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FORMAL REPORT

LEVEL 1 TORNADO PRA FOR THE HIGH FLUX BEAM REACTOR

George E. Bozoki and Cheryl S. Conrad

May 1994

Department of Advanced Technology

BROOKHAVEN NATIONAL LABORATORY
ASSOCIATED UNIVERSITIES, INC.
UPTON, LONG ISLAND, NEW YORK 11973-5000

UNDER CONTRACT NO. DE-AC02-76CH00016 WITH THE
UNITED STATES DEPARTMENT OF ENERGY

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ABSTRACT

This report describes a risk analysis primarily directed at providing an estimate for the frequency of tornado induced damage to the core of the High Flux Beam Reactor (HFBR), and thus it constitutes a Level 1 Probabilistic Risk Assessment (PRA) covering tornado induced accident sequences.

The basic methodology of the risk analysis was to develop a "tornado specific" plant logic model that integrates the internal random hardware failures with failures caused externally by the tornado strike and includes operator errors worsened by the tornado modified environment. The tornado hazard frequency, as well as earlier prepared structural and equipment fragility data (See Ref. [4]), were used as input data to the model. To keep modeling/calculational complexity as simple as reasonable a "bounding" type, slightly conservative, approach was applied. By a thorough screening process a single dominant initiating event was selected as a representative initiator, defined as: "Tornado Induced Loss of Offsite Power." The frequency of this initiator was determined to be 6.37E-5/year. The safety response of the HFBR facility resulted in a total Conditional Core Damage Probability of .621. Thus, the point estimate of the HFBR's Tornado Induced Core Damage Frequency (CDF) was found to be:

$$(CDF)_{Tornado} = 3.96E\text{-}5/\text{year}.$$

This value represents only 7.8% of the internal CDF and thus is considered to be a small contribution to the overall facility risk expressed in terms of total Core Damage Frequency.

In addition to providing the estimate of $(CDF)_{Tornado}$, the report documents the relative importance of various tornado induced system, component, and operator failures that contribute most to $(CDF)_{Tornado}$.

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1.0 INTRODUCTION

1.1 Background and Objective

Throughout the last few years a program has been conducted at Brookhaven National Laboratory (BNL) to develop a complete probabilistic risk profile for its research reactor facility, the High Flux Beam Reactor (HFBR). The reactor facility is located almost at the middle of Long Island, N.Y. (Figure 1.1) As a first phase in the program a Level 1 Probabilistic Risk Assessment has been completed in the late 1980's [1] on the accident sequences initiated by internal events. In the early 1990's, the risk contributions from external initiating events, such as earthquakes [2], fire and flood [3], have been assessed.

The objective of this study is to present the results of a probabilistic risk assessment of accident sequences initiated by a tornado strike to the site of the HFBR. Thus, the study represents the third part in the series of external initiating event analyses.

The tornado PRA, similar to the previous external analyses, is structured to be a "stand alone" document, as practicable. However, it extensively refers to the internal event PRA [1], particularly for detailed descriptions of the facility, operational modes, systems, and logic model assembly. It also utilizes the results of a companion report that describes the tornado/high-wind hazards and the fragilities of structures and components of the HFBR completed recently [4] to provide supporting input for the present study.

In addition, several parts of the seismic PRA [2] are also considered. This is to keep parallelism in the present study with the modifications of the Level 1 internal events model that was introduced into the seismic PRA which describes seismic effects.

1.2 General Approach

The basic approach applied for this Level 1 Tornado PRA follows the recommended practice: integrate the internal random hardware failures with failures caused externally by the tornado strike and include operator errors made more probable by the environment that was changed because of the external event.

By using the basic approach the tornado risk profile of the HFBR, i.e., the frequency of severe core damage, will be determined. In addition, the dominant contributors to plant risk from possible tornado strikes also will be identified.

The steps to develop the tornado risk profile are the following:

1. Identification and quantification of a single tornado induced dominant initiating event. This step strongly utilizes the results of the tornado/high wind hazard and the plant's structure/component fragility analyses [4].
2. Systems modeling. This is the step that involves the modification of the fault

tree models for the reactor safety systems. The modified fault trees will include both the tornado-missile induced failures of the hardware and the "tornado-specific" operator errors.

3. Accident sequence modeling. This step requires developing an appropriate event tree for the tornado initiator.
4. The last step, quantification of the tornado event tree. This step provides the total frequency of core damage due to tornado-initiated accident sequences. It allows for obtaining estimates for tornado risk in terms of effects on public health in subsequent analyses that integrate the results of the core damage analysis with those of the calculations performed for the consequences of tornado initiated accident sequences.

The above steps will be discussed in more detail in subsequent chapters.

1.3 Scope of the Study

The frequencies of tornado induced accident sequences leading to core damage and thus the total tornado related core damage frequency for the HFBR are point estimates. Uncertainty calculations may be performed in a later phase of the HFBR probabilistic safety program.

It is a general belief that the operation of the HFBR at a power level of 60 MW is at higher risk than the operation at a lower (40 MW) level. That was the reason that the internal PRA has primarily considered the 60 MW power level operation. The associated plant logic model (i.e., the assembly of fault trees describing the unavailability of safety systems) thus provides a "worst case" representation of the facility's resilience vis-a-vis accidents.

The present study considers only this "bounding" higher level power operation. Therefore, only the 60 MW internal logic model has been modified by incorporating into it tornado-induced failure events. The basic event unavailability values were kept the same and the time basis for systems' success criteria remained that of the source, i.e., 24 hours. Human errors influenced by the tornado modified environment were treated in a simplified manner.

As is usually the case for these types of studies, second order effects such as tornado induced fires or chemical releases were considered as "out-of-scope."

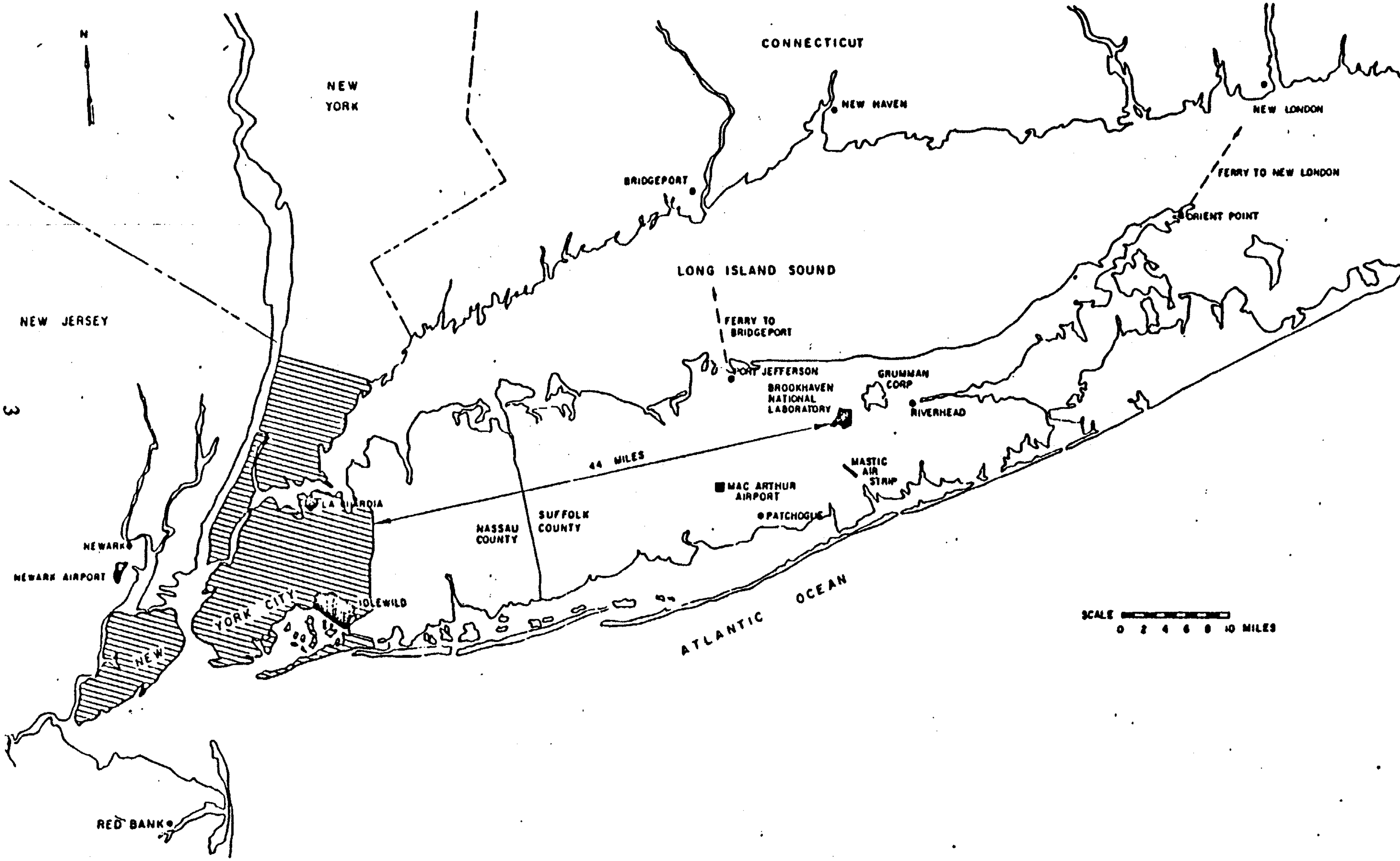

Figure 1.1 Map of Long Island and the BNL Site.

2.0 TORNADO INDUCED INITIATING EVENTS

2.1 Selection of a Single Tornado Induced Dominant Initiating Event

The selection of a single tornado induced dominant initiating event was the result of a thorough screening process.

This process involved:

a. Detailed direct and probabilistic hazard analysis of the BNL site and vulnerability (fragility) analyses of the HFBR structures and components for tornado/straight-wind loads (wind pressure) and missiles (see ref. [4]). The analyses were performed by personnel having general knowledge of wind engineering and experience in tornado (wind)/seismic fragility calculations.

b. A systematic investigation of HFBR design features to determine the response of the facility to tornado/straight-wind strikes. The investigation required the collaboration of analysts experienced in internal/external risk assessment with plant personnel. It consisted of the following three phases:
   - a preliminary "tornado-impact-specific" review of the HFBR systems' descriptions and the operation-procedure manuals as well as the internal PRA system logic,
   - a tornado-impact-specific "talk-through" of the emergency procedures/measures of the facility, and finally
   - a tornado-impact-specific walk-through of the facility.

c. An integration of the information obtained via items a and b with the initiating events identified in the internal PRA.

2.2 Elimination of Potential Straight-Wind Initiators

The risk hazard associated with straight-wind storms (thunderstorms, tropical storms and hurricanes) is discussed in detail for the HFBR site in Ref. [4]. The wind speed (load) for which the basic HFBR structures were originally designed is 120 mph. From straight-wind storms of various types, in general, the hurricanes have wind speed greater than 120 mph. Straight-winds with velocity < 120 mph usually result in loss of offsite power. Therefore, they were accounted for by the various categories of the loss of offsite power initiator LOOP2, LOOP6, and LOOP24 in the internal PRA.

Hurricanes would represent a great risk hazard for an operating HFBR. However, hurricane warnings are usually issued at the east coast of the U.S.A. (and particularly at Long Island) much earlier than their arrivals. Given such an early warning, the HFBR shuts down in an orderly manner, similar to other large experimental facilities at the BNL site.

Thus, hurricanes are effectively screened out as contributors from the list of potential external initiating events for the HFBR.

2.3 HFBR Structural (Wind-Pressure) Fragilities vs Initiating Events

The major structures and outdoor components of the HFBR facility are shown in Figure 2.1. They are: the reactor building (Building 750), the fanhouse (Building 704), the stack (Building 705), the pumphouse (Building 707), the cooling tower building, Helium trailer(s), and several tanks (e.g., secondary water hold-up tank, FA-310; the sulfuric acid storage tank). There are also other structures. However, they are not related to the safety features of the reactor. These are, e.g., the CNF building (Building 751) and the liquid nitrogen tanks. The above structures are made of reinforced concrete, steel, concrete blocks, masonry, aluminum and even wood (the cooling tower).

The wind pressure fragilities associated with several structures deemed to be the most important have been determined in Ref. [4]. The fragility values obtained are expressed in terms of median wind speed (in mph units). Table 2.1 reproduces these values in ranked order for the structures considered. To indicate uncertainty, the logarithmic standard deviations for wind velocity distribution (β_r) and for the structural capacity distributions (β_u) are also shown in the table.

The structural fragility data show that the pumphouse, the reactor building, and the fanhouse are unlikely to sustain any serious structural damage from wind pressure itself. These structures have rather high structural capacities against wind pressure loading.

Other structures, such as the helium trailer, the stack, and the cooling tower building, have lower fragility values. These structures and some outdoor tanks, however, are not vital components of the safety systems. Even if they suffer serious wind damage (e.g., loss of He-makeup, partial loss of secondary water makeup, damage of cooling tower, sulfuric acid release), the associated safety systems and/or the accident management would only be degraded and not completely incapacitated.

Therefore, low wind fragilities of the above structures with a potential partial loss of associated systems (e.g., secondary cooling system) were not considered as tornado induced initiating events.

The situation with regard to the low structural fragility for offsite power loss, however, is completely different. The low structural fragility combined with the extensive missile activity of a tornado strike renders the offsite power network of the HFBR completely vulnerable for tornado strike (consider e.g., the 13.8kV/2.4kV transformers outside the fanhouse). The loss of offsite power causes the loss of all preferred AC power to a number of safety equipment, and thus triggers an early reactor trip. (The plant equipment affected by the loss of offsite power and identified in Ref. [4] is listed in Table 2.2. Notice that the structural fragility of the listed equipment is that of the offsite power loss.)

Table 2.1 HFBR Structural Fragilities

Structure	Median Wind Speed (mph)	β_r	β_u
1. Pumphouse	716.4	0.10	0.21
2. Reactor Building	690.0	0.10	0.15
3. Fanhouse	511.0	0.10	0.21
4. Trailer	203.0	0.10	0.17
5. Stack	171.7	0.10	0.17
6. Cooling Tower Building	137.8	0.10	0.17
7. Offsite Power Loss	60.0	0.25	0.25

Table 2.2 Equipment Fragility Associated with Offsite Power Loss

No.*	Equipment	Median Wind Speed (mph)	β_r	β_u
12	Primary Cooler Cell Motors	60	.25	.25
33	Canal Clean Up Water Pumps	60	.25	.25
34	Heavy Water Transfer Pumps	60	.25	.25
52	Pumphouse Breaker	60	.25	.25
53	Emergency Motor Control Center	60	.25	.25

* Equipment No. is the same that was used for equipment identification in the seismic PRA study [2].

An inspection of the affected equipment and consideration of other system components disabled by system's dependency leads to the conclusion that tornado induced loss of offsite power represents an unquestionable initiating event. In fact, it is not only unquestionable, but it is also a dominating initiator; for during the initiator screening process it was rather difficult to find a potential tornado induced initiating event (see the list of Internal Initiating Events in Appendix A) where the response characteristics of the safety systems would not be encompassed by the loss of offsite power initiator (e.g., general plant transient need not be considered as an independent initiator since it occurs with the loss of offsite power).

2.4 Frequency of Tornado Induced Loss of Offsite Power Initiating Event

Based on the previously described screening process, the present study assumes that loss of offsite power occurs with any tornado strike of the HFBR site. The occurrence frequency of this initiating event can be determined by combining the occurrence frequency of the tornados with magnitude greater than or equal to F_1[1] in the Long Island area with the probability that such a tornado effectively strikes a point structure at the HFBR site (tornado hazard).

The distribution describing the occurrence frequency of F_1 tornados was determined in Ref. [4]. For completeness, it is reproduced here in Table 2.3.

From the distribution, the 85 percentile value, i.e., .637E-04/year is selected as a conservative point value estimate for the frequency of the tornado induced loss of offsite power initiator. The selection of the value is not arbitrary; it represents an "approximate mean" value of the tornado strike frequency distribution. In addition, Ref. [4] used it as a basic quantity in the determination of the tornado missile fragilities for the safety system components.

It is reasonable to assume that the tornado induced loss of offsite power initiator belongs to the LOOP24 category defined in the internal PRA (i.e., it is a loss of offsite power event lasting 6 hours or more) since tornado disrupted power-net cannot be easily repaired.

---

[1]Tornados, like seismic events, are categorized according to their intensity. There are six tornado groups characterized with increasing central wind speed ranges (F-scale). The F-groups are defined as:

Group	F_0	F_1	F_2	F_3	F_4	F_5
Median Wind Speed, mph	40-72	73-112	113-157	158-206	207-260	261-318

For more details see Ref. [4].

Table 2.3 F_1 Tornado Strike Frequency Distribution for a Point Structure at the HFBR Site

Percentile	F_1 Group Median Wind Speed: 92.5mph (1/year)
5.0%	0.394E-05
15.0%	0.734E-05
25.0%	0.107E-04
35.0%	0.145E-04
45.0%	0.190E-04
50.0%	0.216E-04
55.0%	0.247E-04
65.0%	0.323E-04
75.0%	0.436E-04
85.0%	0.637E-04
95.0%	0.119E-03

Finally, a comment is warranted on the selection of the initiating event. Tornados can cause loss of offsite power without striking the HFBR site proper, and wind speeds less than those of an F_1 tornado can potentially initiate a loss of offsite power. However, there would be no damage to plant safety systems (i.e., the probability of damage would be negligible, after all, most of the HFBR structures should resist wind speed up to 120 mph). In these cases core damage could only occur if wind induced loss of offsite power was coupled with random safety system components' failures. Such scenarios, however, were included in the scope of the internal PRA and are not considered in the tornado initiated accident sequences.

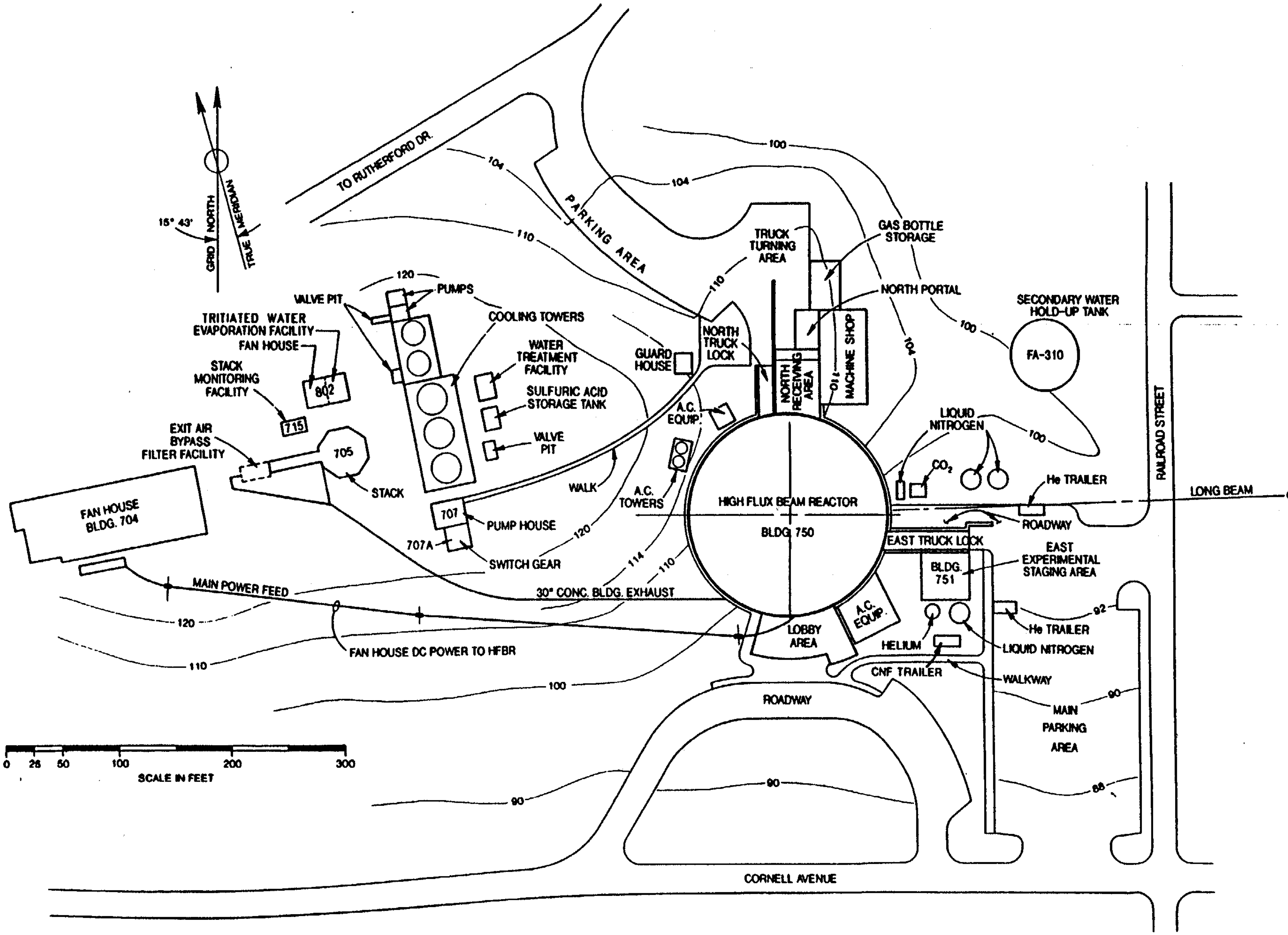

Figure 2.1 HFBR Site Plan.

3.0 MODIFICATION OF THE SYSTEM MODELS

3.1 General

In order to determine the core damage frequencies for tornado induced accident sequences, the fault trees developed for the internal events analysis have been modified by incorporating tornado induced component failures and tornado-specific operator errors. For this modification attention was given to the physical location of the system components because location determines the vulnerability of a component (or a group of components) for tornado effects (missiles/debris) or the extent of secondary failures. For the tornado specific human failures a number of tornado related effects had to be considered: the probability that the operators suffer personal injury, that missiles/structural debris impede the operators from performing certain tasks inside/outside the control room, the increased stress level of the operators, and the time window for additional operators to arrive to help in the accident recovery management.

In a way, an internal event fault tree modified for tornado strike and the corresponding fault tree for a seismic event are rather similar.

3.2 Location of the HFBR Equipment

The majority of the HFBR equipment is housed in the reactor building (a reinforced concrete frame set). An elevation view of the reactor building is shown in Figure 3.1. There are four floors in the building which are designated as the equipment floor (EL. 93'-0"), the experimental floor (EL. 113'-6"), the balcony (EL. 128'-6"), and the operations floor (EL 141'-6"). The building is enclosed by an airtight hemispherical confinement dome, as shown in the figure. The dome is formed from welded 1/4"-thick steel plates supported upon an internal I-beam frame work.

Some equipment is located in the fanhouse (a single story, reinforced-concrete frame structure) and in the pumphouse (a single story masonry structure with reinforced concrete basement and roof).

The areas within the reactor building that were used in the internal PRA for equipment component location identification and also used in the present study are the following:

the operations level outside the control room, OP
the control room (the control room is at the operations level), CR
the experimental level, EX, and
the equipment level, EQ.

Equipment housed in other structures have "structure characteristic" location identifiers: FH denotes fanhouse, PH denotes pumphouse, and OD describes plain outdoor equipment location.

3.3 Tornado Missile Fragility of HFBR Equipment

The tornado missile fragility is a different quantity than the structural fragility of a building/equipment against wind and tornado loads. Tornado missile fragility is used to characterize the damage of equipment caused by tornado-born missiles. While the structural fragility is determined by the conditional probability of failure given a wind speed level expressed in terms of the fastest mph, the tornado missile fragility is unconditionally defined by the annual probability of equipment failure due to missiles.

The tornado missile fragility F_T can be described by the following expression (which is a simplified version of Equation (6.1) of Ref. [4] and is essentially identical with it):

$$F_T = F_E \times P_S \times N = F_E \times D \tag{1}$$

where:

F_E denotes the annual tornado strike probability (i.e., tornado strike frequency) at a site,

P_S denotes the probability that a missile generated by the tornado strike reaches the building containing the equipment under consideration, penetrates barriers, and strikes the equipment areas, and

N denotes the number of missiles generated by a design basis event (e.g., at the HFBR site the gas bottle storage area, parking lots).

The quantity $D = P_S \times N$ can be used conveniently to characterize "the conditional tornado missile damage probability," i.e., the damage probability of the equipment multiplied by the total number of missiles.

The tornado missile fragility for the HFBR equipment was determined by a rather complex and cumbersome numerical calculation as described in Ref. [4]. Depending primarily on the location of the equipment, fragility values were evaluated for the following categories:

- equipment on the operation floor, outside the control room,
- equipment inside the control room,
- equipment inside the fanhouse, and
- equipment inside the pumphouse.

The equipment located on the equipment floor has been excluded from fragility analysis. It was considered highly unlikely that tornado missiles which could penetrate the exterior steel dome and then the thick concrete slabs or the biological shield, would still have enough velocity to damage the equipment.

The fragility values obtained for the above categories are listed in Table 3.1. The equipment identification Nos. are the same as those used in the seismic PRA [2]. For convenience, the table indicates the tornado missile types considered in the fragility calculations and the conditional tornado missile damage probability (D) values. Essentially these latter values are used for quantification of tornado failure events in the modified system fault trees.

Table 3.1 Tornado Missile Fragility of HFBR Equipment

Location	Missile Types*	No.	Equipment	Missile Strike Frequency F(1/year)	Missile Strike Cond. Dam. Prob. D
CR	D,F	2	Air Cylinder	9.93E-6	.156
CR/EQ		5	Flow Control Valve	9.93E-6	.156
CR/EQ		7	Sec. Side Return Valves	9.93E-6	.156
CR		50	Electrical Cable Trays and Conduits	9.93E-6	.156
CR		60	"Deli Case"	9.93E-6	.156
CR		68	Control Room Panels	9.93E-6	.156
CR		75	12/24 DC Battery System	9.93E-6	.156
OP	A,B,D, E,F	6	Poison Water System	2.57E-5	.403
OP		15	Check Valves	2.57E-5	.403
OP		30	Manual Valves	2.57E-5	.403
FH	F	9	Fanhouse 250V Batteries	4.40E-6	.069
		13	Battery Chargers	4.40E-6	.069
		60	Battery Circuit Breaker	4.40E-6	.069
		61	DC Control and Feed Panel	4.40E-6	.069
PH	F	59	DC Distribution Panel	4.08E-6	.064

* Missile Types:

A. 6" Sch. 40 pipe (15')
B. 12" Sch. 40 pipe (15')
C. 1" Solid Steel Rod (3') (does not puncture the barriers)
D. 13.5" Utility Pole (35')
E. Automobile
F. Stackpiece

3.4 Component Fragility Data Assembly

In the internal PRA a sixteen character coding scheme was used to describe a basic event. The scheme is represented by the following character grouping:

SSS CCC NNNNN MMM LL.

The first group describes the system, the second group identifies a generic component type, the third group identifies a specific component, the fourth group specifies the failure mode, and the last group gives the component location.

For tornado missile induced basic events associated with component failure (hardware) another scheme of designators was added to the above event designator scheme. The new scheme has the following form:

TOR-SXY-FMIS

where:

the prefix TOR identifies the event as tornado specific for the database of the computer code used for the HFBR analyses. (The computer code name is IRRAS, and it is described in Ref. [5]),

in the group SXY the characters XY identify the generic equipment type in accordance with the equipment numbering classification given in Table 3.1 (No. of Equipment),

and the group FMIS either indicates that the event is just tornado missile (not structural) fragility related or, if it contains other and/or more characters, it describes missile failures of more components (e.g., valves) that result in the same consequences.

Each event also has, of course, a longer descriptor providing more information. The longer descriptors are given in Table B.5 of Appendix B.

The form of the scheme is analogous to the scheme applied for the seismic analysis. The purpose of the analogy is to keep parallelism between the tornado and the seismic fragilities associated with the same basic event.

3.5 Incorporation of Tornado Missile Induced Basic Events Into the Fault Trees

The list of internal basic events describing component (hardware) failures is given in Table B.1 of Appendix B.1. By reviewing these events according to system and location affiliation and considering the equipment failures of Table 3.1, as well as tornado induced loss of offsite power initiating event, a number of basic events (components) were identified that are potentially affected by tornado missiles. The affected basic events together with the corresponding modifying events (i.e., new events describing the tornado induced failures of the affected components described in the previous section) and the fault trees (systems) where the basic events appear are presented in Table B.3 of Appendix B. Table B.3 was compiled by using the cross reference feature of the IRRAS code.

For fault tree modification largely the procedure worked out for the seismic fault tree development has been applied: whenever an affected basic event appears, it is substituted by an "OR" gate having two inputs: one is the original internal basic event and the other is the new tornado missile induced basic event. The new event will acquire the conditional tornado missile damage probability (D) of the associated equipment given in Table 3.1. Sometimes, if the new event relates to several basic events (like several valves) the new event appears at the appropriate place of the fault tree as a "common cause" failure event.

3.6 Screening and Identification of Tornado Specific Human Errors

The list of internal events describing human errors is shown in Table B.2 of Appendix B. Analogous with the screening process adopted at the component (hardware) analysis, a screening process was also applied for these events. Only those human actions were selected which were assessed to occur after a tornado strike of the HFBR site, when there is only a negligible probability for offsite power recovery within 24 hours. Similar to the seismic human failure selection, the screening process eliminated those events which involved pre-existing failures, like "valve left in the wrong position."

