRD-082	NPRD-2011	1. A: Failures B: Time	2.0	177000.0	2.0	1.1E-05	2.9	6.4E-11	0	Environment
Gyroscope,Rate	Military	AI	NPRD-106	NPRD-2011	1. A: Failures B: Time	3798.0	8891000.0	3,798.0	4.3E-04	1.0	4.8E-11	0	Environment
Gyroscope,Rate	Military	AIF	16953-000	NPRD-2011	1. A: Failures B: Time	236.0	819000.0	236.0	2.9E-04	1.1	3.5E-10	0	Environment
Gyroscope,Rate	Military	ARW	25199-000	NPRD-2011	1. A: Failures B: Time	56.0	135000.0	56.0	4.1E-04	1.2	3.1E-09	0	Environment
Gyroscope,Rate	Military	ARW	NPRD-091	NPRD-2011	1. A: Failures B: Time	9.0	120000.0	9.0	7.5E-05	1.7	6.3E-10	0	Environment
Gyroscope,Rate	Military	GMW	25199-000	NPRD-2011	1. A: Failures B: Time	67.0	295000.0	67.0	2.3E-04	1.2	7.7E-10	0	Environment
Gyroscope,Rate	Military	GMW	NPRD-050	NPRD-2011	1. A: Failures B: Time	4.0	12000.0	4.0	3.3E-04	2.2	2.8E-08	0	Environment
Gyroscope,Rate	Military	GMW	NPRD-083	NPRD-2011	1. A: Failures B: Time	0	54000.0	0.5	9.3E-06	5.6	1.7E-10	0	Environment
Gyroscope,Rate	Military	GMW	NPRD-084	NPRD-2011	1. A: Failures B: Time	272.0	8437000.0	272.0	3.2E-05	1.1	3.8E-12	0	Environment
Gyroscope,Rate	Military	GMW	NPRD-085	NPRD-2011	1. A: Failures B: Time	0	173000.0	0.5	2.9E-06	5.6	1.7E-11	0	Environment
Gyroscope,Rate	Military	GMW	NPRD-095	NPRD-2011	1. A: Failures B: Time	0	37000.0	0.5	1.4E-05	5.6	3.7E-10	0	Environment
Gyroscope,Rate	Military	GMW	NPRD-104	NPRD-2011	1. A: Failures B: Time	0	9400000.0	0.5	5.3E-08	5.6	5.7E-15	0	Environment
Gyroscope,Rate	Military	GMW	NPRD-106	NPRD-2011	1. A: Failures B: Time	22.0	37000.0	22.0	5.9E-04	1.4	1.6E-08	0	Environment
Gyroscope,Rate	Military	N	221015-000	NPRD-2011	1. A: Failures B: Time	0	21402.0	0.5	2.3E-05	5.6	1.1E-09	1	Included in Overall
Gyroscope,Rate	Military	N	221015-000	NPRD-2011	1. A: Failures B: Time	0	5754.0	0.5	8.7E-05	5.6	1.5E-08	0	Included in Overall
Gyroscope,Rate	Military	N	221016-000	NPRD-2011	1. A: Failures B: Time	0	4080.0	0.5	1.2E-04	5.6	3.0E-08	0	Included in Overall
Gyroscope,Rate	Military	N	221017-000	NPRD-2011	1. A: Failures B: Time	0	3384.0	0.5	1.5E-04	5.6	4.4E-08	0	Included in Overall
Gyroscope,Rate	Military	N	221018-000	NPRD-2011	1. A: Failures B: Time	0	4824.0	0.5	1.0E-04	5.6	2.1E-08	0	Included in Overall
Gyroscope,Rate	Military	N	221019-000	NPRD-2011	1. A: Failures B: Time	0	2904.0	0.5	1.7E-04	5.6	5.9E-08	0	Included in Overall
Gyroscope,Rate	Military	N	221020-000	NPRD-2011	1. A: Failures B: Time	0	456.0	0.5	1.1E-03	5.6	2.4E-06	0	Included in Overall
Gyroscope,Rate	Military	NH	24794-000	NPRD-2011	1. A: Failures B: Time	19.0	8028.0	19.0	2.4E-03	1.5	2.9E-07	0	Out of Expected Range
Gyroscope,Rate	Military	NSB	NPRD-080	NPRD-2011	1. A: Failures B: Time	597.0	8418000.0	597.0	7.1E-05	1.1	8.4E-12	1	

Figure F- 14: D-RAD Rate Based Data Sheet for Gyroscopes (Cont.)

Heat Exchanger **D-RAD Rate Based Data Sheet (per hour)**

Heat Exchanger	← Mode Source FMD-97	Parameters for Lognormal(Mean, EF) and Gamma(α, β)								
Failure Mode	Percent	Mean	Error Factor	α	β	SD	Variance			
Overall Critical Rate	100%	1.5E-05	5.0	6.2E-01	4.1E+04	1.9E-05	3.6E-10			
Leaking	73.9%	1.1E-05	5.0	6.2E-01	5.6E+04	1.4E-05	2.0E-10			
Cracked/Fractured	9.2%	1.4E-06	5.0	6.1E-01	4.4E+05	1.8E-06	3.1E-12			
Clogged/Clogging	7.2%	1.1E-06	5.1	6.1E-01	5.6E+05	1.4E-06	1.9E-12			
Out of Specification	3.6%	5.4E-07	5.1	6.0E-01	1.1E+06	7.0E-07	4.9E-13			
Broken	3.2%	4.8E-07	5.1	6.0E-01	1.2E+06	6.2E-07	3.9E-13			
Leakage	2.8%	4.2E-07	5.1	5.9E-01	1.4E+06	5.5E-07	3.0E-13			
Leakage (FSY-HEX-PLG and FWC-HEX-PLG)	**84%**	1.26E-05	5.01	6.2E-01	4.9E+04	1.6E-05	2.6E-10			Leaking+ Clogged/Clogging+ Leakage
		Records Used		42	Failures Used		1,087.8			

Name	Field 1 (Data Sources)	Field 2	Location	Source	Data Type	A	B	Implicit Failures	Mean	EF	Variance	Data Selector	Comment
Heat Exchanger	Overall Critical Rate	pg. 283	Taxonomy 3.1	OREDA V1	2. A: Mean B: SD	1.6E-05	1.7E-05	0.9	1.6E-05	4.2	3.0E-10	1	
Heat Exchanger	Overall Critical Rate	pg. 283	Taxonomy 3.1	OREDA V1	2. A: Mean B: SD	1.7E-05	1.9E-05	0.8	1.7E-05	4.4	3.8E-10	1	
Heat Exchanger, Plate	Overall Critical Rate	pg. 285	Taxonomy 3.1.1	OREDA V1	2. A: Mean B: SD	2.7E-05	1.1E-05	6.0	2.7E-05	1.9	1.2E-10	1	
Heat Exchanger, Plate	Overall Critical Rate	pg. 285	Taxonomy 3.1.1	OREDA V1	2. A: Mean B: SD	2.7E-05	1.1E-05	6.0	2.7E-05	1.9	1.2E-10	1	
Heat Exchanger, Shell and Tube	Overall Critical Rate	pg. 292	Taxonomy 3.1.3	OREDA V1	2. A: Mean B: SD	2.3E-05	2.4E-05	0.9	2.3E-05	4.2	5.9E-10	1	
Heat Exchanger, Shell and Tube	Overall Critical Rate	pg. 292	Taxonomy 3.1.3	OREDA V1	2. A: Mean B: SD	2.5E-05	2.9E-05	0.8	2.5E-05	4.5	8.3E-10	1	
Heat Exchanger, Shell and Tube	Overall Critical Rate	pg. 295	Taxonomy 3.1.3.2	OREDA V1	2. A: Mean B: SD	4.4E-05	1.3E-05	12.0	4.4E-05	1.6	1.6E-10	1	
Heat Exchanger, Shell and Tube	Overall Critical Rate	pg. 295	Taxonomy 3.1.3.2	OREDA V1	2. A: Mean B: SD	6.0E-05	1.7E-05	12.0	6.0E-05	1.6	3.0E-10	1	
Heat Exchanger	Commercial	AUC	NPRD-090	NPRD-2011	1. A: Failures B: Time	649.0	13969000.0	649.0	4.6E-05	1.1	3.3E-12	1	
Heat Exchanger	Commercial	AUC	NPRD-096	NPRD-2011	1. A: Failures B: Time	12.0	320000.0	12.0	3.8E-05	1.6	1.2E-10	1	
Heat Exchanger	Commercial	AUC	NPRD-098	NPRD-2011	1. A: Failures B: Time	7.0	1310000.0	7.0	5.3E-06	1.8	4.1E-12	1	
Heat Exchanger	Commercial	GF	23047-019	NPRD-2011	1. A: Failures B: Time	6.0	294178.0	6.0	2.0E-05	1.9	6.9E-11	1	
Heat Exchanger	Commercial	GF	23047-028	NPRD-2011	1. A: Failures B: Time	0	291704.0	0.5	1.7E-06	5.6	5.9E-12	1	
Heat Exchanger	Commercial	GF	23047-037	NPRD-2011	1. A: Failures B: Time	0	352080.0	0.5	1.4E-06	5.6	4.0E-12	1	
Heat Exchanger	Commercial	GF	23047-038	NPRD-2011	1. A: Failures B: Time	0	684000.0	0.5	7.3E-07	5.6	1.1E-12	1	
Heat Exchanger	Commercial	GF	23047-050	NPRD-2011	1. A: Failures B: Time	0	990040.0	0.5	5.1E-07	5.6	5.1E-13	1	
Heat Exchanger	Commercial	GF	23047-064	NPRD-2011	1. A: Failures B: Time	0	367104.0	0.5	1.4E-06	5.6	3.7E-12	1	
Heat Exchanger	Commercial	GF	23047-071	NPRD-2011	1. A: Failures B: Time	5.0	2561760.0	5.0	2.0E-06	2.0	7.6E-13	1	
Heat Exchanger	Military	AU	NPRD-082	NPRD-2011	1. A: Failures B: Time	1.0	20000.0	1.0	5.0E-05	3.9	2.5E-09	0	Sparse
Heat Exchanger	Military	AU	NPRD-106	NPRD-2011	1. A: Failures B: Time	133.0	9279000.0	133.0	1.4E-05	1.2	1.5E-12	1	
Heat Exchanger	Military	AUC	16953-000	NPRD-2011	1. A: Failures B: Time	2.0	117000.0	2.0	1.7E-05	2.9	1.5E-10	1	
Heat Exchanger	Military	AUF	16953-000	NPRD-2011	1. A: Failures B: Time	7.0	117000.0	7.0	6.0E-05	1.8	5.1E-10	1	
Heat Exchanger	Military	GF	NPRD-054	NPRD-2011	1. A: Failures B: Time	3.0	3318000.0	3.0	9.0E-07	2.4	2.7E-13	1	
Heat Exchanger	Military	GM	10812-000	NPRD-2011	1. A: Failures B: Time	6.0	1548000.0	6.0	3.9E-06	1.9	2.5E-12	1	
Heat Exchanger	Military	GM	NPRD-106	NPRD-2011	1. A: Failures B: Time	3.0	4354000.0	3.0	6.9E-07	2.4	1.6E-13	1	
Heat Exchanger	Military	N/R	25199-000	NPRD-2011	1. A: Failures B: Time	505.0	452369000.0	505.0	1.1E-06	1.1	2.5E-15	0	Environment
Heat Exchanger	Military	NS	23005-000	NPRD-2011	1. A: Failures B: Time	0	549408.0	0.5	9.1E-07	5.6	1.7E-12	0	Environment
Heat Exchanger	Military	NSB	NPRD-080	NPRD-2011	1. A: Failures B: Time	0	206000.0	0.5	2.4E-06	5.6	1.2E-11	0	Environment
Heat Exchanger	Military	SF	10219-034	NPRD-2011	1. A: Failures B: Time	0	7000.0	0.5	7.1E-05	5.6	1.0E-08	0	Sparse
Heat Exchanger	Unknown	AUT	18459-000	NPRD-2011	1. A: Failures B: Time	12.0	440316.0	12.0	2.7E-05	1.6	6.2E-11	1	
Heat Exchanger	Unknown	GF	18354-000	NPRD-2011	1. A: Failures B: Time	148.0	5011066.0	148.0	3.0E-05	1.1	5.9E-12	1	
Heat Exchanger	Unknown	GF	18459-000	NPRD-2011	1. A: Failures B: Time	2.0	625000.0	2.0	3.2E-06	2.9	5.1E-12	1	
Heat Exchanger	Unknown	GM	18459-000	NPRD-2011	1. A: Failures B: Time	3.0	272121.0	3.0	1.1E-05	2.4	4.1E-11	1	
Heat Exchanger	Unknown	NS	18459-000	NPRD-2011	1. A: Failures B: Time	20.0	1449899.0	20.0	1.4E-05	1.4	9.5E-12	0	Environment

Figure F- 14: D-RAD Rate Based Data Sheet for Heat Exchangers

Heat Exchanger Assembly	Military	N	221021-000	NPRD-2011	1. A: Failures B: Time	0	71472.0	0.5	7.0E-06	5.6	9.8E-11	1	Overall
Heat Exchanger Assembly	Military	N	221021-000	NPRD-2011	1. A: Failures B: Time	0	3672.0	0.5	1.4E-04	5.6	3.7E-08	0	Included in Overall
Heat Exchanger Assembly	Military	N	221022-000	NPRD-2011	1. A: Failures B: Time	0	11064.0	0.5	4.5E-05	5.6	4.1E-09	0	Included in Overall
Heat Exchanger Assembly	Military	N	221023-000	NPRD-2011	1. A: Failures B: Time	0	8736.0	0.5	5.7E-05	5.6	6.6E-09	0	Included in Overall
Heat Exchanger Assembly	Military	N	221024-000	NPRD-2011	1. A: Failures B: Time	0	5832.0	0.5	8.6E-05	5.6	1.5E-08	0	Included in Overall
Heat Exchanger Assembly	Military	N	221025-000	NPRD-2011	1. A: Failures B: Time	0	7776.0	0.5	6.4E-05	5.6	8.3E-09	0	Included in Overall
Heat Exchanger Assembly	Military	N	221026-000	NPRD-2011	1. A: Failures B: Time	0	5112.0	0.5	9.8E-05	5.6	1.9E-08	0	Included in Overall
Heat Exchanger Assembly	Military	N	221027-000	NPRD-2011	1. A: Failures B: Time	0	4224.0	0.5	1.2E-04	5.6	2.8E-08	0	Included in Overall
Heat Exchanger Assembly	Military	N	221028-000	NPRD-2011	1. A: Failures B: Time	0	8304.0	0.5	6.0E-05	5.6	7.3E-09	0	Included in Overall
Heat Exchanger Assembly	Military	N	221029-000	NPRD-2011	1. A: Failures B: Time	0	3600.0	0.5	1.4E-04	5.6	3.9E-08	0	Included in Overall
Heat Exchanger Assembly	Military	N	221030-000	NPRD-2011	1. A: Failures B: Time	0	8016.0	0.5	6.2E-05	5.6	7.8E-09	0	Included in Overall
Heat Exchanger Assembly	Military	N	221031-000	NPRD-2011	1. A: Failures B: Time	0	5136.0	0.5	9.7E-05	5.6	1.9E-08	0	Included in Overall
Heat Exchanger,Air To Air,Aircraft	Military	AUA	221001-000	NPRD-2011	1. A: Failures B: Time	24.0	1461856.0	24.0	1.6E-05	1.4	1.1E-11	1	Overall
Heat Exchanger,Air To Air,Aircraft	Military	AUA	221001-000	NPRD-2011	1. A: Failures B: Time	2.0	321692.0	2.0	6.2E-06	2.9	1.9E-11	0	Included in Overall
Heat Exchanger,Air To Air,Aircraft	Military	AUA	221002-000	NPRD-2011	1. A: Failures B: Time	4.0	307908.0	4.0	1.3E-05	2.2	4.2E-11	0	Included in Overall
Heat Exchanger,Air To Air,Aircraft	Military	AUA	221003-000	NPRD-2011	1. A: Failures B: Time	9.0	303476.0	9.0	3.0E-05	1.7	9.8E-11	0	Included in Overall
Heat Exchanger,Air To Air,Aircraft	Military	AUA	221004-000	NPRD-2011	1. A: Failures B: Time	4.0	305860.0	4.0	1.3E-05	2.2	4.3E-11	0	Included in Overall
Heat Exchanger,Air To Air,Aircraft	Military	AUA	221005-000	NPRD-2011	1. A: Failures B: Time	5.0	222920.0	5.0	2.2E-05	2.0	1.0E-10	0	Included in Overall
Heat Exchanger,Radiator	Unknown	GF	18354-000	NPRD-2011	1. A: Failures B: Time	7.0	888000.0	7.0	7.9E-06	1.8	8.9E-12	1	
Heat Exchanger,Radiator	Unknown	GM	18459-000	NPRD-2011	1. A: Failures B: Time	3.0	360586.0	3.0	8.3E-06	2.4	2.3E-11	1	
Heat Exchanger,Water	Commercial	GF	23047-005	NPRD-2011	1. A: Failures B: Time	0	240480.0	0.5	2.1E-06	5.6	8.6E-12	1	
Heat Exchanger,Water	Commercial	GF	23047-033	NPRD-2011	1. A: Failures B: Time	3.0	1330752.0	3.0	2.3E-06	2.4	1.7E-12	1	
Heat Exchanger,Water	Commercial	GF	23047-050	NPRD-2011	1. A: Failures B: Time	0	1189104.0	0.5	4.2E-07	5.6	3.5E-13	1	
Heat Exchanger,Water	Commercial	GF	23047-051	NPRD-2011	1. A: Failures B: Time	0	104208.0	0.5	4.8E-06	5.6	4.6E-11	1	
Heat Exchanger,Water	Commercial	GF	23047-052	NPRD-2011	1. A: Failures B: Time	0	96112.0	0.5	5.2E-06	5.6	5.4E-11	1	
Heat Exchanger,Water	Commercial	GF	23047-062	NPRD-2011	1. A: Failures B: Time	0	77208.0	0.5	6.5E-06	5.6	8.4E-11	1	
Heat Exchanger,Water	Commercial	GF	23047-063	NPRD-2011	1. A: Failures B: Time	0	77184.0	0.5	6.5E-06	5.6	8.4E-11	1	
Heat Exchanger,Water	Commercial	GF	23047-068	NPRD-2011	1. A: Failures B: Time	1.0	49312.0	1.0	2.0E-05	3.9	4.1E-10	1	
Heat Exchanger,Water	Unknown	NS	18459-000	NPRD-2011	1. A: Failures B: Time	5.0	20000.0	5.0	2.5E-04	2.0	1.3E-08	0	Out of Expected Range
Heat Exchangers	Military	AIF	18212-000	NPRD-2011	1. A: Failures B: Time	0	77626.0	0.5	6.4E-06	5.6	8.3E-11	1	
Heat Exchangers	Military	AUF	13514-000	NPRD-2011	1. A: Failures B: Time	6.0	450900.0	6.0	1.3E-05	1.9	3.0E-11	1	

Figure F- 15: D-RAD Rate Based Data Sheet for Heat Exchangers (Cont.)

Inverter, Power **D-RAD Rate Based Data Sheet (per hour)**

Inverter, Power	← Mode Source FMD-2011	Parameters for Lognormal(Mean, EF) and Gamma(α, β)					
Failure Mode	**Percent**	**Mean**	**Error Factor**	**α**	**β**	**SD**	**Variance**
Overall Critical Rate (ELS-TRF-FOF)	100%	7.20E-06	6.05	4.3E-01	6.0E+04	1.1E-05	1.2E-10
Out Of Specification	58%	4.2E-06	6.2	4.2E-01	1.0E+05	6.5E-06	4.2E-11
Overheated	20.0%	1.4E-06	6.7	3.6E-01	2.5E+05	2.4E-06	5.8E-12
No operation	16.6%	1.2E-06	6.9	3.4E-01	2.8E+05	2.0E-06	4.2E-12
Contamination	5.5%	4.0E-07	8.5	2.2E-01	5.7E+05	8.4E-07	7.0E-13
		Records Used		9	Failures Used		25.5

Name	Field 1	Field 2	Location	Source	Data Type	A	B	Implicit Failures	Mean	EF	Variance	Data Selector	Comment
Inverter,Power	23047-009	Commercial	GF	NPRD-2011	1. A: Failures B: Time	0	375176.0	0.5	1.3E-06	5.6	3.6E-12	1	
Inverter,Power	23047-020	Commercial	GF	NPRD-2011	1. A: Failures B: Time	1.0	456072.0	1.0	2.2E-06	3.9	4.8E-12	1	
Inverter,Power	23047-028	Commercial	GF	NPRD-2011	1. A: Failures B: Time	1.0	232966.0	1.0	4.3E-06	3.9	1.8E-11	1	
Inverter,Power	23047-048	Commercial	GF	NPRD-2011	1. A: Failures B: Time	1.0	52968.0	1.0	1.9E-05	3.9	3.6E-10	1	
Inverter,Power	23047-050	Commercial	GF	NPRD-2011	1. A: Failures B: Time	12.0	1327860.0	12.0	9.0E-06	1.6	6.8E-12	1	
Inverter,Power	23047-062	Commercial	GF	NPRD-2011	1. A: Failures B: Time	8.0	386035.0	8.0	2.1E-05	1.8	5.4E-11	1	
Inverter,Power	23047-070	Commercial	GF	NPRD-2011	1. A: Failures B: Time	0	569088.0	0.5	8.8E-07	5.6	1.5E-12	1	
Inverter,Power	23047-090	Commercial	GF	NPRD-2011	1. A: Failures B: Time	1.0	2160365.0	1.0	4.6E-07	3.9	2.1E-13	1	
Regulator,Inverter	221021-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	71472.0	0.5	7.0E-06	5.6	9.8E-11	1	Overall
Regulator,Inverter	221021-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	3672.0	0.5	1.4E-04	5.6	3.7E-08	0	Included in Overall
Regulator,Inverter	221022-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	11064.0	0.5	4.5E-05	5.6	4.1E-09	0	Included in Overall
Regulator,Inverter	221023-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	8736.0	0.5	5.7E-05	5.6	6.6E-09	0	Included in Overall
Regulator,Inverter	221024-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	5832.0	0.5	8.6E-05	5.6	1.5E-08	0	Included in Overall
Regulator,Inverter	221025-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	7776.0	0.5	6.4E-05	5.6	8.3E-09	0	Included in Overall
Regulator,Inverter	221026-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	5112.0	0.5	9.8E-05	5.6	1.9E-08	0	Included in Overall
Regulator,Inverter	221027-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	4224.0	0.5	1.2E-04	5.6	2.8E-08	0	Included in Overall
Regulator,Inverter	221028-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	8304.0	0.5	6.0E-05	5.6	7.3E-09	0	Included in Overall
Regulator,Inverter	221029-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	3600.0	0.5	1.4E-04	5.6	3.9E-08	0	Included in Overall
Regulator,Inverter	221030-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	8016.0	0.5	6.2E-05	5.6	7.8E-09	0	Included in Overall
Regulator,Inverter	221031-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	5136.0	0.5	9.7E-05	5.6	1.9E-08	0	Included in Overall

Figure F- 15: D-RAD Rate Based Data Sheet for Power Inverters

Joystick **D-RAD Rate Based Data Sheet (per hour)**

Joystick	← Mode Source FMD-2011	Parameters for Lognormal(Mean, EF) and Gamma(α, β)					
Failure Mode	Percent	Mean	Error Factor	α	β	SD	Variance
Overall Critical Rate	100%	1.3E-05	7.1	3.2E-01	2.5E+04	2.3E-05	5.3E-10
Broken (DPS-JOY-FOP)	100%	1.30E-05	7.09E+00	3.2E-01	2.5E+04	2.3E-05	5.3E-10
		Records Used	3		Failures Used	3.0	

Name	Data Sources Field 1	Field 2	Location	Source	Data Type	A	B	Implicit Failures	Mean	EF	Variance	Data Selector	Comment
Joystick	23037-000	Military	GM	NPRD-2011	1. A: Failures B: Time	0	481388.0	0.5	1.0E-06	5.6	2.2E-12	1	
Joystick	221015-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	21402.0	0.5	2.3E-05	5.6	1.1E-09	1	Overall
Joystick	221015-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	5754.0	0.5	8.7E-05	5.6	1.5E-08	0	Included in Overall
Joystick	221016-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	4080.0	0.5	1.2E-04	5.6	3.0E-08	0	Included in Overall
Joystick	221017-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	3384.0	0.5	1.5E-04	5.6	4.4E-08	0	Included in Overall
Joystick	221018-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	4824.0	0.5	1.0E-04	5.6	2.1E-08	0	Included in Overall
Joystick	221019-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	2904.0	0.5	1.7E-04	5.6	5.9E-08	0	Included in Overall
Joystick	221020-000	Military	N	NPRD-2011	1. A: Failures B: Time	0	456.0	0.5	1.1E-03	5.6	2.4E-06	0	Included in Overall
Joystick	23005-000	Military	NS	NPRD-2011	1. A: Failures B: Time	2.0	138102.0	2.0	1.4E-05	2.9	1.0E-10	1	

Figure F- 16: D-RAD Rate Based Data Sheet for Joysticks

Latch D-RAD Rate Based Data Sheet (per hour)

Fasteners and Hardware, Latch Assembly ← Mode Source		Parameters for Lognormal(Mean, EF) and Gamma(α, β)					
Failure Mode	Percent	Mean	Error Factor	α	β	SD	Variance
Overall Critical Rate	100%	4.6E-06	6.0	4.4E-01	9.6E+04	6.9E-06	4.8E-11
Inoperative	40%	1.8E-06	6.2	4.1E-01	2.3E+05	2.8E-06	8.1E-12
Broken	20%	9.1E-07	6.5	3.7E-01	4.1E+05	1.5E-06	2.2E-12
Cracked	20%	9.1E-07	6.5	3.7E-01	4.1E+05	1.5E-06	2.2E-12
Worn	20%	9.1E-07	6.5	3.7E-01	4.1E+05	1.5E-06	2.2E-12
Fails* (CYL-FTC-PRLK)	60%	2.74E-06	6.10	4.3E-01	1.6E+05	4.2E-06	1.8E-11
		Records Used	18	Failures Used	32.0		

Name	Field 1	Field 2	Location	Source	Data Type	A	B	Implicit Failures	Mean	EF	Variance	Data Selector	Comment
Latch	Military	ARW	221006-000	NPRD-2011	1. A: Failures B: Time	0	185269.0	0.5	2.7E-06	5.6	1.5E-11	1	Environment
Latch	Military	ARW	221006-000	NPRD-2011	1. A: Failures B: Time	0	185269.0	0.5	2.7E-06	5.6	1.5E-11	0	Included in Overall
Latch	Military	ARW	221007-000	NPRD-2011	1. A: Failures B: Time	0	188202.0	0.5	2.7E-06	5.6	1.4E-11	0	Included in Overall
Latch	Military	ARW	221008-000	NPRD-2011	1. A: Failures B: Time	0	188321.0	0.5	2.7E-06	5.6	1.4E-11	0	Included in Overall
Latch	Military	ARW	221009-000	NPRD-2011	1. A: Failures B: Time	0	178500.0	0.5	2.8E-06	5.6	1.6E-11	0	Included in Overall
Latch	Military	ARW	221010-000	NPRD-2011	1. A: Failures B: Time	0	189602.0	0.5	2.6E-06	5.6	1.4E-11	0	Included in Overall
Latch	Military	ARW	221011-000	NPRD-2011	1. A: Failures B: Time	0	197029.0	0.5	2.5E-06	5.6	1.3E-11	0	Included in Overall
Latch	Military	ARW	221012-000	NPRD-2011	1. A: Failures B: Time	0	185332.0	0.5	2.7E-06	5.6	1.5E-11	0	Included in Overall
Latch	Military	ARW	221013-000	NPRD-2011	1. A: Failures B: Time	0	171983.0	0.5	2.9E-06	5.6	1.7E-11	0	Included in Overall
Latch	Military	ARW	221014-000	NPRD-2011	1. A: Failures B: Time	0	147623.0	0.5	3.4E-06	5.6	2.3E-11	0	Included in Overall
Latch Assembly	Military	AA	221001-000	NPRD-2011	1. A: Failures B: Time	0	1461856.0	0.5	3.4E-07	5.6	2.3E-13	1	Overall
Latch Assembly	Military	AA	221001-000	NPRD-2011	1. A: Failures B: Time	0	321692.0	0.5	1.6E-06	5.6	4.8E-12	0	Included in Overall
Latch Assembly	Military	AA	221002-000	NPRD-2011	1. A: Failures B: Time	0	307908.0	0.5	1.6E-06	5.6	5.3E-12	0	Included in Overall
Latch Assembly	Military	AA	221003-000	NPRD-2011	1. A: Failures B: Time	0	303476.0	0.5	1.6E-06	5.6	5.4E-12	0	Included in Overall
Latch Assembly	Military	AA	221004-000	NPRD-2011	1. A: Failures B: Time	0	305860.0	0.5	1.6E-06	5.6	5.3E-12	0	Included in Overall
Latch Assembly	Military	AA	221005-000	NPRD-2011	1. A: Failures B: Time	0	222920.0	0.5	2.2E-06	5.6	1.0E-11	0	Included in Overall
Latch Assembly	Military	AUA	221001-000	NPRD-2011	1. A: Failures B: Time	4.0	1096392.0	4.0	3.6E-06	2.2	3.3E-12	1	Overall
Latch Assembly	Military	AUA	221001-000	NPRD-2011	1. A: Failures B: Time	1.0	241269.0	1.0	4.1E-06	3.9	1.7E-11	0	Included in Overall
Latch Assembly	Military	AUA	221002-000	NPRD-2011	1. A: Failures B: Time	3.0	230931.0	3.0	1.3E-05	2.4	5.6E-11	0	Included in Overall
Latch Assembly	Military	AUA	221003-000	NPRD-2011	1. A: Failures B: Time	0	227607.0	0.5	2.2E-06	5.6	9.7E-12	0	Included in Overall
Latch Assembly	Military	AUA	221004-000	NPRD-2011	1. A: Failures B: Time	0	229395.0	0.5	2.2E-06	5.6	9.5E-12	0	Included in Overall
Latch Assembly	Military	AUA	221005-000	NPRD-2011	1. A: Failures B: Time	0	167190.0	0.5	3.0E-06	5.6	1.8E-11	0	Included in Overall
Latch Assembly	Military	N	221021-000	NPRD-2011	1. A: Failures B: Time	0	71472.0	0.5	7.0E-06	5.6	9.8E-11	1	Overall
Latch Assembly	Military	N	221021-000	NPRD-2011	1. A: Failures B: Time	0	3672.0	0.5	1.4E-04	5.6	3.7E-08	0	Included in Overall
Latch Assembly	Military	N	221022-000	NPRD-2011	1. A: Failures B: Time	0	11064.0	0.5	4.5E-05	5.6	4.1E-09	0	Included in Overall
Latch Assembly	Military	N	221023-000	NPRD-2011	1. A: Failures B: Time	0	8736.0	0.5	5.7E-05	5.6	6.6E-09	0	Included in Overall
Latch Assembly	Military	N	221024-000	NPRD-2011	1. A: Failures B: Time	0	5832.0	0.5	8.6E-05	5.6	1.5E-08	0	Included in Overall
Latch Assembly	Military	N	221025-000	NPRD-2011	1. A: Failures B: Time	0	7776.0	0.5	6.4E-05	5.6	8.3E-09	0	Included in Overall
Latch Assembly	Military	N	221026-000	NPRD-2011	1. A: Failures B: Time	0	5112.0	0.5	9.8E-05	5.6	1.9E-08	0	Included in Overall
Latch Assembly	Military	N	221027-000	NPRD-2011	1. A: Failures B: Time	0	4224.0	0.5	1.2E-04	5.6	2.8E-08	0	Included in Overall
Latch Assembly	Military	N	221028-000	NPRD-2011	1. A: Failures B: Time	0	8304.0	0.5	6.0E-05	5.6	7.3E-09	0	Included in Overall
Latch Assembly	Military	N	221029-000	NPRD-2011	1. A: Failures B: Time	0	3600.0	0.5	1.4E-04	5.6	3.9E-08	0	Included in Overall
Latch Assembly	Military	N	221030-000	NPRD-2011	1. A: Failures B: Time	0	8016.0	0.5	6.2E-05	5.6	7.8E-09	0	Included in Overall
Latch Assembly	Military	N	221031-000	NPRD-2011	1. A: Failures B: Time	0	5136.0	0.5	9.7E-05	5.6	1.9E-08	0	Included in Overall
Latch Assembly,Aircraft	Military	AUA	221001-000	NPRD-2011	1. A: Failures B: Time	3.0	730928.0	3.0	4.1E-06	2.4	5.6E-12	1	Overall
Latch Assembly,Aircraft	Military	AUA	221001-000	NPRD-2011	1. A: Failures B: Time	0	160846.0	0.5	3.1E-06	5.6	1.9E-11	0	Included in Overall
Latch Assembly,Aircraft	Military	AUA	221002-000	NPRD-2011	1. A: Failures B: Time	0	153954.0	0.5	3.2E-06	5.6	2.1E-11	0	Included in Overall
Latch Assembly,Aircraft	Military	AUA	221003-000	NPRD-2011	1. A: Failures B: Time	1.0	151738.0	1.0	6.6E-06	3.9	4.3E-11	0	Included in Overall
Latch Assembly,Aircraft	Military	AUA	221004-000	NPRD-2011	1. A: Failures B: Time	1.0	152930.0	1.0	6.5E-06	3.9	4.3E-11	0	Included in Overall
Latch Assembly,Aircraft	Military	AUA	221005-000	NPRD-2011	1. A: Failures B: Time	1.0	111460.0	1.0	9.0E-06	3.9	8.0E-11	0	Included in Overall

Figure F- 17: D-RAD Rate Based Data Sheet for Latches

Latch,Door	Military	ARW	221006-000	NPRD-2011	1. A: Failures B: Time	0	699369.0	0.5	7.1E-07	5.6	1.0E-12	1	Overall
Latch,Door	Military	ARW	221006-000	NPRD-2011	1. A: Failures B: Time	0	79401.0	0.5	6.3E-06	5.6	7.9E-11	0	Included in Overall
Latch,Door	Military	ARW	221007-000	NPRD-2011	1. A: Failures B: Time	0	80658.0	0.5	6.2E-06	5.6	7.7E-11	0	Included in Overall
Latch,Door	Military	ARW	221008-000	NPRD-2011	1. A: Failures B: Time	0	80709.0	0.5	6.2E-06	5.6	7.7E-11	0	Included in Overall
Latch,Door	Military	ARW	221009-000	NPRD-2011	1. A: Failures B: Time	0	76500.0	0.5	6.5E-06	5.6	8.5E-11	0	Included in Overall
Latch,Door	Military	ARW	221010-000	NPRD-2011	1. A: Failures B: Time	0	81258.0	0.5	6.2E-06	5.6	7.6E-11	0	Included in Overall
Latch,Door	Military	ARW	221011-000	NPRD-2011	1. A: Failures B: Time	0	84441.0	0.5	5.9E-06	5.6	7.0E-11	0	Included in Overall
Latch,Door	Military	ARW	221012-000	NPRD-2011	1. A: Failures B: Time	0	79428.0	0.5	6.3E-06	5.6	7.9E-11	0	Included in Overall
Latch,Door	Military	ARW	221013-000	NPRD-2011	1. A: Failures B: Time	0	73707.0	0.5	6.8E-06	5.6	9.2E-11	0	Included in Overall
Latch,Door	Military	ARW	221014-000	NPRD-2011	1. A: Failures B: Time	0	63267.0	0.5	7.9E-06	5.6	1.2E-10	0	Included in Overall
Latch,Rotary	Military	ARW	221006-000	NPRD-2011	1. A: Failures B: Time	0	466246.0	0.5	1.1E-06	5.6	2.3E-12	1	Overall
Latch,Rotary	Military	ARW	221006-000	NPRD-2011	1. A: Failures B: Time	0	52934.0	0.5	9.4E-06	5.6	1.8E-10	0	Included in Overall
Latch,Rotary	Military	ARW	221007-000	NPRD-2011	1. A: Failures B: Time	0	53772.0	0.5	9.3E-06	5.6	1.7E-10	0	Included in Overall
Latch,Rotary	Military	ARW	221008-000	NPRD-2011	1. A: Failures B: Time	0	53806.0	0.5	9.3E-06	5.6	1.7E-10	0	Included in Overall
Latch,Rotary	Military	ARW	221009-000	NPRD-2011	1. A: Failures B: Time	0	51000.0	0.5	9.8E-06	5.6	1.9E-10	0	Included in Overall
Latch,Rotary	Military	ARW	221010-000	NPRD-2011	1. A: Failures B: Time	0	54172.0	0.5	9.2E-06	5.6	1.7E-10	0	Included in Overall
Latch,Rotary	Military	ARW	221011-000	NPRD-2011	1. A: Failures B: Time	0	56294.0	0.5	8.9E-06	5.6	1.6E-10	0	Included in Overall
Latch,Rotary	Military	ARW	221012-000	NPRD-2011	1. A: Failures B: Time	0	52952.0	0.5	9.4E-06	5.6	1.8E-10	0	Included in Overall
Latch,Rotary	Military	ARW	221013-000	NPRD-2011	1. A: Failures B: Time	0	49138.0	0.5	1.0E-05	5.6	2.1E-10	0	Included in Overall
Latch,Rotary	Military	ARW	221014-000	NPRD-2011	1. A: Failures B: Time	0	42178.0	0.5	1.2E-05	5.6	2.8E-10	0	Included in Overall
Lever Assembly,Latch	Military	AA	221001-000	NPRD-2011	1. A: Failures B: Time	0	1461856.0	0.5	3.4E-07	5.6	2.3E-13	1	Overall
Lever Assembly,Latch	Military	AA	221001-000	NPRD-2011	1. A: Failures B: Time	0	321692.0	0.5	1.6E-06	5.6	4.8E-12	0	Included in Overall
Lever Assembly,Latch	Military	AA	221002-000	NPRD-2011	1. A: Failures B: Time	0	307908.0	0.5	1.6E-06	5.6	5.3E-12	0	Included in Overall
Lever Assembly,Latch	Military	AA	221003-000	NPRD-2011	1. A: Failures B: Time	0	303476.0	0.5	1.6E-06	5.6	5.4E-12	0	Included in Overall
Lever Assembly,Latch	Military	AA	221004-000	NPRD-2011	1. A: Failures B: Time	0	305860.0	0.5	1.6E-06	5.6	5.3E-12	0	Included in Overall
Lever Assembly,Latch	Military	AA	221005-000	NPRD-2011	1. A: Failures B: Time	0	222920.0	0.5	2.2E-06	5.6	1.0E-11	0	Included in Overall
Side,Latch	Military	ARW	221006-000	NPRD-2011	1. A: Failures B: Time	0	233123.0	0.5	2.1E-06	5.6	9.2E-12	1	Overall
Side,Latch	Military	ARW	221006-000	NPRD-2011	1. A: Failures B: Time	0	26467.0	0.5	1.9E-05	5.6	7.1E-10	0	Included in Overall
Side,Latch	Military	ARW	221007-000	NPRD-2011	1. A: Failures B: Time	0	26886.0	0.5	1.9E-05	5.6	6.9E-10	0	Included in Overall
Side,Latch	Military	ARW	221008-000	NPRD-2011	1. A: Failures B: Time	0	26903.0	0.5	1.9E-05	5.6	6.9E-10	0	Included in Overall
Side,Latch	Military	ARW	221009-000	NPRD-2011	1. A: Failures B: Time	0	25500.0	0.5	2.0E-05	5.6	7.7E-10	0	Included in Overall
Side,Latch	Military	ARW	221010-000	NPRD-2011	1. A: Failures B: Time	0	27086.0	0.5	1.8E-05	5.6	6.8E-10	0	Included in Overall
Side,Latch	Military	ARW	221011-000	NPRD-2011	1. A: Failures B: Time	0	28147.0	0.5	1.8E-05	5.6	6.3E-10	0	Included in Overall
Side,Latch	Military	ARW	221012-000	NPRD-2011	1. A: Failures B: Time	0	26476.0	0.5	1.9E-05	5.6	7.1E-10	0	Included in Overall
Side,Latch	Military	ARW	221013-000	NPRD-2011	1. A: Failures B: Time	0	24569.0	0.5	2.0E-05	5.6	8.3E-10	0	Included in Overall
Side,Latch	Military	ARW	221014-000	NPRD-2011	1. A: Failures B: Time	0	21089.0	0.5	2.4E-05	5.6	1.1E-09	0	Included in Overall
Support,Latch	Military	ARW	221006-000	NPRD-2011	1. A: Failures B: Time	0	233123.0	0.5	2.1E-06	5.6	9.2E-12	1	Overall
Support,Latch	Military	ARW	221006-000	NPRD-2011	1. A: Failures B: Time	0	26467.0	0.5	1.9E-05	5.6	7.1E-10	0	Included in Overall
Support,Latch	Military	ARW	221007-000	NPRD-2011	1. A: Failures B: Time	0	26886.0	0.5	1.9E-05	5.6	6.9E-10	0	Included in Overall
Support,Latch	Military	ARW	221008-000	NPRD-2011	1. A: Failures B: Time	0	26903.0	0.5	1.9E-05	5.6	6.9E-10	0	Included in Overall
Support,Latch	Military	ARW	221009-000	NPRD-2011	1. A: Failures B: Time	0	25500.0	0.5	2.0E-05	5.6	7.7E-10	0	Included in Overall
Support,Latch	Military	ARW	221010-000	NPRD-2011	1. A: Failures B: Time	0	27086.0	0.5	1.8E-05	5.6	6.8E-10	0	Included in Overall
Support,Latch	Military	ARW	221011-000	NPRD-2011	1. A: Failures B: Time	0	28147.0	0.5	1.8E-05	5.6	6.3E-10	0	Included in Overall
Support,Latch	Military	ARW	221012-000	NPRD-2011	1. A: Failures B: Time	0	26476.0	0.5	1.9E-05	5.6	7.1E-10	0	Included in Overall
Support,Latch	Military	ARW	221013-000	NPRD-2011	1. A: Failures B: Time	0	24569.0	0.5	2.0E-05	5.6	8.3E-10	0	Included in Overall
Support,Latch	Military	ARW	221014-000	NPRD-2011	1. A: Failures B: Time	0	21089.0	0.5	2.4E-05	5.6	1.1E-09	0	Included in Overall
Arm,Latch	Military	ARW	221006-000	NPRD-2011	1. A: Failures B: Time	0	233123.0	0.5	2.1E-06	5.6	9.2E-12	1	Overall
Arm,Latch	Military	ARW	221006-000	NPRD-2011	1. A: Failures B: Time	0	26467.0	0.5	1.9E-05	5.6	7.1E-10	0	Included in Overall
Arm,Latch	Military	ARW	221007-000	NPRD-2011	1. A: Failures B: Time	0	26886.0	0.5	1.9E-05	5.6	6.9E-10	0	Included in Overall
Arm,Latch	Military	ARW	221008-000	NPRD-2011	1. A: Failures B: Time	0	26903.0	0.5	1.9E-05	5.6	6.9E-10	0	Included in Overall
Arm,Latch	Military	ARW	221009-000	NPRD-2011	1. A: Failures B: Time	0	25500.0	0.5	2.0E-05	5.6	7.7E-10	0	Included in Overall
Arm,Latch	Military	ARW	221010-000	NPRD-2011	1. A: Failures B: Time	0	27086.0	0.5	1.8E-05	5.6	6.8E-10	0	Included in Overall
Arm,Latch	Military	ARW	221011-000	NPRD-2011	1. A: Failures B: Time	0	28147.0	0.5	1.8E-05	5.6	6.3E-10	0	Included in Overall
Arm,Latch	Military	ARW	221012-000	NPRD-2011	1. A: Failures B: Time	0	26476.0	0.5	1.9E-05	5.6	7.1E-10	0	Included in Overall
Arm,Latch	Military	ARW	221013-000	NPRD-2011	1. A: Failures B: Time	0	24569.0	0.5	2.0E-05	5.6	8.3E-10	0	Included in Overall
Arm,Latch	Military	ARW	221014-000	NPRD-2011	1. A: Failures B: Time	0	21089.0	0.5	2.4E-05	5.6	1.1E-09	0	Included in Overall

Figure F- 18: D-RAD Rate Based Data Sheet for Latches (Cont.)

Cam,Latch,Cargo	Military	ARW	221006-000	NPRD-2011	1. A: Failures B: Time	0	233123.0	0.5	2.1E-06	5.6	9.2E-12	1	Overall
Cam,Latch,Cargo	Military	ARW	221006-000	NPRD-2011	1. A: Failures B: Time	0	26467.0	0.5	1.9E-05	5.6	7.1E-10	0	Included in Overall
Cam,Latch,Cargo	Military	ARW	221007-000	NPRD-2011	1. A: Failures B: Time	0	26886.0	0.5	1.9E-05	5.6	6.9E-10	0	Included in Overall
Cam,Latch,Cargo	Military	ARW	221008-000	NPRD-2011	1. A: Failures B: Time	0	26903.0	0.5	1.9E-05	5.6	6.9E-10	0	Included in Overall
Cam,Latch,Cargo	Military	ARW	221009-000	NPRD-2011	1. A: Failures B: Time	0	25500.0	0.5	2.0E-05	5.6	7.7E-10	0	Included in Overall
Cam,Latch,Cargo	Military	ARW	221010-000	NPRD-2011	1. A: Failures B: Time	0	27086.0	0.5	1.8E-05	5.6	6.8E-10	0	Included in Overall
Cam,Latch,Cargo	Military	ARW	221011-000	NPRD-2011	1. A: Failures B: Time	0	28147.0	0.5	1.8E-05	5.6	6.3E-10	0	Included in Overall
Cam,Latch,Cargo	Military	ARW	221012-000	NPRD-2011	1. A: Failures B: Time	0	26476.0	0.5	1.9E-05	5.6	7.1E-10	0	Included in Overall
Cam,Latch,Cargo	Military	ARW	221013-000	NPRD-2011	1. A: Failures B: Time	0	24569.0	0.5	2.0E-05	5.6	8.3E-10	0	Included in Overall
Cam,Latch,Cargo	Military	ARW	221014-000	NPRD-2011	1. A: Failures B: Time	0	21089.0	0.5	2.4E-05	5.6	1.1E-09	0	Included in Overall
Crank,Latch	Military	ARW	221006-000	NPRD-2011	1. A: Failures B: Time	0	466246.0	0.5	1.1E-06	5.6	2.3E-12	1	Overall
Crank,Latch	Military	ARW	221006-000	NPRD-2011	1. A: Failures B: Time	0	52934.0	0.5	9.4E-06	5.6	1.8E-10	0	Included in Overall
Crank,Latch	Military	ARW	221007-000	NPRD-2011	1. A: Failures B: Time	0	53772.0	0.5	9.3E-06	5.6	1.7E-10	0	Included in Overall
Crank,Latch	Military	ARW	221008-000	NPRD-2011	1. A: Failures B: Time	0	53806.0	0.5	9.3E-06	5.6	1.7E-10	0	Included in Overall
Crank,Latch	Military	ARW	221009-000	NPRD-2011	1. A: Failures B: Time	0	51000.0	0.5	9.8E-06	5.6	1.9E-10	0	Included in Overall
Crank,Latch	Military	ARW	221010-000	NPRD-2011	1. A: Failures B: Time	0	54172.0	0.5	9.2E-06	5.6	1.7E-10	0	Included in Overall
Crank,Latch	Military	ARW	221011-000	NPRD-2011	1. A: Failures B: Time	0	56294.0	0.5	8.9E-06	5.6	1.6E-10	0	Included in Overall
Crank,Latch	Military	ARW	221012-000	NPRD-2011	1. A: Failures B: Time	0	52952.0	0.5	9.4E-06	5.6	1.8E-10	0	Included in Overall
Crank,Latch	Military	ARW	221013-000	NPRD-2011	1. A: Failures B: Time	0	49138.0	0.5	1.0E-05	5.6	2.1E-10	0	Included in Overall
Crank,Latch	Military	ARW	221014-000	NPRD-2011	1. A: Failures B: Time	0	42178.0	0.5	1.2E-05	5.6	2.8E-10	0	Included in Overall
Handle Assembly,Latch	Military	AUA	221001-000	NPRD-2011	1. A: Failures B: Time	4.0	365464.0	4.0	1.1E-05	2.2	3.0E-11	1	Overall
Handle Assembly,Latch	Military	AUA	221001-000	NPRD-2011	1. A: Failures B: Time	2.0	80423.0	2.0	2.5E-05	2.9	3.1E-10	0	Included in Overall
Handle Assembly,Latch	Military	AUA	221002-000	NPRD-2011	1. A: Failures B: Time	2.0	76977.0	2.0	2.6E-05	2.9	3.4E-10	0	Included in Overall
Handle Assembly,Latch	Military	AUA	221003-000	NPRD-2011	1. A: Failures B: Time	0	75869.0	0.5	6.6E-06	5.6	8.7E-11	0	Included in Overall
Handle Assembly,Latch	Military	AUA	221004-000	NPRD-2011	1. A: Failures B: Time	0	76465.0	0.5	6.5E-06	5.6	8.6E-11	0	Included in Overall
Handle Assembly,Latch	Military	AUA	221005-000	NPRD-2011	1. A: Failures B: Time	0	55730.0	0.5	9.0E-06	5.6	1.6E-10	0	Included in Overall
Housing Assembly,Latch	Military	AUA	221001-000	NPRD-2011	1. A: Failures B: Time	6.0	365464.0	6.0	1.6E-05	1.9	4.5E-11	1	Overall
Housing Assembly,Latch	Military	AUA	221001-000	NPRD-2011	1. A: Failures B: Time	0	80423.0	0.5	6.2E-06	5.6	7.7E-11	0	Included in Overall
Housing Assembly,Latch	Military	AUA	221002-000	NPRD-2011	1. A: Failures B: Time	6.0	76977.0	6.0	7.8E-05	1.9	1.0E-09	0	Included in Overall
Housing Assembly,Latch	Military	AUA	221003-000	NPRD-2011	1. A: Failures B: Time	0	75869.0	0.5	6.6E-06	5.6	8.7E-11	0	Included in Overall
Housing Assembly,Latch	Military	AUA	221004-000	NPRD-2011	1. A: Failures B: Time	0	76465.0	0.5	6.5E-06	5.6	8.6E-11	0	Included in Overall
Housing Assembly,Latch	Military	AUA	221005-000	NPRD-2011	1. A: Failures B: Time	0	55730.0	0.5	9.0E-06	5.6	1.6E-10	0	Included in Overall
Housing Latch Assembly	Military	AUA	221001-000	NPRD-2011	1. A: Failures B: Time	7.0	365464.0	7.0	1.9E-05	1.8	5.2E-11	1	Overall
Housing Latch Assembly	Military	AUA	221001-000	NPRD-2011	1. A: Failures B: Time	2.0	80423.0	2.0	2.5E-05	2.9	3.1E-10	0	Included in Overall
Housing Latch Assembly	Military	AUA	221002-000	NPRD-2011	1. A: Failures B: Time	5.0	76977.0	5.0	6.5E-05	2.0	8.4E-10	0	Included in Overall
Housing Latch Assembly	Military	AUA	221003-000	NPRD-2011	1. A: Failures B: Time	0	75869.0	0.5	6.6E-06	5.6	8.7E-11	0	Included in Overall
Housing Latch Assembly	Military	AUA	221004-000	NPRD-2011	1. A: Failures B: Time	0	76465.0	0.5	6.5E-06	5.6	8.6E-11	0	Included in Overall
Housing Latch Assembly	Military	AUA	221005-000	NPRD-2011	1. A: Failures B: Time	0	55730.0	0.5	9.0E-06	5.6	1.6E-10	0	Included in Overall
Keeper Assembly,Latch	Military	AA	221001-000	NPRD-2011	1. A: Failures B: Time	0	730928.0	0.5	6.8E-07	5.6	9.4E-13	1	Overall
Keeper Assembly,Latch	Military	AA	221001-000	NPRD-2011	1. A: Failures B: Time	0	160846.0	0.5	3.1E-06	5.6	1.9E-11	0	Included in Overall
Keeper Assembly,Latch	Military	AA	221002-000	NPRD-2011	1. A: Failures B: Time	0	153954.0	0.5	3.2E-06	5.6	2.1E-11	0	Included in Overall
Keeper Assembly,Latch	Military	AA	221003-000	NPRD-2011	1. A: Failures B: Time	0	151738.0	0.5	3.3E-06	5.6	2.2E-11	0	Included in Overall
Keeper Assembly,Latch	Military	AA	221004-000	NPRD-2011	1. A: Failures B: Time	0	152930.0	0.5	3.3E-06	5.6	2.1E-11	0	Included in Overall
Keeper Assembly,Latch	Military	AA	221005-000	NPRD-2011	1. A: Failures B: Time	0	111460.0	0.5	4.5E-06	5.6	4.0E-11	0	Included in Overall
Keeper,Tension Latch	Military	AUA	221001-000	NPRD-2011	1. A: Failures B: Time	2.0	365464.0	2.0	5.5E-06	2.9	1.5E-11	1	Overall
Keeper,Tension Latch	Military	AUA	221001-000	NPRD-2011	1. A: Failures B: Time	1.0	80423.0	1.0	1.2E-05	3.9	1.5E-10	0	Included in Overall
Keeper,Tension Latch	Military	AUA	221002-000	NPRD-2011	1. A: Failures B: Time	0	76977.0	0.5	6.5E-06	5.6	8.4E-11	0	Included in Overall
Keeper,Tension Latch	Military	AUA	221003-000	NPRD-2011	1. A: Failures B: Time	0	75869.0	0.5	6.6E-06	5.6	8.7E-11	0	Included in Overall
Keeper,Tension Latch	Military	AUA	221004-000	NPRD-2011	1. A: Failures B: Time	1.0	76465.0	1.0	1.3E-05	3.9	1.7E-10	0	Included in Overall
Keeper,Tension Latch	Military	AUA	221005-000	NPRD-2011	1. A: Failures B: Time	0	55730.0	0.5	9.0E-06	5.6	1.6E-10	0	Included in Overall

Figure F- 18: D-RAD Rate Based Data Sheet for Latches (Cont.)

Module, Electronic — **D-RAD Rate Based Data Sheet (per hour)**

OREDA-2015	← Mode Source	Parameters for Lognormal(Mean, EF) and Gamma(α, β)						
Failure Mode	**Percent**	**Mean**	**Error Factor**	**α**	**β**	**SD**	**Variance**	
Overall Critical Rate	100%	5.0E-05	10.5	1.5E-01	3.0E+03	1.3E-04	1.7E-08	
Combined/Common Cause	0.4%	1.8E-07	26.8	1.9E-02	1.0E+05	1.3E-06	1.8E-12	
Control/Signal Failure	78.7%	3.9E-05	10.5	1.5E-01	3.8E+03	1.0E-04	1.1E-08	
Fail to Function on Demand	10.6%	5.3E-06	11.5	1.2E-01	2.3E+04	1.5E-05	2.3E-10	
Insufficient Power	1.6%	8.2E-07	16.4	5.9E-02	7.2E+04	3.4E-06	1.1E-11	
Short Circuit	1.5%	7.4E-07	16.9	5.5E-02	7.5E+04	3.1E-06	9.8E-12	
Spurious Operation	4.5%	2.3E-06	13.0	9.7E-02	4.3E+04	7.3E-06	5.3E-11	
Other Failure Mode	2.8%	1.4E-06	14.3	7.9E-02	5.7E+04	4.9E-06	2.4E-11	
Fails to Operate (SEM-FOP)	95.5%	4.79E-05	10.5	1.5E-01	3.1E+03	1.2E-04	1.5E-08	CC + Signal Failure + F to F on Demand + Insuff Power + Short Circuit + Other
		Records Used		8	**Failures Used**		44.0	

Name	Data Sources Field 1	Field 2	Location	Source	Data Type	A	B	Implicit Failures	Mean	EF	Variance	Data Selector	Comment
Module, Electronic	Overall Critical Rate	5.1	p61	OREDA-2015	2. A: Mean B: SD	7.9E-06	2.5E-05	0.1	7.9E-06	12.6	6.1E-10	1	Overall
Module, Electronic	Combined/Common Cause	5.1	p61	OREDA-2015	2. A: Mean B: SD	4.0E-08	1.7E-07	0.1	4.0E-08	16.8	2.9E-14	0	Included in Overall
Module, Electronic	Control/Signal Failure	5.1	p61	OREDA-2015	2. A: Mean B: SD	6.1E-06	2.5E-05	0.1	6.1E-06	16.0	6.0E-10	0	Included in Overall
Module, Electronic	Fail to Function on Demand	5.1	p61	OREDA-2015	2. A: Mean B: SD	5.7E-07	6.7E-07	0.7	5.7E-07	4.6	4.5E-13	0	Included in Overall
Module, Electronic	Insufficient Power	5.1	p61	OREDA-2015	2. A: Mean B: SD	3.0E-08	9.0E-08	0.11	3.0E-08	12.1	8.1E-15	0	Included in Overall
Module, Electronic	Short Circuit	5.1	p61	OREDA-2015	2. A: Mean B: SD	8.0E-08	2.8E-07	0.1	8.0E-08	14.1	7.8E-14	0	Included in Overall
Module, Electronic	Spurious Operation	5.1	p61	OREDA-2015	2. A: Mean B: SD	7.8E-07	1.9E-06	0.2	7.8E-07	9.7	3.5E-12	0	Included in Overall
Module, Electronic	Other Failure Mode	5.1	p61	OREDA-2015	2. A: Mean B: SD	9.0E-08	1.1E-07	0.7	9.0E-08	4.8	1.2E-14	0	Included in Overall
Module, Electronic	Overall Critical Rate	5.1.1	p80	OREDA-2015	2. A: Mean B: SD	6.4E-06	4.2E-06	2.3	6.4E-06	2.7	1.8E-11	1	Overall
Module, Electronic	Control/Signal Failure	5.1.1	p80	OREDA-2015	2. A: Mean B: SD	5.4E-06	3.8E-06	2.0	5.4E-06	2.9	1.5E-11	0	Included in Overall
Module, Electronic	Fail to Function on Demand	5.1.1	p80	OREDA-2015	2. A: Mean B: SD	6.3E-07	7.1E-07	0.8	6.3E-07	4.4	5.0E-13	0	Included in Overall
Module, Electronic	Spurious Operation	5.1.1	p80	OREDA-2015	2. A: Mean B: SD	6.3E-07	7.1E-07	0.8	6.3E-07	4.4	5.0E-13	0	Included in Overall
Module, Electronic	Overall Critical Rate	5.1.2	p87	OREDA-2015	2. A: Mean B: SD	4.8E-06	1.7E-05	0.1	4.8E-06	14.1	2.8E-10	1	Overall
Module, Electronic	Combined/Common Cause	5.1.2	p87	OREDA-2015	2. A: Mean B: SD	1.0E-07	2.7E-07	0.1	1.0E-07	10.9	7.3E-14	0	Included in Overall
Module, Electronic	Control/Signal Failure	5.1.2	p87	OREDA-2015	2. A: Mean B: SD	4.3E-06	1.7E-05	0.1	4.3E-06	15.8	2.9E-10	0	Included in Overall
Module, Electronic	Fail to Function on Demand	5.1.2	p87	OREDA-2015	2. A: Mean B: SD	2.3E-07	9.0E-07	0.1	2.3E-07	15.6	8.1E-13	0	Included in Overall
Module, Electronic	Short Circuit	5.1.2	p87	OREDA-2015	2. A: Mean B: SD	1.1E-07	4.1E-07	0.1	1.1E-07	14.9	1.7E-13	0	Included in Overall
Module, Electronic	Spurious Operation	5.1.2	p87	OREDA-2015	2. A: Mean B: SD	1.0E-07	2.6E-07	0.1	1.0E-07	10.5	6.8E-14	0	Included in Overall
Module, Electronic	Overall Critical Rate	5.1.3	p91	OREDA-2015	2. A: Mean B: SD	7.1E-07	8.0E-07	0.8	7.1E-07	4.4	6.4E-13	1	Overall
Module, Electronic	Fail to Function on Demand	5.1.3	p91	OREDA-2015	2. A: Mean B: SD	7.1E-07	8.0E-07	0.8	7.1E-07	4.4	6.4E-13	0	Included in Overall
Module, Electronic	Overall Critical Rate	5.1.4	p93	OREDA-2015	2. A: Mean B: SD	3.7E-04	5.9E-05	39.0	3.7E-04	1.3	3.4E-09	1	Overall
Module, Electronic	Control/Signal Failure	5.1.4	p93	OREDA-2015	2. A: Mean B: SD	3.7E-04	5.9E-05	39.0	3.7E-04	1.3	3.4E-09	0	Included in Overall
Module, Electronic	Overall Critical Rate	5.1.5	p97	OREDA-2015	2. A: Mean B: SD	5.7E-06	2.6E-05	0.0	5.7E-06	18.0	6.8E-10	1	Overall
Module, Electronic	Control/Signal Failure	5.1.5	p97	OREDA-2015	2. A: Mean B: SD	5.2E-06	2.6E-05	0.0	5.2E-06	19.6	6.7E-10	0	Included in Overall
Module, Electronic	Fail to Function on Demand	5.1.5	p97	OREDA-2015	2. A: Mean B: SD	6.8E-07	5.0E-07	1.8	6.8E-07	2.9	2.5E-13	0	Included in Overall
Module, Electronic	Short Circuit	5.1.5	p97	OREDA-2015	2. A: Mean B: SD	1.5E-07	1.9E-07	0.6	1.5E-07	5.0	3.6E-14	0	Included in Overall
Module, Electronic	Spurious Operation	5.1.5	p97	OREDA-2015	2. A: Mean B: SD	1.3E-07	2.7E-07	0.2	1.3E-07	8.4	7.3E-14	0	Included in Overall
Module, Electronic	Other Failure Mode	5.1.5	p97	OREDA-2015	2. A: Mean B: SD	2.4E-07	2.7E-07	0.8	2.4E-07	4.4	7.3E-14	0	Included in Overall
Module, Electronic	Overall Critical Rate	5.1.6	p103	OREDA-2015	2. A: Mean B: SD	6.2E-06	7.2E-06	0.7	6.2E-06	4.6	5.2E-11	1	Overall
Module, Electronic	Control/Signal Failure	5.1.6	p103	OREDA-2015	2. A: Mean B: SD	3.0E-07	4.2E-07	0.5	3.0E-07	5.5	1.8E-13	0	Included in Overall
Module, Electronic	Fail to Function on Demand	5.1.6	p103	OREDA-2015	2. A: Mean B: SD	8.1E-07	1.8E-06	0.2	8.1E-07	8.7	3.1E-12	0	Included in Overall
Module, Electronic	Insufficient Power	5.1.6	p103	OREDA-2015	2. A: Mean B: SD	2.6E-07	3.0E-07	0.8	2.6E-07	4.5	9.0E-14	0	Included in Overall
Module, Electronic	Spurious Operation	5.1.6	p103	OREDA-2015	2. A: Mean B: SD	5.1E-06	6.1E-06	0.7	5.1E-06	4.7	3.8E-11	0	Included in Overall
Module, Electronic	Overall Critical Rate	5.1.7	p108	OREDA-2015	2. A: Mean B: SD	4.6E-06	4.6E-06	1.0	4.6E-06	3.9	2.1E-11	1	Overall
Module, Electronic	Fail to function on demand	5.1.7	p108	OREDA-2015	2. A: Mean B: SD	3.4E-06	3.1E-06	1.2	3.4E-06	3.6	9.7E-12	0	Included in Overall
Module, Electronic	Spurious operation	5.1.7	p108	OREDA-2015	2. A: Mean B: SD	8.4E-07	1.4E-06	0.3	8.4E-07	6.8	2.0E-12	0	Included in Overall

Figure F- 19: D-RAD Rate Based Data Sheet for Electronic Modules

Power Supply, Uninterruptible — **D-RAD Rate Based Data Sheet (per hour)**

Power Supply, Uninterruptible	← Mode Source FMD-2016	Parameters for Lognormal(Mean, EF) and Gamma(α, β)						
Failure Mode	**Percent**	**Mean**	**Error Factor**	**α**	**β**	**SD**	**Variance**	
Overall Critical Rate	100%	2.0E-05	9.9	1.7E-01	8.5E+03	4.8E-05	2.3E-09	
Improper Output	32%	6.4E-06	9.9	1.7E-01	2.6E+04	1.6E-05	2.4E-10	
Drift	22.1%	4.4E-06	10.0	1.7E-01	3.8E+04	1.1E-05	1.1E-10	
Broken	15.7%	3.1E-06	10.0	1.6E-01	5.3E+04	7.6E-06	5.8E-11	
Electrical Failure	12.0%	2.4E-06	10.0	1.6E-01	6.9E+04	5.9E-06	3.4E-11	
No Operation	11.7%	2.3E-06	10.0	1.6E-01	7.1E+04	5.7E-06	3.3E-11	
Intermittent	6%	1.2E-06	10.1	1.6E-01	1.3E+05	3.1E-06	9.7E-12	
Fails to Operate (ELS-UPS-FOF)	**72%**	1.41E-05	9.90	1.7E-01	1.2E+04	3.5E-05	1.2E-09	Improper Output+Broken+Elect Failure+No Op
		Records Used	**45**		**Failures Used**	**377.5**		

Name	Field 1 (Data Sources)	Field 2	Location	Source	Data Type	A	B	Implicit Failures	Mean	EF	Variance	Data Selector	Comment
Power Supply,Uninterruptable	221015-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	21402.0	0.5	2.3E-05	5.6	1.1E-09	1	Overall
Power Supply,Uninterruptable	221015-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	5754.0	0.5	8.7E-05	5.6	1.5E-08	0	Included in Overall
Power Supply,Uninterruptable	221016-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	4080.0	0.5	1.2E-04	5.6	3.0E-08	0	Included in Overall
Power Supply,Uninterruptable	221017-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	3384.0	0.5	1.5E-04	5.6	4.4E-08	0	Included in Overall
Power Supply,Uninterruptable	221018-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	4824.0	0.5	1.0E-04	5.6	2.1E-08	0	Included in Overall
Power Supply,Uninterruptable	221019-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	2904.0	0.5	1.7E-04	5.6	5.9E-08	0	Included in Overall
Power Supply,Uninterruptable	221020-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	456.0	0.5	1.1E-03	5.6	2.4E-06	0	Included in Overall
Power Supply,Uninterruptable	800105-000	Military	N	NPRD-2016	1. A: Failures B: Time	110.0	68587320.0	110.0	1.6E-06	1.2	2.3E-14	1	Overall
Power Supply,Uninterruptable	800105-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	2324147.0	0.5	2.2E-07	5.6	9.3E-14	0	Included in Overall
Power Supply,Uninterruptable	800106-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	12572544.0	0.5	4.0E-08	5.6	3.2E-15	0	Included in Overall
Power Supply,Uninterruptable	800107-000	Military	N	NPRD-2016	1. A: Failures B: Time	7.0	20665603.0	7.0	3.4E-07	1.8	1.6E-14	0	Included in Overall
Power Supply,Uninterruptable	800108-000	Military	N	NPRD-2016	1. A: Failures B: Time	103.0	33025026.0	103.0	3.1E-06	1.2	9.4E-14	1	Overall
Power Supply,Uninterruptable,Rackmount	800105-000	Military	N	NPRD-2016	1. A: Failures B: Time	439.0	16555560.0	439.0	2.7E-05	1.1	1.6E-12	0	Included in Overall
Power Supply,Uninterruptable,Rackmount	800105-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	561001.0	0.5	8.9E-07	5.6	1.6E-12	0	Included in Overall
Power Supply,Uninterruptable,Rackmount	800106-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	3034752.0	0.5	1.6E-07	5.6	5.4E-14	0	Included in Overall
Power Supply,Uninterruptable,Rackmount	800107-000	Military	N	NPRD-2016	1. A: Failures B: Time	50.0	4988249.0	50.0	1.0E-05	1.3	2.0E-12	0	Included in Overall
Power Supply,Uninterruptable,Rackmount	800108-000	Military	N	NPRD-2016	1. A: Failures B: Time	389.0	7971558.0	389.0	4.9E-05	1.1	6.1E-12	0	Included in Overall
Power Supply,Uninterruptible	800109-000	Commercial	AC	NPRD-2016	1. A: Failures B: Time	0	5742496.0	0.5	8.7E-08	5.6	1.5E-14	1	Overall
Power Supply,Uninterruptible	800109-000	Commercial	AC	NPRD-2016	1. A: Failures B: Time	0	534704.0	0.5	9.4E-07	5.6	1.7E-12	0	Included in Overall
Power Supply,Uninterruptible	800110-000	Commercial	AC	NPRD-2016	1. A: Failures B: Time	0	574852.0	0.5	8.7E-07	5.6	1.5E-12	0	Included in Overall
Power Supply,Uninterruptible	800111-000	Commercial	AC	NPRD-2016	1. A: Failures B: Time	0	634304.0	0.5	7.9E-07	5.6	1.2E-12	0	Included in Overall
Power Supply,Uninterruptible	800112-000	Commercial	AC	NPRD-2016	1. A: Failures B: Time	0	691912.0	0.5	7.2E-07	5.6	1.0E-12	0	Included in Overall
Power Supply,Uninterruptible	800113-000	Commercial	AC	NPRD-2016	1. A: Failures B: Time	0	638240.0	0.5	7.8E-07	5.6	1.2E-12	0	Included in Overall
Power Supply,Uninterruptible	800114-000	Commercial	AC	NPRD-2016	1. A: Failures B: Time	0	602340.0	0.5	8.3E-07	5.6	1.4E-12	0	Included in Overall
Power Supply,Uninterruptible	800115-000	Commercial	AC	NPRD-2016	1. A: Failures B: Time	0	545968.0	0.5	9.2E-07	5.6	1.7E-12	0	Included in Overall
Power Supply,Uninterruptible	800116-000	Commercial	AC	NPRD-2016	1. A: Failures B: Time	0	529730.0	0.5	9.4E-07	5.6	1.8E-12	0	Included in Overall
Power Supply,Uninterruptible	800117-000	Commercial	AC	NPRD-2016	1. A: Failures B: Time	0	501140.0	0.5	1.0E-06	5.6	2.0E-12	0	Included in Overall
Power Supply,Uninterruptible	800118-000	Commercial	AC	NPRD-2016	1. A: Failures B: Time	0	489306.0	0.5	1.0E-06	5.6	2.1E-12	0	Included in Overall
Power Supply,Uninterruptible	23047-009	Commercial	GF	NPRD-2016	1. A: Failures B: Time	0	1117108.0	0.5	4.5E-07	5.6	4.0E-13	1	
Power Supply,Uninterruptible	23047-016	Commercial	GF	NPRD-2016	1. A: Failures B: Time	0	107760.0	0.5	4.6E-06	5.6	4.3E-11	1	
Power Supply,Uninterruptible	23047-019	Commercial	GF	NPRD-2016	1. A: Failures B: Time	0	60144.0	0.5	8.3E-06	5.6	1.4E-10	1	
Power Supply,Uninterruptible	23047-028	Commercial	GF	NPRD-2016	1. A: Failures B: Time	1.0	97468.0	1.0	1.0E-05	3.9	1.1E-10	1	
Power Supply,Uninterruptible	23047-038	Commercial	GF	NPRD-2016	1. A: Failures B: Time	0	1002960.0	0.5	5.0E-07	5.6	5.0E-13	1	
Power Supply,Uninterruptible	23047-041	Commercial	GF	NPRD-2016	1. A: Failures B: Time	0	211776.0	0.5	2.4E-06	5.6	1.1E-11	1	
Power Supply,Uninterruptible	23047-050	Commercial	GF	NPRD-2016	1. A: Failures B: Time	0	279480.0	0.5	1.8E-06	5.6	6.4E-12	1	
Power Supply,Uninterruptible	23047-058	Commercial	GF	NPRD-2016	1. A: Failures B: Time	1.0	128685.0	1.0	7.8E-06	3.9	6.0E-11	1	
Power Supply,Uninterruptible	23047-063	Commercial	GF	NPRD-2016	1. A: Failures B: Time	4.0	1031608.0	4.0	3.9E-06	2.2	3.8E-12	1	
Power Supply,Uninterruptible	23047-083	Commercial	GF	NPRD-2016	1. A: Failures B: Time	1.0	233164.0	1.0	4.3E-06	3.9	1.8E-11	1	
Power Supply,Uninterruptible	800105-000	Commercial	N	NPRD-2016	1. A: Failures B: Time	2.0	2365080.0	2.0	8.5E-07	2.9	3.6E-13	1	Overall
Power Supply,Uninterruptible	800105-000	Commercial	N	NPRD-2016	1. A: Failures B: Time	0	80143.0	0.5	6.2E-06	5.6	7.8E-11	0	Included in Overall
Power Supply,Uninterruptible	800106-000	Commercial	N	NPRD-2016	1. A: Failures B: Time	1.0	433536.0	1.0	2.3E-06	3.9	5.3E-12	0	Included in Overall
Power Supply,Uninterruptible	800107-000	Commercial	N	NPRD-2016	1. A: Failures B: Time	1.0	712607.0	1.0	1.4E-06	3.9	2.0E-12	0	Included in Overall
Power Supply,Uninterruptible	800108-000	Commercial	N	NPRD-2016	1. A: Failures B: Time	0	1138794.0	0.5	4.4E-07	5.6	3.9E-13	0	Included in Overall

Figure F- 20: D-RAD Rate Based Data Sheet for Uninterruptible Power Supplies

Power Supply,Uninterruptible,Rotary	23047-012	Commercial	GF	NPRD-2016	1. A: Failures B: Time	10.0	378864.0	10.0	2.6E-05	1.7	7.0E-11	1	
Power Supply,Uninterruptible,Rotary	23047-028	Commercial	GF	NPRD-2016	1. A: Failures B: Time	5.0	994752.0	5.0	5.0E-06	2.0	5.1E-12	1	
Power Supply,Uninterruptible,Rotary	23047-049	Commercial	GF	NPRD-2016	1. A: Failures B: Time	2.0	876792.0	2.0	2.3E-06	2.9	2.6E-12	1	
Power Supply,Uninterruptible,Rotary	23047-070	Commercial	GF	NPRD-2016	1. A: Failures B: Time	2.0	193870.0	2.0	1.0E-05	2.9	5.3E-11	1	
Power Supply,Uninterruptible,Rotary	23047-090	Commercial	GF	NPRD-2016	1. A: Failures B: Time	0	916062.0	0.5	5.5E-07	5.6	6.0E-13	1	
Power Supply,Uninterruptible,Rotary	23047-099	Commercial	GF	NPRD-2016	1. A: Failures B: Time	0	96264.0	0.5	5.2E-06	5.6	5.4E-11	1	
Power Supply,Uninterruptible,Rotary	23047-100	Commercial	GF	NPRD-2016	1. A: Failures B: Time	14.0	96240.0	14.0	1.5E-04	1.5	1.5E-09	1	
Power Supply,Uninterruptible,Rotary	23047-103	Commercial	GF	NPRD-2016	1. A: Failures B: Time	25.0	129312.0	25.0	1.9E-04	1.4	1.5E-09	1	
Power Supply,Uninterruptible,Rotary	23047-104	Commercial	GF	NPRD-2016	1. A: Failures B: Time	3.0	192480.0	3.0	1.6E-05	2.4	8.1E-11	1	
Power Supply,Uninterruptible,Rotary	23047-111	Commercial	GF	NPRD-2016	1. A: Failures B: Time	41.0	192480.0	41.0	2.1E-04	1.3	1.1E-09	1	
Power Supply,Uninterruptible,Rotary	23047-115	Commercial	GF	NPRD-2016	1. A: Failures B: Time	16.0	588240.0	16.0	2.7E-05	1.5	4.6E-11	1	
Power Supply,Uninterruptible,Rotary	23047-116	Commercial	GF	NPRD-2016	1. A: Failures B: Time	17.0	288720.0	17.0	5.9E-05	1.5	2.0E-10	1	
Power Supply,Uninterruptible,Solid State	23047-005	Commercial	GF	NPRD-2016	1. A: Failures B: Time	0	319344.0	0.5	1.6E-06	5.6	4.9E-12	1	
Power Supply,Uninterruptible,Solid State	23047-020	Commercial	GF	NPRD-2016	1. A: Failures B: Time	1.0	795824.0	1.0	1.3E-06	3.9	1.6E-12	1	
Power Supply,Uninterruptible,Solid State	23047-025	Commercial	GF	NPRD-2016	1. A: Failures B: Time	0	343008.0	0.5	1.5E-06	5.6	4.2E-12	1	
Power Supply,Uninterruptible,Solid State	23047-038	Commercial	GF	NPRD-2016	1. A: Failures B: Time	0	86040.0	0.5	5.8E-06	5.6	6.8E-11	1	
Power Supply,Uninterruptible,Solid State	23047-041	Commercial	GF	NPRD-2016	1. A: Failures B: Time	2.0	141040.0	2.0	1.4E-05	2.9	1.0E-10	1	
Power Supply,Uninterruptible,Solid State	23047-048	Commercial	GF	NPRD-2016	1. A: Failures B: Time	0	52968.0	0.5	9.4E-06	5.6	1.8E-10	1	
Power Supply,Uninterruptible,Solid State	23047-061	Commercial	GF	NPRD-2016	1. A: Failures B: Time	0	94464.0	0.5	5.3E-06	5.6	5.6E-11	1	
Power Supply,Uninterruptible,Solid State	23047-062	Commercial	GF	NPRD-2016	1. A: Failures B: Time	0	1158120.0	0.5	4.3E-07	5.6	3.7E-13	1	
Power Supply,Uninterruptible,Solid State	23047-063	Commercial	GF	NPRD-2016	1. A: Failures B: Time	0	684240.0	0.5	7.3E-07	5.6	1.1E-12	1	
Power Supply,Uninterruptible,Solid State	23047-067	Commercial	GF	NPRD-2016	1. A: Failures B: Time	1.0	43384.0	1.0	2.3E-05	3.9	5.3E-10	1	
Power Supply,Uninterruptible,Solid State	23047-070	Commercial	GF	NPRD-2016	1. A: Failures B: Time	0	315186.0	0.5	1.6E-06	5.6	5.0E-12	1	
Power Supply,Uninterruptible,Solid State	23047-071	Commercial	GF	NPRD-2016	1. A: Failures B: Time	0	341568.0	0.5	1.5E-06	5.6	4.3E-12	1	
Power Supply,Uninterruptible,Solid State	23047-083	Commercial	GF	NPRD-2016	1. A: Failures B: Time	1.0	116471.0	1.0	8.6E-06	3.9	7.4E-11	1	
Power Supply,Uninterruptible,Solid State	23047-090	Commercial	GF	NPRD-2016	1. A: Failures B: Time	0	1546760.0	0.5	3.2E-07	5.6	2.1E-13	1	
Power Supply,Uninterruptible,Solid State	23047-106	Commercial	GF	NPRD-2016	1. A: Failures B: Time	0	876240.0	0.5	5.7E-07	5.6	6.5E-13	1	
Power Supply,Uninterruptible,Solid State	23047-115	Commercial	GF	NPRD-2016	1. A: Failures B: Time	4.0	784320.0	4.0	5.1E-06	2.2	6.5E-12	1	
Uninterruptible Power Supply	221021-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	71472.0	0.5	7.0E-06	5.6	9.8E-11	1	Included in Overall
Uninterruptible Power Supply	221021-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	3672.0	0.5	1.4E-04	5.6	3.7E-08	0	Included in Overall
Uninterruptible Power Supply	221022-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	11064.0	0.5	4.5E-05	5.6	4.1E-09	0	Included in Overall
Uninterruptible Power Supply	221023-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	8736.0	0.5	5.7E-05	5.6	6.6E-09	0	Included in Overall
Uninterruptible Power Supply	221024-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	5832.0	0.5	8.6E-05	5.6	1.5E-08	0	Included in Overall
Uninterruptible Power Supply	221025-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	7776.0	0.5	6.4E-05	5.6	8.3E-09	0	Included in Overall
Uninterruptible Power Supply	221026-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	5112.0	0.5	9.8E-05	5.6	1.9E-08	0	Included in Overall
Uninterruptible Power Supply	221027-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	4224.0	0.5	1.2E-04	5.6	2.8E-08	0	Included in Overall
Uninterruptible Power Supply	221028-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	8304.0	0.5	6.0E-05	5.6	7.3E-09	0	Included in Overall
Uninterruptible Power Supply	221029-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	3600.0	0.5	1.4E-04	5.6	3.9E-08	0	Included in Overall
Uninterruptible Power Supply	221030-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	8016.0	0.5	6.2E-05	5.6	7.8E-09	0	Included in Overall
Uninterruptible Power Supply	221031-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	5136.0	0.5	9.7E-05	5.6	1.9E-08	0	Included in Overall
Uninterruptible Power Supply,Rackmount	221015-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	21402.0	0.5	2.3E-05	5.6	1.1E-09	1	Overall
Uninterruptible Power Supply,Rackmount	221015-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	5754.0	0.5	8.7E-05	5.6	1.5E-08	0	Included in Overall
Uninterruptible Power Supply,Rackmount	221016-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	4080.0	0.5	1.2E-04	5.6	3.0E-08	0	Included in Overall
Uninterruptible Power Supply,Rackmount	221017-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	3384.0	0.5	1.5E-04	5.6	4.4E-08	0	Included in Overall
Uninterruptible Power Supply,Rackmount	221018-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	4824.0	0.5	1.0E-04	5.6	2.1E-08	0	Included in Overall
Uninterruptible Power Supply,Rackmount	221019-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	2904.0	0.5	1.7E-04	5.6	5.9E-08	0	Included in Overall
Uninterruptible Power Supply,Rackmount	221020-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	456.0	0.5	1.1E-03	5.6	2.4E-06	0	Included in Overall

Figure F- 20: D-RAD Rate Based Data Sheet for Uninterruptible Power Supplies (Cont.)