The selected internal human failure events together with the corresponding tornado specific human failures and the fault trees (systems) where these events appear are presented in Table B.4 of Appendix B. Table B.4 was compiled in the same manner as Table B.3 for the component failures, by using the cross reference feature of the IRRAS code.

The tornado specific human failures are identified by the following designator scheme:

TOR-HEP-ABCDEFGH,

where: TOR is for tornado,

HEP is for human error probability, and

ABCDEFGH is a general designator containing information for cross referencing with the fault trees where they occur.

Each event also has a longer definition providing more descriptive information about the tornado induced human failure. The longer definitions are given in Table B.5 of Appendix

B, together with the longer definitions of the tornado missile induced component failures.

The designator scheme for tornado specific human failure events is purposely kept analogous to the seismic human failure designator scheme. The purpose of the analogy is to keep parallelism between the tornado and seismic activity induced modification of the same human failure event.

The fault trees involving the selected human failure events were modified by the method briefly outlined in Section 3.4; the internal-event-related human errors were "OR-gated" with the corresponding tornado specific human errors.

The modified fault trees (systems) containing both the tornado missile induced basic events and the tornado specific human errors are presented in Appendix C. Appendix C also includes those fault trees of the internal PRA which were not affected by the tornado induced modifications. This is to provide a complete "tornado specific" logic model of the HFBR in the present study.

3.7 Assignment of Tornado Specific Human Error Probabilities

The approach developed to assign probability values to tornado specific human failure events is based on two unique conditions of the HFBR environment:

1. the rather large tornado missile fragility of equipment in the control room (conditional damage probability, D = .156, see Table 3.1), and

2. the relatively short mean arrival time $\tau \approx 1$ hour of off-duty operators after having been alarmed to provide help in accident management. Off-duty operators can be alarmed by a microwave emergency alarm system within half an hour even if the telephone lines are unavailable. (The availability of this information is one of the results of a recent seismic event related drill.)

The first condition allows us to presume that the probability of personal incapacitation (injury) of an operator to perform functions inside/outside the control room is largely coincident with the conditional tornado missile damage probability of equipment in the control room. (Essentially it is deemed even larger because humans are unquestionably more vulnerable for secondary debris, particularly for the "shrapnels" of the large control room windows than instrument racks.)

The approach is similar to that adopted in the seismic human failure probability assignment where the failure probability of the weakest block wall was used to represent the human error probability for any action required to be performed after an earthquake.

Thus, the value D = .156 was assigned to each tornado specific human failure event whose associated internal human action was deemed "required to be performed" within one hour after the tornado strike (i.e., in the time interval 0-1 hour). The selection of such internal human events was based mainly on the information provided by the operator and the original probability assignment made in the internal PRA.

During the subsequent two hours (i.e., in the time range 1-3 hours after the tornado strike) the operator performance probability was considered to be controlled largely by the product of two probabilities:

1. the probability of personal incapacitation, and

2. the average probability that the off-duty operators cannot arrive during two hours (arrival may begin at half an hour after the alarm).

By assuming an exponential probability density function for the probability of non-arrival (with parameter, $\tau \approx 1$ hour), the operator average performance probability can be estimated as .09.

This value was assigned for all tornado specific human failure events when the associated internal human action had to be performed in the 1-3 hour time interval after tornado strike. The selection of such internal human events was, as in the former case, based on information provided by the operator and the original probability assignment made in the internal PRA.

In the 3-24 hour interval after the event, the plant model considers that any off-duty operators that are presumed available will be under post-tornado stress. Under these circumstances, error rates normally ascribed to the actions of these operators are increased by a factor of 5 [Ref. 6] to reflect the added stresses that the operators may be subjected to while attempting to maintain the facility in a stable condition.

The probability values assigned to the individual tornado specific human failures are presented in Table B.5 of Appendix B, together with the tornado missile failure event (component) probabilities.

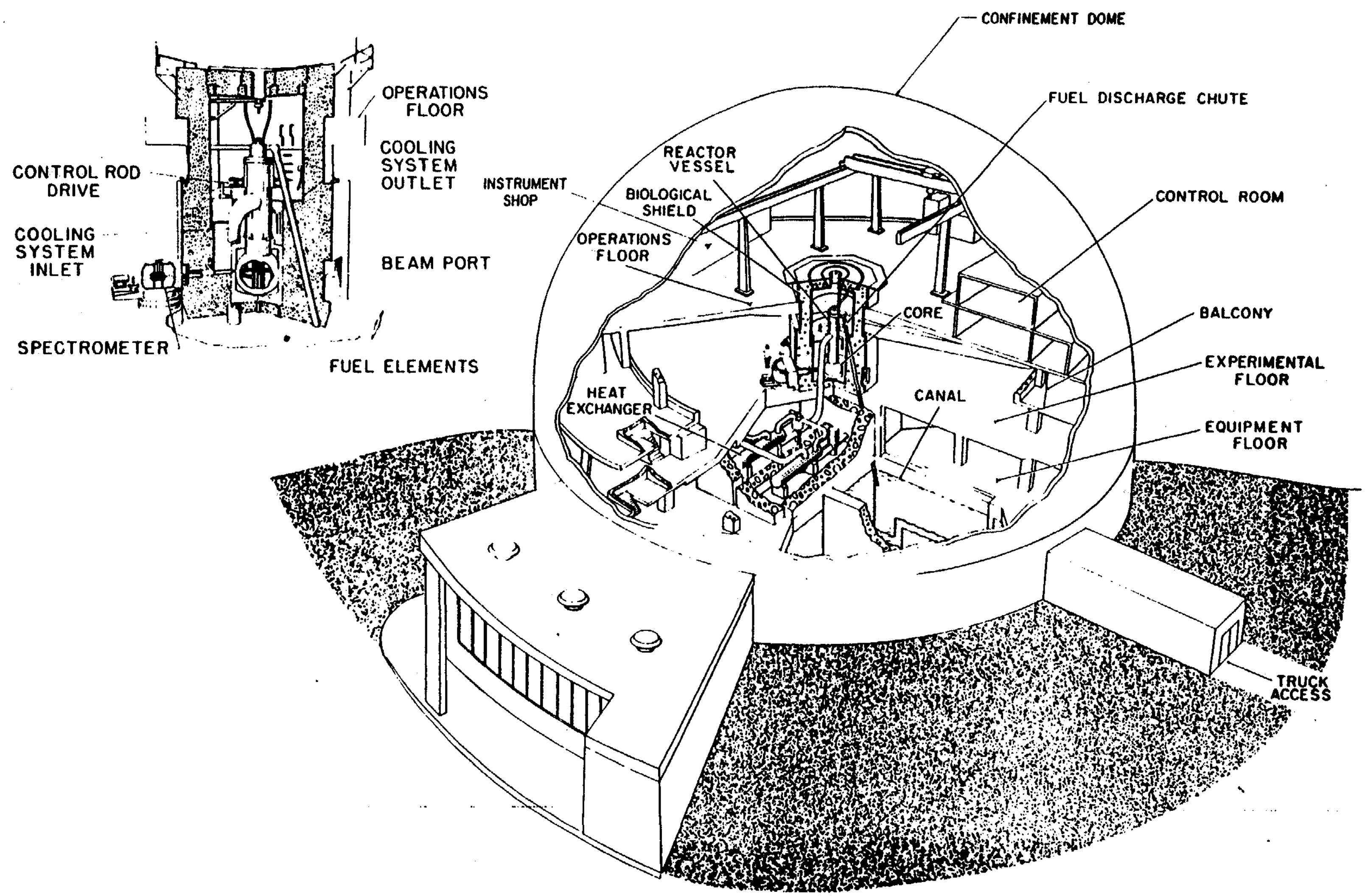

Figure 3.1 Cutaway View of the HFBR Building.

4.0 EVENT SEQUENCE DIAGRAM AND EVENT TREE FOR TORNADO INDUCED LOSS OF OFFSITE POWER INITIATOR

4.1 Event Sequence Diagram

Given a sudden tornado strike at the HFBR site this study presumes that the reactor will suffer an early scram on Loss of Offsite Power. The event will affect practically all the preferred AC power sources of the reactor before the tornado would damage further the various systems. Thus, to trace the potential sequence of events the first task is to clarify the initial conditions of the reactor systems given loss of offsite power without additional tornado damage. This can be done by using the dependency table of the plant logic model (Ref. [1]) describing the connection between the support and frontline systems of the HFBR (see Table 4.1). An inspection of the table immediately provides information about the major components of the safety systems still available just after the loss of offsite power.

For further tracing the possible scenarios as the plant response progresses the most straightforward way is to use the Event Sequence Diagram (ESD) developed in the internal PRA (Ref. [1]) for extended loss of offsite power.

For convenience the ESD is reproduced from the internal PRA (Ref. [1]) on Figures 4.1a through 4.1c. In Figure 4.1a the decision box immediately after the initiator examines if the reactor is scrammed. The next set of decision boxes examines the availability of the forced flow immediately after scram and for a period of 3 minutes. In connection with the 3 minute pony motor operation, the following note is quoted from the internal PRA: "At 60 MW operation, failure to provide forced flow for the first 3 minutes after scram results in a small amount of core damage at the core hot spots. It is estimated that about 1% of the core melts if this condition occurs. To use natural circulation (flow reversal) as a long term core-cooling process, the operators must vent the steam generated in the vessel to the off-gas system. This venting operation requires the manual alignment of some valves in the operations level. However, analysis by the HFBR staff indicates that, in this case, the resulting level of radiation on the operation level is too high to permit the required mitigation actions by the operators to assure long-term cooling of the core. Therefore, in the PRA it is assumed that a loss of forced flow during the first 3 minutes after scram leads to core damage."

The long term forced flow can only be provided by a shutdown pump fed by the propane generator (forced flow from the pony motors would not be available due to insufficient battery power, which is rated to be available only 2 - 3 hours).

There are two event transfers from the portion of the ESD on Figure 4.1a. As noted in Ref. [1], Transfer 1 (Figure 4.1b) describes a condition in which long term forced core cooling is unavailable while secondary cooling is available. The loss of forced convection requires the establishment of flow reversal, i.e., natural circulation of the primary coolant through the core to remove the decay heat. The first block on the figure inquires about the opening of the flow reversal valves. They are expected to open upon tripping of both primary and shutdown pumps. The success criteria for this function is the opening of 3 out of 4 flow reversal valves. If these valves fail to open, core damage is expected to occur. If the flow reversal valves successfully open, then heat removal from the primary coolant needs to be considered.

Steam condensing and makeup is the preferred mode of removing heat from the primary coolant. This is done by depressurizing the reactor to less than 12 psi, draining the vessel to a level below the primary or shutdown inlet, establishing the secondary flow, condensing steam in the primary or secondary cooler, and transferring the condensate back to the vessel using a D_2O transfer pump. Depressurization is a preliminary requirement for steam condensing. It is the first question asked about heat removal from the primary coolant. With the primary and shutdown pumps tripped, the automatic depressurization valve HCe-102 is expected to open automatically. This action causes a rapid depressurization of the reactor. Nevertheless, because of the subsequent high rate of steam generation in the flow reversal mode, the opening of this valve alone is not enough to maintain the vessel pressure below 12 psi. To keep the vessel pressure below 12 psi, the manual depressurization valve, P-102, or the steam vent valves, P-300 A and B (either one), must be manually opened by the operators.

With the reactor depressurized, the operators need to carry out the rest of the tasks required to successfully establish the steam condensing mode. If the steam condensing mode is not established, heat removal can be performed by releasing steam through the depressurization valves and dumping poison water into the vessel.

Transfer 2 going to Figure 4.1c describes the situation in which secondary cooling is unavailable. Forced cooling may initially be available. However, without heat removal from the primary coolant, the pumps will lose their suction head as the coolant becomes saturated and the flow reversal procedure will have to be followed. Figure 4.1c is similar to Figure 4.1b except that steam condensing is not possible due to the unavailability of the secondary cooling system.

4.2 Event Tree

The extended loss of offsite power event tree essentially translates the ESD into the space of system failure states.

Figures 4.2a and 4.2b show the event tree. The top events in the event tree are systems (or combination of system portions and operator actions) whose functions are to trip the reactor, provide forced circulation of the primary coolant, provide secondary cooling through the coolers, establish natural circulation, and provide makeup to the reactor. Table 4.2 presents the most important information about the top events: the success criteria, the associated system(s), the system's function, and the effect of loss of offsite power to the system.

The logic of the individual sequences in the event tree (i.e., the combinations of top event failures and successes) is given in Appendix D.

The event tree provides 172 sequences from which 90 result in core damage (denoted on the event tree by CD).

The quantification of the tree is discussed in the subsequent section.

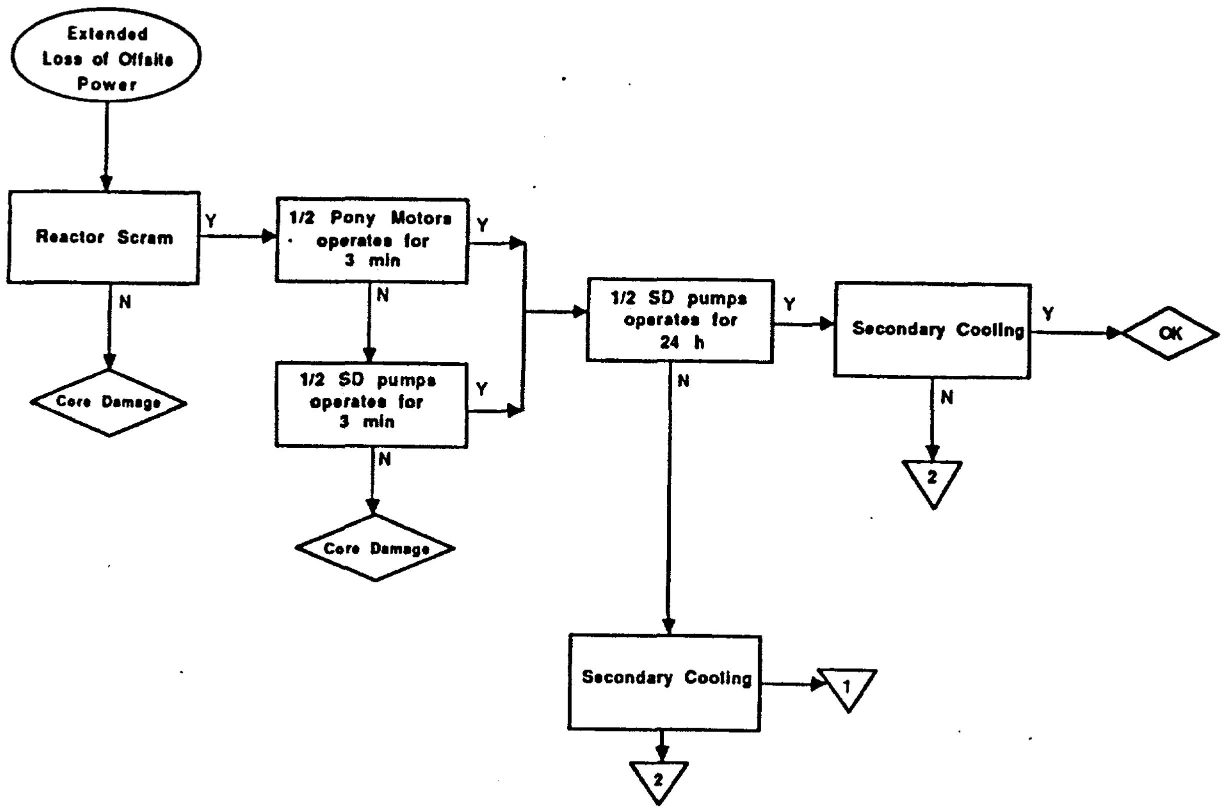

Figure 4.1a Extended Loss of Offsite Power Event Sequence Diagram.

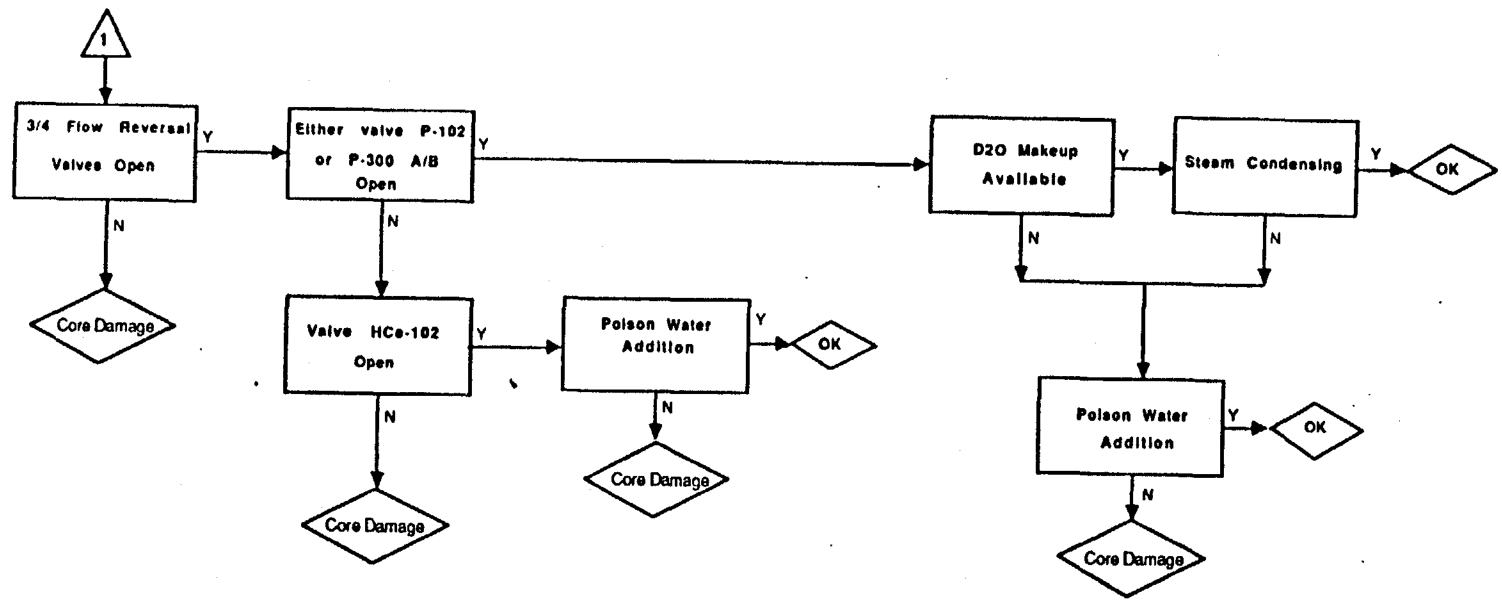

Figure 4.1b Extended Loss of Offsite Power Event Sequence Diagram.

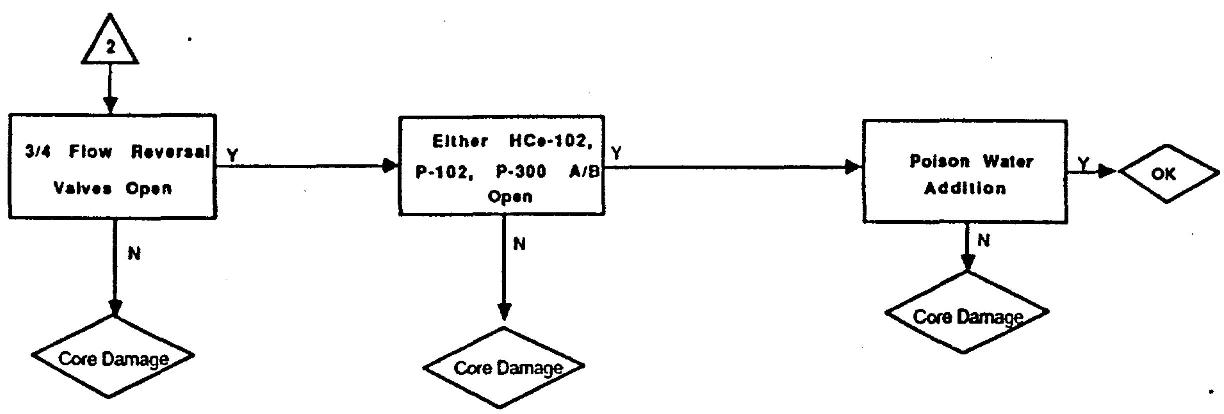

Figure 4.1c Extended Loss of Offsite Power Event Sequence Diagram.

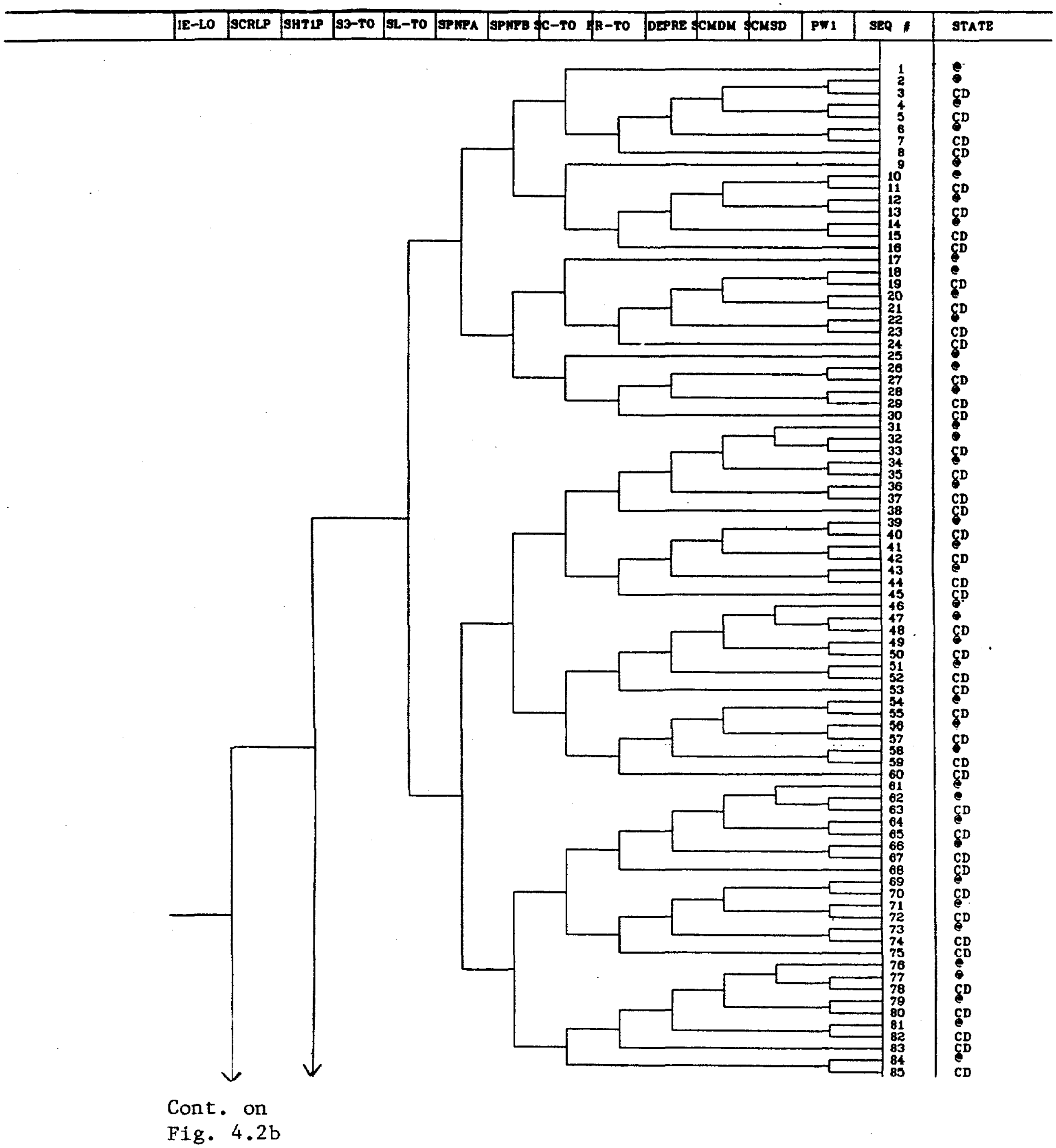

Figure 4.2a Tornado Induced Loss of Offsite Power (LOOP24) Event Tree.

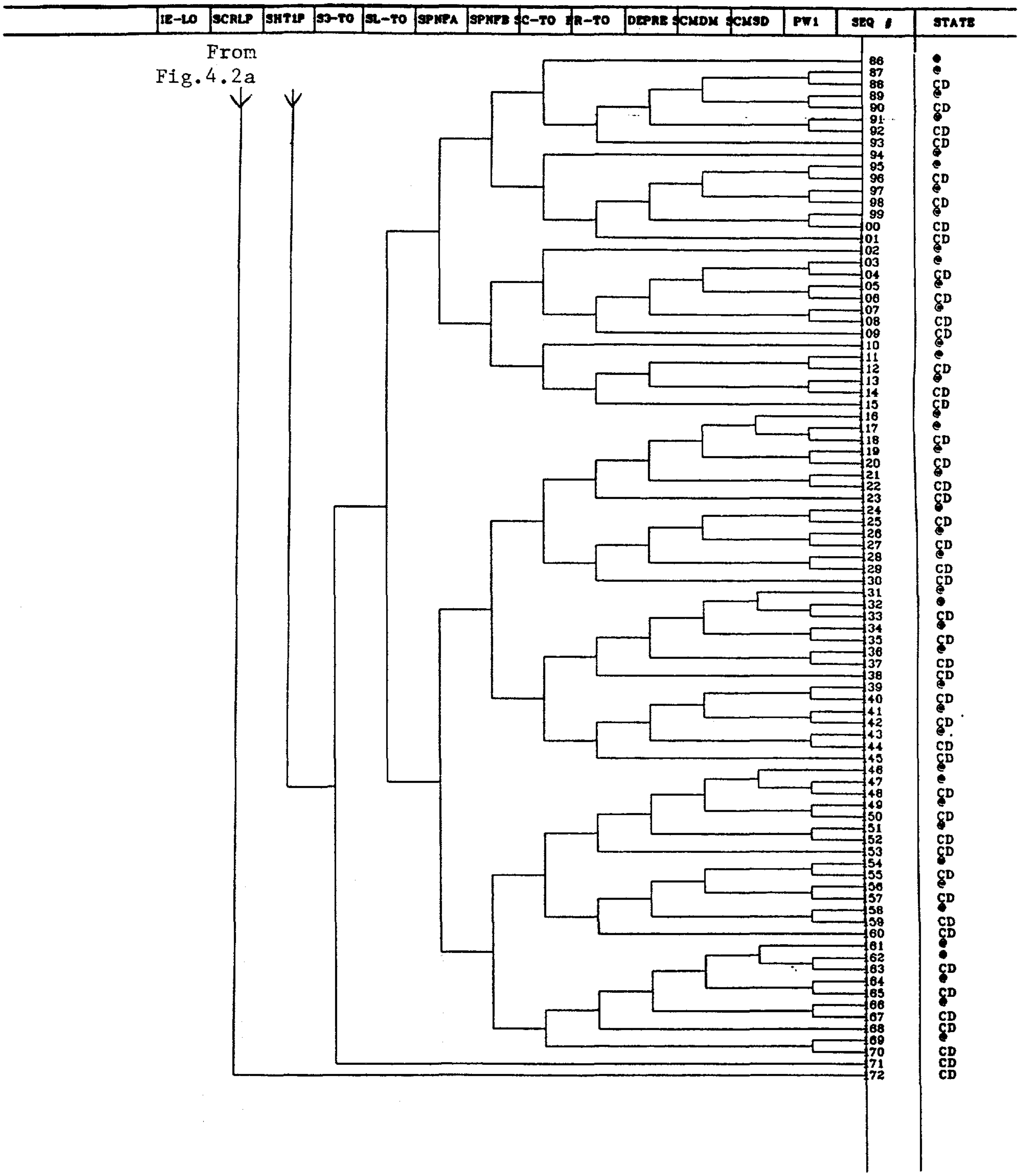

Figure 4.2b Tornado Induced Loss of Offsite Power (LOOP24) Event Tree.