Pump, Hydraulic — **D-RAD Rate Based Data Sheet (per hour)**

Pump, Positive Displacement	← Mode Source FMD-97	Parameters for Lognormal(Mean, EF) and Gamma(α, β)						
Failure Mode	Percent	Mean	Error Factor	α	β	SD	Variance	
Overall Critical Rate	100%	6.0E-05	9.1	2.0E-01	3.3E+03	1.3E-04	1.8E-08	
No Output	54%	3.2E-05	9.1	2.0E-01	6.1E+03	7.2E-05	5.2E-09	
Degraded Operation	44%	2.6E-05	9.1	2.0E-01	7.6E+03	5.9E-05	3.4E-09	
Fails During Operation	3%	1.6E-06	9.2	1.9E-01	1.3E+05	3.5E-06	1.2E-11	
Fails to Run (FSY-PMP-FTR)	**56%**	3.37E-05	9.12	2.0E-01	5.8E+03	7.6E-05	5.8E-09	No Output + Degraded Operation
Dormant	100%	6.9E-07	11.2	1.3E-01	1.9E+05	1.9E-06	3.6E-12	
Dormant Environment Records (DOR)	**8**	**Records Used**	**46**	**Failures Used**	**3,855.1**			

Data Sources

Name	Field 1	Field 2	Location	Source	Data Type	A	B	Implicit Failures	Mean	EF	Variance	Data Selector	Comment
Machinery Pump Centrifugal, Water Fire Fighting	Taxonomy 1.3.1.12	Overall Critical Rate		OREDA-2015	2. A: Mean B: SD	1.7E-05	2.1E-05	0.6	1.7E-05	5.0	4.5E-10	1	
Machinery Pump Centrifugal, Water Injection	Taxonomy 1.3.1.13	Overall Critical Rate		OREDA-2015	3. A: Mean Only	8.0E-07		0.5	8.0E-07	5.6	1.3E-12	1	
Machinery Pump Centrifugal, Water Injection	Taxonomy 1.3.1.8	Overall Critical Rate		OREDA-2015	2. A: Mean B: SD	2.1E-04	2.1E-05	95.0	2.1E-04	1.2	4.5E-10	1	
100 HP Pump	Table C-1	2650788-RAM-1-F1		OREDA 2009	3. A: Mean Only	6.1E-05		0.5	6.1E-05	5.6	7.4E-09	1	
100 HP Pump	Table C-1	2650788-RAM-2-F2		OREDA 2009	3. A: Mean Only	6.1E-05		0.5	6.1E-05	5.6	7.4E-09	1	
Pump	Table 2		MMS 1435-01-99-RP-3995		3. A: Mean Only	3.0E-04		0.5	3.0E-04	5.6	1.8E-07	1	
Pump	Table 2		MMS 1435-01-99-RP-3995		3. A: Mean Only	1.6E-04		0.5	1.6E-04	5.6	5.2E-08	1	
Pump	Table 4		MMS 1435-01-99-RP-3995		3. A: Mean Only	3.4E-06		0.5	3.4E-06	5.6	2.3E-11	1	
Pump,Hydraulic,Motor Driven	Commercial	GF	NPRD-086	NPRD-2011	1. A: Failures B: Time	1.0	279000.0	1.0	3.6E-06	3.9	1.3E-11	1	
Pump,Hydraulic,Motor Driven	Military	AUF	16953-000	NPRD-2011	1. A: Failures B: Time	1.0	59000.0	1.0	1.7E-05	3.9	2.9E-10	0	Environment
Pump,Hydraulic,Motor Driven	Military	GF	NPRD-054	NPRD-2011	1. A: Failures B: Time	21.0	4936000.0	21.0	4.3E-06	1.4	8.6E-13	1	
Pump,Hydraulic,Motor Driven	Military	NS	NPRD-106	NPRD-2011	1. A: Failures B: Time	19.0	436000.0	19.0	4.4E-05	1.5	1.0E-10	1	
Pump,Hydraulic,Motor Driven	Military	NSB	NPRD-094	NPRD-2011	1. A: Failures B: Time	12.0	467000.0	12.0	2.6E-05	1.6	5.5E-11	1	
Pump,Hydraulic,Centrifugal	Commercial	GF	NPRD-018	NPRD-2011	1. A: Failures B: Time	3.0	1451388.0	3.0	2.1E-06	2.4	1.4E-12	1	
Pump,Hydraulic,Centrifugal	Commercial	GF	NPRD-073	NPRD-2011	1. A: Failures B: Time	12.0	914000.0	12.0	1.3E-05	1.6	1.4E-11	1	
Pump,Hydraulic,Centrifugal	Commercial	GF	NPRD-086	NPRD-2011	1. A: Failures B: Time	0	231000.0	0.5	2.2E-06	5.6	9.4E-12	1	
Pump,Hydraulic,Centrifugal	Military	GF	23013-000	NPRD-2011	1. A: Failures B: Time	28.0	2481462.0	28.0	1.1E-05	1.4	4.5E-12	1	
Pump,Hydraulic,Centrifugal	Military	NS	NPRD-106	NPRD-2011	1. A: Failures B: Time	254.0	852000.0	254.0	3.0E-04	1.1	3.5E-10	1	
Pump,Hydraulic,Centrifugal	Unknown	GF	18354-000	NPRD-2011	1. A: Failures B: Time	311.0	4445190.0	311.0	7.0E-05	1.1	1.6E-11	1	
Pump,Hydraulic,Fuel	Commercial	AUT	NPRD-090	NPRD-2012	1. A: Failures B: Time	198.0	10377000.0	198.0	1.9E-05	1.1	1.8E-12	1	Overall
Pump,Hydraulic,Fuel	Commercial	AUT	NPRD-090	NPRD-2012	1. A: Failures B: Time	104.0	1400000.0	104.0	7.4E-05	1.2	5.3E-11	0	Included in Overall
Pump,Hydraulic,Fuel	Commercial	AUT	NPRD-093	NPRD-2013	1. A: Failures B: Time	8.0	610000.0	8.0	1.3E-05	1.8	2.1E-11	0	Included in Overall
Pump,Hydraulic,Fuel	Commercial	AUT	NPRD-096	NPRD-2014	1. A: Failures B: Time	41.0	1240000.0	41.0	3.3E-05	1.3	2.7E-11	0	Included in Overall
Pump,Hydraulic,Fuel	Commercial	AUT	NPRD-098	NPRD-2015	1. A: Failures B: Time	45.0	7127000.0	45.0	6.3E-06	1.3	8.9E-13	0	Included in Overall
Pump,Hydraulic,Fuel	Commercial	GMW	NPRD-063	NPRD-2016	1. A: Failures B: Time	141.0	779000.0	141.0	1.8E-04	1.1	2.3E-10	0	Environment
Pump,Hydraulic,Fuel	Military	A	25199-000	NPRD-2017	1. A: Failures B: Time	1250.0	17376000.0	1,250.0	7.2E-05	1.0	4.1E-12	1	
Pump,Hydraulic,Fuel	Military	A	NPRD-051	NPRD-2018	1. A: Failures B: Time	700.0	7573000.0	700.0	9.2E-05	1.1	1.2E-11	1	
Pump,Hydraulic,Fuel	Military	A	NPRD-082	NPRD-2019	1. A: Failures B: Time	316.0	715000.0	316.0	4.4E-04	1.1	6.2E-10	1	
Pump,Hydraulic,Fuel	Military	ARW	25199-000	NPRD-2020	1. A: Failures B: Time	37.0	193000.0	37.0	1.9E-04	1.3	9.9E-10	0	Environment
Pump,Hydraulic,Fuel	Military	ARW	NPRD-062	NPRD-2021	1. A: Failures B: Time	75.0	224000.0	75.0	3.3E-04	1.2	1.5E-09	0	Environment
Pump,Hydraulic,Fuel	Military	ARW	NPRD-070	NPRD-2022	1. A: Failures B: Time	10.0	14000.0	10.0	7.1E-04	1.7	5.1E-08	0	Environment
Pump,Hydraulic,Fuel	Military	ARW	NPRD-091	NPRD-2023	1. A: Failures B: Time	9.0	340000.0	9.0	2.6E-05	1.7	7.8E-11	0	Environment
Pump,Hydraulic,Fuel	Military	AUF	16953-000	NPRD-2024	1. A: Failures B: Time	61.0	468000.0	61.0	1.3E-04	1.2	2.8E-10	1	
Pump,Hydraulic,Fuel	Military	AUT	NPRD-106	NPRD-2025	1. A: Failures B: Time	72.0	1981000.0	72.0	3.6E-05	1.2	1.8E-11	1	
Pump,Hydraulic,Fuel	Military	GF	25199-000	NPRD-2026	1. A: Failures B: Time	31.0	211000.0	31.0	1.5E-04	1.3	7.0E-10	1	
Pump,Hydraulic,Fuel	Military	GMW	NPRD-095	NPRD-2027	1. A: Failures B: Time	1.0	53000.0	1.0	1.9E-05	3.9	3.6E-10	0	Environment
Pump,Hydraulic,Fuel	Military	GMW	NPRD-106	NPRD-2028	1. A: Failures B: Time	49.0	7429000.0	49.0	6.6E-06	1.3	8.9E-13	0	Environment
Pump,Hydraulic,Fuel	Military	NH	24794-000	NPRD-2029	1. A: Failures B: Time	111.0	74343.0	111.0	1.5E-03	1.2	2.0E-08	0	Environment
Pump,Hydraulic,With Drive,Motor Driven,Electric	Commercial	A	NPRD-098	NPRD-2011	1. A: Failures B: Time	20.0	2903000.0	20.0	6.9E-06	1.4	2.4E-12	0	Environment
Pump,Hydraulic,With Drive,Motor Driven,Electric	Commercial	AIT	NPRD-076	NPRD-2011	1. A: Failures B: Time	98.0	253000.0	98.0	3.9E-04	1.2	1.5E-09	0	Environment
Pump,Hydraulic,With Drive,Motor Driven,Electric	Commercial	AUT	NPRD-093	NPRD-2011	1. A: Failures B: Time	1.0	100000.0	1.0	1.0E-05	3.9	1.0E-10	0	Environment
Pump,Hydraulic,With Drive,Motor Driven,Electric	Military	A	NPRD-082	NPRD-2011	1. A: Failures B: Time	4.0	28000.0	4.0	1.4E-04	2.2	5.1E-09	0	Environment
Pump,Hydraulic,With Drive,Motor Driven,Electric	Military	AU	25199-000	NPRD-2011	1. A: Failures B: Time	455.0	1130000.0	455.0	4.0E-04	1.1	3.6E-10	0	Environment
Pump,Hydraulic,With Drive,Motor Driven,Electric	Military	AU	NPRD-082	NPRD-2011	1. A: Failures B: Time	5.0	14000.0	5.0	3.6E-04	2.0	2.6E-08	0	Environment
Pump,Hydraulic,With Drive,Motor Driven,Electric	Military	AU	NPRD-106	NPRD-2011	1. A: Failures B: Time	63.0	330000.0	63.0	1.9E-04	1.2	5.8E-10	0	Environment
Pump,Hydraulic,With Drive,Motor Driven,Electric	Military	NS	NPRD-106	NPRD-2011	1. A: Failures B: Time	1.0	3000.0	1.0	3.3E-04	3.9	1.1E-07	1	

Figure F- 21: D-RAD Rate Based Data Sheet for Hydraulic Pumps

Pump Unit,Hydraulic	Military	N	221015-000	NPRD-2011	1. A: Failures B: Time	0	92874.0	0.5	5.4E-06	5.6	5.8E-11	1	Overall
Pump Unit,Hydraulic	Military	N	221015-000	NPRD-2011	1. A: Failures B: Time	0	5754.0	0.5	8.7E-05	5.6	1.5E-08	0	Included in Overall
Pump Unit,Hydraulic	Military	N	221016-000	NPRD-2011	1. A: Failures B: Time	0	4080.0	0.5	1.2E-04	5.6	3.0E-08	0	Included in Overall
Pump Unit,Hydraulic	Military	N	221017-000	NPRD-2011	1. A: Failures B: Time	0	3384.0	0.5	1.5E-04	5.6	4.4E-08	0	Included in Overall
Pump Unit,Hydraulic	Military	N	221018-000	NPRD-2011	1. A: Failures B: Time	0	4824.0	0.5	1.0E-04	5.6	2.1E-08	0	Included in Overall
Pump Unit,Hydraulic	Military	N	221019-000	NPRD-2011	1. A: Failures B: Time	0	2904.0	0.5	1.7E-04	5.6	5.9E-08	0	Included in Overall
Pump Unit,Hydraulic	Military	N	221020-000	NPRD-2011	1. A: Failures B: Time	0	456.0	0.5	1.1E-03	5.6	2.4E-06	0	Included in Overall
Pump Unit,Hydraulic	Military	N	221021-000	NPRD-2011	1. A: Failures B: Time	0	3672.0	0.5	1.4E-04	5.6	3.7E-08	0	Included in Overall
Pump Unit,Hydraulic	Military	N	221022-000	NPRD-2011	1. A: Failures B: Time	0	11064.0	0.5	4.5E-05	5.6	4.1E-09	0	Included in Overall
Pump Unit,Hydraulic	Military	N	221023-000	NPRD-2011	1. A: Failures B: Time	0	8736.0	0.5	5.7E-05	5.6	6.6E-09	0	Included in Overall
Pump Unit,Hydraulic	Military	N	221024-000	NPRD-2011	1. A: Failures B: Time	0	5832.0	0.5	8.6E-05	5.6	1.5E-08	0	Included in Overall
Pump Unit,Hydraulic	Military	N	221025-000	NPRD-2011	1. A: Failures B: Time	0	7776.0	0.5	6.4E-05	5.6	8.3E-09	0	Included in Overall
Pump Unit,Hydraulic	Military	N	221026-000	NPRD-2011	1. A: Failures B: Time	0	5112.0	0.5	9.8E-05	5.6	1.9E-08	0	Included in Overall
Pump Unit,Hydraulic	Military	N	221027-000	NPRD-2011	1. A: Failures B: Time	0	4224.0	0.5	1.2E-04	5.6	2.8E-08	0	Included in Overall
Pump Unit,Hydraulic	Military	N	221028-000	NPRD-2011	1. A: Failures B: Time	0	8304.0	0.5	6.0E-05	5.6	7.3E-09	0	Included in Overall
Pump Unit,Hydraulic	Military	N	221029-000	NPRD-2011	1. A: Failures B: Time	0	3600.0	0.5	1.4E-04	5.6	3.9E-08	0	Included in Overall
Pump Unit,Hydraulic	Military	N	221030-000	NPRD-2011	1. A: Failures B: Time	0	8016.0	0.5	6.2E-05	5.6	7.8E-09	0	Included in Overall
Pump Unit,Hydraulic	Military	N	221031-000	NPRD-2011	1. A: Failures B: Time	0	5136.0	0.5	9.7E-05	5.6	1.9E-08	0	Included in Overall
Pump,Hydraulic	Commercial	AIT	NPRD-081	NPRD-2011	1. A: Failures B: Time	37.0	210000.0	37.0	1.8E-04	1.3	8.4E-10	0	Environment
Pump,Hydraulic	Commercial	AIT	NPRD-090	NPRD-2011	1. A: Failures B: Time	22.0	1314000.0	22.0	1.7E-05	1.4	1.3E-11	0	Environment
Pump,Hydraulic	Commercial	AIT	NPRD-096	NPRD-2011	1. A: Failures B: Time	27.0	160000.0	27.0	1.7E-04	1.4	1.1E-09	0	Environment
Pump,Hydraulic	Commercial	AIT	NPRD-098	NPRD-2011	1. A: Failures B: Time	26.0	3920000.0	26.0	6.6E-06	1.4	1.7E-12	0	Environment
Pump,Hydraulic	Commercial	GMW	NPRD-063	NPRD-2011	1. A: Failures B: Time	540.0	373000.0	540.0	1.4E-03	1.1	3.9E-09	0	Environment
Pump,Hydraulic	Military	A	25199-000	NPRD-2011	1. A: Failures B: Time	3304.0	5759000.0	3,304.0	5.7E-04	1.0	1.0E-10	0	Environment
Pump,Hydraulic	Military	A	NPRD-051	NPRD-2011	1. A: Failures B: Time	4002.0	5443000.0	4,002.0	7.4E-04	1.0	1.4E-10	0	Environment
Pump,Hydraulic	Military	A	NPRD-082	NPRD-2011	1. A: Failures B: Time	615.0	664000.0	615.0	9.3E-04	1.1	1.4E-09	0	Environment
Pump,Hydraulic	Military	AU	NPRD-051	NPRD-2011	1. A: Failures B: Time	1106.0	555000.0	1,106.0	2.0E-03	1.1	3.6E-09	0	Out of Expected Range
Pump,Hydraulic	Military	GF	25199-000	NPRD-2011	1. A: Failures B: Time	5.0	2985000.0	5.0	1.7E-06	2.0	5.6E-13	1	
Pump,Hydraulic	Military	GMW	10812-000	NPRD-2011	1. A: Failures B: Time	161.0	2906000.0	161.0	5.5E-05	1.1	1.9E-11	0	Environment
Pump,Hydraulic	Military	GMW	NPRD-050	NPRD-2011	1. A: Failures B: Time	5.0	4000.0	5.0	1.3E-03	2.0	3.1E-07	0	Environment
Pump,Hydraulic	Military	GMW	NPRD-095	NPRD-2011	1. A: Failures B: Time	2.0	67000.0	2.0	3.0E-05	2.9	4.5E-10	0	Environment
Pump,Hydraulic	Military	GMW	NPRD-106	NPRD-2011	1. A: Failures B: Time	734.0	18164000.0	734.0	4.0E-05	1.1	2.2E-12	0	Environment
Pump,Hydraulic	Military	N	221021-000	NPRD-2011	1. A: Failures B: Time	0	142944.0	0.5	3.5E-06	5.6	2.4E-11	1	Overall
Pump,Hydraulic	Military	N	221021-000	NPRD-2011	1. A: Failures B: Time	0	7344.0	0.5	6.8E-05	5.6	9.3E-09	0	Included in Overall
Pump,Hydraulic	Military	N	221022-000	NPRD-2011	1. A: Failures B: Time	0	22128.0	0.5	2.3E-05	5.6	1.0E-09	0	Included in Overall
Pump,Hydraulic	Military	N	221023-000	NPRD-2011	1. A: Failures B: Time	0	17472.0	0.5	2.9E-05	5.6	1.6E-09	0	Included in Overall
Pump,Hydraulic	Military	N	221024-000	NPRD-2011	1. A: Failures B: Time	0	11664.0	0.5	4.3E-05	5.6	3.7E-09	0	Included in Overall
Pump,Hydraulic	Military	N	221025-000	NPRD-2011	1. A: Failures B: Time	0	15552.0	0.5	3.2E-05	5.6	2.1E-09	0	Included in Overall
Pump,Hydraulic	Military	N	221026-000	NPRD-2011	1. A: Failures B: Time	0	10224.0	0.5	4.9E-05	5.6	4.8E-09	0	Included in Overall
Pump,Hydraulic	Military	N	221027-000	NPRD-2011	1. A: Failures B: Time	0	8448.0	0.5	5.9E-05	5.6	7.0E-09	0	Included in Overall
Pump,Hydraulic	Military	N	221028-000	NPRD-2011	1. A: Failures B: Time	0	16608.0	0.5	3.0E-05	5.6	1.8E-09	0	Included in Overall
Pump,Hydraulic	Military	N	221029-000	NPRD-2011	1. A: Failures B: Time	0	7200.0	0.5	6.9E-05	5.6	9.6E-09	0	Included in Overall
Pump,Hydraulic	Military	N	221030-000	NPRD-2011	1. A: Failures B: Time	0	16032.0	0.5	3.1E-05	5.6	1.9E-09	0	Included in Overall
Pump,Hydraulic	Military	N	221031-000	NPRD-2011	1. A: Failures B: Time	0	10272.0	0.5	4.9E-05	5.6	4.7E-09	0	Included in Overall
Pump,Hydraulic	Military	NH	24794-000	NPRD-2011	1. A: Failures B: Time	39.0	118096.0	39.0	3.3E-04	1.3	2.8E-09	0	Environment
Pump,Hydraulic,Centrifugal	Commercial	GF	NPRD-018	NPRD-2011	1. A: Failures B: Time	3.0	1451388.0	3.0	2.1E-06	2.4	1.4E-12	1	
Pump,Hydraulic,Centrifugal	Commercial	GF	NPRD-073	NPRD-2011	1. A: Failures B: Time	12.0	914000.0	12.0	1.3E-05	1.6	1.4E-11	1	
Pump,Hydraulic,Centrifugal	Commercial	GF	NPRD-086	NPRD-2011	1. A: Failures B: Time	0	231000.0	0.5	2.2E-06	5.6	9.4E-12	1	
Pump,Hydraulic,Centrifugal	Military	GF	23013-000	NPRD-2011	1. A: Failures B: Time	28.0	2481462.0	28.0	1.1E-05	1.4	4.5E-12	1	

Figure F- 22: D-RAD Rate Based Data Sheet for Hydraulic Pumps (Cont.)

Pump,Hydraulic,Centrifugal	Military	NS	NPRD-106	NPRD-2011	1. A: Failures B: Time	254.0	852000.0	254.0	3.0E-04	1.1	3.5E-10	0	Environment
Pump,Hydraulic,Centrifugal	Unknown	GF	18354-000	NPRD-2011	1. A: Failures B: Time	311.0	4445190.0	311.0	7.0E-05	1.1	1.6E-11	1	
Pump,Hydraulic,Driven,Auxiliary Power Unit	Military	AA	221001-000	NPRD-2011	1. A: Failures B: Time	0	160846.0	0.5	3.1E-06	5.6	1.9E-11	0	Environment
Pump,Hydraulic,Driven,Auxiliary Power Unit	Military	AA	221002-000	NPRD-2011	1. A: Failures B: Time	0	153954.0	0.5	3.2E-06	5.6	2.1E-11	0	Environment
Pump,Hydraulic,Driven,Auxiliary Power Unit	Military	AA	221003-000	NPRD-2011	1. A: Failures B: Time	0	151738.0	0.5	3.3E-06	5.6	2.2E-11	0	Environment
Pump,Hydraulic,Driven,Auxiliary Power Unit	Military	AA	221004-000	NPRD-2011	1. A: Failures B: Time	0	152930.0	0.5	3.3E-06	5.6	2.1E-11	0	Environment
Pump,Hydraulic,Driven,Auxiliary Power Unit	Military	AA	221005-000	NPRD-2011	1. A: Failures B: Time	0	111460.0	0.5	4.5E-06	5.6	4.0E-11	0	Environment
Pump,Hydraulic,Engine Driven	Military	AA	221001-000	NPRD-2011	1. A: Failures B: Time	0	160846.0	0.5	3.1E-06	5.6	1.9E-11	0	Environment
Pump,Hydraulic,Engine Driven	Military	AA	221002-000	NPRD-2011	1. A: Failures B: Time	0	153954.0	0.5	3.2E-06	5.6	2.1E-11	0	Environment
Pump,Hydraulic,Engine Driven	Military	AA	221003-000	NPRD-2011	1. A: Failures B: Time	0	151738.0	0.5	3.3E-06	5.6	2.2E-11	0	Environment
Pump,Hydraulic,Engine Driven	Military	AA	221004-000	NPRD-2011	1. A: Failures B: Time	0	152930.0	0.5	3.3E-06	5.6	2.1E-11	0	Environment
Pump,Hydraulic,Engine Driven	Military	AA	221005-000	NPRD-2011	1. A: Failures B: Time	0	111460.0	0.5	4.5E-06	5.6	4.0E-11	0	Environment
Pump,Hydraulic,Motor Driven	Commercial	GF	NPRD-086	NPRD-2011	1. A: Failures B: Time	1.0	279000.0	1.0	3.6E-06	3.9	1.3E-11	1	
Pump,Hydraulic,Motor Driven	Military	AUF	16953-000	NPRD-2011	1. A: Failures B: Time	1.0	59000.0	1.0	1.7E-05	3.9	2.9E-10	0	Environment
Pump,Hydraulic,Motor Driven	Military	GF	NPRD-054	NPRD-2011	1. A: Failures B: Time	21.0	4936000.0	21.0	4.3E-06	1.4	8.6E-13	1	
Pump,Hydraulic,Motor Driven	Military	NS	NPRD-106	NPRD-2011	1. A: Failures B: Time	19.0	436000.0	19.0	4.4E-05	1.5	1.0E-10	1	
Pump,Hydraulic,Motor Driven	Military	NSB	NPRD-094	NPRD-2011	1. A: Failures B: Time	12.0	467000.0	12.0	2.6E-05	1.6	5.5E-11	1	
Pump,Hydraulic,Water	Commercial	AUT	NPRD-096	NPRD-2011	1. A: Failures B: Time	18.0	270000.0	18.0	6.7E-05	1.5	2.5E-10	0	Environment
Pump,Hydraulic,Water	Commercial	GMW	NPRD-063	NPRD-2011	1. A: Failures B: Time	265.0	774000.0	265.0	3.4E-04	1.1	4.4E-10	0	Environment
Pump,Hydraulic,Water	Military	A	NPRD-082	NPRD-2011	1. A: Failures B: Time	16.0	84000.0	16.0	1.9E-04	1.5	2.3E-09	0	Environment
Pump,Hydraulic,Fuel	Military	DOR	13253-000	NPRD-2011	1. A: Failures B: Time	0	16140000.0	0.5	3.1E-08	5.6	1.9E-15	1	
Pump,Hydraulic,Fuel	Military	DOR	NPRD-108	NPRD-2011	1. A: Failures B: Time	0	8070000.0	0.5	6.2E-08	5.6	7.7E-15	1	
Pump,Hydraulic,Centrifugal	Military	DOR	13253-000	NPRD-2011	1. A: Failures B: Time	32.0	160000000.0	32.0	2.0E-07	1.3	1.3E-15	1	
Pump,Hydraulic	Military	DOR	13253-000	NPRD-2011	1. A: Failures B: Time	15.0	119002640.0	15.0	1.3E-07	1.5	1.1E-15	1	
Pump,Hydraulic	Military	DOR	NPRD-108	NPRD-2011	1. A: Failures B: Time	0	930000.0	0.5	5.4E-07	5.6	5.8E-13	1	
Pump,Hydraulic	Military	DOR	NPRD-111	NPRD-2011	1. A: Failures B: Time	0	165000.0	0.5	3.0E-06	5.6	1.8E-11	1	
Pump,Hydraulic	Military	DOR	NPRD-114	NPRD-2011	1. A: Failures B: Time	3.0	2004000.0	3.0	1.5E-06	2.4	7.5E-13	1	
Pump,Hydraulic	Military	DOR	NPRD-115	NPRD-2011	1. A: Failures B: Time	0	20280000.0	0.5	2.5E-08	5.6	1.2E-15	1	

Figure F- 22: D-RAD Rate Based Data Sheet for Hydraulic Pumps (Cont.)

Ram, Pipe — **D-RAD Rate Based Data Sheet (per hour)**

← Mode Source		Parameters for Lognormal(Mean, EF) and Gamma(α, β)					
Failure Mode	**Percent**	**Mean**	**Error Factor**	**α**	**β**	**SD**	**Variance**
Overall	100%	2.9E-05	5.6	5.0E-01	1.7E+04	4.1E-05	1.7E-09
Leakage in Closed Position (CYL-FTC-PR)	50%	1.46E-05	7.52	2.9E-01	2.0E+04	2.7E-05	7.5E-10
Fails to Open (CYL-FTO-PR)	50%	1.46E-05	7.52	2.9E-01	2.0E+04	2.7E-05	7.5E-10
		Records Used		2	Failures Used	1.0	

Data Sources Name	Field 1	Field 2	Location	Source	Data Type	A	B	Implicit Failures	Mean	EF	Variance	Data Selector	Comment
Ram, Pipe	Overall		Table IV.5	434-A1, OGP	3. A: Mean Only	3.0E-05		0.5	3.0E-05	5.6	1.8E-09	1	Overall
Ram, Pipe	Leakage in Closed Position		Table IV.5	434-A1, OGP	3. A: Mean Only	2.0E-05		0.5	2.0E-05	5.6	7.9E-10	0	Included in Overall
Ram, Pipe	Fail to Open		Table IV.5	434-A1, OGP	3. A: Mean Only	1.0E-05		0.5	1.0E-05	5.6	2.0E-10	0	Included in Overall
Ram, Pipe			BSEE	2650788-RAM-1-F1	3. A: Mean Only	2.9E-05		0.5	2.9E-05	5.6	1.6E-09	1	Overall

Figure F- 22: D-RAD Rate Based Data Sheet for Pipe Rams

Regulator, Pressure — **D-RAD Rate Based Data Sheet (per hour)**

Valve, Regulator FMD-97	← Mode Source	Parameters for Lognormal(Mean, EF) and Gamma(α, β)					
Failure Mode	Percent	Mean	Error Factor	α	β	SD	Variance
Overall Critical Rate	100%	6.3E-05	8.3	2.3E-01	3.7E+03	1.3E-04	1.7E-08
Leaking	53.8%	3.4E-05	8.3	2.3E-01	6.9E+03	7.0E-05	4.9E-09
Closed	23.1%	1.4E-05	8.3	2.3E-01	1.6E+04	3.0E-05	9.0E-10
Opened	23.1%	1.4E-05	8.3	2.3E-01	1.6E+04	3.0E-05	9.0E-10
Reduced Pressure (PRG-FLO)	23.1%	1.45E-05	8.33	2.3E-01	1.6E+04	3.0E-05	9.0E-10
		Records Used		35	Failures Used		5,495.0

Name	Field 1	Field 2	Location	Source	Data Type	A	B	Implicit Failures	Mean	EF	Variance	Data Selector	Comment
Regulator,Pressure	Military	A	NPRD-051	NPRD-2016	1. A: Failures B: Time	818.0	1111000.0	818.0	7.4E-04	1.1	6.6E-10	1	Overall
Regulator,Pressure	Military	AA	221001-000	NPRD-2016	1. A: Failures B: Time	0	365464.0	0.5	1.4E-06	5.6	3.7E-12	1	Overall
Regulator,Pressure	Military	AA	221001-000	NPRD-2016	1. A: Failures B: Time	0	80423.0	0.5	6.2E-06	5.6	7.7E-11	0	Included in Overall
Regulator,Pressure	Military	AA	221002-000	NPRD-2016	1. A: Failures B: Time	0	76977.0	0.5	6.5E-06	5.6	8.4E-11	0	Included in Overall
Regulator,Pressure	Military	AA	221003-000	NPRD-2016	1. A: Failures B: Time	0	75869.0	0.5	6.6E-06	5.6	8.7E-11	0	Included in Overall
Regulator,Pressure	Military	AA	221004-000	NPRD-2016	1. A: Failures B: Time	0	76465.0	0.50	6.5E-06	5.6	8.6E-11	0	Included in Overall
Regulator,Pressure	Military	AA	221005-000	NPRD-2016	1. A: Failures B: Time	0	55730.0	0.5	9.0E-06	5.6	1.6E-10	0	Included in Overall
Regulator,Pressure	Military	AA	800101-000	NPRD-2016	1. A: Failures B: Time	4.0	303488.0	4.0	1.3E-05	2.2	4.3E-11	1	Overall
Regulator,Pressure	Military	AA	800101-000	NPRD-2016	1. A: Failures B: Time	2.0	73246.0	2.0	2.7E-05	2.9	3.7E-10	0	Included in Overall
Regulator,Pressure	Military	AA	800102-000	NPRD-2016	1. A: Failures B: Time	1.0	74963.0	1.0	1.3E-05	3.9	1.8E-10	0	Included in Overall
Regulator,Pressure	Military	AA	800103-000	NPRD-2016	1. A: Failures B: Time	1.0	76015.0	1.0	1.3E-05	3.9	1.7E-10	0	Included in Overall
Regulator,Pressure	Military	AA	800104-000	NPRD-2016	1. A: Failures B: Time	0	79264.0	0.5	6.3E-06	5.6	8.0E-11	0	Included in Overall
Regulator,Pressure	Military	N	800105-000	NPRD-2016	1. A: Failures B: Time	10.0	4730160.0	10.0	2.1E-06	1.7	4.5E-13	1	Overall
Regulator,Pressure	Military	N	800105-000	NPRD-2016	1. A: Failures B: Time	0	160286.0	0.5	3.1E-06	5.6	1.9E-11	0	Included in Overall
Regulator,Pressure	Military	N	800106-000	NPRD-2016	1. A: Failures B: Time	1.0	867072.0	1.0	1.2E-06	3.9	1.3E-12	0	Included in Overall
Regulator,Pressure	Military	N	800107-000	NPRD-2016	1. A: Failures B: Time	2.0	1425214.0	2.0	1.4E-06	2.9	9.8E-13	0	Included in Overall
Regulator,Pressure	Military	N	800108-000	NPRD-2016	1. A: Failures B: Time	7.0	2277588.0	7.0	3.1E-06	1.8	1.3E-12	0	Included in Overall
Regulator,Pressure,External Tank	Military	AA	221001-000	NPRD-2016	1. A: Failures B: Time	0	365464.0	0.5	1.4E-06	5.6	3.7E-12	1	Overall
Regulator,Pressure,External Tank	Military	AA	221001-000	NPRD-2016	1. A: Failures B: Time	0	80423.0	0.5	6.2E-06	5.6	7.7E-11	0	Included in Overall
Regulator,Pressure,External Tank	Military	AA	221002-000	NPRD-2016	1. A: Failures B: Time	0	76977.0	0.5	6.5E-06	5.6	8.4E-11	0	Included in Overall
Regulator,Pressure,External Tank	Military	AA	221003-000	NPRD-2016	1. A: Failures B: Time	0	75869.0	0.5	6.6E-06	5.6	8.7E-11	0	Included in Overall
Regulator,Pressure,External Tank	Military	AA	221004-000	NPRD-2016	1. A: Failures B: Time	0	76465.0	0.5	6.5E-06	5.6	8.6E-11	0	Included in Overall
Regulator,Pressure,External Tank	Military	AA	221005-000	NPRD-2016	1. A: Failures B: Time	0	55730.0	0.5	9.0E-06	5.6	1.6E-10	0	Included in Overall
Regulator,Pressure,External Tank	Military	AA	800101-000	NPRD-2016	1. A: Failures B: Time	1.0	303488.0	1.0	3.3E-06	3.9	1.1E-11	1	Overall
Regulator,Pressure,External Tank	Military	AA	800101-000	NPRD-2016	1. A: Failures B: Time	0	73246.0	0.5	6.8E-06	5.6	9.3E-11	0	Included in Overall
Regulator,Pressure,External Tank	Military	AA	800102-000	NPRD-2016	1. A: Failures B: Time	1.0	74963.0	1.0	1.3E-05	3.9	1.8E-10	0	Included in Overall
Regulator,Pressure,External Tank	Military	AA	800103-000	NPRD-2016	1. A: Failures B: Time	0	76015.0	0.5	6.6E-06	5.6	8.7E-11	0	Included in Overall
Regulator,Pressure,External Tank	Military	AA	800104-000	NPRD-2016	1. A: Failures B: Time	0	79264.0	0.5	6.3E-06	5.6	8.0E-11	0	Included in Overall
Regulator,Pressure,Hydraulic	Commercial	A	NPRD-090	NPRD-2016	1. A: Failures B: Time	645.0	8270000.0	645.0	7.8E-05	1.1	9.4E-12	1	Overall
Regulator,Pressure,Hydraulic	Commercial	A	NPRD-096	NPRD-2016	1. A: Failures B: Time	49.0	265000.0	49.0	1.8E-04	1.3	7.0E-10	1	Overall
Regulator,Pressure,Hydraulic	Commercial	AIT	NPRD-090	NPRD-2016	1. A: Failures B: Time	840.0	7912000.0	840.0	1.1E-04	1.1	1.3E-11	1	Overall
Regulator,Pressure,Hydraulic	Commercial	AIT	NPRD-096	NPRD-2016	1. A: Failures B: Time	132.0	3074000.0	132.0	4.3E-05	1.2	1.4E-11	1	Overall
Regulator,Pressure,Hydraulic	Commercial	AIT	NPRD-098	NPRD-2016	1. A: Failures B: Time	70.0	870000.0	70.0	8.0E-05	1.2	9.2E-11	1	Overall
Regulator,Pressure,Hydraulic	Military	A	25199-000	NPRD-2016	1. A: Failures B: Time	652.0	9737000.0	652.0	6.7E-05	1.1	6.9E-12	1	Overall
Regulator,Pressure,Hydraulic	Military	A	NPRD-051	NPRD-2016	1. A: Failures B: Time	666.0	4716000.0	666.0	1.4E-04	1.1	3.0E-11	1	Overall

Figure F- 23: D-RAD Rate Based Data Sheet for Pressure Regulators

Regulator,Pressure,Hydraulic	Military	A	NPRD-082	NPRD-2016	1. A: Failures B: Time	401.0	346000.0	401.0	1.2E-03	1.1	3.3E-09	0	Out of Expected Range
Regulator,Pressure,Hydraulic	Military	A	NPRD-106	NPRD-2016	1. A: Failures B: Time	84.0	1843000.0	84.0	4.6E-05	1.2	2.5E-11	1	Overall
Regulator,Pressure,Hydraulic	Military	AIF	16953-000	NPRD-2016	1. A: Failures B: Time	84.0	1052000.0	84.0	8.0E-05	1.2	7.6E-11	1	Overall
Regulator,Pressure,Hydraulic	Military	AIT	25199-000	NPRD-2016	1. A: Failures B: Time	71.0	1915000.0	71.0	3.7E-05	1.2	1.9E-11	1	Overall
Regulator,Pressure,Hydraulic	Military	DOR	13523-000	NPRD-2016	1. A: Failures B: Time	0	383000.0	0.5	1.3E-06	5.6	3.4E-12	1	Overall
Regulator,Pressure,Hydraulic	Military	DOR	NPRD-109	NPRD-2016	1. A: Failures B: Time	0	628000.0	0.5	8.0E-07	5.6	1.3E-12	1	Overall
Regulator,Pressure,Hydraulic	Military	GF	23013-000	NPRD-2016	1. A: Failures B: Time	44.0	17544822.0	44.0	2.5E-06	1.3	1.4E-13	1	Overall
Regulator,Pressure,Hydraulic	Military	GF	NPRD-054	NPRD-2016	1. A: Failures B: Time	3.0	248000.0	3.0	1.2E-05	2.4	4.9E-11	1	Overall
Regulator,Pressure,Hydraulic	Military	GF	NPRD-103	NPRD-2016	1. A: Failures B: Time	0	32000.0	0.5	1.6E-05	5.6	4.9E-10	1	Overall
Regulator,Pressure,Hydraulic	Military	GM	10812-000	NPRD-2016	1. A: Failures B: Time	1.0	1095000.0	1.0	9.1E-07	3.9	8.3E-13	1	Overall
Regulator,Pressure,Hydraulic	Military	GM	23013-000	NPRD-2016	1. A: Failures B: Time	4.0	3121952.0	4.0	1.3E-06	2.2	4.1E-13	1	Overall
Regulator,Pressure,Hydraulic	Military	GM	NPRD-095	NPRD-2016	1. A: Failures B: Time	0	12000.0	0.5	4.2E-05	5.6	3.5E-09	1	Overall
Regulator,Pressure,Hydraulic	Military	GM	NPRD-106	NPRD-2016	1. A: Failures B: Time	193.0	23185000.0	193.0	8.3E-06	1.1	3.6E-13	1	Overall
Regulator,Pressure,Hydraulic	Military	SF	10219-034	NPRD-2016	1. A: Failures B: Time	1.0	350000.0	1.0	2.9E-06	3.9	8.2E-12	1	Overall
Regulator,Pressure,Hydraulic	Unknown	AUT	18459-000	NPRD-2016	1. A: Failures B: Time	1.0	97848.0	1.0	1.0E-05	3.9	1.0E-10	1	Overall
Regulator,Pressure,Hydraulic	Unknown	GF	18459-000	NPRD-2016	1. A: Failures B: Time	3.0	1500000.0	3.0	2.0E-06	2.4	1.3E-12	1	Overall
Regulator,Pressure,Hydraulic	Unknown	GM	18459-000	NPRD-2016	1. A: Failures B: Time	4.0	391083.0	4.0	1.0E-05	2.2	2.6E-11	1	Overall
Regulator,Pressure,Hydraulic	Unknown	ML	18459-000	NPRD-2016	1. A: Failures B: Time	0	216.0	0.5	2.3E-03	5.6	1.1E-05	0	Sparse
Regulator,Pressure,Hydraulic	Unknown	NS	18459-000	NPRD-2016	1. A: Failures B: Time	5.0	142120.0	5.0	3.5E-05	2.0	2.5E-10	1	Overall
Regulator,Pressure,Hydraulic	Military	ARW	NPRD-091	NPRD-2016	1. A: Failures B: Time	26.0	470000.0	26.0	5.5E-05	1.4	1.2E-10	1	Overall
Regulator,Pressure,Hydraulic,Fuel	Military	ARW	NPRD-062	NPRD-2016	1. A: Failures B: Time	39.0	251000.0	39.0	1.6E-04	1.3	6.2E-10	1	Overall
Regulator,Pressure,Hydraulic,Fuel	Military	ARW	NPRD-091	NPRD-2016	1. A: Failures B: Time	2.0	50000.0	2.0	4.0E-05	2.9	8.0E-10	1	Overall
Regulator,Pressure,Hydraulic,Fuel	Military	AU	NPRD-106	NPRD-2016	1. A: Failures B: Time	1031.0	5766000.0	1,031.0	1.8E-04	1.1	3.1E-11	1	Overall
Valve,Hydraulic,Flow Regulator	Military	AC	800109-000	NPRD-2016	1. A: Failures B: Time	9.0	25841232.0	9.0	3.5E-07	1.7	1.3E-14	1	Overall
Valve,Hydraulic,Flow Regulator	Military	AC	800109-000	NPRD-2017	1. A: Failures B: Time	0	2406168.0	0.5	2.1E-07	5.6	8.6E-14	0	Included in Overall
Valve,Hydraulic,Flow Regulator	Military	AC	800110-000	NPRD-2016	1. A: Failures B: Time	8.0	2586834.0	8.0	3.1E-06	1.8	1.2E-12	0	Included in Overall
Valve,Hydraulic,Flow Regulator	Military	AC	800111-000	NPRD-2016	1. A: Failures B: Time	0	2854368.0	0.5	1.8E-07	5.6	6.1E-14	0	Included in Overall
Valve,Hydraulic,Flow Regulator	Military	AC	800112-000	NPRD-2016	1. A: Failures B: Time	0	3113604.0	0.5	1.6E-07	5.6	5.2E-14	0	Included in Overall
Valve,Hydraulic,Flow Regulator	Military	AC	800113-000	NPRD-2016	1. A: Failures B: Time	1.0	2872080.0	1.0	3.5E-07	3.9	1.2E-13	0	Included in Overall
Valve,Hydraulic,Flow Regulator	Military	AC	800114-000	NPRD-2016	1. A: Failures B: Time	0	2710530.0	0.5	1.8E-07	5.6	6.8E-14	0	Included in Overall
Valve,Hydraulic,Flow Regulator	Military	AC	800115-000	NPRD-2016	1. A: Failures B: Time	0	2456856.0	0.5	2.0E-07	5.6	8.3E-14	0	Included in Overall
Valve,Hydraulic,Flow Regulator	Military	AC	800116-000	NPRD-2016	1. A: Failures B: Time	0	2383785.0	0.5	2.1E-07	5.6	8.8E-14	0	Included in Overall
Valve,Hydraulic,Flow Regulator	Military	AC	800117-000	NPRD-2016	1. A: Failures B: Time	0	2255130.0	0.5	2.2E-07	5.6	9.8E-14	0	Included in Overall
Valve,Hydraulic,Flow Regulator	Military	AC	800118-000	NPRD-2016	1. A: Failures B: Time	0	2201877.0	0.5	2.3E-07	5.6	1.0E-13	0	Included in Overall

Figure F- 24: D-RAD Rate Based Data Sheet for Pressure Regulators (Cont.)

Sensor, Motion | **D-RAD Rate Based Data Sheet (per hour)**

Sensor,Motion,Speed	← Mode Source FMD-2016	Parameters for Lognormal(Mean, EF) and Gamma(α, β)					
Failure Mode	**Percent**	**Mean**	**Error Factor**	**α**	**β**	**SD**	**Variance**
Overall Critical Rate	100%	5.1E-05	12.8	1.0E-01	2.0E+03	1.6E-04	2.6E-08
Induced Failure (DPS-VRS-FOP)	48.8%	2.49E-05	12.8	9.9E-02	4.0E+03	7.9E-05	6.2E-09
No Operation	39.0%	2.0E-05	12.8	9.9E-02	5.0E+03	6.3E-05	4.0E-09
Functional Failure	9.8%	5.0E-06	13.0	9.6E-02	1.9E+04	1.6E-05	2.6E-10
Degraded Operation	2.4%	1.2E-06	13.7	8.7E-02	7.1E+04	4.2E-06	1.7E-11
Dormant	100%	1.6E-05	10.5	1.5E-01	9.5E+03	4.1E-05	1.6E-09
Dormant Environment Records (DOR)	**8**	**Records Used**	**13**	**Failures Used**		**294.5**	

Name	Field 1	Field 2	Location	Source	Data Type	A	B	Implicit Failures	Mean	EF	Variance	Data Selector	Comment
Sensor,Motion	Unknown	N/R	27009-000	NPRD-2016	1. A: Failures B: Time	127.0	5958614.0	127.0	2.1E-05	1.2	3.6E-12	1	
Sensor,Motion,Accelerometer,Forced Balanced	Unknown	GM	18459-000	NPRD-2016	1. A: Failures B: Time	8.0	300376.0	8.0	2.7E-05	1.8	8.9E-11	1	
Sensor,Motion,Accelerometer,Linear	Military	AI	NPRD-106	NPRD-2016	1. A: Failures B: Time	114.0	189000.0	114.0	6.0E-04	1.2	3.2E-09	1	
Sensor,Motion,Accelerometer,Pendulum	Commercial	AI	NPRD-079	NPRD-2016	1. A: Failures B: Time	1.0	270000.0	1.0	3.7E-06	3.9	1.4E-11	1	
Sensor,Motion,Accelerometer,Pendulum	Unknown	AUF	18459-000	NPRD-2016	1. A: Failures B: Time	8.0	923102.0	8.00	8.7E-06	1.8	9.4E-12	1	
Sensor,Motion,Accelerometer,Angular	Military	DOR	11233-000	NPRD-2016	1. A: Failures B: Time	0	252000.0	0.5	2.0E-06	5.6	7.9E-12	1	
Sensor,Motion,Accelerometer,Angular	Military	DOR	13253-000	NPRD-2016	1. A: Failures B: Time	0	4930000.0	0.5	1.0E-07	5.6	2.1E-14	1	
Sensor,Motion,Accelerometer,Angular	Military	DOR	NPRD-106	NPRD-2016	1. A: Failures B: Time	22.0	194000.0	22.0	1.1E-04	1.4	5.8E-10	1	
Sensor,Motion,Accelerometer,Pendulum	Military	DOR	13253-000	NPRD-2016	1. A: Failures B: Time	6.0	3120000.0	6.0	1.9E-06	1.9	6.2E-13	1	
Sensor,Motion,Accelerometer,Pendulum	Military	DOR	NPRD-061	NPRD-2016	1. A: Failures B: Time	6.0	3119000.0	6.0	1.9E-06	1.9	6.2E-13	1	
Sensor,Motion,Accelerometer,Linear	Military	DOR	11233-000	NPRD-2016	1. A: Failures B: Time	0	126000.0	0.5	4.0E-06	5.6	3.1E-11	1	
Sensor,Motion,Accelerometer,Linear	Military	DOR	13253-000	NPRD-2016	1. A: Failures B: Time	0	450000.0	0.5	1.1E-06	5.6	2.5E-12	1	
Sensor,Motion,Accelerometer,Linear	Military	DOR	NPRD-111	NPRD-2016	1. A: Failures B: Time	0	2250000.0	0.5	2.2E-07	5.6	9.9E-14	1	

Figure F- 24: D-RAD Rate Based Data Sheet for Motion Sensors

Strainer, Hull Intake **D-RAD Rate Based Data Sheet (per hour)**

N/A	← Mode Source	Parameters for Lognormal(Mean, EF) and Gamma(α, β)					
Failure Mode	Percent	Mean	Error Factor	α	β	SD	Variance
Overall Critical Rate (SWC-SCH-CLG)	100%	6.34E-07	3.71	1.1E+00	1.8E+06	6.0E-07	3.6E-13
		Records Used	2		Failures Used	3.0	

Name	Field 1	Field 2	Location	Source	Data Type	A	B	Implicit Failures	Mean	EF	Variance	Data Selector	Comment
Strainer,Intake	Military	N	800105-000	NPRD-2016	1. A: Failures B: Time	1.0	2365080.0	1.0	4.2E-07	3.9	1.8E-13	1	Overall
Strainer,Intake	Military	N	800105-000	NPRD-2016	1. A: Failures B: Time	0	80143.0	0.5	6.2E-06	5.6	7.8E-11	0	Included in Overall
Strainer,Intake	Military	N	800106-000	NPRD-2016	1. A: Failures B: Time	0	433536.0	0.5	1.2E-06	5.6	2.7E-12	0	Included in Overall
Strainer,Intake	Military	N	800107-000	NPRD-2016	1. A: Failures B: Time	0	712607.0	0.5	7.0E-07	5.6	9.8E-13	0	Included in Overall
Strainer,Intake	Military	N	800108-000	NPRD-2016	1. A: Failures B: Time	1.0	1138794.0	1.0	8.8E-07	3.9	7.7E-13	0	Included in Overall
Strainer,Deck Drain	Military	N	221015-000	NPRD-2016	1. A: Failures B: Time	0	114276.0	0.5	4.4E-06	5.6	3.8E-11	0	Overall
Strainer,Deck Drain	Military	N	221015-000	NPRD-2016	1. A: Failures B: Time	0	11508.0	0.5	4.3E-05	5.6	3.8E-09	0	Included in Overall
Strainer,Deck Drain	Military	N	221016-000	NPRD-2016	1. A: Failures B: Time	0	8160.0	0.5	6.1E-05	5.6	7.5E-09	0	Included in Overall
Strainer,Deck Drain	Military	N	221017-000	NPRD-2016	1. A: Failures B: Time	0	6768.0	0.5	7.4E-05	5.6	1.1E-08	0	Included in Overall
Strainer,Deck Drain	Military	N	221018-000	NPRD-2016	1. A: Failures B: Time	0	9648.0	0.5	5.2E-05	5.6	5.4E-09	0	Included in Overall
Strainer,Deck Drain	Military	N	221019-000	NPRD-2016	1. A: Failures B: Time	0	5808.0	0.5	8.6E-05	5.6	1.5E-08	0	Included in Overall
Strainer,Deck Drain	Military	N	221020-000	NPRD-2016	1. A: Failures B: Time	0	912.0	0.5	5.5E-04	5.6	6.0E-07	0	Included in Overall
Strainer,Deck Drain	Military	N	221021-000	NPRD-2016	1. A: Failures B: Time	0	3672.0	0.5	1.4E-04	5.6	3.7E-08	0	Included in Overall
Strainer,Deck Drain	Military	N	221022-000	NPRD-2016	1. A: Failures B: Time	0	11064.0	0.5	4.5E-05	5.6	4.1E-09	0	Included in Overall
Strainer,Deck Drain	Military	N	221023-000	NPRD-2016	1. A: Failures B: Time	0	8736.0	0.5	5.7E-05	5.6	6.6E-09	0	Included in Overall
Strainer,Deck Drain	Military	N	221024-000	NPRD-2016	1. A: Failures B: Time	0	5832.0	0.5	8.6E-05	5.6	1.5E-08	0	Included in Overall
Strainer,Deck Drain	Military	N	221025-000	NPRD-2016	1. A: Failures B: Time	0	7776.0	0.5	6.4E-05	5.6	8.3E-09	0	Included in Overall
Strainer,Deck Drain	Military	N	221026-000	NPRD-2016	1. A: Failures B: Time	0	5112.0	0.5	9.8E-05	5.6	1.9E-08	0	Included in Overall
Strainer,Deck Drain	Military	N	221027-000	NPRD-2016	1. A: Failures B: Time	0	4224.0	0.5	1.2E-04	5.6	2.8E-08	0	Included in Overall
Strainer,Deck Drain	Military	N	221028-000	NPRD-2016	1. A: Failures B: Time	0	8304.0	0.5	6.0E-05	5.6	7.3E-09	0	Included in Overall
Strainer,Deck Drain	Military	N	221029-000	NPRD-2016	1. A: Failures B: Time	0	3600.0	0.5	1.4E-04	5.6	3.9E-08	0	Included in Overall
Strainer,Deck Drain	Military	N	221030-000	NPRD-2016	1. A: Failures B: Time	0	8016.0	0.5	6.2E-05	5.6	7.8E-09	0	Included in Overall
Strainer,Deck Drain	Military	N	221031-000	NPRD-2016	1. A: Failures B: Time	0	5136.0	0.5	9.7E-05	5.6	1.9E-08	0	Included in Overall
Strainer,Hull Intake	Military	N	800105-000	NPRD-2016	1. A: Failures B: Time	2.0	2365080.0	2.0	8.5E-07	2.9	3.6E-13	1	Overall
Strainer,Hull Intake	Military	N	800105-000	NPRD-2016	1. A: Failures B: Time	0	80143.0	0.5	6.2E-06	5.6	7.8E-11	0	Included in Overall
Strainer,Hull Intake	Military	N	800106-000	NPRD-2016	1. A: Failures B: Time	0	433536.0	0.5	1.2E-06	5.6	2.7E-12	0	Included in Overall
Strainer,Hull Intake	Military	N	800107-000	NPRD-2016	1. A: Failures B: Time	1.0	712607.0	1.0	1.4E-06	3.9	2.0E-12	0	Included in Overall
Strainer,Hull Intake	Military	N	800108-000	NPRD-2016	1. A: Failures B: Time	1.0	1138794.0	1.0	8.8E-07	3.9	7.7E-13	0	Included in Overall

Figure F- 25: D-RAD Rate Based Data Sheet for Hull Intake Strainers

Switchboard — **D-RAD Rate Based Data Sheet (per hour)**

Switchboard	← Mode Source FMD-2011	Parameters for Lognormal(Mean, EF) and Gamma(α, β)					
Failure Mode	**Percent**	**Mean**	**Error Factor**	**α**	**β**	**SD**	**Variance**
Overall Critical Rate	100%	9.7E-06	9.1	2.0E-01	2.0E+04	2.2E-05	4.8E-10
Improper Output (SWB-FOP)	66.7%	6.46E-06	9.20	1.9E-01	3.0E+04	1.5E-05	2.2E-10
Out of Adjustment	33.3%	3.2E-06	9.4	1.9E-01	5.8E+04	7.5E-06	5.6E-11
		Records Used		6	Failures Used		44.0

Data Sources

Name	Field 1	Field 2	Location	Source	Data Type	A	B	Implicit Failures	Mean	EF	Variance	Data Selector	Comment
Switchboard	800105-000	Military	N	NPRD-2016	1. A: Failures B: Time	10.0	2365080.0	10.0	4.2E-06	1.7	1.8E-12	1	Overall
Switchboard	800105-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	80143.0	0.5	6.2E-06	5.6	7.8E-11	0	Included in Overall
Switchboard	800106-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	433536.0	0.5	1.2E-06	5.6	2.7E-12	0	Included in Overall
Switchboard	800107-000	Military	N	NPRD-2016	1. A: Failures B: Time	4.0	712607.0	4.0	5.6E-06	2.2	7.9E-12	0	Included in Overall
Switchboard	800108-000	Military	N	NPRD-2016	1. A: Failures B: Time	6.0	1138794.0	6.0	5.3E-06	1.9	4.6E-12	0	Included in Overall
Switchboard,Alarm	221015-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	21402.0	0.5	2.3E-05	5.6	1.1E-09	1	Overall
Switchboard,Alarm	221015-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	5754.0	0.5	8.7E-05	5.6	1.5E-08	0	Included in Overall
Switchboard,Alarm	221016-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	4080.0	0.5	1.2E-04	5.6	3.0E-08	0	Included in Overall
Switchboard,Alarm	221017-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	3384.0	0.5	1.5E-04	5.6	4.4E-08	0	Included in Overall
Switchboard,Alarm	221018-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	4824.0	0.5	1.0E-04	5.6	2.1E-08	0	Included in Overall
Switchboard,Alarm	221019-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	2904.0	0.5	1.7E-04	5.6	5.9E-08	0	Included in Overall
Switchboard,Alarm	221020-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	456.0	0.5	1.1E-03	5.6	2.4E-06	0	Included in Overall
Switchboard,Alarm	800105-000	Military	N	NPRD-2016	1. A: Failures B: Time	20.0	11825400.0	20.0	1.7E-06	1.4	1.4E-13	1	Overall
Switchboard,Alarm	800105-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	400715.0	0.5	1.2E-06	5.6	3.1E-12	0	Included in Overall
Switchboard,Alarm	800106-000	Military	N	NPRD-2016	1. A: Failures B: Time	1.0	2167680.0	1.0	4.6E-07	3.9	2.1E-13	0	Included in Overall
Switchboard,Alarm	800107-000	Military	N	NPRD-2016	1. A: Failures B: Time	12.0	3563035.0	12.0	3.4E-06	1.6	9.5E-13	0	Included in Overall
Switchboard,Alarm	800108-000	Military	N	NPRD-2016	1. A: Failures B: Time	7.0	5693970.0	7.0	1.2E-06	1.8	2.2E-13	0	Included in Overall
Switchboard,Control	18459-000	Unknown	N	NPRD-2016	1. A: Failures B: Time	82.0	136923.0	82.0	6.0E-04	1.2	4.4E-09	0	Out of Expected Range
Control,Switchboard	221015-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	21402.0	0.5	2.3E-05	5.6	1.1E-09	1	Overall
Control,Switchboard	221015-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	5754.0	0.5	8.7E-05	5.6	1.5E-08	0	Included in Overall
Control,Switchboard	221016-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	4080.0	0.5	1.2E-04	5.6	3.0E-08	0	Included in Overall
Control,Switchboard	221017-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	3384.0	0.5	1.5E-04	5.6	4.4E-08	0	Included in Overall
Control,Switchboard	221018-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	4824.0	0.5	1.0E-04	5.6	2.1E-08	0	Included in Overall
Control,Switchboard	221019-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	2904.0	0.5	1.7E-04	5.6	5.9E-08	0	Included in Overall
Control,Switchboard	221020-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	456.0	0.5	1.1E-03	5.6	2.4E-06	0	Included in Overall
Switchboard,Patching	800105-000	Military	N	NPRD-2016	1. A: Failures B: Time	1.0	2365080.0	1.0	4.2E-07	3.9	1.8E-13	1	Overall
Switchboard,Patching	800105-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	80143.0	0.5	6.2E-06	5.6	7.8E-11	0	Included in Overall
Switchboard,Patching	800106-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	433536.0	0.5	1.2E-06	5.6	2.7E-12	0	Included in Overall
Switchboard,Patching	800107-000	Military	N	NPRD-2016	1. A: Failures B: Time	1.0	712607.0	1.0	1.4E-06	3.9	2.0E-12	0	Included in Overall
Switchboard,Patching	800108-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	1138794.0	0.5	4.4E-07	5.6	3.9E-13	0	Included in Overall
Switchboard,Power	800105-000	Military	N	NPRD-2016	1. A: Failures B: Time	12.0	2365080.0	12.0	5.1E-06	1.6	2.1E-12	1	Overall
Switchboard,Power	800105-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	80143.0	0.5	6.2E-06	5.6	7.8E-11	0	Included in Overall
Switchboard,Power	800106-000	Military	N	NPRD-2016	1. A: Failures B: Time	0	433536.0	0.5	1.2E-06	5.6	2.7E-12	0	Included in Overall
Switchboard,Power	800107-000	Military	N	NPRD-2016	1. A: Failures B: Time	3.0	712607.0	3.0	4.2E-06	2.4	5.9E-12	0	Included in Overall
Switchboard,Power	800108-000	Military	N	NPRD-2016	1. A: Failures B: Time	9.0	1138794.0	9.0	7.9E-06	1.7	6.9E-12	0	Included in Overall

Figure F- 26: D-RAD Rate Based Data Sheet for Switchboards

Thruster — **D-RAD Rate Based Data Sheet (per hour)**

← Mode Source		Parameters for Lognormal(Mean, EF) and Gamma(α, β)					
Failure Mode	**Percent**	**Mean**	**Error Factor**	**α**	**β**	**SD**	**Variance**
Overall Critical Rate (DPS-THR-FTR)	100%	2.43E-05	13.0	9.6E-02	3.9E+03	7.8E-05	6.2E-09
All	100%	2.4E-05	13.0	9.6E-02	3.9E+03	7.8E-05	6.2E-09
		Records Used	13	Failures Used	2,018.5		

Name	Field 1	Field 2	Location	Source	Data Type	A	B	Implicit Failures	Mean	EF	Variance	Data Selector	Comment
Thruster - Azimuth, Fixed Pitch	Overall Critical Rate	Table 5-1	Master's Thesis	KTH2010	3. A: Mean Only	1.0E-04		0.5	1.0E-04	5.6	2.2E-08	1	
Thruster - Azimuth, Controllable Pitch Propeller	Overall Critical Rate	Table 5-1	Master's Thesis	KTH2010	3. A: Mean Only	1.3E-04		0.5	1.3E-04	5.6	3.4E-08	0	
Thruster - Azimuth, Controllable Pitch Propeller	Overall Critical Rate	Table 5-2	Master's Thesis	KTH2010	3. A: Mean Only	5.0E-06		0.5	5.0E-06	5.6	5.0E-11	0	
Thruster - Fixed Axis, Fixed Pitch	Overall Rate	p26	Table 2	Shatto Paper	3. A: Mean Only	8.3E-05		0.5	8.3E-05	5.6	1.4E-08	1	
Thruster - Fixed Axis,Controllable Pitch	Overall Rate	p26	Table 2	Shatto Paper	3. A: Mean Only	1.0E-04		0.5	1.0E-04	5.6	2.2E-08	0	
Thruster - Azimuthing, Fixed Pitch	Overall Rate	p26	Table 2	Shatto Paper	3. A: Mean Only	1.0E-04		0.5	1.0E-04	5.6	2.2E-08	1	
Thruster - Azimuthing,Controllable Pitch	Overall Rate	p26	Table 2	Shatto Paper	3. A: Mean Only	1.3E-04		0.5	1.3E-04	5.6	3.4E-08	0	
Thruster - Finding Frequency	Oil Tankers		Marine Classification Society - Redacted		1. A: Failures B: Time	96.0	24534132.0	96.0	3.9E-06	1.2	1.6E-13	1	
Thruster - Finding Frequency	Oil/Chemical Tankers		Marine Classification Society - Redacted		1. A: Failures B: Time	40.0	28608408.0	40.0	1.4E-06	1.3	4.9E-14	1	
Thruster - Finding Frequency	Gas Carriers		Marine Classification Society - Redacted		1. A: Failures B: Time	2.0	7721064.0	2.0	2.6E-07	2.9	3.4E-14	1	
Thruster - Finding Frequency	Bulk Carriers		Marine Classification Society - Redacted		1. A: Failures B: Time	10.0	6276540.0	10.0	1.6E-06	1.7	2.5E-13	1	
Thruster - Finding Frequency	Dry Cargo		Marine Classification Society - Redacted		1. A: Failures B: Time	83.0	41243832.0	83.0	2.0E-06	1.2	4.9E-14	1	
Thruster - Finding Frequency	Container		Marine Classification Society - Redacted		1. A: Failures B: Time	30.0	15491184.0	30.0	1.9E-06	1.3	1.3E-13	1	
Thruster - Finding Frequency	Passenger		Marine Classification Society - Redacted		1. A: Failures B: Time	426.0	71070756.0	426.0	6.0E-06	1.1	8.4E-14	1	
Thruster - Finding Frequency	Offshore		Marine Classification Society - Redacted		1. A: Failures B: Time	943.0	276288648.0	943.0	3.4E-06	1.1	1.2E-14	1	
Thruster - Finding Frequency	Fishing		Marine Classification Society - Redacted		1. A: Failures B: Time	49.0	49930248.0	49.0	9.8E-07	1.3	2.0E-14	1	
Thruster - Finding Frequency	Other		Marine Classification Society - Redacted		1. A: Failures B: Time	338.0	112913772.0	338.0	3.0E-06	1.1	2.7E-14	1	

Figure F- 27: D-RAD Rate Based Data Sheet for Thrusters

Umbilical — **D-RAD Rate Based Data Sheet (per hour)**

OREDA	← Mode Source	Parameters for Lognormal(Mean, EF) and Gamma(α, β)					
Failure Mode	**Percent**	**Mean**	**Error Factor**	**α**	**β**	**SD**	**Variance**
Overall Critical Rate (ELS-UMB-FOF)	100%	2.47E-06	17.60	5.0E-02	2.0E+04	1.1E-05	1.2E-10
External Leakage	41.2%	1.0E-06	19.4	4.0E-02	4.0E+04	5.1E-06	2.6E-11
Structural Deficiency	23.5%	5.8E-07	21.3	3.2E-02	5.6E+04	3.2E-06	1.0E-11
Plugged	32.4%	8.0E-07	20.1	3.7E-02	4.6E+04	4.1E-06	1.7E-11
Internal Leakage	2.9%	7.3E-08	38.0	7.6E-03	1.0E+05	8.3E-07	6.9E-13
		Records Used	10		Failures Used	5.2	

Modes	
External leakage	14
No immediate effect	1
Structural deficiency	8
Plugged	11
Internal leakage	1

Data Sources													
Name	**Field 1**	**Field 2**	**Location**	**Source**	**Data Type**	**A**	**B**	**Implicit Failures**	**Mean**	**EF**	**Variance**	**Data Selector**	**Comment**
Static Umbilical	Overall Critical Rate	pg. 79	5.1.1	OREDA V1	2. A: Mean B: SD	1.4E-05	3.1E-05	0.2	1.4E-05	8.8	9.6E-10	1	
Dynamic Umbilical	Overall Critical Rate	pg. 90	5.1.3	OREDA V1	2. A: Mean B: SD	1.2E-06	1.2E-06	1.0	1.2E-06	3.9	1.5E-12	1	
Static Umbilical	Overall Critical Rate	pg. 96	5.1.5	OREDA V1	2. A: Mean B: SD	3.3E-06	6.9E-06	0.2	3.3E-06	8.4	4.8E-11	1	
Static Umbilical	Overall Critical Rate	pg. 96	5.1.5	OREDA V1	2. A: Mean B: SD	1.3E-06	1.5E-06	0.8	1.3E-06	4.4	2.1E-12	1	
Static Umbilical	Overall Critical Rate	pg. 96	5.1.5	OREDA V1	2. A: Mean B: SD	4.3E-07	5.2E-07	0.7	4.3E-07	4.8	2.7E-13	1	
Static Umbilical	Overall Critical Rate	pg. 96	5.1.5	OREDA V1	2. A: Mean B: SD	1.4E-06	3.1E-06	0.2	1.4E-06	9.2	9.7E-12	1	
Static Umbilical	Overall Critical Rate	pg. 96	5.1.5	OREDA V1	2. A: Mean B: SD	1.6E-06	1.8E-06	0.8	1.6E-06	4.3	3.1E-12	1	
Dynamic Umbilical	Overall Critical Rate	pg. 100	5.1.6	OREDA V1	2. A: Mean B: SD	6.7E-07	9.9E-07	0.5	6.7E-07	5.9	9.8E-13	1	
Static Umbilical	Overall Critical Rate	pg. 102	5.1.6	OREDA V1	2. A: Mean B: SD	2.4E-07	3.4E-07	0.5	2.4E-07	5.6	1.2E-13	1	
Dynamic Umbilical	Overall Critical Rate	pg. 106	5.1.7	OREDA V1	2. A: Mean B: SD	2.2E-07	4.4E-07	0.3	2.2E-07	8.1	1.9E-13	1	

Figure F- 28: D-RAD Rate Based Data Sheet for Umbilicals

Valve, Check — **D-RAD Rate Based Data Sheet (per hour)**

OREDA-2015	← Mode Source	Parameters for Lognormal(Mean, EF) and Gamma(α, β)						
Failure Mode	**Percent**	**Mean**	**Error Factor**	**α**	**β**	**SD**	**Variance**	
Overall Critical Rate	100%	1.6E-06	9.0	2.0E-01	1.3E+05	3.5E-06	1.2E-11	
Plugged/Choked	0.3%	5.3E-09	18.2	4.7E-02	8.8E+06	2.4E-08	6.0E-16	HYS-SCV-FTO
Leakage in Closed Position	3.5%	5.4E-08	10.4	1.5E-01	2.8E+06	1.4E-07	1.9E-14	
Other Failure Mode	1.2%	1.9E-08	12.5	1.0E-01	5.6E+06	5.8E-08	3.3E-15	
Fail to Close	3.8%	6.0E-08	10.2	1.6E-01	2.6E+06	1.5E-07	2.3E-14	
External Leak	91.2%	1.4E-06	9.0	2.0E-01	1.4E+05	3.2E-06	1.0E-11	
Fails to Open*	0.3%	5.3E-09	18.2	4.7E-02	8.8E+06	2.4E-08	6.0E-16	
Fails to Close (HYS-SCV-FTC)	7.3%	1.14E-07	9.66	1.8E-01	1.5E+06	2.7E-07	7.4E-14	
		Records Used	18		Failures Used		106.2	

Name	Data Sources Field 1	Field 2	Location	Source	Data Type	A	B	Implicit Failures	Mean	EF	Variance	Data Selector	Comment
Valve, Check	Overall Critical Rate	5.1	p61	OREDA-2015	2. A: Mean B: SD	1.2E-07	2.7E-07	0.2	1.2E-07	9.1	7.3E-14	1	Overall
Valve, Check	Plugged/Choked	5.1	p61	OREDA-2015	2. A: Mean B: SD	1.2E-07	2.7E-07	0.2	1.2E-07	9.1	7.3E-14	0	Included in Overall
Valve, Check	Overall Critical Rate	5.1.1	p80	OREDA-2015	2. A: Mean B: SD	5.3E-06	7.4E-06	0.5	5.3E-06	5.6	5.5E-11	1	Overall
Valve, Check	Overall Critical Rate	5.1.2	p87	OREDA-2015	2. A: Mean B: SD	2.0E-07	5.1E-07	0.2	2.0E-07	10.3	2.6E-13	1	Overall
Valve, Check	Plugged/Choked	5.1.2	p87	OREDA-2015	2. A: Mean B: SD	2.0E-07	5.1E-07	0.2	2.0E-07	10.3	2.6E-13	0	Included in Overall
Valve, Check	Overall Critical Rate	5.1.4	p93	OREDA-2015	2. A: Mean B: SD	2.0E-07	2.9E-07	0.5	2.0E-07	5.8	8.4E-14	1	Overall
Valve, Check	Overall Critical Rate	5.1.5	p97	OREDA-2015	2. A: Mean B: SD	9.6E-09	1.4E-08	0.5	9.6E-09	5.6	1.9E-16	0	Out of Expected Range
Valve, Check	Overall Critical Rate	5.1.6	p103	OREDA-2015	2. A: Mean B: SD	1.6E-05	2.3E-05	0.5	1.6E-05	5.6	5.3E-10	0	Out of Expected Range
Valve, Check	Overall Critical Rate	5.3	p125	OREDA-2015	2. A: Mean B: SD	2.0E-08	3.0E-08	0.4	2.0E-08	6.0	9.0E-16	1	Overall
Valve, Check	Overall Critical Rate	5.3.1	p130	OREDA-2015	2. A: Mean B: SD	6.0E-08	9.0E-08	0.4	6.0E-08	6.0	8.1E-15	1	Overall
Valve, Check	Overall Critical Rate	5.3.2	p133	OREDA-2015	2. A: Mean B: SD	3.0E-08	4.0E-08	0.6	3.0E-08	5.3	1.6E-15	1	Overall
Valve, Check	Overall Critical Rate	5.5	p145	OREDA-2015	2. A: Mean B: SD	3.7E-06	5.2E-06	0.5	3.7E-06	5.6	2.7E-11	1	Overall
Valve, Check	Overall Critical Rate	5.5.2	p149	OREDA-2015	2. A: Mean B: SD	3.7E-06	5.2E-06	0.5	3.7E-06	5.6	2.7E-11	1	Overall
Valve, Check	Overall Critical Rate	5.8	p168	OREDA-2015	2. A: Mean B: SD	2.8E-06	3.9E-06	0.5	2.8E-06	5.6	1.5E-11	1	Overall
Valve, Check	Overall Critical Rate	5.8	p169	OREDA-2015	2. A: Mean B: SD	1.2E-06	1.8E-06	0.5	1.2E-06	5.6	3.1E-12	1	Overall
Valve, Check	Overall Critical Rate	5.8	p171	OREDA-2015	2. A: Mean B: SD	1.3E-07	2.9E-07	0.2	1.3E-07	9.0	8.4E-14	1	Overall
Valve, Check	Leakage in Closed Position	5.8	p171	OREDA-2015	2. A: Mean B: SD	1.1E-07	2.8E-07	0.2	1.1E-07	10.3	7.8E-14	0	Included in Overall
Valve, Check	Other Failure Mode	5.8	p171	OREDA-2015	2. A: Mean B: SD	3.0E-08	8.0E-08	0.1	3.0E-08	10.8	6.4E-15	0	Included in Overall
Valve, Check	Overall Critical Rate	5.8.1	p180	OREDA-2015	2. A: Mean B: SD	1.2E-06	1.8E-06	0.5	1.2E-06	5.6	3.1E-12	1	Overall
Valve, Check	Overall Critical Rate	5.8.1	p183	OREDA-2015	2. A: Mean B: SD	1.8E-07	3.6E-07	0.3	1.8E-07	8.1	1.3E-13	1	Overall
Valve, Check	Leakage in Closed Position	5.8.1	p183	OREDA-2015	2. A: Mean B: SD	1.3E-07	7.0E-08	3.4	1.3E-07	2.3	4.9E-15	0	Included in Overall
Valve, Check	Other Failure Mode	5.8.1	p183	OREDA-2015	2. A: Mean B: SD	4.0E-09	1.0E-08	0.2	4.0E-09	10.1	1.0E-16	0	Included in Overall
Valve, Check	Other Failure Mode	5.8.2	p186	OREDA-2015	2. A: Mean B: SD	2.8E-06	3.9E-06	0.5	2.8E-06	5.6	1.5E-11	1	Overall
Valve, Check	Other Failure Mode	5.8.2	p187	OREDA-2015	2. A: Mean B: SD	8.0E-08	1.2E-07	0.4	8.0E-08	6.0	1.4E-14	1	Overall
Valve, Check	Overall Critical Rate		Table 1	OTH 94 995	1. A: Failures B: Time	99.0	28662720.0	99.0	3.5E-06	1.2	1.2E-13	1	Overall
Valve, Check	Fail to Close		Table 1	OTH 94 995	1. A: Failures B: Time	4.0	28662720.0	4.0	1.4E-07	2.2	4.9E-15	0	Included in Overall
Valve, Check	External Leak		Table 1	OTH 94 995	1. A: Failures B: Time	95.0	28662720.0	95.0	3.3E-06	1.2	1.2E-13	0	Included in Overall
Valve, Check, Hydraulic	Overall Critical Rate		Table I.1	434-A1, OGP	3. A: Mean Only	3.1E-06		0.5	3.1E-06	5.6	1.9E-11	1	Overall