Table 4.1 Frontline System and Support System Dependency Modelled in the HFBR PRA

EMCC (supported by propane generator):

- Normally Operating Compressor (GB301A assumed)
- D_2O Transfer Pump GA104C
- Running Shutdown Cooling Pump
- Steam Condensing System (remote closure of primary suction valves)

Offsite Power

All Non-EMCC AC loads
Primary motors
Fanhouse battery chargers
Secondary cooling pumps
Standby compressors (GB301B and C)
Pony motor battery chargers
MCCI :

- Poison water system (light water makeup from fuel storage canal)
- Cell doors to primary and shutdown cells
- D_2O transfer pumps GA104A and B

Fanhouse batteries

- Shutdown cooling water pump
- Closure of 2.4kV AC bkr
- Starting of secondary pumps

Compressed air system

- Steam condensing system (closure of primary suction valves)

Helium system

- D_2O transfer system (FA101 to FA102)
- Poison water system
- D_2O makeup (FA102 to vessel)

Domestic water system

- Compressor cooling
- Secondary cooling water system (supply to break tank, cross-connection tank)
- Poison water system (light water makeup)
- Propane generator cooling

Table 4.2 Definition of Top Events (Failure of Indicated System)

Top Event Designator	System Designator	System Name	System Function Characterization	Success Criteria	LOOP24 Impact
SCRLP	SS	Scram System	Reactor Shutdown - Failure Leads to Core Damage.	For LOOP: Insertion of 4 out of 8 Primary Control Rods	Auto Only
SHT1PCW	P3	Primary Cooling Water, First 3 min.	For 60 MW Operation, 3 min. of Forced Primary Flow is needed after scram. Given failure, shutdown pumps can still be used.	1 out of 2 Primary Pumps, First 3 min. Forced Flow	Only Pony Motors
S3-TOP	S3	Shutdown Cooling First 3 min.	Short Term Operation of the Shutdown Pumps if the Primary Pumps Fail.	1 out of 2 Shutdown Pumps, First 3 min.	Run on Battery or Propane Generator
SL	SL	Shutdown Cooling Long Term	Secondary Heat Removal Can Only Be Established if the Secondary Side of the Primary Coolers are available.	1 out of 2 Shutdown Pumps is Operating 24 hours	Propane Generator
SPNFA, SPNFB	SPA, SPB	Secondary Cooling with Primary Cooler A or B, Steam Condensing Mode	Secondary Cooling via Primary Cooler A or B by Gravity Feed from the Pumphouse Sump, or Cross Connection Flow from Tank FA-309.	Secondary Cooling Flow by Gravity Feed from Pumphouse Sump or X-Conn. from Tank FA-309 during 24 hours	Loss of Pumps
SC-TOP2	SC	Secondary Cooling with Shutdown Cooler	Secondary Cooling via Shutdown Cooler by Gravity Feed from Pumphouse Sump or Cross Connection Flow from Tank FA-309 or Fire Water or Domestic Water via Break-Tank.	Secondary Cooling Flow by Gravity Feed from Pumphouse Sump or X-Conn. from Tank FA-309 or Fire Water or Dom. Water during 24 hours	Loss of Pumps
FR	FR	Flow Reversal Valves	Flow Reversal is needed when no Forced Flow is Available on the Primary Side or when Secondary Cooling is Lost. Failure leads to Core Damage.	Opening 3 out of 4 Flow Reversal Valves	No Effect
DEPRESS	DS	Depressurization System	Depressurization through Valves P-102, P-300A and B (Manual Valves), as well as HCe-102 (automatic) to keep Vessel Pressure below 12 psia. Low Pressure is Required for Long Term Steam Condensing.	Opening 1 out of 4 Valves during 24 hours	No Effect

Table 4.2 Definition of Top Events (Failure of Indicated System) (cont.)

Top Event Designator	System Designator	System Name	System Function Characterization	Success Criteria	LOOP24 Impact
SCMDMU	MU	Heavy Water Makeup	Heavy Water Makeup is Required to Replace the Condensed Steam in the Coolers. Process: Draining the Coolers to Tank FA-101 and Sending the Condensate Back by a D_2O Transfer Pump or Pressurizing the Tank with Helium.	Operation of one D_2O Pump (C) or Helium Pressurization of Tank FA-101	No Normal AC
SCMSD	CS	Steam Condensing, via Shutdown Cooler	Operation of Steam Condensing Using the Shutdown Cooler. Operation Requires: Shutdown Loop Inlet Pipe to the Vessel be Drained to Ensure Free Pathway for the Steam. Secondary Flow through Shutdown Cooler should be Available.	Free Shutdown Loop Pathway for D_2O Steam and Proper Secondary Cooling	No Normal AC
PW1	PW	Poison Water and Light Water	Use Poison Water System as a Source of Light Water Makeup. Water is lost through the Manual/Automatic Depressurization Valves.	Open Valves to Dump Poison Water from Poison Water Tank. Vent Vessel Steam to the Off Gas System and Align Valves for Long Term (24 hours) Water Supply	No Normal AC

5.0 DETERMINATION OF THE CORE DAMAGE FREQUENCY

5.1 Quantification of the Tornado Induced Loss of Offsite Power Event Tree

The quantification of the Tornado Induced Loss of Offsite Power Event Tree was performed in the following steps:

In step 1, the unavailability of each top event was determined by the IRRAS code;

In step 2, a nominal conditional core damage probability value was calculated by IRRAS for each sequence leading to core damage (CD);

In step 3, the nominal sequence values were corrected by hand calculation for successful systems. The successful systems are explicitly shown in the sequence logic (Appendix D) and their success probabilities were determined simply by taking the complementary values of the unavailabilities obtained in Step 1.

(The reason for this stepwise quantification is that the IRRAS code is primarily designed to be a calculational tool for constructing/analyzing internal event PRAs where the probability of a system failure is small. Therefore, the code just uses the value "1" for the probability of a system's success, without evaluating "the success" tree. While the approximation is in order for internal event sequence quantification, it is "overly conservative" in a tornado/seismic PRA. This was found to be indeed true in the present study. It is also to be noted that the IRRAS code eliminates cutsets that are in conflict with those occurring in the successful systems; i.e., if a sequence cutset implies the cutset(s) of one (or more) successful system(s), it is eliminated.)

The unavailability and availability values of the individual top events are listed in Table E.1 of Appendix E. The unavailabilities of the individual top events expressed in terms of cutsets are also presented in Table E.2 of the same Appendix. Presentation of this type facilitates making comparisons with cutset structures of internal/seismic top events.

The sequence conditional core damage probabilities, i.e., the probability values uncorrected and corrected for successful top events, are given in Table E.3 of Appendix E. (The sequence probability truncation value was 1.0E-08.)

By using the corrected sequence probabilities, the Conditional Core Damage Probability (CCDP) for the whole event tree was obtained as:

$$(\mathrm{CCDP})_{\mathrm{LOOP24}} = .572.$$

In addition to the accident scenarios described by the event tree, the large fragilities of the control room equipment prompted us to consider the possibility that core damage would occur if, in the control room vital equipment, wiring for control and instrument were damaged or all the operators (usually three) were incapacitated. (This possibility was not included in the internal PRA. The seismic PRA, however, has considered the loss of control room as a potential cause of core damage.)

For the present study, therefore, it is simply assumed that the event "loss of control room" will occur if two pieces of vital equipment, instrumentation racks, or cable trays are damaged or all three operators become incapacitated (two operators in the control room by a common cause event, e.g., window breaks and one operator in the adjacent supervisory room) during the tornado strike (i.e., within a period of 10-20 minutes). Recalling that the tornado missile fragility of equipment and the incapacitation probability of a person in the control room area is taken to be the same, D=.156, the CCDP associated with the loss of control room is:

$$(CCDP)_{Cont.room} = 2D^2 = 4.87E\text{-}02.$$

Consequently, the total CCDP for the Tornado Induced Loss of Offsite Power initiating event, including the loss of control room, is:

$$(CCDP)_{Tot.} = (CCDP)_{LOOP24} + (CCDP)_{Cont.room} = .621.$$

This value multiplied by the initiating event frequency (see Section 2) gives the total Tornado Induced Core Damage Frequency of the HFBR:

$$(CDF)_{Tornado} = (6.37E\text{-}05) \times (6.21E\text{-}01) = 3.96E\text{-}05/year.$$

5.2 Sensitivity of $(CCDP)_{Tot.}$ for Human Failure Probability Assignment

To explore the effect of a somewhat different tornado specific human failure probability assignment than what was used to calculate the $(CCDP)_{Tot.}$, sensitivity calculations were performed. The $(CCDP)_{Tot.}$ was repeatedly calculated by the procedure described in Section 5.1 for the cases where in the plant model all tornado induced human failure probabilities throughout 24 hrs. were set equal to:

1. zero;
2. .045, half of the value assigned to the human failure probability in the time period 1-3 hours after the beginning of the tornado strike; and
3. .156, the operator incapacitation probability due to tornado missiles.

The $(CCDP)_{Tot.}$ values obtained for the corresponding cases were: .522, .652 and 1.0.

By plotting these values as a function of the associated human failure probabilities, the correlation curve shown in Figure 5.1 can be obtained.

If the $(CCDP)_{Tot.}$ value (.621) determined by the current human failure probability assignment is fitted onto the curve, an "effective" average human failure probability can be obtained. Its value is .035, and it is understood as it was "effectively" assigned to each tornado induced failure event of the plant model.

The relatively low "effective" human failure probability indicates that the current tornado specific human failure probabilities that were assigned in this analysis are reasonable. From the correlation curve one can infer also that the $(CCDP)_{Tot.}$ is not too sensitive to the moderate variation of these probability assignments. That inference is supported by the moderate values obtained for the Fussell-Vesely importance (I) and the Risk Reduction Ratio (RRR).

The Fussell-Vesely importance of the tornado specific human failures is:

$$I(Torn.Sp.H.F.)_{F-V} = \frac{CCDP(.035)_{Tot.} - CCDP(0.0)_{Tot.}}{CCDP(0.35)_{Tot.}} = \frac{.621 - .522}{.621} = .159\,,$$

and the Risk Reduction Ratio is:

$$RRR(Torn.Sp.H.F.) = \frac{CCDP(.035)_{Tot.}}{CCDP(0.0)_{Tot.}} = \frac{.621}{.522} = 1.19\,.$$

5.3 Leading Event Sequences

By reviewing the corrected sequence CCDP values in Table E.3 of Appendix E, one immediately observes that several sequences have rather high CCDPs. These leading sequences represent the major part of the total tornado induced CCDP. In spite of the fact that these sequences have rather limited statistics, they can be used to gain some valuable insights about the contribution of the systems (top events) to the tornado induced core damage frequency.

The first ten leading sequences selected from Table E.3 are reproduced in ranked order in Table 5.1 The table also indicates the sequence logic and, in addition, to facilitate easy understanding, a verbal description. Based on this limited sample of sequences, the systems (top events) can be ranked according to their weighted unavailabilities (i.e., the ratio of CCDPs summed over the sequences where the system in question occurs to the total CCDP of the sample). The ranking process resulted in the following order:

1. PW1, Poison Water System
2. SCMDMU, D_2O Makeup
3. SL-TOP, Shutdown Cooling, Long Term
4. SC-TOP2, Secondary Cooling through the Shutdown Cooler
5. DEPRESS, Depressurization

6. SHT1PCW, Primary Cooling Water System, first 3 min.
7. SPNFA/B, Secondary Cooling (Steam Condensing) through Primary Coolers A or B.

The ordering obtained can be taken as a fairly realistic representation of the systems' contributions to the tornado induced core damage frequency.

Gaining insight can be extended even deeper to the basic event (i.e., system component) level. For that purpose, the leading cutsets of each of the sequences in Table 5.1 were determined with the IRRAS Code. The cutsets are presented in tables in Appendix F; one table for each individual sequence.

It is left to the interested reader to analyze the cutsets individually in detail. Here, just for illustration, only the cutsets of sequences ranked No. 1 and No. 2 are interpreted. The cutsets of Sequence No. 1, for example, show that the sequence is caused by the concatenation of the following basic events (one from each system) shown below:

No. 1, Sequence Logic: SL-TOP*SCMDMU*PW1

System	Basic Events
SL-TOP: Shutdown Cooling - Long Term	Propane Generator Failures (Failures to Run or Maintain Load)
SCMDMU: $D_2 0$ Makeup	Tornado Missile Induced Failures of Supporting He-System's Valves Located at the OP Level - or - Operator Failure to Align He-System in Timely Fashion
PW1: Poison Water System	Tornado Missile Induced Failures of Valves in the Injection Line - or - Simultaneous Failures of the Supporting Low and High Pressure He-Systems, with Tornado Missile Induced Valve Failures in the Latter System

The cutsets of Sequence No. 2 demonstrate that this sequence is essentially the consequence of the concatenation of the following basic events (one from each system):

No. 2, Sequence Logic: SC-TOP2*SCMDMU*PW1

System	Basic Events
SC-TOP2: Secondary Cooling through the Shutdown Cooler	Tornado Missile Induced Failure of the Return Valve AOV-WR3
SCMDMU: $D_2 0$ Makeup	Tornado Missile Induced Failures of Supporting He-System's Valves Located at the OP-Level - or - Operator Failure to Align He-System's Train and Pump Train in Timely Fashion
PW1: Poison Water System	Tornado Missile Induced Failures of Valves in the Injection Line - or - Simultaneous Failures of the Supporting Low and High Pressure He-Systems, with Tornado Missile Induced Valve Failures in the Latter System

Based on the cutset analysis of the leading sequences, one arrives at the conclusion that at the component level tornado missile induced valve failures (because of their large fragilities) are the leading contributors to tornado induced core damage frequency. The result is completely different from that of the seismic PRA where the seismic valve fragilities could be taken as negligible compared to other "internal" valve failures.

Table 5.1 Leading Tornado Induced Event Sequences

Rank No.	Event Tree No.	Sequence CCDF, Corrected	Sequence Logic (Only Failed Systems)	Description
1	35	1.425E-01	SL-TOP*SCMDMU*PW1	Failure of the Shutdown Cooling - Long Term in Conjunction with Failures of the D_2O Makeup and Poison Water Systems
2	5	8.974E-02	SC-TOP2*SCMDMU*PW1	Failure of the Secondary Cooling through the Shutdown Cooler in Conjunction with Failures of the D_2O Makeup and Poison Water Systems
3	7	4.470E-02	SC-TOP2*DEPRESS*PW1	Failure of the Secondary Cooling through the Shutdown Cooler in Conjunction with Failures of the Depressurization and Poison Water Systems
4	37	4.042E-02	SL-TOP*DEPRESS*PW1	Failure of the Shutdown Cooling - Long Term in Conjunction with Failures of the Depressurization and Poison Water Systems
5	42	3.095E-02	SL-TOP*SC-TOP2* SCMDMU*PW1	Failures of the Shutdown Cooling - Long Term and Secondary Cooling through the Shutdown Cooler in Conjunction with Failures of the D_2O Makeup and Poison Water Systems
6	120	2.992E-02	SHT1PCW*SCMDMU*PW1	Failure of the Primary Cooling Water System in the First 3 minutes in Conjunction with the Failures of the D_2O Makeup and Poison Water Systems
7	3	2.271E-02	SC-TOP2*PW1	Failure of the Secondary Cooling through the Shutdown Cooler in Conjunction with the Failure of the Poison Water System
8	90	1.760E-02	SHT1PCW*SC-TOP2* SCMDMU*PW1	Failure of the Primary Cooling Water System in the First 3 minutes together with the Failures of Secondary Cooling through the Shutdown Cooler, the D_2O Makeup and the Poison Water System
9	50	1.692E-02	SL-TOP*SPNFB* SCMDMU*PW1	Failures of the Long Term Shutdown Cooling and the Secondary Cooling (Steam Condensing) through Primary Cooler B in Conjunction with the Failures of the D_2O Makeup and the Poison Water Systems
10	65	1.692E-02	SL-TOP*SPNFA* SCMDMU*PW1	Failures of the Long Term Shutdown Cooling and the Secondary Cooling (Steam Condensing) through Primary Cooler A in Conjunction with the Failures of the D_2O Makeup and Poison Water Systems

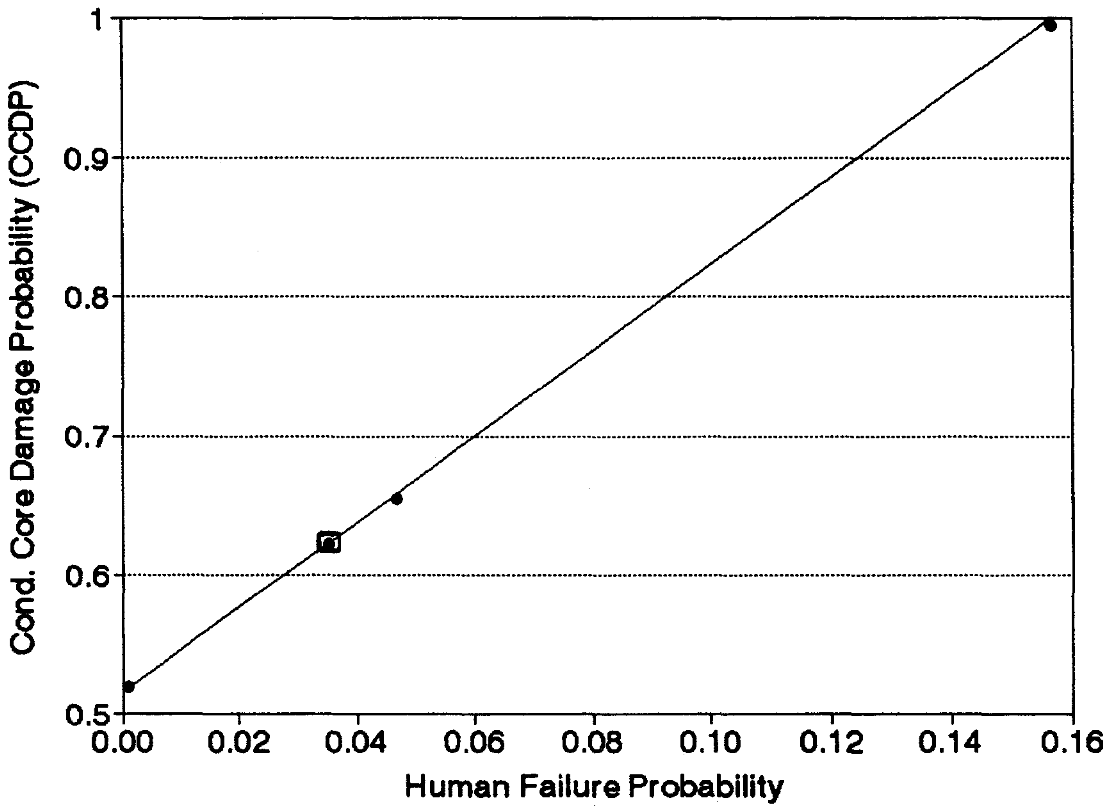

Figure 5.1 Correlation Curve Between CCDP and Human Failure Probability.

6.0 CONCLUSIONS

The results of the tornado risk analysis performed on the HFBR facility are summarized in this section. Conclusions are drawn and some suggestions to reduce the tornado induced core damage frequency are offered.

To develop a tornado specific plant logic model, the tornado hazard frequency and the structural and component equipment data of Ref. [4] were used as basic input data. To keep modeling/calculational complexity as simple as reasonable a "bounding" type (slightly conservative) approach was applied. By a thorough screening process a single dominant initiating event was selected as a representative initiating event. The representative initiating event is defined as: "Tornado Induced Loss of Offsite Power." The frequency of the initiator was determined to be: 6.37E-5/year. The safety response of the facility for this initiating event resulted in a total Conditional Core Damage Probability = .621. Thus, the HFBR's Tornado Induced Core Damage Frequency was found to be:

$$(\mathrm{CDF})_{\mathrm{Tornado}} = 3.96\mathrm{E}\text{-}5/\mathrm{year}.$$

The value is a "point estimate." Its uncertainty might be determined later.

For comparison, the CDF values obtained earlier for the internal initiating events as well as for other external initiators are given below:

Type of Initiating Event	CDF (1/year)
Internal	5.10E-4
Seismic	3.84E-4
Fire	4.01E-5
Flood	1.40E-6

The comparison shows that the tornado induced CDF is only 7.8% of the internal CDF and it is practically the same as the CDF due to fire.

Sensitivity calculations were performed to investigate the effects of changes in the tornado induced human failure probability assignments on the overall results. These calculations showed only moderate $(\mathrm{CDF})_{\mathrm{Tornado}}$ sensitivity to changes in human failure probability (the Fussell-Vesely importance of the tornado specific human failures is $I(Torn.Sp.H.F.)_{F\text{-}V} = .159$), which indicated that the $(\mathrm{CDF})_{\mathrm{Tornado}}$ is dominated by hardware failure.

The systems contributing most to $(CDF)_{Tornado}$ could be ranked as follows:

1. Poison Water; 2. D_2O Makeup; 3. Shutdown Cooling, Long Term;
4. Secondary Cooling through the Shutdown Cooler; 5. Depressurization.

This order can be explained mainly by the fact that many components of these systems (particularly valves) are located at the operation level and are exposed to tornado missile damages and that the operator action failures are also related to the difficulties lining up these systems appropriately and in a timely fashion.

7.0 REFERENCES

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3. Ho, V.S. and Johnson, D.H., "Risk Analysis of Environmental Hazards at the High Flux Beam Reactor," January 1993.

4. Park, Y.J., "Wind/Tornado Hazards and the Fragility of Structures and Components of the HFBR," March 1993.

5. Russell, K., et al., "Integrated Reliability and Risk Analysis System (IRRAS), Version 2.6," NUREG/CR-5300, February 1991.

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APPENDIX A

Initiating Event Categorization

Potential Tornado Induced Initiating Events, Encompassed by the Tornado Induced (LOOP24) Initiator, are Marked with an Asterisk

Table A-1 Initiating Event Categorization

T1: Initiating events with no impact on frontline or support systems. Shutdown mechanism is manual scram or setback.

High in-vessel noise
Failure of experimental system components
Experimental cooler leak
Experimental system leakage
Stack sample causes forced shutdown
* <u>Secondary cooling water system leakage</u>
* <u>Loss of cooling tower fans</u>
Contaminated helium supply
High cover gas pressure causes forced shutdown
Loss of CO_2 supply
Contaminated CO_2
Purification system problem caused forced shutdown
Excessive leak of drain valve in D_2O drain and transfer system
CRD (Control Rod Drive) seal leakage causes forced shutdown
Spurious rod insertion causes forced shutdown
* <u>Loss of confinement causes forced shutdown</u>
Loss of air conditioning causes forced shutdown
Experiment problems cause forced shutdown
Fuel element failure causes forced shutdown
* <u>Scram due to plant occurrences</u>
Out of specification chemistry causes forced shutdown
Spurious fire alarm or trip of fire suppression system causes forced shutdown
* <u>Building ventilation problems cause forced shutdown</u>
Detected fault in PPS (Plant Protection System) causes forced shutdown
Scheduled manual scram
Failures of components in thermal shield and biological shield systems
Reduced flow in thermal shield and biological shield systems causes forced shutdown
Thermal shield and biological shield systems leakage large enough to cause forced shutdown
CNF (Cold Neutron Facility) problem causes forced shutdown
* <u>Momentary loss of commercial offsite power (less than 3 seconds)</u>
Failure of any other instrumentation causes spurious shutdown

T2: Initiating events with impact on one primary pump. Shutdown mechanism is manual scram.

Single primary cooler leak
Single primary pump bearing problem

Table A-1 (continued)

T3: Initiating events with impact on both shutdown pumps. Shutdown mechanism is manual scram or setback.

Shutdown cooler leak
Loss of running and standby shutdown pumps

T4: Initiating events causing total loss of makeup (excluding makeup through helium pressurization of the tanks). Shutdown mechanism is mainly manual scram even though it can result in auto scram.

* <u>Failure of D_2O transfer pumps</u>

T5: Initiating events causing core depressurization through HCe-102 with impact on two primary and two shutdown pumps. Shutdown mechanism is auto scram.

Spurious low-low level logic signal, tripped pumps can't start, pony motors

T6: Initiating events with impact on two primary pumps. Shutdown mechanism is auto scram.

Spurious low-low pressure logic signal
Inadvertent depressurization due to valve openings
Low cover gas pressure caused by pressure controller
Loss of helium supply
Cover gas leakage causes forced shutdown
* <u>Trip of both primary pumps</u>

T7: Initiating events with loss of one cooler (loss of primary cooler A is assumed). Shutdown mechanism is setback or manual scram.

* <u>Trip of one secondary water pump</u>
Inadvertent closure of a cooler valve

T8: Initiating event with loss of secondary cooling to both primary coolers. Shutdown mechanisms are manual scram, setback, and auto scram.

Trip of both running secondary pumps
Inadvertent closure of both primary cooler valves
Rupture in secondary cooling pipes (loss of all pumps and gravity feed capability)

Table A-1 (continued)

T9: Initiating events with mild reactivity transients and no impact on frontline/support system. Shutdown mechanism is auto scram.

Insertion of over-reactive sample causes high flux
Rod withdrawal at power causes high flux
Increasing secondary water flow during startup or at power causes high flux

T10: Initiating events with total loss of one primary loop (both for flow and cooling purposes). Shutdown mechanism is auto scram.

* <u>Inadvertent closure of one primary control valve</u>
  Inadvertent closure of one primary suction valve
  One primary pump seizure
* <u>Trip of one primary pump</u> (this is not as severe as the other initiators in this category)

T11: Initiating events with total loss of both primary loops. Shutdown mechanism is auto scram.

* <u>Inadvertent closure of both primary control valves</u>
  Inadvertent closure of both primary suction valves

T12: Initiating events with loss of both pony motors. Shutdown mechanism is auto scram.

Loss of both pony motors

T13: Initiating events with loss of compressed air system. Shutdown mechanism is auto scram.

* <u>Loss of compressed air</u>

T14: Initiating events with loss of 250V dc power. Shutdown mechanism is auto scram.

* <u>Loss of 250V dc power</u>

Table A-1 (continued)

<u>LOOP</u>: Initiating events caused by loss of offsite power. The shutdown mechanism is auto scram. The impact of frontline/support system depends on the duration of the loss of offsite power.

* <u>Loss of offsite power greater than 3 seconds and less than 2 hours (LOOP2)</u>
* <u>Loss of offsite power greater than 2 hours and less than 6 hours (LOOP6)</u>
* <u>Loss of offsite power greater than 6 hours (LOOP24)</u>

Large LOCA: Initiating events caused by a pipe break of a size greater than 0.81". This results in loss of both shutdown and primary pumps (including pony motors) within 3 minutes after scram. The shutdown mechanism is auto scram (low pressure, low level).

Medium LOCA: Initiating events caused by a pipe break of a size between 0.57" to 0.81". This results in loss of shutdown pumps and primary pump main motors within 3 minutes after scram. The shutdown mechanism is auto scram (low pressure, low level).

Small LOCA: Initiating events caused by a pipe break of a size smaller than 0.57". This size break allows the operation of both primary and shutdown pumps for at least 3 minutes after scram. The shutdown mechanism is auto scram (low pressure, low level). Note that the primary and shutdown cooler tube rupture are included in this category.

Beam Tube Rupture: The small leaks in beam tubes are treated like transients with manual scram (T1). The guillotine or large size break of beam tubes are treated under this category which directly leads to core damage. Shutdown mechanism is auto scram on low pressure or low level.

APPENDIX B

Basic Event Data Tables

B.1 List of Basic Events Used in the Internal PRA

B.2 List of Human Error Basic Events

B.3 Internal PRA Basic Events Affected by Tornado Induced Failures and the Fault Trees (Systems) Where They Appear

B.4 Internal PRA Human Errors that are Affected by a Tornado Event and the Fault Trees (Systems) Where They Appear

B.5 Definitions and Probabilities for Tornado Induced Failures and Human Errors

Appendix B.1
List of Basic Events Used in the Internal PRA

Table B.1

BASIC EVENTS SUMMARY REPORT (Alphabetical Sort)

Family: HFBR-PRA

Event Number	Basic Event Designator	System Code	Generic Comp. Type	Component ID	Fail. Mode	Component Location	Basic Event Description
1	ACPBUSBTFANBUSFH	ACP	BUS	BTFAN	BUS	FH	Beta Factor for Fanhouse Buses
2	ACPBUSBTHFBBUSEQ	ACP	BUS	BTHFB	BUS	EQ	Beta Factor for HFBR Buses
3	ACPBUSBTO12BUSEQ	ACP	BUS	BTO12	BUS	EQ	Beta Factor for Failure of MCC1 and 2
4	ACPBUSEMCC-BUSEQ	ACP	BUS	EMCC-	BUS	EQ	EMCC Bus Failure
5	ACPBUSEXPB-BUSEQ	ACP	BUS	EXPB-	BUS	EQ	Experimental Bus failure
6	ACPBUSFACB-BUSEQ	ACP	BUS	FACB-	BUS	EQ	Facility Bus Failure
7	ACPBUSFAN12BUSFH	ACP	BUS	FAN12	BUS	FH	Random Failure of Fan House Buses
8	ACPBUSFANH1BUSFH	ACP	BUS	FANH1	BUS	FH	Fanhouse Bus # 1 Failure
9	ACPBUSFANH2BUSFH	ACP	BUS	FANH2	BUS	FH	Fanhouse Bus # 2 Failure
10	ACPBUSFH480BUSFH	ACP	BUS	FH480	BUS	FH	480v Fanhouse Bus Failure
11	ACPBUSHFBR-BUSEQ	ACP	BUS	HFBR-	BUS	EQ	Random Failure of HFBR Bus
12	ACPBUSHFBR1BUSEQ	ACP	BUS	HFBR1	BUS	EQ	HFBR Bus # 1 Failure
13	ACPBUSHFBR2BUSEQ	ACP	BUS	HFBR2	BUS	EQ	HFBR Bus #2 Failure
14	ACPBUSMCC1-BUSEQ	ACP	BUS	MCC1-	BUS	EQ	Failure of MCC1
15	ACPBUSMCC12BUSEQ	ACP	BUS	MCC12	BUS	EQ	Random Failure of MCC1 or 2
16	ACPBUSMCC2-BUSOP	ACP	BUS	MCC2-	BUS	OP	Failure of MCC2
17	ACPBUSPH24-BUSPH	ACP	BUS	PH24-	BUS	PH	Pump House 2.4kv ac Bus Failure
18	ACPBUSRBSB-BUSEQ	ACP	BUS	RBSB-	BUS	EQ	Reactor and Building Services Bus Failure
19	ACPCBHBTHIFSOZFH	ACP	CBH	BTHIF	SOZ	FH	Beta Factor of FH Bus #i to HFBR Bus #i BKR(@FH)
20	ACPCBHBTHIHSOZEQ	ACP	CBH	BTHIH	SOZ	EQ	Beta Factor of FH Bus #i to HFBR Bus #i BKR (@HFBR)
21	ACPCBHBTXFRSOZEQ	ACP	CBH	BTXFR	SOZ	EQ	Beta Factor for Supply BKRs of XMFR 1 and 2
22	ACPCBHEMCC-SOZEQ	ACP	CBH	EMCC-	SOZ	EQ	EMCC Control Power BKR(dc)
23	ACPCBHFH24-SOZFH	ACP	CBH	FH24-	SOZ	FH	Supply Breaker to Pump House 2.4kv Bus Fails Open
24	ACPCBHFHB12SOZFH	ACP	CBH	FHB12	SOZ	FH	Fanhouse Bus #1 to Bus #2 Tie BKR Fails Open
25	ACPCBHFHH1FSOZFH	ACP	CBH	FHH1F	SOZ	FH	FH Bus # 1 to HFBR Bus #1 BKR Fails Open (@ FH)
26	ACPCBHFHH1HSOZEQ	ACP	CBH	FHH1H	SOZ	EQ	Fanhouse Bus #1 to HFBR Bus #1 BKR Fails Open (at HFBR)
27	ACPCBHFHH2FSOZFH	ACP	CBH	FHH2F	SOZ	FH	Fanhouse Bus #2 to HFBR Bus #2 BKR Fails Open (at FH)
28	ACPCBHFHH2HSOZEQ	ACP	CBH	FHH2H	SOZ	EQ	Fanhouse Bus #2 to HFBR Bus #2 BKR Fails Open(at HFBR)
29	ACPCBHFHHIFSOZFH	ACP	CBH	FHHIF	SOZ	FH	Random Failure of FH Bus #i to HFBR Bus #i BKR(@FH)
30	ACPCBHFHHIHSOZEQ	ACP	CBH	FHHIH	SOZ	EQ	Random Failure of FH Bus #i to HFBR Bus #i BKR(@HFBR)
31	ACPCBHHFBRTFTCEQ	ACP	CBH	HFBRT	FTC	EQ	HFBR Bus #1 to Bus #2 Tie BKR Can't Close
32	ACPCBHHFBRTHEPEQ	ACP	CBH	HFBRT	HEP	EQ	Shift Doesn't Shut HFBR Bus #2 to Bus #1 Tie BKR
33	ACPCBHXMFR-SOZEQ	ACP	CBH	XMFR-	SOZ	EQ	Random Failure of Supply BKR for XMFR 1 or 2
34	ACPCBHXMFR1SOZEQ	ACP	CBH	XMFR1	SOZ	EQ	#1 XMFR Supply BKR Fails Open
35	ACPCBHXMFR1SOZFH	ACP	CBH	XMFR1	SOZ	FH	#1 13.8/2.4 kv XMFR Output BKR FAils Open
36	ACPCBHXMFR2FTCFH	ACP	CBH	XMFR2	FTC	FH	#2 13.8/2.4 kv XMFR BKR Can't Close
37	ACPCBHXMFR2SOZEQ	ACP	CBH	XMFR2	SOZ	EQ	#2 XMFR Supply BKR Fails Open
38	ACPCBHXMFR3FTCEQ	ACP	CBH	XMFR3	FTC	EQ	#3 XMFR Supply BKR Won't Close
39	ACPCBL480VBSOZFH	ACP	CBL	480VB	SOZ	FH	On-Line Charger AC Input BKR Fails
40	ACPCBL480VSFTCFH	ACP	CBL	480VS	FTC	FH	Off-line Charger AC Input BKR Fails to Close
41	ACPCBLBTMCCSOZEQ	ACP	CBL	BTMCC	SOZ	EQ	Beta Factor for Supply BKRs for MCC1 and 2
42	ACPCBLBTXFRSOZEQ	ACP	CBL	BTXFR	SOZ	EQ	Beta Factor for Output BKRs of XMFR 1 and 2

Table B.1 (continued)

BASIC EVENTS SUMMARY REPORT (Alphabetical Sort)

Family: HFBR-PRA

Event Number	Basic Event Designator	System Code	Generic Comp. Type	Component ID	Fail. Mode	Component Location	Basic Event Description
43	ACPCBLEMCCSSOZEQ	ACP	CBL	EMCCS	SOZ	EQ	EMCC Supplu BKR Fails Open
44	ACPCBLFBEBTSOZEQ	ACP	CBL	FBEBT	SOZ	EQ	Facility Bus to Exp. Bus Tie BKR Fails Open
45	ACPCBLG104ASOZEQ	ACP	CBL	G104A	SOZ	EQ	Pump GA104a Breaker Fails Open
46	ACPCBLG104BSOZEQ	ACP	CBL	G104B	SOZ	EQ	Pump GA104b Breaker Fails Open
47	ACPCBLG104CSOZEQ	ACP	CBL	G104C	SOZ	EQ	Pump GB104C Breaker Fails Open
48	ACPCBLG301CFTCEQ	ACP	CBL	G301C	FTC	EQ	Starter Disconnect Switch Fails to Shut
49	ACPCBLMCC1-SOZEQ	ACP	CBL	MCC1-	SOZ	EQ	MCC #1 Supply BKR Fails Open
50	ACPCBLMCC12SOZEQ	ACP	CBL	MCC12	SOZ	EQ	Random Failure of supply BKR for MCC1 or 2
51	ACPCBLMCC2-SOZEQ	ACP	CBL	MCC2-	SOZ	EQ	MCC #2 Supply BKR FAils Open
52	ACPCBLOFFCHFTCFH	ACP	CBL	OFFCH	FTC	FH	Offline Charger 44v AC Supply BKR Fails Open
53	ACPCBLOLCHGSOZFH	ACP	CBL	OLCHG	SOZ	FH	Online Charger 480vac Supply BKR Fails Open
54	ACPCBLPRPGNSOZEQ	ACP	CBL	PRPGN	SOZ	EQ	Generator Output BKR Fails Open
55	ACPCBLRBSETFTCEQ	ACP	CBL	RBSET	FTC	EQ	Exp. Bus to R&BS Bus Tie BKR Can't Close
56	ACPCBLRBSETHEPEQ	ACP	CBL	RBSET	HEP	EQ	Shift Doesn't Shut Exp. Bus to R&BS Bus Tie BKR
57	ACPCBLRUNCPSOZEQ	ACP	CBL	RUNCP	SOZ	EQ	RUN Compressor BKR on EMCC FAils
58	ACPCBLRUNDSSOZEQ	ACP	CBL	RUNDS	SOZ	EQ	Local Disconnect Switch Fails
59	ACPCBLSTBDSSOZEQ	ACP	CBL	STBDS	SOZ	EQ	Loca Disconnect Switch Fails
60	ACPCBLSTBYASOZEQ	ACP	CBL	STBYA	SOZ	EQ	Standby A/C BKR on MCC#1 Fails Open
61	ACPCBLSTY_CSOZEQ	ACP	CBL	STY_C	SOZ	EQ	STBY/GB301C Switch Fails
62	ACPCBLXMFR-SOZEQ	ACP	CBL	XMFR-	SOZ	EQ	Random Failure of Output BKR for XMFR 1 or 2
63	ACPCBLXMFR1SOZEQ	ACP	CBL	XMFR1	SOZ	EQ	#1 XMFR Output BKR Fails Open
64	ACPCBLXMFR1SOZFH	ACP	CBL	XMFR1	SOZ	FH	#1 13.8/2.4/480v XMFR 480v Output BKR Fails Open
65	ACPCBLXMFR2SOZEQ	ACP	CBL	XMFR2	SOZ	EQ	#2 XMFR Output BKR Fails Open
66	ACPCBLXMFR3FTCEQ	ACP	CBL	XMFR3	FTC	EQ	#3 XMFR Output BKR Won't Close
67	ACPEPGPRPGNFDOEQ	ACP	EPG	PRPGN	FDO	EQ	Propane Generator Fails to Maintain Load
68	ACPEPGPRPGNOPFEQ	ACP	EPG	PRPGN	OPF	EQ	Propane Generator Fails to Start
69	ACPEPGPRPGNVTMEQ	ACP	EPG	PRPGN	VTM	EQ	Propane Generator Unavailable due to Test or Maintenance
70	ACPSTAG301CFDOEQ	ACP	STA	G301C	FDO	EQ	G301C Starter Fails
71	ACPSTARUNSTFDOEQ	ACP	STA	RUNST	FDO	EQ	RUN Compressor Starter Fails
72	ACPSTASTBSTFDOEQ	ACP	STA	STBST	FDO	EQ	STBR Compressor Starter Fails
73	ACPTFHXMFR1FDOFH	ACP	TFH	XMFR1	FDO	FH	#1 13.8/2.4 kv XMFR Fails
74	ACPTFHXMFR2FDOFH	ACP	TFH	XMFR2	FDO	FH	13.8/2.4/480v XMFR #2 Fails
75	ACPTFHXMFR2HEPFH	ACP	TFH	XMFR2	HEP	FH	Shift Doesn't Place #2 13.8/2.4 kv XMFR Online
76	ACPTFHXMFR2UTMFH	ACP	TFH	XMFR2	UTM	FH	13.8/2.4 XMFR #2 Not Available
77	ACPTFLBTO12FDOEQ	ACP	TFL	BTO12	FDO	EQ	Beta Factor for Failure of XMFR 1 and 2
78	ACPTFLXMFR-FDOEQ	ACP	TFL	XMFR-	FDO	EQ	Random Failure of XMFR 1 or 2
79	ACPTFLXMFR1FDOEQ	ACP	TFL	XMFR1	FDO	EQ	2.4/480v XMFR #1 Fails
80	ACPTFLXMFR2FDOEQ	ACP	TFL	XMFR2	FDO	EQ	2.4kv/480v XMFR #2 Fails
81	ACPTFLXMFR3FDOEQ	ACP	TFL	XMFR3	FDO	EQ	#3 2.4kv/480v XMFR Fails
82	ACPTFLXMFR3HEPEQ	ACP	TFL	XMFR3	HEP	EQ	Shift Doesn't Place #3 2.4kv/480v XMFR Online
83	ACPTFSEMERGOPFEQ	ACP	TFS	EMERG	OPF	EQ	EMCC XFR SW. Fails to Shift to "EMERG"
84	ACPTFSNORM-TSOEQ	ACP	TFS	NORM-	TSO	EQ	EMCC XFR Switch Fails in "NORMAL"

Table B.1 (continued)

BASIC EVENTS SUMMARY REPORT (Alphabetical Sort)

Family: HFBR-PRA

Event Number	Basic Event Designator	System Code	Generic Comp. Type	Component ID	Fail. Mode	Component Location	Basic Event Description
85	ACPTFSNRMEGTSOEQ	ACP	TFS	NRMEG	TSO	EQ	EMCC XFR SW in "NORMAL" and "EMERG" Position(CCF)
86	AIRACCARECVILKEQ	AIR	ACC	ARECV	ILK	EQ	Air Receiver Fails
87	AIRCBL-HB48FDOOP	AIR	CBL	-HB48	FDO	OP	circuit bkr hb48 fails open
88	AIRCBLHB48EFDOEQ	AIR	CBL	HB48E	FDO	EQ	circuit bkr hb48 on emcc fails open
89	AIRCPSG301CFDOEQ	AIR	CPS	G301C	FDO	EQ	Air Compressor GB301C Fails to Continue to Run
90	AIRCPSG301CHEPEQ	AIR	CPS	G301C	HEP	EQ	GB301C Not Started by Shift
91	AIRCPSG301COPFEQ	AIR	CPS	G301C	OPF	EQ	GB301C Fails to Start
92	AIRCPSG301CUTMEQ	AIR	CPS	G301C	UTM	EQ	G301C Down for Maintenace
93	AIRCPSRUNC-FDOEQ	AIR	CPS	RUNC-	FDO	EQ	RUN Compressor Fails
94	AIRCPSSTBYCFDOEQ	AIR	CPS	STBYC	FDO	EQ	Standby Compressor Fails to Continue to Run
95	AIRCPSSTBYCOPFEQ	AIR	CPS	STBYC	OPF	EQ	Standby Compressor Fails to Start
96	AIRCPSSTBYCUTMEQ	AIR	CPS	STBYC	UTM	EQ	Standby Compressor Down for Maintenance
97	AIRCPSSTBYYHEPEQ	AIR	CPS	STBYY	HEP	EQ	Operator Doesn't Place "STBY" Compressor to "RUN"
98	AIRDRYDRYERFDOEQ	AIR	DRY	DRYER	FDO	EQ	Dryer Failure
99	AIRFTRAFILTSPZEQ	AIR	FTR	AFILT	SPZ	EQ	Filter A Clogged
100	AIRFTRBFILTSPZEQ	AIR	FTR	BFILT	SPZ	EQ	Filter B Clogged
101	AIRFTROTFLTSPZEQ	AIR	FTR	OTFLT	SPZ	EQ	Outlet Filter Clogged
102	AIRFTRPARTFSPZEQ	AIR	FTR	PARTF	SPZ	EQ	Particulate Filter Clogged
103	AIRFTRRUNFLSPZEQ	AIR	FTR	RUNFL	SPZ	EQ	1 of 3 Filters Clogged
104	AIRFTRSTBFLSPZEQ	AIR	FTR	STBFL	SPZ	EQ	1 of 3 Filters Clogged
105	AIRHXZE302XHEPEQ	AIR	HXZ	E302X	HEP	EQ	Aftercooler Clogged
106	AIRMNVAR100SCZEQ	AIR	MNV	AR100	SCZ	EQ	Manual Valve AR100 Fails Shut
107	AIRMNVAR101FTOEQ	AIR	MNV	AR101	FTO	EQ	Manual Valve AR101 Fails to Operate
108	AIRMNVAR101HEPEQ	AIR	MNV	AR101	HEP	EQ	Operator Fails to Open Manual Valve AR101
109	AIRMNVAR102SCZEQ	AIR	MNV	AR102	SCZ	EQ	Manual Valve AR102 Fails Shut
110	AIRMNVAR103SCZEQ	AIR	MNV	AR103	SCZ	EQ	Manual Valve AR103 Fails Shut
111	AIRMNVAR104FTOEQ	AIR	MNV	AR104	FTO	EQ	Manual Valve AR104 Fails to Operate
112	AIRMNVAR104HEPEQ	AIR	MNV	AR104	HEP	EQ	Operator Fails to Open AR104
113	AIRMNVAR11-SCZEQ	AIR	MNV	AR11-	SCZ	EQ	Manual Valve AR11 Fails Shut
114	AIRMNVAR13-SCZEQ	AIR	MNV	AR13-	SCZ	EQ	Manual Valve AR13 Fails Shut
115	AIRMNVAR14-HEPEQ	AIR	MNV	AR14-	HEP	EQ	Manual Valve AR14 Left Closed
116	AIRMNVAR14-SCZEQ	AIR	MNV	AR14-	SCZ	EQ	Manual Valve AR14 Fails Shut
117	AIRMNVAR14AHEPEQ	AIR	MNV	AR14A	HEP	EQ	Manual Valve AR14A Left Closed
118	AIRMNVAR14ASCZEQ	AIR	MNV	AR14A	SCZ	EQ	Manual Valve AR14A Fails Shut
119	AIRMNVAR15-SCZEQ	AIR	MNV	AR15-	SCZ	EQ	Manual Valve AR15 Fails Shut
120	AIRMNVAR15ASCZEQ	AIR	MNV	AR15A	SCZ	EQ	Manual Valve AR15A Fails Shut
121	AIRMNVAR16-SCZEQ	AIR	MNV	AR16-	SCZ	EQ	Manual Valve AR16 Fails Shut
122	AIRMNVAR17-FTOEQ	AIR	MNV	AR17-	FTO	EQ	Manual Valve AR17 Fails to Operate
123	AIRMNVAR17-HEPEQ	AIR	MNV	AR17-	HEP	EQ	Operator Fails to Open AR17
124	AIRMNVAR18-SCZEQ	AIR	MNV	AR18-	SCZ	EQ	Manual Valve AR18 Fails Shut
125	AIRMNVAR19-SCZEQ	AIR	MNV	AR19-	SCZ	EQ	Manual Valve AR19 Fails Shut
126	AIRMNVAR20-SCZEQ	AIR	MNV	AR20-	SCZ	EQ	Manual Valve AR20 Fails Shut

Table B.1 (continued)

BASIC EVENTS SUMMARY REPORT (Alphabetical Sort)

Family: HFBR-PRA

Event Number	Basic Event Designator	System Code	Generic Comp. Type	Component ID	Fail. Mode	Component Location	Basic Event Description
127	AIRMNVAR21-FTOEQ	AIR	MNV	AR21-	FTO	EQ	Manual Valve AR21 Fails to Operate
128	AIRMNVAR21-HEPEQ	AIR	MNV	AR21-	HEP	EQ	Operator Fails to Open AR21
129	AIRMNVAR22-SCZEQ	AIR	MNV	AR22-	SCZ	EQ	Manual Valve AR22 Fails Shut
130	AIRMNVAR23-SCZEQ	AIR	MNV	AR23-	SCZ	EQ	Manual Valve AR23 Fails Shut
131	AIRMNVAR24-FTOEQ	AIR	MNV	AR24-	FTO	EQ	Manual Valve AR24 Fails to Operate
132	AIRMNVAR24-HEPEQ	AIR	MNV	AR24-	HEP	EQ	Operator Fails To Open AR24
133	AIRMNVAR45AHEPVV	AIR	MNV	AR45A	HEP	VV	Valve AR45a mispositioned
134	AIRMNVAR45AVPZEQ	AIR	MNV	AR45A	VPZ	EQ	air mnv ar45a plugged
135	AIRMNVAR45BHEPVV	AIR	MNV	AR45B	HEP	VV	air MNV AR45B mispositioned
136	AIRMNVAR45BVPZEQ	AIR	MNV	AR45B	VPZ	EQ	air mnv ar45b plugged
137	AIRMNVAR58-SCZEQ	AIR	MNV	AR58-	SCZ	EQ	Manual Valve AR58 Fails Shut
138	AIRMNVAR58ASCZEQ	AIR	MNV	AR58A	SCZ	EQ	Manual Valve AR58A Fails Shut
139	AIRMNVAR78-SCZEQ	AIR	MNV	AR78-	SCZ	EQ	Manual Valve AR78 Fails Shut
140	AIRMNVAR79-SCZEQ	AIR	MNV	AR79-	SCZ	EQ	Manual Valve AR79 Fails Shut
141	AIRMNVAR80-FTOEQ	AIR	MNV	AR80-	FTO	EQ	Manual Valve AR80 Fails to Operate
142	AIRMNVAR80-HEPEQ	AIR	MNV	AR80-	HEP	EQ	Operator Fails to Open AR80
143	AIRMNVAR81-SCZEQ	AIR	MNV	AR81-	SCZ	EQ	Manual Valve AR81 Fails Shut
144	AIRMNVAR82-SCZEQ	AIR	MNV	AR82-	SCZ	EQ	Manual Valve AR82 Fails Shut
145	AIRMNVAR83-FTOEQ	AIR	MNV	AR83-	FTO	EQ	Manual Valve AR83 Fails to Operate
146	AIRMNVAR83-HEPEQ	AIR	MNV	AR83-	HEP	EQ	Operator Fails to Open AR83
147	AIRMNVAR85-SCZEQ	AIR	MNV	AR85-	SCZ	EQ	Manual Valve AR85 Fails Shut
148	AIRMNVAR86-SCZEQ	AIR	MNV	AR86-	SCZ	EQ	Manual Valve AR86 Fails Shut
149	AIRMNVAR87-FTOEQ	AIR	MNV	AR87-	FTO	EQ	Manual Valve AR87 Fails to Operate
150	AIRMNVAR87-HEPEQ	AIR	MNV	AR87-	HEP	EQ	Operator Fails to Open AR87
151	AIRMNVAR99-SCZEQ	AIR	MNV	AR99-	SCZ	EQ	Manual Valve AR99 Fails Shut
152	AIRMOVLCLOPHEPVV	AIR	MOV	LCLOP	HEP	VV	Operator Fails to Operated Manually
153	AIRMOVSUPLYFTCEQ	AIR	MOV	SUPLY	FTC	EQ	air supply spool vlv operator fails
154	AIRPIPAIRLNILKVV	AIR	PIP	AIRLN	ILK	VV	Compressor Airline Rupture Occurs that Can't Be Isolated
155	AIRSWILAGSWOPFEQ	AIR	SWI	LAGSW	OPF	EQ	LAG Pressure Switch Fails
156	AIRSWIR_SSWFDOEQ	AIR	SWI	R_SSW	FDO	EQ	RUN/STBY SEL Switch Fails
157	AIRSWMMTRPBFTCOP	AIR	SWM	MTRPB	FTC	OP	air supply vlv motor pushbutton fails
158	AWP-SYSTEM-UTMEQ	AWP	-SY	STEM-	UTM	EQ	awp system test/maintenance unavailability
159	AWPBKRXXXXXFDOEQ	AWP	BKR	XXXXX	FDO	EQ	awp breaker fails to remain closed
160	AWPMNV-DW42FTOEQ	AWP	MNV	-DW42	FTO	EQ	domestic water valve dw42 fails to open
161	AWPMNV-DW43FTOEQ	AWP	MNV	-DW43	FTO	EQ	domestic water valve dw43 fails to open
162	AWPMNV-TW50FTCEQ	AWP	MNV	-TW50	FTC	EQ	awp valve tw50 fails to close
163	AWPMNVFC101FTCEQ	AWP	MNV	FC101	FTC	EQ	failure to close valve fci101 results in poison removal
164	AWPPMPGA204FDOEQ	AWP	PMP	GA204	FDO	EQ	awp pump ga204 fails to continue to run (hardware failure
165	B1	B1					Break isolation with vessel level above 162.5"
166	B1-COOLER	B1-	COO	LER			BREAK ISOLATION ABOVE 162.5"(COOLER RUPTURE)
167	B2	B2					Break isolation with level between 162.5" and 120.5"
168	B2-COOLER	B2-	COO	LER			BREAK ISOLATION ABOVE 120"(COOLER RUPTURE)

Table B.1 (continued)

BASIC EVENTS SUMMARY REPORT (Alphabetical Sort)

Family: HFBR-PRA

Event Number	Basic Event Designator	System Code	Generic Comp. Type	Component ID	Fail. Mode	Component Location	Basic Event Description
169	BI	BI					MLOCA ISOLATION FAILURE
170	CCWBKRXXXXXFDOEQ	CCW	BKR	XXXXX	FDO	EQ	ccw pump breaker fails to remain open
171	CCWMNV-TW17FTCEQ	CCW	MNV	-TW17	FTC	EQ	valve tw17 (canal vlv) fails to throttle
172	CCWMNV-TW19FTCEQ	CCW	MNV	-TW19	FTC	EQ	canal valve tw19 fails to close
173	CCWPMPGA202FDOEQ	CCW	PMP	GA202	FDO	EQ	ccw pump ga292 fails to continue to run
174	DCPBTRBATT1FDOFH	DCP	BTR	BATT1	FDO	FH	Loss of Battery # 1
175	DCPBTRBATT2FDOFH	DCP	BTR	BATT2	FDO	FH	Loss of Battery # 2
176	DCPBUSEMCC-BUSEQ	DCP	BUS	EMCC-	BUS	EQ	EMCC DC Bus Failure
177	DCPBUSSWGBSBUSPH	DCP	BUS	SWGBS	BUS	PH	Pump House 250v dc SWGR Bus Fails
178	DCPCBHBAT1BSOZFH	DCP	CBH	BAT1B	SOZ	FH	Battery #1 BKR Fails Open
179	DCPCBHBAT2BSOZFH	DCP	CBH	BAT2B	SOZ	FH	Battery #2 BKR Fails Open
180	DCPCBHBKR1BSOZFH	DCP	CBH	BKR1B	SOZ	FH	DC PNL BKR 1B Fails Open
181	DCPCBHBKR1CSOZFH	DCP	CBH	BKR1C	SOZ	FH	DC PNL BKR 1C Fails Open
182	DCPCBHBKR25SOZFH	DCP	CBH	BKR25	SOZ	FH	Fanhouse DC PNL BKR 25 FAils Open
183	DCPCBHBKR28SOZFH	DCP	CBH	BKR28	SOZ	FH	Fanhouse DC PNL BKR 28 Fails Open
184	DCPCBHBKR2BSOZFH	DCP	CBH	BKR2B	SOZ	FH	DC PNL BKR 2C Fails Open
185	DCPCBHBKR2CFTCFH	DCP	CBH	BKR2C	FTC	FH	DC PNL BKR 2C Fails to Close
186	DCPCBHCHBKRSOZFH	DCP	CBH	CHBKR	SOZ	FH	On-line Charger DC Output BKR Fails Open
187	DCPCBHEMCC-SOZEQ	DCP	CBH	EMCC-	SOZ	EQ	EMCC 2400v BKR DC Control Power BKR #1 Fails Open
188	DCPCBHEMCCSSOZEQ	DCP	CBH	EMCCS	SOZ	EQ	EMCC DC Supply BKR Fails Open
189	DCPCBHFEED-SOZPH	DCP	CBH	FEED-	SOZ	PH	Feed BKR to Pump House SWGR Bus Fails Open
190	DCPCBHFHDCPSOZFH	DCP	CBH	FHDCP	SOZ	FH	Fanhouse DC Power Pnl BKR #1 for 2.4kv BKR Control Failsopen
191	DCPCBHOLBKRFTCFH	DCP	CBH	OLBKR	FTC	FH	Offline Charger DC Output BKR Fails to Close
192	DCPCBHSPPLYSOZPH	DCP	CBH	SPPLY	SOZ	PH	Supply BKR to Pump House SWGR Bus Fails Open
193	DCPCBHT1BKRSOZFH	DCP	CBH	T1BKR	SOZ	FH	TB Tie BKR Fails Open
194	DCPCGROFLINFDOFH	DCP	CGR	OFLIN	FDO	FH	Offline Charger Fails to Run
195	DCPCGROFLINHEPFH	DCP	CGR	OFLIN	HEP	FH	Shift Doesn't Place Charger Online
196	DCPCGROFLINOPFFH	DCP	CGR	OFLIN	OPF	FH	Offline Charger Fails to Start
197	DCPCGROFLINUTMFH	DCP	CGR	OFLIN	UTM	FH	Offline Charger Not Available
198	DCPCGRONLINFDOFH	DCP	CGR	ONLIN	FDO	FH	Online Charger Fails
199	DEPACC300AXILKOP	DEP	ACC	300AX	ILK	OP	AIR SUPPLY PRESSURE TOO LOW
200	DEPACC300BXILKOP	DEP	ACC	300BX	ILK	OP	air supply pressure too low B-accumulator
201	DEPAOV300ABHEPOP	DEP	AOV	300AB	HEP	OP	OPERATOR FAIL TO OPEN ANY OF THE STEAM VENT VALVES
202	DEPAOV300AXFTOOP	DEP	AOV	300AX	FTO	OP	P-300A FAILS TO OPEN MECHANICAL FAILURE
203	DEPAOV300BXFTOOP	DEP	AOV	300BX	FTO	OP	P-300B FAIL TO OPEN DUE TO MECHANICAL FAILURES
204	DEPAOVBT300FTOOP	DEP	AOV	BT300	FTO	OP	BETA FACTOR FOR FAILURE OF BOTH P-300A AND P-300B
205	DEPAOVCM300FTOOP	DEP	AOV	CM300	FTO	OP	COMMON CAUSE POTENTIAL FOR P-300A AND B
206	DEPCNC300AXILKOP	DEP	CNC	300AX	ILK	OP	CONNECTOR LEAKAGE PREVENTS ENOUGH AIR FLOW TO THE P-300A&B
207	DEPFHZ300AXHPZOP	DEP	FHZ	300AX	HPZ	OP	FLEXIBLE HOSE CLOGGING PREVENTS AIR FLOW
208	DEPFHZ300AXILKOP	DEP	FHZ	300AX	ILK	OP	FLEXIBLE HOSE RUPTURE PREVENTS AIR FLOW TO P-300A VALVES
209	DEPFHZ300BXHPZOP	DEP	FHZ	300BX	HPZ	OP	FLEXIBLE HOSE CLOGGED-PREVENT AIR FLOW TO P-300B
210	DEPFHZ300BXILKOP	DEP	FHZ	300BX	ILK	OP	FLEXIBLE HOSE RUPTURE PREVENTING AIR FLOW TO P-300B

Table B.1 (continued)

BASIC EVENTS SUMMARY REPORT (Alphabetical Sort)