Figure F- 29: D-RAD Rate Based Data Sheet for Check Valves

Valve, Gate (NPRD-2016) **D-RAD Rate Based Data Sheet (per hour)**

Valve,Hydraulic,Gate Shear	← Mode Source	Parameters for Lognormal(Mean, EF) and Gamma(α, β)					
Failure Mode	**Percent**	**Mean**	**Error Factor**	**α**	**β**	**SD**	**Variance**
Overall Critical Rate	100%	8.6E-06	9.1	2.0E-01	2.3E+04	1.9E-05	3.7E-10
Seal Failure (HOV-FTC, HOV-LKI)	60%	5.12E-06	9.11	2.0E-01	3.9E+04	1.2E-05	1.3E-10
No Operation	25%	2.1E-06	9.1	2.0E-01	9.4E+04	4.7E-06	2.2E-11
Out of Specification	7%	5.6E-07	9.1	2.0E-01	3.5E+05	1.3E-06	1.6E-12
Mechanical Failure	5%	3.9E-07	9.1	2.0E-01	5.1E+05	8.7E-07	7.6E-13
False Operation	3%	2.3E-07	9.1	2.0E-01	8.5E+05	5.2E-07	2.7E-13
Intermittent Operation	2%	1.7E-07	9.1	2.0E-01	1.1E+06	3.9E-07	1.5E-13
		Records Used		19	Failures Used		9,834.5

Name	Data Sources Field 1	Field 2	ID	Source	Data Type	A	B	Implicit Failures	Mean	EF	Variance	Data Selector	Comment
Valve Assembly, Gate	Military	AC	800109-000	NPRD-2016	1. A: Failures B: Time	0	2871248.0	0.5	1.7E-07	5.6	6.1E-14	1	Overall
Valve Assembly, Gate	Military	AC	800109-000	NPRD-2016	1. A: Failures B: Time	0	267352.0	0.5	1.9E-06	5.6	7.0E-12	0	Included in Overall
Valve Assembly, Gate	Military	AC	800110-000	NPRD-2016	1. A: Failures B: Time	0	287426.0	0.5	1.7E-06	5.6	6.1E-12	0	Included in Overall
Valve Assembly, Gate	Military	AC	800111-000	NPRD-2016	1. A: Failures B: Time	0	317152.0	0.5	1.6E-06	5.6	5.0E-12	0	Included in Overall
Valve Assembly, Gate	Military	AC	800112-000	NPRD-2016	1. A: Failures B: Time	0	345956.0	0.5	1.4E-06	5.6	4.2E-12	0	Included in Overall
Valve Assembly, Gate	Military	AC	800113-000	NPRD-2016	1. A: Failures B: Time	0	319120.0	0.5	1.6E-06	5.6	4.9E-12	0	Included in Overall
Valve Assembly, Gate	Military	AC	800114-000	NPRD-2016	1. A: Failures B: Time	0	301170.0	0.5	1.7E-06	5.6	5.5E-12	0	Included in Overall
Valve Assembly, Gate	Military	AC	800115-000	NPRD-2016	1. A: Failures B: Time	0	272984.0	0.5	1.8E-06	5.6	6.7E-12	0	Included in Overall
Valve Assembly, Gate	Military	AC	800116-000	NPRD-2016	1. A: Failures B: Time	0	264865.0	0.5	1.9E-06	5.6	7.1E-12	0	Included in Overall
Valve Assembly, Gate	Military	AC	800117-000	NPRD-2016	1. A: Failures B: Time	0	250570.0	0.5	2.0E-06	5.6	8.0E-12	0	Included in Overall
Valve Assembly, Gate	Military	AC	800118-000	NPRD-2016	1. A: Failures B: Time	1.0	244653.0	1.0	4.1E-06	3.9	1.7E-11	0	Included in Overall
Gate Valve Assembly	Military	N	800105-000	NPRD-2016	1. A: Failures B: Time	2.0	2365080.0	2.0	8.5E-07	2.9	3.6E-13	1	Overall
Gate Valve Assembly	Military	N	800105-000	NPRD-2016	1. A: Failures B: Time	0	80143.0	0.5	6.2E-06	5.6	7.8E-11	0	Included in Overall
Gate Valve Assembly	Military	N	800106-000	NPRD-2016	1. A: Failures B: Time	0	433536.0	0.5	1.2E-06	5.6	2.7E-12	0	Included in Overall
Gate Valve Assembly	Military	N	800107-000	NPRD-2016	1. A: Failures B: Time	2.0	712607.0	2.0	2.8E-06	2.9	3.9E-12	0	Included in Overall
Gate Valve Assembly	Military	N	800108-000	NPRD-2016	1. A: Failures B: Time	0	1138794.0	0.5	4.4E-07	5.6	3.9E-13	0	Included in Overall
Valve, Gate	Military	AC	800109-000	NPRD-2016	1. A: Failures B: Time	5.0	14356240.0	5.0	3.5E-07	2.0	2.4E-14	1	Overall
Valve, Gate	Military	AC	800109-000	NPRD-2016	1. A: Failures B: Time	0	1336760.0	0.5	3.7E-07	5.6	2.8E-13	0	Included in Overall
Valve, Gate	Military	AC	800110-000	NPRD-2016	1. A: Failures B: Time	1.0	1437130.0	1.0	7.0E-07	3.9	4.8E-13	0	Included in Overall
Valve, Gate	Military	AC	800111-000	NPRD-2016	1. A: Failures B: Time	0	1585760.0	0.5	3.2E-07	5.6	2.0E-13	0	Included in Overall
Valve, Gate	Military	AC	800112-000	NPRD-2016	1. A: Failures B: Time	1.0	1729780.0	1.0	5.8E-07	3.9	3.3E-13	0	Included in Overall
Valve, Gate	Military	AC	800113-000	NPRD-2016	1. A: Failures B: Time	2.0	1595600.0	2.0	1.3E-06	2.9	7.9E-13	0	Included in Overall
Valve, Gate	Military	AC	800114-000	NPRD-2016	1. A: Failures B: Time	0	1505850.0	0.5	3.3E-07	5.6	2.2E-13	0	Included in Overall
Valve, Gate	Military	AC	800115-000	NPRD-2016	1. A: Failures B: Time	0	1364920.0	0.5	3.7E-07	5.6	2.7E-13	0	Included in Overall
Valve, Gate	Military	AC	800116-000	NPRD-2016	1. A: Failures B: Time	0	1324325.0	0.5	3.8E-07	5.6	2.9E-13	0	Included in Overall
Valve, Gate	Military	AC	800117-000	NPRD-2016	1. A: Failures B: Time	1.0	1252850.0	1.0	8.0E-07	3.9	6.4E-13	0	Included in Overall
Valve, Gate	Military	AC	800118-000	NPRD-2016	1. A: Failures B: Time	0	1223265.0	0.5	4.1E-07	5.6	3.3E-13	0	Included in Overall
Valve, Gate	Military	ARW	221006-000	NPRD-2016	1. A: Failures B: Time	0	932492.0	0.5	5.4E-07	5.6	5.8E-13	1	Overall
Valve, Gate	Military	ARW	221006-000	NPRD-2016	1. A: Failures B: Time	0	105868.0	0.5	4.7E-06	5.6	4.5E-11	0	Included in Overall
Valve, Gate	Military	ARW	221007-000	NPRD-2016	1. A: Failures B: Time	0	107544.0	0.5	4.6E-06	5.6	4.3E-11	0	Included in Overall
Valve, Gate	Military	ARW	221008-000	NPRD-2016	1. A: Failures B: Time	0	107612.0	0.5	4.6E-06	5.6	4.3E-11	0	Included in Overall
Valve, Gate	Military	ARW	221009-000	NPRD-2016	1. A: Failures B: Time	0	102000.0	0.5	4.9E-06	5.6	4.8E-11	0	Included in Overall
Valve, Gate	Military	ARW	221010-000	NPRD-2016	1. A: Failures B: Time	0	108344.0	0.5	4.6E-06	5.6	4.3E-11	0	Included in Overall
Valve, Gate	Military	ARW	221011-000	NPRD-2016	1. A: Failures B: Time	0	112588.0	0.5	4.4E-06	5.6	3.9E-11	0	Included in Overall
Valve, Gate	Military	ARW	221012-000	NPRD-2016	1. A: Failures B: Time	0	105904.0	0.5	4.7E-06	5.6	4.5E-11	0	Included in Overall
Valve, Gate	Military	ARW	221013-000	NPRD-2016	1. A: Failures B: Time	0	98276.0	0.5	5.1E-06	5.6	5.2E-11	0	Included in Overall
Valve, Gate	Military	ARW	221014-000	NPRD-2016	1. A: Failures B: Time	0	84356.0	0.5	5.9E-06	5.6	7.0E-11	0	Included in Overall
Valve, Gate	Military	N	221015-000	NPRD-2016	1. A: Failures B: Time	0	749070.0	0.5	6.7E-07	5.6	8.9E-13	1	Overall
Valve, Gate	Military	N	221015-000	NPRD-2016	1. A: Failures B: Time	0	201390.0	0.5	2.5E-06	5.6	1.2E-11	0	Included in Overall
Valve, Gate	Military	N	221016-000	NPRD-2016	1. A: Failures B: Time	0	142800.0	0.5	3.5E-06	5.6	2.5E-11	0	Included in Overall
Valve, Gate	Military	N	221017-000	NPRD-2016	1. A: Failures B: Time	0	118440.0	0.5	4.2E-06	5.6	3.6E-11	0	Included in Overall
Valve, Gate	Military	N	221018-000	NPRD-2016	1. A: Failures B: Time	0	168840.0	0.5	3.0E-06	5.6	1.8E-11	0	Included in Overall
Valve, Gate	Military	N	221019-000	NPRD-2016	1. A: Failures B: Time	0	101640.0	0.5	4.9E-06	5.6	4.8E-11	0	Included in Overall
Valve, Gate	Military	N	221020-000	NPRD-2016	1. A: Failures B: Time	0	15960.0	0.5	3.1E-05	5.6	2.0E-09	0	Included in Overall

Figure F- 30: D-RAD Rate Based Data Sheet for Gate Valves

Valve, Gate	Military	N	800105-000	NPRD-2016	1. A: Failures B: Time	9391.0	447000120.0	9,391.0	2.1E-05	1.0	4.7E-14	1	Overall
Valve, Gate	Military	N	800105-000	NPRD-2016	1. A: Failures B: Time	100.0	15147027.0	100.0	6.6E-06	1.2	4.4E-13	0	Included in Overall
Valve, Gate	Military	N	800106-000	NPRD-2016	1. A: Failures B: Time	2003.0	81938304.0	2,003.0	2.4E-05	1.0	3.0E-13	0	Included in Overall
Valve, Gate	Military	N	800107-000	NPRD-2016	1. A: Failures B: Time	3179.0	134682723.0	3,179.0	2.4E-05	1.0	1.8E-13	0	Included in Overall
Valve, Gate	Military	N	800108-000	NPRD-2016	1. A: Failures B: Time	4109.0	215232066.0	4,109.0	1.9E-05	1.0	8.9E-14	0	Included in Overall
Valve, Gate	Military	NH	24794-000	NPRD-2016	1. A: Failures B: Time	18.0	36778.0	18.0	4.9E-04	1.5	1.3E-08	0	Environment
Valve, Gate Shear, Hydraulic	Military	GF	23013-000	NPRD-2016	1. A: Failures B: Time	2.0	1658880.0	2.0	1.2E-06	2.9	7.3E-13	1	
Valve, Gate, Fill, Manual, Hydraulic	Military	ARW	221006-000	NPRD-2016	1. A: Failures B: Time	0	233123.0	0.5	2.1E-06	5.6	9.2E-12	1	Overall
Valve, Gate, Fill, Manual, Hydraulic	Military	ARW	221006-000	NPRD-2016	1. A: Failures B: Time	0	26467.0	0.5	1.9E-05	5.6	7.1E-10	0	Included in Overall
Valve, Gate, Fill, Manual, Hydraulic	Military	ARW	221007-000	NPRD-2016	1. A: Failures B: Time	0	26886.0	0.5	1.9E-05	5.6	6.9E-10	0	Included in Overall
Valve, Gate, Fill, Manual, Hydraulic	Military	ARW	221008-000	NPRD-2016	1. A: Failures B: Time	0	26903.0	0.5	1.9E-05	5.6	6.9E-10	0	Included in Overall
Valve, Gate, Fill, Manual, Hydraulic	Military	ARW	221009-000	NPRD-2016	1. A: Failures B: Time	0	25500.0	0.5	2.0E-05	5.6	7.7E-10	0	Included in Overall
Valve, Gate, Fill, Manual, Hydraulic	Military	ARW	221010-000	NPRD-2016	1. A: Failures B: Time	0	27086.0	0.5	1.8E-05	5.6	6.8E-10	0	Included in Overall
Valve, Gate, Fill, Manual, Hydraulic	Military	ARW	221011-000	NPRD-2016	1. A: Failures B: Time	0	28147.0	0.5	1.8E-05	5.6	6.3E-10	0	Included in Overall
Valve, Gate, Fill, Manual, Hydraulic	Military	ARW	221012-000	NPRD-2016	1. A: Failures B: Time	0	26476.0	0.5	1.9E-05	5.6	7.1E-10	0	Included in Overall
Valve, Gate, Fill, Manual, Hydraulic	Military	ARW	221013-000	NPRD-2016	1. A: Failures B: Time	0	24569.0	0.5	2.0E-05	5.6	8.3E-10	0	Included in Overall
Valve, Gate, Fill, Manual, Hydraulic	Military	ARW	221014-000	NPRD-2016	1. A: Failures B: Time	0	21089.0	0.5	2.4E-05	5.6	1.1E-09	0	Included in Overall
Valve, Gate, Hydraulic, Gate Shear	Military	A	NPRD-106	NPRD-2016	1. A: Failures B: Time	11.0	339000.0	11.0	3.2E-05	1.6	9.6E-11	1	
Valve, Gate, Hydraulic, Gate Shear	Military	ARW	NPRD-091	NPRD-2016	1. A: Failures B: Time	5.0	70000.0	5.0	7.1E-05	2.0	1.0E-09	1	
Valve, Gate, Hydraulic, Gate Shear	Military	GF	23013-000	NPRD-2016	1. A: Failures B: Time	1.0	1658880.0	1.0	6.0E-07	3.9	3.6E-13	1	
Valve, Gate, Hydraulic, Gate Shear	Unknown	GF	18354-000	NPRD-2016	1. A: Failures B: Time	359.0	69273000.0	359.0	5.2E-06	1.1	7.5E-14	1	
Valve, Gate, NC: Normally Closed	Commercial	GF	23047-033	NPRD-2016	1. A: Failures B: Time	0	222048.0	0.5	2.3E-06	5.6	1.0E-11	1	
Valve, Gate, NC: Normally Closed	Commercial	GF	23047-064	NPRD-2016	1. A: Failures B: Time	1.0	347519.0	1.0	2.9E-06	3.9	8.3E-12	1	
Valve, Gate, NC: Normally Closed	Commercial	GF	23047-032	NPRD-2016	1. A: Failures B: Time	1.0	6152158.0	1.0	1.6E-07	3.9	2.6E-14	1	
Valve, Gate, NO: Normally Opened	Commercial	GF	23047-033	NPRD-2016	1. A: Failures B: Time	0	83676984.0	0.5	6.0E-09	5.6	7.1E-17	1	
Valve, Gate, NO: Normally Opened	Commercial	GF	23047-060	NPRD-2016	1. A: Failures B: Time	0	2621480.0	0.5	1.9E-07	5.6	7.3E-14	1	
Valve,Gate,Shear,Hydraulic	Military	GF	23013-000	NPRD-2016	1. A: Failures B: Time	7.0	4166608.0	7.0	1.7E-06	1.8	4.0E-13	1	
Valve,Gate,Shear,Pneumatic	Unknown	GF	18354-000	NPRD-2016	1. A: Failures B: Time	46.0	2406000.0	46.0	1.9E-05	1.3	7.9E-12	1	

Figure F- 31: D-RAD Rate Based Data Sheet for Gate Valves (Cont.)

Valve, Needle **D-RAD Rate Based Data Sheet (per hour)**

FMD-2013	← Mode Source	Parameters for Lognormal(Mean, EF) and Gamma(α, β)					
Failure Mode	**Percent**	**Mean**	**Error Factor**	**α**	**β**	**SD**	**Variance**
Overall Critical Rate	100%	3.5E-06	4.3	8.5E-01	2.4E+05	3.8E-06	1.4E-11
Out of Specification	66.7%	2.3E-06	4.3	8.4E-01	3.6E+05	2.5E-06	6.5E-12
No Operation	16.7%	5.8E-07	4.5	7.5E-01	1.3E+06	6.7E-07	4.5E-13
Seal Failure	16.7%	5.8E-07	4.5	7.5E-01	1.3E+06	6.7E-07	4.5E-13
Closes Uncommanded (ORF-PLG)	16.7%	5.81E-07	4.54	7.5E-01	1.3E+06	6.7E-07	4.5E-13
		Records Used	6	Failures Used	73.5		

Name	Data Sources Field 1	Field 2	Location	Source	Data Type	A	B	Implicit Failures	Mean	EF	Variance	Data Selector	Comment
Valve,Needle	Military	N	221015-000	NPRD-2016	1. A: Failures B: Time	0	114276.0	0.5	4.4E-06	5.6	3.8E-11	1	Overall
Valve,Needle	Military	N	221015-000	NPRD-2016	1. A: Failures B: Time	0	11508.0	0.5	4.3E-05	5.6	3.8E-09	0	Included in Overall
Valve,Needle	Military	N	221016-000	NPRD-2016	1. A: Failures B: Time	0	8160.0	0.5	6.1E-05	5.6	7.5E-09	0	Included in Overall
Valve,Needle	Military	N	221017-000	NPRD-2016	1. A: Failures B: Time	0	6768.0	0.5	7.4E-05	5.6	1.1E-08	0	Included in Overall
Valve,Needle	Military	N	221018-000	NPRD-2016	1. A: Failures B: Time	0	9648.0	0.50	5.2E-05	5.6	5.4E-09	0	Included in Overall
Valve,Needle	Military	N	221019-000	NPRD-2016	1. A: Failures B: Time	0	5808.0	0.5	8.6E-05	5.6	1.5E-08	0	Included in Overall
Valve,Needle	Military	N	221020-000	NPRD-2016	1. A: Failures B: Time	0	912.0	0.5	5.5E-04	5.6	6.0E-07	0	Included in Overall
Valve,Needle	Military	N	221021-000	NPRD-2016	1. A: Failures B: Time	0	3672.0	0.5	1.4E-04	5.6	3.7E-08	0	Included in Overall
Valve,Needle	Military	N	221022-000	NPRD-2016	1. A: Failures B: Time	0	11064.0	0.5	4.5E-05	5.6	4.1E-09	0	Included in Overall
Valve,Needle	Military	N	221023-000	NPRD-2016	1. A: Failures B: Time	0	8736.0	0.5	5.7E-05	5.6	6.6E-09	0	Included in Overall
Valve,Needle	Military	N	221024-000	NPRD-2016	1. A: Failures B: Time	0	5832.0	0.5	8.6E-05	5.6	1.5E-08	0	Included in Overall
Valve,Needle	Military	N	221025-000	NPRD-2016	1. A: Failures B: Time	0	7776.0	0.5	6.4E-05	5.6	8.3E-09	0	Included in Overall
Valve,Needle	Military	N	221026-000	NPRD-2016	1. A: Failures B: Time	0	5112.0	0.5	9.8E-05	5.6	1.9E-08	0	Included in Overall
Valve,Needle	Military	N	221027-000	NPRD-2016	1. A: Failures B: Time	0	4224.0	0.5	1.2E-04	5.6	2.8E-08	0	Included in Overall
Valve,Needle	Military	N	221028-000	NPRD-2016	1. A: Failures B: Time	0	8304.0	0.5	6.0E-05	5.6	7.3E-09	0	Included in Overall
Valve,Needle	Military	N	221029-000	NPRD-2016	1. A: Failures B: Time	0	3600.0	0.5	1.4E-04	5.6	3.9E-08	0	Included in Overall
Valve,Needle	Military	N	221030-000	NPRD-2016	1. A: Failures B: Time	0	8016.0	0.5	6.2E-05	5.6	7.8E-09	0	Included in Overall
Valve,Needle	Military	N	221031-000	NPRD-2016	1. A: Failures B: Time	0	5136.0	0.5	9.7E-05	5.6	1.9E-08	0	Included in Overall
Valve,Needle	Military	N	800105-000	NPRD-2016	1. A: Failures B: Time	40.0	7095240.0	40.0	5.6E-06	1.3	7.9E-13	1	Overall
Valve,Needle	Military	N	800105-000	NPRD-2016	1. A: Failures B: Time	0	240429.0	0.5	2.1E-06	5.6	8.6E-12	0	Included in Overall
Valve,Needle	Military	N	800106-000	NPRD-2016	1. A: Failures B: Time	2.0	1300608.0	2.0	1.5E-06	2.9	1.2E-12	0	Included in Overall
Valve,Needle	Military	N	800107-000	NPRD-2016	1. A: Failures B: Time	10.0	2137821.0	10.0	4.7E-06	1.7	2.2E-12	0	Included in Overall
Valve,Needle	Military	N	800108-000	NPRD-2016	1. A: Failures B: Time	28.0	3416382.0	28.0	8.2E-06	1.4	2.4E-12	0	Included in Overall
Valve,Needle,Hydraulic	Commercial	GM	NPRD-063	NPRD-2016	1. A: Failures B: Time	0	779000.0	0.5	6.4E-07	5.6	8.2E-13	0	Included in Overall
Valve,Needle,Hydraulic	Military	GF	23013-000	NPRD-2016	1. A: Failures B: Time	5.0	3671534.0	5.0	1.4E-06	2.0	3.7E-13	0	Included in Overall
Valve,Needle,Hydraulic	Unknown	GF	18354-000	NPRD-2016	1. A: Failures B: Time	12.0	684000.0	12.0	1.8E-05	1.6	2.6E-11	0	Included in Overall
Stem,Needle Valve	Military	ARW	221006-000	NPRD-2016	1. A: Failures B: Time	0	233123.0	0.5	2.1E-06	5.6	9.2E-12	1	Overall
Stem,Needle Valve	Military	ARW	221006-000	NPRD-2016	1. A: Failures B: Time	0	26467.0	0.5	1.9E-05	5.6	7.1E-10	0	Included in Overall
Stem,Needle Valve	Military	ARW	221007-000	NPRD-2016	1. A: Failures B: Time	0	26886.0	0.5	1.9E-05	5.6	6.9E-10	0	Included in Overall
Stem,Needle Valve	Military	ARW	221008-000	NPRD-2016	1. A: Failures B: Time	0	26903.0	0.5	1.9E-05	5.6	6.9E-10	0	Included in Overall
Stem,Needle Valve	Military	ARW	221009-000	NPRD-2016	1. A: Failures B: Time	0	25500.0	0.5	2.0E-05	5.6	7.7E-10	0	Included in Overall
Stem,Needle Valve	Military	ARW	221010-000	NPRD-2016	1. A: Failures B: Time	0	27086.0	0.5	1.8E-05	5.6	6.8E-10	0	Included in Overall
Stem,Needle Valve	Military	ARW	221011-000	NPRD-2016	1. A: Failures B: Time	0	28147.0	0.5	1.8E-05	5.6	6.3E-10	0	Included in Overall
Stem,Needle Valve	Military	ARW	221012-000	NPRD-2016	1. A: Failures B: Time	0	26476.0	0.5	1.9E-05	5.6	7.1E-10	0	Included in Overall
Stem,Needle Valve	Military	ARW	221013-000	NPRD-2016	1. A: Failures B: Time	0	24569.0	0.5	2.0E-05	5.6	8.3E-10	0	Included in Overall
Stem,Needle Valve	Military	ARW	221014-000	NPRD-2016	1. A: Failures B: Time	0	21089.0	0.5	2.4E-05	5.6	1.1E-09	0	Included in Overall

Figure F- 31: D-RAD Rate Based Data Sheet for Needle Valves

Stem,Needle Valve	Military	N	221015-000	NPRD-2016	1. A: Failures B: Time	0	149814.0	0.5	3.3E-06	5.6	2.2E-11	1	Overall
Stem,Needle Valve	Military	N	221015-000	NPRD-2016	1. A: Failures B: Time	0	40278.0	0.5	1.2E-05	5.6	3.1E-10	0	Included in Overall
Stem,Needle Valve	Military	N	221016-000	NPRD-2016	1. A: Failures B: Time	0	28560.0	0.5	1.8E-05	5.6	6.1E-10	0	Included in Overall
Stem,Needle Valve	Military	N	221017-000	NPRD-2016	1. A: Failures B: Time	0	23688.0	0.5	2.1E-05	5.6	8.9E-10	0	Included in Overall
Stem,Needle Valve	Military	N	221018-000	NPRD-2016	1. A: Failures B: Time	0	33768.0	0.5	1.5E-05	5.6	4.4E-10	0	Included in Overall
Stem,Needle Valve	Military	N	221019-000	NPRD-2016	1. A: Failures B: Time	0	20328.0	0.5	2.5E-05	5.6	1.2E-09	0	Included in Overall
Stem,Needle Valve	Military	N	221020-000	NPRD-2016	1. A: Failures B: Time	0	3192.0	0.5	1.6E-04	5.6	4.9E-08	0	Included in Overall
Stem,Needle Valve	Military	N	800105-000	NPRD-2016	1. A: Failures B: Time	13.0	9460320.0	13.0	1.4E-06	1.6	1.5E-13	1	Overall
Stem,Needle Valve	Military	N	800105-000	NPRD-2016	1. A: Failures B: Time	0	320572.0	0.5	1.6E-06	5.6	4.9E-12	0	Included in Overall
Stem,Needle Valve	Military	N	800106-000	NPRD-2016	1. A: Failures B: Time	6.0	1734144.0	6.0	3.5E-06	1.9	2.0E-12	0	Included in Overall
Stem,Needle Valve	Military	N	800107-000	NPRD-2016	1. A: Failures B: Time	4.0	2850428.0	4.0	1.4E-06	2.2	4.9E-13	0	Included in Overall
Stem,Needle Valve	Military	N	800108-000	NPRD-2016	1. A: Failures B: Time	3.0	4555176.0	3.0	6.6E-07	2.4	1.4E-13	0	Included in Overall
Cartridge,Needle Valve	Military	N	800105-000	NPRD-2016	1. A: Failures B: Time	19.0	4730160.0	19.0	4.0E-06	1.5	8.5E-13	1	Overall
Cartridge,Needle Valve	Military	N	800105-000	NPRD-2016	1. A: Failures B: Time	1.0	160286.0	1.0	6.2E-06	3.9	3.9E-11	0	Included in Overall
Cartridge,Needle Valve	Military	N	800106-000	NPRD-2016	1. A: Failures B: Time	17.0	867072.0	17.0	2.0E-05	1.5	2.3E-11	0	Included in Overall
Cartridge,Needle Valve	Military	N	800107-000	NPRD-2016	1. A: Failures B: Time	1.0	1425214.0	1.0	7.0E-07	3.9	4.9E-13	0	Included in Overall
Cartridge,Needle Valve	Military	N	800108-000	NPRD-2016	1. A: Failures B: Time	0	2277588.0	0.5	2.2E-07	5.6	9.6E-14	0	Included in Overall

Figure F- 32: D-RAD Rate Based Data Sheet for Needle Valves (Cont.)

Valve, Pilot — **D-RAD Rate Based Data Sheet (per hour)**

OREDA-2015	← Mode Source	Parameters for Lognormal(Mean, EF) and Gamma(α, β)						
Failure Mode	**Percent**	**Mean**	**Error Factor**	**α**	**β**	**SD**	**Variance**	
Overall Critical Rate	100%	6.1E-06	3.8	1.1E+00	1.7E+05	6.0E-06	3.5E-11	
Fail to Close	18.8%	1.2E-06	4.3	8.2E-01	7.1E+05	1.3E-06	1.6E-12	
Spurious Operation	31.3%	1.9E-06	4.1	9.3E-01	4.8E+05	2.0E-06	4.0E-12	
External leak	43.8%	2.69E-06	3.97	9.8E-01	3.6E+05	2.7E-06	7.4E-12	PVL-LKE
Internal Leak	6.3%	3.8E-07	5.5	5.2E-01	1.4E+06	5.3E-07	2.8E-13	
Fails to Open*	18.8%	1.2E-06	4.3	8.2E-01	7.1E+05	1.3E-06	1.6E-12	
Fails to Close*	18.8%	1.2E-06	4.3	8.2E-01	7.1E+05	1.3E-06	1.6E-12	
Transfers Open Uncommanded (Leak Internal) (PVL-LKI)	**22%**	1.34E-06	4.25	8.6E-01	6.4E+05	1.5E-06	2.1E-12	
Transfers Closed Uncommanded*	15.6%	9.6E-07	4.5	7.8E-01	8.1E+05	1.1E-06	1.2E-12	
		Records Used		**4**	**Failures Used**		**29.0**	

Data Sources													
Name	**Field 1**	**Field 2**	**Location**	**Source**	**Data Type**	**A**	**B**	**Implicit Failures**	**Mean**	**EF**	**Variance**	**Data Selector**	**Comment**
Valve, Pilot	Overall Critical Rate		Table 1	OTH 94 995	1. A: Failures B: Time	**15.0**	**1288596.0**	15.0	1.2E-05	1.5	9.0E-12	1	Overall
Valve, Pilot	Fail to Close		Table 1	OTH 94 995	1. A: Failures B: Time	3.0	1288596.0	3.0	2.3E-06	2.4	1.8E-12	0	Included in Overall
Valve, Pilot	Spurious Operation		Table 1	OTH 94 995	1. A: Failures B: Time	5.0	1288596.0	5.0	3.9E-06	2.0	3.0E-12	0	Included in Overall
Valve, Pilot	External leak		Table 1	OTH 94 995	1. A: Failures B: Time	7.0	1288596.0	7.0	5.4E-06	1.8	4.2E-12	0	Included in Overall
Valve, Pilot	Internal Leak		Table 1	OTH 94 995	1. A: Failures B: Time	1.0	1288596.0	1.0	7.8E-07	3.9	6.0E-13	0	Included in Overall
Valve, Pilot	Overall Critical Rate		Table I.1	434-A1, OGP	3. A: Mean Only	2.1E-06		0.5	2.1E-06	5.6	8.4E-12	1	Overall
Valve, Pilot	Overall Critical Rate	221015-000		NPRD-2016	1. A: Failures B: Time	**0**	**92874.0**	0.5	5.4E-06	5.6	5.8E-11	1	Overall
Valve, Pilot		221015-000		NPRD-2016	1. A: Failures B: Time	0	5754.0	0.5	8.7E-05	5.6	1.5E-08	0	Included in Overall
Valve, Pilot		221016-000		NPRD-2016	1. A: Failures B: Time	0	4080.0	0.5	1.2E-04	5.6	3.0E-08	0	Included in Overall
Valve, Pilot		221017-000		NPRD-2016	1. A: Failures B: Time	0	3384.0	0.5	1.5E-04	5.6	4.4E-08	0	Included in Overall
Valve, Pilot		221018-000		NPRD-2016	1. A: Failures B: Time	0	4824.0	0.5	1.0E-04	5.6	2.1E-08	0	Included in Overall
Valve, Pilot		221019-000		NPRD-2016	1. A: Failures B: Time	0	2904.0	0.5	1.7E-04	5.6	5.9E-08	0	Included in Overall
Valve, Pilot		221020-000		NPRD-2016	1. A: Failures B: Time	0	456.0	0.5	1.1E-03	5.6	2.4E-06	0	Included in Overall
Valve, Pilot		221021-000		NPRD-2016	1. A: Failures B: Time	0	3672.0	0.5	1.4E-04	5.6	3.7E-08	0	Included in Overall
Valve, Pilot		221022-000		NPRD-2016	1. A: Failures B: Time	0	11064.0	0.5	4.5E-05	5.6	4.1E-09	0	Included in Overall
Valve, Pilot		221023-000		NPRD-2016	1. A: Failures B: Time	0	8736.0	0.5	5.7E-05	5.6	6.6E-09	0	Included in Overall
Valve, Pilot		221024-000		NPRD-2016	1. A: Failures B: Time	0	5832.0	0.5	8.6E-05	5.6	1.5E-08	0	Included in Overall
Valve, Pilot		221025-000		NPRD-2016	1. A: Failures B: Time	0	7776.0	0.5	6.4E-05	5.6	8.3E-09	0	Included in Overall
Valve, Pilot		221026-000		NPRD-2016	1. A: Failures B: Time	0	5112.0	0.5	9.8E-05	5.6	1.9E-08	0	Included in Overall
Valve, Pilot		221027-000		NPRD-2016	1. A: Failures B: Time	0	4224.0	0.5	1.2E-04	5.6	2.8E-08	0	Included in Overall
Valve, Pilot		221028-000		NPRD-2016	1. A: Failures B: Time	0	8304.0	0.5	6.0E-05	5.6	7.3E-09	0	Included in Overall
Valve, Pilot		221029-000		NPRD-2016	1. A: Failures B: Time	0	3600.0	0.5	1.4E-04	5.6	3.9E-08	0	Included in Overall
Valve, Pilot		221030-000		NPRD-2016	1. A: Failures B: Time	0	8016.0	0.5	6.2E-05	5.6	7.8E-09	0	Included in Overall
Valve, Pilot		221031-000		NPRD-2016	1. A: Failures B: Time	0	5136.0	0.5	9.7E-05	5.6	1.9E-08	0	Included in Overall
Valve, Pilot	Overall Critical Rate	800105-000		NPRD-2016	1. A: Failures B: Time	**13.0**	**2365080.0**	13.0	5.5E-06	1.6	2.3E-12	1	Overall
Valve, Pilot		800105-000		NPRD-2016	1. A: Failures B: Time	0	80143.0	0.5	6.2E-06	5.6	7.8E-11	0	Included in Overall
Valve, Pilot		800106-000		NPRD-2016	1. A: Failures B: Time	6.0	433536.0	6.0	1.4E-05	1.9	3.2E-11	0	Included in Overall
Valve, Pilot		800107-000		NPRD-2016	1. A: Failures B: Time	6.0	712607.0	6.0	8.4E-06	1.9	1.2E-11	0	Included in Overall
Valve, Pilot		800108-000		NPRD-2016	1. A: Failures B: Time	1.0	1138794.0	1.0	8.8E-07	3.9	7.7E-13	0	Included in Overall

Figure F- 32: D-RAD Rate Based Data Sheet for Pilot Valves

Valve, Shuttle — **D-RAD Rate Based Data Sheet (per hour)**

Valve, Hydraulic FMD-97	← Mode Source	Parameters for Lognormal(Mean, EF) and Gamma(α, β)					
Failure Mode	**Percent**	**Mean**	**Error Factor**	**α**	**β**	**SD**	**Variance**
Overall Critical Rate	100%	9.6E-06	9.6	1.8E-01	1.9E+04	2.3E-05	5.2E-10
Leaking	66.3%	6.4E-06	10.7	1.4E-01	2.3E+04	1.7E-05	2.8E-10
Jams	24.5%	2.4E-06	14.9	7.3E-02	3.1E+04	8.7E-06	7.7E-11
Out Of Specification	4.7%	4.5E-07	27.9	1.7E-02	3.7E+04	3.5E-06	1.2E-11
Cracked/Fractured	4.4%	4.2E-07	28.6	1.6E-02	3.7E+04	3.4E-06	1.1E-11
Fails (SHV-LKE)	95.2%	9.17E-06	9.70	1.7E-01	1.9E+04	2.2E-05	4.8E-10
Jam/Crack	29%	2.8E-06	14.0	8.3E-02	3.0E+04	9.7E-06	9.4E-11
		Records Used	3		Failures Used	1.5	

Name	Field 1	Field 2	Location	Source	Data Type	A	B	Implicit Failures	Mean	EF	Variance	Data Selector	Comment
Valve,Shuttle	Leaks External	p130	2013 Databook	SINTEF	3. A: Mean Only	4.2E-06		0.5	4.2E-06	5.6	3.5E-11	1	
Valve,Shuttle	Military	AA	221001-000	NPRD-2011	1. A: Failures B: Time	0	365464.0	0.5	1.4E-06	5.6	3.7E-12	1	Overall
Valve,Shuttle	Military	AA	221001-000	NPRD-2011	1. A: Failures B: Time	0	80423.0	0.5	6.2E-06	5.6	7.7E-11	0	Included in Overall
Valve,Shuttle	Military	AA	221002-000	NPRD-2011	1. A: Failures B: Time	0	76977.0	0.5	6.5E-06	5.6	8.4E-11	0	Included in Overall
Valve,Shuttle	Military	AA	221003-000	NPRD-2011	1. A: Failures B: Time	0	75869.0	0.5	6.6E-06	5.6	8.7E-11	0	Included in Overall
Valve,Shuttle	Military	AA	221004-000	NPRD-2011	1. A: Failures B: Time	0	76465.0	0.5	6.5E-06	5.6	8.6E-11	0	Included in Overall
Valve,Shuttle	Military	AA	221005-000	NPRD-2011	1. A: Failures B: Time	0	55730.0	0.5	9.0E-06	5.6	1.6E-10	0	Included in Overall
Valve,Shuttle	Military	N	221015-000	NPRD-2011	1. A: Failures B: Time	0	21402.0	0.5	2.3E-05	5.6	1.1E-09	1	Overall
Valve,Shuttle	Military	N	221015-000	NPRD-2011	1. A: Failures B: Time	0	5754.0	0.5	8.7E-05	5.6	1.5E-08	0	Included in Overall
Valve,Shuttle	Military	N	221016-000	NPRD-2011	1. A: Failures B: Time	0	4080.0	0.5	1.2E-04	5.6	3.0E-08	0	Included in Overall
Valve,Shuttle	Military	N	221017-000	NPRD-2011	1. A: Failures B: Time	0	3384.0	0.5	1.5E-04	5.6	4.4E-08	0	Included in Overall
Valve,Shuttle	Military	N	221018-000	NPRD-2011	1. A: Failures B: Time	0	4824.0	0.5	1.0E-04	5.6	2.1E-08	0	Included in Overall
Valve,Shuttle	Military	N	221019-000	NPRD-2011	1. A: Failures B: Time	0	2904.0	0.5	1.7E-04	5.6	5.9E-08	0	Included in Overall
Valve,Shuttle	Military	N	221020-000	NPRD-2011	1. A: Failures B: Time	0	456.0	0.5	1.1E-03	5.6	2.4E-06	0	Included in Overall
Valve,Spool,Hydraulic	Military	A	NPRD-082	NPRD-2011	1. A: Failures B: Time	146.0	888000.0	146.0	1.6E-04	1.1	1.9E-10	0	Out of Expected Range

Figure F- 33: D-RAD Rate Based Data Sheet for Shuttle Valves

Valve, Solenoid Control — **D-RAD Rate Based Data Sheet (per hour)**

OREDA-2015	← Mode Source	Parameters for Lognormal(Mean, EF) and Gamma(α, β)						
Failure Mode	**Percent**	**Mean**	**Error Factor**	**α**	**β**	**SD**	**Variance**	
Overall Critical Rate	100%	2.7E-07	5.4	5.4E-01	2.0E+06	3.7E-07	1.3E-13	
External Leakage-Utility Medium	27.9%	7.5E-08	6.5	3.8E-01	5.1E+06	1.2E-07	1.5E-14	
Internal Leakage-Utility Medium	36.1%	9.71E-08	6.13	4.2E-01	4.3E+06	1.5E-07	2.2E-14	SVL-LKI
Fail to Function on Demand	17.2%	4.6E-08	7.3	3.1E-01	6.6E+06	8.4E-08	7.0E-15	
Plugged/Choked	1.6%	4.3E-09	17.8	4.9E-02	1.2E+07	1.9E-08	3.7E-16	
Stuck	17.1%	4.6E-08	7.3	3.0E-01	6.6E+06	8.3E-08	7.0E-15	
Fails to Open*	19%	5.0E-08	7.1	3.2E-01	6.3E+06	8.9E-08	8.0E-15	
Fails To Close*	17%	4.6E-08	7.3	3.0E-01	6.6E+06	8.4E-08	7.0E-15	
Transfers Uncommanded	0.2%	4.6E-10	42.1	5.7E-03	1.2E+07	6.1E-09	3.7E-17	
Fails To Regulate (Temp Regulating Valve) (AOV-FOP)	**70%**	1.89E-07	5.57	5.1E-01	2.7E+06	2.7E-07	7.1E-14	Fails To Function + (Stuck+Fails to Open+Fails to Close+XFR uncommanded)
Transfers Closed Uncommanded (Leak External) (SVL-LKE)	**47%**	1.25E-07	5.88	4.6E-01	3.6E+06	1.9E-07	3.4E-14	External Leakge + Fails To Open
		Records Used		8	**Failures Used**		8.6	

Name	Data Sources Field 1	Field 2	Location	Source	Data Type	A	B	Implicit Failures	Mean	EF	Variance	Data Selector	Comment
Solenoid Control Valve	Overall Critical Rate	5.1	p60	OREDA-2015	2. A: Mean B: SD	3.3E-07	3.5E-07	0.9	3.3E-07	4.2	1.2E-13	1	Overall
Solenoid Control Valve	External Leakage-Utility Medium	5.1	p60	OREDA-2015	2. A: Mean B: SD	7.0E-08	1.2E-07	0.3	7.0E-08	6.9	1.4E-14	0	Included in Overall
Solenoid Control Valve	Fail to Function on Demand	5.1	p60	OREDA-2015	2. A: Mean B: SD	1.0E-07	2.2E-07	0.2	1.0E-07	8.9	4.8E-14	0	Included in Overall
Solenoid Control Valve	Internal Leakage-Utility Medium	5.1	p60	OREDA-2015	2. A: Mean B: SD	1.4E-07	2.2E-07	0.4	1.4E-07	6.3	4.8E-14	0	Included in Overall
Solenoid Control Valve	Plugged/Choked	5.1	p60	OREDA-2015	2. A: Mean B: SD	3.0E-08	1.2E-07	0.06	3.0E-08	15.9	1.4E-14	0	Included in Overall
Solenoid Control Valve	Stuck	5.1	p60	OREDA-2015	2. A: Mean B: SD	3.1E-09	3.1E-09	1.0	3.1E-09	3.9	9.5E-18	0	Included in Overall
Solenoid Control Valve	Overall Critical Rate	5.1.1	p80	OREDA-2015	2. A: Mean B: SD	1.1E-07	1.3E-07	0.7	1.1E-07	4.7	1.7E-14	1	Overall
Solenoid Control Valve	Internal Leakage-Utility Medium	5.1.1	p80	OREDA-2015	2. A: Mean B: SD	1.1E-07	1.3E-07	0.7	1.1E-07	4.7	1.7E-14	0	Included in Overall
Solenoid Control Valve	Overall Critical Rate	5.1.2	p87	OREDA-2015	2. A: Mean B: SD	3.6E-07	3.3E-07	1.2	3.6E-07	3.6	1.1E-13	1	Overall
Solenoid Control Valve	External Leakage-Utility Medium	5.1.2	p87	OREDA-2015	2. A: Mean B: SD	1.3E-07	1.2E-07	1.2	1.3E-07	3.6	1.4E-14	0	Included in Overall
Solenoid Control Valve	Fail to Function on Demand	5.1.2	p87	OREDA-2015	2. A: Mean B: SD	5.0E-08	8.0E-08	0.4	5.0E-08	6.4	6.4E-15	0	Included in Overall
Solenoid Control Valve	Internal Leakage-Utility Medium	5.1.2	p87	OREDA-2015	2. A: Mean B: SD	1.2E-07	1.9E-07	0.4	1.2E-07	6.3	3.6E-14	0	Included in Overall
Solenoid Control Valve	Plugged/Choked	5.1.2	p87	OREDA-2015	2. A: Mean B: SD	7.0E-08	2.0E-07	0.1	7.0E-08	11.6	4.0E-14	0	Included in Overall
Solenoid Control Valve	Overall Critical Rate	5.1.3	p91	OREDA-2015	2. A: Mean B: SD	1.2E-07	1.3E-07	0.9	1.2E-07	4.3	1.7E-14	1	Overall
Solenoid Control Valve	Fail to Function on Demand	5.1.3	p91	OREDA-2015	2. A: Mean B: SD	1.2E-07	1.3E-07	0.9	1.2E-07	4.3	1.7E-14	0	Included in Overall
Solenoid Control Valve	Overall Critical Rate	5.1.4	p93	OREDA-2015	2. A: Mean B: SD	3.6E-07	5.1E-07	0.5	3.6E-07	5.6	2.6E-13	1	Overall
Solenoid Control Valve	Overall Critical Rate	5.1.5	p97	OREDA-2015	2. A: Mean B: SD	2.1E-07	3.1E-07	0.5	2.1E-07	5.9	9.6E-14	1	Overall
Solenoid Control Valve	External Leakage-Utility Medium	5.1.5	p97	OREDA-2015	2. A: Mean B: SD	4.0E-08	1.2E-07	0.1	4.0E-08	12.1	1.4E-14	0	Included in Overall
Solenoid Control Valve	Fail to Function on Demand	5.1.5	p97	OREDA-2015	2. A: Mean B: SD	8.0E-08	3.0E-07	0.1	8.0E-08	15.0	9.0E-14	0	Included in Overall
Solenoid Control Valve	Internal Leakage-Utility Medium	5.1.5	p97	OREDA-2015	2. A: Mean B: SD	8.0E-08	7.0E-08	1.3	8.0E-08	3.5	4.9E-15	0	Included in Overall
Solenoid Control Valve	Overall Critical Rate	5.1.6	p103	OREDA-2015	2. A: Mean B: SD	6.4E-07	3.7E-07	3.0	6.4E-07	2.4	1.4E-13	1	Overall
Solenoid Control Valve	External Leakage-Utility Medium	5.1.6	p103	OREDA-2015	2. A: Mean B: SD	4.0E-08	5.0E-08	0.6	4.0E-08	4.9	2.5E-15	0	Included in Overall
Solenoid Control Valve	Fail to Function on Demand	5.1.6	p103	OREDA-2015	2. A: Mean B: SD	2.6E-07	3.7E-07	0.5	2.6E-07	5.6	1.4E-13	0	Included in Overall
Solenoid Control Valve	Internal Leakage-Utility Medium	5.1.6	p103	OREDA-2015	2. A: Mean B: SD	3.9E-07	3.3E-07	1.4	3.9E-07	3.3	1.1E-13	0	Included in Overall
Solenoid Control Valve	Stuck	5.1.6	p103	OREDA-2015	2. A: Mean B: SD	2.0E-08	2.0E-08	1.0	2.0E-08	3.9	4.0E-16	0	Included in Overall
Solenoid Control Valve	Overall Critical Rate	5.1.7	p108	OREDA-2015	2. A: Mean B: SD	2.0E-08	2.0E-08	1.0	2.0E-08	3.9	4.0E-16	1	Overall
Solenoid Control Valve	External Leakage-Utility Medium	5.1.7	p108	OREDA-2015	2. A: Mean B: SD	2.0E-08	2.0E-08	1.0	2.0E-08	3.9	4.0E-16	0	Included in Overall

Figure F- 34: D-RAD Rate Based Data Sheet for Solenoid Control Valves

Actuator, Hydraulic, Demand **GRADS Demand Based Data Sheet (per demand)**

N/A	← Mode Source	Parameters for Lognormal(Mean, EF) and Beta(α, β)					
Failure Mode	**Percent**	**Mean**	**Error Factor**	***a***	***b***	**SD**	**Variance**
Overall (CYL-FTO-CKL and CYL-FTO-RCLK)	100%	2.03E-03	6.46	3.8E-01	1.9E+02	3.3E-03	1.1E-05
		Records Used	5		Failures Used	26.0	

Name	Additional Details			Failures	Demands	Mean	Variance	Data Selector	Rationale
Valves, Hydraulic Operator (VLH)	NUCLARR, 1994	FTO	Nuclear	10	2,564	3.9E-03	1.5E-06	1	
Valves, Hydraulic Operator (VLH)	NUCLARR, 1994	FTO	Nuclear	0	605	8.3E-04	1.4E-06	1	
Valves, Hydraulic Operator (VLH)	NUCLARR, 1994	FTO	Nuclear	1	199	5.0E-03	2.5E-05	1	
Valves, Hydraulic Operator (VLH)	NUCLARR, 1994	FTO	Nuclear	0	1,522	3.3E-04	2.2E-07	1	
Cylinder Assembly,Actuating,Linear	Military	AUA	221001-000	14	188,065	7.4E-05	4.0E-10	1	Overall
Cylinder Assembly,Actuating,Linear	Military	AUA	221001-000	8	42,711	1.9E-04	4.4E-09	0	Included in Overall
Cylinder Assembly,Actuating,Linear	Military	AUA	221002-000	2	40,545	4.9E-05	1.2E-09	0	Included in Overall
Cylinder Assembly,Actuating,Linear	Military	AUA	221003-000	2	38,574	5.2E-05	1.3E-09	0	Included in Overall
Cylinder Assembly,Actuating,Linear	Military	AUA	221004-000	0	38,132	1.3E-05	3.4E-10	0	Included in Overall
Cylinder Assembly,Actuating,Linear	Military	AUA	221005-000	2	28,103	7.1E-05	2.5E-09	0	Included in Overall

Figure F- 35: GRADS Demand Based Data Sheet for Hydraulic Actuators

Pump, Engine Driven, Demand **GRADS Demand Based Data Sheet (per demand)**

N/A	← Mode Source	Parameters for Lognormal(Mean, EF) and Beta(α, β)					
Failure Mode	**Percent**	**Mean**	**Error Factor**	***a***	***b***	**SD**	**Variance**
Overall (EPS-DGN-FTS)	100%	2.11E-03	3.54	1.2E+00	5.8E+02	1.9E-03	3.6E-06
		Records Used	2		Failures Used	44.5	

Name	Additional Details	Failures	Demands	Mean	Variance	Data Selector	Rationale
Engine-Driven Pump (EDP) Fail to Start	SPAR 2010 EDP FTS Nuclear	44	13,647	3.2E-03	2.4E-07	1	
Pump, Includes driver, Fail to Start	Table A14.4, Rasmussen Report (AEC, 1975)	1	500	1.0E-03	2.0E-06	1	
Pump, Diesel, Fails to Start on Demand	Taxonomy 4.2.4.1 PERD	1	27	1.9E-02	6.9E-04	0	Out of Expected Range

Figure F- 36: GRADS Demand Based Data Sheet for Engine Driven Pumps

Pump, Motor Driven, Demand **GRADS Demand Based Data Sheet (per demand)**

N/A	← Mode Source	Parameters for Lognormal(Mean, EF) and Beta(α, β)					
Failure Mode	**Percent**	**Mean**	**Error Factor**	***a***	***b***	**SD**	**Variance**
Overall (PMP-FTS)	100%	1.31E-03	1.14	1.5E+02	1.1E+05	1.1E-04	1.1E-08
		Records Used		1	**Failures Used**		150.0

Data Sources Name	Additional Details			Failures	Demands	Mean	Variance	Data Selector	Rationale
Motor-Driven Pump (MDP) Fail to Start	SPAR 2010	MDP FTS	Nuclear	150	114,473	1.3E-03	1.1E-08	1	

Figure F- 37: GRADS Demand Based Data Sheet for Motor Driven Pumps

Valve, Check, Demand **GRADS Demand Based Data Sheet (per demand)**

Failure Mode Partition		Parameters for Lognormal(Mean, EF) and Beta(α, β)					
Failure Mode	Percent	Mean	Error Factor	a	b	SD	Variance
Overall*	100%	1.9E-04	8.0	2.5E-01	1.3E+03	3.8E-04	1.5E-07
Fail to Close (SCV-FTC)	44.7%	8.66E-05	7.99	2.5E-01	2.9E+03	1.7E-04	2.9E-08
Fail to Open (SCV-FTO)	55.3%	1.07E-04	7.99	2.5E-01	2.4E+03	2.1E-04	4.5E-08

Records Used	7	Failures Used	11.5

Data Sources								Data Selector	Rationale
Name	Additional Details			Failures	Demands	Mean	Variance		
Check Valve (CKV) Fail to Close	SPAR 2010	CKV FTC	Nuclear	8	46,841	1.7E-04	3.6E-09	1	
Check Valve (CKV) Fail to Open	SPAR 2010	CKV FTO	Nuclear	0	46,841	1.1E-05	2.3E-10	1	
Check Valve (CKV) Fail to Open	SPRA 3.2 vlc_420h	CKV FTO	SF	0	1,019	4.9E-04	4.8E-07	1	
Check Valve (CKV) Fail to Open	SPRA 3.2 vlc_420w	CKV FTO	SF	0	20,702	2.4E-05	1.2E-09	1	
Check Valve (CKV) Fail to Open	SPRA 3.2 vlc_520r	CKV FTO	SF	0	1,473	3.4E-04	2.3E-07	1	
Check Valve (CKV) Fail to Open	SPRA 3.2 vlc_525r	CKV FTO	SF	0	2,622	1.9E-04	7.3E-08	1	
Valve,Check	Military	AUA	221001-000	1	188,065	5.3E-06	2.8E-11	1	Aggregate
Valve,Check	Military	AUA	221001-000	1	42,711	2.3E-05	5.5E-10	0	Included in Aggregate
Valve,Check	Military	AUA	221002-000	0	40,545	1.2E-05	3.0E-10	0	Included in Aggregate
Valve,Check	Military	AUA	221003-000	0	38,574	1.3E-05	3.4E-10	0	Included in Aggregate
Valve,Check	Military	AUA	221004-000	0	38,132	1.3E-05	3.4E-10	0	Included in Aggregate
Valve,Check	Military	AUA	221005-000	0	28,103	1.8E-05	6.3E-10	0	Included in Aggregate

Figure F- 38: GRADS Demand Based Data Sheet for Check Valves

Valve, Hydraulic, Demand — **GRADS Demand Based Data Sheet (per demand)**

Failure Mode Partition		Parameters for Lognormal(Mean, EF) and Beta(α, β)					
Failure Mode	Percent	Mean	Error Factor	*a*	*b*	SD	Variance
Overall (HOV-FTO)	100%	5.89E-04	5.67	4.9E-01	8.3E+02	8.4E-04	7.1E-07

Records Used: 2 | Failures Used: 24.5

Data Sources								Data Selector	Rationale
Name	Additional Details			Failures	Demands	Mean	Variance		
Hydraulic-Operated Valve (HOV) Fail to Open/Close	SPAR 2010	HOV FTO/C	Nuclear	24	20,476	1.2E-03	5.7E-08	1	
Valve,Hydraulic,Solenoid	Military	GF	NPRD-074	0	85,000	5.9E-06	6.9E-11	1	

Figure F- 39: GRADS Demand Based Data Sheet for Hydraulic Valves

Valve, Shut Off, Demand — **GRADS Demand Based Data Sheet (per demand)**

N/A	← Mode Source	Parameters for Lognormal(Mean, EF) and Beta(α, β)					
Failure Mode	Percent	Mean	Error Factor	*a*	*b*	SD	Variance
Overall (PVL-FTO)	100%	2.27E-05	7.13	3.2E-01	1.4E+04	4.0E-05	1.6E-09

Records Used: 2 | Failures Used: 6.5

Data Sources								Data Selector	Rationale
Name	Additional Details			Failures	Demands	Mean	Variance		
Valve,Shut Off,Hydraulic	Military	GF	NPRD-074	6	624,000	9.6E-06	1.5E-11	1	
Valve,Shut Off,Pneumatic	Military	GF	NPRD-074	0	14,000	3.6E-05	2.6E-09	1	

Figure F- 40: GRADS Demand Based Data Sheet for Shut-Off Valves

Valve, Solenoid, Demand — **GRADS Demand Based Data Sheet (per demand)**

Failure Mode Partition		Parameters for Lognormal(Mean, EF) and Beta(α, β)					
Failure Mode	Percent	Mean	Error Factor	*a*	*b*	SD	Variance
Overall	100%	2.62E-04	7.51	2.9E-01	1.1E+03	4.9E-04	2.4E-07
Fail to Open/Close (SVL-FTO)	100%	2.62E-04	7.51	2.9E-01	1.1E+03	4.9E-04	2.4E-07

Records Used	7	Failures Used	20.5

Name	Data Sources / Additional Details			Failures	Demands	Mean	Variance	Data Selector	Rationale
Solenoid-Operated Valve (SOV) Fail to Open/Close	SPAR 2010	SOV FTO/C	Nuclear	30	25,650	1.2E-03	4.6E-08	0	Environment
Solenoid-Operated Valve (SOV) Fail to Open/Close	SPRA 3.2 VLS_200a	SOV FTO/C	SF	1	2,038	4.9E-04	2.4E-07	1	
Solenoid-Operated Valve (SOV) Fail to Open/Close	SPRA 3.2 VLS_200n	SOV FTO/C	SF	0	906	5.5E-04	6.1E-07	1	
Solenoid-Operated Valve (SOV) Fail to Open/Close	SPRA 3.2 VLS_200w	SOV FTO/C	SF	1	1,812	5.5E-04	3.0E-07	1	
Solenoid-Operated Valve (SOV) Fail to Open/Close	SPRA 3.2 VLS_200x	SOV FTO/C	SF	0	199	2.5E-03	1.3E-05	0	Sparse
Solenoid-Operated Valve (SOV) Fail to Open/Close	SPRA 3.2 VLS_200p	SOV FTO/C	SF	1	43,092	2.3E-05	5.4E-10	1	
Solenoid-Operated Valve (SOV) Fail to Open/Close	SPRA 3.2 VLS_200d	SOV FTO/C	SF	0	14,072	3.6E-05	2.5E-09	1	
Solenoid-Operated Valve (SOV) Fail to Open/Close	SPRA 3.2 VLS_200e	SOV FTO/C	SF	0	2,882	1.7E-04	6.0E-08	1	
Valve with Actuator, Solenoid Control, Pneumatic	NPRD-054	MIL	GF	16	1,560,000	1.0E-05	6.6E-12	1	

Figure F- 41: GRADS Demand Based Data Sheet for Solenoid Valves

F.2 KICK FREQUENCY DEVELOPMENT

Kick frequency analysis was guided by the MLD development in Section 3.1. The objective was to estimate the kick frequencies for all applicable kick causes during drilling operations. Reference F-5 provides some kick data specifically for the GoM, and has done some work parsing the data that was considered useful for this study.

To tailor the data in [F-5] for the deepwater drillship model, the first step was to estimate the kick frequency for exploration wells in deep water. By choosing deep wells, it could also be assumed that the wells would fit the profile of an HPHT well which was one of the original modeling goals of the drillship PRA. It should be noted; however, that the data in [F-5] does not support the temperature and pressure profile of an HPHT well. From Tables 16-8 and 16-15 [F-5], the kick frequency for deep wells in deepwater was obtained for the years 2011-2015 as shown in Table F- 6. Deepwater refers to wells over 600 M and deep wells are those deeper than 4000 M TVD from [F-5].

Table F- 6: Well Kicks by Water Depth and Well Depth

Well type	Wells Spudded	Kicks	Kick Frequency (per well)
Deepwater	190	82	0.43
Deep Well	215	111	0.52

Because the well assumed in the drillship model meets both the deep well and deepwater criteria above, an average frequency was used. Taking the average of the kick frequencies 0.43 and 0.52 for deepwater and deep wells respectively produces a frequency of 0.475 kicks/well.

The next step was estimating the stage of the well during which the kick occurred. A review of the data revealed that kicks occurred primarily in the reservoir or above in an intermediate casing location. Kicks while drilling and setting conductors and surface casing were handled differently as discussed later. Table 13-16 in [F-5] shows the origin of flow during well control events. The results for exploration wells are shown in Table F- 7.

Table F- 7: Wells Kicks by Location

Location of Flow	Number of Events	Fraction of Total
Reservoir	6	0.429
Non-Reservoir	8	0.571

The values for well type and location of flow can be combined to estimate a kick frequency for deepwater, deep exploration wells by reservoir and non-reservoir. To get to the level of detail in the MLD, Table 16-18 in [F-5] was used. Table F- 8 shows kick causes for GoM deepwater wells.

Table F- 8: Well Kick Causes

Kick Cause	Number of Kicks	Fraction of Total
Swabbing	9	0.122
Low Mud Density[2]	26	0.351
Unexpected Overpressure[2]	26	0.351
Losses	4	0.54
Unknown	4	0.122

The kick causes were then assigned to the well condition. The well condition includes the stage of the well in which the kick occurs (i.e. intermediate casing, reservoir) and what operation is occurring when the kick take place (i.e. drilling, running casing, nothing across the BOP). The fractions of time assumed for the well conditions that occur during drilling and completion of a generic well are shown in Table F- 9.

Table F- 9: Assumptions for Well Conditions / Operations

Well Location	Fraction of Time	Well Operation	Fraction of Time
Surface Casing	0.13	Drilling	0.6
		Running Casing	0.2
		Nothing Across the BOP	0.2
Intermediate Casing	0.47	Drilling	0.7
		Running Casing	0.2
		Nothing Across the BOP	0.1
Reservoir	0.4	Drilling	0.9
		Running Casing	0.1
		Nothing Across the BOP	0.0[3]

With the well conditions and kick frequency/causes estimated, the next step is to combine those estimate and assign them to basic events for the PRA model. From the MLD, the applicable kick initiators are:

- Unexpected overpressure zone
- Swabbing
- Surge
- Low Equivalent Circulating Density
- Excessive mud density
- Gas cut mud
- Weak formation

[2] In [F-5] these two categories were combined and for the model it was assumed they are evenly split.
[3] The period considered in the drillship model is from spudding to reaching Total Depth.

These MLD initiators are then assigned to the location and operation to which they are applicable, as shown in Table F- 10 and Table F- 11 below:

Table F- 10: Kick Initiator Applicability in the Reservoir

MLD Initiator	Drilling	Running Casing[4]	Nothing Across the BOP
Unexpected overpressure zone	X		
Swabbing	X		
Surge	X		
Low equivalent circulating density	X		X
Excessive mud density	X		X
Gas cut mud	X		
Weak formation	X		

Table F- 11: Kick Initiator Applicability for Intermediate Casing

MLD Initiator	Drilling	Running Casing	Nothing Across the BOP
Unexpected overpressure zone	X		
Swabbing	X		
Surge	X	X	
Low equivalent circulating density	X	X	X
Excessive mud density	X	X	X
Gas cut mud	X		
Weak formation	X		

The MLD initiators are mapped to the causes from Holand [F-5], as shown in Table F- 12 below.

[4] The period considered in the drillship model is from spudding to reaching Total Depth..

Table F- 12: MLD / Kick Cause Mapping

MLD Initiator	Cause (from [F-5])	Model Initiator
Unexpected overpressure zone	Unexpected Overpressure / Low Mud Density (50%)	Unexpected overpressure zone
Swabbing	Swabbing	Swabbing
Surge	Losses (while running casing)	Surge
Low equivalent circulating density	Unexpected Overpressure / Low Mud Density (50%)	Low mud density
Excessive mud density	Not assigned	
Gas cut mud	Not assigned	
Weak formation	Losses (while drilling)	Weak formation
	Other	Other kick

The data from Holand [F-5] on unexpected overpressure/low mud density was assumed to be equally split between the unexpected overpressure / low equivalent circulating density MLD initiators. This could also include gas cut mud, and may be refined later. All of these low mud density initiators are treated similarly in the model, so the overall results in the model will not be affected. Losses from [F-5] were assigned to surge while running casing and weak formation while drilling. "Other" from [F-5] was left as is and simply proportioned to the time for each operation/well condition. Examples of the calculations for swabbing and other while drilling in the reservoir are:

Swabbing:

Swabbing percent of kicks (X) * percent of kicks in reservoir (X) * kick frequency =

0.122 * 0.429 * 0.475 = 0.0248 swabbing kicks / well

Other (while drilling in the reservoir):

Other percent of kicks (X) * percent of kicks in reservoir (X) * Percent of time drilling in the reservoir (X) * kick frequency

0.122 * 0.429 * 0.9 * 0.475 = 0.0223

Calculations were done in a similar way for all of the model initiators and the result is shown in Table F-13.

Table F- 13: Kick Initiator Frequencies for PRA Model (per well)

Kick Cause	Reservoir Drilling	Reservoir Running Casing	Reservoir Nothing Across the BOP	Intermediate Casing Drilling	Intermediate Casing Running Casing	Intermediate Casing Nothing Across the BOP
Unexpected overpressure zone	0.0716			0.0954		
Swabbing	0.0248			0.0331		
Surge					0.0029	
Low mud density	0.0644		0.0072	0.0668	0.0191	0.0095
Weak formation	0.0110			0.0117		
Other kick	0.0224		0.0025	0.0232	0.0066	0.0033

The values in Table F- 13 were used in the model and are contained in the basic event listing. They are currently input as point estimates because there was no data to support uncertainty distributions. A concurrent analysis to this report is being performed to further develop kick frequencies with uncertainties.

F.3 WEATHER DATA DEVELOPMENT

Environmental conditions such as wind, waves and currents constitute a considerable challenge for the position keeping capability of drillships. Generally speaking, the aforementioned weather conditions are correlated and wind speed constitutes the main variable affecting positioning. Therefore wind speed is assumed to be the limiting factor in determining the different weather conditions in this risk evaluation.

The first step in identifying and quantifying the types of weather events that could challenge position keeping is to analyze weather data and the corresponding drillship response in terms of the available thruster power. The following weather scenarios are defined:

Nominal Weather: All weather conditions in which four working thrusters are sufficient to maintain position regardless of the orientation of the drillship. This success criteria of four thrusters is determined by the design requirements for a Class 3 DP drillship, in which any single failure (including fire or flooding in a single compartment) should not cause a loss of position under normal environmental conditions. The drillship design for this study includes six thrusters, and no single failure results in more than two thruster failures, hence the success criteria of a minimum of four operating thrusters. It is noted that nominal weather is not an initiator, since this constitutes normal operating conditions. For nominal weather conditions, hardware failures or human error are initiating events. Weather above nominal conditions does constitute an initiating event, and the corresponding initiating event frequency needs to be estimated to use in the PRA model.

Above Nominal Weather: Weather conditions above nominal for which the drillship can still maintain position but only if the DPO properly orients the drillship in order to minimize the weather drag on the vessel. Three different weather conditions were identified in this scenario:

- Squalls
- Winter storms

- Extreme Weather/Hurricanes

In the case of extreme weather/hurricanes, it is assumed that even if the DPO properly orients the drillship, the successful operation of six thrusters during the duration of the hurricane are needed in order to maintain drillship position. Failure of any one thruster during a hurricane constitutes a loss of position event, and it is therefore modelled explicitly.

Above Extreme Weather: Weather conditions harsher than extreme weather for which even all six thruster successfully operating are not sufficient to maintain vessel position. It is recognized that for most extreme weather events, the drillship is generally going to secure the well and leave prior to the weather event's arrival and would only stay if required due to the operation being performed.

This section describes the methodology used to estimate the frequencies of each of the "above nominal weather" scenarios, and the "above extreme weather" scenario. Much of the actual weather data used for the analysis is proprietary in nature, and is not repeated here. Examples of "typical" data are used for illustration purposes.

Squalls and Winter Storms Initiating Events

In order to define and estimate the frequency of the above nominal weather scenarios defined above, it is first necessary to evaluate the drillship's DP capability plot. DP capability plots define a vessel's station-keeping ability under different environmental and operational conditions and they are used to establish the maximum weather conditions in which the vessel can maintain its position and heading for a variety of thruster configurations. For modeling purposes, a generic drillship's DP capability plot is used. Figure F-42 shows the ability of a drillship to keep position with four thrusters operating. It is noted that this DP Capability Plot is shown for illustrative purposes only, and it does not correspond to the generic drillship modeled in the BSEE project. The plot provides the wind speed in knots. As can be noted in Figure F- 42, if the DPO prepares and maintains vessel orientation during elevated weather conditions, the vessel can keep stations in winds up to roughly 60 knots with four thrusters operating. In the absence of any preparation for the onset of a storm and assuming that the vessel is in the worst case orientation (abeam to the wind direction), the maximum wind speed at which the vessel can keep station with four operating thrusters is reduced to about 30 knots.

For the generic vessel being modeled, it is assumed that the vessel can keep station in winds up to roughly 65 knots (109 ft/sec) with four thrusters operating. In the absence of any preparation for the onset of a storm and assuming that the vessel is in the worst case orientation, the maximum wind speed at which the generic vessel can keep station with four operating thrusters is assumed to be about 30 knots (50 ft/sec).

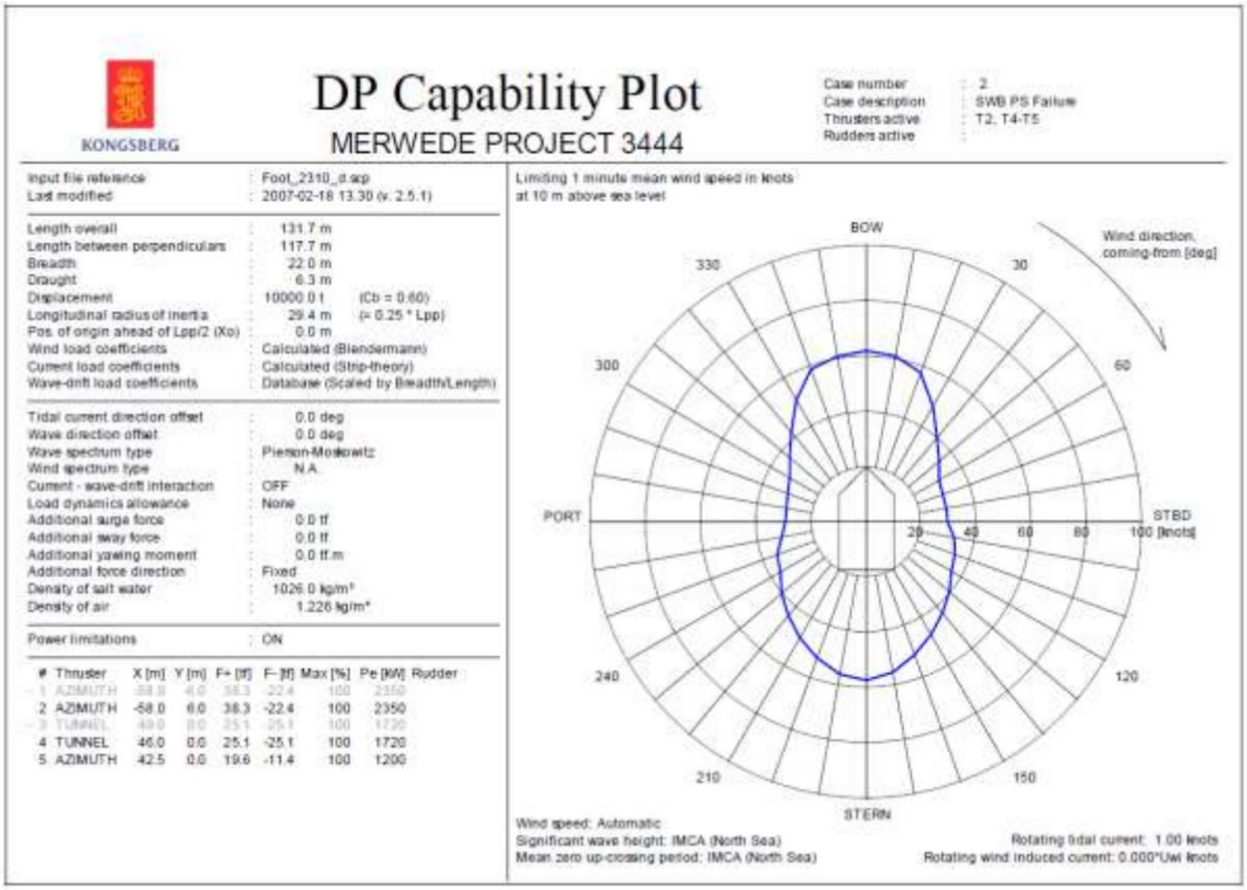


Figure F- 42: Worst Case Failure Capability Plot Example

Weather data was required to establish the general conditions under which a drillship operating in the GoM could be expected to experience at any given time during drilling and completion. Given that well development takes place throughout the year weather data was gathered for all times of the year.

Table F- 14 and Table F- 15 include the types of weather data obtained (with "typical" values). Review of the data is noted that all experienced weather systems defined as squalls or winter storms had maximum wind speeds below 110 ft/s. This means that as long as the drillship is properly oriented before the onset of a squall or winter storm, four operating thrusters are sufficient to maintain position. It is necessary to determine the frequency with which these weather events occur, and to combine these frequencies with the probability of a DPO failing to prepare for the onset of these weather events or failure to correctly enter an offset to reposition the vessel in the DPC.

Table F- 14: Example Squall Wind Speeds[5]

Return Period	1yr	5 yrs	10 yrs	100 yrs
Squall wind speed at least 10 ft/sec (for 1 minute or longer)	70.5	85.0	95.2	105.7

Table F- 15: Example Winter Storm Wind Speeds[5]

	Wind Direction	Wind Speed @ 25 ft (ft/s) (for 1 hr or longer)
1 Year	N	55.1
	NE	48.0
	E	46.2
	SE	40.9
	S	41.2
	SW	45.8
	W	49.0
	NW	54.6
2 Years	N	56.3
	NE	49.4
	E	47.2
	SE	45.6
	S	43.7
	SW	47.9
	W	52.9
	NW	56.4
5 Years… 100 Years	N	61.2
	NE	50.2
	E	49.6
	SE	47.1
	S	45.0
	SW	48.9
	W	54.3
	NW	57.8

Calculation of Squall Frequency

Squall data was obtained in the form of a graph of wind speed versus probability on non-exceedance. The data showed the frequency of potential squalls was found to be approximately 90 peaks in 3 years. Alpha, beta, and gamma are parameters of a Weibull distribution determined for the data are used to determine the

[5] For illustration purposes only, not used in the analysis

distribution of the magnitudes of the wind speeds. Alpha, beta, and the threshold are measured in m/s. Gamma is dimensionless.

To get a distribution for the number of expected squalls in a 70 day period (which is about the average time to drill and complete a well in the GoM), there are three basic steps (the data used in the analysis is not shown due to its proprietary nature, however results using the data are shown):

1. Simulate an arrival rate of peaks, λ (not necessarily squalls)
2. Simulate a number of peaks based on λ
3. Determine how many of the peaks are strong enough to qualify as squalls

The arrival rate λ, is sampled from a gamma distribution with parameters α and β such that:

$$\alpha = n = \text{X peaks and } \beta = \text{T} = \text{Y years} = 1{,}062 \text{ days}$$

The number of arrivals is then sampled from a Poisson distribution with the sampled λ and a time t = 70 days by applying Equation 2-1 below.

$$P(X = x) = \frac{(\lambda t)^x e^{-\lambda t}}{x!} \text{ where } x = 0, 1, 2, \ldots. \quad (2\text{-}1)$$

The wind speed of a given arrival is sampled from a Weibull distribution and then the wind speeds are compared to the threshold to determine whether they meet the criteria for a squall. The parameters of the Weibull distribution are:

α (ft/sec), β (ft/sec), and γ

The equation of the cumulative Weibull distribution is shown in Equation 2-2.

$$F(x) = 1 - e^{(\frac{x-\alpha}{\beta})^{\gamma}} \text{ where } x > 0 \quad (2\text{-}2)$$

The process described above is simulated a large number of times (100,000 Monte Carlo replications) and a plot of the results are shown in Figure F- 43.

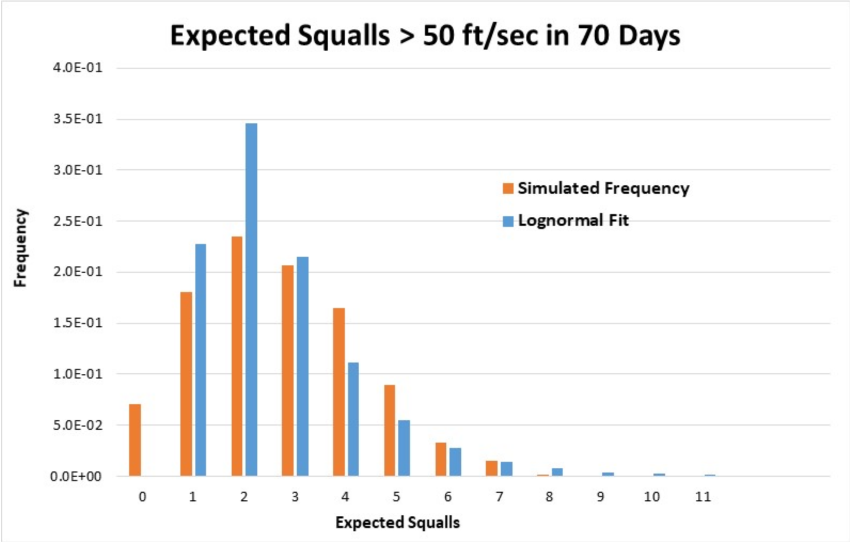


Figure F- 43: Monte Carlo Results for Squall Simulation

The mean number of squalls occurring in a 70 day period is 2.67. In order to establish the uncertainty of the number of squalls estimate the EF is required. The EF is not a measure of error, but rather is a measure of the "width" of the distribution. The EF can be calculated using the lognormal fit shown in Figure F-1, with a lognormal mean of 2.71 and a standard deviation of 1.632. This produces an EF = 2.50. In order to convert the mean estimate per 70 day period to a per hour estimate needed to populate the PRA model, it can be shown that the mean can be simply converted to per hour units, and the error factor is preserved. In conclusion, the hourly frequency of squalls to be used is 1.61E-03/hr with an EF of 2.50.

Calculation of Winter Storm Frequency

The winter storm frequency was estimated using an environmental impact statement for the GoM in 2003 [F-6], which discusses extratropical cyclones. For the purposes of this analysis, extratropical cyclones are considered synonymous with winter storms. Regarding the frequency of occurrence of winter storms in the GoM, Appendix A of the reference document [F-6] states: "The mean number of these storms ranges from 0.9 storms per year near the southern tip of Florida to 4.2 over central Louisiana and an average of 2.9 …" Therefore using 2.9 winter storms/year and converting this value to an hourly rate gives an estimate of 3.31E-04/hr. Since this estimate is given as a rate, without any information on how many storms over how many years, it is not possible to estimate the error factor. In this case, it is then assumed that the mean value is equal to the standard deviation, and assuming a lognormal distribution it is possible to compute the error factor, which turns out to be 3.93.

Extreme Weather

Figure F- 44 shows an example of a DP capability plot, showing the ability of the vessel to keep station with all DPS hardware functioning, i.e. all six thrusters operating. The DP capability plot in the example indicates that this vessel can keep station with winds up to 20 knots at the least favorable wind direction, and up to 100 knots at the most favorable wind direction. Again, this plot is shown for illustrative purposes only and it does not represent the drillship modeled in this study.

For the generic drillship being modeled in this study, it is assumed that if the DPO prepares and maintains vessel orientation by aligning the bow into the wind, the vessel can keep stations in winds up to roughly 79 knots (133 ft/s) with all thrusters in operation. In the absence of any preparation for the onset of a storm and assuming that the vessel is in the worst case orientation (abeam to the wind direction), the maximum wind speed at which the vessel can keep station is assumed to be 38 knots or about 65 ft/s.