Family: HFBR-PRA

Event Number	Basic Event Designator	System Code	Generic Comp. Type	Component ID	Fail. Mode	Component Location	Basic Event Description
211	DEPMNV300AISCZOP	DEP	MNV	300AI	SCZ	OP	ISOLATION VALVE FAILS SHUT PREVENTING AIR FLOW
212	DEPMNV300AXSCZOP	DEP	MNV	300AX	SCZ	OP	AIR SUPPLY REGULATOR FAILS CLOSED
213	DEPMNV300BISCZOP	DEP	MNV	300BI	SCZ	OP	THE P-300B ISOLATION VALVE FAILS SHUT
214	DEPMNV300BKSCZOP	DEP	MNV	300BK	SCZ	OP	p-300B BAK UP ISOLATION VALVE FAILES SHUT
215	DEPMNV300BXSCZOP	DEP	MNV	300BX	SCZ	OP	p-300B REGULATOR VALVE FAILES SHUT
216	DEPMNVP102XFTOOP	DEP	MNV	P102X	FTO	OP	FAILURE OF P-102 TO OPEN PER DEMAND
217	DEPMNVP102XHEPOP	DEP	MNV	P102X	HEP	OP	OPERATOR FAILS TO OPEN P-102 VALVE
218	DMWLOSS	DMW	LOS	$			loss of the domestic water system
219	DMWMNVD230-SCZEQ	DMW	MNV	D230-	SCZ	EQ	Manual Valve DW230 Fails Shut
220	DMWMNVDW26-SCZEQ	DMW	MNV	DW26-	SCZ	EQ	Manual Valve DW36 Fails Shut
221	DMWMNVDW28-SCZEQ	DMW	MNV	DW28-	SCZ	EQ	Manual Valve DW28 Fails Shut
222	DMWMNVDW28ASCZEQ	DMW	MNV	DW28A	SCZ	EQ	Manual Valve DW28A Fails Shut
223	DMWMNVDW28BSCZEQ	DMW	MNV	DW28B	SCZ	EQ	Manual Valve DW 28B Fails Shut
224	DMWMNVDW29-SCZEQ	DMW	MNV	DW29-	SCZ	EQ	Manual Valve DW29 Fails Shut
225	DMWMNVDW29ASCZEQ	DMW	MNV	DW29A	SCZ	EQ	Manual Valve DW29A FAils Shut
226	DMWMNVDW29BFTOEQ	DMW	MNV	DW29B	FTO	EQ	Manual Valve DW29B Fails To Operate
227	DMWMNVDW29BHEPEQ	DMW	MNV	DW29B	HEP	EQ	Operator Fails to Open DW29B
228	DMWMNVDW30ASCZEQ	DMW	MNV	DW30A	SCZ	EQ	Manual Valve DW30A Fails Shut
229	DMWMNVDW30BSCZEQ	DMW	MNV	DW30B	SCZ	EQ	Manual Valve DW30B Fails Shut
230	DMWMNVDW31-SCZEQ	DMW	MNV	DW31-	SCZ	EQ	Manual Valve DW31 Fails Shut
231	DMWMNVDW31ASCZEQ	DMW	MNV	DW31A	SCZ	EQ	Manual Valve DW31A Fails Shut
232	DMWMNVDW47-SCZEQ	DMW	MNV	DW47-	SCZ	EQ	Manual Valve DW47 Fails Shut
233	DMWMNVDW48-FTOEQ	DMW	MNV	DW48-	FTO	EQ	Manual Valve DW48 Fails to Operate
234	DMWMNVDW48-HEPEQ	DMW	MNV	DW48-	HEP	EQ	Operator Fails to Open DW48
235	DMWMNVDW48-SCZEQ	DMW	MNV	DW48-	SCZ	EQ	Manual Valve DW48 Fails Shut
236	DMWMNVDW49-SCZEQ	DMW	MNV	DW49-	SCZ	EQ	Manual Valve DW49 Fails Shut
237	DMWMNVDW50-SCZEQ	DMW	MNV	DW50-	SCZ	EQ	Manual Valve DW50 Fails Shut
238	DMWSOVDWASVSCZEQ	DMW	SOV	DWASV	SCZ	EQ	GB301A Aftercooler DW Solenoid Valve Fails Shut
239	DMWSOVDWBSVSCZEQ	DMW	SOV	DWBSV	SCZ	EQ	GB301B Aftercooler DW Solenoid Valve Fails Shut
240	DMWTCVDWARGSCZEQ	DMW	TCV	DWARG	SCZ	EQ	DW Regulating Valve to GB301A Oil Cooler Fails Shut
241	DMWTCVDWBRGSCZEQ	DMW	TCV	DWBRG	SCZ	EQ	DW Regulating Valve to Gb301B Oil Cooler Fails Shut
242	DMWTCVDWCRRSCZEQ	DMW	TCV	DWCRR	SCZ	EQ	DW Regulating VAlve to GB301C Oil Cooler Fails Shut
243	DWSMNVXXXX1FTOEQ	DWS	MNV	XXXX1	FTO	EQ	domestic water valve fails to open
244	DWSMNVXXXX2FTOEQ	DWS	MNV	XXXX2	FTO	EQ	domestic water valve fails to open
245	DWSMNVXXXX3FTOEQ	DWS	MNV	XXXX3	FTO	EQ	domestic water valve fails to open
246	DWSXFRHOSEFAILEQ	DWS	XFR	HOSEF	AIL	EQ	flow through domestic water jumper hose fails
247	FRVFRV2OF4VFTOVL	FRV	FRV	2OF4V	FTO	VL	Failure of 2 out of 4 Flow Reversal Valves to Open
248	FRVFRVBTO2VFTOVL	FRV	FRV	BTO2V	FTO	VL	Beta Factor for Falow Reversal Valves to Open
249	FRVFRVRANDMFTOVL	FRV	FRV	RANDM	FTO	VL	Random Failure of A Flow Reversal VAlve to Open
250	HESMNV-HE23FTOEQ	HES	MNV	-HE23	FTO	EQ	Helium Fill Valve HE23 Fails to Open
251	HESMNV-HE27FTOOP	HES	MNV	-HE27	FTO	OP	helium valve he27 fails to open
252	HESMNV-HE28FTOOP	HES	MNV	-HE28	FTO	OP	helium valve he28 fails to open

Table B.1 (continued)

BASIC EVENTS SUMMARY REPORT (Alphabetical Sort)

Family: HFBR-PRA

Event Number	Basic Event Designator	System Code	Generic Comp. Type	Component ID	Fail. Mode	Component Location	Basic Event Description
253	HESMNV-HE29FTOOP	HES	MNV	-HE29	FTO	OP	helium valve he29 fails to open
254	HESMNV-HE5AFTOOP	HES	MNV	-HE5A	FTO	OP	Valve HE5A Fails to Open
255	HESSYSTEM--FTOVV	HES	SYS	TEM--	FTO	VV	helium system fails
256	HOUSE-3MIN	HOU	SE-	3MIN			Discredit any operator action to restore power in 3 min.
257	HOUSE-COOLER	HOU	SE-	COOLER			IE of cooler tube rupture
258	HOUSE-LOOP2	HOU	SE-	LOOP2			Loss of Offsite Power Less Than 2 Hours
259	HOUSE-LOOP24	HOU	SE-	LOOP24			Loss of Offsite Power for 24 Hours
260	HOUSE-LOOP6	HOU	SE-	LOOP6			Loss of Offsite Power for 6 Hours
261	HOUSE-MLOCA	HOU	SE-	MLOCA			HOUSE FOR MLOCA
262	HOUSE-PONY	HOU	SE-	PONY			Specialize ac power for pony motors(T for IE-LOOP2)
263	HOUSE-SLOCA	HOU	SE-	SLOCA			Small LOCA Initiating Event
264	HOUSE-T10	HOU	SE-	T10			TRANSIENT CATEGORY T-10
265	HOUSE-T11	HOU	SE-	T11			TRANSIENT CATEGORY T-11
266	HOUSE-T12	HOU	SE-	T12			CATEGORY-12 TRANSIENTS
267	HOUSE-T13	HOU	SE-	T13			Loss of Compressed Air System Initiating Event
268	HOUSE-T14	HOU	SE-	T14			Loss of 250v Dc at Fanhouse DC Panel(Initiating Event)
269	HOUSE-T2	HOU	SE-	T2			TRANSIENT CATEGORY T-2
270	HOUSE-T3	HOU	SE-	T3			TRANSIENT CATEGORY T-3
271	HOUSE-T4	HOU	SE-	T4			TRANSIENT CATEGORY T-4
272	HOUSE-T5	HOU	SE-	T5			CATEGORY-5 TRANSIENTS
273	HOUSE-T6	HOU	SE-	T6			CATEGORY-6 TRANSIENTS
274	HOUSE-T7	HOU	SE-	T7			TRANSIENT CATEGORY T-7
275	HOUSE-T8	HOU	SE-	T8			TRANSIENT CATEGORY T-8
276	HWD-CLRAHEPFTSVV	HWD	-CL	RAHEP	FTS	VV	Operator Fails to Align for Draining Cooler A
277	HWD-CLRBHEPFTSVV	HWD	-CL	RBHEP	FTS	VV	Operator Fails to Align for Draining Cooler B
278	HWDMNV-DA10FTOEQ	HWD	MNV	-DA10	FTO	EQ	drain valve da10 fails to open
279	HWDMNV-DA11FTOEQ	HWD	MNV	-DA11	FTO	EQ	drain valve da11 fails to open
280	HWDMNV-DA14FTOEQ	HWD	MNV	-DA14	FTO	EQ	drain valve da14 fails to open
281	HWDMNV-DA15FTOEQ	HWD	MNV	-DA15	FTO	EQ	drain valve da15 fails to open
282	HWDMNV-DA5-FRCEQ	HWD	MNV	-DA5-	FRC	EQ	drain valve da5 fails to reclose
283	HWDMNV-DA5-FTOEQ	HWD	MNV	-DA5-	FTO	EQ	drain valve da5 fails to open
284	HWDMNV-DA6-FRCEQ	HWD	MNV	-DA6-	FRC	EQ	drain valve da6 fails to reclose
285	HWDMNV-DA6-FTOEQ	HWD	MNV	-DA6-	FTO	EQ	drain valve da6 fails to open
286	HWDMNV-P118FTCEQ	HWD	MNV	-P118	FTC	EQ	drain valve p118 fails to close
287	HWTALIGN---HEPVV	HWT	ALI	GN---	HEP	VV	Operator Fails to Align in time (subseq injectn @ 1.5 hrs)
288	HWTALIGN3HRHEPVV	HWT	ALI	GN3HR	HEP	VV	Operator Fails to Align in 3 Hours(subseq injectn @ 1.5 hrs)
289	HWTCKV-XXXXFTREQ	HWT	CKV	-XXXX	FTR	EQ	Check in Pump Suction stuck
290	HWTCKV-YYYYFTCEQ	HWT	CKV	-YYYY	FTC	EQ	Check Valve near P47 fails to close
291	HWTCKV-YYYYFTOEQ	HWT	CKV	-YYYY	FTO	EQ	Check Valve near P47 fails to operate
292	HWTCKVG104AFTOEQ	HWT	CKV	G104A	FTO	EQ	Pump Discharge Check Valve Fails to Open
293	HWTCKVG104BFTOEQ	HWT	CKV	G104B	FTO	EQ	Pump GA104b Discharge Valve Fails to Open
294	HWTCKVG104CFTOEQ	HWT	CKV	G104C	FTO	EQ	Pump GB104c Discharge Check Valve Fails to Open

Table B.1 (continued)

BASIC EVENTS SUMMARY REPORT (Alphabetical Sort)

Family: HFBR-PRA

Event Number	Basic Event Designator	System Code	Generic Comp. Type	Component ID	Fail. Mode	Component Location	Basic Event Description
295	HWTCKVINJCTFTOOP	HWT	CKV	INJCT	FTO	OP	FA102 Injection Valve Fails to Open
296	HWTCKVNNSSCFTOOP	HWT	CKV	NNSSC	FTO	OP	Check Valve NNS/SC3 Fails to Open
297	HWTLTM90HESHEPVV	HWT	LTM	90HES	HEP	VV	oper fails to trans D20 w/helium in 90 min from fa101
298	HWTLTM90PMPHEPVV	HWT	LTM	90PMP	HEP	VV	oper fails to trans D20 w/ pumps in 90 min from fa101
299	HWTMNV--CD3HEPEQ	HWT	MNV	--CD3	HEP	EQ	Valve CD3 Open
300	HWTMNV--CD4HEPEQ	HWT	MNV	--CD4	HEP	EQ	Valve CD4 Open
301	HWTMNV-DA7-HEPEQ	HWT	MNV	-DA7-	HEP	EQ	HWT DA7 valve Left Open
302	HWTMNV-P01-FTOOP	HWT	MNV	-P01-	FTO	OP	Valve P01 Fails to Open
303	HWTMNV-P02-HEPOP	HWT	MNV	-P02-	HEP	OP	Operator Fails to Close P02
304	HWTMNV-P03-FTOOP	HWT	MNV	-P03-	FTO	OP	Valve P03 Fails to Open
305	HWTMNV-P113FTCEQ	HWT	MNV	-P113	FTC	EQ	offgas vent valve p113 fails to close
306	HWTMNV-P122HEPEQ	HWT	MNV	-P122	HEP	EQ	operator fails to close valve p122
307	HWTMNV-P174FTOEQ	HWT	MNV	-P174	FTO	EQ	Valve P174 Fails to Open
308	HWTMNV-P175FTOEQ	HWT	MNV	-P175	FTO	EQ	Valve P175 Fails to Open
309	HWTMNV-P42-FTCOP	HWT	MNV	-P42-	FTC	OP	Valve P42 Open
310	HWTMNV-P47-FTCEQ	HWT	MNV	-P47-	FTC	EQ	Valve P47 is open
311	HWTMNV-P47-FTOEQ	HWT	MNV	-P47-	FTO	EQ	Valve P47 Fails to Open(Normally Open)
312	HWTMNV-P48-FTOEQ	HWT	MNV	-P48-	FTO	EQ	Valve P48 Fails to Open
313	HWTMNV-P49-FTCEQ	HWT	MNV	-P49-	FTC	EQ	Valve P49 Fails to Close
314	HWTMNV-P50-FTCEQ	HWT	MNV	-P50-	FTC	EQ	Valve P50 Fails to Close
315	HWTMNV-P51-FTOEQ	HWT	MNV	-P51-	FTO	EQ	Valve P51 Fails to Open
316	HWTMNV-P52-FTCEQ	HWT	MNV	-P52-	FTC	EQ	VAlve P52 Fails to Close
317	HWTMNV-P53-HEPEQ	HWT	MNV	-P53-	HEP	EQ	Valve P53 Left Open
318	HWTMNV-P54-FTOEQ	HWT	MNV	-P54-	FTO	EQ	Valve P54 Fails to Open
319	HWTMNV-P54-HEPEQ	HWT	MNV	-P54-	HEP	EQ	Valve P54 Left Open
320	HWTMNV-P55-HEPEQ	HWT	MNV	-P55-	HEP	EQ	Valve P55 Left Open
321	HWTMNV-P56-FTOEQ	HWT	MNV	-P56-	FTO	EQ	Valve P56 Fails to Open
322	HWTMNV-P56-HEPEQ	HWT	MNV	-P56-	HEP	EQ	Valve P56 Left Open
323	HWTMNV-P57-FTOOP	HWT	MNV	-P57-	FTO	OP	valve p57 fails to open
324	HWTMNV-P57-HEPEQ	HWT	MNV	-P57-	HEP	EQ	Valve P57 Left Open
325	HWTMNV-P58-FTCEQ	HWT	MNV	-P58-	FTC	EQ	Valve P58 Fails to Close
326	HWTMNV-P87-FTOOP	HWT	MNV	-P87-	FTO	OP	valve p87 fails to open
327	HWTMNV-P88-FTOOP	HWT	MNV	-P88-	FTO	OP	valve p88 fails to open
328	HWTMNV-P89-FTCEQ	HWT	MNV	-P89-	FTC	EQ	valve p89 fails to close
329	HWTPMP104ABFTREQ	HWT	PMP	104AB	FTR	EQ	random failure of pump 104a or b to run (24 hr mission ti
330	HWTPMP104ABFTSEQ	HWT	PMP	104AB	FTS	EQ	random failure of pump 104a or b to start (10 starts assu
331	HWTPMPBTOABFTREQ	HWT	PMP	BTOAB	FTR	EQ	beta factor hwt pump ga104a or b fails to run
332	HWTPMPBTOABFTSEQ	HWT	PMP	BTOAB	FTS	EQ	Beta Factor for Pumps 104A and B to Start
333	HWTPMPG104AFTREQ	HWT	PMP	G104A	FTR	EQ	hwt pump ga104a fails to run (24 hour misson time)
334	HWTPMPG104AFTSEQ	HWT	PMP	G104A	FTS	EQ	hwt pump ga104a fails to start (10 starts assumed)
335	HWTPMPG104AJAMEQ	HWT	PMP	G104A	JAM	EQ	pump g104a impeller jams
336	HWTPMPG104AUTMVV	HWT	PMP	G104A	UTM	VV	hwt pump ga104a test and maintenance unavailability

Table B.1 (continued)

BASIC EVENTS SUMMARY REPORT (Alphabetical Sort)

Family: HFBR-PRA

Event Number	Basic Event Designator	System Code	Generic Comp. Type	Component ID	Fail. Mode	Component Location	Basic Event Description
337	HWTPMPG104BFTREQ	HWT	PMP	G104B	FTR	EQ	hwt pump ga104b fails to run (24 hour misson time)
338	HWTPMPG104BFTSEQ	HWT	PMP	G104B	FTS	EQ	hwt pump ga104b fails to start (10 starts assumed)
339	HWTPMPG104BJAMEQ	HWT	PMP	G104B	JAM	EQ	pump g104b impeller jams
340	HWTPMPG104BUTMVV	HWT	PMP	G104B	UTM	VV	hwt pump ga104b test and maintenance unavailability
341	HWTPMPG104CFTREQ	HWT	PMP	G104C	FTR	EQ	hwt pump ga104c fails to run (24 hour misson time)
342	HWTPMPG104CFTSEQ	HWT	PMP	G104C	FTS	EQ	hwt pump ga104c fails to start (10 starts assumed)
343	HWTPMPG104CUTMVV	HWT	PMP	G104C	UTM	VV	hwt pump ga104c test and maintenance unavailability
344	HWTSRVSV103FTREQ	HWT	SRV	SV103	FTR	EQ	Sv103 Stuck Open
345	HWTTNKFA101INSEQ	HWT	TNK	FA101	INS	EQ	insufficient D2O in fa101
346	HWTTNKFA102INSOP	HWT	TNK	FA102	INS	OP	Insufficient D2O in FA102
347	IE-BTR	IE-	BTR				IE: BEAM TUBE RUPTURE
348	IE-COOLER	IE-	COO	LER			IE FREQUENCY:COOLER TUBE RUPTURE
349	IE-LLOCA	IE-	LLO	CA			LARGE LOCA INITIATING EVENT
350	IE-LOOP2	IE-	LOO	P2			LOOP 2 INITITAING EVENT
351	IE-LOOP24	IE-	LOO	P24			LOOP 24 INITITAING EVENT
352	IE-LOOP6	IE-	LOO	P6			LOOP 6 INITIATING EVENT
353	IE-MLOCA	IE-	MLO	CA			medium LOCA INITIATING EVENT
354	IE-SLOCA	IE-	SLO	CA			SMALL LOCA INITIATING EVENT
355	IE-T1	IE-	T1				T1 INITIATING EVENT
356	IE-T10	IE-	T10				T10 INITIATING EVENT
357	IE-T11	IE-	T11				T11 INITIATING EVENT
358	IE-T12	IE-	T12				T12 INITIATING EVENT
359	IE-T13	IE-	T13				T13 INITIATING EVENT
360	IE-T14	IE-	T14				T14 INITIATING EVENT
361	IE-T2	IE-	T2				T2 INITIATING EVENT
362	IE-T3	IE-	T3				T3 INITIATING EVENT
363	IE-T5	IE-	T5				T5 INITIATING EVENT
364	IE-T6	IE-	T6				T6 INITIATING EVENT
365	IE-T7	IE-	T7				T7 INITIATING EVENT
366	IE-T8	IE-	T8				T8 INITIATING EVENT
367	IE-T9	IE-	T9				Transient Initiating Event Frequency T9
368	IE-TRANSIENT	IE-	TRA	NSIEN	T		GENERIC TRANSIENT INITIATING EVENT
369	LOOP-INDUCED	LOO	P-I	NDUCE	D		Loss of Offsite Power Subsequent to the IE
370	NEPMNV300AKSCZOP	NEP	MNV	300AK	SCZ	OP	THE BACK UP ISOLATION VALVE FAILS SHUT
371	OFGMNV--P17FTCOP	OFG	MNV	--P17	FTC	OP	Offgas Vent Valve P17 Fails to Close
372	PC3AOVBTOABSCZVV	PC3	AOV	BTOAB	SCZ	VV	THE BETA VALUE FOR COMMON CAUSE OF SUCTION OR DISCHARGE VALV
373	PC3AOVCMOABSCZVV	PC3	AOV	CMOAB	SCZ	VV	COMMON CAUSE POTENTIAL OF SUCTION OR DISCHRGE VALVE
374	PC3AOVHC01ASCZVV	PC3	AOV	HC01A	SCZ	VV	FAILURE OF PRI. CONTROL VALVE-TRAIN A IN THE FIRST 3 MIN.
375	PC3AOVHC01BSCZVV	PC3	AOV	HC01B	SCZ	VV	FAILURE OF PRIMARY CONTROL VALVE-TRAIN B FOR THE FIRST 3 MIN
376	PC3AOVHC02ASCZVV	PC3	AOV	HC02A	SCZ	VV	FAILURE OF PRIMARY SUCTION VALVE-TRAIN A FIRST 3 MIN.
377	PC3AOVHC02BSCZVV	PC3	AOV	HC02B	SCZ	VV	FAILURE OF PRIMARY SUCTION VALVE-TRAIN B FIRST 3 MIN.
378	PC3BRGG101AFDOVV	PC3	BRG	G101A	FDO	VV	FAILURE OF THE MAIN PUMP-A BEARINGS SEIZURE FIRST 3 MIN

Table B.1 (continued)

BASIC EVENTS SUMMARY REPORT (Alphabetical Sort)

Family: HFBR-PRA

Event Number	Basic Event Designator	System Code	Generic Comp. Type	Component ID	Fail. Mode	Component Location	Basic Event Description
379	PC3BRGG101BFDOVV	PC3	BRG	G101B	FDO	VV	FAILURE OF MAIN PUMP-B BEARINGS SEIZURE FIRST 3 MIN.
380	PC3BTRGP01AFDOVV	PC3	BTR	GP01A	FDO	VV	FAILURE OF PONY MOTOR BATTERY-A TO PROVIDE POWER PER DEMAN
381	PC3BTRGP01BFDOVV	PC3	BTR	GP01B	FDO	VV	FAILURE OF PONY MOTOR BATTERY-B TO PROVIDE POWER PER DEMAN
382	PC3CBHGA01AFDOVV	PC3	CBH	GA01A	FDO	VV	FAILURE OF MAIN MOTOR BREAKER TRAIN-A FIRST 3 MIN.
383	PC3CBHGA01BSOZEQ	PC3	CBH	GA01B	SOZ	EQ	FAILURE OF MAIN MOTOR BREAKER TRAIN-B FIRST 3 MIN.
384	PC3CBLGP01AFDOVV	PC3	CBL	GP01A	FDO	VV	FAILURE OF PONY MOTOR-A PUMP BREAKER FIRST 3 MIN
385	PC3CBLGP01BFDOVV	PC3	CBL	GP01B	FDO	VV	FAILURE OF PONY MOTOR-B PUMP BREAKER FIRST 3 MIN.
386	PC3CGRGP01AFDOVV	PC3	CGR	GP01A	FDO	VV	FAILURE OF PONY MOTOR-A BATTERY CHARGER FIRST 3 MIN.
387	PC3CGRGP01BFDOVV	PC3	CGR	GP01B	FDO	VV	FAILURE OF PONY MOTOR-B BATTERY CHARGER FIRST 3 MIN.
388	PC3DMRBT0ABOPFVV	PC3	DMR	BT0AB	OPF	VV	THE BETA FACTOR FOR BOTH PONY MOTORS FAILURE TO RUN
389	PC3DMRCM0ABOPFVV	PC3	DMR	CM0AB	OPF	VV	COMMON MODE POTENTIAL FOR BOTH PONY MOTORS FAILE TO ENGAGE
390	PC3DMRGP01AOPFVV	PC3	DMR	GP01A	OPF	VV	FAILURE OF PONY MOTOR-A TO ENGAGE MECHANICALLY
391	PC3DMRGP01AUTM	PC3	DMR	GP01A	UTM		MAINTENANCE DOWNTIME CONTRIBUTION OF PONY MOTOR A
392	PC3DMRGP01BOPFVV	PC3	DMR	GP01B	OPF	VV	FAILURE OF PONY MOTOR B TO ENGAGE MECHANICALLY
393	PC3DMRGP01BUTM	PC3	DMR	GP01B	UTM		MAINTENANCE DOWNTIME FOR PONY MOTOR-B
394	PC3HXZEA01AILKVV	PC3	HXZ	EA01A	ILK	VV	PRIMARY COOLER LEAKAGE
395	PC3HXZEA01BILKVV	PC3	HXZ	EA01B	ILK	VV	PRIMARY COOLER-B LEAKAGE
396	PC3MTRBT0ABFDOVV	PC3	MTR	BT0AB	FDO	VV	THE BETA FACTOR FOR SEIZURE OF BOTH PRIMARY PUMPS
397	PC3MTRCM0ABFDOVV	PC3	MTR	CM0AB	FDO	VV	COMMON MODE POTENTIAL BOTH PRIM. PUMP SEIZURES FIRST 3 MIN
398	PC3MTRGA01AFDOVV	PC3	MTR	GA01A	FDO	VV	FAILURE OF MAIN PRIMARY MOTOR-A FIRST 3 MIN
399	PC3MTRGA01BFDOVV	PC3	MTR	GA01B	FDO	VV	FAILURE OF MAIN MOTOR-B FIRST 3 MIN.
400	PC3PMPBT0ABFDOVV	PC3	PMP	BT0AB	FDO	VV	THE BETA FACTOR FOR FAILURE OF BOTH MAIN PUMPS (SEIZURE)
401	PC3PMPCM0ABFDOVV	PC3	PMP	CM0AB	FDO	VV	THE COMMON MODE POTENTIAL FOR BOTH MAIN PUMPS(SEIZURE)
402	PC3SELG101AFDOVV	PC3	SEL	G101A	FDO	VV	SEAL FAILURE IN PUMP-A CAUSING SEIZURE IN FIRST 3 MIN.
403	PC3SELG101BFDOVV	PC3	SEL	G101B	FDO	VV	SEAL FAILURE IN PUMP-B CAUSING SEIZURE IN FIRST 3 MIN.
404	PCLAOVBT0ABSCZVV	PCL	AOV	BT0AB	SCZ	VV	Beta Factor for HCV101A and B
405	PCLAOVCM0ABSCZVV	PCL	AOV	CM0AB	SCZ	VV	COMMON CAUSE POTENTIAL OF SUCTION OR DISCHARGE VALVE
406	PCLAOVCM0ABSCZVV	PCL	AOV	CM0AB	SCZ	VV	Random Failure of HCV101a OR B
407	PCLAOVHC01AFTOVV	PCL	AOV	HC01A	FTO	VV	primary coolant vlv hc102a fails to OPEN
408	PCLAOVHC01ASCZVV	PCL	AOV	HC01A	SCZ	VV	FAILURE OF PRIMARY CONTROL VALVE-TRAIN A IN 24 HOURS
409	PCLAOVHC01BSCZVV	PCL	AOV	HC01B	SCZ	VV	FAILURE OF PRIMARY CONTROL VALVE-TRAIN B IN 24 HOURS
410	PCLAOVHC02ASCZVV	PCL	AOV	HC02A	SCZ	VV	FAILURE OF PRIMARY SUCTION VALVE-TRAIN A IN 24 HOURS
411	PCLAOVHC02BSCZVV	PCL	AOV	HC02B	SCZ	VV	FAILURE OF PRIMARY SUCTION VALVE TRAIN B IN 24 HOURS
412	PCLAOVHC1ABFTCEQ	PCL	AOV	HC1AB	FTC	EQ	Valve he102a/b fails to close
413	PCLAOVHC01ASCZVV	PCL	AOV	HC01A	SCZ	VV	Primary Cooler Valve Fails Shut
414	PCLAOVHC01BFTOVV	PCL	AOV	HC01B	FTO	VV	Primar Cooler Valve HCV101B Fails to Open
415	PCLAOVHC01BSCZVV	PCL	AOV	HC01B	SCZ	VV	Primary Cooler Valve HCV101 B Fails Shut
416	PCLBRGG101AFDOVV	PCL	BRG	G101A	FDO	VV	FAILURE OF THE MAIN PUMP BEARINGS SEIZURE IN 24 HOURS
417	PCLBRGG101BFDOVV	PCL	BRG	G101B	FDO	VV	FAILURE OF MAIN MOTOR BEARING IN 24 HRS/PUMP SEIZURE
418	PCLBTRGP01AFDOVV	PCL	BTR	GP01A	FDO	VV	FAILURE OF PONY MOTOR BATTERY A TO PROVIDE POWER PER DEMA
419	PCLBTRGP01BFDOVV	PCL	BTR	GP01B	FDO	VV	FAILURE OF PONY MOTOR BATTERY B TO PROVIDE POWER PER DEMA
420	PCLCBHGA01AFDOVV	PCL	CBH	GA01A	FDO	VV	FAILURE OF MAIN MOTOR BREAKER TRAIN-A IN 24 HOURS

Table B.1 (continued)

BASIC EVENTS SUMMARY REPORT (Alphabetical Sort)