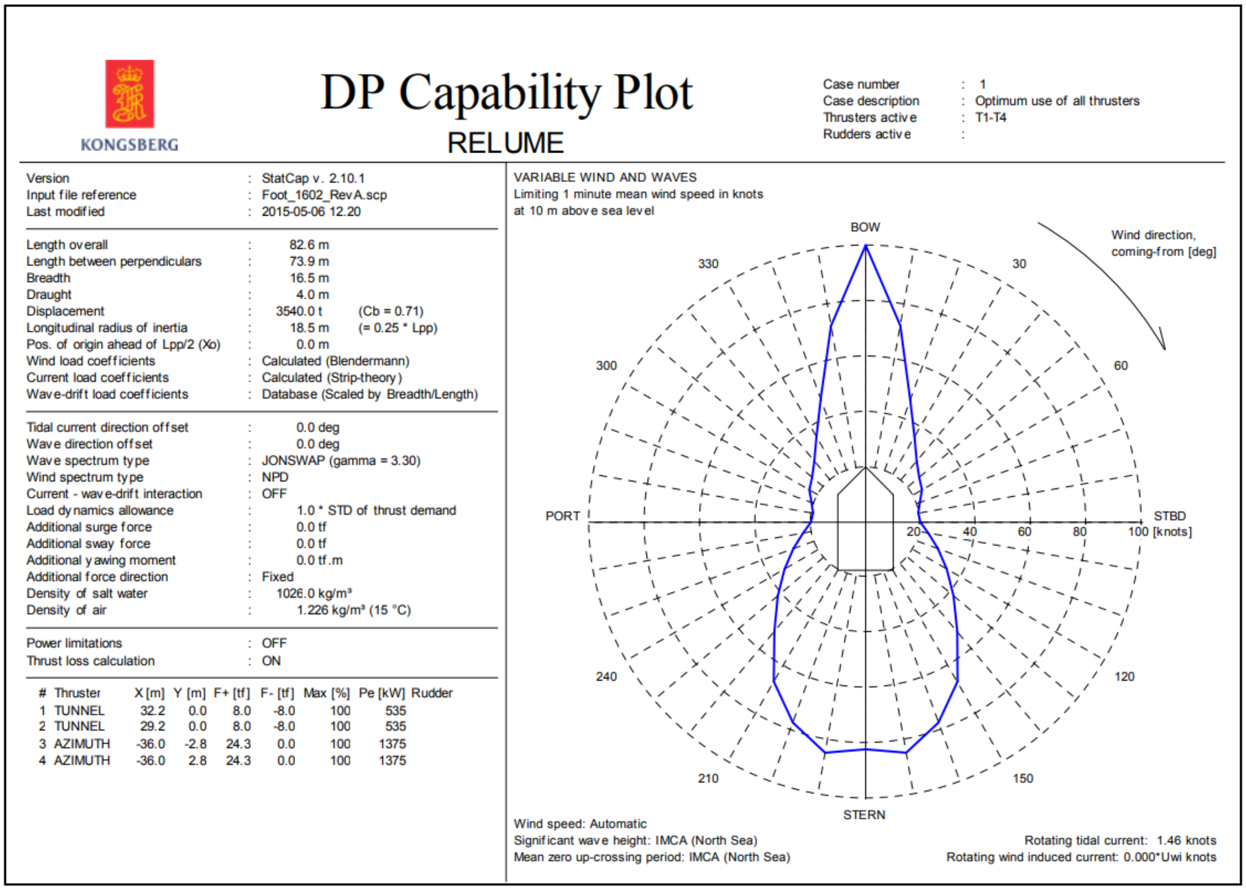


Figure F- 44: All Thrusters Operating Capability Plot Example

Based on the weather data obtained, sudden hurricanes represent the lone weather system that contributes to an extreme weather environment.

Two factors related to sudden hurricanes need to be considered in the DPS PRA model. First is the frequency of occurrence. Second is the average duration of this type of extreme weather environment.

Calculation of Sudden Hurricane Frequency

With regard to the frequency of occurrence, the approach is similar to that used to establish the frequency of winter storms. Based on the weather data obtained, 19 sudden hurricanes occurred during a 60 year period. This gives a yearly rate of $= 19/60 = 0.317$ per year. Converting this estimate to hours produces an occurrence rate of 3.62E-05 per hour. In this case the number of events and the period of time are known, so applying statistical analysis the error factor can be calculated, In this case an error factor of 1.5 is obtained.

Sudden Hurricane Duration Estimation Approach

The following approach was used to establish the four hour time period attributed to the duration of an average sudden hurricane. The weather data obtained contained a table showing the time duration of sudden hurricanes as a percentage of the maximum wind speed in one hour intervals 24 hours before and after the occurrence of the maximum wind speed (Table F- 16).

Table F- 16: Sudden Hurricane Duration[6]

Hours from Peak	Tall and Thin Tropical Cyclones			Short and Wide Tropical Cyclones		
	Normalized to Peak Value		100 yr wind speed event (ft/s)	Normalized to Peak Value		100 yr wind speed event (ft/s)
	Mean	Std Dev		Mean	Std Dev	
-24.0	0.35	0.06	33.4	0.40	0.1	38,2
. . .	Actual chart arrival to	used shows 24 hrs after	data for departure	each hour	from 24 hrs	prior to
0.0	1.0	0.0	98.6	0.63	0.00	62.1
. . .						
24.0	0.41	0.06	39.1	0.39	0.12	37.2

From the data used, it was clear that the normalized peak values for the tall and thin tropical cyclones were higher than those for the short and wide tropical cyclones; therefore, the tall and thin tropical cyclones were established as the limiting case. Additional information showing the maximum wind cases for 50-year and 100-year sudden hurricanes was also provided in the weather data obtained. Since the wind speeds for the 100-year sudden hurricane were the highest, this data was used.

An examination of the wind speeds used for sudden hurricanes indicates the maximum wind speed was about 120 ft/s for the 1 minute duration. The mean values for the tall and thin tropical cyclones were multiplied by the maximum wind speed to establish how long winds in a sudden hurricane were above the 109 ft/s threshold established previously using the capability plots as lower limit for extreme weather. The results are shown in Table F- 17.

Table F- 17: Extreme Weather Environment Duration

Hours From Peak	Normalized Mean	Wind Speed
-24	0.33	38.61
-23	0.35	40.95
-22	0.38	44.46

[6] For illustration purposes only, not used in the analysis

Hours From Peak	Normalized Mean	Wind Speed
-21	0.40	46.80
-20	0.42	49.14
-19	0.43	50.31
-18	0.44	51.48
-17	0.44	51.48
-16	0.44	51.48
-15	0.46	53.82
-14	0.47	54.99
-13	0.48	56.16
-12	0.50	58.50
-11	0.52	60.84
-10	0.54	63.18
-9	0.55	64.35
-8	0.58	67.86
-7	0.61	71.37
-6	0.65	76.05
-5	0.70	81.90
-4	0.75	87.75
-3	0.82	95.94
-2	0.88	102.96
-1	0.94	109.98
0	1.00	117.00
1	0.86	100.62
2	0.79	92.43
3	0.76	88.92
4	0.69	80.73
5	0.69	80.73
6	0.72	84.24
7	0.73	85.41
8	0.71	83.07
9	0.69	80.73
10	0.67	78.39
11	0.65	76.05
12	0.62	72.54
13	0.60	70.20
14	0.57	66.69
15	0.56	65.52
16	0.55	64.35

Hours From Peak	Normalized Mean	Wind Speed
17	0.53	62.01
18	0.52	60.84
19	0.51	59.67
20	0.50	58.50
21	0.49	57.33
22	0.47	54.99
23	0.46	53.82
24	0.45	52.65

Based on the results, the yellow highlighted region shows that the sudden hurricane only exceeds the 109 ft/s threshold for two hours during the observed time period. Allowing for some margin of uncertainty and given that the wind speeds for the one hour time periods on either side of the extreme weather threshold are above 100 ft/s (see light yellow highlights), the duration for sudden hurricanes was set at 4 hours.

Above Extreme Weather

Table F- 18 presents an example of wind speed data obtained at one GoM location. This table includes the mean and standard deviation for 1hr Wind Speed for each month of the year. Since drilling operations take place at any time of the year, some statistical analysis is necessary to obtain average values of probability of wind exceedance.

As mentioned earlier in this chapter, upon observation of data similar to that shown in Figure F-46, with all 6 thrusters operating, if the DPO prepares and maintains vessel orientation by aligning the bow into the wind, the vessel is assumed to keep station in winds up to roughly 79 knots (133 ft/s). Therefore "above extreme weather" is defined as those weather conditions in which the wind speed exceeds 133 ft/s. To estimate the probability of wind exceedance of 133 ft/s during each month, it is assumed that wind speed is lognormally distributed with mean value and standard deviation equal to the values indicated in the table. Using this lognormal distribution for each month, the probability of exceedance of 133 ft/s can be calculated for each month, as shown in Table F- 19. The average monthly probability of exceedance is calculated, and changing units the hourly probability of exceedance is computed, resulting in 5.71E-10 /hr. The error factor was obtained by calculating the standard deviation of the monthly probability of exceedance among the 12 months, and using the formula for the error factor of a lognormal distribution with the same mean and standard deviation as the 12 month probabilities of exceedance. This calculated error factor is 3.17.

Table F- 18: Example Wind Speed Data[7]

Month	Min Wind Speed (ft/s)	Mean Wind Speed (ft/s)	Max Wind Speed (ft/s)	Std. Dev. Wind Speed (ft/s)	Probability of Exceedance 99	Probability of Exceedance 95	Probability of Exceedance 50	Probability of Exceedance 5	Probability of Exceedance 1
Jan.	3.1	26.1	63.4	8.57	7.58	12.1	25.2	44.1	50.9
Feb.	2.9	25.8	62.4	8.89	7.31	11.7	24.8	45.1	51.2
Mar.									
Apr.			Data	similar	to above	obtained			
May			for	each	month				
June									
July									
Aug.									
Sept.									
Oct.									
Nov.									
Dec.									

Table F- 19: Probability of Wind Speed Exceedance

Month	Mean	StD	P(X>133)
Jan	25.5	9.52	1.00E-06
Feb	24.96	9.38	8.55E-07
Mar	23.96	9.34	1.04E-06
Apr	23	8.26	9.31E-08
May	19.87	7.15	9.40E-09
Jun	17.67	6.48	2.31E-09
Jul	14.8	5.85	1.31E-09
Aug	14.64	6.26	1.14E-08
Sep	19.57	8.51	7.44E-07
Oct	23.38	8.6	2.12E-07
Nov	25.21	8.91	2.60E-07
Dec	25.67	9.42	7.70E-07
Avearge per month:			**4.17E-07**
Average per hour:			**5.71E-10**

[7] For illustration purposes only, not used in the analysis

Well Operations Offset

During normal operations repositioning the vessel inside the green operation area is sometimes necessary. These events are related to operations being performed and not weather, but since the probability of incorrectly entering an offset under these conditions is applied in much the same manner in the model, it is included in this section. Vessel offsets may be required in the following examples:

- In order to minimize the flex joint angle to prevent binding as the casing passes through the flex joint/BOP, it is sometimes necessary to do a small offset.
- In situations where the riser experiences ocean currents, the requirement to offset the vessel to minimize the upper or lower flex joint angle might be required.

The frequency with which well operation require the DPO to enter an offset into the DPC to move the vessel to another portion of the green operation area is assumed to occur an average of four times per well. Assuming a logarithmic uncertainty with mean value equals to the standard deviation, an error factor of 3.93 is calculated. Since the PRA model requires a frequency of offsets per hour, and the current model assumes a well completion time of 70 days, the four events per well estimate is converted to 2.38E-03 offsets per hour, with the same error factor of 3.93. It is noted that if the well completion time used (70 days) is changed in the future, the above hourly estimate needs to be modified to preserve the assumption of four offsets per well.

Summary of Weather Data

Table F- 20 shows the final data estimates used in the BSEE PRA model.

Table F- 20: Summary of Weather Data Used in PRA Model

Event	Description	Failure Model	Lambda	Mission Time	Distrib. Type	Uncert. Value	Corr. Class	Calc. Prob.
ABOV-EXT-WEATHER-F-IE	Above Extreme Weather (Initiating Event)	3	5.71E-10		Log Normal	3.17	EXT-WEA	5.71E-10
D-W-O-OPER-F-IE	Run/Retrieval Offset Frequency per hour (initiating event)	3	2.38E-03		Log Normal	3.93	OFFSET	2.38E-03
D-W-O-OPER	Run/Retrieval Offset probability per hour	3	2.38E-03	72	Log Normal	3.93	OFFSET	1.58E-01
DPS-FRQ-WEA-HURR	Probability of Extreme Weather	3	3.62E-05	72	Log Normal	1.5	WEA-HURR	2.60E-03
DPS-FRQ-WEA-HURR-F-IE	Frequency of Extreme Weather/Hurricane per hour (initiating event)	3	3.62E-05		Log Normal	1.5	WEA-HURR	3.62E-05
DPS-FRQ-WEA-SQUA	Probability of a Squall	3	1.61E-03	72	Log Normal	2.5	WEA-SQUA	1.10E-01
DPS-FRQ-WEA-SQUA-F-IE	Frequency of a Squall per hour (initiating event)	3	1.61E-03		Log Normal	2.5	WEA-SQUA	1.61E-03
DPS-WEA-WINT	Probability of Winter Storm	3	3.31E-04	72	Log Normal	3.93	WEA-WINT	2.36E-02
DPS-WEA-WINT-F-IE	Frequency of Winter Storm per hour	3	3.31E-04		Log Normal	3.93	WEA-WINT	3.31E-04

F.4 REFERENCES

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F-5 Holand, Per, "Loss of Well Control and Size Estimators, Phase I and II", Exprosoft, ES201471/2, 2017.

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APPENDIX G- BASIC EVENT LISTING

Table G- 1: Basic Event Listing

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
BOP-CYL-FTC-BSRDP	Blind shear rams fail to close and seal when drill string is in the hole	0.1	1	0.1			Beta	9	BOP-BSRCYL-FTC-DP	
BOP-CYL-FTO-CKL1	Choke and Kill Line Lock CKL1 Fails to Unlock	2.03E-03	1	2.03E-03			LogNormal	6.46	BOP-CYL-FTO-CKL	CKL-FTO
BOP-CYL-FTO-CKL2	Choke and Kill Line Lock CKL2 Fails to Unlock	2.03E-03	1	2.03E-03			LogNormal	6.46	BOP-CYL-FTO-CKL	CKL-FTO
BOP-CYL-FTO-RC13	Riser Connector Lock RC13 Fails to Unlock	2.03E-03	1	2.03E-03			LogNormal	6.46	BOP-CYL-FTO-RCLK	
BOP-HOV-FTO-CH2	Lower Inner Choke Valve Fails to Open	5.89E-04	1	5.89E-04			LogNormal	5.67	BOP-HOV-FTO	HOV-FTO
BOP-HOV-FTO-CH3	Upper Inner Choke Valve Fails to Open	5.89E-04	1	5.89E-04			LogNormal	5.67	BOP-HOV-FTO	HOV-FTO
BOP-HUM-ERR-DP-HANGOFF	Driller fails to position drillpipe properly before activating shear ram	1.60E-01	1	1.60E-01			LogNormal	5	HUM-ERR-HANGOFF	
BOP-HUM-ERR-EMERGDIS	Operator fails to initiate emergency disconnect successfully	4.90E-04	1	4.90E-04			LogNormal	13.8	HUM-ERR-EMERGDIS	
BOP-HUM-ERR-IBOP1	Human error - failure to install IBOP	1.60E-01	1	1.60E-01			LogNormal	5	HUM-ERR-IBOP-INSTALL	
BOP-HUM-ERR-KICKDET	Operator fails to realize a kick has occurred or does not take timely action	3.70E-04	1	3.70E-04			LogNormal	7.7	HUM-ERR-KICKDET	
BOP-HUM-ERR-PODSEL	Operator failure to manually shift to the blue pod after yellow pod failure	1.24E-04	1	1.24E-04			LogNormal	5.3	HUM-ERR-PODSEL	
BOP-PVL-FTO-AJ1	Upper annular close pilot operated valve AJ1 fails to open on demand (Yellow)	2.27E-05	1	2.27E-05			LogNormal	7.13	BOP-PVL-FTO	PVL-FTO
BOP-PVL-FTO-AJ2	Upper annular close pilot operated valve AJ2 fails to open on demand (Blue)	2.27E-05	1	2.27E-05			LogNormal	7.13	BOP-PVL-FTO	PVL-FTO
BOP-PVL-FTO-AJ3	Lower Annular Pilot operated valve AJ3 fails to open on demand (Yellow)	2.27E-05	1	2.27E-05			LogNormal	7.13	BOP-PVL-FTO	PVL-FTO
BOP-PVL-FTO-AJ4	Lower annular close pilot operated valve AJ4 fails to open on demand (Blue)	2.27E-05	1	2.27E-05			LogNormal	7.13	BOP-PVL-FTO	PVL-FTO
BOP-PVL-FTO-B01	Blind Shear Ram High Pressure close Pilot operated valve BO1 fails to open on demand (Yellow)	2.27E-05	1	2.27E-05			LogNormal	7.13	BOP-PVL-FTO	PVL-FTO
BOP-PVL-FTO-B02	Blind Shear Ram High Pressure Pilot operated valve BO2 fails to open on demand (Blue)	2.27E-05	1	2.27E-05			LogNormal	7.13	BOP-PVL-FTO	PVL-FTO
BOP-PVL-FTO-B03	Blind shear ram timing circuit pilot operated valve fails to open	2.27E-05	1	2.27E-05			LogNormal	7.13	BOP-PVL-FTO	PVL-FTO

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
BOP-PVL-FTO-B04	Blind shear ram lock timing circuit pilot operated valve fails to open	2.27E-05	1	2.27E-05			LogNormal	7.13	BOP-PVL-FTO	PVL-FTO
BOP-PVL-FTO-B05	Hydraulic Auto Shear Valve B05 Fails to Open	2.27E-05	1	2.27E-05			LogNormal	7.13	BOP-PVL-FTO	PVL-FTO
BOP-PVL-FTO-B11	Blind shear ram lock timing circuit pilot operated valve fails to open	2.27E-05	1	2.27E-05			LogNormal	7.13	BOP-PVL-FTO	PVL-FTO
BOP-PVL-FTO-B12	Blind Shear Ram Lock Pilot operated valve B12 fails to open on demand (Blue)	2.27E-05	1	2.27E-05			LogNormal	7.13	BOP-PVL-FTO	PVL-FTO
BOP-PVL-FTO-B13	Blind Shear Ram Locks Pilot operated valve B13 fails to open on demand (Yellow)	2.27E-05	1	2.27E-05			LogNormal	7.13	BOP-PVL-FTO	PVL-FTO
BOP-PVL-FTO-B14	Blind shear ram lock timing circuit timing pilot operated valve fails to open	2.27E-05	1	2.27E-05			LogNormal	7.13	BOP-PVL-FTO	PVL-FTO
BOP-PVL-FTO-CKL7	Choke & Kill Line Primary Unlock Pilot Operated Valve Fails to Open (Yellow)	2.27E-05	1	2.27E-05			LogNormal	7.13	BOP-PVL-FTO	PVL-FTO
BOP-PVL-FTO-CKL9	Choke & Kill Line Secondary Unlock Pilot Operated Valve Fails to Open (Yellow)	2.27E-05	1	2.27E-05			LogNormal	7.13	BOP-PVL-FTO	PVL-FTO
BOP-PVL-FTO-G02	Casing Shear High Pressure Pilot operated valve G02 fails to open on demand (Blue)	2.27E-05	1	2.27E-05			LogNormal	7.13	BOP-PVL-FTO	PVL-FTO
BOP-PVL-FTO-G03	Casing Shear High Pressure pilot operated G03 fails to open on demand (Yellow)	2.27E-05	1	2.27E-05			LogNormal	7.13	BOP-PVL-FTO	PVL-FTO
BOP-PVL-FTO-G05	Middle pipe ram lock pilot operated hydraulic valve G05 fails to open on demand (Yellow)	2.27E-05	1	2.27E-05			LogNormal	7.13	BOP-PVL-FTO	PVL-FTO
BOP-PVL-FTO-G06	Middle pipe ram lock pilot operated hydraulic valve G06 fails to open on demand (Blue)	2.27E-05	1	2.27E-05			LogNormal	7.13	BOP-PVL-FTO	PVL-FTO
BOP-PVL-FTO-G07	Middle pipe ram close pilot operated hydraulic valve G07 fails to open on demand (Yellow)	2.27E-05	1	2.27E-05			LogNormal	7.13	BOP-PVL-FTO	PVL-FTO
BOP-PVL-FTO-G07O	Middle pipe ram open pilot operated hydraulic valve G07o fails to open on demand (Yellow)	2.27E-05	1	2.27E-05			LogNormal	7.13	BOP-PVL-FTO	PVL-FTO

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
BOP-PVL-FTO-G08	Middle pipe ram close pilot operated hydraulic valve G08 fails to open on demand (Blue)	2.27E-05	1	2.27E-05			LogNormal	7.13	BOP-PVL-FTO	PVL-FTO
BOP-PVL-FTO-G08O	Middle pipe ram open pilot operated hydraulic valve G08o fails to open on demand (Blue)	2.27E-05	1	2.27E-05			LogNormal	7.13	BOP-PVL-FTO	PVL-FTO
BOP-PVL-FTO-G09	Upper pipe ram lock Pilot operated hydraulic valve G09 fails to open on demand (Yellow)	2.27E-05	1	2.27E-05			LogNormal	7.13	BOP-PVL-FTO	PVL-FTO
BOP-PVL-FTO-G10	Upper pipe ram lock Pilot operated hydraulic valve G10 fails to open on demand (Blue)	2.27E-05	1	2.27E-05			LogNormal	7.13	BOP-PVL-FTO	PVL-FTO
BOP-PVL-FTO-G11	Upper pipe ram close pilot operated hydraulic valve G11 fails to open on demand (Yellow)	2.27E-05	1	2.27E-05			LogNormal	7.13	BOP-PVL-FTO	PVL-FTO
BOP-PVL-FTO-G11O	Upper pipe ram close pilot operated hydraulic valve G11o fails to open on demand (Yellow)	2.27E-05	1	2.27E-05			LogNormal	7.13	BOP-PVL-FTO	PVL-FTO
BOP-PVL-FTO-G12	Upper pipe ram close pilot operated hydraulic valve G12 fails to open on demand (Blue)	2.27E-05	1	2.27E-05			LogNormal	7.13	BOP-PVL-FTO	PVL-FTO
BOP-PVL-FTO-G12O	Upper pipe ram open pilot operated hydraulic valve G12o fails to open on demand (Blue)	2.27E-05	1	2.27E-05			LogNormal	7.13	BOP-PVL-FTO	PVL-FTO
BOP-PVL-FTO-G13	Lower pipe ram lock pilot operated hydraulic valve G13 fails to open on demand (Yellow)	2.27E-05	1	2.27E-05			LogNormal	7.13	BOP-PVL-FTO	PVL-FTO
BOP-PVL-FTO-G14	Lower pipe ram lock pilot operated hydraulic valve G14 fails to open on demand (Blue)	2.27E-05	1	2.27E-05			LogNormal	7.13	BOP-PVL-FTO	PVL-FTO
BOP-PVL-FTO-G15	Lower pipe ram close pilot operated hydraulic valve G15 fails to open on demand (Yellow)	2.27E-05	1	2.27E-05			LogNormal	7.13	BOP-PVL-FTO	PVL-FTO

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
BOP-PVL-FTO-G15O	Lower pipe ram open pilot operated hydraulic valve G15o fails to open on demand (Yellow)	2.27E-05	1	2.27E-05			LogNormal	7.13	BOP-PVL-FTO	PVL-FTO
BOP-PVL-FTO-G16	Lower pipe ram close pilot operated hydraulic valve G16 fails to open on demand (Blue)	2.27E-05	1	2.27E-05			LogNormal	7.13	BOP-PVL-FTO	PVL-FTO
BOP-PVL-FTO-G16O	Lower pipe ram open pilot operated hydraulic valve G16o fails to open on demand (Blue)	2.27E-05	1	2.27E-05			LogNormal	7.13	BOP-PVL-FTO	PVL-FTO
BOP-PVL-FTO-L01	Pod select pilot operated valve L01 fails to open on demand (Blue)	2.27E-05	1	2.27E-05			LogNormal	7.13	BOP-PVL-FTO	PVL-FTO
BOP-PVL-FTO-L03	Pod select pilot operated valve L03 fails to open on demand (blue)	2.27E-05	1	2.27E-05			LogNormal	7.13	BOP-PVL-FTO	PVL-FTO
BOP-PVL-FTO-RC5	Riser Connector Primary Unlock Pilot Operated Valve Fails to Open (Yellow)	2.27E-05	1	2.27E-05			LogNormal	7.13	BOP-PVL-FTO	PVL-FTO
BOP-PVL-FTO-RC7	Riser Connector Secondary Unlock Pilot Operated Valve Fails to Open (Yellow)	2.27E-05	1	2.27E-05			LogNormal	7.13	BOP-PVL-FTO	PVL-FTO
BOP-PVL-FTO-V03	Blue pod supply isolation pilot valve V03 fails to open on demand	2.27E-05	1	2.27E-05			LogNormal	7.13	BOP-PVL-FTO	PVL-FTO
BOP-PVL-FTO-V05	Blue rigid conduit isolator pilot valve V05 fails to open on demand	2.27E-05	1	2.27E-05			LogNormal	7.13	BOP-PVL-FTO	PVL-FTO
BOP-SCV-FTC-CASESHOE1	Casing Shoe Fails To Close	8.66E-05	1	8.66E-05			LogNormal	7.99	BOP-SCV-FTC	CHV-FTC
BOP-SCV-FTC-FLTVLV1	Float Valve Fails To Close	8.66E-05	1	8.66E-05			LogNormal	7.99	BOP-SCV-FTC	CHV-FTC
BOP-SCV-FTC-IBOP1	IBOP Fails To Close	8.66E-05	1	8.66E-05			LogNormal	7.99	BOP-SCV-FTC	CHV-FTC
BOP-SCV-FTC-K01	Pilot supply check valve K01 fails to close (Blue)	8.66E-05	1	8.66E-05			LogNormal	7.99	BOP-SCV-FTC	CHV-FTC
BOP-SCV-FTC-K02	Pilot supply check valve K02 fails to close (Yellow)	8.66E-05	1	8.66E-05			LogNormal	7.99	BOP-SCV-FTC	CHV-FTC
BOP-SCV-FTO-A00	BOP accumulator charge check valve A00 fails to open on demand	1.07E-04	1	1.07E-04			LogNormal	7.99	BOP-SCV-FTO	CHV-FTO
BOP-SCV-FTO-K01	Pilot supply check valve K01 fails to open (Blue)	1.07E-04	1	1.07E-04			LogNormal	7.99	BOP-SCV-FTO	CHV-FTO
BOP-SCV-FTO-K02	Pilot supply check valve K02 fails to open (Yellow)	1.07E-04	1	1.07E-04			LogNormal	7.99	BOP-SCV-FTO	CHV-FTO
BOP-SCV-FTO-Q01L	Left side spring check valve of Q01 fails to open	1.07E-04	1	1.07E-04			LogNormal	7.99	BOP-SCV-FTO	CHV-FTO
BOP-SCV-FTO-Q01R	Right side check valve of Q01 fails to open	1.07E-04	1	1.07E-04			LogNormal	7.99	BOP-SCV-FTO	CHV-FTO
BOP-SCV-FTO-Q02L	Left side hydraulic spring check valve of Q02 fails to open	1.07E-04	1	1.07E-04			LogNormal	7.99	BOP-SCV-FTO	CHV-FTO
BOP-SCV-FTO-Q02R	Right side hydraulic spring check valve of Q02 fails to open	1.07E-04	1	1.07E-04			LogNormal	7.99	BOP-SCV-FTO	CHV-FTO

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
BOP-SCV-FTO-W01	Spring check valve on topsides supply filter assembly W01 in RCM fails to open (Blue)	1.07E-04	1	1.07E-04			LogNormal	7.99	BOP-SCV-FTO	CHV-FTO
BOP-SCV-FTO-W02	Spring check valve on topsides supply filter assembly W02 in RCM fails to open (Yellow)	1.07E-04	1	1.07E-04			LogNormal	7.99	BOP-SCV-FTO	CHV-FTO
BOP-SCV-FTO-Z01	Rigid conduit manifold check valve Z01 fails to open (Blue)	1.07E-04	1	1.07E-04			LogNormal	7.99	BOP-SCV-FTO	CHV-FTO
BOP-SCV-FTO-Z02	Rigid conduit manifold check valve Z02 fails to open (Yellow)	1.07E-04	1	1.07E-04			LogNormal	7.99	BOP-SCV-FTO	CHV-FTO
BOP-SEA-DEG-LOWERANN	Lower annular elastomer damaged while stripping in pipe	0.1	1	0.1			PointValue		BOP-SEA-DEG	
BOP-SEA-DEG-UPPERANN	Upper annular elastomer damaged while stripping in pipe	0.1	1	0.1			PointValue		BOP-SEA-DEG	
BOP-SVL-FTO-AL1	Upper annular close solenoid valve AL1 fails to open on demand providing (Yellow)	2.62E-04	1	2.62E-04			LogNormal	7.51	BOP-SVL-FTO	SVL-FTO
BOP-SVL-FTO-AL2	Upper annular close solenoid valve AL2 fails to open on demand providing (Blue)	2.62E-04	1	2.62E-04			LogNormal	7.51	BOP-SVL-FTO	SVL-FTO
BOP-SVL-FTO-AL7	Lower annular close Solenoid valve AL7 fails to open on demand (Yellow)	2.62E-04	1	2.62E-04			LogNormal	7.51	BOP-SVL-FTO	SVL-FTO
BOP-SVL-FTO-AL8	Lower annular close solenoid valve AL8 fails to open on demand providing (Blue)	2.62E-04	1	2.62E-04			LogNormal	7.51	BOP-SVL-FTO	SVL-FTO
BOP-SVL-FTO-C01	Blind Shear Ram High Pressure close Solenoid valve CO1 fails to open on demand (Yellow)	2.62E-04	1	2.62E-04			LogNormal	7.51	BOP-SVL-FTO	SVL-FTO
BOP-SVL-FTO-C02	Blind Shear Ram High Pressure close Solenoid valve CO2 fails to open on demand (Blue)	2.62E-04	1	2.62E-04			LogNormal	7.51	BOP-SVL-FTO	SVL-FTO
BOP-SVL-FTO-C12	Blind Shear Ram Lock Solenoid operated valve C12 fails to open on demand (Yellow)	2.62E-04	1	2.62E-04			LogNormal	7.51	BOP-SVL-FTO	SVL-FTO
BOP-SVL-FTO-C13	Blind Shear Ram Lock Solenoid operated valve C13 fails to open on demand (Blue)	2.62E-04	1	2.62E-04			LogNormal	7.51	BOP-SVL-FTO	SVL-FTO
BOP-SVL-FTO-CKL3	Choke & Kill Line Primary Unlock Solenoid Operated Valve Fails to Open (Yellow)	2.62E-04	1	2.62E-04			LogNormal	7.51	BOP-SVL-FTO	SVL-FTO
BOP-SVL-FTO-CKL5	Choke & Kill Line Secondary Unlock Solenoid Operated Valve Fails to Open (Yellow)	2.62E-04	1	2.62E-04			LogNormal	7.51	BOP-SVL-FTO	SVL-FTO
BOP-SVL-FTO-H01	Casing Shear High Pressure close Solenoid valve H01 fails to open on demand (Yellow)	2.62E-04	1	2.62E-04			LogNormal	7.51	BOP-SVL-FTO	SVL-FTO

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
BOP-SVL-FTO-H02	Casing Shear High Pressure close Solenoid valve H02 fails to open on demand (Blue)	2.62E-04	1	2.62E-04			LogNormal	7.51	BOP-SVL-FTO	SVL-FTO
BOP-SVL-FTO-H03	Middle pipe ram lock solenoid operated hydraulic valve H03 fails to open on demand (Yellow)	2.62E-04	1	2.62E-04			LogNormal	7.51	BOP-SVL-FTO	SVL-FTO
BOP-SVL-FTO-H04	Middle pipe ram lock solenoid operated hydraulic valve H04 fails to open on demand (Blue)	2.62E-04	1	2.62E-04			LogNormal	7.51	BOP-SVL-FTO	SVL-FTO
BOP-SVL-FTO-H05	Middle pipe ram close solenoid operated hydraulic valve H05 fails to open on demand (Yellow)	2.62E-04	1	2.62E-04			LogNormal	7.51	BOP-SVL-FTO	SVL-FTO
BOP-SVL-FTO-H05O	Middle pipe ram open solenoid operated hydraulic valve H05o fails to open on demand (Yellow)	2.62E-04	1	2.62E-04			LogNormal	7.51	BOP-SVL-FTO	SVL-FTO
BOP-SVL-FTO-H06	Middle pipe ram close solenoid operated hydraulic valve H06 fails to open on demand (Blue)	2.62E-04	1	2.62E-04			LogNormal	7.51	BOP-SVL-FTO	SVL-FTO
BOP-SVL-FTO-H06O	Middle pipe ram open solenoid operated hydraulic valve H06o fails to open on demand (Blue)	2.62E-04	1	2.62E-04			LogNormal	7.51	BOP-SVL-FTO	SVL-FTO
BOP-SVL-FTO-H07	Upper pipe ram lock Solenoid operated hydraulic valve H07 fails to open on demand (Yellow)	2.62E-04	1	2.62E-04			LogNormal	7.51	BOP-SVL-FTO	SVL-FTO
BOP-SVL-FTO-H08	Upper pipe ram lock Solenoid operated hydraulic valve H08 fails to open on demand (Blue)	2.62E-04	1	2.62E-04			LogNormal	7.51	BOP-SVL-FTO	SVL-FTO
BOP-SVL-FTO-H09	Upper pipe ram close solenoid operated hydraulic valve H09 fails to open on demand (Yellow)	2.62E-04	1	2.62E-04			LogNormal	7.51	BOP-SVL-FTO	SVL-FTO
BOP-SVL-FTO-H09O	Upper pipe ram open solenoid operated hydraulic valve H09o fails to open on demand (Yellow)	2.62E-04	1	2.62E-04			LogNormal	7.51	BOP-SVL-FTO	SVL-FTO
BOP-SVL-FTO-H10	Upper pipe ram close solenoid operated hydraulic valve H10 fails to open on demand (Blue)	2.62E-04	1	2.62E-04			LogNormal	7.51	BOP-SVL-FTO	SVL-FTO

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
BOP-SVL-FTO-H10O	Upper pipe ram open solenoid operated hydraulic valve H10o fails to open on demand (Blue)	2.62E-04	1	2.62E-04			LogNormal	7.51	BOP-SVL-FTO	SVL-FTO
BOP-SVL-FTO-H11	Lower pipe ram lock solenoid operated hydraulic valve H11 fails to open on demand (Yellow)	2.62E-04	1	2.62E-04			LogNormal	7.51	BOP-SVL-FTO	SVL-FTO
BOP-SVL-FTO-H12	Lower pipe ram lock solenoid operated hydraulic valve H12 fails to open on demand (Blue)	2.62E-04	1	2.62E-04			LogNormal	7.51	BOP-SVL-FTO	SVL-FTO
BOP-SVL-FTO-H13	Lower pipe ram close solenoid operated hydraulic valve H13 fails to open on demand (Yellow)	2.62E-04	1	2.62E-04			LogNormal	7.51	BOP-SVL-FTO	SVL-FTO
BOP-SVL-FTO-H13O	Lower pipe ram open solenoid operated hydraulic valve H13o fails to open on demand (Yellow)	2.62E-04	1	2.62E-04			LogNormal	7.51	BOP-SVL-FTO	SVL-FTO
BOP-SVL-FTO-H14	Lower pipe ram close solenoid operated valve H14 fails to open on demand (Blue)	2.62E-04	1	2.62E-04			LogNormal	7.51	BOP-SVL-FTO	SVL-FTO
BOP-SVL-FTO-H14O	Lower pipe ram Open solenoid operated valve H14o fails to open on demand (Blue)	2.62E-04	1	2.62E-04			LogNormal	7.51	BOP-SVL-FTO	SVL-FTO
BOP-SVL-FTO-J01	Pod select solenoid operated valve J01 fails to open on demand (Blue)	2.62E-04	1	2.62E-04			LogNormal	7.51	BOP-SVL-FTO	SVL-FTO
BOP-SVL-FTO-RC1	Riser Connector Primary Unlock Solenoid Operated Valve Fails to Open (Yellow)	2.62E-04	1	2.62E-04			LogNormal	7.51	BOP-SVL-FTO	SVL-FTO
BOP-SVL-FTO-RC3	Riser Connector Secondary Unlock Solenoid Operated Valve Fails to Open (Yellow)	2.62E-04	1	2.62E-04			LogNormal	7.51	BOP-SVL-FTO	SVL-FTO
BOP-SVL-FTO-Y08	Blue pod supply isolation solenoid valve Y08 fails to open on demand	2.62E-04	1	2.62E-04			LogNormal	7.51	BOP-SVL-FTO	SVL-FTO
BOP-SVL-FTO-Y11	Blue rigid conduit isolator solenoid operated hydraulic valve Y11 fails to open on demand	2.62E-04	1	2.62E-04			LogNormal	7.51	BOP-SVL-FTO	SVL-FTO
CASE-COUPLING-PRESENT-BS	Case Coupling prevents blind shear ram from cutting casing	2.00E-02	1	2.00E-02			PointValue		CASE-COUPLING-PRESENT	
CASE-COUPLING-PRESENT-CS	Casing Coupling prevents casing shear from cutting pipe	2.00E-02	1	2.00E-02			PointValue		CASE-COUPLING-PRESENT	
D-W-S-STRM-OFST-HRA	Human Error Resulting in Incorrectly Entering the Offset into the DP System (Extreme Weather, Winter Storm, Squall)	4.20E-05	1	4.20E-05			LogNormal	4.9	STRM-OFST-HRA	

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
DP-TOOLJOINT-PRESENT-BSR	Drillpipe tool joint is present across the BSR	0.1	1	0.1			PointValue		DP-TOOLJOINT	
DP-TOOLJOINT-PRESENT-CSR	Drillpipe tool joint is present across the CSR	0.1	1	0.1			PointValue		DP-TOOLJOINT	
DPS-HUM-ERR-CSRECOV	Human Error Failure to Adequately Recover from Control System Failure in Which Drive-off is Initiated	4.30E-03	1	4.30E-03			LogNormal	7.2	HUM-ERR-CSRECOV	
DPS-HUM-ERR-JOYSTICK	Human Error Failure to Control Vessel Using the Independent Joystick	8.00E-02	1	8.00E-02			LogNormal	10	HUM-ERR-JOYSTICK	
DPS-WEA-HRA-PREP	Human Error Failure to Orient the Vessel for the Onset of Elevated Weather	8.10E-04	1	8.10E-04			LogNormal	3.2	WEA-HRA-PREP	
DRIFT-OFF	Drift-off due to less than adequate thrusters available	1	1	1			PointValue			
DRIFT-OFF_DUETOHARDWARE	Drift-off due to less than adequate thrusters available (equipment failure)	1	1	1			PointValue			
DRIVE-OFF-HUMERR	Drive-off due to human error	1	1	1			PointValue			
DRIVE-OFF-POSREF	Drive-off due to loss of position reference	1	1	1			PointValue			
EMPTYBOPKICK	Kick with nothing across the BOP	1	1	1			PointValue			
EPS-DGN-FTS-C03	Diesel Generator 3 Fails to Start	2.11E-03	1	2.11E-03			LogNormal	3.54	EPS-DGN-FTS	DGN-FTS
EPS-DGN-FTS-P05	Diesel Generator 5 Fails to Start	2.11E-03	1	2.11E-03			LogNormal	3.54	EPS-DGN-FTS	DGN-FTS
EPS-DGN-FTS-S01	Diesel Generator 1 Fails to Start	2.11E-03	1	2.11E-03			LogNormal	3.54	EPS-DGN-FTS	DGN-FTS
FORMATIONFRACTURE_BH	Bullheading leads to fracturing the formation (placeholder)	0.5	1	0.5			PointValue		FORMFRACTURE_BH	
FORMPRESS002	Choke system after upper and lower valves fail to regulate backpressure	0	1	0			PointValue			
FORMPRESSHIGH	Formation pressure/flow is high (placeholder)	1.00E-02	1	1.00E-02			PointValue		FORM-PRE-HIGH	
FORM_PRESS_ANNULAR	Formation pressure above annular design pressure (placeholder)	5.00E-02	1	5.00E-02			PointValue		FORM_PRESS_ANN	
FSY-PMP-FTR-SFS2H	Starboard Electrically Driven Fuel Supply Pump #2 Fails to Run (Extreme Weather)	1.31E-03	1	1.31E-03			LogNormal	1.14	FSY-PMP-FTS-H	ELECPMP-FTS
FSY-PMP-FTS-CFS2	Center Electrically Driven Fuel Supply Pump #2 Fails to Start	1.31E-03	1	1.31E-03			LogNormal	1.14	FSY-PMP-FTS	ELECPMP-FTS
FSY-PMP-FTS-CFS2H	Center Electrically Driven Fuel Supply Pump #2 Fails to Start (Extreme Weather)	1.31E-03	1	1.31E-03			LogNormal	1.14	FSY-PMP-FTS-H	ELECPMP-FTS
FSY-PMP-FTS-PFS2	Port Electrically Driven Fuel Supply Pump #2 Fails to Start	1.31E-03	1	1.31E-03			LogNormal	1.14	FSY-PMP-FTS	ELECPMP-FTS
FSY-PMP-FTS-PFS2H	Port Electrically Driven Fuel Supply Pump #2 Fails to Start (Extreme Weather)	1.31E-03	1	1.31E-03			LogNormal	1.14	FSY-PMP-FTS-H	ELECPMP-FTS

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
FSY-PMP-FTS-SFS2	Starboard Electrically Driven Fuel Supply Pump #2 Fails to Start	1.31E-03	1	1.31E-03			LogNormal	1.14	FSY-PMP-FTS	ELECPMP-FTS
FSY-PMP-FTS-SFS2H	Starboard Electrically Driven Fuel Supply Pump #2 Fails to Start (Extreme Weather)	1.31E-03	1	1.31E-03			LogNormal	1.14	FSY-PMP-FTS-H	ELECPMP-FTS
FWC-PMP-FTS-AC43	Aft Center Electrically Driven Fresh Water Thruster Cooling Pump (Thruster 6) Fails to Start	1.31E-03	1	1.31E-03			LogNormal	1.14	FWC-PMP-FTS	ELECPMP-FTS
FWC-PMP-FTS-AC43H	Aft Center Electrically Driven Fresh Water Thruster Cooling Pump AC43 (Thruster 6) Fails to Start (Extreme Weather)	1.31E-03	1	1.31E-03			LogNormal	1.14	FWC-PMP-FTS	ELECPMP-FTS
FWC-PMP-FTS-AP43	Aft Port Electrically Driven Fresh Water Thruster Cooling Pump AP43 (Thruster 5) Fails to Start	1.31E-03	1	1.31E-03			LogNormal	1.14	FWC-PMP-FTS	ELECPMP-FTS
FWC-PMP-FTS-AP43H	Aft Port Electrically Driven Fresh Water Thruster Cooling Pump AP43 (Thruster 5) Fails to Start (Extreme Weather)	1.31E-03	1	1.31E-03			LogNormal	1.14	FWC-PMP-FTS	ELECPMP-FTS
FWC-PMP-FTS-AS43	Aft Starboard Electrically Driven Fresh Water Thruster Cooling Pump AS43 (Thruster 4) Fails to Start	1.31E-03	1	1.31E-03			LogNormal	1.14	FWC-PMP-FTS	ELECPMP-FTS
FWC-PMP-FTS-AS43H	Aft Starboard Electrically Driven Fresh Water Thruster Cooling Pump As43 (Thruster 4) Fails to Start (Extreme Weather)	1.31E-03	1	1.31E-03			LogNormal	1.14	FWC-PMP-FTS	ELECPMP-FTS
FWC-PMP-FTS-FC09	Forward Center Electrically Driven Fresh Water Thruster Cooling Pump (Thruster 1) Fails to Start	1.31E-03	1	1.31E-03			LogNormal	1.14	FWC-PMP-FTS	ELECPMP-FTS
FWC-PMP-FTS-FC09H	Forward Center Electrically Driven Fresh Water Thruster Cooling Pump FC09 (Thruster 1) Fails to Start (Extreme Weather)	1.31E-03	1	1.31E-03			LogNormal	1.14	FWC-PMP-FTS	ELECPMP-FTS
FWC-PMP-FTS-FP09	Forward Port Electrically Driven Fresh Water Thruster Cooling Pump (Thruster 3) Fails to Start	1.31E-03	1	1.31E-03			LogNormal	1.14	FWC-PMP-FTS	ELECPMP-FTS
FWC-PMP-FTS-FP09H	Forward Port Electrically Driven Fresh Water Thruster Cooling Pump FP09 (Thruster 3) Fails to Start (Extreme Weather)	1.31E-03	1	1.31E-03			LogNormal	1.14	FWC-PMP-FTS	ELECPMP-FTS
FWC-PMP-FTS-FS09	Forward Starboard Electrically Driven Fresh Water Thruster Cooling Pump FS09 (Thruster 2) Fails to Start	1.31E-03	1	1.31E-03			LogNormal	1.14	FWC-PMP-FTS	ELECPMP-FTS
FWC-PMP-FTS-FS09H	Forward Starb Electrically Driven Fresh Water Thruster Cooling Pump FS09 (Thruster 2) Fails to Start (Extreme Weather)	1.31E-03	1	1.31E-03			LogNormal	1.14	FWC-PMP-FTS	ELECPMP-FTS
HIGH-MUD-DENSITY-D-IC	High mud density leads to kick while drilling, intermediate casing ops	0	1	0			PointValue			
HIGH-MUD-DENSITY-D-PZ	High mud density leads to kick while drilling, reservoir ops	0	1	0			PointValue			

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
HIGHMUDDENSITY-RC-IC	High mud density leads to kick while running casing, intermediate casing ops	0	1	0			PointValue			
HIGHMUDDENSITY-RC-PZ	High mud density leads to kick while running casing, reservoir ops	0	1	0			PointValue			
KICKRUNNINGCASING	Well Kick While Running Casing	1	1	1			PointValue			
KICKWHILEDRILLING	Well Kick While Drilling	1	1	1			PointValue			
LOW-MUD-DENSITY-D-IC	Low mud density/volume leads to kick while drilling, intermediate casing ops	6.68E-02	1	6.68E-02			PointValue		LOW-MUD-DEN-D-IC	
LOW-MUD-DENSITY-D-PZ	Low mud density/volume leads to kick while drilling, reservoir ops	6.44E-02	1	6.44E-02			PointValue		LOW-MUD-DEN-D-PZ	
LOW-MUD-DENSITY-D-SC	Low mud density/volume leads to kick while drilling during surface casing operations	0	1	0			PointValue		LOW-MUD-DEN-D-SC	
LOW-MUD-DENSITY-NABOP-IC	Low mud density causes kick with nothing across the BOP, intermediate casing ops	9.45E-03	1	9.45E-03			PointValue		LOW-MUD-DEN-NABOP-IC	
LOW-MUD-DENSITY-NABOP-PZ	Low mud density causes kick with nothing across the BOP, reservoir ops	7.16E-03	1	7.16E-03			PointValue		LOW-MUD-DEN-NABOP-PZ	
LOW-MUD-DENSITY-NABOP-SC	Low mud density/volume leads to kick nothing in the hole, surface casing ops	3.53E-04	1	3.53E-04			PointValue	0	LOW-MUD-DEN-NABOP-SC	
LOW-MUD-DENSITY-RC-IC	Low mud density/volume leads to kick while running casing, intermediate casing ops	1.91E-02	1	1.91E-02			PointValue		LOW-MUD-DEN-RC-IC	
LOW-MUD-DENSITY-RC-PZ	Low mud density/volume leads to kick while running casing, reservoir ops	0	1	0			PointValue		LOW-MUD-DEN-RC-PZ	
LOW-MUD-DENSITY-RC-SC	Low mud density/volume leads to kick while running casing during surface casing operation	9.71E-04	1	9.71E-04			PointValue		LOW-MUD-DEN-RC-SC	
OTHERKICK-D-IC	Kick from undefined caused while drilling, intermediate casing op	2.30E-02	1	2.30E-02			PointValue		OTHER-KICK-D-IC	
OTHERKICK-D-PZ	Kick from undefined caused while drilling, reservoir ops	2.22E-02	1	2.22E-02			PointValue		OTHER-KICK-D-PZ	
OTHERKICK-NABOP-IC	Kick from undefined caused with nothing across the BOP intermediate casing ops	3.28E-03	1	3.28E-03			PointValue		OTHER-KICK-NABOP-IC	

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
OTHERKICK-NABOP-PZ	Kick from undefined caused with nothing across the BOP reservoir ops	2.46E-03	1	2.46E-03			PointValue		OTHER-KICK-NABOP-PZ	
OTHERKICK-RC-IC	Kick from undefined caused while running casing intermediate casing ops	6.57E-03	1	6.57E-03			PointValue		OTHER-KICK-RC-IC	
OTHERKICK-RC-PZ	Kick from undefined caused while running casing reservoir ops	0	1	0			PointValue		OTHER-KICK-RC-PZ	
PUSH-OFF	Push-off due to above extreme weather	1	1	1			PointValue			
RISER-PARTS	Riser parts following a failed disconnect	5.00E-01	1	5.00E-01			PointValue		RIS-PARTS	
RISER-PARTS-DRIVE	Riser parts following a loss of location due to drive-off	1	1	1			PointValue		RIS-PARTS-DRIVE	
RISER-PARTS-KICK	Ensure that riser doesn't part during a well kick	0	1	0			PointValue		RIS-PARTS-KICK	
ROV-FAILURE	ROV fails (Undeveloped since only impacts the amount of time spill occurs)	0	1	0			PointValue			
SURGE-D-IC	Surge effect causes well kick while drilling, intermediate casing ops	0	1	0			PointValue		SURG-D-IC	
SURGE-D-PZ	Surge effect causes well kick while drilling, reservoir ops	0	1	0			PointValue		SURG-D-PZ	
SURGE-RC-IC	Surge effect causes well kick while running casing, intermediate casing ops	2.93E-03	1	2.93E-03			PointValue		SURG-RC-IC	
SURGE-RC-PZ	Surge effect causes well kick while running casing reservoir ops	0	1	0			PointValue		SURG-RC-PZ	
SWABBING-D-IC	Swab effect causes well kick while drilling, intermediate casing ops	3.31E-02	1	3.31E-02			PointValue		SWABB-D-IC	
SWABBING-D-PZ	Swab effect causes well kick while drilling, reservoir ops	2.48E-02	1	2.48E-02			PointValue		SWAB-D-PZ	
SWC-PMP-FTS-AC02	Aft Center Electrically Driven Sea Water Cooling Pump Fails to Start	1.31E-03	1	1.31E-03			LogNormal	1.14	SWC-PMP-FTS	ELECPMP-FTS
SWC-PMP-FTS-AP02	Aft Port Electrically Driven Sea Water Cooling Pump Fails to Start	1.31E-03	1	1.31E-03			LogNormal	1.14	SWC-PMP-FTS	ELECPMP-FTS
SWC-PMP-FTS-AS02	Aft Starboard Electrically Driven Sea Water Cooling Pump Fails to Start	1.31E-03	1	1.31E-03			LogNormal	1.14	SWC-PMP-FTS	ELECPMP-FTS
SWC-PMP-FTS-FC02	Forward Center Electrically Driven Sea Water Cooling Pump Fails to Start	1.31E-03	1	1.31E-03			LogNormal	1.14	SWC-PMP-FTS	ELECPMP-FTS
SWC-PMP-FTS-FC02H	Forward Center Electrically Driven Sea Water Cooling Pump Fails to Start (Extreme Weather)	1.31E-03	1	1.31E-03			LogNormal	1.14	SWC-PMP-FTS	ELECPMP-FTS

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
SWC-PMP-FTS-FP02	Forward Port Electrically Driven Sea Water Cooling Pump Fails to Start	1.31E-03	1	1.31E-03			LogNormal	1.14	SWC-PMP-FTS	ELECPMP-FTS
SWC-PMP-FTS-FP02H	Forward Port Electrically Driven Sea Water Cooling Pump Fails to Start (Extreme Weather)	1.31E-03	1	1.31E-03			LogNormal	1.14	SWC-PMP-FTS	ELECPMP-FTS
SWC-PMP-FTS-FS02	Forward Starboard Electrically Driven Sea Water Cooling Pump Fails to Start	1.31E-03	1	1.31E-03			LogNormal	1.14	SWC-PMP-FTS	ELECPMP-FTS
SWC-PMP-FTS-FS02H	Forward Starboard Electrically Driven Sea Water Cooling Pump Fails to Start (Extreme Weather)	1.31E-03	1	1.31E-03			LogNormal	1.14	SWC-PMP-FTS	ELECPMP-FTS
UNDERGROUND_BO	Underground blowout after formation fractures (placeholder)	1.00E-02	1	1.00E-02			PointValue		UNDER_GROUND_BO	
UNEXOVERP-D-IC	Unexpected Overpressure zone while drilling, intermediate casing ops	9.54E-02	1	9.54E-02			PointValue		UNEXP-OVERP-D-IC	
UNEXOVERP-D-PZ	Unexpected Overpressure zone while drilling, reservoir ops	7.16E-02	1	7.16E-02			PointValue		UNEXP-OVERP-D-PZ	
UNEXPOVP-D-SC	Unexpected Overpressure zone while drilling during surface casing operations	1.68E-03	1	1.68E-03			PointValue		UNEXP-OVERP-D-SC	
UNEXPOVP-RC-SC	Unexpected Overpressure zone while drilling during surface casing operations	0	1	0			PointValue		UNEXP-OVERP-RC-SC	
WEAKFORM-D-IC	Weak formation / incorrect fracture pressure data lead to kick while drilling, intermediate casing ops	1.17E-02	1	1.17E-02			PointValue		WEAK-FORM-D-IC	
WEAKFORM-D-PZ	Weak formation / incorrect fracture pressure data lead to kick while drilling, reservoir ops	1.10E-02	1	1.10E-02			PointValue		WEAK-FORM-D-PZ	
WEAKFORM-D-SC	Weak formation / incorrect fracture pressure data lead to kick while drilling during surface casing operations	0	1	0			PointValue		WEAK-FORM-D-SC	
WEAKFORM-RC-IC	Weak formation / incorrect fracture pressure data lead to kick while running casing, intermediate casing ops	0	1	0			PointValue		WEAK-FORM-RC-IC	
WEAKFORM-RC-PZ	Weak formation / incorrect fracture pressure data lead to kick while running casing, reservoir ops	0	1	0			PointValue		WEAK-FORM-RC-PZ	
BOP-ACC-LKI-AH1	Subsea BOP accumulator AH1 fails due to internal leak	4.70E-05	3		2.80E-07	168	LogNormal	9.57	BOP-ACC-LKI	ACC-LKI
BOP-ACC-LKI-AH2	Subsea BOP accumulator AH2 fails due to internal leak	4.70E-05	3		2.80E-07	168	LogNormal	9.57	BOP-ACC-LKI	ACC-LKI

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
BOP-ACC-LKI-AH3	Subsea BOP accumulator AH3 fails due to internal leak	4.70E-05	3		2.80E-07	168	LogNormal	9.57	BOP-ACC-LKI	ACC-LKI
BOP-ACC-LKI-AH4	Subsea BOP accumulator AH4 fails due to internal leak	4.70E-05	3		2.80E-07	168	LogNormal	9.57	BOP-ACC-LKI	ACC-LKI
BOP-ACC-LKI-AH5	Subsea BOP accumulator AH5 fails due to internal leak	4.70E-05	3		2.80E-07	168	LogNormal	9.57	BOP-ACC-LKI	ACC-LKI
BOP-ACC-LKI-AH6	Subsea BOP accumulator AH6 fails due to internal leak	4.70E-05	3		2.80E-07	168	LogNormal	9.57	BOP-ACC-LKI	ACC-LKI
BOP-ACC-LKI-AH7	Subsea BOP accumulator AH7 fails due to internal leak	4.70E-05	3		2.80E-07	168	LogNormal	9.57	BOP-ACC-LKI	ACC-LKI
BOP-ACC-LKI-AM1	Upper annular precharge damping accumulator internal leak	4.70E-05	3		2.80E-07	168	LogNormal	9.57	BOP-ACC-LKI	ACC-LKI
BOP-ACC-LKI-AM10	Lower annular accumulator AM10 leaks internally (Blue)	4.70E-05	3		2.80E-07	168	LogNormal	9.57	BOP-ACC-LKI	ACC-LKI
BOP-ACC-LKI-AM2	Upper annular accumulator AM2 leaks internally (Yellow)	4.70E-05	3		2.80E-07	168	LogNormal	9.57	BOP-ACC-LKI	ACC-LKI
BOP-ACC-LKI-AM3	Upper annular accumulator AM3 leaks internally (Blue)	4.70E-05	3		2.80E-07	168	LogNormal	9.57	BOP-ACC-LKI	ACC-LKI
BOP-ACC-LKI-AM4	Upper annular accumulator AM4 leaks internally (Yellow)	4.70E-05	3		2.80E-07	168	LogNormal	9.57	BOP-ACC-LKI	ACC-LKI
BOP-ACC-LKI-AM5	Upper annular accumulator AM5 leaks internally (Blue)	4.70E-05	3		2.80E-07	168	LogNormal	9.57	BOP-ACC-LKI	ACC-LKI
BOP-ACC-LKI-AM7	Lower annular Accumulator AM7 leaks internally (Yellow)	4.70E-05	3		2.80E-07	168	LogNormal	9.57	BOP-ACC-LKI	ACC-LKI
BOP-ACC-LKI-AM8	Lower annular accumulator AM8 leaks internally (Blue)	4.70E-05	3		2.80E-07	168	LogNormal	9.57	BOP-ACC-LKI	ACC-LKI
BOP-ACC-LKI-AM9	Lower Annular Accumulator AM9 leaks internally (Yellow)	4.70E-05	3		2.80E-07	168	LogNormal	9.57	BOP-ACC-LKI	ACC-LKI
BOP-ACC-LKI-D02	Blind shear ram lock timing accumulator internal leak	4.70E-05	3		2.80E-07	168	LogNormal	9.57	BOP-ACC-LKI	
BOP-ACC-LKI-D03	Blind shear ram timing accumulator internal leak	4.70E-05	3		2.80E-07	168	LogNormal	9.57	BOP-ACC-LKI	ACC-LKI
BOP-ACC-LKI-F06	Lower annular precharge damping accumulator internal leak	4.70E-05	3		2.80E-07	168	LogNormal	9.57	BOP-ACC-LKI	ACC-LKI
BOP-ACC-LKI-R01	Hydraulic pilot accumulator R01 leaks internal (Blue)	4.70E-05	3		2.80E-07	168	LogNormal	9.57	BOP-ACC-LKI	ACC-LKI
BOP-ACC-LKI-R02	Hydraulic pilot accumulator R02 leaks internal (Yellow)	4.70E-05	3		2.80E-07	168	LogNormal	9.57	BOP-ACC-LKI	ACC-LKI
BOP-ACC-LKI-R03	Hydraulic pilot accumulator R03 leaks internal (Blue)	4.70E-05	3		2.80E-07	168	LogNormal	9.57	BOP-ACC-LKI	ACC-LKI
BOP-ACC-LKI-R04	Hydraulic pilot accumulator R04 leaks internally (Yellow)	4.70E-05	3		2.80E-07	168	LogNormal	9.57	BOP-ACC-LKI	ACC-LKI
BOP-ACC-LKI-R05	Subsea manifold pressure regulator accumulator R05 internal leak (Blue)	4.70E-05	3		2.80E-07	168	LogNormal	9.57	BOP-ACC-LKI	ACC-LKI
BOP-ACC-LKI-R06	Subsea manifold pressure regulator accumulator R06 internal leak (Yellow)	4.70E-05	3		2.80E-07	168	LogNormal	9.57	BOP-ACC-LKI	ACC-LKI

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
BOP-ACC-LKI-R07	Subsea manifold pressure regulator accumulator R07 internal leak (Blue)	4.70E-05	3		2.80E-07	168	LogNormal	9.57	BOP-ACC-LKI	ACC-LKI
BOP-ACC-LKI-R08	Subsea manifold pressure regulator accumulator R08 internal leak (Yellow)	4.70E-05	3		2.80E-07	168	LogNormal	9.57	BOP-ACC-LKI	ACC-LKI
BOP-CYL-FTC-BSL1	Blind shear lock fails to lock or stay locked	4.60E-04	3		2.74E-06	168	LogNormal	6.1	BOP-LOCK-FTC	LCK-FTC
BOP-CYL-FTC-CSR1	Casing shear ram binds and fails to close and shear properly	3.69E-03	3		2.20E-05	168	LogNormal	13.5	BOP-CYL-FTC-CSR	
BOP-CYL-FTC-LANN	The lower annular fails to close due to sticking, jamming etc.	1.30E-02	3		7.80E-05	168	LogNormal	9.81	BOP-CYL-FTC-ANN	ANN-FTC
BOP-CYL-FTC-LPR	Lower pipe ram fails to close and seal properly	2.45E-03	3		1.46E-05	168	LogNormal	7.52	BOP-CYL-FTC-PR	PRA-FTC
BOP-CYL-FTC-LPRL	Lower pipe ram Lock fails to close and seal properly	4.60E-04	3		2.74E-06	168	LogNormal	6.1	BOP-LOCK-FTC	LCK-FTC
BOP-CYL-FTC-MPR	Middle pipe ram fails to close and seal properly	2.45E-03	3		1.46E-05	168	LogNormal	7.52	BOP-CYL-FTC-PR	PRA-FTC
BOP-CYL-FTC-MPRL	Middle pipe ram Lock fails to close and seal properly	4.60E-04	3		2.74E-06	168	LogNormal	6.1	BOP-LOCK-FTC	LCK-FTC
BOP-CYL-FTC-UANN	Upper annular fails to close due to sticking, jamming etc.	1.30E-02	3		7.80E-05	168	LogNormal	9.81	BOP-CYL-FTC-ANN	ANN-FTC
BOP-CYL-FTC-UPR	Upper pipe ram fails to close and seal properly	2.45E-03	3		1.46E-05	168	LogNormal	7.52	BOP-CYL-FTC-PR	PRA-FTC
BOP-CYL-FTC-UPRL	Upper pipe ram Lock fails to close and latch properly	4.60E-04	3		2.74E-06	168	LogNormal	6.1	BOP-LOCK-FTC	LCK-FTC
BOP-CYL-FTO-LPR	Lower pipe ram fails to open	2.45E-03	3		1.46E-05	168	LogNormal	7.52	BOP-CYL-FTO-PR	PRA-FTO
BOP-CYL-FTO-MPR	Middle pipe ram fails to open	2.45E-03	3		1.46E-05	168	LogNormal	7.52	BOP-CYL-FTO-PR	PRA-FTO
BOP-CYL-FTO-UPR	Upper pipe ram fails to open	2.45E-03	3		1.46E-05	168	LogNormal	7.52	BOP-CYL-FTO-PR	PRA-FTO
BOP-CYL-JAM-BSRNABOP	Blind shear rams fail to close and seal when nothing is across the BOP	3.69E-03	3		2.20E-05	168	LogNormal	13.5	BOP-BSRCYL-JAM-NABOP	
BOP-FLT-PLG-Q01L	Left side filter of Q01 is plugged	5.76E-05	3		3.43E-07	168	LogNormal	9.51	BOP-FLT-PLG	FLT-PLG
BOP-FLT-PLG-Q01R	Right side filter on Q01 plugs	5.76E-05	3		3.43E-07	168	LogNormal	9.51	BOP-FLT-PLG	FLT-PLG
BOP-FLT-PLG-Q02L	Left side hydraulic filter of Q02 is plugged	5.76E-05	3		3.43E-07	168	LogNormal	9.51	BOP-FLT-PLG	FLT-PLG
BOP-FLT-PLG-Q02R	Right side hydraulic filter on Q02 plugs	5.76E-05	3		3.43E-07	168	LogNormal	9.51	BOP-FLT-PLG	FLT-PLG
BOP-FLT-PLG-W01	Topsides supply filter W01 in RCM plugs (Blue)	5.76E-05	3		3.43E-07	168	LogNormal	9.51	BOP-FLT-PLG	FLT-PLG
BOP-FLT-PLG-W02	Topsides supply filter W02 in RCM plugs (Yellow)	5.76E-05	3		3.43E-07	168	LogNormal	9.51	BOP-FLT-PLG	FLT-PLG
BOP-HOV-LKI-CH2	Lower Inner Choke Valve Internal Leakage	8.60E-04	3		5.12E-06	168	LogNormal	9.11	BOP-HOV-LKI	HOV-LKI
BOP-HOV-LKI-CH3	Upper Inner Choke Valve Internal Leakage	8.60E-04	3		5.12E-06	168	LogNormal	9.11	BOP-HOV-LKI	HOV-LKI
BOP-HOV-LKI-CH4	Lower Outer Choke Valve Internal Leakage	8.60E-04	3		5.12E-06	168	LogNormal	9.11	BOP-HOV-LKI	HOV-LKI
BOP-HOV-LKI-CH5	Upper Outer Choke Valve Internal Leakage	8.60E-04	3		5.12E-06	168	LogNormal	9.11	BOP-HOV-LKI	HOV-LKI
BOP-HOV-LKI-KI2	Lower Inner Kill Valve Internal Leakage	8.60E-04	3		5.12E-06	168	LogNormal	9.11	BOP-HOV-LKI	HOV-LKI
BOP-HOV-LKI-KI3	Upper Inner Kill Valve Internal Leakage	8.60E-04	3		5.12E-06	168	LogNormal	9.11	BOP-HOV-LKI	HOV-LKI

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
BOP-HOV-LKI-KI7	Lower Outer Kill Valve Internal Leakage	8.60E-04	3		5.12E-06	168	LogNormal	9.11	BOP-HOV-LKI	HOV-LKI
BOP-HOV-LKI-KI8	Upper outer kill valve Internal Leakage	8.60E-04	3		5.12E-06	168	LogNormal	9.11	BOP-HOV-LKI	HOV-LKI
BOP-ORF-PLG-D01	Blind shear ram timing circuit orifice plugged	9.76E-05	3		5.81E-07	168	LogNormal	4.54	BOP-ORF-PLG	ORF-PLG
BOP-ORF-PLG-D02	Blind shear ram lock timing orifice plugged	9.76E-05	3		5.81E-07	168	LogNormal	4.54	BOP-ORF-PLG	ORF-PLG
BOP-PRG-FLO-AO1	Upper annular pressure regulator AO1 fails low and fails to provide hydraulics to upper annular (Yellow)	2.43E-03	3		1.45E-05	168	LogNormal	8.33	BOP-PRG-FLO	PRG-FLO
BOP-PRG-FLO-AO2	Upper annular pressure regulator AO2 fails low and fails to provide hydraulics to upper annular (Blue)	2.43E-03	3		1.45E-05	168	LogNormal	8.33	BOP-PRG-FLO	PRG-FLO
BOP-PRG-FLO-AO3	Lower Annular Pressure regulator AO3 fails low and fails to provide hydraulics to upper annular (Yellow)	2.43E-03	3		1.45E-05	168	LogNormal	8.33	BOP-PRG-FLO	PRG-FLO
BOP-PRG-FLO-AO4	Lower annular pressure regulator AO4 fails low and fails to provide hydraulics to upper annular (Blue)	2.43E-03	3		1.45E-05	168	LogNormal	8.33	BOP-PRG-FLO	PRG-FLO
BOP-PRG-FLO-I01	Subsea manifold pressure regulator I01 fails low (Blue)	2.43E-03	3		1.45E-05	168	LogNormal	8.33	BOP-PRG-FLO	PRG-FLO
BOP-PRG-FLO-I02	Subsea manifold pressure regulator I02 fails low (Yellow)	2.43E-03	3		1.45E-05	168	LogNormal	8.33	BOP-PRG-FLO	PRG-FLO
BOP-PRG-FLO-R01	Blind shear ram lock timing pressure regulator fails low or off	2.43E-03	3		1.45E-05	168	LogNormal	8.33	BOP-PRG-FLO	PRG-FLO
BOP-PRG-FLO-T01	Rigid conduit manifold 3000 psi pressure regulator T01 fails low (Blue)	2.43E-03	3		1.45E-05	168	LogNormal	8.33	BOP-PRG-FLO	PRG-FLO
BOP-PRG-FLO-T02	Rigid conduit manifold 3000 PSI pressure regulator T02 fails low	2.43E-03	3		1.45E-05	168	LogNormal	8.33	BOP-PRG-FLO	PRG-FLO
BOP-PVL-LKE-AE4	Yellow BOP accumulator isolator pilot operated valve AE4 external leak	4.52E-04	3		2.69E-06	168	LogNormal	3.97	BOP-PVL-LKE	PVL-LKE
BOP-PVL-LKE-L02	Pod select pilot operated valve L02 external leak (Yellow)	4.52E-04	3		2.69E-06	168	LogNormal	3.97	BOP-PVL-LKE	PVL-LKE
BOP-PVL-LKE-L04	Casing Shear 5K supply Pilot Valve L04 external leak (Yellow)	4.52E-04	3		2.69E-06	168	LogNormal	3.97	BOP-PVL-LKE	PVL-LKE
BOP-PVL-LKE-V02	Yellow BOP accumulator charge pilot valve V02 external leak	4.52E-04	3		2.69E-06	168	LogNormal	3.97	BOP-PVL-LKE	PVL-LKE
BOP-PVL-LKE-V04	Yellow pod supply isolation pilot valve V04 external leak	4.52E-04	3		2.69E-06	168	LogNormal	3.97	BOP-PVL-LKE	PVL-LKE
BOP-PVL-LKE-V06	Yellow rigid conduit isolator pilot valve V06 external leakage	4.52E-04	3		2.69E-06	168	LogNormal	3.97	BOP-PVL-LKE	PVL-LKE
BOP-PVL-LKI-AE1	BOP accumulator dump pilot operated hydraulic valve AE1 internal leakage	2.25E-04	3		1.34E-06	168	LogNormal	4.25	BOP-PVL-LKI	PVL-LKI
BOP-PVL-LKI-AE2	BOP accumulator dump pilot operated hydraulic valve AE2 internal leakage	2.25E-04	3		1.34E-06	168	LogNormal	4.25	BOP-PVL-LKI	PVL-LKI
BOP-PVL-LKI-V09	Blue RCM flush pilot operated hydraulic valve V09 leakage	9.65E-05	3		1.34E-06	72	LogNormal	4.25	BOP-PVL-LKI	PVL-LKI

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
BOP-PVL-LKI-V10	Yellow RCM flush pilot operated hydraulic valve V10 leakage	9.65E-05	3		1.34E-06	72	LogNormal	4.25	BOP-PVL-LKI	PVL-LKI
BOP-SEM-FOP-BLUEA	Control pod SEM A fails off on the blue side	4.02E-03	3		4.79E-05	84	LogNormal	10.5	BOP-SEM-FOP	MODELE-FOP
BOP-SEM-FOP-BLUEB	Control pod SEM B fails off on the blue side	4.02E-03	3		4.79E-05	84	LogNormal	10.5	BOP-SEM-FOP	MODELE-FOP
BOP-SEM-FOP-YELLOWA	Control pod SEM A fails off on the yellow side	4.02E-03	3		4.79E-05	84	LogNormal	10.5	BOP-SEM-FOP	MODELE-FOP
BOP-SEM-FOP-YELLOWB	Control pod SEM B fails off on the yellow side	4.02E-03	3		4.79E-05	84	LogNormal	10.5	BOP-SEM-FOP	MODELE-FOP
BOP-SHV-LKE-A01	Blind Shear Ram High pressure close shuttle valve A01 jams/external leak	1.54E-03	3		9.17E-06	168	LogNormal	9.7	BOP-SHV-LKE	SHV-LKE
BOP-SHV-LKE-A02	Blind Shear Ram High pressure close shuttle valve A02 jams/external leak	1.54E-03	3		9.17E-06	168	LogNormal	9.7	BOP-SHV-LKE	SHV-LKE
BOP-SHV-LKE-A03	Blind Shear Ram High pressure close shuttle valve A03 jams/external leak	1.54E-03	3		9.17E-06	168	LogNormal	9.7	BOP-SHV-LKE	SHV-LKE
BOP-SHV-LKE-A04	Blind Shear Ram High pressure close shuttle valve A04 jams/external leak	1.54E-03	3		9.17E-06	168	LogNormal	9.7	BOP-SHV-LKE	SHV-LKE
BOP-SHV-LKE-A05	Blind Shear Ram High pressure close shuttle valve A05 jams/external leak	1.54E-03	3		9.17E-06	168	LogNormal	9.7	BOP-SHV-LKE	SHV-LKE
BOP-SHV-LKE-A12	Blind Shear Ram Lock shuttle valve A12 jams/external leak	1.54E-03	3		9.17E-06	168	LogNormal	9.7	BOP-SHV-LKE	SHV-LKE
BOP-SHV-LKE-A13	Blind Shear Ram Lock shuttle valve A13 jams/external leak	1.54E-03	3		9.17E-06	168	LogNormal	9.7	BOP-SHV-LKE	SHV-LKE
BOP-SHV-LKE-A14	Blind Shear Ram Lock shuttle valve A14 jams/external leak	1.54E-03	3		9.17E-06	168	LogNormal	9.7	BOP-SHV-LKE	SHV-LKE
BOP-SHV-LKE-AI1	Upper annular close shuttle valve AI1 jams/external leak	1.54E-03	3		9.17E-06	168	LogNormal	9.7	BOP-SHV-LKE	SHV-LKE
BOP-SHV-LKE-AI2	Lower annular close shuttle valve AI2 jam/external leak	1.54E-03	3		9.17E-06	168	LogNormal	9.7	BOP-SHV-LKE	SHV-LKE
BOP-SHV-LKE-CKL12	Choke & Kill Line Primary Unlock Shuttle Valve CKL12 jams/external leak	1.54E-03	3		9.17E-06	168	LogNormal	9.7	BOP-SHV-LKE	SHV-LKE
BOP-SHV-LKE-CKL13	Choke & Kill Line Secondary Unlock Shuttle Valve CKL13 jams/external leak	1.54E-03	3		9.17E-06	168	LogNormal	9.7	BOP-SHV-LKE	SHV-LKE
BOP-SHV-LKE-F02	Casing Shear HP close shuttle valve F02 jams/external leak	1.54E-03	3		9.17E-06	168	LogNormal	9.7	BOP-SHV-LKE	SHV-LKE
BOP-SHV-LKE-F04	Casing Shear HP close shuttle valve F04 jams/external leak	1.54E-03	3		9.17E-06	168	LogNormal	9.7	BOP-SHV-LKE	SHV-LKE

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
BOP-SHV-LKE-F05	Casing Shear HP close shuttle valve F05 jams/external leak	1.54E-03	3		9.17E-06	168	LogNormal	9.7	BOP-SHV-LKE	SHV-LKE
BOP-SHV-LKE-F06	Casing Shear close shuttle valve F06 jams/external leak	1.54E-03	3		9.17E-06	168	LogNormal	9.7	BOP-SHV-LKE	SHV-LKE
BOP-SHV-LKE-F07	Casing Shear ROV close shuttle valve F07 jams/external leak	1.54E-03	3		9.17E-06	168	LogNormal	9.7	BOP-SHV-LKE	SHV-LKE
BOP-SHV-LKE-F08	Middle pipe ram lock shuttle valve F08 jams/external leak	1.54E-03	3		9.17E-06	168	LogNormal	9.7	BOP-SHV-LKE	SHV-LKE
BOP-SHV-LKE-F09	Middle pipe ram lock shuttle valve F09 jams/external leak	1.54E-03	3		9.17E-06	168	LogNormal	9.7	BOP-SHV-LKE	SHV-LKE
BOP-SHV-LKE-F10	Middle pipe ram close shuttle valve F10 jams/external leak	1.54E-03	3		9.17E-06	168	LogNormal	9.7	BOP-SHV-LKE	SHV-LKE
BOP-SHV-LKE-F11	Middle pipe ram close shuttle valve F11 jams/external leak	1.54E-03	3		9.17E-06	168	LogNormal	9.7	BOP-SHV-LKE	SHV-LKE
BOP-SHV-LKE-F11O	Middle pipe ram open shuttle valve F11o jams/external leak	1.54E-03	3		9.17E-06	168	LogNormal	9.7	BOP-SHV-LKE	SHV-LKE
BOP-SHV-LKE-F12	Upper pipe ram lock Shuttle valve (F12) jams/external leak	1.54E-03	3		9.17E-06	168	LogNormal	9.7	BOP-SHV-LKE	SHV-LKE
BOP-SHV-LKE-F13	Upper pipe ram close shuttle valve F13 jams/external leak	1.54E-03	3		9.17E-06	168	LogNormal	9.7	BOP-SHV-LKE	SHV-LKE
BOP-SHV-LKE-F13O	Upper pipe ram open shuttle valve F13o jams/external leak	1.54E-03	3		9.17E-06	168	LogNormal	9.7	BOP-SHV-LKE	SHV-LKE
BOP-SHV-LKE-F14	Lower pipe ram lock shuttle valve F14 jams/external leak	1.54E-03	3		9.17E-06	168	LogNormal	9.7	BOP-SHV-LKE	SHV-LKE
BOP-SHV-LKE-F15	Lower pipe ram close shuttle valve F15 jams/external leak	1.54E-03	3		9.17E-06	168	LogNormal	9.7	BOP-SHV-LKE	SHV-LKE
BOP-SHV-LKE-F15O	Lower pipe ram open shuttle valve F15o jams/external leak	1.54E-03	3		9.17E-06	168	LogNormal	9.7	BOP-SHV-LKE	SHV-LKE
BOP-SHV-LKE-RC10	Riser Connector Primary Unlock Shuttle Valve RC10 jams/external leak	1.54E-03	3		9.17E-06	168	LogNormal	9.7	BOP-SHV-LKE	SHV-LKE
BOP-SHV-LKE-RC11	Riser Connector Secondary Unlock Shuttle Valve RC11 jams/external leak	1.54E-03	3		9.17E-06	168	LogNormal	9.7	BOP-SHV-LKE	SHV-LKE
BOP-SHV-LKE-RC12	Riser Connector Secondary Unlock Shuttle Valve RC12 jams/external leak	1.54E-03	3		9.17E-06	168	LogNormal	9.7	BOP-SHV-LKE	SHV-LKE
BOP-SHV-LKE-RC9	Riser Connector Primary Unlock Shuttle Valve RC9 jams/external leak	1.54E-03	3		9.17E-06	168	LogNormal	9.7	BOP-SHV-LKE	SHV-LKE

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
BOP-SHV-LKE-X02	BOP accumulator charge shuttle valve X02 jams/external leak	1.54E-03	3		9.17E-06	168	LogNormal	9.7	BOP-SHV-LKE	SHV-LKE
BOP-SVL-LKE-AG4	Yellow BOP accumulator isolator solenoid operated valve AG4 external leak	2.10E-05	3		1.25E-07	168	LogNormal	5.88	BOP-SVL-LKE	SVL-LKE
BOP-SVL-LKE-J02	Pod select solenoid operated valve J02 external leak (Yellow)	2.10E-05	3		1.25E-07	168	LogNormal	5.88	BOP-SVL-LKE	SVL-LKE
BOP-SVL-LKE-Y02	Yellow BOP accumulator charge solenoid operated valve Y02 external leak	2.10E-05	3		1.25E-07	168	LogNormal	5.88	BOP-SVL-LKE	SVL-LKE
BOP-SVL-LKE-Y06	Yellow pod supply isolation solenoid valve Y06 external leak	2.10E-05	3		1.25E-07	168	LogNormal	5.88	BOP-SVL-LKE	SVL-LKE
BOP-SVL-LKE-Y10	Yellow rigid conduit isolator solenoid operated hydraulic valve Y10 external leak	2.10E-05	3		1.25E-07	168	LogNormal	5.88	BOP-SVL-LKE	SVL-LKE
BOP-SVL-LKI-AL11	Lower annular pressure decrease solenoid operated valve AL11 internal leak (Yellow)	1.63E-05	3		9.71E-08	168	LogNormal	6.13	BOP-SVL-LKI	SVL-LKI
BOP-SVL-LKI-AL12	Lower annular pressure decrease solenoid valve AL12 internal leak (Blue)	1.63E-05	3		9.71E-08	168	LogNormal	6.13	BOP-SVL-LKI	SVL-LKI
BOP-SVL-LKI-AL5	Upper annular pressure decrease solenoid valve AL5 internal leak (Yellow)	1.63E-05	3		9.71E-08	168	LogNormal	6.13	BOP-SVL-LKI	SVL-LKI
BOP-SVL-LKI-AL6	Upper annular pressure decrease solenoid valve AL6 internal leak (Blue)	1.63E-05	3		9.71E-08	168	LogNormal	6.13	BOP-SVL-LKI	SVL-LKI
BOP-SVL-LKI-J05	Subsea manifold pressure regulator decrease solenoid valve J05 internal leak (Blue)	1.63E-05	3		9.71E-08	168	LogNormal	6.13	BOP-SVL-LKI	SVL-LKI
BOP-SVL-LKI-J06	Subsea manifold pressure regulator decrease solenoid valve J06 internal leak (Yellow)	1.63E-05	3		9.71E-08	168	LogNormal	6.13	BOP-SVL-LKI	SVL-LKI
BOP-SVL-LKI-J07	Blue Pilot supply dump valve J07 internal leak	1.63E-05	3		9.71E-08	168	LogNormal	6.13	BOP-SVL-LKI	SVL-LKI
BOP-SVL-LKI-J08	Yellow Pilot supply dump valve J08 internal leak	1.63E-05	3		9.71E-08	168	LogNormal	6.13	BOP-SVL-LKI	SVL-LKI
D-W-O-OPER-FREQ	Probability of Run/Retrieval Offset	5.82E-02	3		8.33E-04	72	LogNormal	3.93	D-W-O-OPER	OFFSET
DPS-COM-FOP-BC01-KI	DP Backup Computer BC01 Fails Off	6.63E-03	3		3.96E-05	168	LogNormal	8	DPS-COM-FOP	COMP-FOP
DPS-COM-FOP-BC01-RT	DP Backup Computer BC01 Fails Off	2.89E-04	3		3.96E-05	7.3	LogNormal	8	DPS-COM-FOP-RT	COMP-FOP
DPS-COM-FOP-BC01H	DP Backup Computer BC01 Fails Off (Extreme Weather)	1.58E-04	3		3.96E-05	4	LogNormal	8	DPS-COM-FOP	COMP-FOP

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
DPS-COM-FOP-PC01-KI	DP Computer PC01 Fails Off	2.85E-03	3		3.96E-05	72	LogNormal	8	DPS-COM-FOP	COMP-FOP
DPS-COM-FOP-PC01-RT	DP Computer PC01 Fails Off	2.89E-04	3		3.96E-05	7.3	LogNormal	8	DPS-COM-FOP-RT	COMP-FOP
DPS-COM-FOP-PC01H	DP Computer PC01 Fails Off (Extreme Weather)	1.58E-04	3		3.96E-05	4	LogNormal	8	DPS-COM-FOP	COMP-FOP
DPS-COM-FOP-PC02-KI	DP Computer PC02 Fails Off	2.85E-03	3		3.96E-05	72	LogNormal	8	DPS-COM-FOP	COMP-FOP
DPS-COM-FOP-PC02-RT	DP Computer PC02 Fails Off	2.89E-04	3		3.96E-05	7.3	LogNormal	8	DPS-COM-FOP-RT	COMP-FOP
DPS-COM-FOP-PC02H	DP Computer PC02 Fails Off (Extreme Weather)	1.58E-04	3		3.96E-05	4	LogNormal	8	DPS-COM-FOP	COMP-FOP
DPS-COM-FOP-PC03-KI	DP Computer PC03 Fails Off	2.85E-03	3		3.96E-05	72	LogNormal	8	DPS-COM-FOP	COMP-FOP
DPS-COM-FOP-PC03-RT	DP Computer PC03 Fails Off	2.89E-04	3		3.96E-05	7.3	LogNormal	8	DPS-COM-FOP-RT	COMP-FOP
DPS-COM-FOP-PC03H	DP Computer PC03 Fails Off (Extreme Weather)	1.58E-04	3		3.96E-05	4	LogNormal	8	DPS-COM-FOP	COMP-FOP
DPS-FRQ-WEA-HURR	Probability of Extreme Weather	2.60E-03	3		3.62E-05	72	LogNormal	1.5	DPS-WEA-HURR	WEA-HURR
DPS-FRQ-WEA-SQUA	Probability of a Squall	1.02E-01	3		1.50E-03	72	LogNormal	2.5	DPS-WEA-SQUA	WEA-SQUA
DPS-FRQ-WEA-WINT	Probability of Winter Storm	2.36E-02	3		3.31E-04	72	LogNormal	3.93	DPS-WEA-WINT	WEA-WINT
DPS-GPS-DEG-01	Differential GPS 1 Fails Degraded	6.81E-04	3		9.46E-06	72	LogNormal	9.9	DPS-GPS-DEG	GPS-DEG
DPS-GPS-DEG-02	Differential GPS 2 Fails Degraded	6.81E-04	3		9.46E-06	72	LogNormal	9.9	DPS-GPS-DEG	GPS-DEG
DPS-GPS-FOP-01-KI	Differential GPS 1 Fails Off	1.40E-03	3		1.95E-05	72	LogNormal	9.25	DPS-GPS-FOP	GPS-FOP
DPS-GPS-FOP-01-RT	Differential GPS 1 Fails Off	1.42E-04	3		1.95E-05	7.3	LogNormal	9.25	DPS-GPS-FOP-RT	GPS-FOP
DPS-GPS-FOP-01H	Differential GPS 1 Fails Off (Extreme Weather)	7.80E-05	3		1.95E-05	4	LogNormal	9.25	DPS-GPS-FOP	GPS-FOP
DPS-GPS-FOP-02-KI	Differential GPS 2 Fails Off	1.40E-03	3		1.95E-05	72	LogNormal	9.25	DPS-GPS-FOP	GPS-FOP
DPS-GPS-FOP-02-RT	Differential GPS 2 Fails Off	1.42E-04	3		1.95E-05	7.3	LogNormal	9.25	DPS-GPS-FOP-RT	GPS-FOP
DPS-GPS-FOP-02H	Differential GPS 2 Fails Off (Extreme Weather)	7.80E-05	3		1.95E-05	4	LogNormal	9.25	DPS-GPS-FOP	GPS-FOP
DPS-GYC-FOP-01-KI	Gyro Compass Sensor 1 Fails Off	1.27E-03	3		1.76E-05	72	LogNormal	4.99	DPS-GYC-FOP	GYRO-FOP
DPS-GYC-FOP-01-RT	Gyro Compass Sensor 1 Fails Off	1.29E-04	3		1.76E-05	7.3	LogNormal	4.99	DPS-GYC-FOP-RT	GYRO-FOP
DPS-GYC-FOP-01H	Gyro Compass Sensor 1 Fails Off (Extreme Weather)	7.04E-05	3		1.76E-05	4	LogNormal	4.99	DPS-GYC-FOP	GYRO-FOP
DPS-GYC-FOP-02-KI	Gyro Compass Sensor 2 Fails Off	1.27E-03	3		1.76E-05	72	LogNormal	4.99	DPS-GYC-FOP	GYRO-FOP
DPS-GYC-FOP-02-RT	Gyro Compass Sensor 2 Fails Off	1.29E-04	3		1.76E-05	7.3	LogNormal	4.99	DPS-GYC-FOP-RT	GYRO-FOP
DPS-GYC-FOP-02H	Gyro Compass Sensor 2 Fails Off (Extreme Weather)	7.04E-05	3		1.76E-05	4	LogNormal	4.99	DPS-GYC-FOP	GYRO-FOP
DPS-GYC-FOP-03-KI	Gyro Compass Sensor 3 Fails Off	1.27E-03	3		1.76E-05	72	LogNormal	4.99	DPS-GYC-FOP	GYRO-FOP
DPS-GYC-FOP-03-RT	Gyro Compass Sensor 3 Fails Off	1.29E-04	3		1.76E-05	7.3	LogNormal	4.99	DPS-GYC-FOP-RT	GYRO-FOP
DPS-GYC-FOP-03H	Gyro Compass Sensor 3 Fails Off (Extreme Weather)	7.04E-05	3		1.76E-05	4	LogNormal	4.99	DPS-GYC-FOP	GYRO-FOP
DPS-HYS-DEG-01	Hydroacoustic Position Reference Sensor 1 Fails Degraded	3.38E-03	3		4.70E-05	72	LogNormal	9.61	DPS-HYS-DEG	ACOU_DEG

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
DPS-HYS-DEG-02	Hydroacoustic Position Reference Sensor 2 Fails Degraded	3.38E-03	3		4.70E-05	72	LogNormal	9.61	DPS-HYS-DEG	ACOU_DEG
DPS-HYS-FOP-01-KI	Hydroacoustic Position Reference Sensor 1 Fails Off	5.62E-03	3		7.83E-05	72	LogNormal	8.76	DPS-HYS-FOP	ACOU-FOP
DPS-HYS-FOP-01-RT	Hydroacoustic Position Reference Sensor 1 Fails Off	5.71E-04	3		7.83E-05	7.3	LogNormal	8.76	DPS-HYS-FOP-RT	ACOU-FOP
DPS-HYS-FOP-01H	Hydroacoustic Position Reference Sensor 1 Fails Off (Extreme Weather)	3.13E-04	3		7.83E-05	4	LogNormal	8.76	DPS-HYS-FOP	ACOU-FOP
DPS-HYS-FOP-02-KI	Hydroacoustic Position Reference Sensor 2 Fails Off	5.62E-03	3		7.83E-05	72	LogNormal	8.76	DPS-HYS-FOP	ACOU-FOP
DPS-HYS-FOP-02-RT	Hydroacoustic Position Reference Sensor 2 Fails Off	5.71E-04	3		7.83E-05	7.3	LogNormal	8.76	DPS-HYS-FOP-RT	ACOU-FOP
DPS-HYS-FOP-02H	Hydroacoustic Position Reference Sensor 2 Fails Off (Extreme Weather)	3.13E-04	3		7.83E-05	4	LogNormal	8.76	DPS-HYS-FOP	ACOU-FOP
DPS-THR-FTR-AT04	Aft Thruster 4 Fails to Run	1.75E-03	3		2.43E-05	72	LogNormal	13	DPS-THR-FTR	THR-FTR
DPS-THR-FTR-AT04H	Aft Thruster 4 Fails to Run (Extreme Weather)	9.72E-05	3		2.43E-05	4	LogNormal	13	DPS-THR-FTR	THR-FTR
DPS-THR-FTR-AT05	Aft Thruster 5 Fails to Run	1.75E-03	3		2.43E-05	72	LogNormal	13	DPS-THR-FTR	THR-FTR
DPS-THR-FTR-AT05H	Aft Thruster 5 Fails to Run (Extreme Weather)	9.72E-05	3		2.43E-05	4	LogNormal	13	DPS-THR-FTR	THR-FTR
DPS-THR-FTR-AT06	Aft Thruster 6 Fails to Run	1.75E-03	3		2.43E-05	72	LogNormal	13	DPS-THR-FTR	THR-FTR
DPS-THR-FTR-AT06H	Aft Thruster 6 Fails to Run (Extreme Weather)	9.72E-05	3		2.43E-05	4	LogNormal	13	DPS-THR-FTR	THR-FTR
DPS-THR-FTR-FT01	Forward Thruster 1 Fails to Run	1.75E-03	3		2.43E-05	72	LogNormal	13	DPS-THR-FTR	THR-FTR
DPS-THR-FTR-FT01H	Forward Thruster 1 Fails to Run (Extreme Weather)	9.72E-05	3		2.43E-05	4	LogNormal	13	DPS-THR-FTR	THR-FTR
DPS-THR-FTR-FT02	Forward Thruster 2 Fails to Run	1.75E-03	3		2.43E-05	72	LogNormal	13	DPS-THR-FTR	THR-FTR
DPS-THR-FTR-FT02H	Forward Thruster 2 Fails to Run (Extreme Weather)	9.72E-05	3		2.43E-05	4	LogNormal	13	DPS-THR-FTR	THR-FTR
DPS-THR-FTR-FT03	Forward Thruster 3 Fails to Run	1.75E-03	3		2.43E-05	72	LogNormal	13	DPS-THR-FTR	THR-FTR
DPS-THR-FTR-FT03H	Forward Thruster 3 Fails to Run (Extreme Weather)	9.72E-05	3		2.43E-05	4	LogNormal	13	DPS-THR-FTR	THR-FTR
DPS-VRS-FOP-01-KI	Vertical Reference Sensor 1 Fails Off	1.79E-03	3		2.49E-05	72	LogNormal	12.8	DPS-VRS-FOP	MOTSENS-FOP
DPS-VRS-FOP-01-RT	Vertical Reference Sensor 1 Fails Off	1.82E-04	3		2.49E-05	7.3	LogNormal	12.8	DPS-VRS-FOP-RT	MOTSENS-FOP
DPS-VRS-FOP-01H	Vertical Reference Sensor 1 Fails Off (Extreme Weather)	9.96E-05	3		2.49E-05	4	LogNormal	12.8	DPS-VRS-FOP	MOTSENS-FOP
DPS-VRS-FOP-02-KI	Vertical Reference Sensor 2 Fails Off	1.79E-03	3		2.49E-05	72	LogNormal	12.8	DPS-VRS-FOP	MOTSENS-FOP
DPS-VRS-FOP-02-RT	Vertical Reference Sensor 2 Fails Off	1.82E-04	3		2.49E-05	7.3	LogNormal	12.8	DPS-VRS-FOP-RT	MOTSENS-FOP

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
DPS-VRS-FOP-02H	Vertical Reference Sensor 2 Fails Off (Extreme Weather)	9.96E-05	3		2.49E-05	4	LogNormal	12.8	DPS-VRS-FOP	MOTSENS-FOP
DPS-VRS-FOP-03-KI	Vertical Reference Sensor 3 Fails Off	1.79E-03	3		2.49E-05	72	LogNormal	12.8	DPS-VRS-FOP	MOTSENS-FOP
DPS-VRS-FOP-03-RT	Vertical Reference Sensor 3 Fails Off	1.82E-04	3		2.49E-05	7.3	LogNormal	12.8	DPS-VRS-FOP-RT	MOTSENS-FOP
DPS-VRS-FOP-03H	Vertical Reference Sensor 3 Fails Off (Extreme Weather)	9.96E-05	3		2.49E-05	4	LogNormal	12.8	DPS-VRS-FOP	MOTSENS-FOP
DPS-WIS-DEG-01	Wind Sensor 1 Fails Degraded	1.55E-03	3		2.15E-05	72	LogNormal	7.38	DPS-WIS-DEG	WINDSENS-DEG
DPS-WIS-DEG-02	Wind Sensor 2 Fails Degraded	1.55E-03	3		2.15E-05	72	LogNormal	7.38	DPS-WIS-DEG	WINDSENS-DEG
DPS-WIS-DEG-03	Wind Sensor 3 Fails Degraded	1.55E-03	3		2.15E-05	72	LogNormal	7.38	DPS-WIS-DEG	WINDSENS-DEG
DPS-WIS-FOP-01H	Wind Sensor 1 Fails Off (Extreme Weather)	4.28E-05	3		1.07E-05	4	LogNormal	9.28	DPS-WIS-FOP-H	WINDSENS-FOF
DPS-WIS-FOP-02H	Wind Sensor 2 Fails Off (Extreme Weather)	4.28E-05	3		1.07E-05	4	LogNormal	9.28	DPS-WIS-FOP-H	WINDSENS-FOF
DPS-WIS-FOP-03H	Wind Sensor 3 Fails Off (Extreme Weather)	4.28E-05	3		1.07E-05	4	LogNormal	9.28	DPS-WIS-FOP-H	WINDSENS-FOF
ELS-CCU-FOF-SE01	Central control unit fails off	2.85E-03	3		3.96E-05	72	LogNormal	8	ELS-CCU-FOF	COMP-FOF
ELS-CCU-FOF-SE12	Central control unit fails off	2.85E-03	3		3.96E-05	72	LogNormal	8	ELS-CCU-FOF	COMP-FOF
ELS-CTL-FOF-SE02	Control panel 1 fails off	1.24E-03	3		1.72E-05	72	LogNormal	15.2	ELS-CTL-FOF	CTRLPNL-FOP
ELS-CTL-FOF-SE03	Control panel 2 fails off	1.24E-03	3		1.72E-05	72	LogNormal	15.2	ELS-CTL-FOF	CTRLPNL-FOP
ELS-CTL-FOF-SE13	Control panel 1 fails off	1.24E-03	3		1.72E-05	72	LogNormal	15.2	ELS-CTL-FOF	CTRLPNL-FOP
ELS-CTL-FOF-SE14	Control panel 2 fails off	1.24E-03	3		1.72E-05	72	LogNormal	15.2	ELS-CTL-FOF	CTRLPNL-FOP
ELS-JBX-FOF-SE07	Junction box fails to operate	4.65E-04	3		6.46E-06	72	LogNormal	9.2	ELS-JBX-FOF	SWB-FOP
ELS-JBX-FOF-SE18	Junction box fails to operate	4.65E-04	3		6.46E-06	72	LogNormal	9.2	ELS-JBX-FOF	SWB-FOP
ELS-PDP-FOF-SE04	Power distribution panel fails off	1.17E-04	3		1.62E-06	72	LogNormal	7.56	ELS-PDP-FOF	ELECBUS-FOP
ELS-PDP-FOF-SE15	Power distribution panel fails off	1.17E-04	3		1.62E-06	72	LogNormal	7.56	ELS-PDP-FOF	ELECBUS-FOP
ELS-TRF-FOF-SE11	Subsea transformer fails to operate	5.18E-04	3		7.20E-06	72	LogNormal	6.05	ELS-TRF-FOF	TRF-FOF
ELS-TRF-FOF-SE22	Subsea transformer fails to operate	5.18E-04	3		7.20E-06	72	LogNormal	6.05	ELS-TRF-FOF	TRF-FOF
ELS-UMB-FOF-SE09	Umbilical breaks or is sheared and fails to provide electrical signal subsea	1.78E-04	3		2.47E-06	72	LogNormal	17.6	ELS-UMB-FOF	UMB-FOF
ELS-UMB-FOF-SE20	Umbilical breaks or is sheared and fails to provide electrical signal subsea	1.78E-04	3		2.47E-06	72	LogNormal	17.6	ELS-UMB-FOF	UMB-FOF
ELS-UPS-FOF-SE06	UPS SE06 fails to operate	1.02E-03	3		1.41E-05	72	LogNormal	9.9	ELS-UPS-FOF	UPS-FOF
ELS-UPS-FOF-SE17	UPS SE17 fails to operate	1.02E-03	3		1.41E-05	72	LogNormal	9.9	ELS-UPS-FOF	UPS-FOF
EME-ESD-SPO-001	Emergency Shutdown System 1 Spuriously Causes Loss of Power (Starboard Group)	3.53E-03	3		4.91E-05	72	LogNormal	8	EME-ESD-SPO	COMP-SPO

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
EME-ESD-SPO-001SH	Emergency Shutdown System 1 Spuriously Causes Loss of Power (Extreme Weather)	1.96E-04	3		4.91E-05	4	LogNormal	8	EME-ESD-SPO-H	COMP-SPO
EME-ESD-SPO-002	Emergency Shutdown System 2 Spuriously Causes Loss of Power (Center Group)	3.53E-03	3		4.91E-05	72	LogNormal	8	EME-ESD-SPO	COMP-SPO
EME-ESD-SPO-002SH	Emergency Shutdown System 2 Spuriously Causes Loss of Power (Extreme Weather)	1.96E-04	3		4.91E-05	4	LogNormal	8	EME-ESD-SPO-H	COMP-SPO
EME-ESD-SPO-003	Emergency Shutdown System 3 Spuriously Causes Loss of Power (Port Group)	3.53E-03	3		4.91E-05	72	LogNormal	8	EME-ESD-SPO	COMP-SPO
EME-ESD-SPO-003SH	Emergency Shutdown System 3 Spuriously Causes Loss of Power (Extreme Weather)	1.96E-04	3		4.91E-05	4	LogNormal	8	EME-ESD-SPO-H	COMP-SPO
EPS-BUS-FOP-CB02	Center Electrical Bus Fails to Operate	1.17E-04	3		1.62E-06	72	LogNormal	7.56	EPS-BUS-FOP	ELECBUS-FOP
EPS-BUS-FOP-CB02H	Center Electrical Bus Fails to Operate (Extreme Weather)	6.48E-06	3		1.62E-06	4	LogNormal	7.56	EPS-BUS-FOP-H	ELECBUS-FOP
EPS-BUS-FOP-PB03	Port Electrical Bus Fails to Operate	1.17E-04	3		1.62E-06	72	LogNormal	7.56	EPS-BUS-FOP	ELECBUS-FOP
EPS-BUS-FOP-PB03H	Port Electrical Bus Fails to Operate (Extreme Weather)	6.48E-06	3		1.62E-06	4	LogNormal	7.56	EPS-BUS-FOP-H	ELECBUS-FOP
EPS-BUS-FOP-SB01	Starboard Electrical Bus Fails to Operate	1.17E-04	3		1.62E-06	72	LogNormal	7.56	EPS-BUS-FOP	ELECBUS-FOP
EPS-BUS-FOP-SB01H	Starboard Electrical Bus Fails to Operate (Extreme Weather)	6.48E-06	3		1.62E-06	4	LogNormal	7.56	EPS-BUS-FOP-H	ELECBUS-FOP
EPS-DGN-FTR-C03	Diesel Generator 3 Fails to Run	4.02E-03	3		5.59E-05	72	LogNormal	7.39	EPS-DGN-FTR	DGN-FTR
EPS-DGN-FTR-C03H	Diesel Generator 3 Fails to Run (Extreme Weather)	2.24E-04	3		5.59E-05	4	LogNormal	7.39	EPS-DGN-FTR-H	DGN-FTR
EPS-DGN-FTR-C04	Diesel Generator 4 Fails to Run	4.02E-03	3		5.59E-05	72	LogNormal	7.39	EPS-DGN-FTR	DGN-FTR
EPS-DGN-FTR-C04H	Diesel Generator 4 Fails to Run (Extreme Weather)	2.24E-04	3		5.59E-05	4	LogNormal	7.39	EPS-DGN-FTR-H	DGN-FTR
EPS-DGN-FTR-P05	Diesel Generator 5 Fails to Run	4.02E-03	3		5.59E-05	72	LogNormal	7.39	EPS-DGN-FTR	DGN-FTR
EPS-DGN-FTR-P05H	Diesel Generator 5 Fails to Run (Extreme Weather)	2.24E-04	3		5.59E-05	4	LogNormal	7.39	EPS-DGN-FTR-H	DGN-FTR
EPS-DGN-FTR-P06	Diesel Generator 6 Fails to Run	4.02E-03	3		5.59E-05	72	LogNormal	7.39	EPS-DGN-FTR	DGN-FTR
EPS-DGN-FTR-P06H	Diesel Generator 6 Fails to Run (Extreme Weather)	2.24E-04	3		5.59E-05	4	LogNormal	7.39	EPS-DGN-FTR-H	DGN-FTR
EPS-DGN-FTR-S01	Diesel Generator 1 Fails to Run	4.02E-03	3		5.59E-05	72	LogNormal	7.39	EPS-DGN-FTR	DGN-FTR
EPS-DGN-FTR-S01H	Diesel Generator 1 Fails to Run (Extreme Weather)	2.24E-04	3		5.59E-05	4	LogNormal	7.39	EPS-DGN-FTR-H	DGN-FTR
EPS-DGN-FTR-S02	Diesel Generator 2 Fails to Run	4.02E-03	3		5.59E-05	72	LogNormal	7.39	EPS-DGN-FTR	DGN-FTR
EPS-DGN-FTR-S02H	Diesel Generator 2 Fails to Run (Extreme Weather)	2.24E-04	3		5.59E-05	4	LogNormal	7.39	EPS-DGN-FTR-H	DGN-FTR

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
EPS-SWB-FOP-CS02	Center Switchboard Fails to Operate	4.65E-04	3		6.46E-06	72	LogNormal	9.2	EPS-SWB-FOP	SWB-FOP
EPS-SWB-FOP-CS02H	Center Switchboard Fails to Operate (Extreme Weather)	2.58E-05	3		6.46E-06	4	LogNormal	9.2	EPS-SWB-FOP-H	SWB-FOP
EPS-SWB-FOP-PS03	Port Switchboard Fails to Operate	4.65E-04	3		6.46E-06	72	LogNormal	9.2	EPS-SWB-FOP	SWB-FOP
EPS-SWB-FOP-PS03H	Port Switchboard Fails to Operate (Extreme Weather)	2.58E-05	3		6.46E-06	4	LogNormal	9.2	EPS-SWB-FOP-H	SWB-FOP
EPS-SWB-FOP-SS01	Starboard Switchboard Fails to Operate	4.65E-04	3		6.46E-06	72	LogNormal	9.2	EPS-SWB-FOP	SWB-FOP
EPS-SWB-FOP-SS01H	Starboard Switchboard Fails to Operate (Extreme Weather)	6.48E-06	3		1.62E-06	4	LogNormal	7.56	EPS-BUS-FOP-H	ELECBUS-FOP
FSY-FLT-PLG-CFS1	Center Fuel System Filter 1 Fails Clogged	2.47E-05	3		3.43E-07	72	LogNormal	9.51	FSY-FLT-PLG	FLT-PLG
FSY-FLT-PLG-CFS1H	Center Fuel System Filter 1 Fails Clogged (Extreme Weather)	1.37E-06	3		3.43E-07	4	LogNormal	9.51	FSY-FLT-PLG-H	FLT-PLG
FSY-FLT-PLG-CFS2	Center Fuel System Filter 2 Fails Clogged	2.47E-05	3		3.43E-07	72	LogNormal	9.51	FSY-FLT-PLG	FLT-PLG
FSY-FLT-PLG-CFS2H	Center Fuel System Filter 2 Fails Clogged (Extreme Weather)	1.37E-06	3		3.43E-07	4	LogNormal	9.51	FSY-FLT-PLG-H	FLT-PLG
FSY-FLT-PLG-CFS3	Center Fuel System Filter 3 Fails Clogged	2.47E-05	3		3.43E-07	72	LogNormal	9.51	FSY-FLT-PLG	FLT-PLG
FSY-FLT-PLG-CFS3H	Center Fuel System Filter 3 Fails Clogged (Extreme Weather)	1.37E-06	3		3.43E-07	4	LogNormal	9.51	FSY-FLT-PLG-H	FLT-PLG
FSY-FLT-PLG-CFS4	Center Fuel System Filter 4 Fails Clogged	2.47E-05	3		3.43E-07	72	LogNormal	9.51	FSY-FLT-PLG	FLT-PLG
FSY-FLT-PLG-CFS4H	Center Fuel System Filter 4 Fails Clogged (Extreme Weather)	1.37E-06	3		3.43E-07	4	LogNormal	9.51	FSY-FLT-PLG-H	FLT-PLG
FSY-FLT-PLG-PFS1	Port Fuel System Filter 1 Fails Clogged	2.47E-05	3		3.43E-07	72	LogNormal	9.51	FSY-FLT-PLG	FLT-PLG
FSY-FLT-PLG-PFS1H	Port Fuel System Filter 1 Fails Clogged (Extreme Weather)	1.37E-06	3		3.43E-07	4	LogNormal	9.51	FSY-FLT-PLG-H	FLT-PLG
FSY-FLT-PLG-PFS2	Port Fuel System Filter 2 Fails Clogged	2.47E-05	3		3.43E-07	72	LogNormal	9.51	FSY-FLT-PLG	FLT-PLG
FSY-FLT-PLG-PFS2H	Port Fuel System Filter 2 Fails Clogged (Extreme Weather)	1.37E-06	3		3.43E-07	4	LogNormal	9.51	FSY-FLT-PLG-H	FLT-PLG
FSY-FLT-PLG-PFS3	Port Fuel System Filter 3 Fails Clogged	2.47E-05	3		3.43E-07	72	LogNormal	9.51	FSY-FLT-PLG	FLT-PLG
FSY-FLT-PLG-PFS3H	Port Fuel System Filter 3 Fails Clogged (Extreme Weather)	1.37E-06	3		3.43E-07	4	LogNormal	9.51	FSY-FLT-PLG-H	FLT-PLG
FSY-FLT-PLG-PFS4	Port Fuel System Filter 4 Fails Clogged	2.47E-05	3		3.43E-07	72	LogNormal	9.51	FSY-FLT-PLG	FLT-PLG
FSY-FLT-PLG-PFS4H	Port Fuel System Filter 4 Fails Clogged (Extreme Weather)	1.37E-06	3		3.43E-07	4	LogNormal	9.51	FSY-FLT-PLG-H	FLT-PLG
FSY-FLT-PLG-SFS1	Starboard Fuel System Filter 1 Fails Clogged	2.47E-05	3		3.43E-07	72	LogNormal	9.51	FSY-FLT-PLG	FLT-PLG
FSY-FLT-PLG-SFS1H	Starboard Fuel System Filter 1 Fails Clogged (Extreme Weather)	1.37E-06	3		3.43E-07	4	LogNormal	9.51	FSY-FLT-PLG-H	FLT-PLG
FSY-FLT-PLG-SFS2	Starboard Fuel System Filter 2 Fails Clogged	2.47E-05	3		3.43E-07	72	LogNormal	9.51	FSY-FLT-PLG	FLT-PLG

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
FSY-FLT-PLG-SFS2H	Starboard Fuel System Filter 2 Fails Clogged (Extreme Weather)	1.37E-06	3		3.43E-07	4	LogNormal	9.51	FSY-FLT-PLG-H	FLT-PLG
FSY-FLT-PLG-SFS3	Starboard Fuel System Filter 3 Fails Clogged	2.47E-05	3		3.43E-07	72	LogNormal	9.51	FSY-FLT-PLG	FLT-PLG
FSY-FLT-PLG-SFS3H	Starboard Fuel System Filter 3 Fails Clogged (Extreme Weather)	1.37E-06	3		3.43E-07	4	LogNormal	9.51	FSY-FLT-PLG-H	FLT-PLG
FSY-FLT-PLG-SFS4	Starboard Fuel System Filter 4 Fails Clogged	2.47E-05	3		3.43E-07	72	LogNormal	9.51	FSY-FLT-PLG	FLT-PLG
FSY-FLT-PLG-SFS4H	Starboard Fuel System Filter 4 Fails Clogged (Extreme Weather)	1.37E-06	3		3.43E-07	4	LogNormal	9.51	FSY-FLT-PLG-H	FLT-PLG
FSY-HEX-PLG-CFS0	Center Fuel System Fuel Cooler Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FSY-HEX-PLG	HEATEXCH-PLG
FSY-HEX-PLG-CFS0H	Center Fuel System Fuel Cooler Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FSY-HEX-PLG-H	HEATEXCH-PLG
FSY-HEX-PLG-PFS0	Port Fuel System Fuel Cooler Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FSY-HEX-PLG	HEATEXCH-PLG
FSY-HEX-PLG-PFS0H	Port Fuel System Fuel Cooler Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FSY-HEX-PLG-H	HEATEXCH-PLG
FSY-HEX-PLG-SFS0	Starboard Fuel System Fuel Cooler Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FSY-HEX-PLG	HEATEXCH-PLG
FSY-HEX-PLG-SFS0H	Starboard Fuel System Fuel Cooler Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FSY-HEX-PLG-H	HEATEXCH-PLG
FSY-PMP-FTR-CFS1	Center Electrically Driven Fuel Supply Pump #1 Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	FSY-PMP-FTR	ELECPMP-FTR
FSY-PMP-FTR-CFS1H	Center Electrically Driven Fuel Supply Pump #1 Fails to Run (Extreme Weather)	1.35E-04	3		3.37E-05	4	LogNormal	9.12	FSY-PMP-FTR-H	ELECPMP-FTR
FSY-PMP-FTR-CFS2	Center Electrically Driven Fuel Supply Pump #2 Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	FSY-PMP-FTR	ELECPMP-FTR
FSY-PMP-FTR-CFS2H	Center Electrically Driven Fuel Supply Pump #2 Fails to Run (Extreme Weather)	1.35E-04	3		3.37E-05	4	LogNormal	9.12	FSY-PMP-FTR-H	ELECPMP-FTR
FSY-PMP-FTR-PFS1	Port Electrically Driven Fuel Supply Pump #1 Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	FSY-PMP-FTR	ELECPMP-FTR
FSY-PMP-FTR-PFS1H	Port Electrically Driven Fuel Supply Pump #1 Fails to Run (Extreme Weather)	1.35E-04	3		3.37E-05	4	LogNormal	9.12	FSY-PMP-FTR-H	ELECPMP-FTR
FSY-PMP-FTR-PFS2	Port Electrically Driven Fuel Supply Pump #2 Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	FSY-PMP-FTR	ELECPMP-FTR
FSY-PMP-FTR-PFS2H	Port Electrically Driven Fuel Supply Pump #2 Fails to Run (Extreme Weather)	1.35E-04	3		3.37E-05	4	LogNormal	9.12	FSY-PMP-FTR-H	ELECPMP-FTR

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
FSY-PMP-FTR-SFS1	Starboard Electrically Driven Fuel Supply Pump #1 Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	FSY-PMP-FTR	ELECPMP-FTR
FSY-PMP-FTR-SFS1H	Starboard Electrically Driven Fuel Supply Pump #1 Fails to Run (Extreme Weather)	1.35E-04	3		3.37E-05	4	LogNormal	9.12	FSY-PMP-FTR-H	ELECPMP-FTR
FSY-PMP-FTR-SFS2	Starboard Electrically Driven Fuel Supply Pump #2 Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	FSY-PMP-FTR	ELECPMP-FTR
FWC-AOV-FOP-AC09	Temperature Regulating Valve (Generator 3 Cooling System) Fails to Regulate	1.36E-05	3		1.89E-07	72	LogNormal	5.57	FWC-AOV-FOP	TEMPREGVLV-FOP
FWC-AOV-FOP-AC09H	Temperature Regulating Valve (Generator 3 Cooling System) Fails to Regulate (Extreme Weather)	7.56E-07	3		1.89E-07	4	LogNormal	5.57	FWC-AOV-FOP-H	TEMPREGVLV-FOP
FWC-AOV-FOP-AC25	Temperature Regulating Valve (Generator 4 Cooling System) Fails to Regulate	1.36E-05	3		1.89E-07	72	LogNormal	5.57	FWC-AOV-FOP	TEMPREGVLV-FOP
FWC-AOV-FOP-AC25H	Temperature Regulating Valve (Generator 4 Cooling System) Fails to Regulate (Extreme Weather)	7.56E-07	3		1.89E-07	4	LogNormal	5.57	FWC-AOV-FOP-H	TEMPREGVLV-FOP
FWC-AOV-FOP-AC42	Temperature Regulating Valve (Thruster 6 Cooling System) Fails to Regulate	1.36E-05	3		1.89E-07	72	LogNormal	5.57	FWC-AOV-FOP	TEMPREGVLV-FOP
FWC-AOV-FOP-AC42H	Temperature Regulating Valve (Thruster 6 Cooling System) Fails to Regulate (Extreme Weather)	7.56E-07	3		1.89E-07	4	LogNormal	5.57	FWC-AOV-FOP-H	TEMPREGVLV-FOP
FWC-AOV-FOP-AP09	Temperature Regulating Valve (Generator 5 Cooling System) Fails to Regulate (Extreme Weather)	1.36E-05	3		1.89E-07	72	LogNormal	5.57	FWC-AOV-FOP	TEMPREGVLV-FOP
FWC-AOV-FOP-AP09H	Temperature Regulating Valve (Generator 5 Cooling System) Fails to Regulate	7.56E-07	3		1.89E-07	4	LogNormal	5.57	FWC-AOV-FOP-H	TEMPREGVLV-FOP
FWC-AOV-FOP-AP25	Temperature Regulating Valve (Generator 6 Cooling System) Fails to Regulate	1.36E-05	3		1.89E-07	72	LogNormal	5.57	FWC-AOV-FOP	TEMPREGVLV-FOP
FWC-AOV-FOP-AP25H	Temperature Regulating Valve (Generator 6 Cooling System) Fails to Regulate (Extreme Weather)	7.56E-07	3		1.89E-07	4	LogNormal	5.57	FWC-AOV-FOP-H	TEMPREGVLV-FOP
FWC-AOV-FOP-AP42	Temperature Regulating Valve (Thruster 5 Cooling System) Fails to Regulate	1.36E-05	3		1.89E-07	72	LogNormal	5.57	FWC-AOV-FOP	TEMPREGVLV-FOP
FWC-AOV-FOP-AP42H	Temperature Regulating Valve (Thruster 5 Cooling System) Fails to Regulate (Extreme Weather)	7.56E-07	3		1.89E-07	4	LogNormal	5.57	FWC-AOV-FOP-H	TEMPREGVLV-FOP
FWC-AOV-FOP-AS09	Temperature Regulating Valve (Generator 1 Cooling System) Fails to Regulate	1.36E-05	3		1.89E-07	72	LogNormal	5.57	FWC-AOV-FOP	TEMPREGVLV-FOP
FWC-AOV-FOP-AS09H	Temperature Regulating Valve (Generator 1 Cooling System) Fails to Regulate (Extreme Weather)	7.56E-07	3		1.89E-07	4	LogNormal	5.57	FWC-AOV-FOP-H	TEMPREGVLV-FOP
FWC-AOV-FOP-AS25	Temperature Regulating Valve (Generator 2 Cooling System) Fails to Regulate	1.36E-05	3		1.89E-07	72	LogNormal	5.57	FWC-AOV-FOP	TEMPREGVLV-FOP
FWC-AOV-FOP-AS25H	Temperature Regulating Valve (Generator 2 Cooling System) Fails to Regulate (Extreme Weather)	7.56E-07	3		1.89E-07	4	LogNormal	5.57	FWC-AOV-FOP-H	TEMPREGVLV-FOP
FWC-AOV-FOP-AS42	Temperature Regulating Valve (Thruster 4 Cooling System) Fails to Regulate	1.36E-05	3		1.89E-07	72	LogNormal	5.57	FWC-AOV-FOP	TEMPREGVLV-FOP
FWC-AOV-FOP-AS42H	Temperature Regulating Valve (Thruster 4 Cooling System) Fails to Regulate (Extreme Weather)	7.56E-07	3		1.89E-07	4	LogNormal	5.57	FWC-AOV-FOP-H	TEMPREGVLV-FOP

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
FWC-AOV-FOP-FC08	Temperature Regulating Valve (Thruster 1 Cooling System) Fails to Regulate	1.36E-05	3		1.89E-07	72	LogNormal	5.57	FWC-AOV-FOP	TEMPREGVLV-FOP
FWC-AOV-FOP-FC08H	Temperature Regulating Valve (Thruster 1 Cooling System) Fails to Regulate (Extreme Weather)	7.56E-07	3		1.89E-07	4	LogNormal	5.57	FWC-AOV-FOP-H	TEMPREGVLV-FOP
FWC-AOV-FOP-FP08	Temperature Regulating Valve (Thruster 3 Cooling System) Fails to Regulate	1.36E-05	3		1.89E-07	72	LogNormal	5.57	FWC-AOV-FOP	TEMPREGVLV-FOP
FWC-AOV-FOP-FP08H	Temperature Regulating Valve (Thruster 3 Cooling System) Fails to Regulate (Extreme Weather)	7.56E-07	3		1.89E-07	4	LogNormal	5.57	FWC-AOV-FOP-H	TEMPREGVLV-FOP
FWC-AOV-FOP-FS08	Temperature Regulating Valve (Thruster 2 Cooling System) Fails to Regulate	1.36E-05	3		1.89E-07	72	LogNormal	5.57	FWC-AOV-FOP	TEMPREGVLV-FOP
FWC-AOV-FOP-FS08H	Temperature Regulating Valve (Thruster 2 Cooling System) Fails to Regulate (Extreme Weather)	7.56E-07	3		1.89E-07	4	LogNormal	5.57	FWC-AOV-FOP-H	TEMPREGVLV-FOP
FWC-HEX-PLG-AC06	Aft Center Freshwater Cooler Leaks or Plugs/Clogs (Gens. 3&4)	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AC06H	Aft Center Freshwater Cooler Leaks or Plugs/Clogs (Gens. 3&4) (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AC07	Aft Center Freshwater Cooler Leaks or Plugs/Clogs (Thruster 6)	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AC07H	Aft Center Freshwater Cooler Leaks or Plugs/Clogs (Thruster 6) (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AC16	Diesel 3 Low Temp. Air Cooler Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AC16H	Diesel 3 Low Temp. Air Cooler Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AC17	Diesel 3 Lube Oil Cooler Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AC17H	Diesel 3 Lube Oil Cooler Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AC21	Diesel 3 High Temp. Air Cooler Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AC21H	Diesel 3 High Temp. Air Cooler Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AC22	Generator 3 Lube Oil Cooler Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AC22H	Generator 3 Lube Oil Cooler Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AC23	Generator 3 Air Cooler Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AC23H	Generator 3 Air Cooler Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
FWC-HEX-PLG-AC24	Generator 3 Engine Fuel Oil Cooler Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AC24H	Generator 3 Engine Fuel Oil Cooler Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AC32	Diesel 4 Low Temp. Air Cooler Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AC32H	Diesel 4 Low Temp. Air Cooler Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AC33	Diesel 4 Lube Oil Cooler Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AC33H	Diesel 4 Lube Oil Cooler Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AC37	Diesel 4 High Temp. Air Cooler Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AC37H	Diesel 4 High Temp. Air Cooler Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AC38	Generator 4 Lube Oil Cooler Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AC38H	Generator 4 Lube Oil Cooler Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AC39	Generator 4 Air Cooler Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AC39H	Generator 4 Air Cooler Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AC40	Generator 4 Engine Fuel Oil Cooler Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AC40H	Generator 4 Engine Fuel Oil Cooler Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AC47	Thruster 6 Transformer Cooling Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AC47H	Thruster 6 Transformer Cooling Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AC48	Thruster 6 Diesel Start Air Compressor Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AC48H	Thruster 6 Diesel Start Air Compressor Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AC49	Thruster 6 Variable Frequency Drive Room Air Conditioning Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
FWC-HEX-PLG-AC49H	Thruster 6 Variable Frequency Drive Room Air Conditioning Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AC50	Thruster 6 Variable Frequency Drive Cooling Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AC50H	Thruster 6 Variable Frequency Drive Cooling Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AC51	Thruster 6 Electrical Motor Cooling Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AC51H	Thruster 6 Electrical Motor Cooling Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AC52	Thruster 6 Lube Oil Cooling Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AC52H	Thruster 6 Lube Oil Cooling Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AC53	Thruster 6 Hydraulics Cooling Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AC53H	Thruster 6 Hydraulics Cooling Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AP06	Aft Port Freshwater Cooler Leaks or Plugs/Clogs (Gens. 5&6)	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AP06H	Aft Port Freshwater Cooler Leaks or Plugs/Clogs (Gens. 5&6) (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AP07	Aft Port Freshwater Cooler Leaks or Plugs/Clogs (Thruster 5)	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AP07H	Aft Port Freshwater Cooler Leaks or Plugs/Clogs (Thruster 5) (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AP16	Diesel 5 Low Temp. Air Cooler Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AP16H	Diesel 5 Low Temp. Air Cooler Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AP17	Diesel 5 Lube Oil Cooler Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AP17H	Diesel 5 Lube Oil Cooler Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AP21	Diesel 5 High Temp. Air Cooler Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
FWC-HEX-PLG-AP21H	Diesel 5 High Temp. Air Cooler Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AP22	Generator 5 Lube Oil Cooler Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AP22H	Generator 5 Lube Oil Cooler Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AP23	Generator 5 Air Cooler Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AP23H	Generator 5 Air Cooler Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AP24	Generator 5 Engine Fuel Oil Cooler Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AP24H	Generator 5 Engine Fuel Oil Cooler Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AP32	Diesel 6 Low Temp. Air Cooler Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AP32H	Diesel 6 Low Temp. Air Cooler Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AP33	Diesel 6 Lube Oil Cooler Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AP33H	Diesel 6 Lube Oil Cooler Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AP37	Diesel 6 High Temp. Air Cooler Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AP37H	Diesel 6 High Temp. Air Cooler Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AP38	Generator 6 Lube Oil Cooler Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AP38H	Generator 6 Lube Oil Cooler Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AP39	Generator 6 Air Cooler Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AP39H	Generator 6 Air Cooler Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AP40	Generator 6 Engine Fuel Oil Cooler Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AP40H	Generator 6 Engine Fuel Oil Cooler Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AP47	Thruster 5 Transformer Cooling Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AP47H	Thruster 5 Transformer Cooling Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
FWC-HEX-PLG-AP48	Thruster 5 Diesel Start Air Compressor Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AP48H	Thruster 5 Diesel Start Air Compressor Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AP49	Thruster 5 VFD Room Air Conditioning Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AP49H	Thruster 5 VFD Room Air Conditioning Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AP50	Thruster 5 VFD Cooling Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AP50H	Thruster 5 VFD Cooling Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AP51	Thruster 5 Electrical Motor Cooling Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AP51H	Thruster 5 Electrical Motor Cooling Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AP52	Thruster 5 Lube Oil Cooling Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AP52H	Thruster 5 Lube Oil Cooling Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AP53	Thruster 5 Hydraulics Cooling Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AP53H	Thruster 5 Hydraulics Cooling Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AS06	Aft Starboard Freshwater Cooler Leaks or Plugs/Clogs (Gens. 1&2)	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AS06H	Aft Starboard Freshwater Cooler Leaks or Plugs/Clogs (Gens. 1&2) (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AS07	Aft Starboard Freshwater Cooler Leaks or Plugs/Clogs (Thruster 4)	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AS07H	Aft Starboard Freshwater Cooler Leaks or Plugs/Clogs (Thruster 4) (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AS16	Diesel 1 Low Temp. Air Cooler Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
FWC-HEX-PLG-AS16H	Diesel 1 Low Temp. Air Cooler Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AS17	Diesel 1 Lube Oil Cooler Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AS17H	Diesel 1 Lube Oil Cooler Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AS21	Diesel 1 High Temp. Air Cooler Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AS21H	Diesel 1 High Temp. Air Cooler Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AS22	Generator 1 Lube Oil Cooler Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AS22H	Generator 1 Lube Oil Cooler Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AS23	Generator 1 Air Cooler Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AS23H	Generator 1 Air Cooler Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AS24	Generator 1 Engine Fuel Oil Cooler Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AS24H	Generator 1 Engine Fuel Oil Cooler Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AS32	Diesel 2 Low Temp. Air Cooler Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AS32H	Diesel 2 Low Temp. Air Cooler Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AS33	Diesel 2 Lube Oil Cooler Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AS33H	Diesel 2 Lube Oil Cooler Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AS37	Diesel 2 High Temp. Air Cooler Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AS37H	Diesel 2 High Temp. Air Cooler Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AS38	Generator 2 Lube Oil Cooler Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AS38H	Generator 2 Lube Oil Cooler Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AS39	Generator 2 Air Cooler Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AS39H	Generator 2 Air Cooler Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AS40	Generator 2 Engine Fuel Oil Cooler Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
FWC-HEX-PLG-AS40H	Generator 2 Engine Fuel Oil Cooler Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AS47	Thruster 4 Transformer Cooling Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AS47H	Thruster 4 Transformer Cooling Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AS48	Thruster 4 Diesel Start Air Compressor Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AS48H	Thruster 4 Diesel Start Air Compressor Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AS49	Thruster 4 VFD Room Air Conditioning Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AS49H	Thruster 4 VFD Room Air Conditioning Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AS50	Thruster 4 VFD Cooling Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AS50H	Thruster 4 VFD Cooling Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AS51	Thruster 4 Electrical Motor Cooling Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AS51H	Thruster 4 Electrical Motor Cooling Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AS52	Thruster 4 Lube Oil Cooling Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AS52H	Thruster 4 Lube Oil Cooling Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-AS53	Thruster 4 Hydraulics Cooling Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-AS53H	Thruster 4 Hydraulics Cooling Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-FC06	Fwd. Center Freshwater Cooler Leaks or Plugs/Clogs (Thruster 1)	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-FC06H	Fwd. Center Freshwater Cooler Leaks or Plugs/Clogs (Thruster 1) (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-FC13	Thruster 1 Transformer Cooling Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
FWC-HEX-PLG-FC13H	Thruster 1 Transformer Cooling Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-FC14	Thruster 1 Diesel Start Air Compressor Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-FC14H	Thruster 1 Diesel Start Air Compressor Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-FC15	Thruster 1 VFD Room Air Conditioning Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-FC15H	Thruster 1 VFD Room Air Conditioning Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-FC16	Thruster 1 VFD Cooling Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-FC16H	Thruster 1 VFD Cooling Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-FC17	Thruster 1 Electrical Motor Cooling Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-FC17H	Thruster 1 Electrical Motor Cooling Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-FC18	Thruster 1 Lube Oil Cooling Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-FC18H	Thruster 1 Lube Oil Cooling Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-FC19	Thruster 1 Hydraulics Cooling Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-FC19H	Thruster 1 Hydraulics Cooling Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-FP06	Fwd. Port Freshwater Cooler Leaks or Plugs/Clogs (Thruster 3)	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-FP06H	Fwd. Port Freshwater Cooler Leaks or Plugs/Clogs (Thruster 3) (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-FP13	Thruster 3 Transformer Cooling Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-FP13H	Thruster 3 Transformer Cooling Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-FP14	Thruster 3 Diesel Start Air Compressor Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
FWC-HEX-PLG-FP14H	Thruster 3 Diesel Start Air Compressor Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-FP15	Thruster 3 VFD Room Air Conditioning Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-FP15H	Thruster 3 VFD Room Air Conditioning Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-FP16	Thruster 3 VFD Cooling Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-FP16H	Thruster 3 VFD Cooling Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-FP17	Thruster 3 Electrical Motor Cooling Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-FP17H	Thruster 3 Electrical Motor Cooling Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-FP18	Thruster 3 Lube Oil Cooling Leaks or Plugs/Clogs	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-FP18H	Thruster 3 Lube Oil Cooling Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-FP19	Thruster 3 Hydraulics Cooling Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-FP19H	Thruster 3 Hydraulics Cooling Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-FS06	Fwd. Starboard Freshwater Cooler Leaks or Plugs/Clogs (Thruster 2)	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-FS06H	Fwd. Starboard Freshwater Cooler Leaks or Plugs/Clogs (Thruster 2) (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-FS13	Thruster 2 Transformer Cooling Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-FS13H	Thruster 2 Transformer Cooling Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-FS14	Thruster 2 Diesel Start Air Compressor Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-FS14H	Thruster 2 Diesel Start Air Compressor Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
FWC-HEX-PLG-FS15	Thruster 2 VFD Room Air Conditioning Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-FS15H	Thruster 2 VFD Room Air Conditioning Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-FS16	Thruster 2 VFD Cooling Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-FS16H	Thruster 2 VFD Cooling Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-FS17	Thruster 2 Electrical Motor Cooling Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-FS17H	Thruster 2 Electrical Motor Cooling Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-FS18	Thruster 2 Lube Oil Cooling Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-FS18H	Thruster 2 Lube Oil Cooling Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-HEX-PLG-FS19	Thruster 2 Hydraulics Cooling Leaks or Plugs/Clogs	9.07E-04	3		1.26E-05	72	LogNormal	5.01	FWC-HEX-PLG	HEATEXCH-PLG
FWC-HEX-PLG-FS19H	Thruster 2 Hydraulics Cooling Leaks or Plugs/Clogs (Extreme Weather)	5.04E-05	3		1.26E-05	4	LogNormal	5.01	FWC-HEX-PLG-H	HEATEXCH-PLG
FWC-PMP-FTR-AC10	Aft Center Electrically Driven Fresh Water Diesel Low Temp. Cooling Pump (Gen. 3 Cooling System) Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	SWC-PMP-FTR	ELECPMP-FTR
FWC-PMP-FTR-AC10H	Aft Center Electrically Driven Fresh Water Diesel Low Temp. Cooling Pump (Gen. 3 Cooling System) Fails to Run (SH)	1.35E-04	3		3.37E-05	4	LogNormal	9.12	FWC-PMP-FTR-H	ELECPMP-FTR
FWC-PMP-FTR-AC11	Aft Center Electrically Driven Fresh Water Generator Cooling Pump (Gen. 3 Cooling System) Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	FWC-PMP-FTR	ELECPMP-FTR
FWC-PMP-FTR-AC11H	Aft Center Electrically Driven Fresh Water Generator Cooling Pump (Gen. 3 Cooling System) Fails to Run (SH)	1.35E-04	3		3.37E-05	4	LogNormal	9.12	FWC-PMP-FTR-H	ELECPMP-FTR
FWC-PMP-FTR-AC18	Aft Center Electrically Driven Fresh Water Diesel High Temp. Cooling Pump (Gen. 3 Cooling System) Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	FWC-PMP-FTR	ELECPMP-FTR
FWC-PMP-FTR-AC18H	Aft Center Electrically Driven Fresh Water Diesel High Temp. Cooling Pump (Gen. 3 Cooling System) Fails to Run (SH)	1.35E-04	3		3.37E-05	4	LogNormal	9.12	FWC-PMP-FTR-H	ELECPMP-FTR
FWC-PMP-FTR-AC26	Aft Center Electrically Driven Fresh Water Diesel Low Temp. Cooling Pump (Gen. 4 Cooling System) Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	FWC-PMP-FTR	ELECPMP-FTR
FWC-PMP-FTR-AC26H	Aft Center Electrically Driven Fresh Water Diesel Low Temp. Cooling Pump (Gen. 4 Cooling System) Fails to Run (SH)	1.35E-04	3		3.37E-05	4	LogNormal	9.12	FWC-PMP-FTR-H	ELECPMP-FTR
FWC-PMP-FTR-AC27	Aft Center Electrically Driven Fresh Water Generator Cooling Pump (Gen. 4 Cooling System) Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	FWC-PMP-FTR	ELECPMP-FTR
FWC-PMP-FTR-AC27H	Aft Center Electrically Driven Fresh Water Generator Cooling Pump (Gen. 4 Cooling System) Fails to Run (Extreme Weather	1.35E-04	3		3.37E-05	4	LogNormal	9.12	FWC-PMP-FTR-H	ELECPMP-FTR

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
FWC-PMP-FTR-AC34	Aft Center Electrically Driven Fresh Water Diesel High Temp. Cooling Pump (Gen. 4 Cooling System) Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	FWC-PMP-FTR	ELECPMP-FTR
FWC-PMP-FTR-AC34H	Aft Center Electrically Driven Fresh Water Diesel High Temp. Cooling Pump (Gen. 4 Cooling System) Fails to Run (SH)	1.35E-04	3		3.37E-05	4	LogNormal	9.12	FWC-PMP-FTR-H	ELECPMP-FTR
FWC-PMP-FTR-AC43	Aft Center Electrically Driven Fresh Water Thruster Cooling Pump AC43 (Thruster 6) Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	FWC-PMP-FTR	ELECPMP-FTR
FWC-PMP-FTR-AC43H	Aft Center Electrically Driven Fresh Water Thruster Cooling Pump AC43 (Thruster 6) Fails to Run (Extreme Weather)	1.35E-04	3		3.37E-05	4	LogNormal	9.12	FWC-PMP-FTR-H	ELECPMP-FTR
FWC-PMP-FTR-AC44	Aft Center Electrically Driven Fresh Water Thruster Cooling Pump (Thruster 6) Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	FWC-PMP-FTR	ELECPMP-FTR
FWC-PMP-FTR-AC44H	Aft Center Electrically Driven Fresh Water Thruster Cooling Pump AC44 (Thruster 6) Fails to Run (Extreme Weather)	1.35E-04	3		3.37E-05	4	LogNormal	9.12	FWC-PMP-FTR-H	ELECPMP-FTR
FWC-PMP-FTR-AP10	Aft Port Electrically Driven Fresh Water Diesel Low Temp. Cooling Pump (Gen. 5 Cooling System) Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	FWC-PMP-FTR	ELECPMP-FTR
FWC-PMP-FTR-AP10H	Aft Port Electrically Driven Fresh Water Diesel Low Temp. Cooling Pump (Gen. 5 Cooling System) Fails to Run (SH)	1.35E-04	3		3.37E-05	4	LogNormal	9.12	FWC-PMP-FTR-H	ELECPMP-FTR
FWC-PMP-FTR-AP11	Aft Port Electrically Driven Fresh Water Generator Cooling Pump (Gen. 5 Cooling System) Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	FWC-PMP-FTR	ELECPMP-FTR
FWC-PMP-FTR-AP11H	Aft Port Electrically Driven Fresh Water Generator Cooling Pump (Gen. 5 Cooling System) Fails to Run (SH)	1.35E-04	3		3.37E-05	4	LogNormal	9.12	FWC-PMP-FTR-H	ELECPMP-FTR
FWC-PMP-FTR-AP18	Aft Port Electrically Driven Fresh Water Diesel High Temp. Cooling Pump (Gen. 5 Cooling System) Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	FWC-PMP-FTR	ELECPMP-FTR
FWC-PMP-FTR-AP18H	Aft Port Electrically Driven Fresh Water Diesel High Temp. Cooling Pump (Gen. 5 Cooling System) Fails to Run (SH)	1.35E-04	3		3.37E-05	4	LogNormal	9.12	FWC-PMP-FTR-H	ELECPMP-FTR
FWC-PMP-FTR-AP26	Aft Port Electrically Driven Fresh Water Diesel Low Temp. Cooling Pump (Gen. 6 Cooling System) Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	FSY-PMP-FTR	ELECPMP-FTR
FWC-PMP-FTR-AP26H	Aft Port Electrically Driven Fresh Water Diesel Low Temp. Cooling Pump (Gen. 6 Cooling System) Fails to Run (SH)	1.35E-04	3		3.37E-05	4	LogNormal	9.12	FWC-PMP-FTR-H	ELECPMP-FTR
FWC-PMP-FTR-AP27	Aft Port Electrically Driven Fresh Water Generator Cooling Pump (Gen. 6 Cooling System) Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	HYS-PMP-FTR	ELECPMP-FTR
FWC-PMP-FTR-AP27H	Aft Port Electrically Driven Fresh Water Generator Cooling Pump (Gen. 6 Cooling System) Fails to Run (SH)	1.35E-04	3		3.37E-05	4	LogNormal	9.12	FWC-PMP-FTR-H	ELECPMP-FTR
FWC-PMP-FTR-AP34	Aft Port Electrically Driven Fresh Water Diesel High Temp. Cooling Pump (Gen. 6 Cooling System) Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	FWC-PMP-FTR	ELECPMP-FTR
FWC-PMP-FTR-AP34H	Aft Port Electrically Driven Fresh Water Diesel High Temp. Cooling Pump (Gen. 6 Cooling System) Fails to Run (SH)	1.35E-04	3		3.37E-05	4	LogNormal	9.12	FWC-PMP-FTR-H	ELECPMP-FTR
FWC-PMP-FTR-AP43	Aft Port Electrically Driven Fresh Water Thruster Cooling Pump AP43 (Thruster 5) Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	FWC-PMP-FTR	ELECPMP-FTR
FWC-PMP-FTR-AP43H	Aft Port Electrically Driven Fresh Water Thruster Cooling Pump AP43 (Thruster 5) Fails to Run (Extreme Weather)	1.35E-04	3		3.37E-05	4	LogNormal	9.12	FWC-PMP-FTR-H	ELECPMP-FTR

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
FWC-PMP-FTR-AP44	Aft Port Electrically Driven Fresh Water Thruster Cooling Pump AP44 (Thruster 5) Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	FWC-PMP-FTR	ELECPMP-FTR
FWC-PMP-FTR-AP44H	Aft Port Electrically Driven Fresh Water Thruster Cooling Pump AP44 (Thruster 5) Fails to Run (Extreme Weather)	1.35E-04	3		3.37E-05	4	LogNormal	9.12	FWC-PMP-FTR-H	ELECPMP-FTR
FWC-PMP-FTR-AS10	Aft Starboard Electrically Driven Fresh Water Diesel Low Temp. Cooling Pump (Gen. 1 Cooling System) Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	FWC-PMP-FTR	ELECPMP-FTR
FWC-PMP-FTR-AS10H	Aft Starboard Electrically Driven Fresh Water Diesel Low Temp. Cooling Pump (Gen. 1 Cooling System) Fails to Run (SH)	1.35E-04	3		3.37E-05	4	LogNormal	9.12	FWC-PMP-FTR-H	ELECPMP-FTR
FWC-PMP-FTR-AS11	Aft Starboard Electrically Driven Fresh Water Generator Cooling Pump (Gen. 1 Cooling System) Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	FWC-PMP-FTR	ELECPMP-FTR
FWC-PMP-FTR-AS11H	Aft Starboard Electrically Driven Fresh Water Generator Cooling Pump (Gen. 1 Cooling System) Fails to Run (SH)	1.35E-04	3		3.37E-05	4	LogNormal	9.12	FWC-PMP-FTR-H	ELECPMP-FTR
FWC-PMP-FTR-AS18	Aft Starboard Electrically Driven Fresh Water Diesel High Temp. Cooling Pump (Gen. 1 Cooling System) Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	FWC-PMP-FTR	ELECPMP-FTR
FWC-PMP-FTR-AS18H	Aft Starboard Electrically Driven Fresh Water Diesel High Temp. Cooling Pump (Gen. 1 Cooling System) Fails to Run (SH)	1.35E-04	3		3.37E-05	4	LogNormal	9.12	FWC-PMP-FTR-H	ELECPMP-FTR
FWC-PMP-FTR-AS26	Aft Starboard Electrically Driven Fresh Water Diesel Low Temp. Cooling Pump (Gen. 2 Cooling System) Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	FWC-PMP-FTR	ELECPMP-FTR
FWC-PMP-FTR-AS26H	Aft Starboard Electrically Driven Fresh Water Diesel Low Temp. Cooling Pump (Gen. 2 Cooling System) Fails to Run (SH)	1.35E-04	3		3.37E-05	4	LogNormal	9.12	FWC-PMP-FTR-H	ELECPMP-FTR
FWC-PMP-FTR-AS27	Aft Starboard Electrically Driven Fresh Water Generator Cooling Pump (Gen. 2 Cooling System) Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	FWC-PMP-FTR	ELECPMP-FTR
FWC-PMP-FTR-AS27H	Aft Starboard Electrically Driven Fresh Water Generator Cooling Pump (Gen. 2 Cooling System) Fails to Run (SH)	1.35E-04	3		3.37E-05	4	LogNormal	9.12	FWC-PMP-FTR-H	ELECPMP-FTR
FWC-PMP-FTR-AS34	Aft Starboard Electrically Driven Fresh Water Diesel High Temp. Cooling Pump (Gen. 2 Cooling System) Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	FWC-PMP-FTR	ELECPMP-FTR
FWC-PMP-FTR-AS34H	Aft Starboard Electrically Driven Fresh Water Diesel High Temp. Cooling Pump (Gen. 2 Cooling System) Fails to Run (SH)	1.35E-04	3		3.37E-05	4	LogNormal	9.12	FWC-PMP-FTR-H	ELECPMP-FTR
FWC-PMP-FTR-AS43	Aft Starboard Electrically Driven Fresh Water Thruster Cooling Pump AS43 (Thruster 4) Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	FWC-PMP-FTR	ELECPMP-FTR
FWC-PMP-FTR-AS43H	Aft Starboard Electrically Driven Fresh Water Thruster Cooling Pump AS43 (Thruster 4) Fails to Run (Extreme Weather)	1.35E-04	3		3.37E-05	4	LogNormal	9.12	FWC-PMP-FTR-H	ELECPMP-FTR
FWC-PMP-FTR-AS44	Aft Starboard Electrically Driven Fresh Water Thruster Cooling Pump AS44 (Thruster 4) Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	FWC-PMP-FTR	ELECPMP-FTR
FWC-PMP-FTR-AS44H	Aft Starboard Electrically Driven Fresh Water Thruster Cooling Pump AS44 (Thruster 4) Fails to Run (Extreme Weather)	1.35E-04	3		3.37E-05	4	LogNormal	9.12	FWC-PMP-FTR-H	ELECPMP-FTR
FWC-PMP-FTR-FC09	Forward Center Electrically Driven Fresh Water Thruster Cooling Pump FC09 (Thruster 1) Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	FWC-PMP-FTR	ELECPMP-FTR
FWC-PMP-FTR-FC09H	Forward Center Electrically Driven Fresh Water Thruster Cooling Pump FC09 (Thruster 1) Fails to Run (Extreme Weather)	1.35E-04	3		3.37E-05	4	LogNormal	9.12	FWC-PMP-FTR-H	ELECPMP-FTR

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
FWC-PMP-FTR-FC10	Forward Center Electrically Driven Fresh Water Thruster Cooling Pump (Thruster 1) Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	FWC-PMP-FTR	ELECPMP-FTR
FWC-PMP-FTR-FC10H	Forward Center Electrically Driven Fresh Water Thruster Cooling Pump FC10 (Thruster 1) Fails to Run (Extreme Weather)	1.35E-04	3		3.37E-05	4	LogNormal	9.12	FWC-PMP-FTR-H	ELECPMP-FTR
FWC-PMP-FTR-FP09	Forward Port Electrically Driven Fresh Water Thruster Cooling Pump FP09 (Thruster 3) Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	FWC-PMP-FTR	ELECPMP-FTR
FWC-PMP-FTR-FP09H	Forward Port Electrically Driven Fresh Water Thruster Cooling Pump FP09 (Thruster 3) Fails to Run (Extreme Weather)	1.35E-04	3		3.37E-05	4	LogNormal	9.12	FSY-PMP-FTR-H	ELECPMP-FTR
FWC-PMP-FTR-FP10	Forward Port Electrically Driven Fresh Water Thruster Cooling Pump (Thruster 3) Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	FWC-PMP-FTR	ELECPMP-FTR
FWC-PMP-FTR-FP10H	Forward Port Electrically Driven Fresh Water Thruster Cooling Pump FP10 (Thruster 3) Fails to Run (Extreme Weather)	1.35E-04	3		3.37E-05	4	LogNormal	9.12	FWC-PMP-FTR-H	ELECPMP-FTR
FWC-PMP-FTR-FS09	Forward Center Electrically Driven Fresh Water Thruster Cooling Pump FS09 (Thruster 2) Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	FWC-PMP-FTR	ELECPMP-FTR
FWC-PMP-FTR-FS09H	Forward Starboard Electrically Driven Fresh Water Thruster Cooling Pump FS09 (Thruster 2) Fails to Run (Extreme Weather)	1.35E-04	3		3.37E-05	4	LogNormal	9.12	FWC-PMP-FTR-H	ELECPMP-FTR
FWC-PMP-FTR-FS10	Forward Starboard Electrically Driven Fresh Water Thruster Cooling Pump FS10 (Thruster 2) Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	FWC-PMP-FTR	ELECPMP-FTR
FWC-PMP-FTR-FS10H	Forward Starboard Electrically Driven Fresh Water Thruster Cooling Pump (Thruster 2) Fails to Run (Extreme Weather)	1.35E-04	3		3.37E-05	4	LogNormal	9.12	FWC-PMP-FTR-H	ELECPMP-FTR
HYS-ACC-LKE-SH07	Accumulator fails leaking (bank 1, bottle 1)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH08	Accumulator fails leaking (bank 1, bottle 2)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH09	Accumulator fails leaking (bank 1, bottle 3)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH10	Accumulator fails leaking (bank 1, bottle 4)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH11	Accumulator fails leaking (bank 1, bottle 5)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH12	Accumulator fails leaking (bank 1, bottle 6)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH13	Accumulator fails leaking (bank 1, bottle 7)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH14	Accumulator fails leaking (bank 1, bottle 8)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH15	Accumulator fails leaking (bank 1, bottle 9)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH16	Accumulator fails leaking (bank 1, bottle 10)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH17	Accumulator fails leaking (bank 2, bottle 1)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH18	Accumulator fails leaking (bank 2, bottle 2)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH19	Accumulator fails leaking (bank 2, bottle 3)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
HYS-ACC-LKE-SH20	Accumulator fails leaking (bank 2, bottle 4)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH21	Accumulator fails leaking (bank 2, bottle 5)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH22	Accumulator fails leaking (bank 2, bottle 6)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH23	Accumulator fails leaking (bank 2, bottle 7)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH24	Accumulator fails leaking (bank 2, bottle 8)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH25	Accumulator fails leaking (bank 2, bottle 9)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH26	Accumulator fails leaking (bank 2, bottle 10)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH27	Accumulator fails leaking (bank 3, bottle 1)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH28	Accumulator fails leaking (bank 3, bottle 2)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH29	Accumulator fails leaking (bank 3, bottle 3)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH30	Accumulator fails leaking (bank 3, bottle 4)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH31	Accumulator fails leaking (bank 3, bottle 5)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH32	Accumulator fails leaking (bank 3, bottle 6)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH33	Accumulator fails leaking (bank 3, bottle 7)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH34	Accumulator fails leaking (bank 3, bottle 8)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH35	Accumulator fails leaking (bank 3, bottle 9)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH36	Accumulator fails leaking (bank 3, bottle 10)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH37	Accumulator fails leaking (bank 4, bottle 1)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH38	Accumulator fails leaking (bank 4, bottle 2)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH39	Accumulator fails leaking (bank 4, bottle 3)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH40	Accumulator fails leaking (bank 4, bottle 4)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH41	Accumulator fails leaking (bank 4, bottle 5)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH42	Accumulator fails leaking (bank 4, bottle 6)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH43	Accumulator fails leaking (bank 4, bottle 7)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH44	Accumulator fails leaking (bank 4, bottle 8)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH45	Accumulator fails leaking (bank 4, bottle 9)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH46	Accumulator fails leaking (bank 4, bottle 10)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH47	Accumulator fails leaking (bank 5, bottle 1)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH48	Accumulator fails leaking (bank 5, bottle 2)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH49	Accumulator fails leaking (bank 5, bottle 3)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH50	Accumulator fails leaking (bank 5, bottle 4)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH51	Accumulator fails leaking (bank 5, bottle 5)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
HYS-ACC-LKE-SH52	Accumulator fails leaking (bank 5, bottle 6)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH53	Accumulator fails leaking (bank 5, bottle 7)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH54	Accumulator fails leaking (bank 5, bottle 8)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH55	Accumulator fails leaking (bank 5, bottle 9)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH56	Accumulator fails leaking (bank 5, bottle 10)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH57	Accumulator fails leaking (bank 6, bottle 1)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH58	Accumulator fails leaking (bank 6, bottle 2)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH59	Accumulator fails leaking (bank 6, bottle 3)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH60	Accumulator fails leaking (bank 6, bottle 4)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH61	Accumulator fails leaking (bank 6, bottle 5)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH62	Accumulator fails leaking (bank 6, bottle 6)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH63	Accumulator fails leaking (bank 6, bottle 7)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH64	Accumulator fails leaking (bank 6, bottle 8)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH65	Accumulator fails leaking (bank 6, bottle 9)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH66	Accumulator fails leaking (bank 6, bottle 10)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH67	Accumulator fails leaking (bank 7, bottle 1)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH68	Accumulator fails leaking (bank 7, bottle 2)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH69	Accumulator fails leaking (bank 7, bottle 3)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH70	Accumulator fails leaking (bank 7, bottle 4)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH71	Accumulator fails leaking (bank 7, bottle 5)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH72	Accumulator fails leaking (bank 7, bottle 6)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH73	Accumulator fails leaking (bank 7, bottle 7)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH74	Accumulator fails leaking (bank 7, bottle 8)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH75	Accumulator fails leaking (bank 7, bottle 9)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH76	Accumulator fails leaking (bank 7, bottle 10)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH77	Accumulator fails leaking (bank 8, bottle 1)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH78	Accumulator fails leaking (bank 8, bottle 2)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH79	Accumulator fails leaking (bank 8, bottle 3)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH80	Accumulator fails leaking (bank 8, bottle 4)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH81	Accumulator fails leaking (bank 8, bottle 5)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH82	Accumulator fails leaking (bank 8, bottle 6)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH83	Accumulator fails leaking (bank 8, bottle 7)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
HYS-ACC-LKE-SH84	Accumulator fails leaking (bank 8, bottle 8)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH85	Accumulator fails leaking (bank 8, bottle 9)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-ACC-LKE-SH86	Accumulator fails leaking (bank 8, bottle 10)	1.53E-05	3		2.12E-07	72	LogNormal	9.99	HYS-ACC-LKE	ACC-LKE
HYS-FLT-PLG-SH01	HPU screen filter 1 fails clogged	2.47E-05	3		3.43E-07	72	LogNormal	9.51	HYS-FLT-PLG	FLT-PLG
HYS-FLT-PLG-SH04	HPU screen filter 2 fails clogged	2.47E-05	3		3.43E-07	72	LogNormal	9.51	HYS-FLT-PLG	FLT-PLG
HYS-FLT-PLG-SH11	HPU 400 micron filter 1 fails clogged	2.47E-05	3		3.43E-07	72	LogNormal	9.51	HYS-FLT-PLG	FLT-PLG
HYS-FLT-PLG-SH13	HPU 400 micron filter 2 fails clogged	2.47E-05	3		3.43E-07	72	LogNormal	9.51	HYS-FLT-PLG	FLT-PLG
HYS-PMP-FTR-SH02	HPU pump 1 fails to run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	HYS-PMP-FTR	ELECPMP-FTR
HYS-PMP-FTR-SH05	HPU pump 2 fails to run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	HYS-PMP-FTR	ELECPMP-FTR
HYS-SCV-FTC-SH87	HPU pressure relief valve leaks in the closed position	8.21E-06	3		1.14E-07	72	LogNormal	9.66	HYS-SCV-FTC	CHV-R-FTC
HYS-SCV-FTO-ALP1	HPU check valve alpha 1 value	3.82E-07	3		5.30E-09	72	LogNormal	18.2	HYS-SCV-FTO	CHV-R-FTO
HYS-SCV-FTO-ALP2	HPU check valve alpha 2 value	3.82E-07	3		5.30E-09	72	LogNormal	18.2	HYS-SCV-FTO	CHV-R-FTO
HYS-SCV-FTO-SH03	HPU check valve 1 fails to open	3.82E-07	3		5.30E-09	72	LogNormal	18.2	HYS-SCV-FTO	CHV-R-FTO
HYS-SCV-FTO-SH06	HPU check valve 2 fails to open	3.82E-07	3		5.30E-09	72	LogNormal	18.2	HYS-SCV-FTO	CHV-R-FTO
HYS-SCV-FTO-SH12	HPU bypass check valve 1 fails to open	3.82E-07	3		5.30E-09	72	LogNormal	18.2	HYS-SCV-FTO	CHV-R-FTO
HYS-SCV-FTO-SH14	HPU bypass check valve 2 fails to open	3.82E-07	3		5.30E-09	72	LogNormal	18.2	HYS-SCV-FTO	CHV-R-FTO
SWC-PMP-FTR-AC02	Aft Center Electrically Driven Sea Water Cooling Pump Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	SWC-PMP-FTR	ELECPMP-FTR
SWC-PMP-FTR-AC02H	Aft Center Electrically Driven Sea Water Cooling Pump Fails to Run (Extreme Weather)	1.35E-04	3		3.37E-05	4	LogNormal	9.12	SWC-PMP-FTR-H	ELECPMP-FTR
SWC-PMP-FTR-AC03	Aft Center Electrically Driven Sea Water Cooling Pump Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	SWC-PMP-FTR	ELECPMP-FTR
SWC-PMP-FTR-AC03H	Aft Center Electrically Driven Sea Water Cooling Pump Fails to Run (Extreme Weather)	1.35E-04	3		3.37E-05	4	LogNormal	9.12	SWC-PMP-FTR-H	ELECPMP-FTR
SWC-PMP-FTR-AP02	Aft Port Electrically Driven Sea Water Cooling Pump Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	SWC-PMP-FTR	ELECPMP-FTR
SWC-PMP-FTR-AP02H	Aft Port Electrically Driven Sea Water Cooling Pump Fails to Run (Extreme Weather)	1.35E-04	3		3.37E-05	4	LogNormal	9.12	SWC-PMP-FTR-H	ELECPMP-FTR
SWC-PMP-FTR-AP03	Aft Port Electrically Driven Sea Water Cooling Pump Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	SWC-PMP-FTR	ELECPMP-FTR