Family: HFBR-PRA

Event Number	Basic Event Designator	System Code	Generic Comp. Type	Component ID	Fail. Mode	Component Location	Basic Event Description
421	PCLCBHGA01BSOZEQ	PCL	CBH	GA01B	SOZ	EQ	FAILURE OF MAIN MOTOR BREAKER TRAIN-B IN 24 HOURS
422	PCLCBLGP01AFDOVV	PCL	CBL	GP01A	FDO	VV	FAILURE OF PONY MOTOR BREAKER TRAIN-A IN 24 HOURS
423	PCLCBLGP01BFDOVV	PCL	CBL	GP01B	FDO	VV	FAILURE OF PONY MOTOR BREAKER TRAIN-B IN 24 HOURS
424	PCLCGRGP01AFDOVV	PCL	CGR	GP01A	FDO	VV	FAILURE OF PONY MOTOR-A CHARGER IN 24 HOURS
425	PCLCGRGP01BFDOVV	PCL	CGR	GP01B	FDO	VV	FAILURE OF PONY MOTOR-B CHARGER IN 24 HOURS
426	PCLDMRBTOABFDOVV	PCL	DMR	BTOAB	FDO	VV	FAILURE OF TWO PONY MOTORS TO RUN FOR 24 HRS (BETA FACTOR)
427	PCLDMRBTOABOPFVV	PCL	DMR	BTOAB	OPF	VV	THE BETA FACTOR FOR BOTH PONY MOTORS FAIL TO OPERATE
428	PCLDMRCMOABFDOVV	PCL	DMR	CMOAB	FDO	VV	COMMON MODE POTENTIAL FOR BOTH PONYS FAIL TO RUN FOR 24 HRS
429	PCLDMRCMABFDOVV	PCL	DMR	CMABF	DOV	V	common mode potential for failure of pony moyors to run
430	PCLDMRGP01AFDOVV	PCL	DMR	GP01A	FDO	VV	failure of pony motor to continue run for 24hrs
431	PCLDMRGP01AUTM	PCL	DMR	GP01A	UTM		MAINTENANCE DOWNTIME CONTRIBUTION OF PONY MOTOR A
432	PCLDMRGP01BFDOVV	PCL	DMR	GP01B	FDO	VV	failure of the pony motor b to continue to run for 24 hrs
433	PCLDMRGP01BUTM	PCL	DMR	GP01B	UTM		MAINTENANCE DOWNTIME FOR PONY MOTOR B
434	PCLHXZEA01AILKVV	PCL	HXZ	EA01A	ILK	VV	primary cooler b leakage
435	PCLHXZEA01BILKVV	PCL	HXZ	EA01B	ILK	VV	primary cooler b leakage
436	PCLMTRBTOABFDOVV	PCL	MTR	BTOAB	FDO	VV	THE BETA FACTOR FOR SEIZURE OF BOTH PRIMARY PUMPS
437	PCLMTRCMOABFDOVV	PCL	MTR	CMOAB	FDO	VV	COMMON MODE POTENTIAL FOR BOTH PRIMARY PUMP SEIZURES IN 24
438	PCLMTRGA01AFDOVV	PCL	MTR	GA01A	FDO	VV	FAILURE OF PRIMARY PUMP MOTOR-A IN 24 HOURS
439	PCLMTRGA01AFTSVV	PCL	MTR	GA01A	FTS	VV	failure of main pump a to start
440	PCLMTRGA01BFDOVV	PCL	MTR	GA01B	FDO	VV	FAILURE OF MAIN MOTOR-B IN 24 HRS
441	PCLMTRGA01BFTSVV	PCL	MTR	GA01B	FTS	VV	failure of main pump b to start
442	PCLPMPBTOABFDOVV	PCL	PMP	BTOAB	FDO	VV	THE BETA FACTOR FOR FAILURE OF BOTH PUMPS (SEIZURE)
443	PCLPMPCMOABFDOVV	PCL	PMP	CMOAB	FDO	VV	THE COMMON MODE POTENTIAL FOR BOTH MAIN PUMPS (SEIZURE)
444	PCLSELG101AFDOVV	PCL	SEL	G101A	FDO	VV	SEAL FAILURE IN PUMP-A CAUSING SEIZURE IN 24 HOURS
445	PCLSELG101BFDOVV	PCL	SEL	G101B	FDO	VV	SEAL FAILURE IN PUMP-B CAUSING SEIZURE IN 24 HOURS
446	PCWCBLDMTRAFDOEQ	PCW	CBL	DMTRA	FDO	EQ	primary cooler a cell door motor breaker fails open
447	PCWCBLDMTRBFDOEQ	PCW	CBL	DMTRB	FDO	EQ	primary cooler b cell door motor breaker fails open
448	PCWCELDAMTRFTSEQ	PCW	CEL	DAMTR	FTS	EQ	primary cooler a cell door motor fails to start
449	PCWCELDBMTRFTSEQ	PCW	CEL	DBMTR	FTS	EQ	primary cooler b cell door motor fails to start
450	PCWPMP-----FTREQ	PCW	PMP	-----	FTR	EQ	primary pump continues to operate
451	PW1AOVHC102FTOOP	PW1	AOV	HC102	FTO	OP	Hce-102 Fails to Open
452	PW1E33	PW1	E33				house event loop/transient with core vulnerable =1 (true)
453	PW1E34	PW1	E34				house event loop/transient with core vulnerable =1 (true)
454	PW2E44	PW2	E44				house event loop/transient with core vulnerable =1 (true)
455	PWCSCMSYS--UTMVV	PWC	SCM	SYS--	UTM	VV	primary coolers test or maintenance unavailability
456	PWS---LPHESFTRVV	PWS	---	LPHES	FTR	VV	low pressure helium system fails
457	PWS-SYSTEM-UTMVV	PWS	-SY	STEM-	UTM	VV	pws test and maintenance unavailability
458	PWSFLX-HOSE-PZOP	PWS	FLX	-HOSE	-PZ	OP	flex hose plugged
459	PWSFLXHOSE-UATOP	PWS	FLX	HOSE-	UAT	OP	flex hose not reattached post test
460	PWSLWM-HEP-ALNVV	PWS	LWM	-HEP-	ALN	VV	failure to align pws correctly
461	PWSMNV-P110HEPOP	PWS	MNV	-P110	HEP	OP	valve p110 is not closed by the operator(incl in top hep)
462	PWSMNV-P112FTOOP	PWS	MNV	-P112	FTO	OP	valve p112 fails to open

Table B.1 (continued)

BASIC EVENTS SUMMARY REPORT (Alphabetical Sort)

Family: HFBR-PRA

Event Number	Basic Event Designator	System Code	Generic Comp. Type	Component ID	Fail. Mode	Component Location	Basic Event Description
463	PWSMNV-P134-LOOP	PWS	MNV	-P134	-LO	OP	valve p134 inadvertently left open post maintenance
464	PWSMNV-P134FTCOP	PWS	MNV	-P134	FTC	OP	valve p134 fails to close
465	PWSMNV-P134HEPVV	PWS	MNV	-P134	HEP	VV	operator fails to correct diversion
466	PWSMNV-TW21FTOOP	PWS	MNV	-TW21	FTO	OP	valve tw21 (spring loaded vlv) fails to open
467	PWSMNV-TW24FTOOP	PWS	MNV	-TW24	FTO	OP	valve tw24 fails to open
468	PWSMNV-TW25FTOOP	PWS	MNV	-TW25	FTO	OP	valve tw25 fails to open
469	PWSMNV-TW27FTOOP	PWS	MNV	-TW27	FTO	OP	valve tw27 (tank vent vlv) fails to open
470	PWSMNV-TW27HEPOP	PWS	MNV	-TW27	HEP	OP	valve tw27 (tank vent) inadvertently left open
471	PWSMNV-TW28-PZOP	PWS	MNV	-TW28	-PZ	OP	valve tw28 is plugged
472	PWSMNV-TW28FTOOP	PWS	MNV	-TW28	FTO	OP	valve tw28 fails to open
473	PWSMNVP111-FTOOP	PWS	MNV	P111-	FTO	OP	valve p111 fails to open
474	PWSSRVSV202FTROP	PWS	SRV	SV202	FTR	OP	safety valve sv202 fails to reseat
475	PWSSYS--HEPFTSVV	PWS	SYS	--HEP	FTS	VV	operator reluctance to initiate the pws
476	PWSSYS-HEP-ALNVV	PWS	SYS	-HEP-	ALN	VV	failure to align the pws correctly
477	PWSSYS-HEP-WSHVV	PWS	SYS	-HEP-	WSH	VV	pw washout post loca (operator fails to control level)
478	PWSTNKFA202LEKOP	PWS	TNK	FA202	LEK	OP	pw tank fa202 leaks or ruptures upon pressurization
479	PWSTNKFA202LOWOP	PWS	TNK	FA202	LOW	OP	insufficient inventory in pw storage tank fa202
480	RCSSYS--PI-MSCVV	RCS	SYS	--PI-	MSC	VV	rcs pressure transmitter miscalibration
481	RCSSYSPRESSHGHVV	RCS	SYS	PRESS	HGH	VV	failure to maintain rcs pressure below 250 psig
482	REFBUSFHBXXFDOVV	REF	BUS	FHBXX	FDO	VV	fhb power line to control box failure
483	REFBUSMISCLFDOVV	REF	BUS	MISCL	FDO	VV	miscelanous reel wiring or fuse failure
484	REFCLCCLUCHFDOVV	REF	CLC	CLUCH	FDO	VV	reel clutch failure
485	REFCNC1OT13ILKVV	REF	CNC	1OT13	ILK	VV	one out of 13 hook disconnects fails and leak the air
486	REFELMTFALLFDOVV	REF	ELM	TFALL	FDO	VV	element falls during withdrawl when improperly hooked
487	REFELMTIMPRHEPVV	REF	ELM	TIMPR	HEP	VV	element is improperly hooked
488	REFELMTLOOSHEPVV	REF	ELM	TLOOS	HEP	VV	stuck element can not be knocked loosed
489	REFELMTRELSHNGVV	REF	ELM	TRELS	HNG	VV	fallen element hangs up (does not go to vessel or canal)
490	REFELMTRENDHEPVV	REF	ELM	TREND	HEP	VV	can't return the element to canal/vessel(no mech failure)
491	REFELMTSTUCFDOVV	REF	ELM	TSTUC	FDO	VV	element physically stuck in bonnet
492	REFFANFHBNSHEPVV	REF	FAN	FHBNS	HEP	VV	fuel handeling blower (FHB) not started (per refueling/14
493	REFFANFHBXXFDOVV	REF	FAN	FHBXX	FDO	VV	fuel handling blower failed during operation
494	REFFHZAIRMSFDOVV	REF	FHZ	AIRMS	FDO	VV	air hoses inside and outside tritium cont. fail
495	REFFHZHOOKXILKVV	REF	FHZ	HOOKX	ILK	VV	hook's hose fail
496	REFFHZLINKGFDOVV	REF	FHZ	LINKG	FDO	VV	the linkage shaft and the hose failure of slide
497	REFFHZWIRESILKVV	REF	FHZ	WIRES	ILK	VV	hook's hose and wire breaks
498	REFHOKJAMEDFDOVV	REF	HOK	JAMED	FDO	VV	mechanical jamming of the hook
499	REFHOKOPENXHEPVV	REF	HOK	OPENX	HEP	VV	inadvertant opening of the hook pickup head
500	REFHOKPIKUPSOZVV	REF	HOK	PIKUP	SOZ	VV	pickup head suddenly opens
501	REFINBONNETHEPVV	REF	INB	ONNET	HEP	VV	element not fully raised in to bonnet(therefore not coole
502	REFMNV3WAYXFDOVV	REF	MNV	3WAYX	FDO	VV	control box three way valve fail
503	REFMNVBTRFLSCZVV	REF	MNV	BTRFL	SCZ	VV	air butterfly valve suddenly close
504	REFMNVNOTOPHEPVV	REF	MNV	NOTOP	HEP	VV	air butterfly valve not opened by operator(per refueling/

Table B.1 (continued)

BASIC EVENTS SUMMARY REPORT (Alphabetical Sort)

Family: HFBR-PRA

Event Number	Basic Event Designator	System Code	Generic Comp. Type	Component ID	Fail. Mode	Component Location	Basic Event Description
505	REFMNVSL3WYSCZVV	REF	MNV	SL3WY	SCZ	VV	the slide 3-way valve suddenly close
506	REFMTRRELMTFDOVV	REF	MTR	RELMT	FDO	VV	reel motor fails during operation
507	REFREELMECHFDOVV	REF	REE	LMECH	FDO	VV	reel mechanical failures
508	REFSLDJAMEDFDOVV	REF	SLD	JAMED	FDO	VV	slide or piston jammed
509	REFSLDJMMEDFDOVV	REF	SLD	JMMED	FDO	VV	slide not full over then jammed (note-2)'
510	REFSLDJMMEDHEPVV	REF	SLD	JMMED	HEP	VV	element not raised enough then slide jammed
511	REFSWI1OTF4ILKVV	REF	SWI	1OTF4	ILK	VV	one out of four slide disconnects fail
512	REFSWIFHBXXFDOVV	REF	SWI	FHBXX	FDO	VV	fuel handling blower switch fails
513	REFWLMTREWDHEPVV	REF	WLM	TREWD	HEP	VV	can't return element to canal/vessel(mech. failures present)
514	S3LCKVP100XFTOEQ	S3L	CKV	P100X	FTO	EQ	Check valve P100 fails to open
515	S3LMNVP100XHEPEQ	S3L	MNV	P100X	HEP	EQ	Manual valve P100 left closed
516	SB-COOLER	SB-	COO	LER			BREAK IN SHUTDOWN COOLER
517	SB-SLOCA	SB-	SLO	CA			Break occurred in shutdown system
518	SCM8E2	SCM	8E2				House event "steam condensing with D20 makeup = true"
519	SCMSYS-HEPFTSVV	SCM	SYS	-HEPF	TSV	V	Operator Failure to Align for Steam Condensing
520	SCRCBLBT101FTOVV	SCR	CBL	BT101	FTO	VV	BETA FACTOR FOR FAILURE OF K101 TO OPEN
521	SCRCBLBT103FTOVV	SCR	CBL	BT103	FTO	VV	BETA FACTOR FOR K-103 FAIL TO OPEN
522	SCRCBLBTK06FTOVV	SCR	CBL	BTK06	FTO	VV	COMMON CAUSE BETA FACTOR FOR SCRAM BREAKERS K106-A, B, C
523	SCRCBLCM101FTOVV	SCR	CBL	CM101	FTO	VV	COMMON CAUSE POTENTIAL FOR BREAKERS K-101 FAIL TO OPEN
524	SCRCBLCM103FTOVV	SCR	CBL	CM103	FTO	VV	COMMON CAUSE POTENTIAL FOR K-103 BREAKERS FAIL TO OPEN
525	SCRCBLCMK06FTOVV	SCR	CBL	CMK06	FTO	VV	COMMON CAUSE POTENTIAL FOR 2/3 K106 BREAKERS FAIL TO OPEN
526	SCRCBLK101AFTOVV	SCR	CBL	K101A	FTO	VV	FAILURE OF K101A TO OPEN PER DEMAND
527	SCRCBLK101BFTOVV	SCR	CBL	K101B	FTO	VV	FAILURE OF BREAKER K101B TO OPEN PER DEMAND
528	SCRCBLK101CFTOVV	SCR	CBL	K101C	FTO	VV	FAILURE OF CIRCUIT BREAKER K101C TO OPEN PER DEMAND
529	SCRCBLK103AFTOVV	SCR	CBL	K103A	FTO	VV	FAILURE OF BREKER K103A TO OPEN PER DEMAND
530	SCRCBLK103BFTOVV	SCR	CBL	K103B	FTO	VV	FAILURE OF BREKER K103B TO OPEN PER DEMAND
531	SCRCBLK103CFTOVV	SCR	CBL	K103C	FTO	VV	FAILURE OF BREKER K103C TO OPEN PER DEMAND
532	SCRCBLK106AFTOVV	SCR	CBL	K106A	FTO	VV	FAILURE OF SCRAM BREAKER K106A TO OPEN PER DEMAND
533	SCRCBLK106BFTOVV	SCR	CBL	K106B	FTO	VV	FAILURE OF SCRAM BREAKER 106B TO OPEN PER DEMAND
534	SCRCBLK106CFTOVV	SCR	CBL	K106C	FTO	VV	FAILURE OF SCRAM BREAKER 106C TO OPEN PER EDEMAND
535	SCRCRDBTPRIOPFVV	SCR	CRD	BTPRI	OPF	VV	BETA FACTOR FOR 5 OUT OF 8 ROD MECHANICAL FAILURE
536	SCRCRDCMPRIOPFVV	SCR	CRD	CMPRI	OPF	VV	COMMON MODE POTENTIAL FOR MECH. FAILURE OF PRIM. ROD
537	SCREMLBTNSSFDOVV	SCR	EML	BTNSS	FDO	VV	BETA FACTOR FOR WIDE RANGE NSS SAFETY AMPLIFIER
538	SCREMLCMNSSFDOVV	SCR	EML	CMNSS	FDO	VV	COMMON MODE POTENTIAL FOR WIDE RANGE AMPLIFIER TO FAIL
539	SCREMLNSSCAFDOVV	SCR	EML	NSSCA	FDO	VV	FAILURE OF WIDE RANGE AMPLIFIER CHANNEL-A
540	SCREMLNSSCBFDOVV	SCR	EML	NSSCB	FDO	VV	FAILURE OF WIDE RANGE AMPLIFIER CHANNEL B
541	SCREMLNSSCCFDOVV	SCR	EML	NSSCC	FDO	VV	FAILURE OF WIDE RANGE AMPLIFIER CHANNEL C
542	SCRFTDFRA10FDOVV	SCR	FTD	FRA10	FDO	VV	FAILURE OF FLOW TRANSMITTER FRa100
543	SCRFTDGA01AFDOVV	SCR	FTD	GA01A	FDO	VV	FAILURE OF FLOW TRANSDUCER FOR GA101A
544	SCRFTDGA01BFDOVV	SCR	FTD	GA01B	FDO	VV	FAILURE OF FLOW TRANSDUCER FOR GA101B
545	SCRIZCNSSCAFDOVV	SCR	IZC	NSSCA	FDO	VV	FAILURE OF IONIZATION CHAMBER CHANNEL A
546	SCRIZCNSSCBFDOVV	SCR	IZC	NSSCB	FDO	VV	FAILURE OF IONIZATION CHAMBER CHANNEL B

Table B.1 (continued)

BASIC EVENTS SUMMARY REPORT (Alphabetical Sort)

Family: HFBR-PRA

Event Number	Basic Event Designator	System Code	Generic Comp. Type	Component ID	Fail. Mode	Component Location	Basic Event Description
547	SCRIZCNSSCCFDOVV	SCR	IZC	NSSCC	FDO	VV	FAILURE OF IONIZATION CHAMBER CHANNEL C
548	SCRPTDDA101FDOVV	SCR	PTD	DA101	FDO	VV	FAILURE OF CORE DELTA P TRANSDUCER Pda101
549	SCRPTDDA102FDOVV	SCR	PTD	DA102	FDO	VV	FAILURE OF CORE DELTA P TRANSDUCER Pda 102
550	SCRPTDDA103FDOVV	SCR	PTD	DA103	FDO	VV	FAILURE OF CORE DELTA P TRANSDUCER Pda-103
551	SCWALMP123XOPFCR	SCW	ALM	P123X	OPF	CR	Failure of low level alarm of P1, P2, and P-3 sump -IEEE 50
552	SCWALMP45XXOPFCR	SCW	ALM	P45XX	OPF	CR	Failure of low level alarm of P-4 and P-5 sump - IEEE 500
553	SCWAOVHEP12BFTEQ	SCW	AOV	HEP12	BFT	EQ	Dependency factor for operator inadvert. close WR-1 and WR-
554	SCWAOVWR-12BFTEQ	SCW	AOV	WR-12	BFT	EQ	Beta factor for AOV's WR-1 and WR-2 transfer closed
555	SCWAOVWR-12HEPEQ	SCW	AOV	WR-12	HEP	EQ	Any of WR-1 or WR-2 inadvertently closed by operators
556	SCWAOVWR-12SCZEQ	SCW	AOV	WR-12	SCZ	EQ	Any of WR-1 or WR-2 transfers closed
557	SCWAOVWR-1XHEPEQ	SCW	AOV	WR-1X	HEP	EQ	Air operated valve WR-1 inadvertently closed by operators
558	SCWAOVWR-1XSCZEQ	SCW	AOV	WR-1X	SCZ	EQ	AOV WR-1 transfers closed
559	SCWAOVWR-2XHEPEQ	SCW	AOV	WR-2X	HEP	EQ	AOV WR-2 inadvertently closed by operators
560	SCWAOVWR-2XSCZEQ	SCW	AOV	WR-2X	SCZ	EQ	AOV WR-2 transfers closed
561	SCWAOVWR-3XHEPEQ	SCW	AOV	WR-3X	HEP	EQ	AOV WR-3 inadvertently closed by operators
562	SCWAOVWR-3XSCZEQ	SCW	AOV	WR-3X	SCZ	EQ	AOV WR-3 transfers closed
563	SCWBRKP-4BKFOPPH	SCW	BRK	P-4BK	FOP	PH	Pump P-4 breaker fails open
564	SCWBRKP-5BKFOPPH	SCW	BRK	P-5BK	FOP	PH	Pump P-5 breaker fails open
565	SCWCBRP-1XXOPFPH	SCW	CBR	P-1XX	OPF	PH	Pump P-1 breaker fails open
566	SCWCBRP-2XXOPFPH	SCW	CBR	P-2XX	OPF	PH	Pump P-2 breaker fails open
567	SCWCBRP-3XXOPFPH	SCW	CBR	P-3XX	OPF	PH	Pump P-3 breaker fails open
568	SCWCKVBETAFFTOPH	SCW	CKV	BETAF	FTO	PH	Beta factor for check valves fail to open
569	SCWCKVCV-D1FTOPH	SCW	CKV	CV-D1	FTO	PH	Check valve near MNV D1 fails to open (fails closed)
570	SCWCKVCV-D1ILKPH	SCW	CKV	CV-D1	ILK	PH	Gross internal leakage of check valve near MNV D1
571	SCWCKVCV-D2FTOPH	SCW	CKV	CV-D2	FTO	PH	Check valve near MNV D2 fails to open (fails closed)
572	SCWCKVCV-D2ILKPH	SCW	CKV	CV-D2	ILK	PH	Gross internal leakage of check valve near MNV D2
573	SCWCKVCV-D3FTOPH	SCW	CKV	CV-D3	FTO	PH	Check valve near MNV D3 fails to open (fails closed)
574	SCWCKVCV-D3ILKPH	SCW	CKV	CV-D3	ILK	PH	Gross internal leakage of check valve near MNV D3
575	SCWCKVCVXXXFTOPH	SCW	CKV	CVXXX	FTO	PH	Common-mode failure between check valves near D1, D2, and D
576	SCWCKVFWCKVFTOEQ	SCW	CKV	FWCKV	FTO	EQ	Check valve on fire water line fails to open
577	SCWCKVWR-15FTOEQ	SCW	CKV	WR-15	FTO	EQ	Check valve near WR-15 fails to open
578	SCWCKVWS-20FTOPH	SCW	CKV	WS-20	FTO	PH	Check valve after WS-20 fails closed (fails to open)
579	SCWCKVWS-20ILKPH	SCW	CKV	WS-20	ILK	PH	Gross internal leakage through check valve after WS-20
580	SCWCKVWS-3XILKEQ	SCW	CKV	WS-3X	ILK	EQ	Gross internal leakage through check valve after WS-3
581	SCWCONFIREAOPFXX	SCW	CON	FIREA	OPF	XX	Failure of fire water connection A (???)
582	SCWCONFIREBOPFXX	SCW	CON	FIREB	OPF	XX	Failure of fire water connection B (???)
583	SCWCOOE101ASSLEQ	SCW	COO	E101A	SSL	EQ	Shell side leak through cooler EA-101A
584	SCWCOOE101BSSLEQ	SCW	COO	E101B	SSL	EQ	Shell side leak on cooler EA-101B
585	SCWFLSNOACTHEPCT	SCW	FLS	NOACT	HEP	CT	Operators do not take action to unclog flume screens
586	SCWFLSP-45XHEPCT	SCW	FLS	P-45X	HEP	CT	Operators inadvertently shutdown any of P-4 or P-5 pumps
587	SCWFLSP123XCLGCT	SCW	FLS	P123X	CLG	CT	Flume screen clogged on sump of pumps P-1, P-2, and P_3
588	SCWFLSP45XXCLGPH	SCW	FLS	P45XX	CLG	PH	Flume screen clogged on sump of pumps P-4 and P-5

Table B.1 (continued)

BASIC EVENTS SUMMARY REPORT (Alphabetical Sort)

Family: HFBR-PRA

Event Number	Basic Event Designator	System Code	Generic Comp. Type	Component ID	Fail. Mode	Component Location	Basic Event Description
589	SCWLCVMCV-1FTCPH	SCW	LCV	MCV-1	FTC	PH	Air operated CT level control valve fails to close
590	SCWLTDP123XOPFPH	SCW	LTD	P123X	OPF	PH	Failure of level sensor of P1, P2, and P3 sump
591	SCWLTDP45XXOPFCT	SCW	LTD	P45XX	OPF	CT	Failure of level alarm of P4 and P5 sump
592	SCWMNVBETAFFTOPH	SCW	MNV	BETAF	FTO	PH	Beta factor for MNV D1, D2, and D3 fail to open
593	SCWMNVD-123FTOPH	SCW	MNV	D-123	FTO	PH	Manual valve (any of D1, D2, D3) fails to open (common mode)
594	SCWMNVD-1XXFTOPH	SCW	MNV	D-1XX	FTO	PH	Manual valve D1 fails to open (fails closed)
595	SCWMNVD-2XXFTOPH	SCW	MNV	D-2XX	FTO	PH	Manual valve D2 fails to open (fails closed)
596	SCWMNVD-3XXFTOPH	SCW	MNV	D-3XX	FTO	PH	Manual valve D3 fails to open (fails closed)
597	SCWMNVD1XXXFTCPH	SCW	MNV	D1XXX	FTC	PH	Manual valve D1 fails to close (fails open)
598	SCWMNVD1XXXHEPPH	SCW	MNV	D1XXX	HEP	PH	Operators do not close valve D1
599	SCWMNVD2XXXFTCPH	SCW	MNV	D2XXX	FTC	PH	Manual valve D2 fails to close (fails open)
600	SCWMNVD2XXXHEPPH	SCW	MNV	D2XXX	HEP	PH	Operators do not close valve D2
601	SCWMNVD3XXXFTCPH	SCW	MNV	D3XXX	FTC	PH	Manual valve D3 fails to close (fails open)
602	SCWMNVD3XXXHEPPH	SCW	MNV	D3XXX	HEP	PH	Operators do not close valve D3
603	SCWMNVDW-1XFTOEQ	SCW	MNV	DW-1X	FTO	EQ	Manual valve DW-1 fails to open (fails closed)
604	SCWMNVDW-1XHEPEQ	SCW	MNV	DW-1X	HEP	EQ	Operators do not open valve DW-1
605	SCWMNVMV-25FTCPH	SCW	MNV	MV-25	FTC	PH	Manual valve MV-25 fails to close (fails open)
606	SCWMNVMV-25HEPPH	SCW	MNV	MV-25	HEP	PH	Operators do not close valve 25
607	SCWMNVMV-29FTOPH	SCW	MNV	MV-29	FTO	PH	Manual valve 29 fails to open (fails closed)
608	SCWMNVW1418HEPEQ	SCW	MNV	W1418	HEP	EQ	Operators fail to establish return flow path (EA-103)
609	SCWMNVW19FOHEPXX	SCW	MNV	W19FO	HEP	XX	Operators do not open valve 19
610	SCWMNVW8-19HEPEQ	SCW	MNV	W8-19	HEP	EQ	Operators fail to establish return flow path (EA-101A)
611	SCWMNVW9-20HEPEQ	SCW	MNV	W9-20	HEP	EQ	Operators fail to establish return flow path (EA-101B)
612	SCWMNVWR-14FTOEQ	SCW	MNV	WR-14	FTO	EQ	Manual valve WR-14 fails to open (fails closed)
613	SCWMNVWR-14HEPEQ	SCW	MNV	WR-14	HEP	EQ	Operators do not open WR-14
614	SCWMNVWR-15HEPEQ	SCW	MNV	WR-15	HEP	EQ	Operators do not open WR-15
615	SCWMNVWR-18FTOEQ	SCW	MNV	WR-18	FTO	EQ	Manual valve WR-18 fails to open
616	SCWMNVWR-18HEPEQ	SCW	MNV	WR-18	HEP	EQ	Operators do not open valve WR-18
617	SCWMNVWR-19FTOEQ	SCW	MNV	WR-19	FTO	EQ	Manual valve WR-19 fails to open (fails closed)
618	SCWMNVWR-20FTOEQ	SCW	MNV	WR-20	FTO	EQ	Manual valve WR-20 fails to open (fails closed)
619	SCWMNVWR-8XFTOEQ	SCW	MNV	WR-8X	FTO	EQ	Manual valve WR-8 fails to open (fails closed)
620	SCWMNVWR-9XFTOEQ	SCW	MNV	WR-9X	FTO	EQ	Manual valve WR-9 fails to open (fails closed)
621	SCWMNVWS-19FTOXX	SCW	MNV	WS-19	FTO	XX	Manual valve WS-19 fails to open (fails closed)
622	SCWMNVWS-20FTCPH	SCW	MNV	WS-20	FTC	PH	Manual valve WS-20 fails to close (fails open)
623	SCWMNVWS-20HEPPH	SCW	MNV	WS-20	HEP	PH	Operators do not close valve WS-20
624	SCWMOVHEP12BFTEQ	SCW	MOV	HEP12	BFT	EQ	Beta factor for operators inadvert. closing both WS-1 & WS-2
625	SCWMOVWS-12BFTEQ	SCW	MOV	WS-12	BFT	EQ	Beta factor for spurious closure of WS-1 and WS-2
626	SCWMOVWS-12HEPEQ	SCW	MOV	WS-12	HEP	EQ	Operators inadvertently close any of WS-1 or WS-2
627	SCWMOVWS-12SCZEQ	SCW	MOV	WS-12	SCZ	EQ	Spurious closure of any of WS-1 or WS-2
628	SCWMOVWS-1XHEPEQ	SCW	MOV	WS-1X	HEP	EQ	Operator inadvertently closes WS-1
629	SCWMOVWS-1XSCZEQ	SCW	MOV	WS-1X	SCZ	EQ	Spurious closure of MOV WS-1 (EA101-A cooler supply)
630	SCWMOVWS-2XHEPEQ	SCW	MOV	WS-2X	HEP	EQ	Operator inadvertently closes WS-2