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
SWC-PMP-FTR-AP03H	Aft Port Electrically Driven Sea Water Cooling Pump Fails to Run (Extreme Weather)	1.35E-04	3		3.37E-05	4	LogNormal	9.12	SWC-PMP-FTR-H	ELECPMP-FTR
SWC-PMP-FTR-AS02	Aft Starboard Electrically Driven Sea Water Cooling Pump Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	SWC-PMP-FTR	ELECPMP-FTR
SWC-PMP-FTR-AS02H	Aft Starboard Electrically Driven Sea Water Cooling Pump Fails to Run (Extreme Weather)	1.35E-04	3		3.37E-05	4	LogNormal	9.12	SWC-PMP-FTR-H	ELECPMP-FTR
SWC-PMP-FTR-AS03	Aft Starboard Electrically Driven Sea Water Cooling Pump Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	SWC-PMP-FTR	ELECPMP-FTR
SWC-PMP-FTR-AS03H	Aft Starboard Electrically Driven Sea Water Cooling Pump Fails to Run (Extreme Weather)	1.35E-04	3		3.37E-05	4	LogNormal	9.12	SWC-PMP-FTR-H	ELECPMP-FTR
SWC-PMP-FTR-FC02	Forward Center Electrically Driven Sea Water Cooling Pump Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	SWC-PMP-FTR	ELECPMP-FTR
SWC-PMP-FTR-FC02H	Forward Center Electrically Driven Sea Water Cooling Pump Fails to Run (Extreme Weather)	1.35E-04	3		3.37E-05	4	LogNormal	9.12	SWC-PMP-FTR-H	ELECPMP-FTR
SWC-PMP-FTR-FC03	Forward Center Electrically Driven Sea Water Cooling Pump Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	SWC-PMP-FTR	ELECPMP-FTR
SWC-PMP-FTR-FC03H	Forward Center Electrically Driven Sea Water Cooling Pump Fails to Run (Extreme Weather)	1.35E-04	3		3.37E-05	4	LogNormal	9.12	SWC-PMP-FTR-H	ELECPMP-FTR
SWC-PMP-FTR-FP02	Forward Port Electrically Driven Sea Water Cooling Pump Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	SWC-PMP-FTR	ELECPMP-FTR
SWC-PMP-FTR-FP02H	Forward Port Electrically Driven Sea Water Cooling Pump Fails to Run (Extreme Weather)	1.35E-04	3		3.37E-05	4	LogNormal	9.12	SWC-PMP-FTR-H	ELECPMP-FTR
SWC-PMP-FTR-FP03	Forward Port Electrically Driven Sea Water Cooling Pump Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	SWC-PMP-FTR	ELECPMP-FTR
SWC-PMP-FTR-FP03H	Forward Port Electrically Driven Sea Water Cooling Pump Fails to Run (Extreme Weather)	1.35E-04	3		3.37E-05	4	LogNormal	9.12	SWC-PMP-FTR-H	ELECPMP-FTR
SWC-PMP-FTR-FS02	Forward Starboard Electrically Driven Sea Water Cooling Pump Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	SWC-PMP-FTR	ELECPMP-FTR

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
SWC-PMP-FTR-FS02H	Forward Starboard Electrically Driven Sea Water Cooling Pump Fails to Run (Extreme Weather)	1.35E-04	3		3.37E-05	4	LogNormal	9.12	SWC-PMP-FTR-H	ELECPMP-FTR
SWC-PMP-FTR-FS03	Forward Starboard Electrically Driven Sea Water Cooling Pump Fails to Run	2.42E-03	3		3.37E-05	72	LogNormal	9.12	SWC-PMP-FTR	ELECPMP-FTR
SWC-PMP-FTR-FS03H	Forward Starboard Electrically Driven Sea Water Cooling Pump Fails to Run (Extreme Weather)	1.35E-04	3		3.37E-05	4	LogNormal	9.12	SWC-PMP-FTR-H	ELECPMP-FTR
SWC-SCH-CLG-APSC1	Aft Port Sea Chest APSC1 Clogged	4.57E-05	3		6.34E-07	72	LogNormal	3.71	SWC-SCH-CLG	HULLINT-CLG
SWC-SCH-CLG-ASSC2	Aft Starboard Sea Chest ASSC2 Clogged	4.57E-05	3		6.34E-07	72	LogNormal	3.71	SWC-SCH-CLG	HULLINT-CLG
SWC-SCH-CLG-FPSC3	Forward Port Sea Chest FPSC3 Clogged	4.57E-05	3		6.34E-07	72	LogNormal	3.71	SWC-SCH-CLG	HULLINT-CLG
SWC-SCH-CLG-FSSC4	Forward Starboard Sea Chest FSSC4 Clogged	4.57E-05	3		6.34E-07	72	LogNormal	3.71	SWC-SCH-CLG	HULLINT-CLG
DPS-JOY-FOP-00	Failure of the Joystick Control System	1.09E-03	7		1.30E-05	168	LogNormal	7.09	DPS-JOY-FOP	JOY-FOP
ABOV-EXT-WEATHER-F-IE	Above Extreme Weather (Initiating Event)		N	5.71E-10			LogNormal	3.17	ABOV-EXT-WEATHER-IE	EXT-WEA
ABOV-EXT-WEATHER-IE	Above Extreme Weather (Initiating Event)		N	5.71E-10			LogNormal	3.17		EXT-WEA
COLLISION_IE	Collision causes a loss of position as Initiating Event (Not modeled)		N	0						
D-W-O-OPER-F-IE	Run/Retrieval Offset Frequency per hour (initiating event)		N	2.38E-03			LogNormal	3.93	D-W-O-OPER-IE	OFFSET
DPS-COM-FOP-PC01-F-IE	DP Computer PC01 Fails Off		N	3.96E-05			LogNormal	8	DPS-COM-FOP-F-IE	COMP-FOP
DPS-COM-FOP-PC02-F-IE	DP Computer PC02 Fails Off		N	3.96E-05			LogNormal	8	DPS-COM-FOP-F-IE	COMP-FOP
DPS-COM-FOP-PC03-F-IE	DP Computer PC03 Fails Off		N	3.96E-05			LogNormal	8	DPS-COM-FOP-F-IE	COMP-FOP
DPS-FRQ-WEA-HURR-F-IE	Frequency of Extreme Weather/Hurricane per hour (initiating event)		N	3.62E-05			LogNormal	1.5	DPS-WEA-HURR-F-IE	WEA-HURR
DPS-FRQ-WEA-SQUA-F-IE	Frequency of a Squall per hour (initiating event)		N	1.61E-03			LogNormal	2.5	DPS-WEA-SQUA-F-IE	WEA-SQUA
DPS-FRQ-WEA-WINT-F-IE	Frequency of Winter Storm per hour (initiating event)		N	3.31E-04			LogNormal	3.93	DPS-WEA-WINT-F-IE	WEA-WINT
DPS-GPS-DEG-01-F-IE	Differential GPS 1 Fails Degraded as Initiating event		N	9.46E-06			LogNormal	9.9	DPS-GPS-DEG-F-IE	GPS-DEG
DPS-GPS-DEG-02-F-IE	Differential GPS 2 Fails Degraded as initiating event		N	9.46E-06			LogNormal	9.9	DPS-GPS-DEG-F-IE	GPS-DEG
DPS-GPS-FOP-01-F-IE	Differential GPS 1 Fails Off		N	1.95E-05			LogNormal	9.25	DPS-GPS-FOP-F-IE	GPS-FOP
DPS-GPS-FOP-02-F-IE	Differential GPS 2 Fails Off		N	1.95E-05			LogNormal	9.25	DPS-GPS-FOP-F-IE	GPS-FOP
DPS-GYC-FOP-01-F-IE	Gyro Compass Sensor 1 Fails Off		N	1.76E-05			LogNormal	4.99	DPS-GYC-FOP-F-IE	GYRO-FOP
DPS-GYC-FOP-02-F-IE	Gyro Compass Sensor 2 Fails Off		N	1.76E-05			LogNormal	4.99	DPS-GYC-FOP-F-IE	GYRO-FOP
DPS-GYC-FOP-03-F-IE	Gyro Compass Sensor 3 Fails Off		N	1.76E-05			LogNormal	4.99	DPS-GYC-FOP-F-IE	GYRO-FOP

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
DPS-HYS-DEG-01-F-IE	Hydroacoustic Position Reference Sensor 1 Fails Degraded as initiating event		N	4.70E-05			LogNormal	9.61	DPS-HYS-DEG-F-IE	ACOU-DEG
DPS-HYS-DEG-02-F-IE	Hydroacoustic Position Reference Sensor 2 Fails Degraded as initiating event		N	4.70E-05			LogNormal	9.61	DPS-HYS-DEG-F-IE	ACOU-DEG
DPS-HYS-FOP-01-F-IE	Hydroacoustic Position Reference Sensor 1 Fails Off		N	7.83E-05			LogNormal	8.76	DPS-HYS-FOP-F-IE	ACOU-FOP
DPS-HYS-FOP-02-F-IE	Hydroacoustic Position Reference Sensor 2 Fails Off		N	7.83E-05			LogNormal	8.76	DPS-HYS-FOP-F-IE	ACOU-FOP
DPS-THR-FTR-AT04-F-IE	Aft Thruster 4 Fails to Run		N	2.43E-05			LogNormal	13	DPS-THR-FTR-F-IE	THR-FTR
DPS-THR-FTR-AT05-F-IE	Aft Thruster 5 Fails to Run		N	2.43E-05			LogNormal	13	DPS-THR-FTR-F-IE	THR-FTR
DPS-THR-FTR-AT06-F-IE	Aft Thruster 6 Fails to Run		N	2.43E-05			LogNormal	13	DPS-THR-FTR-F-IE	THR-FTR
DPS-THR-FTR-FT01-F-IE	Forward Thruster 1 Fails to Run		N	2.43E-05			LogNormal	13	DPS-THR-FTR-F-IE	THR-FTR
DPS-THR-FTR-FT02-F-IE	Forward Thruster 2 Fails to Run		N	2.43E-05			LogNormal	13	DPS-THR-FTR-F-IE	THR-FTR
DPS-THR-FTR-FT03-F-IE	Forward Thruster 3 Fails to Run		N	2.43E-05			LogNormal	13	DPS-THR-FTR-F-IE	THR-FTR
DPS-VRS-FOP-01-F-IE	Vertical Reference Sensor 1 Fails Off		N	2.49E-05			LogNormal	12.8	DPS-VRS-FOP-F-IE	MOTSENS-FOP
DPS-VRS-FOP-02-F-IE	Vertical Reference Sensor 2 Fails Off		N	2.49E-05			LogNormal	12.8	DPS-VRS-FOP-F-IE	MOTSENS-FOP
DPS-VRS-FOP-03-F-IE	Vertical Reference Sensor 3 Fails Off		N	2.49E-05			LogNormal	12.8	DPS-VRS-FOP-F-IE	MOTSENS-FOP
DPS-WIS-DEG-01-F-IE	Wind Sensor 1 Fails Degraded		N	2.15E-05			LogNormal	7.38	DPS-WIS-DEG-F-IE	WINDSENS-DEG
DPS-WIS-DEG-02-F-IE	Wind Sensor 2 Fails Degraded		N	2.15E-05			LogNormal	7.38	DPS-WIS-DEG-F-IE	WINDSENS-DEG
DPS-WIS-DEG-03-F-IE	Wind Sensor 3 Fails Degraded		N	2.15E-05			LogNormal	7.38	DPS-WIS-DEG-F-IE	WINDSENS-DEG
EME-ESD-SPO-001-F-IE	Emergency Shutdown System 1 Spuriously Causes Loss of Power (Starboard Group)		N	4.91E-05			LogNormal	8	EME-ESD-SPO-F-IE	COMP-SPO
EME-ESD-SPO-002-F-IE	Emergency Shutdown System 2 Spuriously Causes Loss of Power (Center Group)		N	4.91E-05			LogNormal	8	EME-ESD-SPO-F-IE	COMP-SPO
EME-ESD-SPO-003-F-IE	Emergency Shutdown System 3 Spuriously Causes Loss of Power (Port Group)		N	4.91E-05			LogNormal	8	EME-ESD-SPO-F-IE	COMP-SPO
EPS-BUS-FOP-CB02-F-IE	Center Electrical Bus Fails to Operate		N	1.62E-06			LogNormal	7.56	EPS-BUS-FOP-F-IE	ELECBUS-FOP
EPS-BUS-FOP-PB03-F-IE	Port Electrical Bus Fails to Operate		N	1.62E-06			LogNormal	7.56	EPS-BUS-FOP-F-IE	ELECBUS-FOP
EPS-BUS-FOP-SB01-F-IE	Starboard Electrical Bus Fails to Operate		N	1.62E-06			LogNormal	7.56	EPS-BUS-FOP-F-IE	ELECBUS-FOP
EPS-DGN-FTR-C04-F-IE	Diesel Generator 4 Fails to Run		N	5.59E-05			LogNormal	7.39	EPS-DGN-FTR-F-IE	DGN-FTR
EPS-DGN-FTR-P06-F-IE	Diesel Generator 6 Fails to Run		N	5.59E-05			LogNormal	7.39	EPS-DGN-FTR-F-IE	DGN-FTR

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
EPS-DGN-FTR-S02-F-IE	Diesel Generator 2 Fails to Run		N	5.59E-05			LogNormal	7.39	EPS-DGN-FTR-F-IE	DGN-FTR
EPS-SWB-FOP-CS02-F-IE	Center Switchboard Fails to Operate		N	6.46E-06			LogNormal	9.2	EPS-SWB-FOP-F-IE	SWB-FOP
EPS-SWB-FOP-PS03-F-IE	Port Switchboard Fails to Operate		N	6.46E-06			LogNormal	9.2	EPS-SWB-FOP-F-IE	SWB-FOP
EPS-SWB-FOP-SS01-F-IE	Starboard Switchboard Fails to Operate		N	6.46E-06			LogNormal	9.2	EPS-SWB-FOP-F-IE	SWB-FOP
FSY-FLT-PLG-CFS1-F-IE	Center Fuel System Filter 1 Fails Clogged		N	3.43E-07			LogNormal	9.51	FSY-FLT-PLG-F-IE	FLT-PLG
FSY-FLT-PLG-CFS2-F-IE	Center Fuel System Filter 2 Fails Clogged		N	3.43E-07			LogNormal	9.51	FSY-FLT-PLG-F-IE	FLT-PLG
FSY-FLT-PLG-CFS4-F-IE	Center Fuel System Filter 4 Fails Clogged		N	3.43E-07			LogNormal	9.51	FSY-FLT-PLG-F-IE	FLT-PLG
FSY-FLT-PLG-PFS1-F-IE	Port Fuel System Filter 1 Fails Clogged		N	3.43E-07			LogNormal	9.51	FSY-FLT-PLG-F-IE	FLT-PLG
FSY-FLT-PLG-PFS2-F-IE	Port Fuel System Filter 2 Fails Clogged		N	3.43E-07			LogNormal	9.51	FSY-FLT-PLG-F-IE	FLT-PLG
FSY-FLT-PLG-PFS4-F-IE	Port Fuel System Filter 4 Fails Clogged		N	3.43E-07			LogNormal	9.51	FSY-FLT-PLG-F-IE	FLT-PLG
FSY-FLT-PLG-SFS1-F-IE	Starboard Fuel System Filter 1 Fails Clogged		N	3.43E-07			LogNormal	9.51	FSY-FLT-PLG-F-IE	FLT-PLG
FSY-FLT-PLG-SFS2-F-IE	Starboard Fuel System Filter 2 Fails Clogged		N	3.43E-07			LogNormal	9.51	FSY-FLT-PLG-F-IE	FLT-PLG
FSY-FLT-PLG-SFS4-F-IE	Starboard Fuel System Filter 4 Fails Clogged		N	3.43E-07			LogNormal	9.51	FSY-FLT-PLG-F-IE	FLT-PLG
FSY-HEX-PLG-CFS0-F-IE	Center Fuel System Fuel Cooler Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FSY-HEX-PLG-F-IE	HEATEXCH-PLG
FSY-HEX-PLG-PFS0-F-IE	Port Fuel System Fuel Cooler Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FSY-HEX-PLG-F-IE	HEATEXCH-PLG
FSY-HEX-PLG-SFS0-F-IE	Starboard Fuel System Fuel Cooler Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FSY-HEX-PLG-F-IE	HEATEXCH-PLG
FSY-PMP-FTR-CFS1-F-IE	Center Electrically Driven Fuel Supply Pump #1 Fails to Run		N	3.37E-05			LogNormal	9.12	FSY-PMP-FTR-F-IE	ELECPMP-FTR
FSY-PMP-FTR-PFS1-F-IE	Port Electrically Driven Fuel Supply Pump #1 Fails to Run		N	3.37E-05			LogNormal	9.12	FSY-PMP-FTR-F-IE	ELECPMP-FTR
FSY-PMP-FTR-SFS1-F-IE	Starboard Electrically Driven Fuel Supply Pump #1 Fails to Run		N	3.37E-05			LogNormal	9.12	FSY-PMP-FTR-F-IE	ELECPMP-FTR
FWC-AOV-FOP-AC25-F-IE	Temperature Regulating Valve (Generator 4 Cooling System) Fails to Regulate		N	1.89E-07			LogNormal	5.57	FWC-AOV-FOP-F-IE	TEMPREGVLV-FOP
FWC-AOV-FOP-AC42-F-IE	Temperature Regulating Valve (Thruster 6 Cooling System) Fails to Regulate		N	1.89E-07			LogNormal	5.57	FWC-AOV-FOP-F-IE	TEMPREGVLV-FOP
FWC-AOV-FOP-AP25-F-IE	Temperature Regulating Valve (Generator 6 Cooling System) Fails to Regulate		N	1.89E-07			LogNormal	5.57	FWC-AOV-FOP-F-IE	TEMPREGVLV-FOP
FWC-AOV-FOP-AP42-F-IE	Temperature Regulating Valve (Thruster 5 Cooling System) Fails to Regulate		N	1.89E-07			LogNormal	5.57	FWC-AOV-FOP-F-IE	TEMPREGVLV-FOP
FWC-AOV-FOP-AS25-F-IE	Temperature Regulating Valve (Generator 2 Cooling System) Fails to Regulate		N	1.89E-07			LogNormal	5.57	FWC-AOV-FOP-F-IE	TEMPREGVLV-FOP
FWC-AOV-FOP-AS42-F-IE	Temperature Regulating Valve (Thruster 4 Cooling System) Fails to Regulate		N	1.89E-07			LogNormal	5.57	FWC-AOV-FOP-F-IE	TEMPREGVLV-FOP
FWC-AOV-FOP-FC08-F-IE	Temperature Regulating Valve (Thruster 1 Cooling System) Fails to Regulate		N	1.89E-07			LogNormal	5.57	FWC-AOV-FOP-F-IE	TEMPREGVLV-FOP
FWC-AOV-FOP-FP08-F-IE	Temperature Regulating Valve (Thruster 3 Cooling System) Fails to Regulate		N	1.89E-07			LogNormal	5.57	FWC-AOV-FOP-F-IE	TEMPREGVLV-FOP

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
FWC-AOV-FOP-FS08-F-IE	Temperature Regulating Valve (Thruster 2 Cooling System) Fails to Regulate		N	1.89E-07			LogNormal	5.57	FWC-AOV-FOP-F-IE	TEMPREGVLV-FOP
FWC-HEX-PLG-AC06-F-IE	Aft Center Freshwater Cooler Leaks or Plugs/Clogs (Gens. 3&4)		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-AC07-F-IE	Aft Center Freshwater Cooler Leaks or Plugs/Clogs (Thruster 6)		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-AC32-F-IE	Diesel 4 Low Temp. Air Cooler Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-AC33-F-IE	Diesel 4 Lube Oil Cooler Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-AC37-F-IE	Diesel 4 High Temp. Air Cooler Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-AC38-F-IE	Generator 4 Lube Oil Cooler Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-AC39-F-IE	Generator 4 Air Cooler Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-AC40-F-IE	Generator 4 Engine Fuel Oil Cooler Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-AC47-F-IE	Thruster 6 Transformer Cooling Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-AC48-F-IE	Thruster 6 Diesel Start Air Compressor Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-AC49-F-IE	Thruster 6 Variable Frequency Drive Room Air Conditioning Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-AC50-F-IE	Thruster 6 Variable Frequency Drive Cooling Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-AC51-F-IE	Thruster 6 Electrical Motor Cooling Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-AC52-F-IE	Thruster 6 Lube Oil Cooling Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-AC53-F-IE	Thruster 6 Hydraulics Cooling Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-AP06-F-IE	Aft Port Freshwater Cooler Leaks or Plugs/Clogs (Gens. 5&6)		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-AP07-F-IE	Aft Port Freshwater Cooler Leaks or Plugs/Clogs (Thruster 5)		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-AP32-F-IE	Diesel 6 Low Temp. Air Cooler Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-AP33-F-IE	Diesel 6 Lube Oil Cooler Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-AP37-F-IE	Diesel 6 High Temp. Air Cooler Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-AP38-F-IE	Generator 6 Lube Oil Cooler Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-AP39-F-IE	Generator 6 Air Cooler Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-AP40-F-IE	Generator 6 Engine Fuel Oil Cooler Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-AP47-F-IE	Thruster 5 Transformer Cooling Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
FWC-HEX-PLG-AP48-F-IE	Thruster 5 Diesel Start Air Compressor Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-AP49-F-IE	Thruster 5 VFD Room Air Conditioning Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-AP50-F-IE	Thruster 5 VFD Cooling Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-AP51-F-IE	Thruster 5 Electrical Motor Cooling Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-AP52-F-IE	Thruster 5 Lube Oil Cooling Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-AP53-F-IE	Thruster 5 Hydraulics Cooling Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-AS06-F-IE	Aft Starboard Freshwater Cooler Leaks or Plugs/Clogs (Gens. 1&2)		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-AS07-F-IE	Aft Starboard Freshwater Cooler Leaks or Plugs/Clogs (Thruster 4)		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-AS32-F-IE	Diesel 2 Low Temp. Air Cooler Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-AS33-F-IE	Diesel 2 Lube Oil Cooler Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-AS37-F-IE	Diesel 2 High Temp. Air Cooler Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-AS38-F-IE	Generator 2 Lube Oil Cooler Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-AS39-F-IE	Generator 2 Air Cooler Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-AS40-F-IE	Generator 2 Engine Fuel Oil Cooler Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-AS47-F-IE	Thruster 4 Transformer Cooling Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-AS48-F-IE	Thruster 4 Diesel Start Air Compressor Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-AS49-F-IE	Thruster 4 VFD Room Air Conditioning Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-AS50-F-IE	Thruster 4 VFD Cooling Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-AS51-F-IE	Thruster 4 Electrical Motor Cooling Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-AS52-F-IE	Thruster 4 Lube Oil Cooling Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-AS53-F-IE	Thruster 4 Hydraulics Cooling Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-FC06-F-IE	Fwd. Center Freshwater Cooler Leaks or Plugs/Clogs (Thruster 1)		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-FC13-F-IE	Thruster 1 Transformer Cooling Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-FC14-F-IE	Thruster 1 Diesel Start Air Compressor Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-FC15-F-IE	Thruster 1 VFD Room Air Conditioning Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-FC16-F-IE	Thruster 1 VFD Cooling Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
FWC-HEX-PLG-FC17-F-IE	Thruster 1 Electrical Motor Cooling Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-FC18-F-IE	Thruster 1 Lube Oil Cooling Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-FC19-F-IE	Thruster 1 Hydraulics Cooling Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-FP06-F-IE	Fwd. Port Freshwater Cooler Leaks or Plugs/Clogs (Thruster 3)		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-FP13-F-IE	Thruster 3 Transformer Cooling Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-FP14-F-IE	Thruster 3 Diesel Start Air Compressor Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-FP15-F-IE	Thruster 3 VFD Room Air Conditioning Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-FP16-F-IE	Thruster 3 VFD Cooling Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-FP17-F-IE	Thruster 3 Electrical Motor Cooling Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-FP18-F-IE	Thruster 3 Lube Oil Cooling Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-FP19-F-IE	Thruster 3 Hydraulics Cooling Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-FS06-F-IE	Fwd. Starboard Freshwater Cooler Leaks or Plugs/Clogs (Thruster 2)		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-FS13-F-IE	Thruster 2 Transformer Cooling Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-FS14-F-IE	Thruster 2 Diesel Start Air Compressor Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-FS15-F-IE	Thruster 2 VFD Room Air Conditioning Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-FS16-F-IE	Thruster 2 VFD Cooling Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-FS17-F-IE	Thruster 2 Electrical Motor Cooling Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-FS18-F-IE	Thruster 2 Lube Oil Cooling Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-HEX-PLG-FS19-F-IE	Thruster 2 Hydraulics Cooling Leaks or Plugs/Clogs		N	1.26E-05			LogNormal	5.01	FWC-HEX-PLG-F-IE	HEATEXCH-PLG
FWC-PMP-FTR-AC26-F-IE	Aft Center Electrically Driven Fresh Water Diesel Low Temp. Cooling Pump (Gen. 4 Cooling System) Fails to Run		N	3.37E-05			LogNormal	9.12	FWC-PMP-FTR-F-IE	ELECPMP-FTR
FWC-PMP-FTR-AC27-F-IE	Aft Center Electrically Driven Fresh Water Generator Cooling Pump (Gen. 4 Cooling System) Fails to Run		N	3.37E-05			LogNormal	9.12	FWC-PMP-FTR-F-IE	ELECPMP-FTR
FWC-PMP-FTR-AC34-F-IE	Aft Center Electrically Driven Fresh Water Diesel High Temp. Cooling Pump (Gen. 4 Cooling System) Fails to Run		N	3.37E-05			LogNormal	9.12	FWC-PMP-FTR-F-IE	ELECPMP-FTR
FWC-PMP-FTR-AC44-F-IE	Aft Center Electrically Driven Fresh Water Thruster Cooling Pump (Thruster 6) Fails to Run		N	3.37E-05			LogNormal	9.12	FWC-PMP-FTR-F-IE	ELECPMP-FTR
FWC-PMP-FTR-AP26-F-IE	Aft Port Electrically Driven Fresh Water Diesel Low Temp. Cooling Pump (Gen. 6 Cooling System) Fails to Run		N	3.37E-05			LogNormal	9.12	FWC-PMP-FTR-F-IE	ELECPMP-FTR

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
FWC-PMP-FTR-AP27-F-IE	Aft Port Electrically Driven Fresh Water Generator Cooling Pump (Gen. 6 Cooling System) Fails to Run		N	3.37E-05			LogNormal	9.12	FWC-PMP-FTR-F-IE	ELECPMP-FTR
FWC-PMP-FTR-AP34-F-IE	Aft Port Electrically Driven Fresh Water Diesel High Temp. Cooling Pump (Gen. 6 Cooling System) Fails to Run		N	3.37E-05			LogNormal	9.12	FWC-PMP-FTR-F-IE	ELECPMP-FTR
FWC-PMP-FTR-AP44-F-IE	Aft Port Electrically Driven Fresh Water Thruster Cooling Pump AP44 (Thruster 5) Fails to Run		N	3.37E-05			LogNormal	9.12	FWC-PMP-FTR-F-IE	ELECPMP-FTR
FWC-PMP-FTR-AS26-F-IE	Aft Starboard Electrically Driven Fresh Water Diesel Low Temp. Cooling Pump (Gen. 2 Cooling System) Fails to Run		N	3.37E-05			LogNormal	9.12	FWC-PMP-FTR-F-IE	ELECPMP-FTR
FWC-PMP-FTR-AS27-F-IE	Aft Starboard Electrically Driven Fresh Water Generator Cooling Pump (Gen. 2 Cooling System) Fails to Run		N	3.37E-05			LogNormal	9.12	FWC-PMP-FTR-F-IE	ELECPMP-FTR
FWC-PMP-FTR-AS34-F-IE	Aft Starboard Electrically Driven Fresh Water Diesel High Temp. Cooling Pump (Gen. 2 Cooling System) Fails to Run		N	3.37E-05			LogNormal	9.12	FWC-PMP-FTR-F-IE	ELECPMP-FTR
FWC-PMP-FTR-AS44-F-IE	Aft Starboard Electrically Driven Fresh Water Thruster Cooling Pump AS44 (Thruster 4) Fails to Run		N	3.37E-05			LogNormal	9.12	FWC-PMP-FTR-F-IE	ELECPMP-FTR
FWC-PMP-FTR-FC10-F-IE	Forward Center Electrically Driven Fresh Water Thruster Cooling Pump (Thruster 1) Fails to Run		N	3.37E-05			LogNormal	9.12	FWC-PMP-FTR-F-IE	ELECPMP-FTR
FWC-PMP-FTR-FP10-F-IE	Forward Port Electrically Driven Fresh Water Thruster Cooling Pump (Thruster 3) Fails to Run		N	3.37E-05			LogNormal	9.12	FWC-PMP-FTR-F-IE	ELECPMP-FTR
FWC-PMP-FTR-FS10-F-IE	Forward Starboard Electrically Driven Fresh Water Thruster Cooling Pump FS10 (Thruster 2) Fails to Run		N	3.37E-05			LogNormal	9.12	FWC-PMP-FTR-F-IE	ELECPMP-FTR
SWC-PMP-FTR-AC03-F-IE	Aft Center Electrically Driven Sea Water Cooling Pump Fails to Run		N	3.37E-05			LogNormal	9.12	SWC-PMP-FTR-F-IE	ELECPMP-FTR
SWC-PMP-FTR-AP03-F-IE	Aft Port Electrically Driven Sea Water Cooling Pump Fails to Run		N	3.37E-05			LogNormal	9.12	FWC-PMP-FTR-F-IE	ELECPMP-FTR
SWC-PMP-FTR-AS03-F-IE	Aft Starboard Electrically Driven Sea Water Cooling Pump Fails to Run		N	3.37E-05			LogNormal	9.12	SWC-PMP-FTR-F-IE	ELECPMP-FTR
SWC-PMP-FTR-FC03-F-IE	Forward Center Electrically Driven Sea Water Cooling Pump Fails to Run		N	3.37E-05			LogNormal	9.12	SWC-PMP-FTR-F-IE	ELECPMP-FTR
SWC-PMP-FTR-FP03-F-IE	Forward Port Electrically Driven Sea Water Cooling Pump Fails to Run		N	3.37E-05			LogNormal	9.12	SWC-PMP-FTR-F-IE	ELECPMP-FTR
SWC-PMP-FTR-FS03-F-IE	Forward Starboard Electrically Driven Sea Water Cooling Pump Fails to Run		N	3.37E-05			LogNormal	9.12	SWC-PMP-FTR-F-IE	ELECPMP-FTR
SWC-SCH-CLG-APSC1-F-IE	Aft Port Sea Chest APSC1 Clogged		N	6.34E-07			LogNormal	3.71	SWC-SCH-CLG-F-IE	HULLINT-CLG
SWC-SCH-CLG-ASSC2-F-IE	Aft Starboard Sea Chest ASSC2 Clogged		N	6.34E-07			LogNormal	3.71	SWC-SCH-CLG-F-IE	HULLINT-CLG
SWC-SCH-CLG-FPSC3-F-IE	Forward Port Sea Chest FPSC3 Clogged		N	6.34E-07			LogNormal	3.71	SWC-SCH-CLG-F-IE	HULLINT-CLG

Event	Description	Calc. Prob.	Failure Type	Probability/ Frequency	Lambda	Mission Time	Distribution	EF	Template	Correlation Class
ACC-STACK-RECHARGE-FREQ	Stack accumulators need to be recharged (Assume once per well)	1	1	1			PointValue		ACC-RECHARGE-FREQ	
SWC-SCH-CLG-FSSC4-F-IE	Forward Starboard Sea Chest fSSC4 Clogged		N	6.34E-07			LogNormal	3.71	SWC-SCH-CLG-F-IE	

- \- These events are used as a flag to indicate a specific scenario occurs

APPENDIX H- COMMON CAUSE EVENT DESCRIPTIONS

H.1 INTRODUCTION

A Common Cause Failure (CCF) event is a dependent failure in which two or more components fail simultaneously, or within a short time interval, and are a direct result of a shared cause, such as:

- Environmental factors (vibration, thermal stress, humidity, etc.)
- Manufacturing defects
- Human error (installation error, improper maintenance, etc.)
- Design error

CCF events do not include failures due to support systems (e.g., three computers fail due to loss of a single power supply). Such failures are normally modeled explicitly in a fault tree analysis. Therefore, CCF events are dependent failures not otherwise accounted for in a probabilistic risk model.

There are a few models to evaluate CCF. In this project the following two methods have been used:

- Beta Factor
- Alpha Factor

The oldest and simplest method is the Beta Factor model in which common cause is modeled by multiplying the failure probability of a single item (independent failure) by a constant (the common cause factor or beta factor) to obtain the probability that multiple failures occur due to the same cause. This model is often used for simple, dually redundant systems where the global common cause term of all components failing is driving the risk. The common cause factor is usually low (3%-12%) but there may be instances where it could be of much higher values.

For systems where the exact combinations of failures are important, a more comprehensive method such as the Alpha Factor model is needed. An example would be where a drillship has six thrusters for positioning, and certain combinations (e.g. losing all aft or forward thrusters) can lead to failure coupled with the necessary environmental conditions. Another simplification used in this study is to group common cause failure combinations into one "global" common cause term, one that accounts for all like components failing. For example, if there are four similar pumps in a system (P1, P2, P3 and P4) and at least three pumps are needed for the system to succeed, the combination of pump failures that would fail the system are:

- Six combinations of independent failures of any two pumps: P1*P2, P1*P3, P1*P4, P2*P3, P2*P4, P3*P4

- Six common cause failures of any two pumps: CCFP1P2, CCFP1P3, CCFP1P4, CCFP2P3, CCFP2P4, CCFP3P4

- Four common cause failures of any three pumps: CCFP1P2P3, CCFP1P2P4, CCFP1P3P4, CCFP2P3P4

- One common cause failure of all four pumps: CCFP1P2P3P4

Using the global cause term simplification, instead of including in the fault tree the eleven common cause terms shown above, only one global CCF term is included that accounts for all the eleven combinations.

The PRA Procedures Guide for Offshore Applications [H-1] explains the process of common cause failure modeling, as well as the Beta Factor and Alpha Factor methods. The United States Nuclear Regulatory Commission CCF Parameter Estimations [H-2] provides more details on CCF parameter quantification.

For normally operating components, common cause failures as initiators were not modeled. The only exception is for the sea chests, for which common cause clogging of the two aft sea chests, and of the two forward sea chests are included as potential initiators. However, after the initiator, i.e. post-initiator, common cause failure events are included for all applicable components.

In this analysis, the Beta Factor model was implemented with a common cause factor of 5%. This value is consistent with values used in other industries (e.g., nuclear, space, etc.) and is the value recommended by the data source "SINTEF Reliability Data for Safety Instrumented Systems" [H-3]. In SAPHIRE the Beta Factor model is captured using a Compound event that multiplies the beta value (BETA-CCF) by the independent failure probability of the component.

For the more complex common cause events, the Alpha Factor model is used with the CCF factors computed on a case by case basis as explained in this Appendix. In SAPHIRE, the Alpha Factor model is implemented in one of two ways:

- Using a RaspCCF event with the R-Common Cause Failure and Alpha Factor failure model when all combinations of common cause events within the common cause group are relevant to include for modelling the system failure.

- Using a Compound event (similar to the Beta Factor model) when all combinations of failures within the common cause group are merged into a global alpha factor which is calculated with assistance of the Global Alpha Model Uncertainty Tool (GAMUT) [H4]. GAMUT is a tool developed in-house by NASA expressly for this purpose. The use of this routine is necessary when not all combinations of common cause failures cause the system failure (and therefore SAPHIRE cannot correct for this directly).

In both cases, the alpha factors used in the CCF calculations are obtained from the US Nuclear Regulatory Commission, CCF Parameter Estimations, 2012 Update [H2].

H.2 IMPLEMENTATION OF THE BETA FACTOR MODEL

The implementation of common cause events using the Beta Factor model is straight forward, so only one such event is described here as an example. Table H- 1 lists all CCF events in the model so all Beta factor CCF events can be identified and reviewed.

As an example, the CCF failure of the RCM pressure regulators T01 and T02 is chosen. As a pre-requisite to defining the CCF event, all the independent failures have to be defined and entered in SAPHIRE. For this case, the basic events BOP-PRG-FLO-T01 and BOP-PRG-FLO-T02, as well as the common cause beta factor BETA-CCF are entered as basic event in SAPHIRE. Recall that the Beta Factor is defined as a "Value" event 0.05. A new basic event, BOP-PRG-FLO-T0102CCF, corresponding to the common cause failure of the two pressure regulators T01 and T02 is created. The new event is set using a Failure Model "C-Compound Event", Library "PLUGUTIL" and Procedure "MULTIPLY", as can be seen in Figure H-1. At this point the independent event and beta factor can be entered with the "ADD Event" button. The events can also be added by dragging them from the "Basic Events" list in SAPHIRE into the space for Event 0 and Event 1. In this case, one of the independent failures BOP-PRG-FLO-T02 (the other independent failure has the same value, so only one is added), and the beta factor BETA-CCF are added to the common cause event. SAPHIRE then calculates the common cause probability by multiplying the two events added, i.e. BOP-PRG-FLO-T02 and the beta factor BETA-CCF.

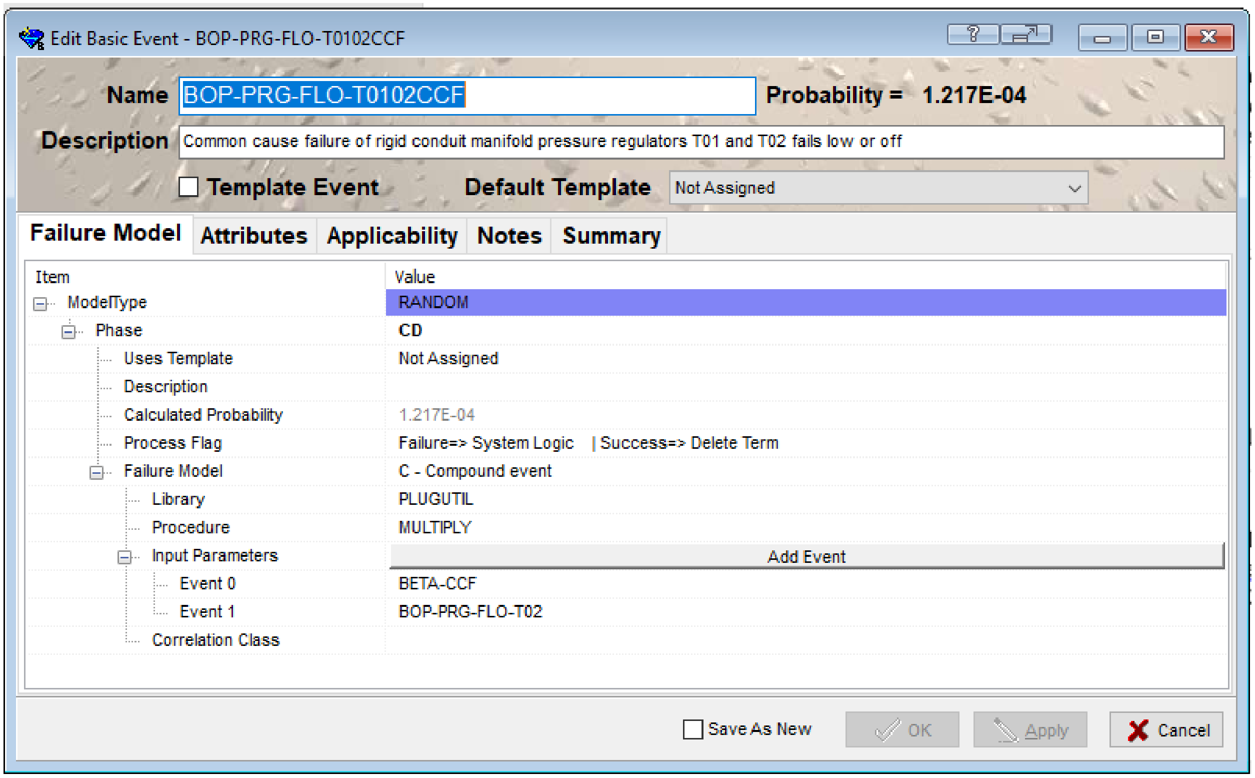


Figure H- 1: SAPHIRE screen to define Beta Factor CCF event

The calculated probability is summarized below including CCF basic event name, Calculated CCF Probability, Failure Type "C" for Compound, Method "Beta", Failure Criteria "All" (meaning all components in the group fail together), Independent Failure Events and CCF Factors (in this case Beta factor).

CCF BASIC EVENT NAME	CALC CCF PROB	FAILURE TYPE	METHOD	FAILURE CRITERIA	INDEPENDENT FAILURE EVENTS	CCF FACTORS
BOP-PRG-FLO-T0102CCF	1.22E-04	C	Beta	All	BOP-PRG-FLO-T01 BOP-PRG-FLO-T02	BETA-CCF

H.3 IMPLEMENTATION OF THE ALPHA FACTOR MODEL (RaspCCF)

The example selected to demonstrate the RaspCCF modeling is the thruster cooling common cause events. There are two redundant auxiliary cooling water pumps per thruster, one running and one in standby. The fresh water pumps for each thruster are located in separate compartments and due to the large number of them, the only common cause events considered credible are within each thruster, i.e. two cooling pumps. The cooling pumps involved are:

- Thruster FT01: Feedwater cooling pumps FC09 and FC10
- Thruster FT02: Feedwater cooling pumps FS09 and FS10
- Thruster FT03: Feedwater cooling pumps FP09 and FP10
- Thruster AT04: Feedwater cooling pumps AS43 and AS44
- Thruster AT05: Feedwater cooling pumps AP43 and AP44
- Thruster AT06: Feedwater cooling pumps AC43 and AC44

The following common cause events are included, one per thruster, for both nominal weather and extreme weather:

- WC-PMP-FTR-1ALLCCF Common Cause Failure of Thruster 1 Fresh Water Cooling Pumps
- FWC-PMP-FTR-1ALLCCFH Common Cause Failure of Thruster 1 Fresh Water Cooling Pumps (Extreme Weather)
- FWC-PMP-FTR-2ALLCCF Common Cause Failure of Thruster 2 Fresh Water Cooling Pumps
- FWC-PMP-FTR-2ALLCCFH Common Cause Failure of Thruster 2 Fresh Water Cooling Pumps (Extreme Weather)
- FWC-PMP-FTR-3ALLCCF Common Cause Failure of Thruster 3 Fresh Water Cooling Pumps
- FWC-PMP-FTR-3ALLCCFH Common Cause Failure of Thruster 3 Fresh Water Cooling Pumps (Extreme Weather)
- FWC-PMP-FTR-4ALLCCF Common Cause Failure of Thruster 4 Fresh Water Cooling Pumps
- FWC-PMP-FTR-4ALLCCFH Common Cause Failure of Thruster 4 Fresh Water Cooling Pumps (Extreme Weather)
- FWC-PMP-FTR-5ALLCCF Common Cause Failure of Thruster 5 Fresh Water Cooling Pumps
- FWC-PMP-FTR-5ALLCCFH Common Cause Failure of Thruster 5 Fresh Water Cooling Pumps (Extreme Weather)
- FWC-PMP-FTR-6ALLCCF Common Cause Failure of Thruster 6 Fresh Water Cooling Pumps
- FWC-PMP-FTR-6ALLCCFH Common Cause Failure of Thruster 6 Fresh Water Cooling Pumps (Extreme Weather)

As a pre-requisite to defining the alpha factor CCF event, all the independent failures have to be defined and entered in SAPHIRE. Taking the first basic event FWC-PMP-FTR-1ALLCCF, the independent failure basic events FWC-PMP-FTR-FC10 and FWC-PMP-FTR-FC09 are defined. Additionally the alpha factors have to be entered in SAPHIRE as "Value" events. In this case: D-O-C-EPMP-TALP1-FTR and D-O-C-EPMP-TALP2-FTR. It is recalled that the alpha factors used in this study are generic alpha factors from [H-2]. At this point the CCF event that involves those two events can be defined. A new basic event is created, in this case by the name FWC-PMP-FTR-1ALLCCF, corresponding to the common cause failure of the two fresh water cooling pumps FC09 and FC10.

For these pumps, the alpha factor model was selected, using the Failure Type "R – Common Cause Failure" (RaspCCF) option in SAPHIRE. The event involves two fresh water cooling pumps failing to run. While the independent failure rates are the same for nominal weather and extreme weather, their failure probabilities are different because the mission times are different. The alpha factors are the same for all cases and the values correspond to the Alpha Factors for Generic Rate CCF Distribution in a group of 2 components [H-2]:

CCF FACTOR NAME	CCF FACTOR DESCRIPTION	FACTOR	EF
D-O-C-EPMP-TALP1-FTR	Common Cause Alpha 1 Value for Thruster FWC Pumps	9.64E-01	1.0
D-O-C-EPMP-TALP2-FTR	Common Cause Alpha 2 Value for Thruster FWC Pumps	3.56E-02	1.3

The error factors EF for the Beta Factors were calculated assuming that they are lognormally distributed by diving the 95th percentile by the median value, as given in the generic CCF factor tables [H-2].

Figure H-2 shows the SAPHIRE Common Cause Failure window for one of the fresh water cooling pumps common cause events. It is noted that "Alpha Factors" is selected as Model, Testing Scheme is "Staggered" and Results Detail Level is "Rolled Up". The latter means that all common cause combinations in the group would be rolled up into one global common cause event. Since this example includes only two pumps, there is no difference between the Rolled Up or Full Detail. In this window the user identifies the applicable independent failure events (in this case failure to run of fresh water cooling pumps FC09 and FC10), and the alpha factors. It is noted that the Alpha Factors are entered in the Factors column of the basic event window.

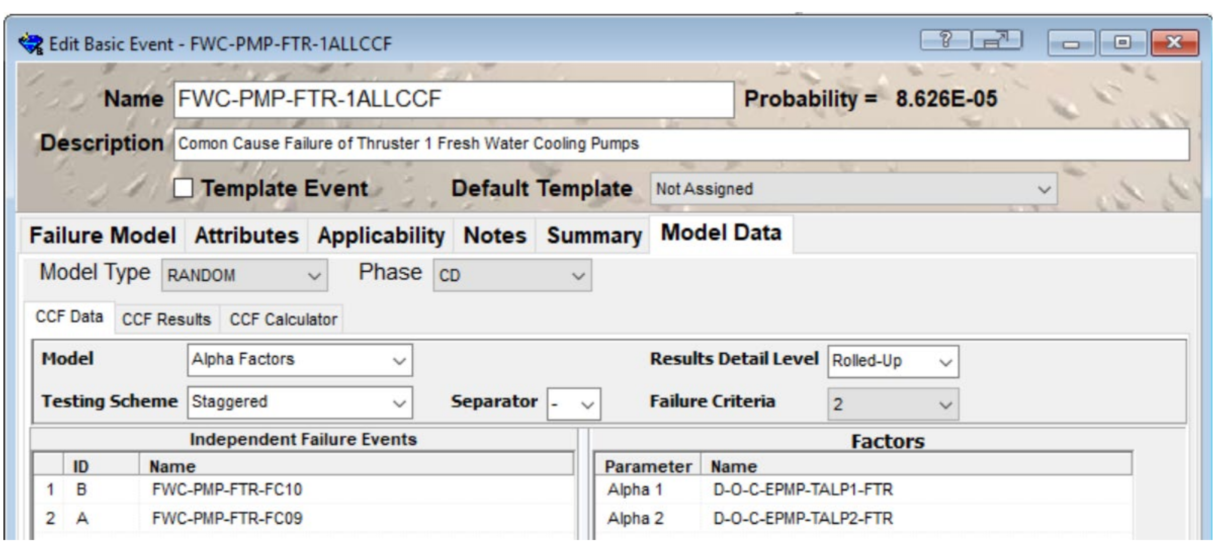


Figure H- 2: RaspCCF Window for Alpha Factor CCF Event

SAPHIRE calculates the CCF probability of failure based on the parameters selected. The calculated CCF probabilities are:

CCF BASIC EVENT NAME	CALC CCF PROB	FAILURE TYPE	METHOD	FAILURE CRITERIA	INDEPENDENT FAILURE EVENTS	CCF FACTORS
FWC-PMP-FTR-1ALLCCF	8.63E-05	R	Alpha	2	FWC-PMP-FTR-FC10 FWC-PMP-FTR-FC09	D-O-C-EPMP-TALP1-FTR D-O-C-EPMP-TALP2-FTR
FWC-PMP-FTR-1ALLCCFH	4.80E-06	R	Alpha	2	FWC-PMP-FTR-FC10H FWC-PMP-FTR-FC09H	D-O-C-EPMP-TALP1-FTR D-O-C-EPMP-TALP2-FTR
FWC-PMP-FTR-2ALLCCF	8.63E-05	R	Alpha	2	FWC-PMP-FTR-FS10 FWC-PMP-FTR-FS09	D-O-C-EPMP-TALP1-FTR D-O-C-EPMP-TALP2-FTR
FWC-PMP-FTR-2ALLCCFH	4.80E-06	R	Alpha	2	FWC-PMP-FTR-FS10H FWC-PMP-FTR-FS09H	D-O-C-EPMP-TALP1-FTR D-O-C-EPMP-TALP2-FTR
FWC-PMP-FTR-3ALLCCF	8.63E-05	R	Alpha	2	FWC-PMP-FTR-FP10 FWC-PMP-FTR-FP09	D-O-C-EPMP-TALP1-FTR D-O-C-EPMP-TALP2-FTR
FWC-PMP-FTR-3ALLCCFH	4.80E-06	R	Alpha	2	FWC-PMP-FTR-FP10H FWC-PMP-FTR-FP09H	D-O-C-EPMP-TALP1-FTR D-O-C-EPMP-TALP2-FTR
FWC-PMP-FTR-4ALLCCF	8.63E-05	R	Alpha	2	FWC-PMP-FTR-AS44 FWC-PMP-FTR-AS43	D-O-C-EPMP-TALP1-FTR D-O-C-EPMP-TALP2-FTR
FWC-PMP-FTR-4ALLCCFH	4.80E-06	R	Alpha	2	FWC-PMP-FTR-AS44H FWC-PMP-FTR-AS43H	D-O-C-EPMP-TALP1-FTR D-O-C-EPMP-TALP2-FTR
FWC-PMP-FTR-5ALLCCF	8.63E-05	R	Alpha	2	FWC-PMP-FTR-AP44 FWC-PMP-FTR-AP43	D-O-C-EPMP-TALP1-FTR D-O-C-EPMP-TALP2-FTR
FWC-PMP-FTR-5ALLCCFH	4.80E-06	R	Alpha	2	FWC-PMP-FTR-AP44H FWC-PMP-FTR-AP43H	D-O-C-EPMP-TALP1-FTR D-O-C-EPMP-TALP2-FTR
FWC-PMP-FTR-6ALLCCF	8.63E-05	R	Alpha	2	FWC-PMP-FTR-AC44 FWC-PMP-FTR-AC43	D-O-C-EPMP-TALP1-FTR D-O-C-EPMP-TALP2-FTR
FWC-PMP-FTR-6ALLCCFH	4.80E-06	R	Alpha	2	FWC-PMP-FTR-AC44H FWC-PMP-FTR-AC43H	D-O-C-EPMP-TALP1-FTR D-O-C-EPMP-TALP2-FTR

The calculated CCF probability is 0.04 of the independent failure probability which is very similar to the 0.05 CCF factor assumed for the Beta Factor model.

H.4 IMPLEMENTATION OF THE ALPHA FACTOR MODEL (GAMUT)

Fresh Water Cooling System, Diesel Generator Cooling:

There are six diesel generators arranged to feed three power generating systems. Two generators feed each power bus. During normal operation, within each bus, one generator is on-line and running and the other is off-line but maintained as a hot standby. Each diesel generator is cooled by three non-redundant fresh water pumps (one low temperature cooling pump, one high temperature cooling pump and one generator cooling water pump). Only common cause failure events of the fresh water cooling pumps and the temperature regulating valves within each power generating system are considered credible. Therefore a CCF group of six fresh water pumps per generator group and another CCF group of two temperature regulating valves were considered, as follows:

Aft Starboard Generator Group:

- Fresh Water cooling pumps AS10, AS11, AS18, AS26, AS27, AS34
- Temperature Regulating Valves FWC-AOV-FOP-AS09 and FWC-AOV-FOP-AS25

Aft Center Generator Group:

- Fresh Water cooling pumps AC10, AC11, AC18, AC26, AC27, AC34
- Temperature Regulating Valves FWC-AOV-FOP-AC09 and FWC-AOV-FOP-AC25

Aft Port Generator Group:

- Fresh Water cooling pumps AP10, AP11, AP18, AP26, AP27, AP34
- Temperature Regulating Valves FWC-AOV-FOP-AP09 and FWC-AOV-FOP-AP25

Fresh Water Cooling Pumps CCF events:

The following common cause events are included. Each event has one per power generating group, for both nominal weather and extreme weather:

FWC-PMP-FTR-CNT34CCF	Common Cause Failure of Diesel Fresh Water Pumps for Generators 3 & 4 (Center generator group)
FWC-PMP-FTR-CNT34CCFH	Common Cause Failure of Diesel Fresh Water Pumps for Generators 3 & 4 (Center generator group) - Extreme Weather
FWC-PMP-FTR-PRT56CCF	Common Cause Failure of Diesel Fresh Water Pumps for Generators 5 & 6 (Port generator group)
FWC-PMP-FTR-PRT56CCFH	Common Cause Failure of Diesel Fresh Water Pumps for Generators 5 & 6 (Port generator group) - Extreme Weather
FWC-PMP-FTR-STB12CCF	Common Cause Failure of Diesel Fresh Water Pumps for Generators 1 & 2 (Starboard generator group)

FWC-PMP-FTR-STB12CCFH Common Cause Failure of Diesel Fresh Water Pumps for Generators 1 & 2 (Starboard generator group) - Extreme Weather

For these pump CCF events, the alpha factor model was selected. It is noted by looking at the design configuration in Figure E-20 that not all CCF combinations would cause failure of both diesel generators in the power generating system. While failure of all 6 pumps, or any 5 or 4 pumps within each group would certainly cause failure of both generators, not all failure combinations of two or three pumps would achieve the same result. In order to calculate a global common cause factor that includes only those combinations that result in both diesel generator failures, GAMUT [H4] is used in combination with an EXCEL macro. The macro is used to help identify and count the exact number of fresh water cooling pump combinations that cause both diesel generator failures. GAMUT uses the Alpha Factors for Generic Rate CCF Distribution [H2], in this case for a group of six components. Figure H-3 shows the global alpha factor with EF to be used in SAPHIRE. It also shows in the column labeled c_k the number of combinations for each common cause group that can cause system failure (in this case two diesel generators failure).

k	System Status	c_k	$\binom{m-1}{k-1}$	α_k	Var(α_k)	$\overline{Q}_k^{(m)}$ Mean	$\overline{Q}_k^{(m)}$ Variance
1	OK	0	1.0E+00	9.76E-01	6.2E-06	0.0E+00	0.0E+00
2	LOC	9	5.0E+00	6.8E-03	1.8E-06	1.2E-02	5.7E-06
3	LOC	18	1.0E+01	6.8E-03	1.8E-06	1.2E-02	5.7E-06
4	LOC	15	1.0E+01	5.4E-03	1.4E-06	8.0E-03	3.1E-06
5	LOC	6	5.0E+00	3.0E-03	7.9E-07	3.6E-03	1.1E-06
6	LOC	1	1.0E+00	2.3E-03	6.0E-07	2.3E-03	6.0E-07

Global Results	LOC	LOM
Global Alpha, A	3.85E-02	0.0E+00
Variance	1.6E-05	0.0E+00
5th	3.2E-02	-----
Median	3.8E-02	-----
95th	4.5E-02	-----
Beta Parameter *a*	8.7E+01	-----
Beta Parameter *b*	2.2E+03	-----
Error Factor	1.19	-----
α_t	1.06	

$Q_{Independent}$	
Mean	9.8E-01
Variance	6.2E-06
Beta Parameter *a*	3.7E+03
Beta Parameter *b*	9.3E+01

Figure H- 3: GAMUT Calculation Results

The resulting common cause factor is:

CCF FACTOR NAME: FWC-PMP-FTR-2GRP3-GLOCCF

CCF FACTOR DESCRIPTION: Global CCF for DGN cooling water pumps, 2 trains of 3 pumps, corrected for critical failures

FACTOR: 3.85E-02

EF: 1.19

The common cause events are entered using the Failure Type "C – Compound Event" option, since the global CCF is a single value calculated by GAMUT [H4]. The compound event allows for the multiplication of two factors (the independent failure probability and the global CCF factor. While the independent failure rates are the same for nominal weather and extreme weather, their failure probabilities are different because the mission times are different. The alpha factors are the same for all cases. The resulting CCF probabilities are:

CCF BASIC EVENT NAME	CALC CCF PROB	FAILURE TYPE	METHOD	FAILURE CRITERIA	INDEPENDENT FAILURE EVENTS	CCF FACTORS
FWC-PMP-FTR-CNT34CCF	9.33E-05	C	Alpha (GAMUT)	Custom	FWC-PMP-FTR-AC10	FWC-PMP-FTR-2GRP3-GLOCCF
FWC-PMP-FTR-CNT34CCFH	5.19E-06	C	Alpha (GAMUT)	Custom	FWC-PMP-FTR-AC10H	FWC-PMP-FTR-2GRP3-GLOCCF
FWC-PMP-FTR-PRT56CCF	9.33E-05	C	Alpha (GAMUT)	Custom	FWC-PMP-FTR-AP10	FWC-PMP-FTR-2GRP3-GLOCCF
FWC-PMP-FTR-PRT56CCFH	5.19E-06	C	Alpha (GAMUT)	Custom	FWC-PMP-FTR-AP10H	FWC-PMP-FTR-2GRP3-GLOCCF
FWC-PMP-FTR-STB12CCF	9.33E-05	C	Alpha (GAMUT)	Custom	FWC-PMP-FTR-AS10	FWC-PMP-FTR-2GRP3-GLOCCF
FWC-PMP-FTR-STB12CCFH	5.19E-06	C	Alpha (GAMUT)	Custom	FWC-PMP-FTR-AS10H	FWC-PMP-FTR-2GRP3-GLOCCF

It is noted that Failure Criteria is indicated as "Custom" because it is calculated on a case by case basis depending on the success criteria. In each case the calculations are performed using GAMUT [H4] and the Excel macro).

Temperature Regulating Valves CCF events:

The following common cause events are included assuming two regulating valves per power generating group:

FWC-AOV-FOP-AC0925CCF	Common Cause Failure of Diesel Temp. Reg. Valve for Generators 3 & 4 (AC09 and AC25)
FWC-AOV-FOP-AP0925CCF	Common Cause Failure of Diesel Temp. Reg. Valve for Generators 5 & 6 (AP09 and AP25)
FWC-AOV-FOP-AS0925CCF	Common Cause Failure of Diesel Temp. Reg. Valve for Generators 1 & 2 (AS09 and AS25)

The alpha factor model was selected to model the CCF for these valves. The Failure Type "R – Common Cause Failure" (RaspCCF) option in SAPHIRE was selected and set for a group of two. The event involves two temperature regulating valves failing to operate. The alpha factors are the same for all three cases and the values correspond to the Alpha Factors for Generic Rate CCF Distribution in a group of 2 components [H2]:

CCF FACTOR NAME	CCF FACTOR DESCRIPTION	FACTOR	EF
D-O-C-TVLV-ALP1-FTR	Alpha 1 Value for Temperature Regulating Valve Common Cause Failure	9.78E-01	1.00
D-O-C-TVLV-ALP2-FTR	Alpha 2 Value for Temperature Regulating Valve Common Cause Failure	2.19E-02	1.40

After creating the CCF basic events and entering the corresponding information as explained earlier, SAPHIRE calculates the CCF probability of failure based on the parameters selected. The calculated CCF probabilities are:

CCF BASIC EVENT NAME	CALC CCF PROB	FAILURE TYPE	METHOD	FAILURE CRITERIA	INDEPENDENT FAILURE EVENTS	CCF FACTORS
FWC-AOV-FOP-AC0925CCF	2.98E-07	R	Alpha	2	FWC-AOV-FOP-AC09 FWC-AOV-FOP-AC25	D-O-C-TVLV-ALP1-FTR D-O-C-TVLV-ALP2-FTR
FWC-AOV-FOP-AP0925CCF	2.98E-07	R	Alpha	2	FWC-AOV-FOP-AP09 FWC-AOV-FOP-AP25	D-O-C-TVLV-ALP1-FTR D-O-C-TVLV-ALP2-FTR
FWC-AOV-FOP-AS0925CCF	2.98E-07	R	Alpha	2	FWC-AOV-FOP-AS09 FWC-AOV-FOP-AS25	D-O-C-TVLV-ALP1-FTR D-O-C-TVLV-ALP2-FTR

Sea Water Cooling System

Twelve sea water cooling pumps provide cooling to nine fresh water coolers. Figure E-22 shows the arrangement of these pumps. The 12 sea water pumps are arranged in pairs, one in operation and the other in standby. Three pairs are located in the aft region of the drillship and the other three pairs are located in the forward region. Each aft pair cools two fresh water coolers, a power diesel generator group cooler and a thruster cooler. Each forward pair cools a thruster cooler.

- Aft Starboard Generator Group and Thruster AT04: Sea Water cooling pumps AS02, AS03
- Aft Center Generator Group and Thruster AT06: Sea Water cooling pumps AC02, AC03
- Aft Port Generator Group and Thruster AT05: Sea Water cooling pumps AP02, AP03
- Thruster FT02 (forward starboard): Sea Water cooling pumps FS02, FS03
- Thruster FT01 (forward center): Sea Water cooling pumps FC02, FC03
- Thruster FT03 (forward port): Sea Water cooling pumps FP02, FP03

A common cause failure group of twelve sea water pumps was considered. The following common cause events are modeled:

SWC-PMP-FTR-GLO2CCF-T123	CCF of Sea Water Pumps (all combinations that fail 2 or more thrusters, given that one forward thruster has failed)
SWC-PMP-FTR-GLO2CCF-T456	CCF of Sea Water Pumps (all combinations that fail 2 or more thrusters, given that one aft thruster has failed)
SWC-PMP-FTR-GLOBAL1CCFH	CCF of Cooling System Sea Water Pumps during a kick control (all comb that fail 1 or more thrusters) - Extreme Weather
SWC-PMP-FTR-GLOBAL3CCF	CCF of Cooling System Sea Water Pumps during a kick control (all combinations that fail 3 or more thrusters)

For these pump CCF events, the alpha factor model was selected. It is noted by looking at the design configuration in Figure E-22 that not all CCF combinations would cause the required thruster failures. In order to calculate a global common cause factor for each CCF event, GAMUT [H4] is used in combination with an EXCEL macro as explained earlier. The macro is used to help identify and count the exact number of sea water cooling pump combinations that cause the applicable thruster failures. GAMUT [H4] uses the Alpha Factors for Generic Rate CCF Distribution [H2], however the maximum CCF group size is 8. Since in this case the CCF group is twelve components, GAMUT [H4] extrapolates the parameters accordingly.

SWC-PMP-FTR-GLO2CCF-T123:

This CCF event is used for the DRIFT-OFFPUSH-OFF_IEFT_FRE fault tree, when thruster 1, 2 or 3 fails as an initiating event. The CCF corresponds to a group of 12 Sea Water Cooling pumps causing failures of 2 or more thrusters (since one thruster has already failed, thruster 1, 2 or 3 for this case). Critical failures were obtained using the EXCEL macro because not all combinations of SWC pump failures cause 2 or more thruster failures. It should be noted that failure of some SWC pumps affect the thrusters directly, while others affect diesel generator operation and by extension the thrusters driven by them. Figure H-4 shows the 12 calculated alpha factors as well as the global alpha factor with EF to be used in SAPHIRE.

k	System Status	c_k	$\binom{m-1}{k-1}$	α_k	Var(α_k)	$\bar{Q}_k^{(m)}$ Mean	$\bar{Q}_k^{(m)}$ Variance
1	OK	0	1.0E+00	9.77E-01	6.6E-05	0.0E+00	0.0E+00
2	LOC	2	1.1E+01	1.0E-02	3.1E-05	1.8E-03	1.0E-06
3	LOC	20	5.5E+01	5.5E-03	1.5E-05	2.0E-03	2.0E-06
4	LOC	92	1.7E+02	3.0E-03	9.7E-06	1.7E-03	3.0E-06
5	LOC	256	3.3E+02	1.7E-03	6.5E-06	1.3E-03	3.9E-06
6	LOC	468	4.6E+02	9.6E-04	3.4E-06	9.7E-04	3.4E-06
7	LOC	568	4.6E+02	5.6E-04	1.2E-06	6.9E-04	1.8E-06
8	LOC	447	3.3E+02	3.5E-04	3.7E-07	4.7E-04	6.8E-07
9	LOC	220	1.7E+02	2.3E-04	7.2E-07	3.1E-04	1.3E-06
10	LOC	66	5.5E+01	1.7E-04	5.3E-07	2.1E-04	7.6E-07
11	LOC	12	1.1E+01	1.4E-04	4.2E-07	1.5E-04	5.0E-07
12	LOC	1	1.0E+00	1.2E-04	3.6E-07	1.2E-04	3.6E-07

Global Results	LOC	LOM
Global Alpha, A	9.70E-03	0.0E+00
Variance	1.9E-05	0.0E+00
5th	3.8E-03	-----
Median	9.1E-03	-----
95th	1.8E-02	-----
Beta Parameter *a*	5.0E+00	-----
Beta Parameter *b*	5.1E+02	-----
Error Factor	2.02	-----
α_t	1.05	

$Q_{Independent}$	
Mean	9.8E-01
Variance	6.6E-05
Beta Parameter *a*	3.3E+02
Beta Parameter *b*	7.6E+00

Figure H- 4: GAMUT Calculation Results for SWC-PMP-FTR-GLO2CCF-T123

The resulting common cause factor is:

CCF FACTOR NAME SWC-PMP-FTR-ALP2THR-T123

CCF FACTOR DESCRIPTION Global Alpha Factor for SWC-PMP-FTR (Calculated with GAMUT using modified critical failures to fail 2 or more thrusters after thruster 1, 2 or 3 failure)

FACTOR 9.70E-03

EF 2.02

SWC-PMP-FTR-GLO2CCF-T456:

This CCF event is used for the DRIFT-OFFPUSH-OFF_IEFT_FRE fault tree, when thruster 4, 5 or 6 fails as an initiating event. The CCF corresponds to a group of 12 Sea Water Cooling pumps causing failures of 2 or more thrusters (since one thruster has already failed, thruster 4, 5 or 6 for this case). Critical failures were obtained using the EXCEL macro because not all combinations of SWC pump failures cause 2 or more thruster failures. It should be noted again that failure of some SWC pumps affect the thrusters directly, while others affect diesel generator operation and by extension the thrusters driven by them. Figure H-5 shows the 12 calculated alpha factors as well as the global alpha factor with EF to be used in SAPHIRE.

k	System Status	c_k	$\binom{m-1}{k-1}$	α_k	Var(α_k)	$\bar{Q}_k^{(m)}$ Mean	$\bar{Q}_k^{(m)}$ Variance
1	OK	0	1.0E+00	9.77E-01	6.6E-05	0.0E+00	0.0E+00
2	LOC	2	1.1E+01	1.0E-02	3.1E-05	1.8E-03	1.0E-06
3	LOC	20	5.5E+01	5.5E-03	1.5E-05	2.0E-03	2.0E-06
4	LOC	94	1.7E+02	3.0E-03	9.7E-06	1.7E-03	3.1E-06
5	LOC	272	3.3E+02	1.7E-03	6.5E-06	1.4E-03	4.4E-06
6	LOC	516	4.6E+02	9.6E-04	3.4E-06	1.1E-03	4.2E-06
7	LOC	632	4.6E+02	5.6E-04	1.2E-06	7.7E-04	2.2E-06
8	LOC	479	3.3E+02	3.5E-04	3.7E-07	5.1E-04	7.8E-07
9	LOC	220	1.7E+02	2.3E-04	7.2E-07	3.1E-04	1.3E-06
10	LOC	66	5.5E+01	1.7E-04	5.3E-07	2.1E-04	7.6E-07
11	LOC	12	1.1E+01	1.4E-04	4.2E-07	1.5E-04	5.0E-07
12	LOC	1	1.0E+00	1.2E-04	3.6E-07	1.2E-04	3.6E-07

Global Results	LOC	LOM
Global Alpha, A	1.00E-02	0.0E+00
Variance	2.1E-05	0.0E+00
5th	3.9E-03	-----
Median	9.4E-03	-----
95th	1.8E-02	-----
Beta Parameter *a*	4.8E+00	-----
Beta Parameter *b*	4.7E+02	-----
Error Factor	2.04	-----
α_t	1.05	

$Q_{Independent}$	
Mean	9.8E-01
Variance	6.6E-05
Beta Parameter *a*	3.3E+02
Beta Parameter *b*	7.6E+00

Figure H- 5: GAMUT Calculation Results for SWC-PMP-FTR-GLO2CCF-T456

The resulting common cause factor is:

CCF FACTOR NAME	SWC-PMP-FTR-ALP2THR-T456
CCF FACTOR DESCRIPTION	Global Alpha Factor for SWC-PMP-FTR (Calculated with GAMUT using modified critical failures to fail 2 or more thrusters after thruster 4, 5 or 6 failure)
FACTOR	1.00E-02
EF	2.04

SWC-PMP-FTR-GLOBAL1CCFH:

This CCF event is used for the D_THRST_HURR fault tree to model thruster failure during extreme weather. During extreme weather, it is assumed that all thrusters need to succeed in order to keep position; hence, any one thruster failure would fail position keeping. The CCF corresponds to a group of 12 Sea Water Cooling pumps causing failures of 1 or more thrusters. Critical failures were obtained using the EXCEL macro because not all combinations of SWC pump failures cause 1 or more thruster failures. It should be noted again that failure of some SWC pumps affect the thrusters directly, while others affect diesel generator operation and by extension the thrusters driven by them. Figure H-6 shows the 12 calculated alpha factors as well as the global alpha factor with EF to be used in SAPHIRE.

k	System Status	c_k	$\binom{m-1}{k-1}$	α_k	Var(α_k)	$\bar{Q}_k^{(m)}$ Mean	$\bar{Q}_k^{(m)}$ Variance
1	OK	0	1.0E+00	9.77E-01	6.6E-05	0.0E+00	0.0E+00
2	LOC	6	1.1E+01	1.0E-02	3.1E-05	5.4E-03	9.2E-06
3	LOC	60	5.5E+01	5.5E-03	1.5E-05	6.0E-03	1.8E-05
4	LOC	255	1.7E+02	3.0E-03	9.7E-06	4.6E-03	2.3E-05
5	LOC	600	3.3E+02	1.7E-03	6.5E-06	3.1E-03	2.2E-05
6	LOC	860	4.6E+02	9.6E-04	3.4E-06	1.8E-03	1.2E-05
7	LOC	792	4.6E+02	5.6E-04	1.2E-06	9.7E-04	3.5E-06
8	LOC	495	3.3E+02	3.5E-04	3.7E-07	5.3E-04	8.4E-07
9	LOC	220	1.7E+02	2.3E-04	7.2E-07	3.1E-04	1.3E-06
10	LOC	66	5.5E+01	1.7E-04	5.3E-07	2.1E-04	7.6E-07
11	LOC	12	1.1E+01	1.4E-04	4.2E-07	1.5E-04	5.0E-07
12	LOC	1	1.0E+00	1.2E-04	3.6E-07	1.2E-04	3.6E-07

Global Results		
	LOC	LOM
Global Alpha, A	2.31E-02	0.0E+00
Variance	9.0E-05	0.0E+00
5th	1.0E-02	-----
Median	2.2E-02	-----
95th	4.1E-02	-----
Beta Parameter *a*	5.8E+00	-----
Beta Parameter *b*	2.4E+02	-----
Error Factor	1.91	-----
α_t	1.05	
$Q_{Independent}$		
Mean	9.8E-01	
Variance	6.6E-05	
Beta Parameter *a*	3.3E+02	
Beta Parameter *b*	7.6E+00	

Figure H- 6: GAMUT Calculation Results for SWC-PMP-FTR-GLOBAL1CCFH

The resulting common cause factor is:

CCF FACTOR NAME	SWC-PMP-FTR-ALP1THRH
CCF FACTOR DESCRIPTION	Global Alpha Factor for SWC-PMP-FTR (using modified critical failures to fail 1 or more thrusters) - Extreme Weather
FACTOR	2.31E-02
EF	1.91

SWC-PMP-FTR-GLOBAL3CCF:

This CCF event is used for the DRIFT-OFFPUSH-OFF_KICK fault tree, i.e. a loss of propulsion while controlling a kick. The CCF event corresponds to a group of 12 Sea Water Cooling pumps causing the failure of 3 or more thrusters. Critical failures were obtained using the EXCEL macro because not all combinations of SWC pump failures cause 3 or more thruster failures. It should be noted again that failure of some SWC pumps affect the thrusters directly, while others affect diesel generator operation and by extension the thrusters driven by them. Figure H-7 shows the 12 calculated alpha factors as well as the global alpha factor with EF to be used in SAPHIRE.

k	System Status	c_k	$\binom{m-1}{k-1}$	α_k	Var(α_k)	$\bar{Q}_k^{(m)}$ Mean	$\bar{Q}_k^{(m)}$ Variance
1	OK	0	1.0E+00	9.77E-01	6.6E-05	0.0E+00	0.0E+00
2	OK	0	1.1E+01	1.0E-02	3.1E-05	0.0E+00	0.0E+00
3	OK	0	5.5E+01	5.5E-03	1.5E-05	0.0E+00	0.0E+00
4	LOC	9	1.7E+02	3.0E-03	9.7E-06	1.6E-04	2.9E-08
5	LOC	72	3.3E+02	1.7E-03	6.5E-06	3.7E-04	3.1E-07
6	LOC	236	4.6E+02	9.6E-04	3.4E-06	4.9E-04	8.8E-07
7	LOC	408	4.6E+02	5.6E-04	1.2E-06	5.0E-04	9.2E-07
8	LOC	399	3.3E+02	3.5E-04	3.7E-07	4.2E-04	5.4E-07
9	LOC	220	1.7E+02	2.3E-04	7.2E-07	3.1E-04	1.3E-06
10	LOC	66	5.5E+01	1.7E-04	5.3E-07	2.1E-04	7.6E-07
11	LOC	12	1.1E+01	1.4E-04	4.2E-07	1.5E-04	5.0E-07
12	LOC	1	1.0E+00	1.2E-04	3.6E-07	1.2E-04	3.6E-07

Global Results	LOC	LOM
Global Alpha, *A*	2.73E-03	0.0E+00
Variance	5.6E-06	0.0E+00
5th	2.6E-04	-----
Median	2.1E-03	-----
95th	7.4E-03	-----
Beta Parameter *a*	1.3E+00	-----
Beta Parameter *b*	4.9E+02	-----
Error Factor	3.42	-----
α_t	1.05	
$Q_{Independent}$		
Mean	9.8E-01	
Variance	6.6E-05	
Beta Parameter *a*	3.3E+02	
Beta Parameter *b*	7.6E+00	

Figure H- 7: GAMUT Calculation Results for SWC-PMP-FTR-GLOBAL3CCF

The resulting common cause factor is:

CCF FACTOR NAME	SWC-PMP-FTR-ALP3THR
CCF FACTOR DESCRIPTION	Global Alpha Factor for SWC-PMP-FTR (Calculated with GAMUT using modified critical failures to fail 3 or more thrusters)
FACTOR	2.73E-03
EF	3.42

In SAPHIRE, the four common cause events explained above are entered using the Failure Type "C – Compound Event" option, since the global CCF is calculated by GAMUT [H4]. The compound event allows for the multiplication of two factors (the independent failure probability and the global CCF factor), and they are both entered in SAPHIRE. The resulting CCF probabilities are:

CCF BASIC EVENT NAME	CALC CCF PROB	FAILURE TYPE	METHOD	FAILURE CRITERIA	INDEPENDENT FAILURE EVENTS	CCF FACTORS
SWC-PMP-FTR-GLO2CCF-T123	2.35E-05	C	Alpha (GAMUT)	Custom	SWC-PMP-FTR-FS03	SWC-PMP-FTR-ALP2THR-T123
SWC-PMP-FTR-GLO2CCF-T456	2.42E-05	C	Alpha (GAMUT)	Custom	SWC-PMP-FTR-FS03	SWC-PMP-FTR-ALP2THR-T456
SWC-PMP-FTR-GLOBAL1CCFH	3.11E-06	C	Alpha (GAMUT)	Custom	SWC-PMP-FTR-FS03H	SWC-PMP-FTR-ALP1THRH
SWC-PMP-FTR-GLOBAL3CCF	6.62E-06	C	Alpha (GAMUT)	Custom	SWC-PMP-FTR-FS03	SWC-PMP-FTR-ALP3THR

Diesel Generators

There are six diesel generators total arranged to feed three power generating systems. Two generators feed each power bus. During normal operation, within each bus, one generator is on-line and running and the other is off-line but maintained as a hot standby. Each power group feeds two thrusters as follows:

- Thrusters FT01 and AT06: Diesel Generators C03 and C04 (center power group)
- Thrusters FT02 and AT04: Diesel Generators S01 and S02 (starboard power group)
- Thrusters FT03 and AT05: Diesel Generators P05 and P06 (port power group)

Therefore a CCF group of six diesel generators was considered for the following common cause events:

EPS-DGN-FTR-GLOBAL2CCF	Common Cause Failure of the Diesel Generators failing two or more thrusters
EPS-DGN-FTR-GLOBAL3CCF	Common Cause Failure of the Diesel Generators failing three or more thrusters

EPS-DGN-FTR-GLOBAL2CCF:

This CCF event is used for the DRIFT-OFFPUSH-OFF_IEFT_FRE fault tree, when one thruster fails as an initiating event. The CCF corresponds to a group of 6 diesel generators causing failures of 2 or more thrusters (since one thruster has already failed). Critical failures were obtained using the EXCEL macro because not all combinations of diesel generator failures cause 2 or more thruster failures. Figure H-8 shows the global alpha factor with EF to be used in SAPHIRE for this CCF event.

k	System Status	c_k	$\binom{m-1}{k-1}$	α_k	Var(α_k)	$\bar{Q}_k^{(m)}$ Mean	$\bar{Q}_k^{(m)}$ Variance
1	OK	0	1.0E+00	9.76E-01	6.2E-06	0.0E+00	0.0E+00
2	LOC	2	5.0E+00	6.8E-03	1.8E-06	2.7E-03	2.8E-07
3	LOC	8	1.0E+01	6.8E-03	1.8E-06	5.4E-03	1.1E-06
4	LOC	11	1.0E+01	5.4E-03	1.4E-06	5.9E-03	1.7E-06
5	LOC	6	5.0E+00	3.0E-03	7.9E-07	3.6E-03	1.1E-06
6	LOC	1	1.0E+00	2.3E-03	6.0E-07	2.3E-03	6.0E-07

Global Results	LOC	LOM
Global Alpha, A	2.00E-02	0.0E+00
Variance	4.8E-06	0.0E+00
5th	1.7E-02	-----
Median	2.0E-02	-----
95th	2.4E-02	-----
Beta Parameter *a*	8.1E+01	-----
Beta Parameter *b*	4.0E+03	-----
Error Factor	1.20	-----
α_t	1.06	

$Q_{Independent}$	
Mean	9.8E-01
Variance	6.2E-06
Beta Parameter *a*	3.7E+03
Beta Parameter *b*	9.3E+01

Figure H- 8: GAMUT Calculation Results for EPS-DGN-FTR-GLOBAL2CCF

The resulting common cause factor is:

CCF FACTOR NAME	EPS-DGN-FTR-ALP2THR
CCF FACTOR DESCRIPTION	Global Alpha Factor for DGN-FTR (Calculated with GAMUT using modified critical failures to fail 2 or more thrusters)
FACTOR	2.00E-02
EF	1.2

EPS-DGN-FTR-GLOBAL3CCF:

This CCF event is used for the DRIFT-OFFPUSH-OFF_KICK fault tree. The CCF corresponds to a group of 6 diesel generators causing failures of 3 or more thrusters (success criteria for nominal weather is four thrusters running). Critical failures were obtained using the EXCEL macro because not all combinations of diesel generator failures cause 3 or more thruster failures. Figure H-9 shows the global alpha factor with EF to be used in SAPHIRE for this CCF event.

k	System Status	c_k	$\binom{m-1}{k-1}$	α_k	Var(α_k)	$\bar{Q}_k^{(m)}$ Mean	$\bar{Q}_k^{(m)}$ Variance
1	OK	0	1.0E+00	9.76E-01	6.2E-06	0.0E+00	0.0E+00
2	OK	0	5.0E+00	6.8E-03	1.8E-06	0.0E+00	0.0E+00
3	OK	0	1.0E+01	6.8E-03	1.8E-06	0.0E+00	0.0E+00
4	LOC	3	1.0E+01	5.4E-03	1.4E-06	1.6E-03	1.3E-07
5	LOC	6	5.0E+00	3.0E-03	7.9E-07	3.6E-03	1.1E-06
6	LOC	1	1.0E+00	2.3E-03	6.0E-07	2.3E-03	6.0E-07

Global Results	LOC	LOM
Global Alpha, A	7.55E-03	0.0E+00
Variance	1.9E-06	0.0E+00
5th	5.4E-03	-----
Median	7.5E-03	-----
95th	9.9E-03	-----
Beta Parameter *a*	3.0E+01	-----
Beta Parameter *b*	4.0E+03	-----
Error Factor	1.34	-----
α_t	1.06	

$Q_{Independent}$	
Mean	9.8E-01
Variance	6.2E-06
Beta Parameter *a*	3.7E+03
Beta Parameter *b*	9.3E+01

Figure H- 9: GAMUT Calculation Results for EPS-DGN-FTR-GLOBAL3CCF

The resulting common cause factor is:

CCF FACTOR NAME EPS-DGN-FTR-ALP3THR

CCF FACTOR DESCRIPTION Global Alpha Factor for DGN-FTR (Calculated with GAMUT using modified critical failures to fail 3 or more thrusters)

FACTOR 7.55E-03

EF 1.34

In SAPHIRE, the two common cause events explained above are entered using the Failure Type "C – Compound Event" option, since the global CCF is calculated by GAMUT [H4], not SAPHIRE. The compound event allows for the multiplication of two factors (the independent failure probability and the global CCF factor), and they are both entered in SAPHIRE. The resulting CCF probabilities are:

CCF BASIC EVENT NAME	CALC CCF PROB	FAILURE TYPE	METHOD	FAILURE CRITERIA	INDEPENDENT FAILURE EVENTS	CCF FACTORS
EPS-DGN-FTR-GLOBAL2CCF	8.03E-05	C	Alpha (GAMUT)	Custom	EPS-DGN-FTR-C03	EPS-DGN-FTR-ALP2THR
EPS-DGN-FTR-GLOBAL3CCF	3.03E-05	C	Alpha (GAMUT)	Custom	EPS-DGN-FTR-C03	EPS-DGN-FTR-ALP3THR

Surface Hydraulics Accumulators

The surface hydraulic accumulators are used to supply hydraulic pressure for subsea operation of the BOP. They are arranged in four racks, each containing two banks of 10 accumulators. The success criteria for each bank of ten accumulation system is that all 10 accumulators in a bank must be operational for that bank to be considered functioning. The success criteria for each rack is that at least one bank of the two should be operational. Accumulator common cause failures were only considered with each rack. The following CCF events were included in the PRA model:

- HYS-ACC-LKE-CCF1 Common cause failure of the surface hydraulic accumulators (Rack 1)
- HYS-ACC-LKE-CCF2 Common cause failure of the surface hydraulic accumulators (Rack 2)
- HYS-ACC-LKE-CCF3 Common cause failure of the surface hydraulic accumulators (Rack 3)
- HYS-ACC-LKE-CCF4 Common cause failure of the surface hydraulic accumulators (Rack 4)

Since not all combinations of accumulator common cause failures cause a rack failure, GAMUT [H4] and the accompanying EXCEL macro is used to calculate the applicable combinations. A CCF group of 20 accumulators is considered, and only those failure combinations that fail at least one accumulator in the first bank and one in the second bank can cause rack failure.

Using the GAMUT [H4] model, a global alpha value was calculated and applied to each accumulator rack. The global alpha value is provided in Figure H-10 below.

k	System Status	c_k	$\binom{m-1}{k-1}$	α_k	Var(α_k)	$\bar{Q}_k^{(m)}$ Mean	$\bar{Q}_k^{(m)}$ Variance
1	OK	0	1.0E+00	9.77E-01	6.1E-05	0.0E+00	0.0E+00
2	LOC	100	1.9E+01	9.6E-03	2.9E-05	5.1E-02	8.0E-04
3	LOC	900	1.7E+02	5.3E-03	1.4E-05	2.8E-02	3.9E-04
4	LOC	4425	9.7E+02	2.9E-03	9.0E-06	1.3E-02	1.9E-04
5	LOC	15000	3.9E+03	1.6E-03	6.1E-06	6.3E-03	9.1E-05
6	LOC	38340	1.2E+04	9.2E-04	3.1E-06	3.0E-03	3.4E-05
7	LOC	77280	2.7E+04	5.4E-04	1.1E-06	1.6E-03	9.0E-06
8	LOC	125880	5.0E+04	3.4E-04	3.5E-07	8.5E-04	2.2E-06
9	LOC	167940	7.6E+04	2.3E-04	6.7E-07	5.0E-04	3.3E-06
10	LOC	184754	9.2E+04	1.7E-04	4.9E-07	3.3E-04	2.0E-06
11	LOC	167960	9.2E+04	1.3E-04	3.9E-07	2.4E-04	1.3E-06
12	LOC	125970	7.6E+04	1.1E-04	3.4E-07	1.9E-04	9.5E-07
13	LOC	77520	5.0E+04	1.1E-04	3.1E-07	1.6E-04	7.4E-07
14	LOC	38760	2.7E+04	1.0E-04	3.0E-07	1.4E-04	6.0E-07
15	LOC	15504	1.2E+04	9.7E-05	2.9E-07	1.3E-04	5.1E-07
16	LOC	4845	3.9E+03	9.5E-05	2.8E-07	1.2E-04	4.4E-07
17	LOC	1140	9.7E+02	9.4E-05	2.8E-07	1.1E-04	3.9E-07
18	LOC	190	1.7E+02	9.4E-05	2.8E-07	1.0E-04	3.5E-07
19	LOC	20	1.9E+01	9.4E-05	2.8E-07	9.9E-05	3.1E-07
20	LOC	1	1.0E+00	9.4E-05	2.8E-07	9.4E-05	2.8E-07

Global Results	LOC	LOM
Global Alpha, *A*	1.06E-01	0.0E+00
Variance	1.5E-03	0.0E+00
5th	5.0E-02	-----
Median	1.0E-01	-----
95th	1.8E-01	-----
Beta Parameter *a*	6.5E+00	-----
Beta Parameter *b*	5.5E+01	-----
Error Factor	1.80	-----
α_t	1.06	
$Q_{Independent}$		
Mean	9.8E-01	
Variance	6.1E-05	
Beta Parameter *a*	3.5E+02	
Beta Parameter *b*	8.1E+00	

Figure H- 10: GAMUT Calculation Results for HYS-ACC-LKE-CCF

The resulting common cause factor is:

CCF FACTOR NAME HYS-ACC-LKE-ALP

CCF FACTOR DESCRIPTION HPU accumulators global alpha value

FACTOR 1.06E-01

EF 1.8

All four common cause events have the same global alpha factor since all racks have the same configuration.

In SAPHIRE, the four common cause events explained above are entered using the Failure Type "C – Compound Event" option, since the global CCF is calculated by GAMUT [H4]. The compound event allows for the multiplication of two factors (the independent failure probability and the global CCF factor), and they are both entered in SAPHIRE. The resulting CCF probabilities are:

CCF BASIC EVENT NAME	CALC CCF PROB	FAILURE TYPE	METHOD	FAILURE CRITERIA	INDEPENDENT FAILURE EVENTS	CCF FACTORS
HYS-ACC-LKE-CCF1	1.68E-06	C	Alpha (GAMUT)	Custom	HYS-ACC-LKE-SH07	HYS-ACC-LKE-ALP
HYS-ACC-LKE-CCF2	1.68E-06	C	Alpha (GAMUT)	Custom	HYS-ACC-LKE-SH27	HYS-ACC-LKE-ALP
HYS-ACC-LKE-CCF3	1.68E-06	C	Alpha (GAMUT)	Custom	HYS-ACC-LKE-SH47	HYS-ACC-LKE-ALP
HYS-ACC-LKE-CCF4	1.68E-06	C	Alpha (GAMUT)	Custom	HYS-ACC-LKE-SH67	HYS-ACC-LKE-ALP

Table H- 1: List of all Common Cause Events in the Baseline PRA Model

CCF BASIC EVENT NAME	DESCRIPTION	CALC CCF PROB	FAILURE TYPE	METHOD	FAILURE CRITERIA	INDEPENDENT FAILURE EVENTS	CCF FACTORS
BOP-CYL-FTC-ULANNCCF	Common cause failure to close of upper and lower annular	6.51E-04	C	Beta	All	BOP-CYL-FTC-UANN	BETA-CCF
BOP-CYL-FTC-ULMLCCF	Common cause failure of upper, lower, middle pipe ram locks to close	2.30E-05	C	Beta	All	BOP-CYL-FTC-UPRL	BETA-CCF
BOP-CYL-FTC-ULMPRCCF	Common cause failure to close of upper, lower and middle pipe rams	1.22E-04	C	Beta	All	BOP-CYL-FTC-UPR	BETA-CCF
BOP-CYL-FTC-ULPRCCF	Common cause failure to close of upper and lower pipe rams (basic event has shuttle valve data)	7.70E-05	C	Beta	All	BOP-SHV-LKE-F13	BETA-CCF
BOP-CYL-FTO-ULMPRCCF	Common cause failure to open of upper, lower and middle pipe rams	1.22E-04	C	Beta	All	BOP-CYL-FTO-LPR	BETA-CCF
BOP-FLT-PLG-Q0102CCF	Common cause plugging failure of the filters on Q02 and Q01	2.88E-06	C	Beta	All	BOP-FLT-PLG-Q02R	BETA-CCF
BOP-FLT-PLG-W0102CCF	Common cause failure of topsides supply filters W02 and W01 in RCM plug	2.88E-06	C	Beta	All	BOP-FLT-PLG-W02	BETA-CCF
BOP-HOV-FTO-ALLCCF	Upper and Lower Choke & Valves Common Cause Failure to Open	2.95E-05	C	Beta	All	BOP-HOV-FTO-CH2	BETA-CCF
BOP-PRG-FLO-AO1O2CCF	Common Cause failure (fails low) of upper annular pressure regulators AO1 and AO2 (Yellow and Blue)	1.22E-04	C	Beta	All	BOP-PRG-FLO-AO1	BETA-CCF
BOP-PRG-FLO-AO3O4CCF	Common Cause failure (fails low) of lower annular pressure regulators AO3 and AO4	1.22E-04	C	Beta	All	BOP-PRG-FLO-AO3	BETA-CCF
BOP-PRG-FLO-I0102CCF	Common cause failure of subsea manifold pressure regulators I02 and I01	1.22E-04	C	Beta	All	BOP-PRG-FLO-I02	BETA-CCF
BOP-PRG-FLO-T0102CCF	Common cause failure of rigid conduit manifold pressure regulators T01 and T02 fails low or off	1.22E-04	C	Beta	All	BOP-PRG-FLO-T02	BETA-CCF
BOP-PVL-FTO-AJ12CCF	Common cause failure to open of upper annular close pilot valves AJ1 and AJ2	1.13E-06	C	Beta	All	BOP-PVL-FTO-AJ1	BETA-CCF

CCF BASIC EVENT NAME	DESCRIPTION	CALC CCF PROB	FAILURE TYPE	METHOD	FAILURE CRITERIA	INDEPENDENT FAILURE EVENTS	CCF FACTORS
BOP-PVL-FTO-AJ34CCF	Common Cause failure to open of lower annular close pilot valves AJ3 and AJ4	1.13E-06	C	Beta	All	BOP-PVL-FTO-AJ3	BETA-CCF
BOP-PVL-FTO-B0102CCF	Blind Shear Ram High Pressure close Pilot operated valves BO1 and BO2 common cause failure to open on demand	1.13E-06	C	Beta	All	BOP-PVL-FTO-B01	BETA-CCF
BOP-PVL-FTO-B1213CCF	Blind Shear Ram Locks Pilot operated valves B12 and B13 common cause failure to open on demand	1.13E-06	C	Beta	All	BOP-PVL-FTO-B13	BETA-CCF
BOP-PVL-FTO-CKL79CCF	Common Cause Choke & Kill Line Unlock Pilot Operated Valves Fail to Open	1.13E-06	C	Beta	All	BOP-PVL-FTO-CKL9	BETA-CCF
BOP-PVL-FTO-G0203CCF	Casing shear High pressure supply CCF of PVL G02, G03 Fail to Open	1.13E-06	C	Beta	All	BOP-PVL-FTO-G05	BETA-CCF
BOP-PVL-FTO-G0506CCF	Common cause failure to open of middle pipe ram lock pilot operated valves G05 and G06	1.13E-06	C	Beta	All	BOP-PVL-FTO-G05	BETA-CCF
BOP-PVL-FTO-G0708CCF	Common cause failure to open of middle pipe ram close pilot operated valves G07 and G08	1.13E-06	C	Beta	All	BOP-PVL-FTO-G07	BETA-CCF
BOP-PVL-FTO-G07O08OCCF	Common cause failure to open of middle pipe ram open pilot operated valves G07o and G08o	1.13E-06	C	Beta	All	BOP-PVL-FTO-G08O	BETA-CCF
BOP-PVL-FTO-G0910CCF	Common cause failure to open of upper pipe ram lock pilot operated valves G09 and G10	1.13E-06	C	Beta	All	BOP-PVL-FTO-G09	BETA-CCF
BOP-PVL-FTO-G1112CCF	Common cause failure to open of upper pipe ram close pilot operated valves G11 and G12	1.13E-06	C	Beta	All	BOP-PVL-FTO-G11	BETA-CCF
BOP-PVL-FTO-G11O12OCCF	Common cause failure to open of upper pipe ram open pilot operated valves G11o and G12o	1.13E-06	C	Beta	All	BOP-PVL-FTO-G11O	BETA-CCF
BOP-PVL-FTO-G1314CCF	Lower pipe ram lock common cause failure to open of pilot operated valves G13 and G14	1.13E-06	C	Beta	All	BOP-PVL-FTO-G13	BETA-CCF

CCF BASIC EVENT NAME	DESCRIPTION	CALC CCF PROB	FAILURE TYPE	METHOD	FAILURE CRITERIA	INDEPENDENT FAILURE EVENTS	CCF FACTORS
BOP-PVL-FTO-G1516CCF	Common cause failure to open of lower pipe ram close pilot operated valves G15 and G16	1.13E-06	C	Beta	All	BOP-PVL-FTO-G15	BETA-CCF
BOP-PVL-FTO-G15O16OCCF	Common cause failure to open of lower pipe ram open pilot operated valves G15o and G16o	1.13E-06	C	Beta	All	BOP-PVL-FTO-G15	BETA-CCF
BOP-PVL-FTO-RC57CCF	Common Cause Riser Connector Unlock Pilot Operated Valves Failure to Open	1.13E-06	C	Beta	All	BOP-PVL-FTO-RC7	BETA-CCF
BOP-SCV-FTO-Q0102CCF	Common cause failure to open of check valves in Q01 and 2	5.35E-06	C	Beta	All	BOP-SCV-FTO-Q02L	BETA-CCF
BOP-SCV-FTO-W0102CCF	Common cause failure of topsides supply spring check valve W02 and W01 in RCM fails to open	5.35E-06	C	Beta	All	BOP-SCV-FTO-W02	BETA-CCF
BOP-SEM-FTO-CCF	Common cause failure of the control pod SEMs	2.69E-05	R	Alpha	4	BOP-SEM-FOP-BLUEA BOP-SEM-FOP-BLUEB BOP-SEM-FOP-YELLOWA BOP-SEM-FOP-YELLOWB	BOP-SEM-FTO-ALP1 BOP-SEM-FTO-ALP2 BOP-SEM-FTO-ALP3 BOP-SEM-FTO-ALP4
BOP-SHV-LKE-AI12CCF	Common cause jam/external leak failure of upper annular close shuttle valves AI1 and AI2	7.70E-05	C	Beta	All	BOP-SHV-LKE-AI1	BETA-CCF
BOP-SHV-LKE-F10111315CCF	Common cause failure of pipe ram shuttle valves jam/external leak	7.70E-05	C	Beta	All	BOP-SHV-LKE-F10	BETA-CCF
BOP-SVL-FTO-AL12CCF	Common cause failure to open of upper annular close solenoid valves AL1 and AL2	1.31E-05	C	Beta	All	BOP-SVL-FTO-AL1	BETA-CCF
BOP-SVL-FTO-AL78CCF	Common Cause Fails to Open lower annular close solenoid valves AL7 and AL8	1.31E-05	C	Beta	All	BOP-SVL-FTO-AL7	BETA-CCF
BOP-SVL-FTO-C0102CCF	Blind Shear Ram High Pressure close Solenoid valves CO1 and CO2 common cause failure to open on demand	1.31E-05	C	Beta	All	BOP-SVL-FTO-C01	BETA-CCF
BOP-SVL-FTO-C1213CCF	Blind Shear Ram Lock Solenoid operated valves C12 and C13 common cause failure to open on demand	1.31E-05	C	Beta	All	BOP-SVL-FTO-C12	BETA-CCF

CCF BASIC EVENT NAME	DESCRIPTION	CALC CCF PROB	FAILURE TYPE	METHOD	FAILURE CRITERIA	INDEPENDENT FAILURE EVENTS	CCF FACTORS
BOP-SVL-FTO-CKLRC35CCF	Common Cause Choke & Kill Line Unlock Solenoid Operated Valves Fail to Open	1.31E-05	C	Beta	All	BOP-SVL-FTO-RC3	BETA-CCF
BOP-SVL-FTO-H0102CCF	Casing shear Solenoid valves CCF of SVL-H01 and H02 Fails To Open	1.31E-05	C	Beta	All	BOP-SVL-FTO-H01	BETA-CCF
BOP-SVL-FTO-H0304CCF	Common cause failure to open of middle pipe ram lock solenoid operated valves H03 and H04	1.31E-05	C	Beta	All	BOP-SVL-FTO-H03	BETA-CCF
BOP-SVL-FTO-H0506CCF	Common cause failure to open of middle pipe ram close solenoid operated valves H05 and H06	1.31E-05	C	Beta	All	BOP-SVL-FTO-H05	BETA-CCF
BOP-SVL-FTO-H05O06OCCF	Common cause failure to open of middle pipe ram open solenoid operated valves H05o and H06o	1.31E-05	C	Beta	All	BOP-SVL-FTO-H06O	BETA-CCF
BOP-SVL-FTO-H0708CCF	Common cause failure to open of upper pipe ram lock solenoid operated valves H07 and H08	1.31E-05	C	Beta	All	BOP-SVL-FTO-H07	BETA-CCF
BOP-SVL-FTO-H0910CCF	Common cause failure to open of upper pipe ram close solenoid operated valves H09 and H10	1.31E-05	C	Beta	All	BOP-SVL-FTO-H09	BETA-CCF
BOP-SVL-FTO-H09O10OCCF	Common cause failure to open of upper pipe ram open solenoid operated valves H09o and H10o	1.31E-05	C	Beta	All	BOP-SVL-FTO-H09O	BETA-CCF
BOP-SVL-FTO-H1112CCF	Common cause failure to open of lower pipe ram lock solenoid operated valves H11 and H12	1.31E-05	C	Beta	All	BOP-SVL-FTO-H11	BETA-CCF
BOP-SVL-FTO-H1314CCF	Common cause failure to open of lower pipe ram close solenoid operated valves H13 and H14	1.31E-05	C	Beta	All	BOP-SVL-FTO-H13	BETA-CCF
BOP-SVL-FTO-H13O14OCCF	Common cause failure to open of lower pipe ram close solenoid operated valves H13o and H14o	1.31E-05	C	Beta	All	BOP-SVL-FTO-H13	BETA-CCF
BOP-SVL-FTO-RC13CCF	Common Cause Riser Connector Primary Unlock Solenoid Operated Valve Failure to Open	1.31E-05	C	Beta	All	BOP-SVL-FTO-RC1	BETA-CCF

CCF BASIC EVENT NAME	DESCRIPTION	CALC CCF PROB	FAILURE TYPE	METHOD	FAILURE CRITERIA	INDEPENDENT FAILURE EVENTS	CCF FACTORS
DPS-COM-FOP-PC010203CCFH	Common Cause Failure of the DP Computers PC01, PC02, PC03 (Extreme Weather)	1.05E-06	R	Alpha	4	DPS-COM-FOP-BC01H DPS-COM-FOP-PC01H DPS-COM-FOP-PC02H DPS-COM-FOP-PC03H	D-C-C-DPCP-ALP1-FOF D-C-C-DPCP-ALP2-FOF D-C-C-DPCP-ALP3-FOF D-C-C-DPCP-ALP4-FOF
DPS-COM-FOP-PC0102CCF	Common Cause Failure of the DP Computers PC01 and PC02	4.13E-06	R	Alpha	2	DPS-COM-FOP-PC02-RT DPS-COM-FOP-PC01-RT	D-C-C-DPCP-ALP1-FOF D-C-C-DPCP-ALP2-FOF
DPS-COM-FOP-PC0103CCF	Common Cause Failure of the DP Computers PC01 and PC03	4.13E-06	R	Alpha	2	DPS-COM-FOP-PC03-RT DPS-COM-FOP-PC01-RT	D-C-C-DPCP-ALP1-FOF D-C-C-DPCP-ALP2-FOF
DPS-COM-FOP-PC0203CCF	Common Cause Failure of the DP Computers PC02 and PC03	4.13E-06	R	Alpha	2	DPS-COM-FOP-PC02-RT DPS-COM-FOP-PC03-RT	D-C-C-DPCP-ALP1-FOF D-C-C-DPCP-ALP2-FOF
DPS-COM-FOP-PC123CCF-KI	Common Cause Failure of the DP Computers PC01, PC02, PC03	1.90E-05	R	Alpha	4	DPS-COM-FOP-PC01-KI DPS-COM-FOP-PC02-KI DPS-COM-FOP-PC03-KI DPS-COM-FOP-BC01-KI	D-C-C-DPCP-ALP1-FOF D-C-C-DPCP-ALP2-FOF D-C-C-DPCP-ALP3-FOF D-C-C-DPCP-ALP4-FOF
DPS-GPS-FOP-0102CCF	Common Cause Failure of the Differential GPS Antennas	5.07E-06	R	Alpha	2	DPS-GPS-FOP-01-RT DPS-GPS-FOP-02-RT	D-C-C-DGPS-ALP1-FOF D-C-C-DGPS-ALP2-FOF
DPS-GPS-FOP-0102CCFH	Common Cause Failure of the Differential GPS Antennas (Extreme Weather)	2.78E-06	R	Alpha	2	DPS-GPS-FOP-01H DPS-GPS-FOP-02H	D-C-C-DGPS-ALP1-FOF D-C-C-DGPS-ALP2-FOF
DPS-GPS-FOP-0102CCF-KI	Common Cause Failure of the Differential GPS Antennas	5.00E-05	R	Alpha	2	DPS-GPS-FOP-02-KI DPS-GPS-FOP-01-KI	D-C-C-DGPS-ALP1-FOF D-C-C-DGPS-ALP2-FOF
DPS-GYC-FOP-010203CCFH	Common Cause Failure of the Gyro Compass Sensors (Extreme Weather)	1.01E-06	R	Alpha	3	DPS-GYC-FOP-01H DPS-GYC-FOP-02H DPS-GYC-FOP-03H	D-C-C-GCOM-ALP1-FOF D-C-C-GCOM-ALP2-FOF D-C-C-GCOM-ALP3-FOF
DPS-GYC-FOP-010203CCF-KI	Common Cause Failure of the Gyro Compass Sensors	1.83E-05	R	Alpha	3	DPS-GYC-FOP-01-KI DPS-GYC-FOP-02-KI DPS-GYC-FOP-03-KI	D-C-C-GCOM-ALP1-FOF D-C-C-GCOM-ALP2-FOF D-C-C-GCOM-ALP3-FOF
DPS-GYC-FOP-GS0102CCF	Common Cause Failure of Gyro Compass Sensors GS01 and 02	2.43E-06	R	Alpha	2	DPS-GYC-FOP-02-RT DPS-GYC-FOP-01-RT	D-C-C-GCOM-ALP1-FOF D-C-C-GCOM-ALP2-FOF
DPS-GYC-FOP-GS0103CCF	Common Cause Failure of Gyro Compass Sensors GS01 and 03	2.43E-06	R	Alpha	2	DPS-GYC-FOP-03-RT DPS-GYC-FOP-01-RT	D-C-C-GCOM-ALP1-FOF D-C-C-GCOM-ALP2-FOF
DPS-GYC-FOP-GS0203CCF	Common Cause Failure of Gyro Compass Sensors GS02 and 03	2.43E-06	R	Alpha	2	DPS-GYC-FOP-02-RT DPS-GYC-FOP-03-RT	D-C-C-GCOM-ALP1-FOF D-C-C-GCOM-ALP2-FOF

CCF BASIC EVENT NAME	DESCRIPTION	CALC CCF PROB	FAILURE TYPE	METHOD	FAILURE CRITERIA	INDEPENDENT FAILURE EVENTS	CCF FACTORS
DPS-HYS-FOP-0102CCF	Common Cause Failure of the Hydroacoustic Position Reference Sensors	2.03E-05	R	Alpha	2	DPS-HYS-FOP-01-RT DPS-HYS-FOP-02-RT	D-C-C-HPRS-ALP1-FOF D-C-C-HPRS-ALP2-FOF
DPS-HYS-FOP-0102CCFH	Common Cause Failure of the Hydroacoustic Position Reference Sensors (Extreme Weather)	1.12E-05	R	Alpha	2	DPS-HYS-FOP-01H DPS-HYS-FOP-02H	D-C-C-HPRS-ALP1-FOF D-C-C-HPRS-ALP2-FOF
DPS-HYS-FOP-0102CCF-KI	Common Cause Failure of the Hydroacoustic Position Reference Sensors	2.00E-04	R	Alpha	2	DPS-HYS-FOP-01-KI DPS-HYS-FOP-02-KI	D-C-C-HPRS-ALP1-FOF D-C-C-HPRS-ALP2-FOF
DPS-THR-12345CCF	Common Cause Failure of Thrusters FT01 FT02 FT03 AT04 and AT05	6.66E-05	R	Alpha	2	DPS-THR-FTR-FT01 DPS-THR-FTR-FT02 DPS-THR-FTR-FT03 DPS-THR-FTR-AT04 DPS-THR-FTR-AT05	D-T-L-THST-ALP1-FTR D-T-L-THST-ALP2-FTR D-T-L-THST-ALP3-FTR D-T-L-THST-ALP4-FTR D-T-L-THST-ALP5-FTR
DPS-THR-12346CCF	Common Cause Failure of Thrusters FT01 FT02 FT03 AT04 and AT06	6.66E-05	R	Alpha	2	DPS-THR-FTR-FT01 DPS-THR-FTR-FT02 DPS-THR-FTR-FT03 DPS-THR-FTR-AT04 DPS-THR-FTR-AT06	D-T-L-THST-ALP1-FTR D-T-L-THST-ALP2-FTR D-T-L-THST-ALP3-FTR D-T-L-THST-ALP4-FTR D-T-L-THST-ALP5-FTR
DPS-THR-12356CCF	Common Cause Failure of Thrusters FT01 FT02 FT03 AT05 and AT06	6.66E-05	R	Alpha	2	DPS-THR-FTR-FT01 DPS-THR-FTR-FT02 DPS-THR-FTR-FT03 DPS-THR-FTR-AT05 DPS-THR-FTR-AT06	D-T-L-THST-ALP1-FTR D-T-L-THST-ALP2-FTR D-T-L-THST-ALP3-FTR D-T-L-THST-ALP4-FTR D-T-L-THST-ALP5-FTR
DPS-THR-12456CCF	Common Cause Failure of Thrusters FT01 FT02 AT04 AT05 and AT06	6.66E-05	R	Alpha	2	DPS-THR-FTR-FT01 DPS-THR-FTR-FT02 DPS-THR-FTR-AT04 DPS-THR-FTR-AT05 DPS-THR-FTR-AT06	D-T-L-THST-ALP1-FTR D-T-L-THST-ALP2-FTR D-T-L-THST-ALP3-FTR D-T-L-THST-ALP4-FTR D-T-L-THST-ALP5-FTR
DPS-THR-13456CCF	Common Cause Failure of Thrusters FT01 FT03 AT04 AT05 and AT06	6.66E-05	R	Alpha	2	DPS-THR-FTR-FT01 DPS-THR-FTR-FT03 DPS-THR-FTR-AT04 DPS-THR-FTR-AT05 DPS-THR-FTR-AT06	D-T-L-THST-ALP1-FTR D-T-L-THST-ALP2-FTR D-T-L-THST-ALP3-FTR D-T-L-THST-ALP4-FTR D-T-L-THST-ALP5-FTR

CCF BASIC EVENT NAME	DESCRIPTION	CALC CCF PROB	FAILURE TYPE	METHOD	FAILURE CRITERIA	INDEPENDENT FAILURE EVENTS	CCF FACTORS
DPS-THR-23456CCF	Common Cause Failure of Thrusters FT02 FT03 AT04 AT05 and AT06	6.66E-05	R	Alpha	2	DPS-THR-FTR-FT02 DPS-THR-FTR-FT03 DPS-THR-FTR-AT04 DPS-THR-FTR-AT05 DPS-THR-FTR-AT06	D-T-L-THST-ALP1-FTR D-T-L-THST-ALP2-FTR D-T-L-THST-ALP3-FTR D-T-L-THST-ALP4-FTR D-T-L-THST-ALP5-FTR
DPS-THR-FTR-ALLCCF	Common Cause Failure of the Thrusters (3 or more)	4.84E-05	R	Alpha	3	DPS-THR-FTR-FT01 DPS-THR-FTR-FT02 DPS-THR-FTR-FT03 DPS-THR-FTR-AT04 DPS-THR-FTR-AT05 DPS-THR-FTR-AT06	D-T-L-THST-ALP1-FTR D-T-L-THST-ALP2-FTR D-T-L-THST-ALP3-FTR D-T-L-THST-ALP4-FTR D-T-L-THST-ALP5-FTR D-T-L-THST-ALP6-FTR
DPS-VRS-FOP-010203CCFH	Common Cause Failure of the Vertical Reference Sensors (Extreme Weather)	7.23E-07	R	Alpha	3	DPS-VRS-FOP-01H DPS-VRS-FOP-02H DPS-VRS-FOP-03H	D-C-C-VRSN-ALP1-FOF D-C-C-VRSN-ALP2-FOF D-C-C-VRSN-ALP3-FOF
DPS-VRS-FOP-010203CCF-KI	Common Cause Failure of the Vertical Reference Sensors	1.31E-05	R	Alpha	3	DPS-VRS-FOP-01-KI DPS-VRS-FOP-02-KI DPS-VRS-FOP-03-KI	D-C-C-VRSN-ALP1-FOF D-C-C-VRSN-ALP2-FOF D-C-C-VRSN-ALP3-FOF
DPS-VRS-FOP-VS0102CCF	Common Cause Failure of the Vertical Reference Sensors VS01 and VS02	2.94E-06	R	Alpha	2	DPS-VRS-FOP-02-RT DPS-VRS-FOP-01-RT	D-C-C-VRSN-ALP1-FOF D-C-C-VRSN-ALP2-FOF
DPS-VRS-FOP-VS0103CCF	Common Cause Failure of the Vertical Reference Sensors VS01 and VS03	2.94E-06	R	Alpha	2	DPS-VRS-FOP-01-RT DPS-VRS-FOP-03-RT	D-C-C-VRSN-ALP1-FOF D-C-C-VRSN-ALP2-FOF
DPS-VRS-FOP-VS0203CCF	Common Cause Failure of the Vertical Reference Sensors VS02 and VS03	2.94E-06	R	Alpha	2	DPS-VRS-FOP-02-RT DPS-VRS-FOP-03-RT	D-C-C-VRSN-ALP1-FOF D-C-C-VRSN-ALP2-FOF
DPS-WIS-FOP-010203CCFH	Common Cause Failure of the Wind Sensors (Extreme Weather)	6.16E-07	R	Alpha	3	DPS-WIS-FOP-01H DPS-WIS-FOP-02H DPS-WIS-FOP-03H	D-C-C-WSEN-ALP1-FOF D-C-C-WSEN-ALP2-FOF D-C-C-WSEN-ALP3-FOF
ELS-CCU-FOF-CCF	Common cause failure of the central control units	1.01E-04	R	Alpha	2	ELS-CCU-FOF-SE01 ELS-CCU-FOF-SE12	ELS-CCU-FOF-ALP1 ELS-CCU-FOF-ALP2
ELS-CTL-FOF-CCF	Common cause failure of the control panels	8.24E-06	R	Alpha	4	ELS-CTL-FOF-SE02 ELS-CTL-FOF-SE03 ELS-CTL-FOF-SE13 ELS-CTL-FOF-SE14	ELS-CTL-FOF-ALP1 ELS-CTL-FOF-ALP2 ELS-CTL-FOF-ALP3 ELS-CTL-FOF-ALP4
ELS-JBX-FOF-CCF	Common cause failure of the junction boxes	1.66E-05	R	Alpha	2	ELS-JBX-FOF-SE07 ELS-JBX-FOF-SE18	ELS-JBX-FOF-ALP1 ELS-JBX-FOF-ALP2
ELS-PDP-FOF-CCF	Common cause failure of the power distribution panels	4.15E-06	R	Alpha	2	ELS-PDP-FOF-SE04 ELS-PDP-FOF-SE15	ELS-PDP-FOF-ALP1 ELS-PDP-FOF-ALP2

CCF BASIC EVENT NAME	DESCRIPTION	CALC CCF PROB	FAILURE TYPE	METHOD	FAILURE CRITERIA	INDEPENDENT FAILURE EVENTS	CCF FACTORS
ELS-TRF-FOF-CCF	Common Cause Failure of the Subsea Transformers	1.84E-05	R	Alpha	2	ELS-TRF-FOF-SE11 ELS-TRF-FOF-SE22	ELS-TRF-FOF-ALP1 ELS-TRF-FOF-ALP2
ELS-UMB-FOF-CCF	Common cause failure of the umbilicals	6.33E-06	R	Alpha	2	ELS-UMB-FOF-SE09 ELS-UMB-FOF-SE20	ELS-UMB-FOF-ALP1 ELS-UMB-FOF-ALP2
ELS-UPS-FOF-CCF	Common cause failure of the UPSs SE06 and SE17	3.61E-05	R	Alpha	2	ELS-UPS-FOF-SE06 ELS-UPS-FOF-SE17	ELS-UPS-FOF-ALP1 ELS-UPS-FOF-ALP2
EPS-DGN-FTR-GLOBAL2CCF	Common Cause Failure of the Diesel Generators failing two or more thrusters	3.90E-05	C	Alpha (GAMUT)	Varies	EPS-DGN-FTR-C03	EPS-DGN-FTR-ALP2THR
EPS-DGN-FTR-GLOBAL3CCF	Common Cause Failure of the Diesel Generators failing three or more thrusters	3.03E-05	C	Alpha (GAMUT)	Varies	EPS-DGN-FTR-C03	EPS-DGN-FTR-ALP3THR
FSY-FLT-PLG-CFS34CCF	Common Cause Failure of the Center Fuel Filters - Clogged	8.79E-07	R	Alpha	2	FSY-FLT-PLG-CFS3 FSY-FLT-PLG-CFS4	D-F-C-FLTR-ALP1-CLG D-F-C-FLTR-ALP2-CLG
FSY-FLT-PLG-CFS34CCFH	Common Cause Failure of the Center Fuel Filters - Clogged (Extreme Weather)	4.88E-08	R	Alpha	2	FSY-FLT-PLG-CFS3H FSY-FLT-PLG-CFS4H	D-F-C-FLTR-ALP1-CLG D-F-C-FLTR-ALP2-CLG
FSY-FLT-PLG-PFS34CCF	Common Cause Failure of the Port Fuel Filters - Clogged	8.79E-07	R	Alpha	2	FSY-FLT-PLG-PFS3 FSY-FLT-PLG-PFS4	D-F-C-FLTR-ALP1-CLG D-F-C-FLTR-ALP2-CLG
FSY-FLT-PLG-PFS34CCFH	Common Cause Failure of the Port Fuel Filters - Clogged (Extreme Weather)	4.88E-08	R	Alpha	2	FSY-FLT-PLG-PFS3H FSY-FLT-PLG-PFS4H	D-F-C-FLTR-ALP1-CLG D-F-C-FLTR-ALP2-CLG
FSY-FLT-PLG-SFS34CCF	Common Cause Failure of the Starboard Fuel Filters - Clogged	8.79E-07	R	Alpha	2	FSY-FLT-PLG-SFS3 FSY-FLT-PLG-SFS4	D-F-C-FLTR-ALP1-CLG D-F-C-FLTR-ALP2-CLG
FSY-FLT-PLG-SFS34CCFH	Common Cause Failure of the Starboard Fuel Filters - Clogged (Extreme Weather)	4.88E-08	R	Alpha	2	FSY-FLT-PLG-SFS3H FSY-FLT-PLG-SFS4H	D-F-C-FLTR-ALP1-CLG D-F-C-FLTR-ALP2-CLG
FSY-PMP-FTR-CFS12CCF	Common Cause Failure of the Center Electric Fuel Pumps	8.63E-05	R	Alpha	2	FSY-PMP-FTR-CFS1 FSY-PMP-FTR-CFS2	D-F-C-EPMP-ALP1-FTR D-F-C-EPMP-ALP2-FTR
FSY-PMP-FTR-CFS12CCFH	Common Cause Failure of the Center Electric Fuel Pumps (Extreme Weather)	4.80E-06	R	Alpha	2	FSY-PMP-FTR-CFS1H FSY-PMP-FTR-CFS2H	D-F-C-EPMP-ALP1-FTR D-F-C-EPMP-ALP2-FTR
FSY-PMP-FTR-PFS12CCF	Common Cause Failure of the Port Electric Fuel Pumps	8.63E-05	R	Alpha	2	FSY-PMP-FTR-PFS1 FSY-PMP-FTR-PFS2	D-F-C-EPMP-ALP1-FTR D-F-C-EPMP-ALP2-FTR
FSY-PMP-FTR-PFS12CCFH	Common Cause Failure of the Port Electric Fuel Pumps (Extreme Weather)	4.80E-06	R	Alpha	2	FSY-PMP-FTR-PFS1H FSY-PMP-FTR-PFS2H	D-F-C-EPMP-ALP1-FTR D-F-C-EPMP-ALP2-FTR

CCF BASIC EVENT NAME	DESCRIPTION	CALC CCF PROB	FAILURE TYPE	METHOD	FAILURE CRITERIA	INDEPENDENT FAILURE EVENTS	CCF FACTORS
FSY-PMP-FTR-SFS12CCF	Common Cause Failure of the Starboard Electric Fuel Pumps	8.63E-05	R	Alpha	2	FSY-PMP-FTR-SFS1 FSY-PMP-FTR-SFS2	D-F-C-EPMP-ALP1-FTR D-F-C-EPMP-ALP2-FTR
FSY-PMP-FTR-SFS12CCFH	Common Cause Failure of the Starboard Electric Fuel Pumps (Extreme Weather)	4.80E-06	R	Alpha	2	FSY-PMP-FTR-SFS1H FSY-PMP-FTR-SFS2H	D-F-C-EPMP-ALP1-FTR D-F-C-EPMP-ALP2-FTR
FWC-AOV-FOP-AC0925CCF	Common Cause Failure of Diesel Temp. Reg. Valve for Generators 3 & 4 (AC09 and AC25)	2.98E-07	R	Alpha	2	FWC-AOV-FOP-AC09 FWC-AOV-FOP-AC25	D-O-C-TVLV-ALP1-FTR D-O-C-TVLV-ALP2-FTR
FWC-AOV-FOP-AP0925CCF	Common Cause Failure of Diesel Temp. Reg. Valve for Generators 5 & 6 (AP09 and AP25)	2.98E-07	R	Alpha	2	FWC-AOV-FOP-AP09 FWC-AOV-FOP-AP25	D-O-C-TVLV-ALP1-FTR D-O-C-TVLV-ALP2-FTR
FWC-AOV-FOP-AS0925CCF	Common Cause Failure of Diesel Temp. Reg. Valve for Generators 1 & 2 (AS09 and AS25)	2.98E-07	R	Alpha	2	FWC-AOV-FOP-AS09 FWC-AOV-FOP-AS25	D-O-C-TVLV-ALP1-FTR D-O-C-TVLV-ALP2-FTR
FWC-PMP-FTR-1ALLCCF	Common Cause Failure of Thruster 1 Fresh Water Cooling Pumps	8.63E-05	R	Alpha	2	FWC-PMP-FTR-FC10 FWC-PMP-FTR-FC09	D-O-C-EPMP-TALP1-FTR D-O-C-EPMP-TALP2-FTR
FWC-PMP-FTR-1ALLCCFH	Common Cause Failure of Thruster 1 Fresh Water Cooling Pumps (Extreme Weather)	4.80E-06	R	Alpha	2	FWC-PMP-FTR-FC10H FWC-PMP-FTR-FC09H	D-O-C-EPMP-TALP1-FTR D-O-C-EPMP-TALP2-FTR
FWC-PMP-FTR-2ALLCCF	Common Cause Failure of Thruster 2 Fresh Water Cooling Pumps	8.63E-05	R	Alpha	2	FWC-PMP-FTR-FS10 FWC-PMP-FTR-FS09	D-O-C-EPMP-TALP1-FTR D-O-C-EPMP-TALP2-FTR
FWC-PMP-FTR-2ALLCCFH	Common Cause Failure of Thruster 2 Fresh Water Cooling Pumps (Extreme Weather)	4.80E-06	R	Alpha	2	FWC-PMP-FTR-FS10H FWC-PMP-FTR-FS09H	D-O-C-EPMP-TALP1-FTR D-O-C-EPMP-TALP2-FTR
FWC-PMP-FTR-3ALLCCF	Common Cause Failure of Thruster 3 Fresh Water Cooling Pumps	8.63E-05	R	Alpha	2	FWC-PMP-FTR-FP10 FWC-PMP-FTR-FP09	D-O-C-EPMP-TALP1-FTR D-O-C-EPMP-TALP2-FTR
FWC-PMP-FTR-3ALLCCFH	Common Cause Failure of Thruster 3 Fresh Water Cooling Pumps (Extreme Weather)	4.80E-06	R	Alpha	2	FWC-PMP-FTR-FP10H FWC-PMP-FTR-FP09H	D-O-C-EPMP-TALP1-FTR D-O-C-EPMP-TALP2-FTR
FWC-PMP-FTR-4ALLCCF	Common Cause Failure of Thruster 4 Fresh Water Cooling Pumps	8.63E-05	R	Alpha	2	FWC-PMP-FTR-AS44 FWC-PMP-FTR-AS43	D-O-C-EPMP-TALP1-FTR D-O-C-EPMP-TALP2-FTR
FWC-PMP-FTR-4ALLCCFH	Common Cause Failure of Thruster 4 Fresh Water Cooling Pumps (Extreme Weather)	4.80E-06	R	Alpha	2	FWC-PMP-FTR-AS44H FWC-PMP-FTR-AS43H	D-O-C-EPMP-TALP1-FTR D-O-C-EPMP-TALP2-FTR
FWC-PMP-FTR-5ALLCCF	Common Cause Failure of Thruster 5 Fresh Water Cooling Pumps	8.63E-05	R	Alpha	2	FWC-PMP-FTR-AP44 FWC-PMP-FTR-AP43	D-O-C-EPMP-TALP1-FTR D-O-C-EPMP-TALP2-FTR

CCF BASIC EVENT NAME	DESCRIPTION	CALC CCF PROB	FAILURE TYPE	METHOD	FAILURE CRITERIA	INDEPENDENT FAILURE EVENTS	CCF FACTORS
FWC-PMP-FTR-5ALLCCFH	Common Cause Failure of Thruster 5 Fresh Water Cooling Pumps (Extreme Weather)	4.80E-06	R	Alpha	2	FWC-PMP-FTR-AP44H FWC-PMP-FTR-AP43H	D-O-C-EPMP-TALP1-FTR D-O-C-EPMP-TALP2-FTR
FWC-PMP-FTR-6ALLCCF	Common Cause Failure of Thruster 6 Fresh Water Cooling Pumps	8.63E-05	R	Alpha	2	FWC-PMP-FTR-AC44 FWC-PMP-FTR-AC43	D-O-C-EPMP-TALP1-FTR D-O-C-EPMP-TALP2-FTR
FWC-PMP-FTR-6ALLCCFH	Common Cause Failure of Thruster 6 Fresh Water Cooling Pumps (Extreme Weather)	4.80E-06	R	Alpha	2	FWC-PMP-FTR-AC44H FWC-PMP-FTR-AC43H	D-O-C-EPMP-TALP1-FTR D-O-C-EPMP-TALP2-FTR
FWC-PMP-FTR-CNT34CCF	Common Cause Failure of Diesel Fresh Water Pumps for Generators 3 & 4 (Center generator group)	9.33E-05	C	Alpha (GAMUT)	Varies	FWC-PMP-FTR-AC10	FWC-PMP-FTR-2GRP3-GLOCCF
FWC-PMP-FTR-CNT34CCFH	Common Cause Failure of Diesel Fresh Water Pumps for Generators 3 & 4 (Center generator group) - Extreme Weather	5.19E-06	C	Alpha (GAMUT)	Varies	FWC-PMP-FTR-AC10H	FWC-PMP-FTR-2GRP3-GLOCCF
FWC-PMP-FTR-PRT56CCF	Common Cause Failure of Diesel Fresh Water Pumps for Generators 5 & 6 (Port generator group)	9.33E-05	C	Alpha (GAMUT)	Varies	FWC-PMP-FTR-AP10	FWC-PMP-FTR-2GRP3-GLOCCF
FWC-PMP-FTR-PRT56CCFH	Common Cause Failure of Diesel Fresh Water Pumps for Generators 5 & 6 (Port generator group) - Extreme Weather	5.19E-06	C	Alpha (GAMUT)	Varies	FWC-PMP-FTR-AP10H	FWC-PMP-FTR-2GRP3-GLOCCF
FWC-PMP-FTR-STB12CCF	Common Cause Failure of Diesel Fresh Water Pumps for Generators 1 & 2 (Starboard generator group)	9.33E-05	C	Alpha (GAMUT)	Varies	FWC-PMP-FTR-AS10	FWC-PMP-FTR-2GRP3-GLOCCF
FWC-PMP-FTR-STB12CCFH	Common Cause Failure of Diesel Fresh Water Pumps for Generators 1 & 2 (Starboard generator group) - Extreme Weather	5.19E-06	C	Alpha (GAMUT)	Varies	FWC-PMP-FTR-AS10H	FWC-PMP-FTR-2GRP3-GLOCCF
HYS-ACC-LKE-CCF1	Common cause failure of the surface hydraulic accumulators (Rack 1)	1.68E-06	C	Alpha (GAMUT)	Custom	HYS-ACC-LKE-SH07	HYS-ACC-LKE-ALP
HYS-ACC-LKE-CCF2	Common cause failure of the surface hydraulic accumulators (Rack 2)	1.68E-06	C	Alpha (GAMUT)	Custom	HYS-ACC-LKE-SH27	HYS-ACC-LKE-ALP
HYS-ACC-LKE-CCF3	Common cause failure of the surface hydraulic accumulators (Rack 3)	1.68E-06	C	Alpha (GAMUT)	Custom	HYS-ACC-LKE-SH47	HYS-ACC-LKE-ALP

CCF BASIC EVENT NAME	DESCRIPTION	CALC CCF PROB	FAILURE TYPE	METHOD	FAILURE CRITERIA	INDEPENDENT FAILURE EVENTS	CCF FACTORS
HYS-ACC-LKE-CCF4	Common cause failure of the surface hydraulic accumulators (Rack 4)	1.68E-06	C	Alpha (GAMUT)	Custom	HYS-ACC-LKE-SH67	HYS-ACC-LKE-ALP
HYS-FLT-PLG-CCFM	Common cause failure of the 400 micron filters	8.79E-07	R	Alpha	2	HYS-FLT-PLG-SH11 HYS-FLT-PLG-SH13	HYS-FLT-PLG-ALP1 HYS-FLT-PLG-ALP2
HYS-FLT-PLG-CCFS	Common cause failure of the screen filters	8.79E-07	R	Alpha	2	HYS-FLT-PLG-SH01 HYS-FLT-PLG-SH04	HYS-FLT-PLG-ALP1 HYS-FLT-PLG-ALP2
HYS-PMP-FTR-CCF	Common cause failure of the HPU pumps	8.63E-05	R	Alpha	2	HYS-PMP-FTR-SH02 HYS-PMP-FTR-SH05	HYS-PMP-FTR-ALP1 HYS-PMP-FTR-ALP2
HYS-SCV-FTO-CCF	Common cause failure of the HPU check valves	1.46E-13	R	Alpha	2	HYS-SCV-FTO-SH03 HYS-SCV-FTO-SH06	HYS-SCV-FTO-ALP1 HYS-SCV-FTO-ALP2
HYS-SCV-FTO-CCFB	Common cause failure of the bypass check valves	1.46E-13	R	Alpha	2	HYS-SCV-FTO-SH12 HYS-SCV-FTO-SH14	HYS-SCV-FTO-ALP1 HYS-SCV-FTO-ALP2
SWC-PMP-FTR-GLO2CCF-T123	CCF of Cooling System Sea Water Pumps (all combinations that fail 2 or more thrusters)	2.35E-05	C	Alpha (GAMUT)	Varies	SWC-PMP-FTR-FS03	SWC-PMP-FTR-ALP2THR-T123
SWC-PMP-FTR-GLO2CCF-T456	CCF of Cooling System Sea Water Pumps (all combinations that fail 2 or more thrusters)	2.42E-05	C	Alpha (GAMUT)	Varies	SWC-PMP-FTR-FS03	SWC-PMP-FTR-ALP2THR-T456
SWC-PMP-FTR-GLOBAL1CCFH	CCF of Cooling System Sea Water Pumps during a kick control (all comb that fail 1 or more thrusters) - Extreme Weather	3.11E-06	C	Alpha (GAMUT)	Varies	SWC-PMP-FTR-FS03H	SWC-PMP-FTR-ALP1THRH
SWC-PMP-FTR-GLOBAL3CCF	CCF of Cooling System Sea Water Pumps during a kick control (all combinations that fail 3 or more thrusters)	6.62E-06	C	Alpha (GAMUT)	Varies	SWC-PMP-FTR-FS03	SWC-PMP-FTR-ALP3THR
SWC-SCH-CLG-AP1AS2-CCF	Common Cause Failure of Aft Sea Chests APSC1 and ASSC2	2.28E-06	C	Beta	All	SWC-SCH-CLG-APSC1	BETA-CCF
SWC-SCH-CLG-AP1S2-CCF-IE	Common Cause Failure of Aft Sea Chests APSC1 and ASSC2 as Initiator	3.17E-08	C	Beta	All	SWC-SCH-CLG-ASSC2-F-IE	BETA-CCF
SWC-SCH-CLG-FP3S4-CCF	Common Cause Failure of Forward Sea Chests FPSC3 and FSSC4	2.28E-06	C	Beta	All	SWC-SCH-CLG-FSSC4	BETA-CCF
SWC-SCH-CLG-FP3S4-CCF-IE	Common Cause Failure of Forward Sea Chests FPSC3 and FSSC4 as Initiator	3.17E-08	C	Beta	All	SWC-SCH-CLG-FPSC3-F-IE	BETA-CCF

H.5 REFERENCES

H1 NASA, "JSC-BSEE-NA-24402-02, Probabilistic Risk Assessment Procedures Guide for Offshore Applications," 2021.

H2 U.S. Nuclear Regulatory Commission, "CCF Parameter Estimations, 2012 Update", November 2013, https://nrcoe.inl.gov/resultsdb/publicdocs/CCF/ccfparamest2012.pdf

H3 SINTEF “Reliability Data for Safety Instrumented System”, 2013 Edition.

H4 GAMUT, Global Alpha Model Uncertainty Tool, JSC NC4 Analysis Team In-House Tool.

APPENDIX I- PRA HRA WORKSHEETS

I.1 HRA WORKSHEETS

This Appendix provides the HRA worksheets and descriptions for each human error event used in the PRA model.

HRA Basic Event: **DPS-HUM-ERR-CSRECOV**

Description Block: Human Error Failure to Adequately Recover from a Control System Failure in Which Drive-off is Initiated

Location of Event in Model: This event is located in the sub-fault trees addressing a loss of DPS control resulting in the vessel driving off location; D_CONT_L_DRIVE and D_CONT_L_DRIVE_F_IE. This HRA is populated by the template event HUM-ERR-CSRECOV.

Discussion and description: The DP control system provides feedback to the operator concerning the health of the DP system. However, in the event of a system malfunction, alarm or degraded operating capability, the system operator should evaluate the status information of the system to determine what has malfunctioned and what needs to be done to allow the system to continue to maintain location. This basic event captures the possibility that the operator incorrectly diagnoses, or takes incorrect remedial action or inaction, that results in the control system incorrectly recognizing vessel position, which results in driving the vessel off location in an attempt to correct the vessel position, resulting in a loss of position.

For HRA **DPS-HUM-ERR-CSRECOV** the automated spreadsheet CHRAC [I-1] is used and the following steps are performed by interviewing a subject matter expert. The spreadsheet utilizes the PRA Team's adaptation of CREAM [I-2] to do this HRA analysis and is performed by a knowledgeable HRA practitioner utilizing input of information from a subject matter expert. The following steps are used by CHRAC.

STEP 1 - Identify Failures and Recovery Actions

DPS-HUM-ERR-CSRECOV

Description	Task	Failure or Recovery?	If Recovery, applies to which Failures? 1	2	3	4	5					
acknowledge the alarm	1	Failure	○	○	○	○	○	○	○	○	○	○
identifies source of the alarm	2	Failure	○	○	○	○	○	○	○	○	○	○
Gather more information	3	Failure	○	○	○	○	○	○	○	○	○	○
Take corrective action	4	Failure	○	○	○	○	○	○	○	○	○	○
Verify the action is correct	5	Recovery	◉	◉	◉	◉	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
		No Recovery Action	○	○	○	○	◉	◉	◉	◉	◉	◉

STEP 2 - Cognitive Activity Matrix

Description	Task	Cognitive Activity	Cognitive Demand				Skip
			Observation	Interpretation	Planning	Execution	
Acknowledge the alarm	1	Execute	○	○	○	◉	○
Identifies source of the alarm	2	Identify	○	◉	○	○	○
Gather more information	3	Diagnose	○	◉	○	○	○
Take corrective action	4	Execute	○	○	○	◉	○
Verify the action is correct	5	Monitor	○	◉	○	○	○

STEP 3 - Cognitive Demand Failures

Cognitive Demand	Classification	Median	Potential Cognitive Demand Failure	Task 1	2	3	4	5
Observation	O1	1.0E-03	Observation of wrong object (response is given to the wrong stimulus or event)	○	○	○	○	○
	O2	3.0E-03	Wrong identification made (Omission. Overlooking a signal or a measurement)	○	○	○	○	○
	O3	3.0E-03	Observation Not Made (Omission. Overlooking a signal or a measurement)	○	○	○	○	○
Interpretation	I1	2.0E-01	Faulty diagnosis (either a wrong diagnosis or an incomplete diagnosis)	○	○	◉	○	○
	I2	1.0E-02	Decision error (either not making a decision or making a wrong or incomplete decision)	○	◉	○	○	◉
	I3	1.0E-02	Delayed interpretation (not made in time)	○	○	○	○	○
Planning	P1	1.0E-02	Priority error (as in selecting the wrong goal, intention)	○	○	○	○	○
	P2	1.0E-02	Inadequate plan formulated (when the plan is either incomplete or directly wrong)	○	○	○	○	○
Execution	E1	3.0E-03	Execution of wrong type performed (with regard to force, distance, speed, or direction)	○	○	○	◉	○
	E2	3.0E-03	Action performed at wrong time (either too early or too late)	○	○	○	○	○
	E3	5.0E-04	Action on wrong object (neighbor, similar or unrelated)	○	○	○	○	○
	E4	3.0E-03	Action performed out of sequence (repetitions, jumps, and reversals)	○	○	○	○	○
	E5	3.0E-02	Action missed, not performed (omission), including the omission of the last actions in a series ("undershoot")	◉	○	○	○	○

STEP 4 - Weighting Factors for Common Performance Conditions (CPCs)

	Task				
CPC	**1**	**2**	**3**	**4**	**5**
	Execution	Interpretation	Interpretation	Execution	Interpretation
Adequacy of Organization	Efficient	Efficient	Efficient	Efficient	Efficient
Working Conditions	Advantageous	Advantageous	Advantageous	Advantageous	Advantageous
Adequacy of MMI	Supportive	Supportive	Supportive	Supportive	Supportive
Procedures / Plans	Appropriate	Appropriate	Appropriate	Appropriate	Appropriate
Number of Goals	Matching	Matching	Matching	Matching	Matching
Available Time	Adequate	Adequate	Adequate	Adequate	Adequate
Time of Day	Adjusted	Adjusted	Adjusted	Adjusted	Adjusted
Training and Preparation	High Exp	High Exp	High Exp	High Exp	High Exp
Crew Collaboration	Efficient	Efficient	Efficient	Efficient	Efficient
Overall Weighting Factor	**0.13**	**0.20**	**0.20**	**0.13**	**0.20**

STEP 5 - Cognitive Failure Probabilities (CFPs)

	Task				
	1	**2**	**3**	**4**	**5**
Failure (F) / Recovery (R)	F	F	**F**	F	**R**
Median Nominal CFP	3.0E-02	1.0E-02	**2.0E-01**	3.0E-03	1.0E-02
Median Adjusted CFP	3.8E-03	2.0E-03	**4.0E-02**	3.8E-04	2.0E-03
Error Factor (EF)	5.0	5.0	**5.0**	5.0	
Mean Adjusted CFP	6.2E-03	3.2E-03	**6.5E-02**	6.2E-04	
Zero	○	○	○	○	○
Low	○	○	○	○	●
Moderate	○	○	○	○	○
High	○	○	○	○	○
Complete	○	○	○	○	○
Skip	●	●	●	●	○
Recovery Median Adjusted CFP (with dependency)					5.2E-02
Recovery EF					3.2
Recovery Mean					6.6E-02
Recovery Action associated with this Failure	5	5	**5**	5	
Mean Adjusted CFP * Recovery Mean (Maximum)	4.1E-04	2.1E-04	**4.3E-03**	4.1E-05	

Determine the level of dependency for *recovery tasks* only.

Final Results

Mean Adjusted CFP * Recovery Mean (Maximum) = 4.3E-03
Mean Adjusted CFP = 6.5E-02
CFP EF = 5.0
Recovery Action = 5
Recovery Mean = 6.6E-02
Recovery EF = 3.2

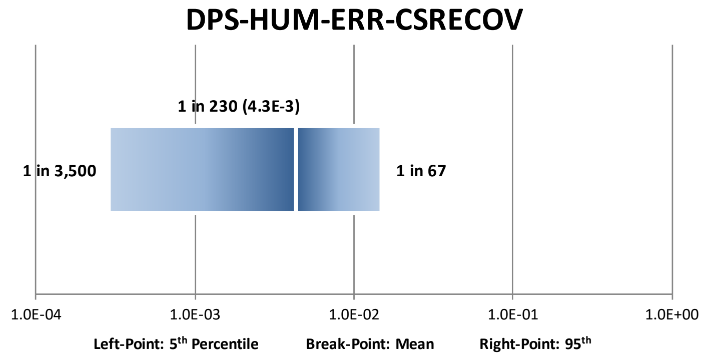
Significant Digits = 2

CHRAC RESULTS

Total Failure Probability		
Statistic	**Value**	**One in:**
Mean =	**4.3E-03**	230
EF =	**7.2**	-----
5th =	2.9E-04	3,500
50th =	2.1E-03	480
95th =	1.5E-02	67

The recommended number of significant digits is two.

Feel free to adjust the graph (axes, labels, etc.) to best suit your result.



Results discussion: CHRAC takes the information that is contained in steps 1 through 4 to produce the results shown in step 5. It converts medians to means since HRA values are done as a median of a lognormal distribution. It then needs to be converted to a mean for purposes of use in the PRA. It takes the "Recovery" factors times their assigned failure events and compares them. From this comparison it takes the highest value which, in this case, is Task 5 times Task 3 to get 4.3E-03. It also computes the EF of 7.2 and displays it on a "Band-Aid" chart to represent the mean and the 5^{th} and 95^{th} uncertainty range. So the failure probability of the DPS operator failing to properly diagnose or correct a degraded system resulting in the vessel driving off location is 4.3E-03 (or 1 in 230).

HRA Basic Event: **DPS-HUM-ERR-JOYSTICK**

Description Block: Human Error Failure to Control Vessel Using the Independent Joystick

Location of Event in Model: This event is located in the control portion of the nominal operating environment model. It is in the sub-fault tree, D_CONT_L_JYSTK. This HRA event is populated by the template event HUM-ERR-JOYSTICK.

Discussion and description: In the event that the DP primary and back-up control systems fail, vessel location can be maintained, at least temporarily, using the joystick controller. This event captures the possibility that the person responsible for maintaining position using the joystick fails to hold position which results in the vessel losing position and reaching the red watch circle. It is assumed that the joystick cannot be used to hold position in elevated weather conditions.

For HRA **DPS-HUM-ERR-JOYSTICK** the automated spreadsheet CHRAC is used and the following steps are performed by interviewing a subject matter expert. The spreadsheet utilizes the PRA Team's adaptation of CREAM to do this HRA analysis and is performed by a knowledgeable HRA practitioner utilizing input of information from a Subject Matter Expert. The following steps are used by CHRAC.

STEP 1 - Identify Failures and Recovery Actions

DPS-HUM-ERR-JOYSTICK

Description	Task	Failure or Recovery?	If Recovery, applies to which Failures?									
			1									
Fails to maintain position with joystick	1	Failure	○	○	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
		No Recovery Action	◉	◉	◉	◉	◉	◉	◉	◉	◉	◉

STEP 2 - Cognitive Activity Matrix

Description	Task	Cognitive Activity	Cognitive Demand				Skip
			Observation	Interpretation	Planning	Execution	
Fails to maintain position with joystick	1	Maintain	○	○	○	◉	○

STEP 3 - Cognitive Demand Failures

Cognitive Demand	Classification	Median	Potential Cognitive Demand Failure	Task 1
Observation	O1	1.0E-03	Observation of wrong object (response is given to the wrong stimulus or event)	○
	O2	3.0E-03	Wrong identification made (Omission. Overlooking a signal or a measurement)	○
	O3	3.0E-03	Observation Not Made (Omission. Overlooking a signal or a measurement)	○
Interpretation	I1	2.0E-01	Faulty diagnosis (either a wrong diagnosis or an incomplete diagnosis)	○
	I2	1.0E-02	Decision error (either not making a decision or making a wrong or incomplete decision)	○
	I3	1.0E-02	Delayed interpretation (not made in time)	○
Planning	P1	1.0E-02	Priority error (as in selecting the wrong goal, intention)	○
	P2	1.0E-02	Inadequate plan formulated (when the plan is either incomplete or directly wrong)	○
Execution	E1	3.0E-03	Execution of wrong type performed (with regard to force, distance, speed, or direction)	◉
	E2	3.0E-03	Action performed at wrong time (either too early or too late)	○
	E3	5.0E-04	Action on wrong object (neighbor, similar or unrelated)	○
	E4	3.0E-03	Action performed out of sequence (repetitions, jumps, and reversals)	○
	E5	3.0E-02	Action missed, not performed (omission), including the omission of the last actions in a series ("undershoot")	○
			Skip	○

STEP 4 - Weighting Factors for Common Performance Conditions (CPCs)

CPC	Task 1 Execution
Adequacy of Organization	Efficient
Working Conditions	Compatible
Adequacy of MMI	Tolerable
Procedures / Plans	Acceptable
Number of Goals	Matching
Available Time	Cont Inadequate
Time of Day	Adjusted
Training and Preparation	Inadequate Exp
Crew Collaboration	Efficient
Overall Weighting Factor	**10.00**

STEP 5 - Cognitive Failure Probabilities (CFPs)

	Task 1
Failure (F) / Recovery (R)	F
Median Nominal CFP	3.0E-03
Median Adjusted CFP	3.0E-02
Error Factor (EF)	10.0
Mean Adjusted CFP	8.0E-02
Zero	○
Low	○
Moderate	○
High	○
Complete	○
Skip	◉
Recovery Median Adjusted CFP (with dependency)	
Recovery EF	
Recovery Mean	
Recovery Action associated with this Failure	
Mean Adjusted CFP * Recovery Mean (Maximum)	8.0E-02

Determine the level of dependency for *recovery tasks* only.

Final Results

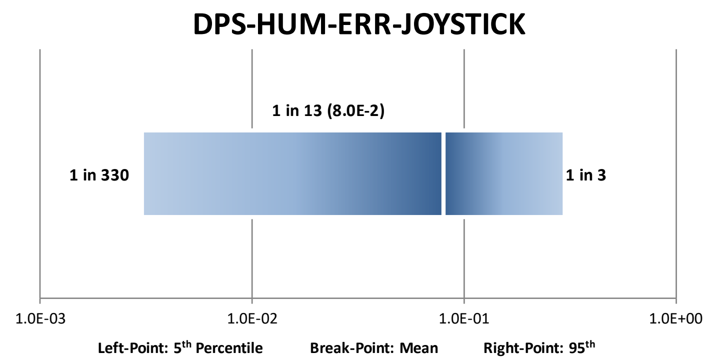
Mean Adjusted CFP * Recovery Mean (Maximum) =	8.0E-02
Mean Adjusted CFP =	8.0E-02
CFP EF =	10.0
Recovery Action =	
Recovery Mean =	
Recovery EF =	
Significant Digits =	2

CHRAC RESULTS

Total Failure Probability		
Statistic	**Value**	**One in:**
Mean =	**8.0E-02**	13
EF =	**10.0**	-----
5th =	3.0E-03	330
50th =	3.0E-02	33
95th =	3.0E-01	3

The recommended number of significant digits is two.

Feel free to adjust the graph (axes, labels, etc.) to best suit your result.



Results discussion: CHRAC takes the information that is contained in steps 1 through 4 to produce the results shown in step 5. It converts medians to means since HRA values are done as a median of a lognormal distribution. It then needs to be converted to a mean for purposes of use in the PRA. It takes the "Recovery" factors times their assigned failure events and compares them. From this comparison it takes the highest value and multiplies it with the recovery action. Since this event is purely a recovery action the value assigned to the recovery action is the representative value, which in this case is 8.0E-02. The error factor is calculated to be 10.0. The "Band-Aid" chart shows the mean and the 5^{th} and 95^{th} uncertainty range. So the failure probability of the DPS operator to maintain location using the joystick is 8.0E-02 (or 1 in 13).

HRA Basic Event: **D-W-S-STRM-OFST-HRA**

Description Block: Human Error Resulting in Incorrectly Entering the Offset into the DP System (Extreme Weather, Winter Storm, Squall)

Location of Event in Model: This event is located in the sub-fault trees; D_OFFSET_HRA_STRM and DRIVE-OFF_IEFT_FRE. This event is multiplied by the frequency of occurrence of squalls (DPS-FRQ-WEA-SQUA or DPS-FRQ-WEA-SQUA-F-IE), winter storms (DPS-FRQ-WEA-WINT or DPS-FRQ-WEA-WINT-F-IE), sudden hurricanes (DPS-FRQ-WEA-HURR or DPS-FRQ-WEA-HURR-F-IE), and the need to move the MODU for well operations (DPS-FRQ-OFS-OPER or DPS-FRQ-OFS-OPER-F-IE) to obtain the respective probabilities for a human error under each of these conditions. This HRA event is populated by the template event STRM-OFST-HRA.

Discussion and description: In the event that an upcoming weather system threatens to overtake the vessel, the DPO may be required to reposition the vessel within the green operation area to prevent getting pushed to or beyond the edge by the weather. Repositioning the vessel requires that an offset be entered into the control system that will move the vessel to the desired offset position. This event captures the risk that this operation is performed incorrectly and the vessel drives off its location resulting in a loss of position.

For HRA **DPS-WEA-HRA-OFST** the automated spreadsheet CHRAC is used and the following steps are performed by interviewing a subject matter expert. The spreadsheet utilizes the PRA Team's adaptation of CREAM to do this HRA analysis and is performed by a knowledgeable HRA practitioner utilizing input of information from a Subject Matter Expert. The following steps are used by CHRAC.

STEP 1 - Identify Failures and Recovery Actions

DPS-WEA-HRA-OFST

Description	Task	Failure or Recovery?	If Recovery, applies to which Failures?									
			1	2								
Initiate offset	1	Failure	○	○	○	○	○	○	○	○	○	○
Monitors status	2	Recovery	◉	○	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
		No Recovery Action	○	◉	◉	◉	◉	◉	◉	◉	◉	◉

STEP 2 - Cognitive Activity Matrix

Description	Task	Cognitive Activity	Cognitive Demand				Skip
			Observation	Interpretation	Planning	Execution	
Initiate offset	1	Execute	○	○	○	●	○
Monitors status	2	Identify	○	●	○	○	○

STEP 3 - Cognitive Demand Failures

Cognitive Demand	Classification	Median	Potential Cognitive Demand Failure	Task 1	Task 2
Observation	O1	1.0E-03	Observation of wrong object (response is given to the wrong stimulus or event)	○	○
	O2	3.0E-03	Wrong identification made (Omission. Overlooking a signal or a measurement)	○	○
	O3	3.0E-03	Observation Not Made (Omission. Overlooking a signal or a measurement)	○	○
Interpretation	I1	2.0E-01	Faulty diagnosis (either a wrong diagnosis or an incomplete diagnosis)	○	○
	I2	1.0E-02	Decision error (either not making a decision or making a wrong or incomplete decision)	○	●
	I3	1.0E-02	Delayed interpretation (not made in time)	○	○
Planning	P1	1.0E-02	Priority error (as in selecting the wrong goal, intention)	○	○
	P2	1.0E-02	Inadequate plan formulated (when the plan is either incomplete or directly wrong)	○	○
Execution	E1	3.0E-03	Execution of wrong type performed (with regard to force, distance, speed, or direction)	●	○
	E2	3.0E-03	Action performed at wrong time (either too early or too late)	○	○
	E3	5.0E-04	Action on wrong object (neighbor, similar or unrelated)	○	○
	E4	3.0E-03	Action performed out of sequence (repetitions, jumps, and reversals)	○	○
	E5	3.0E-02	Action missed, not performed (omission), including the omission of the last actions in a series ("undershoot")	○	○
			Skip	○	○

STEP 4 - Weighting Factors for Common Performance Conditions (CPCs)

	Task	
CPC	**1**	**2**
	Execution	Interpretation
Adequacy of Organization	Efficient	Efficient
Working Conditions	Compatible	Compatible
Adequacy of MMI	Supportive	Supportive
Procedures / Plans	Appropriate	Appropriate
Number of Goals	Matching	Matching
Available Time	Adequate	Temp Inadequate
Time of Day	Adjusted	Adjusted
Training and Preparation	High Exp	High Exp
Crew Collaboration	Efficient	Efficient
Overall Weighting Factor	**0.16**	**0.50**

STEP 5 - Cognitive Failure Probabilities (CFPs)

	Task	
	1	**2**
Failure (F) / Recovery (R)	**F**	**R**
Median Nominal CFP	**3.0E-03**	1.0E-02
Median Adjusted CFP	**4.8E-04**	5.0E-03
Error Factor (EF)	**3.0**	
Mean Adjusted CFP	**6.0E-04**	
Zero	○	○
Low	○	◉
Moderate	○	○
High	○	○
Complete	○	○
Skip	◉	○
Recovery Median Adjusted CFP (with dependency)		5.5E-02
Recovery EF		3.2
Recovery Mean		7.0E-02
Recovery Action associated with this Failure	**2**	
Mean Adjusted CFP * Recovery Mean (Maximum)	**4.2E-05**	

Determine the level of dependency for *recovery tasks* only.

Final Results

Mean Adjusted CFP * Recovery Mean (Maximum) = 4.2E-05
Mean Adjusted CFP = 6.0E-04
CFP EF = 3.0
Recovery Action = 2
Recovery Mean = 7.0E-02
Recovery EF = 3.2

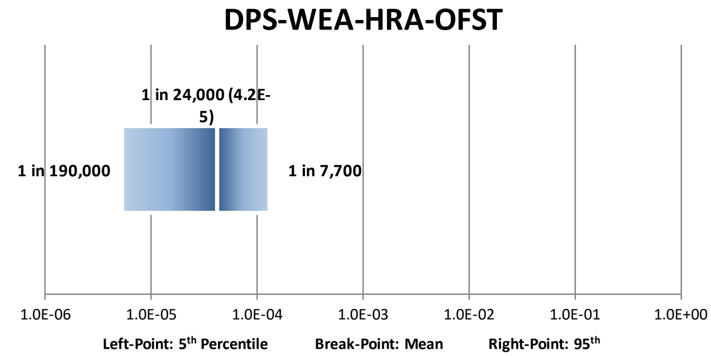
Significant Digits = 2

CHRAC RESULTS

Total Failure Probability		
Statistic	**Value**	**One in:**
Mean =	**4.2E-05**	24,000
EF =	**4.9**	-----
5th =	5.4E-06	190,000
50th =	2.6E-05	38,000
95th =	1.3E-04	7,700

The recommended number of significant digits is two.

Feel free to adjust the graph (axes, labels, etc.) to best suit your result.



Results discussion: CHRAC takes the information that is contained in steps 1 through 4 to produce the results shown in step 5. It converts medians to means since HRA values are done as a median of a lognormal distribution. It then needs to be converted to a mean for purposes of use in the PRA. It takes the "Recovery" factors times their assigned failure events and compares them. From this comparison it takes the highest value which, in this case, is Task 5 times Task 3 to get 4.2E-05. It also computes the EF of 4.9 and displays it on a "Band-Aid" chart to represent the mean and the 5^{th} and 95^{th} uncertainty range. So the failure probability of the DPS operator failing to properly enter an offset prior to the onset of an elevated weather system resulting in the vessel driving off location is 4.2E-05 (or 1 in 24,000).

HRA Basic Event: **DPS-WEA-HRA-PREP**

Description Block: Human Error Failure to Orient the Vessel for the Onset of Elevated Weather

Location of Event in Model: This event is part of a three compound events that are used in the model to determine the probability of human error to correctly orient the vessel prior to the onset of elevated weather. This event is multiplied by the frequency of occurrence of squalls (DPS-FRQ-WEA-SQUA-F-IE), winter storms (DPS-FRQ-WEA-WINT-F-IE), and sudden hurricanes (DPS-FRQ-WEA-HURR-F-IE) to obtain the respective probabilities that the vessel is not properly positioned. This HRA event is populated by the template event WEA-HRA-PREP.

Discussion and description: In the event that an incoming weather system approaches the vessel, the DPO will be required to position the bow of the vessel into the wind to provide optimum capability to withstand the storm and maintain location. This event captures the risk that the operator fails to orient the vessel correctly and the weather front causes the vessel to drift-off its location to the point that a loss of position occurs.

For HRA **DPS-WEA-HRA-PREP** the automated spreadsheet CHRAC is used and the following steps are performed by interviewing a subject matter expert. The spreadsheet utilizes the PRA Team's adaptation of CREAM to do this HRA analysis and is performed by a knowledgeable HRA practitioner utilizing input of information from a Subject Matter Expert. The following steps are used by CHRAC.

STEP 1 - Identify Failures and Recovery Actions — **DPS-WEA-HRA-PREP**

Description	Task	Failure or Recovery?	If Recovery, applies to which Failures?									
			1	2	3	4						
Monitor for weather	1	Failure	○	○	○	○	○	○	○	○	○	○
observe for incoming storms	2	Failure	○	○	○	○	○	○	○	○	○	○
Prepare for oncoming storms	3	Failure	○	○	○	○	○	○	○	○	○	○
Independent monitoring and action	4	Recovery	◉	◉	◉	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
		No Recovery Action	○	○	○	◉	◉	◉	◉	◉	◉	◉

STEP 2 - Cognitive Activity Matrix

Description	Task	Cognitive Activity	Cognitive Demand				Skip
			Observation	Interpretation	Planning	Execution	
Monitor for weather	1	Monitor	◉	○	○	○	○
Observe for incoming storms	2	Observe	◉	○	○	○	○
Prepare for oncoming storms	3	Execute	○	○	○	◉	○
Independent monitoring and action	4	Execute	○	○	○	◉	○

STEP 3 - Cognitive Demand Failures

Cognitive Demand	Classification	Median	Potential Cognitive Demand Failure	Task 1	Task 2	Task 3	Task 4
Observation	O1	1.0E-03	Observation of wrong object (response is given to the wrong stimulus or event)	○	○	○	○
	O2	3.0E-03	Wrong identification made (Omission. Overlooking a signal or a measurement)	○	◉	○	○
	O3	3.0E-03	Observation Not Made (Omission. Overlooking a signal or a measurement)	◉	○	○	○
Interpretation	I1	2.0E-01	Faulty diagnosis (either a wrong diagnosis or an incomplete diagnosis)	○	○	○	○
	I2	1.0E-02	Decision error (either not making a decision or making a wrong or incomplete decision)	○	○	○	○
	I3	1.0E-02	Delayed interpretation (not made in time)	○	○	○	○
Planning	P1	1.0E-02	Priority error (as in selecting the wrong goal, intention)	○	○	○	○
	P2	1.0E-02	Inadequate plan formulated (when the plan is either incomplete or directly wrong)	○	○	○	○
Execution	E1	3.0E-03	Execution of wrong type performed (with regard to force, distance, speed, or direction)	○	○	○	○
	E2	3.0E-03	Action performed at wrong time (either too early or too late)	○	○	○	◉
	E3	5.0E-04	Action on wrong object (neighbor, similar or unrelated)	○	○	○	○
	E4	3.0E-03	Action performed out of sequence (repetitions, jumps, and reversals)	○	○	○	○
	E5	3.0E-02	Action missed, not performed (omission), including the omission of the last actions in a series ("undershoot")	○	○	◉	○
			Skip	○	○	○	○

STEP 4 - Weighting Factors for Common Performance Conditions (CPCs)

	Task			
CPC	**1**	**2**	**3**	**4**
	Observation	Observation	Execution	Execution
Adequacy of Organization	Efficient	Efficient	Efficient	Efficient
Working Conditions	Compatible	Compatible	Compatible	Compatible
Adequacy of MMI	Adequate	Adequate	Adequate	Adequate
Procedures / Plans	Acceptable	Acceptable	Acceptable	Acceptable
Number of Goals	Matching	Matching	Matching	Matching
Available Time	Adequate	Adequate	Adequate	Temp Inadequate
Time of Day	Adjusted	Adjusted	Adjusted	Adjusted
Training and Preparation	High Exp	High Exp	High Exp	High Exp
Crew Collaboration	Efficient	Efficient	Efficient	Efficient
Overall Weighting Factor	**0.40**	**0.40**	**0.40**	**0.80**

STEP 5 - Cognitive Failure Probabilities (CFPs)

Determine the level of dependency for *recovery tasks* only.