Table B.1 (continued)

BASIC EVENTS SUMMARY REPORT (Alphabetical Sort)

Family: HFBR-PRA

Event Number	Basic Event Designator	System Code	Generic Comp. Type	Component ID	Fail. Mode	Component Location	Basic Event Description
631	SCWMOVWS-2XSCZEQ	SCW	MOV	WS-2X	SCZ	EQ	Spurious closure of MOV WS-2
632	SCWMOVWS-3XFTCEQ	SCW	MOV	WS-3X	FTC	EQ	MOV WS-3 fails to close
633	SCWMOVWS-3XHEPEQ	SCW	MOV	WS-3X	HEP	EQ	Operators inadvertently closes WS-3
634	SCWMOVWS-3XSCZEQ	SCW	MOV	WS-3X	SCZ	EQ	Spurious closure of MOV WS-3
635	SCWMOVWS-3XSPOEQ	SCW	MOV	WS-3X	SPO	EQ	Spurious opening of WS-3 (transfers open).
636	SCWMOVWS3FCHEPEQ	SCW	MOV	WS3FC	HEP	EQ	Operators fail to close WS-3
637	SCWPMPBETAFFTRPH	SCW	PMP	BETAF	FTR	PH	Beta factor for pumps P1, P2, and P3 fail to run
638	SCWPMPBETAFFTSPH	SCW	PMP	BETAF	FTS	PH	Beta factor for pumps P1, P2, and P3 fail to start
639	SCWPMPHEPXXBFTPH	SCW	PMP	HEPXX	BFT	PH	Beta factor for operators fail to put all three pumps onli
640	SCWPMPP-123HEPPH	SCW	PMP	P-123	HEP	PH	Beta factor for all three discharge valves left closed
641	SCWPMPP-1XXFTRPH	SCW	PMP	P-1XX	FTR	PH	Pump P-1 fails to run
642	SCWPMPP-1XXFTSPH	SCW	PMP	P-1XX	FTS	PH	Pump P-1 fails to start
643	SCWPMPP-1XXHEPPH	SCW	PMP	P-1XX	HEP	PH	Operators do not put pump P-1 on line
644	SCWPMPP-1XXUTMPH	SCW	PMP	P-1XX	UTM	PH	Unavailability of pump P-1 due to test and maintenance (??
645	SCWPMPP-2XXFTRPH	SCW	PMP	P-2XX	FTR	PH	Pump P-2 fails to run
646	SCWPMPP-2XXFTSPH	SCW	PMP	P-2XX	FTS	PH	Pump P-2 fail to start
647	SCWPMPP-2XXHEPPH	SCW	PMP	P-2XX	HEP	PH	Operators do not put pump P-2 on line
648	SCWPMPP-2XXUTMPH	SCW	PMP	P-2XX	UTM	PH	Unavailability of pump P-2 due to test and maintenance (??
649	SCWPMPP-3XXFTRPH	SCW	PMP	P-3XX	FTR	PH	Pump P-3 fails to run
650	SCWPMPP-3XXFTSPH	SCW	PMP	P-3XX	FTS	PH	Pump P-3 fails to start
651	SCWPMPP-3XXHEPPH	SCW	PMP	P-3XX	HEP	PH	Operators do not put pump P-3 on line
652	SCWPMPP-3XXUTMPH	SCW	PMP	P-3XX	UTM	PH	Unavailability of pump P-3 due to test and maintenance (??
653	SCWPMPP-4XXFTRPH	SCW	PMP	P-4XX	FTR	PH	Pump P-4 fails to run
654	SCWPMPP-4XXHEPPH	SCW	PMP	P-4XX	HEP	PH	Operators inadvertently shut off pump P-4
655	SCWPMPP-5XXFTRPH	SCW	PMP	P-5XX	FTR	PH	Pump P-5 fails to run
656	SCWPMPP-5XXHEPPH	SCW	PMP	P-5XX	HEP	PH	Operators inadvertently shut off pump P-5
657	SCWPMPP123XFTRPH	SCW	PMP	P123X	FTR	PH	Any of pumps P-1, P-2, and P-3 fail to run
658	SCWPMPP123XFTSPH	SCW	PMP	P123X	FTS	PH	Any of pumps P-1, P-2, and P-3 fail to start (common mode)
659	SCWPMPP45BFFTRPH	SCW	PMP	P45BF	FTR	PH	Beta factor for pumps P-4 and P-5 fail to run
660	SCWPMPP45XXFTRPH	SCW	PMP	P45XX	FTR	PH	Any of pumps P-4 and P-5 fail to run
661	SCWSWMP-1XXOPFPH	SCW	SWM	P-1XX	OPF	PH	Failure of manual electric switch of pump P-1
662	SCWSWMP-2XXOPFPH	SCW	SWM	P-2XX	OPF	PH	Failure of manual electric switch of Pump P-2
663	SCWSWMP-3XXOPFPH	SCW	SWM	P-3XX	OPF	PH	Failure of manual electric switch of pump P-3
664	SCWTNKFA309HEPPH	SCW	TNK	FA309	HEP	PH	Operators fail to establish flow path from tank FA-309
665	SD3BRKG102ASOZEQ	SD3	BRK	G102A	SOZ	EQ	Running pump dc supply breaker fails open
666	SD3BRKG102BSOZEQ	SD3	BRK	G102B	SOZ	EQ	Standby pump dc supply breaker fails open
667	SD3BRKRECTFSOZEQ	SD3	BRK	RECTF	SOZ	EQ	Rectifier breaker fails open
668	SD3CKVFRVLNFTOEQ	SD3	CKV	FRVLN	FTO	EQ	Check valve on line to flow reversal valves fails to open
669	SD3CKVP100XFTOEQ	SD3	CKV	P100X	FTO	EQ	Check valve P100 fails to open (3 min)
670	SD3CKVP97XXILKEQ	SD3	CKV	P97XX	ILK	EQ	Gross internal leakage through check valve P97
671	SD3CKVP98XXFTOEQ	SD3	CKV	P98XX	FTO	EQ	Check valve P98 fails to open (3 min)
672	SD3CKVP99XXILKEQ	SD3	CKV	P99XX	ILK	EQ	Gross internal leakage through check valve P-99

Table B.1 (continued)

BASIC EVENTS SUMMARY REPORT (Alphabetical Sort)

Family: HFBR-PRA

Event Number	Basic Event Designator	System Code	Generic Comp. Type	Component ID	Fail. Mode	Component Location	Basic Event Description
673	SD3LOLOLEVLSATEQ	SD3	LOL	OLEVL	SAT	EQ	Spurious actuation of low-low level during transient (3 min)
674	SD3MNVP100XHEPEQ	SD3	MNV	P100X	HEP	EQ	Manual valve P100 left open
675	SD3MNVP98XXHEPEQ	SD3	MNV	P98XX	HEP	EQ	Manual valve P98 left closed
676	SD3PMPG102AFTREQ	SD3	PMP	G102A	FTR	EQ	Pump GA-102A fails to run (3 min)
677	SD3PMPG102BFTSEQ	SD3	PMP	G102B	FTS	EQ	Pump Ga-102B fails to start
678	SD3PMPG102BUTMEQ	SD3	PMP	G102B	UTM	EQ	Standby pump unavailable due to maintenance
679	SD3RLYG102BFTOEQ	SD3	RLY	G102B	FTO	EQ	Relay fails to close contacts on demand (stby pump switch)
680	SD3RTFG102AFDOEQ	SD3	RTF	G102A	FDO	EQ	Rectifier fails during operation (same as battery charger)
681	SD3RTFG102AUTMEQ	SD3	RTF	G102A	UTM	EQ	Rectifier unavailable due to maintenance
682	SD3SWICONSLHEPCR	SD3	SWI	CONSL	HEP	CR	console switched to off
683	SD3SWIG102ASOZEQ	SD3	SWI	G102A	SOZ	EQ	Running pump EMCC disconnect switch fails open
684	SD3SWIG102BLO-EQ	SD3	SWI	G102B	LO-	EQ	Standby pump switch local disconnect (left) open
685	SD3SWINHANDHEPCR	SD3	SWI	NHAND	HEP	CR	Operators do not put console switch in "HAND"
686	SD3TFSG102AFDOEQ	SD3	TFS	G102A	FDO	EQ	Running pump transfer switch fails during oper. (SOZ-relays)
687	SD3TFSG102AOPFEQ	SD3	TFS	G102A	OPF	EQ	Running pump transfer switch fails to transfer
688	SD3TFSG102BFDOEQ	SD3	TFS	G102B	FDO	EQ	Standby pump transfer switch fails during oper. (SOZ-relays)
689	SDCCBLDRMTRFDOEQ	SDC	CBL	DRMTR	FDO	EQ	sd cooler cell door motor breaker fails open
690	SDCCELDRMTRFTSEQ	SDC	CEL	DRMTR	FTS	EQ	sd cooler cell door motor fails to start
691	SDCMNV--P95FTCEQ	SDC	MNV	--P95	FTC	EQ	sd pump valve p95 fails to close
692	SDCMNV--P96FTCEQ	SDC	MNV	--P96	FTC	EQ	sd pump valve p96 fails to close
693	SDCMNV--P97FTCEQ	SDC	MNV	--P97	FTC	EQ	sd pump valve p97 fails to close
694	SDCMNV--P99FTCEQ	SDC	MNV	--P99	FTC	EQ	sd pump valve p99 fails to close
695	SDCMNV-BETAFTCEQ	SDC	MNV	-BETA	FTC	EQ	beta factor for SD pump isolation valves ftc
696	SDCMNV-P101FTCEQ	SDC	MNV	-P101	FTC	EQ	Bypass Valve P101 Fail to Close
697	SDCMNV-PXXXFTCEQ	SDC	MNV	-PXXX	FTC	EQ	random failure of one SD pump isolation valve
698	SDCSCMSYS--UTMVV	SDC	SCM	SYS--	UTM	VV	sdc scm test and maintenance unavailability
699	SDLBRKG102ASOZEQ	SDL	BRK	G102A	SOZ	EQ	Running pump DC supply breaker fails open
700	SDLBRKG102BSOZEQ	SDL	BRK	G102B	SOZ	EQ	Standby pump DC supply breaker fails open
701	SDLBRKRECTFSOZEQ	SDL	BRK	RECTF	SOZ	EQ	Running pump rectifier breaker fails open
702	SDLCKVP97XXILKEQ	SDL	CKV	P97XX	ILK	EQ	Gross internal leakage through check valve P97
703	SDLCKVP99XXILKEQ	SDL	CKV	P99XX	ILK	EQ	Gross internal leakage through check valve P99
704	SDLLOLOLEVLSATEQ	SDL	LOL	OLEVL	SAT	EQ	Spurious actuation of low-low level during transient
705	SDLPMPG102AFTREQ	SDL	PMP	G102A	FTR	EQ	Pump GA-102A fails to run
706	SDLPMPG102BFTREQ	SDL	PMP	G102B	FTR	EQ	Standby pump fails to run
707	SDLPMPG102BFTSEQ	SDL	PMP	G102B	FTS	EQ	Pump GA-102B fails to start
708	SDLPMPG102BSBGEQ	SDL	PMP	G102B	SBG	EQ	Steam binding of standby pump
709	SDLPMPNOVNTHEPEQ	SDL	PMP	NOVNT	HEP	EQ	Pump casing not vented by the operators (gas binding)
710	SDLRLYG102BFTOEQ	SDL	RLY	G102B	FTO	EQ	Relay fails to close contact on demand (stby pump switch)
711	SDLRTFG102AFDOEQ	SDL	RTF	G102A	FDO	EQ	Rectifier fails during operation
712	SDLSWICONSLHEPCR	SDL	SWI	CONSL	HEP	CR	console switched to off
713	SDLSWIG102ASOZEQ	SDL	SWI	G102A	SOZ	EQ	Running pump EMCC disconnect switch fails open
714	SDLSWIG102BLO-EQ	SDL	SWI	G102B	LO-	EQ	Standby pump local disconnect switch left open

Table B.1 (continued)

BASIC EVENTS SUMMARY REPORT (Alphabetical Sort)

Family: HFBR-PRA

Event Number	Basic Event Designator	System Code	Generic Comp. Type	Component ID	Fail. Mode	Component Location	Basic Event Description
715	SDLSWINHANDHEPCR	SDL	SWI	NHAND	HEP	CR	Operators do not put standby pump console switch in "HAND"
716	SDLTFSG102AFDOEQ	SDL	TFS	G102A	FDO	EQ	Running pump transfer switch fails during operation
717	SDLTFSG102AOPFEQ	SDL	TFS	G102A	OPF	EQ	Running pump transfer switch fails to transfer
718	SDLTFSG102BFDOEQ	SDL	TFS	G102B	FDO	EQ	Standby pump transfer switch fails

Appendix B.2
List of Human Error Basic Events

Table B.2

HUMAN ERROR BASIC EVENTS SUMMARY REPORT

Family: HFBR-PRA

Event Number	Basic Event Designator	System Code	Generic Comp. Type	Component ID	Fail. Mode	Component Location	Basic Event Description
32	ACPCBHHFBRTHEPEQ	ACP	CBH	HFBRT	HEP	EQ	Shift Doesn't Shut HFBR Bus #2 to Bus #1 Tie BKR
56	ACPCBLRBSETHEPEQ	ACP	CBL	RBSET	HEP	EQ	Shift Doesn't Shut Exp. Bus to R&BS Bus Tie BKR
75	ACPTFHXMFR2HEPFH	ACP	TFH	XMFR2	HEP	FH	Shift Doesn't Place #2 13.8/2.4 kv XMFR Online
82	ACPTFLXMFR3HEPEQ	ACP	TFL	XMFR3	HEP	EQ	Shift Doesn't Place #3 2.4kv/480v XMFR Online
90	AIRCPSG301CHEPEQ	AIR	CPS	G301C	HEP	EQ	GB301C Not Started by Shift
97	AIRCPSSTBYYHEPEQ	AIR	CPS	STBYY	HEP	EQ	Operator Doesn't Place "STBY" Compressor to "RUN"
105	AIRHXZE302XHEPEQ	AIR	HXZ	E302X	HEP	EQ	Aftercooler Clogged
108	AIRMNVAR101HEPEQ	AIR	MNV	AR101	HEP	EQ	Operator Fails to Open Manual Valve AR101
112	AIRMNVAR104HEPEQ	AIR	MNV	AR104	HEP	EQ	Operator Fails to Open AR104
115	AIRMNVAR14-HEPEQ	AIR	MNV	AR14-	HEP	EQ	Manual Valve AR14 Left Closed
117	AIRMNVAR14AHEPEQ	AIR	MNV	AR14A	HEP	EQ	Manual Valve AR14A Left Closed
123	AIRMNVAR17-HEPEQ	AIR	MNV	AR17-	HEP	EQ	Operator Fails to Open AR17
128	AIRMNVAR21-HEPEQ	AIR	MNV	AR21-	HEP	EQ	Operator Fails to Open AR21
132	AIRMNVAR24-HEPEQ	AIR	MNV	AR24-	HEP	EQ	Operator Fails To Open AR24
133	AIRMNVAR45AHEPVV	AIR	MNV	AR45A	HEP	VV	Valve AR45a mispositioned
135	AIRMNVAR45BHEPVV	AIR	MNV	AR45B	HEP	VV	air MNV AR45B mispositioned
142	AIRMNVAR80-HEPEQ	AIR	MNV	AR80-	HEP	EQ	Operator Fails to Open AR80
146	AIRMNVAR83-HEPEQ	AIR	MNV	AR83-	HEP	EQ	Operator Fails to Open AR83
150	AIRMNVAR87-HEPEQ	AIR	MNV	AR87-	HEP	EQ	Operator Fails to Open AR87
152	AIRMOVLCLOPHEPVV	AIR	MOV	LCLOP	HEP	VV	Operator Fails to Operated Manually
195	DCPCGROFLINHEPFH	DCP	CGR	OFLIN	HEP	FH	Shift Doesn't Place Charger Online
201	DEPAOV300ABHEPOP	DEP	AOV	300AB	HEP	OP	OPERATOR FAIL TO OPEN ANY OF THE STEAM VENT VALVES
217	DEPMNVP102XHEPOP	DEP	MNV	P102X	HEP	OP	OPERATOR FAILS TO OPEN P-102 VALVE
227	DMWMNVDW29BHEPEQ	DMW	MNV	DW29B	HEP	EQ	Operator Fails to Open DW29B
234	DMWMNVDW48-HEPEQ	DMW	MNV	DW48-	HEP	EQ	Operator Fails to Open DW48
276	HWD-CLRAHEPFTSVV	HWD	-CL	RAHEP	FTS	VV	Operator fails to Align for Draining Cooler A
277	HWD-CLRBHEPFTSVV	HWD	-CL	RBHEP	FTS	VV	Operator fails to Align for Draining Cooler B
287	HWTALIGN---HEPVV	HWT	ALI	GN---	HEP	VV	Operator Fails to Align in time (subseq injectn @ 1.5 hrs)
288	HWTALIGN3HRHEPVV	HWT	ALI	GN3HR	HEP	VV	Operator Fails to Align in 3 Hours(subseq injectn @ 1.5 hrs)
297	HWTLTM90HESHEPVV	HWT	LTM	90HES	HEP	VV	oper fails to trans D20 w/helium in 90 min from fa101
298	HWTLTM90PMPHEPVV	HWT	LTM	90PMP	HEP	VV	oper fails to trans D20 w/ pumps in 90 min from fa101
299	HWTMNV--CD3HEPEQ	HWT	MNV	--CD3	HEP	EQ	Valve CD3 Open
300	HWTMNV--CD4HEPEQ	HWT	MNV	--CD4	HEP	EQ	Valve CD4 Open
301	HWTMNV-DA7-HEPEQ	HWT	MNV	-DA7-	HEP	EQ	HWT DA7 valve Left Open
303	HWTMNV-P02-HEPOP	HWT	MNV	-P02-	HEP	OP	Operator Fails to Close P02
306	HWTMNV-P122HEPEQ	HWT	MNV	-P122	HEP	EQ	operator fails to close valve p122
317	HWTMNV-P53-HEPEQ	HWT	MNV	-P53-	HEP	EQ	Valve P53 Left Open
319	HWTMNV-P54-HEPEQ	HWT	MNV	-P54-	HEP	EQ	Valve P54 Left Open
320	HWTMNV-P55-HEPEQ	HWT	MNV	-P55-	HEP	EQ	Valve P55 Left Open
322	HWTMNV-P56-HEPEQ	HWT	MNV	-P56-	HEP	EQ	Valve P56 Left Open
324	HWTMNV-P57-HEPEQ	HWT	MNV	-P57-	HEP	EQ	Valve P57 Left Open
460	PWSSLWM-HEP-ALNVV	PWS	LWM	-HEP-	ALN	VV	failure to align pws correctly

Table B.2 (Continued)

HUMAN ERROR BASIC EVENTS SUMMARY REPORT

Family: HFBR-PRA

Event Number	Basic Event Designator	System Code	Generic Comp. Type	Component ID	Fail. Mode	Component Location	Basic Event Description
461	PWSMNV-P110HEPOP	PWS	MNV	-P110	HEP	OP	valve p110 is not closed by the operator(incl in top hep)
465	PWSMNV-P134HEPVV	PWS	MNV	-P134	HEP	VV	operator fails to correct diversion
470	PWSMNV-TW27HEPOP	PWS	MNV	-TW27	HEP	OP	valve tw27 (tank vent) inadvertantly left open
475	PWSSYS--HEPFTSVV	PWS	SYS	--HEP	FTS	VV	operator reluctance to initiate pws
476	PWSSYS-HEP-ALNVV	PWS	SYS	-HEP-	ALN	VV	failure to align the pws correctly
477	PWSSYS-HEP-WSHVV	PWS	SYS	-HEP-	WSH	VV	pw washout post loca (operator fails to control level)
487	REFELMTIMPRHEPVV	REF	ELM	TIMPR	HEP	VV	element is improperly hooked
488	REFELMTLOOSHEPVV	REF	ELM	TLOOS	HEP	VV	stuck element can not be knocked loosed
490	REFELMTRENDHEPVV	REF	ELM	TREND	HEP	VV	can't return the element to canal/vessel(no mech failure)
492	REFFANFHBNSHEPVV	REF	FAN	FHBNS	HEP	VV	fuel handeling blower (FHB) not started (per refueling/14)
499	REFHOKOPENXHEPVV	REF	HOK	OPENX	HEP	VV	inadvertant opening of the hook pickup head
501	REFINBONNETHEPVV	REF	INB	ONNET	HEP	VV	element not fully raised in to bonnet(therefore not cooled)
504	REFMNVNOTOPHEPVV	REF	MNV	NOTOP	HEP	VV	air butterfly valve not opened by operator(per refueling/14
510	REFSLDJMMEDHEPVV	REF	SLD	JMMED	HEP	VV	element not raised enough then slide jammed
513	REFWLMTREWDHEPVV	REF	WLM	TREWD	HEP	VV	can't return element to canal/vessel(mech. failures present
515	S3LMNVP100XHEPEQ	S3L	MNV	P100X	HEP	EQ	Manual valve P100 left closed
519	SCMSYS-HEPFTSVV	SCM	SYS	-HEPF	TSV	V	Operator fails to align for steam condensing
553	SCWAOVHEP12BFTEQ	SCW	AOV	HEP12	BFT	EQ	Dependency factor for operator inadver. close WR-1 and WR-2
555	SCWAOVWR-12HEPEQ	SCW	AOV	WR-12	HEP	EQ	Any of WR-1 or WR-2 inadvertently closed by operators
557	SCWAOVWR-1XHEPEQ	SCW	AOV	WR-1X	HEP	EQ	Air operated valve WR-1 inadvertently closed by operators
559	SCWAOVWR-2XHEPEQ	SCW	AOV	WR-2X	HEP	EQ	AOV WR-2 inadvertently closed by operators
561	SCWAOVWR-3XHEPEQ	SCW	AOV	WR-3X	HEP	EQ	AOV WR-3 inadvertently closed by operators
585	SCWFLSNOACTHEPCT	SCW	FLS	NOACT	HEP	CT	Operators do not take action to unclog flume screens
586	SCWFLSP-45XHEPCT	SCW	FLS	P-45X	HEP	CT	Operators inadvertently shutdown any of P-4 or P-5 pumps
598	SCWMNVD1XXXHEPPH	SCW	MNV	D1XXX	HEP	PH	Operators do not close valve D1
600	SCWMNVD2XXXHEPPH	SCW	MNV	D2XXX	HEP	PH	Operators do not close valve D2
602	SCWMNVD3XXXHEPPH	SCW	MNV	D3XXX	HEP	PH	Operators do not close valve D3
604	SCWMNVDW-1XHEPEQ	SCW	MNV	DW-1X	HEP	EQ	Operators do not open valve DW-1
606	SCWMNVMV-25HEPPH	SCW	MNV	MV-25	HEP	PH	Operators do not close valve 25
608	SCWMNVW1418HEPEQ	SCW	MNV	W1418	HEP	EQ	Operators fail to establish return flow path (EA-103)
609	SCWMNVW19FOHEPXX	SCW	MNV	W19FO	HEP	XX	Operators do not open valve 19
610	SCWMNVW8-19HEPEQ	SCW	MNV	W8-19	HEP	EQ	Operators fail to establish return flow path (EA-101A)
611	SCWMNVW9-20HEPEQ	SCW	MNV	W9-20	HEP	EQ	Operators fail to establish return flow path (EA-101B)
613	SCWMNVWR-14HEPEQ	SCW	MNV	WR-14	HEP	EQ	Operators do not open WR-14
614	SCWMNVWR-15HEPEQ	SCW	MNV	WR-15	HEP	EQ	Operators do not open WR-15
616	SCWMNVWR-18HEPEQ	SCW	MNV	WR-18	HEP	EQ	Operators do not open valve WR-18
623	SCWMNVWS-20HEPPH	SCW	MNV	WS-20	HEP	PH	Operators do not close valve WS-20
624	SCWMOVHEP12BFTEQ	SCW	MOV	HEP12	BFT	EQ	Beta factor for operators inadvert. closing both WS-1 & WS
626	SCWMOVWS-12HEPEQ	SCW	MOV	WS-12	HEP	EQ	Operators inadvertently close any of WS-1 or WS-2
628	SCWMOVWS-1XHEPEQ	SCW	MOV	WS-1X	HEP	EQ	Operator inadvertently closes WS-1
630	SCWMOVWS-2XHEPEQ	SCW	MOV	WS-2X	HEP	EQ	Operator inadvertently closes WS-2
633	SCWMOVWS-3XHEPEQ	SCW	MOV	WS-3X	HEP	EQ	Operators inadvertently closes WS-3

Table B.2 (Continued)

HUMAN ERROR BASIC EVENTS SUMMARY REPORT

Family: HFBR-PRA

Event Number	Basic Event Designator	System Code	Generic Comp. Type	Component ID	Fail. Mode	Component Location	Basic Event Description
636	SCWMOVWS3FCHEPEQ	SCW	MOV	WS3FC	HEP	EQ	Operators fail to close WS-3
639	SCWPMPHEPXXBFTPH	SCW	PMP	HEPXX	BFT	PH	Beta factor for operators to fail to put all three pumps onl
640	SCWPMPP-123HEPPH	SCW	PMP	P-123	HEP	PH	Beta factor for all three discharge valves left closed
643	SCWPMPP-1XXHEPPH	SCW	PMP	P-1XX	HEP	PH	Operators do not put pump P-1 on line
647	SCWPMPP-2XXHEPPH	SCW	PMP	P-2XX	HEP	PH	Operators do not put pump P-2 on line
651	SCWPMPP-3XXHEPPH	SCW	PMP	P-3XX	HEP	PH	Operators do not put pump P-3 on line
654	SCWPMPP-4XXHEPPH	SCW	PMP	P-4XX	HEP	PH	Operators inadvertently shut off pump P-4
656	SCWPMPP-5XXHEPPH	SCW	PMP	P-5XX	HEP	PH	Operators inadvertently shut off pump P-5
664	SCWTNKFA309HEPPH	SCW	TNK	FA309	HEP	PH	Operators fail to establish flow path from tank FA-309
674	SD3MNVP100XHEPEQ	SD3	MNV	P100X	HEP	EQ	Manual valve P100 left open
675	SD3MNVP98XXHEPEQ	SD3	MNV	P98XX	HEP	EQ	Manual valve P98 left closed
682	SD3SWICONSLHEPCR	SD3	SWI	CONSL	HEP	CR	console switched to off
685	SD3SWINHANDHEPCR	SD3	SWI	NHAND	HEP	CR	Operators do not put console switch in "HAND"
709	SDLPMPNOVNTHEPEQ	SDL	PMP	NOVNT	HEP	EQ	Pump casing not vented by the operators (gas binding)
712	SDLSWICONSLHEPCR	SDL	SWI	CONSL	HEP	CR	console switched to off
715	SDLSWINHANDHEPCR	SDL	SWI	NHAND	HEP	CR	Operators do not put standby pump console switch in "HAND"

Appendix B.3
Internal PRA Basic Events Affected by Tornado Induced Failures and the Fault Trees (Systems) Where They Appear

Table B.3 Internal PRA Basic Events Affected by Tornado Induced Failures and the Fault Trees (Systems) Where They Appear