	Task			
	1	**2**	**3**	**4**
Failure (F) / Recovery (R)	F	F	F	**R**
Median Nominal CFP	3.0E-03	3.0E-03	**3.0E-02**	3.0E-03
Median Adjusted CFP	1.2E-03	1.2E-03	**1.2E-02**	2.4E-03
Error Factor (EF)	3.0	3.0	**1.3**	
Mean Adjusted CFP	1.5E-03	1.5E-03	**1.2E-02**	
Zero	○	○	○	○
Low	○	○	○	●
Moderate	○	○	○	○
High	○	○	○	○
Complete	○	○	○	○
Skip	●	●	●	○
Recovery Median Adjusted CFP (with dependency)				5.2E-02
Recovery EF				3.2
Recovery Mean				6.7E-02
Recovery Action associated with this Failure	4	4	**4**	
Mean Adjusted CFP * Recovery Mean (Maximum)	1.0E-04	1.0E-04	**8.1E-04**	

Final Results

Mean Adjusted CFP * Recovery Mean (Maximum) = 8.1E-04
Mean Adjusted CFP = 1.2E-02
CFP EF = 1.3
Recovery Action = 4
Recovery Mean = 6.7E-02
Recovery EF = 3.2

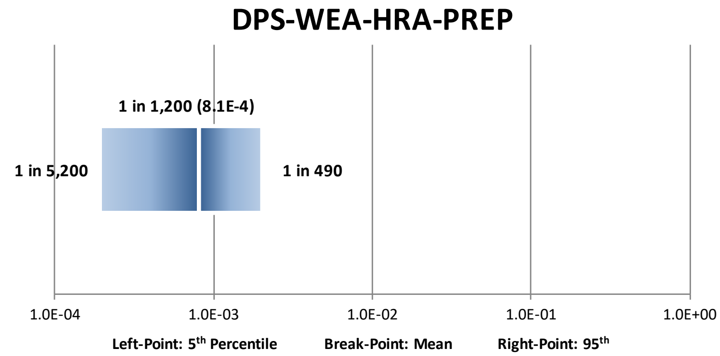
Significant Digits = 2

CHRAC RESULTS

Total Failure Probability		
Statistic	**Value**	**One in:**
Mean =	**8.1E-04**	1,200
EF =	**3.2**	-----
5th =	1.9E-04	5,200
50th =	6.3E-04	1,600
95th =	2.0E-03	490

The recommended number of significant digits is two.

Feel free to adjust the graph (axes, labels, etc.) to best suit your result.



Results discussion: CHRAC takes the information that is contained in steps 1 through 4 to produce the results shown in step 5. It converts medians to means since HRA values are done as a median of a lognormal distribution. It then needs to be converted to a mean for purposes of use in the PRA. It takes the "Recovery" factors times their assigned failure events and compares them. From this comparison it takes the highest value which, in this case, is Task 5 times Task 3 to get 8.1E-04. It also computes the EF of 3.2 and displays it on a "Band-Aid" chart to represent the mean and the 5th and 95th uncertainty range. So the failure probability of the DPS operator failing to orient the vessel into the wind prior to the onset of an elevated weather system resulting in the vessel drifting off location is 8.1E-04 (or 1 in 1200).

HRA Basic Event: **BOP-HUM-ERR-PODSEL**

Description Block: Operator Failure to Manually Shift to the Blue Pod after a Yellow Pod Failure

Location of Event in Model: This event is in all of the sub-fault trees involving failure of the yellow and blue pods; BOP_BLIND_SHEAR, BOP_CASING_SHEAR, BOP_LOWER_ANNULAR_B, BOP_LOWER_PIPE_RAM_B, BOP_LPR_LOCK, BOP_MIDDLE_PIPE_RAM_B, BOP_MPR_LOCK, BOP_UPPER_ANNULAR_B, BOP_UPPER_PIPE_RAM_B, BOP_UPR_LOCK. It will show up close to the top of each function that is modeled and may show up many times under that function. This HRA event is populated by the template event HUM-ERR-PODSEL.

Discussion and description: The model is set up with the BOP using the yellow pod for control. If for any reason hydraulics fails in the yellow pod side, the driller will shift to the blue pod. To make this shift is a straight-forward and routine event. As a matter of normal operation the pods are shifted every week or so. The redundancy in the control system is high and there are a number of ways to shift from yellow hydraulics to blue or vice versa. In the simplest way only a button push or two is required from the driller's panel. There are a number of ways that the driller will know that the attempt to shift has been successful.

For HRA: **BOP-HUM-ERR-PODSEL** the automated spreadsheet CHRAC is used and the following steps are performed by interviewing a subject matter expert. The spreadsheet utilizes the PRA Team's adaptation of CREAM to do this HRA analysis and is performed by a knowledgeable HRA practitioner utilizing input of information from a subject matter expert. The following steps are used by CHRAC.

STEP 1 - Identify Failures and Recovery Actions — **BOP-HUM-ERR-PODSEL**

Description	Task	Failure or Recovery?	If Recovery, applies to which Failures? 1	2	3							
Fails to realize a yellow pod component is not working correctly	1	Failure	○	○	○	○	○	○	○	○	○	○
Fails to Initiate pod change	2	Failure	○	○	○	○	○	○	○	○	○	○
Verifies indications and mud flow stops	3	Recovery	◉	◉	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
		No Recovery Action	○	○	◉	◉	◉	◉	◉	◉	◉	◉

STEP 2 - Cognitive Activity Matrix

	Description	Task	Cognitive Activity	Cognitive Demand				Skip
				Observation	Interpretation	Planning	Execution	
F	Fails to realize a yellow pod component is not working correctly	1	Monitor	●	○	○	○	○
F	Fails to Initiate pod change	2	Execute	○	○	○	●	○
R	Verifies indications and mud flow stops	3	Verify	●	○	○	○	○
				○	○	○	○	●
				○	○	○	○	●
				○	○	○	○	●
				○	○	○	○	●
				○	○	○	○	●
				○	○	○	○	●
				○	○	○	○	●

STEP 3 - Cognitive Demand Failures

Cognitive Demand	Classification	Median	Potential Cognitive Demand Failure	Task 1	Task 2	Task 3
Observation	O1	1.0E-03	Observation of wrong object (response is given to the wrong stimulus or event)	○	○	○
	O2	3.0E-03	Wrong identification made (Omission. Overlooking a signal or a measurement)	○	○	○
	O3	3.0E-03	Observation Not Made (Omission. Overlooking a signal or a measurement)	●	○	●
Interpretation	I1	2.0E-01	Faulty diagnosis (either a wrong diagnosis or an incomplete diagnosis)	○	○	○
	I2	1.0E-02	Decision error (either not making a decision or making a wrong or incomplete decision)	○	○	○
	I3	1.0E-02	Delayed interpretation (not made in time)	○	○	○
Planning	P1	1.0E-02	Priority error (as in selecting the wrong goal, intention)	○	○	○
	P2	1.0E-02	Inadequate plan formulated (when the plan is either incomplete or directly wrong)	○	○	○
Execution	E1	3.0E-03	Execution of wrong type performed (with regard to force, distance, speed, or direction)	○	○	○
	E2	3.0E-03	Action performed at wrong time (either too early or too late)	○	●	○
	E3	5.0E-04	Action on wrong object (neighbor, similar or unrelated)	○	○	○
	E4	3.0E-03	Action performed out of sequence (repetitions, jumps, and reversals)	○	○	○
	E5	3.0E-02	Action missed, not performed (omission), including the omission of the last actions in a series ("undershoot")	○	○	○
			Skip	○	○	○

STEP 4 - Weighting Factors for Common Performance Conditions (CPCs)

CPC	Task 1 Observation	Task 2 Execution	Task 3 Observation
Adequacy of Organization	Efficient	Efficient	Efficient
Working Conditions	Compatible	Compatible	Compatible
Adequacy of MMI	Supportive	Supportive	Supportive
Procedures / Plans	Appropriate	Appropriate	Appropriate
Number of Goals	Fewer	Fewer	Fewer
Available Time	Adequate	Adequate	Adequate
Time of Day	Adjusted	Adjusted	Adjusted
Training and Preparation	High Exp	High Exp	High Exp
Crew Collaboration	Efficient	Efficient	Efficient
Overall Weighting Factor	**0.16**	**0.16**	**0.16**

STEP 5 - Cognitive Failure Probabilities (CFPs)

	Task 1	Task 2	Task 3
Failure (F) / Recovery (R)	**F**	**F**	**R**
Median Nominal CFP	**3.0E-03**	**3.0E-03**	3.0E-03
Median Adjusted CFP	**4.8E-04**	**4.8E-04**	4.8E-04
Error Factor (EF)	**3.0**	**3.0**	
Mean Adjusted CFP	**6.0E-04**	**6.0E-04**	
Zero	○	○	○
Low	○	○	○
Moderate	○	○	●
High	○	○	○
Complete	○	○	○
Skip	●	●	○
Recovery Median Adjusted CFP (with dependency)			1.4E-01
Recovery EF			3.5
Recovery Mean			1.9E-01
Recovery Action associated with this Failure	3	3	
Mean Adjusted CFP * Recovery Mean (Maximum)	**1.2E-04**	**1.2E-04**	

Determine the level of dependency for *recovery tasks* only.

Final Results

Mean Adjusted CFP * Recovery Mean (Maximum) = 1.2E-04
Mean Adjusted CFP = 6.0E-04
CFP EF = 3.0
Recovery Action = 3
Recovery Mean = 1.9E-01
Recovery EF = 3.5

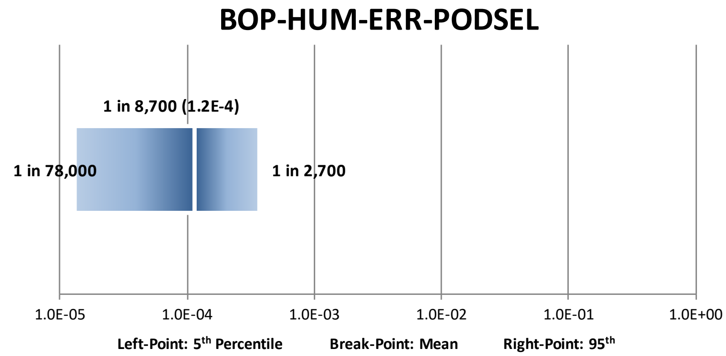
Significant Digits = 2

CHRAC RESULTS

Total Failure Probability		
Statistic	**Value**	**One in:**
Mean =	**1.2E-04**	8,700
EF =	**5.3**	-----
5th =	1.3E-05	78,000
50th =	6.9E-05	15,000
95th =	3.7E-04	2,700

The recommended number of significant digits is two.

Feel free to adjust the graph (axes, labels, etc.) to best suit your result.



Results discussion: CHRAC takes the information that is contained in steps 1 through 4 to produce the results shown in step 5. It converts medians to means since HRA values are done as a median of a lognormal distribution. It then needs to be converted to a mean for purposes of use in the PRA. It takes the "Recovery" factors times their assigned failure events and compares them. From this comparison it takes the highest value which, in this case, could be Task Three times either Task One or Two to get 1.2E-04. It also computes the EF of 5.3 and displays it on a "Band-Aid" chart to represent the mean and the 5th and 95th uncertainty range. So the failure probability of the driller to take appropriate action, to switch from the yellow pod to the blue pod is 1.2E-04 (or 1 in 8,700) with the uncertainty as shown.

HRA Basic Event: **BOP-HUM-ERR-EMERGDIS**

Description Block: Operator fails to initiate emergency disconnect successfully

Location of Event in Model: This event shows up in the model whenever emergency disconnect is required and human error might prevent the process from happening. There are three sub-fault trees, which capture all modeled operating conditions under which emergency disconnect might be required, where this event can be found; EMERGDIS (normal operations), EMERGDIS_POS (loss of position), and EMERGDIS_WK (well kill). This HRA event is populated by the template event HUM-ERR-EMERGDIS.

Discussion and description: During the drilling process there may be times when an Emergency Disconnect needs to be performed. Such events are expected to be rare and are the result of loss of position-keeping, major storms, and potentially in response to a loss of containment when hydrocarbons are past the BOP. These events can happen fast enough that a planned disconnect cannot be performed. Written procedures are used and it is a process that is trained on and performed by experienced personnel. The time that is available to perform an emergency disconnect can be short but it is variable.

For HRA: **BOP-HUM-ERR-EMERGDIS** the automated spreadsheet CHRAC is used and the following steps are performed by interviewing a subject matter expert. The spreadsheet utilizes the PRA Team's adaptation of CREAM to do this HRA analysis and is performed by a knowledgeable HRA practitioner utilizing input of information from a Subject Matter Expert. The following steps are used by CHRAC.

STEP 1 - Identify Failures and Recovery Actions — **BOP-HUM-ERR-EMERGDIS**

Description	Task	Failure or Recovery?	If Recovery, applies to which Failures? 1	2								
Push ED button	1	Failure	○	○	○	○	○	○	○	○	○	○
Verify correct indication of action	2	Recovery	◉	○	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
		No Recovery Action	○	◉	◉	◉	◉	◉	◉	◉	◉	◉

STEP 2 - Cognitive Activity Matrix

Description	Task	Cognitive Activity	Cognitive Demand				Skip
			Observation	Interpretation	Planning	Execution	
Push ED button	1	Execute	○	○	○	◉	○
Verify correct indication of action	2	Verify	◉	○	○	○	○

STEP 3 - Cognitive Demand Failures

Cognitive Demand	Classification	Median	Potential Cognitive Demand Failure	Task 1	Task 2
Observation	O1	1.0E-03	Observation of wrong object (response is given to the wrong stimulus or event)	○	○
	O2	3.0E-03	Wrong identification made (Omission. Overlooking a signal or a measurement)	○	○
	O3	3.0E-03	Observation Not Made (Omission. Overlooking a signal or a measurement)	○	◉
Interpretation	I1	2.0E-01	Faulty diagnosis (either a wrong diagnosis or an incomplete diagnosis)	○	○
	I2	1.0E-02	Decision error (either not making a decision or making a wrong or incomplete decision)	○	○
	I3	1.0E-02	Delayed interpretation (not made in time)	○	○
Planning	P1	1.0E-02	Priority error (as in selecting the wrong goal, intention)	○	○
	P2	1.0E-02	Inadequate plan formulated (when the plan is either incomplete or directly wrong)	○	○
Execution	E1	3.0E-03	Execution of wrong type performed (with regard to force, distance, speed, or direction)	○	○
	E2	3.0E-03	Action performed at wrong time (either too early or too late)	◉	○
	E3	5.0E-04	Action on wrong object (neighbor, similar or unrelated)	○	○
	E4	3.0E-03	Action performed out of sequence (repetitions, jumps, and reversals)	○	○
	E5	3.0E-02	Action missed, not performed (omission), including the omission of the last actions in a series ("undershoot")	○	○
			Skip	○	○

STEP 4 - Weighting Factors for Common Performance Conditions (CPCs)

CPC	Task 1 Execution	Task 2 Observation
Adequacy of Organization	Efficient	Efficient
Working Conditions	Compatible	Compatible
Adequacy of MMI	Adequate	Adequate
Procedures / Plans	Appropriate	Appropriate
Number of Goals	Few er	Few er
Available Time	Adequate	Adequate
Time of Day	Adjusted	Adjusted
Training and Preparation	High Exp	High Exp
Crew Collaboration	Efficient	Efficient
Overall Weighting Factor	**0.32**	**0.32**

STEP 5 - Cognitive Failure Probabilities (CFPs)

	Task 1	Task 2
Failure (F) / Recovery (R)	F	R
Median Nominal CFP	3.0E-03	3.0E-03
Median Adjusted CFP	9.6E-04	9.6E-04
Error Factor (EF)	10.0	
Mean Adjusted CFP	2.6E-03	
Zero	○	○
Low	○	○
Moderate	○	◉
High	○	○
Complete	○	○
Skip	◉	○
Recovery Median Adjusted CFP (with dependency)		1.4E-01
Recovery EF		3.5
Recovery Mean		1.9E-01
Recovery Action associated with this Failure	2	
Mean Adjusted CFP * Recovery Mean (Maximum)	4.9E-04	

Determine the level of dependency for *recovery tasks* only.

Final Results

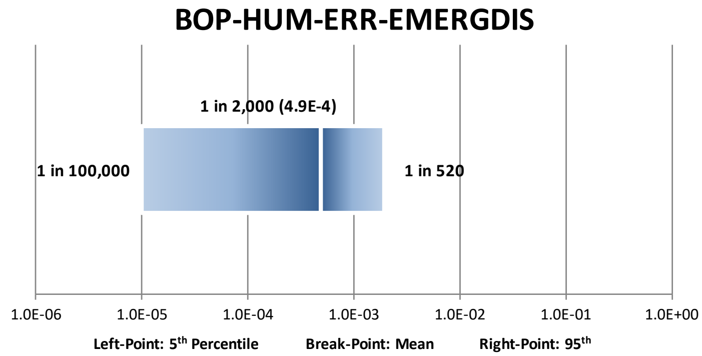
Mean Adjusted CFP * Recovery Mean (Maximum) =	4.9E-04
Mean Adjusted CFP =	2.6E-03
CFP EF =	10.0
Recovery Action =	2
Recovery Mean =	1.9E-01
Recovery EF =	3.5
Significant Digits =	2

CHRAC RESULTS

Total Failure Probability		
Statistic	**Value**	**One in:**
Mean =	**4.9E-04**	2,000
EF =	**13.8**	-----
5th =	1.0E-05	100,000
50th =	1.4E-04	7,300
95th =	1.9E-03	520

The recommended number of significant digits is two.

Feel free to adjust the graph (axes, labels, etc.) to best suit your result.



Results discussion: CHRAC takes the information that is contained in steps 1 through 4 to produce the results shown in step 5. It converts medians to means since HRA values are done as a median of a lognormal distribution. It then needs to be converted to a means for purposes of use in the PRA. It takes the "Recovery" factors times their assigned failure events and compares them. From this comparison it takes the highest value which, in this case, is Task Two times Task One to get 4.9E-04. It also computes the EF of 13.8 and displays it on a "Band-Aid" chart to represent the mean and the 5th and 95th uncertainty range. So the failure probability of the driller to successfully complete an emergency disconnect is 4.9E-04 (or 1 in 2,000). The results for this HRA can be variable based on the time available to perform the task. However, it is a straight forward action that is trained on and can be done quickly. The value that is derived is for a situation that has a reasonable amount of time to take the action.

HRA Basic Event: **BOP-HUM-ERR-KICKDET**

Description Block: Operator fails to realize a kick has occurred or does not take timely action

Location of Event in Model: This basic event shows up under the KICKDETECT fault tree which is a top event in the NOTHING_BOP, DRILLING, and CASING event trees. This HRA event is populated by the template event HUM-ERR-KICKDET.

Discussion and description: In this human action the operator (specifically the driller) is supervising the drilling operation. As part of this job the driller is monitoring the mud flow. If there is a kick the mud flow return will increase and there will be a mismatch of the mud flow into the well versus the return. The driller will need to realize that this has happened and take the appropriate action. For large kicks the time to realize a kick has happened varies. For this analysis it is assumed that the time available is on the order of 45 minutes. Large kicks are relatively rare and are not considered part of a routine daily operation of drilling. The driller has several duties and works in a relatively noisy and busy environment. The tasks of isolating the BOP are relatively straight forward and can be done from the driller's control panel. The action to isolate the BOP can be done from other panels if the driller's control panel is inaccessible for some reason. It is possible that the Captain or the Tool Pusher might take this action if the driller fails to do so, although these stations are not manned 24/7. Also it is possible that personnel located remotely can alert the driller to take action. Thus, credit is taken for the possibility of recovery by independent means.

For HRA: **BOP-HUM-ERR-KICKDET** the automated spreadsheet CHRAC is used and the following steps are performed by interviewing a subject matter expert. The spreadsheet utilizes the PRA Team's adaptation of CREAM to do this HRA analysis and is performed by a knowledgeable HRA practitioner utilizing input of information from a Subject Matter Expert. The following steps are used by CHRAC.

STEP 1 - Identify Failures and Recovery Actions

BOP-HUM-ERR-KICKDET

Description	Task	Failure or Recovery?	If Recovery, applies to which Failures?									
			1	2	3							
Watches Mud Flow and Realizes a Problem	1	Failure	○	○	○	○	○	○	○	○	○	○
Closes in Well	2	Failure	○	○	○	○	○	○	○	○	○	○
Independent Monitoring Takes Action if None is Taken	3	Recovery	●	●	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
			○	○	○	○	○	○	○	○	○	○
		No Recovery Action	○	○	●	●	●	●	●	●	●	●

STEP 2 - Cognitive Activity Matrix

Description	Task	Cognitive Activity	Cognitive Demand				Skip
			Observation	Interpretation	Planning	Execution	
Watches Mud Flow and Realizes a Problem	1	Monitor	●	○	○	○	○
Closes in Well	2	Execute	○	○	○	●	○
Independent Monitoring Takes Action if None is Taken	3	Execute	○	○	○	●	○

STEP 3 - Cognitive Demand Failures

Cognitive Demand	Classification	Median	Potential Cognitive Demand Failure	Task 1	Task 2	Task 3
Observation	O1	1.0E-03	Observation of wrong object (response is given to the wrong stimulus or event)	○	○	○
	O2	3.0E-03	Wrong identification made (Omission. Overlooking a signal or a measurement)	○	○	○
	O3	3.0E-03	Observation Not Made (Omission. Overlooking a signal or a measurement)	◉	○	○
Interpretation	I1	2.0E-01	Faulty diagnosis (either a wrong diagnosis or an incomplete diagnosis)	○	○	○
	I2	1.0E-02	Decision error (either not making a decision or making a wrong or incomplete decision)	○	○	○
	I3	1.0E-02	Delayed interpretation (not made in time)	○	○	○
Planning	P1	1.0E-02	Priority error (as in selecting the wrong goal, intention)	○	○	○
	P2	1.0E-02	Inadequate plan formulated (when the plan is either incomplete or directly wrong)	○	○	○
Execution	E1	3.0E-03	Execution of wrong type performed (with regard to force, distance, speed, or direction)	○	○	○
	E2	3.0E-03	Action performed at wrong time (either too early or too late)	○	◉	◉
	E3	5.0E-04	Action on wrong object (neighbor, similar or unrelated)	○	○	○
	E4	3.0E-03	Action performed out of sequence (repetitions, jumps, and reversals)	○	○	○
	E5	3.0E-02	Action missed, not performed (omission), including the omission of the last actions in a series ("undershoot")	○	○	○
			Skip	○	○	○

STEP 4 - Weighting Factors for Common Performance Conditions (CPCs)

CPC	Task 1 Observation	Task 2 Execution	Task 3 Execution
Adequacy of Organization	Efficient	Efficient	Efficient
Working Conditions	Compatible	Compatible	Compatible
Adequacy of MMI	Adequate	Adequate	Adequate
Procedures / Plans	Acceptable	Acceptable	Acceptable
Number of Goals	Matching	Few er	Few er
Available Time	Adequate	Adequate	Adequate
Time of Day	Adjusted	Adjusted	Adjusted
Training and Preparation	High Exp	High Exp	High Exp
Crew Collaboration	Efficient	Efficient	Efficient
Overall Weighting Factor	**0.40**	**0.40**	**0.40**

STEP 5 - Cognitive Failure Probabilities (CFPs)

	Task 1	Task 2	Task 3
Failure (F) / Recovery (R)	**F**	**F**	**R**
Median Nominal CFP	**3.0E-03**	**3.0E-03**	3.0E-03
Median Adjusted CFP	**1.2E-03**	**1.2E-03**	1.2E-03
Error Factor (EF)	**5.0**	**5.0**	
Mean Adjusted CFP	**1.9E-03**	**1.9E-03**	

Determine the level of dependency for *recovery tasks* only.

	1	2	3
Zero	○	○	○
Low	○	○	○
Moderate	○	○	●
High	○	○	○
Complete	○	○	○
Skip	●	●	○

	Task 1	Task 2	Task 3
Recovery Median Adjusted CFP (with dependency)			1.4E-01
Recovery EF			3.5
Recovery Mean			1.9E-01
Recovery Action associated with this Failure	3	3	
Mean Adjusted CFP * Recovery Mean (Maximum)	**3.7E-04**	**3.7E-04**	

Final Results

lean Adjusted CFP * Recovery Mean (Maximum) = 3.7E-04
Mean Adjusted CFP = 1.9E-03
CFP EF = 5.0
Recovery Action = 3
Recovery Mean = 1.9E-01
Recovery EF = 3.5

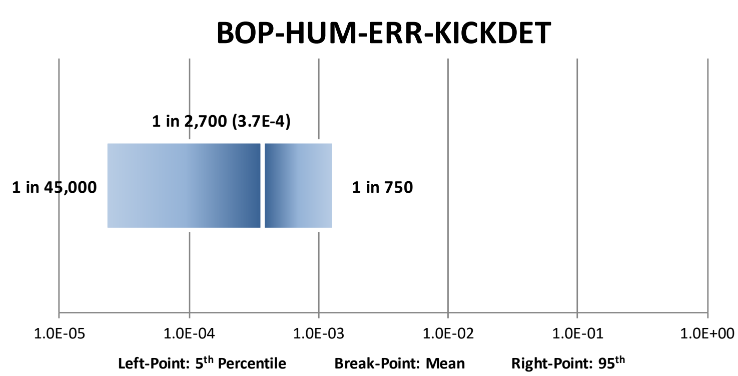
Significant Digits = 2

CHRAC RESULTS

Total Failure Probability		
Statistic	**Value**	**One in:**
Mean =	**3.7E-04**	2,700
EF =	**7.7**	-----
5th =	2.2E-05	45,000
50th =	1.7E-04	5,800
95th =	1.3E-03	750

The recommended number of significant digits is two.

Feel free to adjust the graph (axes, labels, etc.) to best suit your result.



Results discussion: CHRAC takes the information that is contained in steps 1 through 4 to produce the results shown in step 5. It converts medians to means since HRA values are done as a median of a lognormal distribution. It then needs to be converted to a mean for purposes of use in the PRA. It takes the "Recovery" factors times their assigned failure events and compares them. From this comparison it takes the highest value which, in this case, is Task Two times Task One to get 3.7E-04. It also computes the EF of 7.7 and displays it on a "Band-Aid" chart to represent the mean and the 5th and 95th uncertainty range. So the failure probability of the driller to successfully complete an emergency disconnect is 3.7E-04 (or 1 in 2700). The results for this HRA can be variable based on the time available to perform the task. However, it is an action that is trained on and can be done quickly by experienced personnel. The value that is derived is for a situation that has a reasonable amount of time to take the action.

The final two human errors considered in the model were not analyzed with CHRAC and were assigned screening values until a more detailed analysis could be performed, if necessary.

HRA Basic Event: **BOP-HUM-ERR-IBOP1**

Description Block: Human error - failure to install IBOP

Location of Event in Model: This event shows up under the IBOP_FLTVLV_FAILS fault tree which is a top event in the DRILLING event tree.

Discussion and description: The IBOP is a valve to prevent a release from the well up through the drillpipe. Failure to install this valve could result in hydrocarbons being uncontained in the event of a well kick. It is important to remember that the IBOP is not the only potential barrier to uncontained hydrocarbons. It is simply one in a series. This HRA calculated the probability that personnel fail to install the IBOP valve.

This event was assigned a probability of 0.016 with EF of 5.0. This probability is a screening value taken from Table 2.1.4-4 of the Human Reliability Analysis HRA Data Report [I-3]. The values in this table are calculated using NUREG/CR-1278 [I-4] as a basis. The task of installing the IBOP is assumed to occur under one adverse condition (kick) and would typically require between 10 and 30 minutes to accomplish. This HRA event is populated by the template event HUM-ERR-IBOP-INSTALL.

HRA Basic Event: **BOP-HUM-ERR-DP-HANGOFF**

Description Block: Driller fails to position drillpipe properly before activating shear ram

Location of Event in Model: This event is included in the model in any case when shearing casing is being attempted using either the blind shear ram or the casing shear rams. This event can be found under the sub-fault trees NONSHEARABLE_BSTJ, NONSHEARABLE_BSTJWK, NONSHEARABLE_CSTJ, and NONSHEARABLE_CSTJ_WK. It is populated by the template event HUM-ERR-HANGOFF.

Discussion and description: The driller must space out the drillpipe to ensure that a tool joint is not in the shearing path of either the blind shear ram or the casing shear ram. It is assumed that the blind shear ram and casing shear ram designs will not cut though a tool joint. Failure to space out could result in a failed attempt to shear the drillpipe which ultimately could prevent shutting in the well. .

This event was assigned a probability of 0.016 with an EF of 5.0. This probability is a screening value taken from Table 2.1.4-4 of the Human Reliability Analysis HRA Data Report [I-3]. The values in this table are calculated using NUREG/CR-1278 [I-4] as a basis. The task of installing the IBOP is assumed to occur under one adverse condition (kick) and would typically require between 10 and 30 minutes to accomplish.

I.2 REFERENCES

I-1 CHRAC. CREAM HRA Calculator, JSC NC4 Analysis Team In-House Tool.

I-2 Hollnagel, Erik. Cognitive reliability and error analysis method (CREAM). Elsevier, 1998.

I-3 Hamlin, T. L., "Human Reliability Analysis (HRA) Data Report", Volume III, Book 2, Rev. 3.0, November 2008

I-4 Swain, A. D. and Guttman, H. E., "Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Applications", NUREG\CR-1278, Nuclear Regulatory Document, August 1983.

APPENDIX J- TOP CUT SETS

Table J- 1: Overall Loss of Containment Top 20 Cut Sets

#	Prob/Freq	Total %	Cut Set	Description
Total	4.00E-04	100	(506490 Original Cut Sets)	
1	1.16E-05	2.90		
	1.00E+00		<INIT>	Start of Event Tree
	1.22E-04		BOP-PRG-FLO-T0102CCF	Common cause failure of rigid conduit manifold pressure regulators T01 and T02 fails low or off
	1.00E+00		/CASING_SHEAR_FAIL_EDNAB	Casing Shear not required if nothing across the BOP - Emergency Disconnect
	1.00E+00		KICKWHILEDRILLING	Well Kick While Drilling
	9.54E-02		UNEXOVERP-D-IC	Unexpected Overpressure zone while drilling, intermediate casing ops
2	9.20E-06	2.30		
	1.00E+00		<INIT>	Start of Event Tree
	1.00E+00		BLIND_SHEAR_FAIL_EDDR1	BSR fails to shut in well previous failure or nonshearable when drillpipe is present - Emergency Disconnect
	9.65E-05		BOP-PVL-LKI-V10	Yellow RCM flush pilot operated hydraulic valve V10 leakage
	1.00E+00		CASING_SHEAR_FAIL_EDDR1	Setting casing shear to failed state when drillpipe is across (previously failed) - Emergency Disconnect
	1.00E+00		KICKWHILEDRILLING	Well Kick While Drilling
	1.00E+00		/NONSHEARABLE_BS0	Nonshearable across the blind shear set to 0
	1.00E+00		/NONSHEARABLE_CS0	Nonshearable across the casing shear set to 0
	9.54E-02		UNEXOVERP-D-IC	Unexpected Overpressure zone while drilling, intermediate casing ops
3	9.20E-06	2.30		
	1.00E+00		<INIT>	Start of Event Tree
	1.00E+00		BLIND_SHEAR_FAIL_EDDR1	BSR fails to shut in well previous failure or nonshearable when drillpipe is present - Emergency Disconnect
	9.65E-05		BOP-PVL-LKI-V09	Blue RCM flush pilot operated hydraulic valve V09 leakage
	1.00E+00		CASING_SHEAR_FAIL_EDDR1	Setting casing shear to failed state when drillpipe is across (previously failed) - Emergency Disconnect
	1.00E+00		KICKWHILEDRILLING	Well Kick While Drilling
	1.00E+00		/NONSHEARABLE_BS0	Nonshearable across the blind shear set to 0
	1.00E+00		/NONSHEARABLE_CS0	Nonshearable across the casing shear set to 0
	9.54E-02		UNEXOVERP-D-IC	Unexpected Overpressure zone while drilling, intermediate casing ops
4	8.71E-06	2.18		
	1.00E+00		<INIT>	Start of Event Tree
	1.22E-04		BOP-PRG-FLO-T0102CCF	Common cause failure of rigid conduit manifold pressure regulators T01 and T02 fails low or off
	1.00E+00		/CASING_SHEAR_FAIL_EDNAB	Casing Shear not required if nothing across the BOP - Emergency Disconnect
	1.00E+00		KICKWHILEDRILLING	Well Kick While Drilling
	7.16E-02		UNEXOVERP-D-PZ	Unexpected Overpressure zone while drilling, reservoir ops
5	8.12E-06	2.03		
	1.00E+00		<INIT>	Start of Event Tree

#	Prob/Freq	Total %	Cut Set	Description
Total	4.00E-04	100	(506490 Original Cut Sets)	
	1.22E-04		BOP-PRG-FLO-T0102CCF	Common cause failure of rigid conduit manifold pressure regulators T01 and T02 fails low or off
	1.00E+00		/CASING_SHEAR_FAIL_EDNAB	Casing Shear not required if nothing across the BOP - Emergency Disconnect
	1.00E+00		KICKWHILEDRILLING	Well Kick While Drilling
	6.68E-02		LOW-MUD-DENSITY-D-IC	Low mud density/volume leads to kick while drilling, intermediate casing ops
6	7.83E-06	1.96		
	1.00E+00		<INIT>	Start of Event Tree
	1.22E-04		BOP-PRG-FLO-T0102CCF	Common cause failure of rigid conduit manifold pressure regulators T01 and T02 fails low or off
	1.00E+00		/CASING_SHEAR_FAIL_EDNAB	Casing Shear not required if nothing across the BOP - Emergency Disconnect
	1.00E+00		KICKWHILEDRILLING	Well Kick While Drilling
	6.44E-02		LOW-MUD-DENSITY-D-PZ	Low mud density/volume leads to kick while drilling, reservoir ops
7	6.90E-06	1.73		
	1.00E+00		<INIT>	Start of Event Tree
	1.00E+00		BLIND_SHEAR_FAIL_EDDR1	BSR fails to shut in well previous failure or nonshearable when drillpipe is present - Emergency Disconnect
	9.65E-05		BOP-PVL-LKI-V10	Yellow RCM flush pilot operated hydraulic valve V10 leakage
	1.00E+00		CASING_SHEAR_FAIL_EDDR1	Setting casing shear to failed state when drillpipe is across (previously failed) - Emergency Disconnect
	1.00E+00		KICKWHILEDRILLING	Well Kick While Drilling
	1.00E+00		/NONSHEARABLE_BS0	Nonshearable across the blind shear set to 0
	1.00E+00		/NONSHEARABLE_CS0	Nonshearable across the casing shear set to 0
	7.16E-02		UNEXOVERP-D-PZ	Unexpected Overpressure zone while drilling, reservoir ops
8	6.90E-06	1.73		
	1.00E+00		<INIT>	Start of Event Tree
	1.00E+00		BLIND_SHEAR_FAIL_EDDR1	BSR fails to shut in well previous failure or nonshearable when drillpipe is present - Emergency Disconnect
	9.65E-05		BOP-PVL-LKI-V09	Blue RCM flush pilot operated hydraulic valve V09 leakage
	1.00E+00		CASING_SHEAR_FAIL_EDDR1	Setting casing shear to failed state when drillpipe is across (previously failed) - Emergency Disconnect
	1.00E+00		KICKWHILEDRILLING	Well Kick While Drilling
	1.00E+00		/NONSHEARABLE_BS0	Nonshearable across the blind shear set to 0
	1.00E+00		/NONSHEARABLE_CS0	Nonshearable across the casing shear set to 0
	7.16E-02		UNEXOVERP-D-PZ	Unexpected Overpressure zone while drilling, reservoir ops
9	6.44E-06	1.61		
	1.00E+00		<INIT>	Start of Event Tree
	1.00E+00		BLIND_SHEAR_FAIL_EDDR1	BSR fails to shut in well previous failure or nonshearable when drillpipe is present - Emergency Disconnect
	9.65E-05		BOP-PVL-LKI-V10	Yellow RCM flush pilot operated hydraulic valve V10 leakage

#	Prob/Freq	Total %	Cut Set	Description
Total	4.00E-04	100	(506490 Original Cut Sets)	
	1.00E+00		CASING_SHEAR_FAIL_EDDR1	Setting casing shear to failed state when drillpipe is across (previously failed) - Emergency Disconnect
	1.00E+00		KICKWHILEDRILLING	Well Kick While Drilling
	6.68E-02		LOW-MUD-DENSITY-D-IC	Low mud density/volume leads to kick while drilling, intermediate casing ops
	1.00E+00		/NONSHEARABLE_BS0	Nonshearable across the blind shear set to 0
	1.00E+00		/NONSHEARABLE_CS0	Nonshearable across the casing shear set to 0
10	6.44E-06	1.61		
	1.00E+00		<INIT>	Start of Event Tree
	1.00E+00		BLIND_SHEAR_FAIL_EDDR1	BSR fails to shut in well previous failure or nonshearable when drillpipe is present - Emergency Disconnect
	9.65E-05		BOP-PVL-LKI-V09	Blue RCM flush pilot operated hydraulic valve V09 leakage
	1.00E+00		CASING_SHEAR_FAIL_EDDR1	Setting casing shear to failed state when drillpipe is across (previously failed) - Emergency Disconnect
	1.00E+00		KICKWHILEDRILLING	Well Kick While Drilling
	6.68E-02		LOW-MUD-DENSITY-D-IC	Low mud density/volume leads to kick while drilling, intermediate casing ops
	1.00E+00		/NONSHEARABLE_BS0	Nonshearable across the blind shear set to 0
	1.00E+00		/NONSHEARABLE_CS0	Nonshearable across the casing shear set to 0
11	6.21E-06	1.55		
	1.00E+00		<INIT>	Start of Event Tree
	1.00E+00		BLIND_SHEAR_FAIL_EDDR1	BSR fails to shut in well previous failure or nonshearable when drillpipe is present - Emergency Disconnect
	9.65E-05		BOP-PVL-LKI-V10	Yellow RCM flush pilot operated hydraulic valve V10 leakage
	1.00E+00		CASING_SHEAR_FAIL_EDDR1	Setting casing shear to failed state when drillpipe is across (previously failed) - Emergency Disconnect
	1.00E+00		KICKWHILEDRILLING	Well Kick While Drilling
	6.44E-02		LOW-MUD-DENSITY-D-PZ	Low mud density/volume leads to kick while drilling, reservoir ops
	1.00E+00		/NONSHEARABLE_BS0	Nonshearable across the blind shear set to 0
	1.00E+00		/NONSHEARABLE_CS0	Nonshearable across the casing shear set to 0
12	6.21E-06	1.55		
	1.00E+00		<INIT>	Start of Event Tree
	1.00E+00		BLIND_SHEAR_FAIL_EDDR1	BSR fails to shut in well previous failure or nonshearable when drillpipe is present - Emergency Disconnect
	9.65E-05		BOP-PVL-LKI-V09	Blue RCM flush pilot operated hydraulic valve V09 leakage
	1.00E+00		CASING_SHEAR_FAIL_EDDR1	Setting casing shear to failed state when drillpipe is across (previously failed) - Emergency Disconnect
	1.00E+00		KICKWHILEDRILLING	Well Kick While Drilling
	6.44E-02		LOW-MUD-DENSITY-D-PZ	Low mud density/volume leads to kick while drilling, reservoir ops
	1.00E+00		/NONSHEARABLE_BS0	Nonshearable across the blind shear set to 0
	1.00E+00		/NONSHEARABLE_CS0	Nonshearable across the casing shear set to 0
13	4.03E-06	1.01		
	1.00E+00		<INIT>	Start of Event Tree

#	Prob/Freq	Total %	Cut Set	Description
Total	4.00E-04	100	(506490 Original Cut Sets)	
	1.22E-04		BOP-PRG-FLO-T0102CCF	Common cause failure of rigid conduit manifold pressure regulators T01 and T02 fails low or off
	1.00E+00		/CASING_SHEAR_FAIL_EDNAB	Casing Shear not required if nothing across the BOP - Emergency Disconnect
	1.00E+00		KICKWHILEDRILLING	Well Kick While Drilling
	3.31E-02		SWABBING-D-IC	Swab effect causes well kick while drilling, intermediate casing ops
14	3.19E-06	0.80		
	1.00E+00		<INIT>	Start of Event Tree
	1.00E+00		BLIND_SHEAR_FAIL_EDDR1	BSR fails to shut in well previous failure or nonshearable when drillpipe is present - Emergency Disconnect
	9.65E-05		BOP-PVL-LKI-V10	Yellow RCM flush pilot operated hydraulic valve V10 leakage
	1.00E+00		CASING_SHEAR_FAIL_EDDR1	Setting casing shear to failed state when drillpipe is across (previously failed) - Emergency Disconnect
	1.00E+00		KICKWHILEDRILLING	Well Kick While Drilling
	1.00E+00		/NONSHEARABLE_BS0	Nonshearable across the blind shear set to 0
	1.00E+00		/NONSHEARABLE_CS0	Nonshearable across the casing shear set to 0
	3.31E-02		SWABBING-D-IC	Swab effect causes well kick while drilling, intermediate casing ops
15	3.19E-06	0.80		
	1.00E+00		<INIT>	Start of Event Tree
	1.00E+00		BLIND_SHEAR_FAIL_EDDR1	BSR fails to shut in well previous failure or nonshearable when drillpipe is present - Emergency Disconnect
	9.65E-05		BOP-PVL-LKI-V09	Blue RCM flush pilot operated hydraulic valve V09 leakage
	1.00E+00		CASING_SHEAR_FAIL_EDDR1	Setting casing shear to failed state when drillpipe is across (previously failed) - Emergency Disconnect
	1.00E+00		KICKWHILEDRILLING	Well Kick While Drilling
	1.00E+00		/NONSHEARABLE_BS0	Nonshearable across the blind shear set to 0
	1.00E+00		/NONSHEARABLE_CS0	Nonshearable across the casing shear set to 0
	3.31E-02		SWABBING-D-IC	Swab effect causes well kick while drilling, intermediate casing ops
16	3.02E-06	0.76		
	1.00E+00		<INIT>	Start of Event Tree
	1.22E-04		BOP-PRG-FLO-T0102CCF	Common cause failure of rigid conduit manifold pressure regulators T01 and T02 fails low or off
	1.00E+00		/CASING_SHEAR_FAIL_EDNAB	Casing Shear not required if nothing across the BOP - Emergency Disconnect
	1.00E+00		KICKWHILEDRILLING	Well Kick While Drilling
	2.48E-02		SWABBING-D-PZ	Swab effect causes well kick while drilling, reservoir ops
17	2.91E-06	0.73		
	1.00E+00		<INIT>	Start of Event Tree
	3.69E-03		BOP-BSRCYL-JAM-NABOP	Blind shear rams fail to close and seal when nothing is across the BOP
	1.61E-03		DPS-FRQ-WEA-SQUA-F-IE	Frequency of a Squall per hour (initiating event)
	8.10E-04		DPS-WEA-HRA-PREP	Human Error Failure to Orient the Vessel for the Onset of Elevated Weather

#	Prob/Freq	Total %	Cut Set	Description
Total	4.00E-04	100	(506490 Original Cut Sets)	
	9.00E-01		DRILLSTRINGIN_PZ	Drill String In - Production Zone
	4.00E-01		PRODUCTIONZONE	Production Zone
	1.68E+03		WELL_COMPLETION_TIME	Number of Hours for an average well completion
18	2.80E-06	0.70		
	1.00E+00		<INIT>	Start of Event Tree
	1.22E-04		BOP-PRG-FLO-T0102CCF	Common cause failure of rigid conduit manifold pressure regulators T01 and T02 fails low or off
	1.00E+00		/CASING_SHEAR_FAIL_EDNAB	Casing Shear not required if nothing across the BOP - Emergency Disconnect
	1.00E+00		KICKWHILEDRILLING	Well Kick While Drilling
	2.30E-02		OTHERKICK-D-IC	Kick from undefined caused while drilling, intermediate casing op
19	2.70E-06	0.67		
	1.00E+00		<INIT>	Start of Event Tree
	1.22E-04		BOP-PRG-FLO-T0102CCF	Common cause failure of rigid conduit manifold pressure regulators T01 and T02 fails low or off
	1.00E+00		/CASING_SHEAR_FAIL_EDNAB	Casing Shear not required if nothing across the BOP - Emergency Disconnect
	1.00E+00		KICKWHILEDRILLING	Well Kick While Drilling
	2.22E-02		OTHERKICK-D-PZ	Kick from undefined caused while drilling, reservoir ops
20	2.56E-06	0.64		
	1.00E+00		<INIT>	Start of Event Tree
	1.00E+00		BLIND_SHEAR_FAIL_EDDR1	BSR fails to shut in well previous failure or nonshearable when drillpipe is present - Emergency Disconnect
	2.69E-05		BOP-SEM-FTO-CCF	Common cause failure of the control pod SEMs
	1.00E+00		CASING_SHEAR_FAIL_EDDR1	Setting casing shear to failed state when drillpipe is across (previously failed) - Emergency Disconnect
	1.00E+00		KICKWHILEDRILLING	Well Kick While Drilling
	1.00E+00		/NONSHEARABLE_BS0	Nonshearable across the blind shear set to 0
	1.00E+00		/NONSHEARABLE_CS0	Nonshearable across the casing shear set to 0
	9.54E-02		UNEXOVERP-D-IC	Unexpected Overpressure zone while drilling, intermediate casing ops

Table J- 2: Kick Related Loss of Containment Top 20 Cut Sets

#	Prob/Freq	Total %	Cut Set	Description
Total	1.99E-04	100	(80535 Original Cut Sets)	
1	1.16E-05	5.83		
	1.00E+00		<INIT>	Start of Event Tree
	1.22E-04		BOP-PRG-FLO-T0102CCF	Common cause failure of rigid conduit manifold pressure regulators T01 and T02 fails low or off
	1.00E+00		/CASING_SHEAR_FAIL_EDNAB	Casing Shear not required if nothing across the BOP - Emergency Disconnect
	1.00E+00		KICKWHILEDRILLING	Well Kick While Drilling
	9.54E-02		UNEXOVERP-D-IC	Unexpected Overpressure zone while drilling, intermediate casing ops
2	9.20E-06	4.62		
	1.00E+00		<INIT>	Start of Event Tree
	1.00E+00		BLIND_SHEAR_FAIL_EDDR1	BSR fails to shut in well previous failure or nonshearable when drillpipe is present - Emergency Disconnect
	9.65E-05		BOP-PVL-LKI-V10	Yellow RCM flush pilot operated hydraulic valve V10 leakage
	1.00E+00		CASING_SHEAR_FAIL_EDDR1	Setting casing shear to failed state when drillpipe is across (previously failed) - Emergency Disconnect
	1.00E+00		KICKWHILEDRILLING	Well Kick While Drilling
	1.00E+00		/NONSHEARABLE_BS0	Nonshearable across the blind shear set to 0
	1.00E+00		/NONSHEARABLE_CS0	Nonshearable across the casing shear set to 0
	9.54E-02		UNEXOVERP-D-IC	Unexpected Overpressure zone while drilling, intermediate casing ops
3	9.20E-06	4.62		
	1.00E+00		<INIT>	Start of Event Tree
	1.00E+00		BLIND_SHEAR_FAIL_EDDR1	BSR fails to shut in well previous failure or nonshearable when drillpipe is present - Emergency Disconnect
	9.65E-05		BOP-PVL-LKI-V09	Blue RCM flush pilot operated hydraulic valve V09 leakage
	1.00E+00		CASING_SHEAR_FAIL_EDDR1	Setting casing shear to failed state when drillpipe is across (previously failed) - Emergency Disconnect
	1.00E+00		KICKWHILEDRILLING	Well Kick While Drilling
	1.00E+00		/NONSHEARABLE_BS0	Nonshearable across the blind shear set to 0
	1.00E+00		/NONSHEARABLE_CS0	Nonshearable across the casing shear set to 0
	9.54E-02		UNEXOVERP-D-IC	Unexpected Overpressure zone while drilling, intermediate casing ops
4	8.71E-06	4.37		
	1.00E+00		<INIT>	Start of Event Tree
	1.22E-04		BOP-PRG-FLO-T0102CCF	Common cause failure of rigid conduit manifold pressure regulators T01 and T02 fails low or off
	1.00E+00		/CASING_SHEAR_FAIL_EDNAB	Casing Shear not required if nothing across the BOP - Emergency Disconnect
	1.00E+00		KICKWHILEDRILLING	Well Kick While Drilling
	7.16E-02		UNEXOVERP-D-PZ	Unexpected Overpressure zone while drilling, reservoir ops
5	8.12E-06	4.08		
	1.00E+00		<INIT>	Start of Event Tree
	1.22E-04		BOP-PRG-FLO-T0102CCF	Common cause failure of rigid conduit manifold pressure regulators T01 and T02 fails low or off

#	Prob/Freq	Total %	Cut Set	Description
	1.00E+00		/CASING_SHEAR_FAIL_EDNAB	Casing Shear not required if nothing across the BOP - Emergency Disconnect
	1.00E+00		KICKWHILEDRILLING	Well Kick While Drilling
	6.68E-02		LOW-MUD-DENSITY-D-IC	Low mud density/volume leads to kick while drilling, intermediate casing ops
6	7.83E-06	3.94		
	1.00E+00		<INIT>	Start of Event Tree
	1.22E-04		BOP-PRG-FLO-T0102CCF	Common cause failure of rigid conduit manifold pressure regulators T01 and T02 fails low or off
	1.00E+00		/CASING_SHEAR_FAIL_EDNAB	Casing Shear not required if nothing across the BOP - Emergency Disconnect
	1.00E+00		KICKWHILEDRILLING	Well Kick While Drilling
	6.44E-02		LOW-MUD-DENSITY-D-PZ	Low mud density/volume leads to kick while drilling, reservoir ops
7	6.90E-06	3.47		
	1.00E+00		<INIT>	Start of Event Tree
	1.00E+00		BLIND_SHEAR_FAIL_EDDR1	BSR fails to shut in well previous failure or nonshearable when drillpipe is present - Emergency Disconnect
	9.65E-05		BOP-PVL-LKI-V10	Yellow RCM flush pilot operated hydraulic valve V10 leakage
	1.00E+00		CASING_SHEAR_FAIL_EDDR1	Setting casing shear to failed state when drillpipe is across (previously failed) - Emergency Disconnect
	1.00E+00		KICKWHILEDRILLING	Well Kick While Drilling
	1.00E+00		/NONSHEARABLE_BS0	Nonshearable across the blind shear set to 0
	1.00E+00		/NONSHEARABLE_CS0	Nonshearable across the casing shear set to 0
	7.16E-02		UNEXOVERP-D-PZ	Unexpected Overpressure zone while drilling, reservoir ops
8	6.90E-06	3.47		
	1.00E+00		<INIT>	Start of Event Tree
	1.00E+00		BLIND_SHEAR_FAIL_EDDR1	BSR fails to shut in well previous failure or nonshearable when drillpipe is present - Emergency Disconnect
	9.65E-05		BOP-PVL-LKI-V09	Blue RCM flush pilot operated hydraulic valve V09 leakage
	1.00E+00		CASING_SHEAR_FAIL_EDDR1	Setting casing shear to failed state when drillpipe is across (previously failed) - Emergency Disconnect
	1.00E+00		KICKWHILEDRILLING	Well Kick While Drilling
	1.00E+00		/NONSHEARABLE_BS0	Nonshearable across the blind shear set to 0
	1.00E+00		/NONSHEARABLE_CS0	Nonshearable across the casing shear set to 0
	7.16E-02		UNEXOVERP-D-PZ	Unexpected Overpressure zone while drilling, reservoir ops
9	6.44E-06	3.24		
	1.00E+00		<INIT>	Start of Event Tree
	1.00E+00		BLIND_SHEAR_FAIL_EDDR1	BSR fails to shut in well previous failure or nonshearable when drillpipe is present - Emergency Disconnect
	9.65E-05		BOP-PVL-LKI-V10	Yellow RCM flush pilot operated hydraulic valve V10 leakage
	1.00E+00		CASING_SHEAR_FAIL_EDDR1	Setting casing shear to failed state when drillpipe is across (previously failed) - Emergency Disconnect
	1.00E+00		KICKWHILEDRILLING	Well Kick While Drilling
	6.68E-02		LOW-MUD-DENSITY-D-IC	Low mud density/volume leads to kick while drilling, intermediate casing ops
	1.00E+00		/NONSHEARABLE_BS0	Nonshearable across the blind shear set to 0

#	Prob/Freq	Total %	Cut Set	Description
	1.00E+00		/NONSHEARABLE_CS0	Nonshearable across the casing shear set to 0
10	6.44E-06	3.24		
	1.00E+00		<INIT>	Start of Event Tree
	1.00E+00		BLIND_SHEAR_FAIL_EDDR1	BSR fails to shut in well previous failure or nonshearable when drillpipe is present - Emergency Disconnect
	9.65E-05		BOP-PVL-LKI-V09	Blue RCM flush pilot operated hydraulic valve V09 leakage
	1.00E+00		CASING_SHEAR_FAIL_EDDR1	Setting casing shear to failed state when drillpipe is across (previously failed) - Emergency Disconnect
	1.00E+00		KICKWHILEDRILLING	Well Kick While Drilling
	6.68E-02		LOW-MUD-DENSITY-D-IC	Low mud density/volume leads to kick while drilling, intermediate casing ops
	1.00E+00		/NONSHEARABLE_BS0	Nonshearable across the blind shear set to 0
	1.00E+00		/NONSHEARABLE_CS0	Nonshearable across the casing shear set to 0
11	6.21E-06	3.12		
	1.00E+00		<INIT>	Start of Event Tree
	1.00E+00		BLIND_SHEAR_FAIL_EDDR1	BSR fails to shut in well previous failure or nonshearable when drillpipe is present - Emergency Disconnect
	9.65E-05		BOP-PVL-LKI-V10	Yellow RCM flush pilot operated hydraulic valve V10 leakage
	1.00E+00		CASING_SHEAR_FAIL_EDDR1	Setting casing shear to failed state when drillpipe is across (previously failed) - Emergency Disconnect
	1.00E+00		KICKWHILEDRILLING	Well Kick While Drilling
	6.44E-02		LOW-MUD-DENSITY-D-PZ	Low mud density/volume leads to kick while drilling, reservoir ops
	1.00E+00		/NONSHEARABLE_BS0	Nonshearable across the blind shear set to 0
	1.00E+00		/NONSHEARABLE_CS0	Nonshearable across the casing shear set to 0
12	6.21E-06	3.12		
	1.00E+00		<INIT>	Start of Event Tree
	1.00E+00		BLIND_SHEAR_FAIL_EDDR1	BSR fails to shut in well previous failure or nonshearable when drillpipe is present - Emergency Disconnect
	9.65E-05		BOP-PVL-LKI-V09	Blue RCM flush pilot operated hydraulic valve V09 leakage
	1.00E+00		CASING_SHEAR_FAIL_EDDR1	Setting casing shear to failed state when drillpipe is across (previously failed) - Emergency Disconnect
	1.00E+00		KICKWHILEDRILLING	Well Kick While Drilling
	6.44E-02		LOW-MUD-DENSITY-D-PZ	Low mud density/volume leads to kick while drilling, reservoir ops
	1.00E+00		/NONSHEARABLE_BS0	Nonshearable across the blind shear set to 0
	1.00E+00		/NONSHEARABLE_CS0	Nonshearable across the casing shear set to 0
13	4.03E-06	2.02		
	1.00E+00		<INIT>	Start of Event Tree
	1.22E-04		BOP-PRG-FLO-T0102CCF	Common cause failure of rigid conduit manifold pressure regulators T01 and T02 fails low or off
	1.00E+00		/CASING_SHEAR_FAIL_EDNAB	Casing Shear not required if nothing across the BOP - Emergency Disconnect
	1.00E+00		KICKWHILEDRILLING	Well Kick While Drilling
	3.31E-02		SWABBING-D-IC	Swab effect causes well kick while drilling, intermediate casing ops
14	3.19E-06	1.6		
	1.00E+00		<INIT>	Start of Event Tree

#	Prob/Freq	Total %	Cut Set	Description
	1.00E+00		BLIND_SHEAR_FAIL_EDDR1	BSR fails to shut in well previous failure or nonshearable when drillpipe is present - Emergency Disconnect
	9.65E-05		BOP-PVL-LKI-V10	Yellow RCM flush pilot operated hydraulic valve V10 leakage
	1.00E+00		CASING_SHEAR_FAIL_EDDR1	Setting casing shear to failed state when drillpipe is across (previously failed) - Emergency Disconnect
	1.00E+00		KICKWHILEDRILLING	Well Kick While Drilling
	1.00E+00		/NONSHEARABLE_BS0	Nonshearable across the blind shear set to 0
	1.00E+00		/NONSHEARABLE_CS0	Nonshearable across the casing shear set to 0
	3.31E-02		SWABBING-D-IC	Swab effect causes well kick while drilling, intermediate casing ops
15	3.19E-06	1.6		
	1.00E+00		<INIT>	Start of Event Tree
	1.00E+00		BLIND_SHEAR_FAIL_EDDR1	BSR fails to shut in well previous failure or nonshearable when drillpipe is present - Emergency Disconnect
	9.65E-05		BOP-PVL-LKI-V09	Blue RCM flush pilot operated hydraulic valve V09 leakage
	1.00E+00		CASING_SHEAR_FAIL_EDDR1	Setting casing shear to failed state when drillpipe is across (previously failed) - Emergency Disconnect
	1.00E+00		KICKWHILEDRILLING	Well Kick While Drilling
	1.00E+00		/NONSHEARABLE_BS0	Nonshearable across the blind shear set to 0
	1.00E+00		/NONSHEARABLE_CS0	Nonshearable across the casing shear set to 0
	3.31E-02		SWABBING-D-IC	Swab effect causes well kick while drilling, intermediate casing ops
16	3.02E-06	1.52		
	1.00E+00		<INIT>	Start of Event Tree
	1.22E-04		BOP-PRG-FLO-T0102CCF	Common cause failure of rigid conduit manifold pressure regulators T01 and T02 fails low or off
	1.00E+00		/CASING_SHEAR_FAIL_EDNAB	Casing Shear not required if nothing across the BOP - Emergency Disconnect
	1.00E+00		KICKWHILEDRILLING	Well Kick While Drilling
	2.48E-02		SWABBING-D-PZ	Swab effect causes well kick while drilling, reservoir ops
17	2.80E-06	1.4		
	1.00E+00		<INIT>	Start of Event Tree
	1.22E-04		BOP-PRG-FLO-T0102CCF	Common cause failure of rigid conduit manifold pressure regulators T01 and T02 fails low or off
	1.00E+00		/CASING_SHEAR_FAIL_EDNAB	Casing Shear not required if nothing across the BOP - Emergency Disconnect
	1.00E+00		KICKWHILEDRILLING	Well Kick While Drilling
	2.30E-02		OTHERKICK-D-IC	Kick from undefined caused while drilling, intermediate casing op
18	2.70E-06	1.35		
	1.00E+00		<INIT>	Start of Event Tree
	1.22E-04		BOP-PRG-FLO-T0102CCF	Common cause failure of rigid conduit manifold pressure regulators T01 and T02 fails low or off
	1.00E+00		/CASING_SHEAR_FAIL_EDNAB	Casing Shear not required if nothing across the BOP - Emergency Disconnect
	1.00E+00		KICKWHILEDRILLING	Well Kick While Drilling
	2.22E-02		OTHERKICK-D-PZ	Kick from undefined caused while drilling, reservoir ops
19	2.56E-06	1.29		

#	Prob/Freq	Total %	Cut Set	Description
	1.00E+00		<INIT>	Start of Event Tree
	1.00E+00		BLIND_SHEAR_FAIL_EDDR1	BSR fails to shut in well previous failure or nonshearable when drillpipe is present - Emergency Disconnect
	2.69E-05		BOP-SEM-FTO-CCF	Common cause failure of the control pod SEMs
	1.00E+00		CASING_SHEAR_FAIL_EDDR1	Setting casing shear to failed state when drillpipe is across (previously failed) - Emergency Disconnect
	1.00E+00		KICKWHILEDRILLING	Well Kick While Drilling
	1.00E+00		/NONSHEARABLE_BS0	Nonshearable across the blind shear set to 0
	1.00E+00		/NONSHEARABLE_CS0	Nonshearable across the casing shear set to 0
	9.54E-02		UNEXOVERP-D-IC	Unexpected Overpressure zone while drilling, intermediate casing ops
20	2.40E-06	1.2		
	1.00E+00		<INIT>	Start of Event Tree
	1.00E+00		BLIND_SHEAR_FAIL_EDDR1	BSR fails to shut in well previous failure or nonshearable when drillpipe is present - Emergency Disconnect
	9.65E-05		BOP-PVL-LKI-V10	Yellow RCM flush pilot operated hydraulic valve V10 leakage
	1.00E+00		CASING_SHEAR_FAIL_EDDR1	Setting casing shear to failed state when drillpipe is across (previously failed) - Emergency Disconnect
	1.00E+00		KICKWHILEDRILLING	Well Kick While Drilling
	1.00E+00		/NONSHEARABLE_BS0	Nonshearable across the blind shear set to 0
	1.00E+00		/NONSHEARABLE_CS0	Nonshearable across the casing shear set to 0
	2.48E-02		SWABBING-D-PZ	Swab effect causes well kick while drilling, reservoir ops

Table J- 3: Loss of Position Related Loss of Containment Top 20 Cut Sets

#	Prob/Freq	Total %	Cut Set	Description
Total	2.01E-04	100	(425955 Original Cut Sets)	
1	2.91E-06	1.45		
	1.00E+00		<INIT>	Start of Event Tree
	3.69E-03		BOP-BSRCYL-JAM-NABOP	Blind shear rams fail to close and seal when nothing is across the BOP
	1.61E-03		DPS-FRQ-WEA-SQUA-F-IE	Frequency of a Squall per hour (initiating event)
	8.10E-04		DPS-WEA-HRA-PREP	Human Error Failure to Orient the Vessel for the Onset of Elevated Weather
	9.00E-01		DRILLSTRINGIN_PZ	Drill String In - Production Zone
	4.00E-01		PRODUCTIONZONE	Production Zone
	1.68E+03		WELL_COMPLETION_TIME	Number of Hours for an average well completion
2	1.26E-06	0.63		
	1.00E+00		<INIT>	Start of Event Tree
	1.00E-01		BOP-CYL-FTC-BSRDP	Blind shear rams fail to close and seal when drill string is in the hole
	1.60E-01		BOP-HUM-ERR-DP-HANGOFF	Driller fails to position drillpipe properly before activating shear ram
	1.00E-01		DP-TOOLJOINT-PRESENT-CSR	Drillpipe tool joint is present across the CSR
	1.61E-03		DPS-FRQ-WEA-SQUA-F-IE	Frequency of a Squall per hour (initiating event)
	8.10E-04		DPS-WEA-HRA-PREP	Human Error Failure to Orient the Vessel for the Onset of Elevated Weather
	9.00E-01		DRILLSTRINGIN_PZ	Drill String In - Production Zone
	4.00E-01		PRODUCTIONZONE	Production Zone
	1.68E+03		WELL_COMPLETION_TIME	Number of Hours for an average well completion
3	1.21E-06	0.6		
	1.00E+00		<INIT>	Start of Event Tree
	1.54E-03		BOP-SHV-LKE-A13	Blind Shear Ram Lock shuttle valve A13 jams/external leak
	1.61E-03		DPS-FRQ-WEA-SQUA-F-IE	Frequency of a Squall per hour (initiating event)
	8.10E-04		DPS-WEA-HRA-PREP	Human Error Failure to Orient the Vessel for the Onset of Elevated Weather
	9.00E-01		DRILLSTRINGIN_PZ	Drill String In - Production Zone
	4.00E-01		PRODUCTIONZONE	Production Zone
	1.68E+03		WELL_COMPLETION_TIME	Number of Hours for an average well completion
4	1.21E-06	0.6		
	1.00E+00		<INIT>	Start of Event Tree
	1.54E-03		BOP-SHV-LKE-A12	Blind Shear Ram Lock shuttle valve A12 jams/external leak
	1.61E-03		DPS-FRQ-WEA-SQUA-F-IE	Frequency of a Squall per hour (initiating event)
	8.10E-04		DPS-WEA-HRA-PREP	Human Error Failure to Orient the Vessel for the Onset of Elevated Weather
	9.00E-01		DRILLSTRINGIN_PZ	Drill String In - Production Zone
	4.00E-01		PRODUCTIONZONE	Production Zone
	1.68E+03		WELL_COMPLETION_TIME	Number of Hours for an average well completion
5	1.21E-06	0.6		
	1.00E+00		<INIT>	Start of Event Tree
	1.54E-03		BOP-SHV-LKE-A01	Blind Shear Ram High pressure close shuttle valve A01 jams/external leak
	1.61E-03		DPS-FRQ-WEA-SQUA-F-IE	Frequency of a Squall per hour (initiating event)

#	Prob/Freq	Total %	Cut Set	Description
	8.10E-04		DPS-WEA-HRA-PREP	Human Error Failure to Orient the Vessel for the Onset of Elevated Weather
	9.00E-01		DRILLSTRINGIN_PZ	Drill String In - Production Zone
	4.00E-01		PRODUCTIONZONE	Production Zone
	1.68E+03		WELL_COMPLETION_TIME	Number of Hours for an average well completion
6	9.59E-07	0.48		
	1.00E+00		<INIT>	Start of Event Tree
	2.43E-03		BOP-PRG-FLO-T02	Rigid conduit manifold 3000 PSI pressure regulator T02 fails low
	1.61E-03		DPS-FRQ-WEA-SQUA-F-IE	Frequency of a Squall per hour (initiating event)
	8.10E-04		DPS-WEA-HRA-PREP	Human Error Failure to Orient the Vessel for the Onset of Elevated Weather
	9.00E-01		DRILLSTRINGIN_PZ	Drill String In - Production Zone
	4.00E-01		PRODUCTIONZONE	Production Zone
	5.00E-01		/RISER_PARTS	Riser parts following a failed disconnect
	1.68E+03		WELL_COMPLETION_TIME	Number of Hours for an average well completion
7	6.04E-07	0.3		
	1.00E+00		<INIT>	Start of Event Tree
	1.00E-01		BOP-CYL-FTC-BSRDP	Blind shear rams fail to close and seal when drill string is in the hole
	2.38E-03		D-W-O-OPER-F-IE	Run/Retrieval Offset Frequency per hour (initiating event)
	4.20E-05		D-W-S-STRM-OFST-HRA	Human Error Resulting in Incorrectly Entering the Offset into the DP System (Extreme Weather, Winter Storm, Squall)
	1.00E-01		DP-TOOLJOINT-PRESENT-CSR	Drillpipe tool joint is present across the CSR
	9.00E-01		DRILLSTRINGIN_PZ	Drill String In - Production Zone
	1.00E+00		DRIVE-OFF-HUMERR	Drive-off due to human error
	4.00E-01		PRODUCTIONZONE	Production Zone
	1.68E+03		WELL_COMPLETION_TIME	Number of Hours for an average well completion
8	5.98E-07	0.3		
	1.00E+00		<INIT>	Start of Event Tree
	3.69E-03		BOP-BSRCYL-JAM-NABOP	Blind shear rams fail to close and seal when nothing is across the BOP
	3.31E-04		DPS-FRQ-WEA-WINT-F-IE	Frequency of Winter Storm per hour (initiating event)
	8.10E-04		DPS-WEA-HRA-PREP	Human Error Failure to Orient the Vessel for the Onset of Elevated Weather
	9.00E-01		DRILLSTRINGIN_PZ	Drill String In - Production Zone
	4.00E-01		PRODUCTIONZONE	Production Zone
	1.68E+03		WELL_COMPLETION_TIME	Number of Hours for an average well completion
9	4.09E-07	0.2		
	1.00E+00		<INIT>	Start of Event Tree
	1.00E-01		BOP-CYL-FTC-BSRDP	Blind shear rams fail to close and seal when drill string is in the hole
	4.20E-05		D-W-S-STRM-OFST-HRA	Human Error Resulting in Incorrectly Entering the Offset into the DP System (Extreme Weather, Winter Storm, Squall)
	1.00E-01		DP-TOOLJOINT-PRESENT-CSR	Drillpipe tool joint is present across the CSR
	1.61E-03		DPS-FRQ-WEA-SQUA-F-IE	Frequency of a Squall per hour (initiating event)
	9.00E-01		DRILLSTRINGIN_PZ	Drill String In - Production Zone

#	Prob/Freq	Total %	Cut Set	Description
	1.00E+00		DRIVE-OFF-HUMERR	Drive-off due to human error
	4.00E-01		PRODUCTIONZONE	Production Zone
	1.68E+03		WELL_COMPLETION_TIME	Number of Hours for an average well completion
10	3.87E-07	0.19		
	1.00E+00		<INIT>	Start of Event Tree
	3.69E-03		BOP-BSRCYL-JAM-NABOP	Blind shear rams fail to close and seal when nothing is across the BOP
	1.00E+00		DRIFT-OFF_DUETOHARDWARE	Drift-off due to less than adequate thrusters available (equipment failure)
	9.00E-01		DRILLSTRINGIN_PZ	Drill String In - Production Zone
	3.53E-03		EME-ESD-SPO-001	Emergency Shutdown System 1 Spuriously Causes Loss of Power (Starboard Group)
	4.91E-05		EME-ESD-SPO-003-F-IE	Emergency Shutdown System 3 Spuriously Causes Loss of Power (Port Group)
	4.00E-01		PRODUCTIONZONE	Production Zone
	1.68E+03		WELL_COMPLETION_TIME	Number of Hours for an average well completion
11	3.87E-07	0.19		
	1.00E+00		<INIT>	Start of Event Tree
	3.69E-03		BOP-BSRCYL-JAM-NABOP	Blind shear rams fail to close and seal when nothing is across the BOP
	1.00E+00		DRIFT-OFF_DUETOHARDWARE	Drift-off due to less than adequate thrusters available (equipment failure)
	9.00E-01		DRILLSTRINGIN_PZ	Drill String In - Production Zone
	3.53E-03		EME-ESD-SPO-002	Emergency Shutdown System 2 Spuriously Causes Loss of Power (Center Group)
	4.91E-05		EME-ESD-SPO-003-F-IE	Emergency Shutdown System 3 Spuriously Causes Loss of Power (Port Group)
	4.00E-01		PRODUCTIONZONE	Production Zone
	1.68E+03		WELL_COMPLETION_TIME	Number of Hours for an average well completion
12	3.87E-07	0.19		
	1.00E+00		<INIT>	Start of Event Tree
	3.69E-03		BOP-BSRCYL-JAM-NABOP	Blind shear rams fail to close and seal when nothing is across the BOP
	1.00E+00		DRIFT-OFF_DUETOHARDWARE	Drift-off due to less than adequate thrusters available (equipment failure)
	9.00E-01		DRILLSTRINGIN_PZ	Drill String In - Production Zone
	4.91E-05		EME-ESD-SPO-001-F-IE	Emergency Shutdown System 1 Spuriously Causes Loss of Power (Starboard Group)
	3.53E-03		EME-ESD-SPO-003	Emergency Shutdown System 3 Spuriously Causes Loss of Power (Port Group)
	4.00E-01		PRODUCTIONZONE	Production Zone
	1.68E+03		WELL_COMPLETION_TIME	Number of Hours for an average well completion
13	3.87E-07	0.19		
	1.00E+00		<INIT>	Start of Event Tree
	3.69E-03		BOP-BSRCYL-JAM-NABOP	Blind shear rams fail to close and seal when nothing is across the BOP
	1.00E+00		DRIFT-OFF_DUETOHARDWARE	Drift-off due to less than adequate thrusters available (equipment failure)
	9.00E-01		DRILLSTRINGIN_PZ	Drill String In - Production Zone

#	Prob/Freq	Total %	Cut Set	Description
	4.91E-05		EME-ESD-SPO-002-F-IE	Emergency Shutdown System 2 Spuriously Causes Loss of Power (Center Group)
	3.53E-03		EME-ESD-SPO-003	Emergency Shutdown System 3 Spuriously Causes Loss of Power (Port Group)
	4.00E-01		PRODUCTIONZONE	Production Zone
	1.68E+03		WELL_COMPLETION_TIME	Number of Hours for an average well completion
14	3.87E-07	0.19		
	1.00E+00		<INIT>	Start of Event Tree
	3.69E-03		BOP-BSRCYL-JAM-NABOP	Blind shear rams fail to close and seal when nothing is across the BOP
	1.00E+00		DRIFT-OFF_DUETOHARDWARE	Drift-off due to less than adequate thrusters available (equipment failure)
	9.00E-01		DRILLSTRINGIN_PZ	Drill String In - Production Zone
	3.53E-03		EME-ESD-SPO-001	Emergency Shutdown System 1 Spuriously Causes Loss of Power (Starboard Group)
	4.91E-05		EME-ESD-SPO-002-F-IE	Emergency Shutdown System 2 Spuriously Causes Loss of Power (Center Group)
	4.00E-01		PRODUCTIONZONE	Production Zone
	1.68E+03		WELL_COMPLETION_TIME	Number of Hours for an average well completion
15	3.87E-07	0.19		
	1.00E+00		<INIT>	Start of Event Tree
	3.69E-03		BOP-BSRCYL-JAM-NABOP	Blind shear rams fail to close and seal when nothing is across the BOP
	1.00E+00		DRIFT-OFF_DUETOHARDWARE	Drift-off due to less than adequate thrusters available (equipment failure)
	9.00E-01		DRILLSTRINGIN_PZ	Drill String In - Production Zone
	4.91E-05		EME-ESD-SPO-001-F-IE	Emergency Shutdown System 1 Spuriously Causes Loss of Power (Starboard Group)
	3.53E-03		EME-ESD-SPO-002	Emergency Shutdown System 2 Spuriously Causes Loss of Power (Center Group)
	4.00E-01		PRODUCTIONZONE	Production Zone
	1.68E+03		WELL_COMPLETION_TIME	Number of Hours for an average well completion
16	3.63E-07	0.18		
	1.00E+00		<INIT>	Start of Event Tree
	4.60E-04		BOP-CYL-FTC-BSL1	Blind shear lock fails to lock or stay locked
	1.61E-03		DPS-FRQ-WEA-SQUA-F-IE	Frequency of a Squall per hour (initiating event)
	8.10E-04		DPS-WEA-HRA-PREP	Human Error Failure to Orient the Vessel for the Onset of Elevated Weather
	9.00E-01		DRILLSTRINGIN_PZ	Drill String In - Production Zone
	4.00E-01		PRODUCTIONZONE	Production Zone
	1.68E+03		WELL_COMPLETION_TIME	Number of Hours for an average well completion
17	3.23E-07	0.16		
	1.00E+00		<INIT>	Start of Event Tree
	3.69E-03		BOP-BSRCYL-JAM-NABOP	Blind shear rams fail to close and seal when nothing is across the BOP
	1.00E+00		/CASING_SHEAR_FAIL_EDNAB	Casing Shear not required if nothing across the BOP - Emergency Disconnect
	1.61E-03		DPS-FRQ-WEA-SQUA-F-IE	Frequency of a Squall per hour (initiating event)

#	Prob/Freq	Total %	Cut Set	Description
	8.10E-04		DPS-WEA-HRA-PREP	Human Error Failure to Orient the Vessel for the Onset of Elevated Weather
	1.00E-01		OPENHOLE_PZ	Open Hole - Production Zone
	4.00E-01		PRODUCTIONZONE	Production Zone
	1.68E+03		WELL_COMPLETION_TIME	Number of Hours for an average well completion
18	2.91E-07	0.14		
	1.00E+00		<INIT>	Start of Event Tree
	1.00E-01		BOP-CYL-FTC-BSRDP	Blind shear rams fail to close and seal when drill string is in the hole
	3.69E-03		BOP-CYL-FTC-CSR1	Casing shear ram binds and fails to close and shear properly
	1.61E-03		DPS-FRQ-WEA-SQUA-F-IE	Frequency of a Squall per hour (initiating event)
	8.10E-04		DPS-WEA-HRA-PREP	Human Error Failure to Orient the Vessel for the Onset of Elevated Weather
	9.00E-01		DRILLSTRINGIN_PZ	Drill String In - Production Zone
	4.00E-01		PRODUCTIONZONE	Production Zone
	1.68E+03		WELL_COMPLETION_TIME	Number of Hours for an average well completion
19	2.59E-07	0.13		
	1.00E+00		<INIT>	Start of Event Tree
	1.00E-01		BOP-CYL-FTC-BSRDP	Blind shear rams fail to close and seal when drill string is in the hole
	1.60E-01		BOP-HUM-ERR-DP-HANGOFF	Driller fails to position drillpipe properly before activating shear ram
	1.00E-01		DP-TOOLJOINT-PRESENT-CSR	Drillpipe tool joint is present across the CSR
	3.31E-04		DPS-FRQ-WEA-WINT-F-IE	Frequency of Winter Storm per hour (initiating event)
	8.10E-04		DPS-WEA-HRA-PREP	Human Error Failure to Orient the Vessel for the Onset of Elevated Weather
	9.00E-01		DRILLSTRINGIN_PZ	Drill String In - Production Zone
	4.00E-01		PRODUCTIONZONE	Production Zone
	1.68E+03		WELL_COMPLETION_TIME	Number of Hours for an average well completion
20	2.50E-07	0.12		
	1.00E+00		<INIT>	Start of Event Tree
	1.54E-03		BOP-SHV-LKE-A13	Blind Shear Ram Lock shuttle valve A13 jams/external leak
	3.31E-04		DPS-FRQ-WEA-WINT-F-IE	Frequency of Winter Storm per hour (initiating event)
	8.10E-04		DPS-WEA-HRA-PREP	Human Error Failure to Orient the Vessel for the Onset of Elevated Weather
	9.00E-01		DRILLSTRINGIN_PZ	Drill String In - Production Zone
	4.00E-01		PRODUCTIONZONE	Production Zone
	1.68E+03		WELL_COMPLETION_TIME	Number of Hours for an average well completion