EVENT-SYSTEM LOGIC REFERENCE REPORT

FAMILY: HFBR-TOR

SYSTEM NAME	BASIC EVENT	TORNADO BASIC EVENT
DCBKR28, DCBKR283	DCPCBHBAT1BSOZFH	TOR-S60-FMIS
DCBKR28, DCBKR283	DCPCBHBAT2BSOZFH	TOR-S60-FMIS
DCBKR28, DCBKR283	DCPBTRBATT1FDOFH	TOR-S09-FMIS
DCBKR28, DCBKR283	DCPBTRBATT2FDOFH	TOR-S09-FMIS
DCPUMPHS	DCPCBHBKR25SOZFH	TOR-S59-FMIS
DCPUMPHS	DCPCBHFEED-SOZPH	TOR-S59-FMIS
DCPUMPHS	DCPCBHSPPLYSOZPH	TOR-S59-FMIS
DCSDP3, DCSDPL, DCNONSDP	DCPCBHBKR1BSOZFH	TOR-S61-FMIS
DCSDP3, DCSDPL, DCNONSDP	DCPCBHBKR2BSOZFH	TOR-S61-FMIS
DEPRESS	DEPMNVP102XFTOOP	TOR-S30-P102
LOPEMCC		TOR-PROP-MSIV**
LOPEMCC, SC-TRN05, CMPSDAIR, PW3	DMWLOSS*	
OFLINCGR	DCPCBHBKR2CFTCFH	TOR-S61-FMIS
P300A	DEPMNV300AXSCZOP	TOR-S30-300A-IX
P300A	DEPACC300AXILKOP	TOR-S02-FMIS
P300A	DEPMNV300AISCZOP	TOR-S30-300A-IX
P300B	DEPMNV300BISCZOP	TOR-S30-300B-IX
P300B	DEPACC300BXILKOP	TOR-S02-FMIS
P300B	DEPMNV300BKSCZOP	TOR-S30-300B-IX
PCWA3	PC3AOVHC01ASCZVV	TOR-S05-FMIS
PCWB3	PC3AOVHC01BSCZVV	TOR-S05-FMIS
PW1	PW1AOVHC102FTOOP	TOR-S06-FMIS
PW1	HESMNV-HE29FTOOP	TOR-S30-HE2789
PW1	HESMNV-HE28FTOOP	TOR-S30-HE2789
PW1	HESMNV-HE27FTOOP	TOR-S30-HE2789
PW2	PWSMNVP111-FTOOP	TOR-S30-P1112T28
PW2	PWSMNV-P112FTOOP	TOR-S30-P1112T28
PW2	PWSMNV-TW28FTOOP	TOR-S30-P1112T28
PW4	PWSMNV-TW24FTOOP	TOR-S30-TW21457
PW4	PWSMNV-TW25FTOOP	TOR-S30-TW21457
PW4	PWSMNV-TW27FTOOP	TOR-S30-TW21457
PW4	PWSMNV-TW21FTOOP	TOR-S30-TW21457
SC-TRN01, SC-TRN02, SC-TRN03, SC-TRN04, SC-TRN05	SCWAOVWR-3XSCZEQ	TOR-S07-FMIS
SC-TRN02, SP-TRN02, SP-TRN05	SCWCKVWS-20FTOPH	TOR-S21-FMIS
SCM5	HESMNV-HE5AFTOOP	TOR-S30-H5A1317C
SCM5	HWTMNV-P01-FTOOP	TOR-S30-H5A1317C
SCM5	HWTMNV-P03-FTOOP	TOR-S30-H5A1317C
SCM5	OFGMNV--P17FTCOP	TOR-S30-H5A1317C
SCM5	HWTCKVINJCTFTOOP	TOR-S30-H5A1317C
SCM8MUP	HWTMNV-P01-FTOOP	TOR-S30-P1578788
SCM8MUP	HWTMNV-P57-FTOOP	TOR-S30-P1578788
SCM8MUP	HWTMNV-P87-FTOOP	TOR-S30-P1578788
SCM8MUP	HWTMNV-P88-FTOOP	TOR-S30-P1578788
SP-TRN01	SCWAOVWR-1XSCZEQ	TOR-S07-FMIS
SP-TRN04	SCWAOVWR-2XSCZEQ	TOR-S07-FMIS

* Value changed. ** New stand-alone event. file: torevnt.wq2

Appendix B.4
Internal PRA Human Errors that are Affected by a Tornado Event and the Fault Trees (Systems) Where They Appear

Table B.4

EVENT-SYSTEM LOGIC REFERENCE REPORT
FAMILY: HFBR-TOR

SYSTEM NAME	BASIC EVENT	TORNADO BASIC EVENT
AIRG10	AIRMNVAR104HEPEQ	TOR-HEP-AIRG112
AIRG11	AIRMNVAR101HEPEQ	TOR-HEP-AIRG112
AIRG14	AIRCPSSTBYYHEPEQ	TOR-HEP-AIRG14
AIRG1C	DMWMNVDW29BHEPEQ	TOR-HEP-AIRG1C29
AIRG1C, AIRG1AB	DMWMNVDW48-HEPEQ	TOR-HEP-AIRG1CAB
AIRG3	AIRMNVAR21-HEPEQ	TOR-HEP-AIRG3
AIRG6	AIRMNVAR17-HEPEQ	TOR-HEP-AIRG6
AIRG7	AIRMNVAR83-HEPEQ	TOR-HEP-AIRG7-83
AIRG7	AIRMNVAR80-HEPEQ	TOR-HEP-AIRG7-80
AIRG8	AIRMNVAR87-HEPEQ	TOR-HEP-AIRG8
AIRG9	AIRMNVAR24-HEPEQ	TOR-HEP-AIRG9
DEPRESS	DEPAOV300ABHEPOP	TOR-HEP-DEP-300
DEPRESS	DEPMNVP102XHEPOP	TOR-HEP-DEP-102
PW1	PWSSYS-HEP-ALNVV	TOR-HEP-PW1
PW3	PWSLWM-HEP-ALNVV	TOR-HEP-PW3-ALN
S3-TOP	SD3SWINHANDHEPCR	TOR-HEP-S3TOP
SC-TRN01, SC-TRN02, SC-TRN03	SCWMOVWS-3XHEPEQ	TOR-HEP-SSSM3X
SC-TRN01, SC-TRN02, SC-TRN03, SC-TRN04, SC-TRN05	SCWAOVWR-3XHEPEQ	TOR-HEP-SSSA3X
SC-TRN02, SC-TRN03	SCWMNVW1418HEPEQ	TOR-HEP-SS1418
SC-TRN03, SP-TRN03, SP-TRN06	SCWMNVD3XXXHEPPH	TOR-HEP-SSS3X
SC-TRN03, SP-TRN03, SP-TRN06	SCWTNKFA309HEPPH	TOR-HEP-SSSTNK
SC-TRN03, SP-TRN03, SP-TRN06	SCWMNVWS-20HEPPH	TOR-HEP-SSSMOV20
SC-TRN03, SP-TRN03, SP-TRN06	SCWMNVD1XXXHEPPH	TOR-HEP-SSS1X
SC-TRN03, SP-TRN03, SP-TRN06	SCWMNVD2XXXHEPPH	TOR-HEP-SSS2X
SC-TRN04, SC-TRN05	SCWMNVWR-15HEPEQ	TOR-HEP-SS141518
SC-TRN04	SCWMNVW19FOHEPXX	TOR-HEP-SC4MNV19
SC-TRN04, SC-TRN05	SCWMNVWR-18HEPEQ	TOR-HEP-SS141518
SC-TRN04, SC-TRN05	SCWMOVWS3FCHEPEQ	TOR-HEP-SS45MOV3
SC-TRN04, SC-TRN05	SCWMNVWR-14HEPEQ	TOR-HEP-SS1418
SC-TRN05	SCWMNVDW-1XHEPEQ	TOR-HEP-SC5MNV1
SCM7	AIRMOVLCLOPHEPVV	TOR-HEP-SCM7
SCM8MUP	HWD-CLRAHEPFTSVV	TOR-HEP-SCM8MUP
SCM8MUP	HWD-CLRBHEPFTSVV	TOR-HEP-SCM8MUP
SCM9MUP	HWTLTM90PMPHEPVV	TOR-HEP-SCM9MPU
SCM9MUP	HWTLTM90HESHEPVV	TOR-HEP-SCM9MHES
SCMDMU	HWTALIGN---HEPVV	TOR-HEP-SCMDMU
SCMSD	SCMSYS-HEPFTSVV	TOR-HEP-SSS
SL-TOP, SL-TRN06, SLS-TOP	SDLPMPMOVNTHEPEQ	TOR-HEP-SSSSDPMP
SL-TOP, SL-TRN06, SLS-TOP	SDLSWINHANDHEPCR	TOR-HEP-SSSSDCR
SP-TRN01	SCWAOVWR-1XHEPEQ	TOR-HEP-SP1-1X
SP-TRN01, SP-TRN02, SP-TRN03	SCWMOVWS-1XHEPEQ	TOR-HEP-SPWS1X
SP-TRN02, SP-TRN03	SCWMNVW8-19HEPEQ	TOR-HEP-SP23M19
SP-TRN04	SCWAOVWR-2XHEPEQ	TOR-HEP-SP4-2X
SP-TRN04, SP-TRN05, SP-TRN06	SCWMOVWS-2XHEPEQ	TOR-HEP-SPM2X
SP-TRN05, SP-TRN06	SCWMNVW9-20HEPEQ	TOR-HEP-SP56M20
SP-TRN06	SCWMNVMV-25HEPPH	TOR-HEP-SP6MN25
SP-TRN11	SCWMOVWS-12HEPEQ	TOR-HEP-SP11M12
SP-TRN12	SCWAOVWR-12HEPEQ	TOR-HEP-SPTRN12

Appendix B.5
Definitions and Probabilities for Tornado Induced Hardware Failures and Human Errors

Table B.5

BASIC EVENTS PROBABILITY REPORT

Family: HFBR-TOR Case: ALTERNATE

vent umber	Primary Name	Calculation Type	Mean Probability	Lamda*	Tau*
1	TOR-HEP-AIRG112	1	9.000E-002	+0.000E+000	+0.000E+000
	Op. Fails to Open Manual Valve AR 104 Due to Tornado				
2	TOR-HEP-AIRG14	1	9.000E-002	+0.000E+000	+0.000E+000
	Op. Does Not Place "Stby" Compressor to "Run" Due to Tornado				
3	TOR-HEP-AIRG1C29	1	9.000E-002	+0.000E+000	+0.000E+000
	Op. Fails to Open DW29B Due to Tornado				
4	TOR-HEP-AIRG1CAB	1	9.000E-002	+0.000E+000	+0.000E+000
	Op. Fails to Open Manual Valve DW48 Due to Tornado				
5	TOR-HEP-AIRG3	1	9.000E-002	+0.000E+000	+0.000E+000
	Op. Fails to Open Manual Valve AR21 Due to Tornado				
6	TOR-HEP-AIRG6	1	9.000E-002	+0.000E+000	+0.000E+000
	Op. Fails to Open Manual Valve AR17 Due to Tornado				
7	TOR-HEP-AIRG7-80	1	9.000E-002	+0.000E+000	+0.000E+000
	Op. Fails to Open Manual Valve AR80 Due to Tornado				
8	TOR-HEP-AIRG7-83	1	9.000E-002	+0.000E+000	+0.000E+000
	Op. Fails to Open Manual Valve AR83 Due to Tornado				
9	TOR-HEP-AIRG8	1	9.000E-002	+0.000E+000	+0.000E+000
	Op. Fails to Open Manual Valve AR87 Due to Tornado				
10	TOR-HEP-AIRG9	1	9.000E-002	+0.000E+000	+0.000E+000
	Op. Fails to Open Manual Valve AR24 Due to Tornado				
11	TOR-HEP-DEP-102	1	1.560E-001	+0.000E+000	+0.000E+000
	Op. Fails to Open PV 102 Due to Tornado				
12	TOR-HEP-DEP-300	1	1.560E-001	+0.000E+000	+0.000E+000
	Op. Fails to Open Any of the Sys. Vent. Valves Due to Tornad				
13	TOR-HEP-PW1	1	9.000E-002	+0.000E+000	+0.000E+000
	Failure to Align Systems Correctly Due to Tornado				
14	TOR-HEP-PW3-ALN	1	9.000E-002	+0.000E+000	+0.000E+000
	Failure to Align System Correctly Due to Tornado				
15	TOR-HEP-S3TOP	1	1.560E-001	+0.000E+000	+0.000E+000
	Ops. Do Not Put Console Switch to "Hand" Due to Tornado				
16	TOR-HEP-SC4MNV19	1	5.000E-004	+0.000E+000	+0.000E+000
	Ops. Do Not Open VS19 Due to Tornado				
17	TOR-HEP-SC5MNV1	1	5.000E-004	+0.000E+000	+0.000E+000
	Ops. Do Not Open Valve DW-1 Due to Tornado				
18	TOR-HEP-SCM7	1	5.000E-004	+0.000E+000	+0.000E+000
	Op. Fails to Operate Manually Due to Tornado				
19	TOR-HEP-SCM8MUP	1	5.000E-004	+0.000E+000	+0.000E+000
	Op. Fails to Align for Draining Cooler (A/B) Due to Tornado				
20	TOR-HEP-SCM9MHES	1	9.000E-002	+0.000E+000	+0.000E+000
	Op. Fails to Transfer D2O w/Hel in 90 Min Due to Tornado				
21	TOR-HEP-SCM9MPU	1	9.000E-002	+0.000E+000	+0.000E+000
	Op. Fails to Transfer D2O w/Pumps in 90 Min Due to Tornado				
22	TOR-HEP-SCMDMU	1	9.000E-002	+0.000E+000	+0.000E+000
	Op. Fails to Align in Time (Subs Inj to 1.5 Hrs) Due to Torn				
23	TOR-HEP-SP1-1X	1	5.000E-004	+0.000E+000	+0.000E+000
	Air Op. Valve WR-1 Inadvert Closed by Op. Due to Tor Stress				
24	TOR-HEP-SP11M12	1	5.000E-004	+0.000E+000	+0.000E+000
	Op. Inadv Closes Suction Vlv WS-1 or WS-2 Due to Tor Stress				

* Standard failure rate parameters used in the IRRAS code but not applicable in the present table.

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BASIC EVENTS PROBABILITY REPORT

Family: HFBR-TOR Case: ALTERNATE

Event Number	Primary Name	Calculation Type	Mean Probability	Lamda*	Tau*
25	TOR-HEP-SP23M19	1	9.000E-002	+0.000E+000	+0.000E+000
	Ops. Fail to Establish Flow Return Path EA-101A Due to Torn				
26	TOR-HEP-SP4-2X	1	5.000E-004	+0.000E+000	+0.000E+000
	Op. Inadvert. Closed WR-2 (Air Op. Valve) Due to Tor Stress				
27	TOR-HEP-SP56M20	1	9.000E-002	+0.000E+000	+0.000E+000
	Op. Fails to Establish Return Flowpath (EA-101B) Due to Torn				
28	TOR-HEP-SP6MN25	1	9.000E-002	+0.000E+000	+0.000E+000
	Ops. Do Not Close Valve 25 Due to Tornado				
29	TOR-HEP-SPM2X	1	5.000E-004	+0.000E+000	+0.000E+000
	Ops. Inadvert. Close WS-2 Due to Tornado Stress				
30	TOR-HEP-SPTRN12	1	5.000E-004	+0.000E+000	+0.000E+000
	Op. Inadvert Closes Return Vlv WR-1 or WR-2 Due to Tor Stres				
31	TOR-HEP-SPWS1X	1	5.000E-004	+0.000E+000	+0.000E+000
	Ops. Inadvert Close WS-1 Due to Tornado Stress				
32	TOR-HEP-SS141518	1	5.000E-004	+0.000E+000	+0.000E+000
	Ops. Do Not Open MNV WR-14/WR-15/ WR-18 Tornado				
33	TOR-HEP-SS1418	1	9.000E-002	+0.000E+000	+0.000E+000
	Ops. Fail to Establish Return Flow Path EA-103 Due to				
34	TOR-HEP-SS45MOV3	1	5.000E-004	+0.000E+000	+0.000E+000
	Ops. Fail to Close WS-3 Due to Tornado				
35	TOR-HEP-SSS	1	9.000E-002	+0.000E+000	+0.000E+000
	Op. Fails to Align for Steam Condensing Mode Due to Tornado				
36	TOR-HEP-SSS1X	1	9.000E-002	+0.000E+000	+0.000E+000
	Ops. Do Not Close Manual Valve D1 Due to Tornado				
37	TOR-HEP-SSS2X	1	9.000E-002	+0.000E+000	+0.000E+000
	Ops. Do Not Close Manual Valve D2 Due to Tornado				
38	TOR-HEP-SSS3X	1	9.000E-002	+0.000E+000	+0.000E+000
	Ops. Do Not Close Manual Valve D3 Due to Tornado				
39	TOR-HEP-SSSA3X	1	5.000E-004	+0.000E+000	+0.000E+000
	Ops. Inadvert. Close WR-3 Due to Tornado Stress				
40	TOR-HEP-SSSM3X	1	5.000E-004	+0.000E+000	+0.000E+000
	Ops. Inadvert. Close WS-3 Due to Tornado Stress				
41	TOR-HEP-SSSMOV20	1	9.000E-002	+0.000E+000	+0.000E+000
	Op. Fails to Close WS-20 Due to Tornado				
42	TOR-HEP-SSSSDCR	1	1.560E-001	+0.000E+000	+0.000E+000
	Ops. Do Not Put Stby Pump Cons. Switch to "Hand" Due to Torn				
43	TOR-HEP-SSSSDPMP	1	9.000E-002	+0.000E+000	+0.000E+000
	Pump Casing Not Vented by Ops. (Gas Binding) Due to Tornado				
44	TOR-HEP-SSSTNK	1	9.000E-002	+0.000E+000	+0.000E+000
	Ops Fail to Establish Path from Tank FA-309 Due to Tornado				
45	TOR-PROP-MSIV	1	5.000E-003	+0.000E+000	+0.000E+000
	Loss of propane during 24 hours due to tornado				
46	TOR-S02-FMIS	1	1.560E-001	+0.000E+000	+0.000E+000
	AIR CYCLINDER FAILURE DUE TO TORNADO				
47	TOR-S05-FMIS	1	1.560E-001	+0.000E+000	+0.000E+000
	FAILURE OF PRIMARY CONTROL VALVE DUE TO TORNADO				
48	TOR-S06-FMIS	1	4.030E-001	+0.000E+000	+0.000E+000
	Auto depressurization valve HC102 fails to open due to torna				

BASIC EVENTS PROBABILITY REPORT

Family: HFBR-TOR Case: ALTERNATE

vent umber	Primary Name	Calculation Type	Mean Probability	Lamda*	Tau*
49	TOR-S07-FMIS	1	1.560E-001	+0.000E+000	+0.000E+000
	Failure of return valve due to tornado				
50	TOR-S09-FMIS	1	6.900E-002	+0.000E+000	+0.000E+000
	Fanhouse battery failure due to tornado				
51	TOR-S21-FMIS	1	1.560E-001	+0.000E+000	+0.000E+000
	WS-20 valve clogs due to tornado debris				
52	TOR-S30-300A-IX	1	4.030E-001	+0.000E+000	+0.000E+000
	AIR SUPPLY REG. VALVE 300AX OR ISO. VALVE 300AI FAIL DUE TO				
53	TOR-S30-300B-IX	1	4.030E-001	+0.000E+000	+0.000E+000
	AIR SUPPLY REG. VALVE 300BX OR ISO. VALVE 300BI FAIL DUE TO				
54	TOR-S30-H5A1317C	1	4.030E-001	+0.000E+000	+0.000E+000
	Failure of MNVs He5A, P1, P3, P17 and CKVINJ due to tornado				
55	TOR-S30-HE2789	1	4.030E-001	+0.000E+000	+0.000E+000
	Failure of valves HE 27, 28, 29 due to tornado				
56	TOR-S30-P102	1	4.030E-001	+0.000E+000	+0.000E+000
	VALVE P102 FAILS DUE TO TORNADO				
57	TOR-S30-P1112T28	1	4.030E-001	+0.000E+000	+0.000E+000
	Failures of injection line valves, P111, P112, TW 28 due to				
58	TOR-S30-P1578788	1	4.030E-001	+0.000E+000	+0.000E+000
	Failure of MNVs P1, P51, P87, P88 and CKVINJ due to tornado				
59	TOR-S30-TW21457	1	4.030E-001	+0.000E+000	+0.000E+000
	Failure of valves TW 21, 24, 25, 27 due to tornado				
60	TOR-S59-FMIS	1	6.400E-002	+0.000E+000	+0.000E+000
	Pumphouse DC dist. panel failure due to tornado				
61	TOR-S60-FMIS	1	6.900E-002	+0.000E+000	+0.000E+000
	Fanhouse battery breaker failure due to tornado				
62	TOR-S61-FMIS	1	6.900E-002	+0.000E+000	+0.000E+000
	Loss of DC control due to tornado				

APPENDIX C

System Fault Trees Modified for Tornado Initiator*

C.1 Reactor Scram and Setback Systems

C.2 Primary Cooling Water System

C.3 Shutdown Cooling Water System Modified for Tornado Initiator

C.4 Secondary Cooling Water System Modified for Tornado Initiator

C.5 Flow Reversal Valves

C.6 Depressurization System Modified for Tornado Initiator

C.7 Steam Condensing and D_2O Makeup System Modified for Tornado Initiator

C.8 Poison Water System Modified for Tornado Initiator

C.9 AC Power System Modified for Tornado Initiator

C.10 DC Power System Modified for Tornado Initiator

C.11 Compressed Air System Modified for Tornado Initiator

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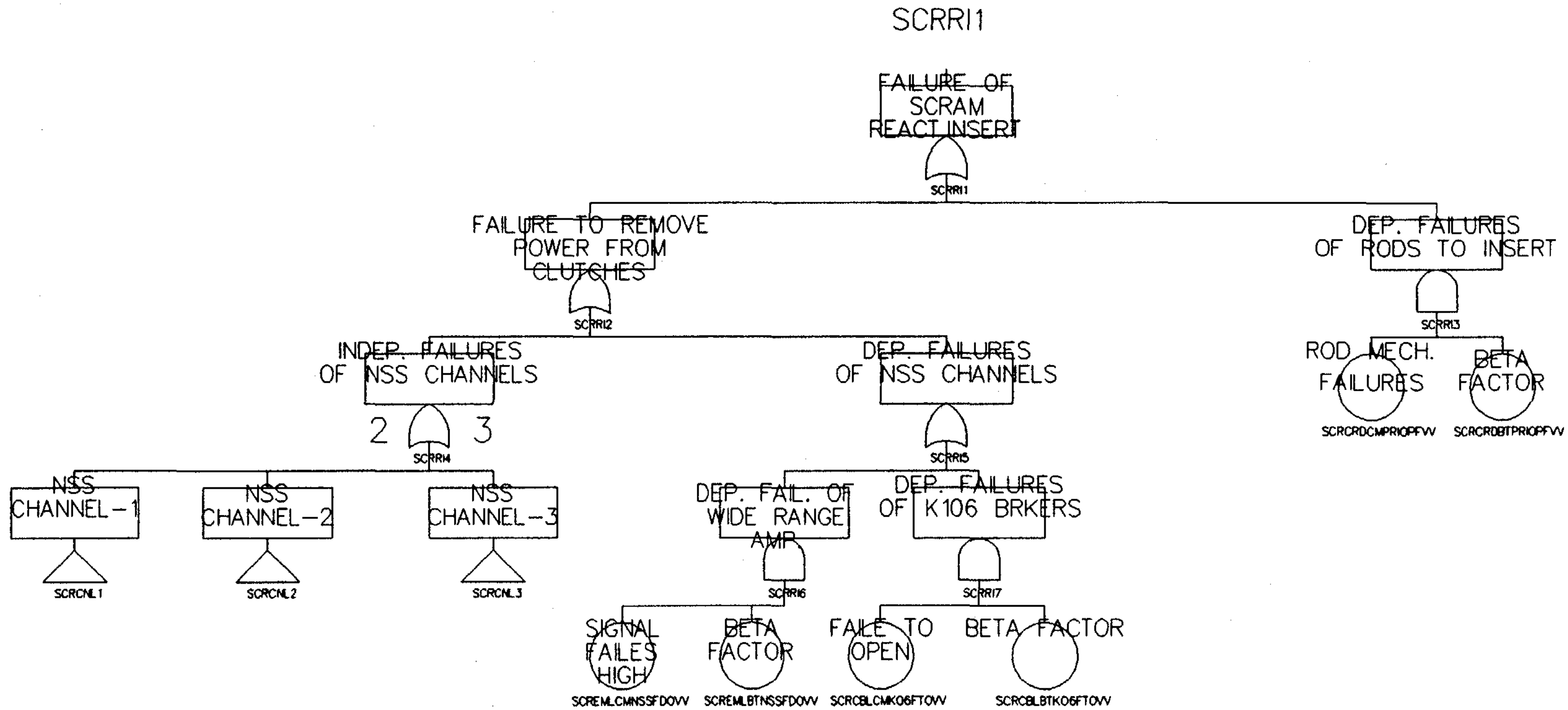
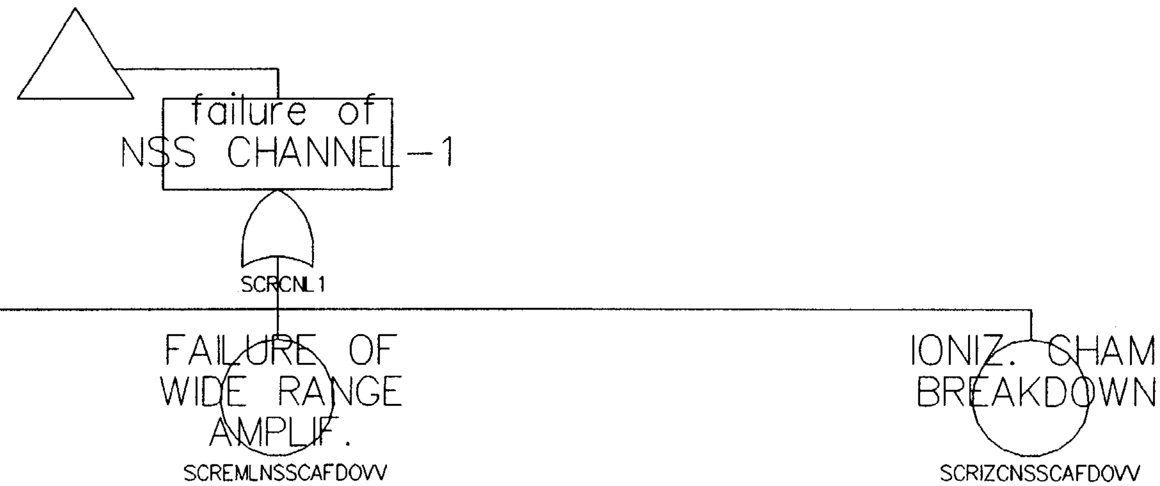
* **System fault trees C.1, C.2, and C.5 are given here for a complete presentation of the tornado model.**

Appendix C.1 Reactor Scram and Setback Systems



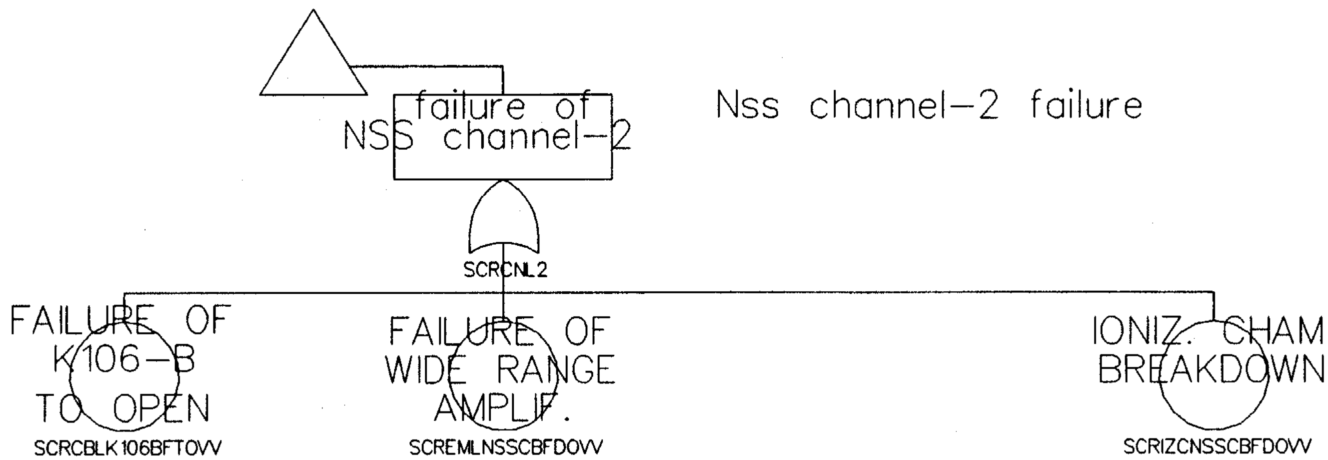
* note scram relay breakers refer to a pair of contacts. Name breaker may not be appropraite



* note that low scram signal causes auto trip

* Also note that breakers refers to a pair of contacts

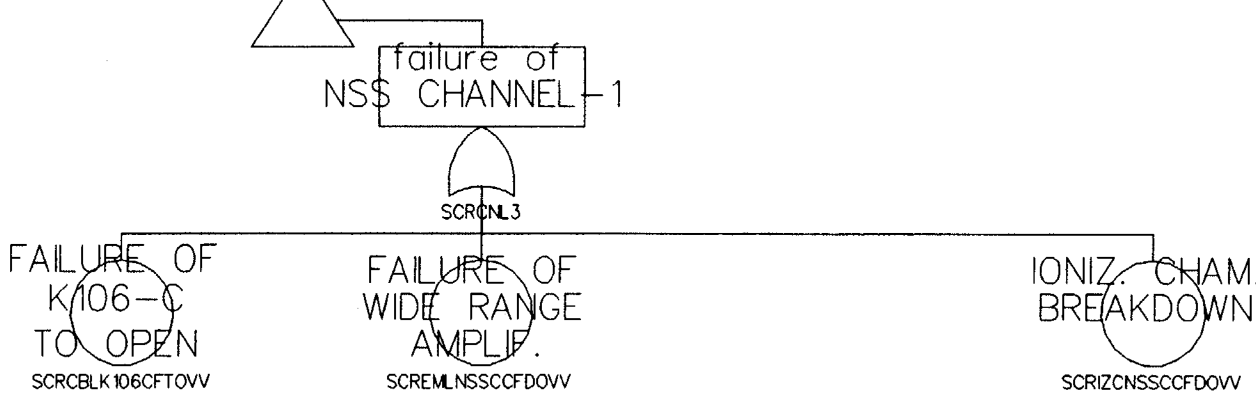
Nss channel-2 failure



* note low signal failure causes
auto scram trip

* Also note that breakers refer to
a pair of contacts

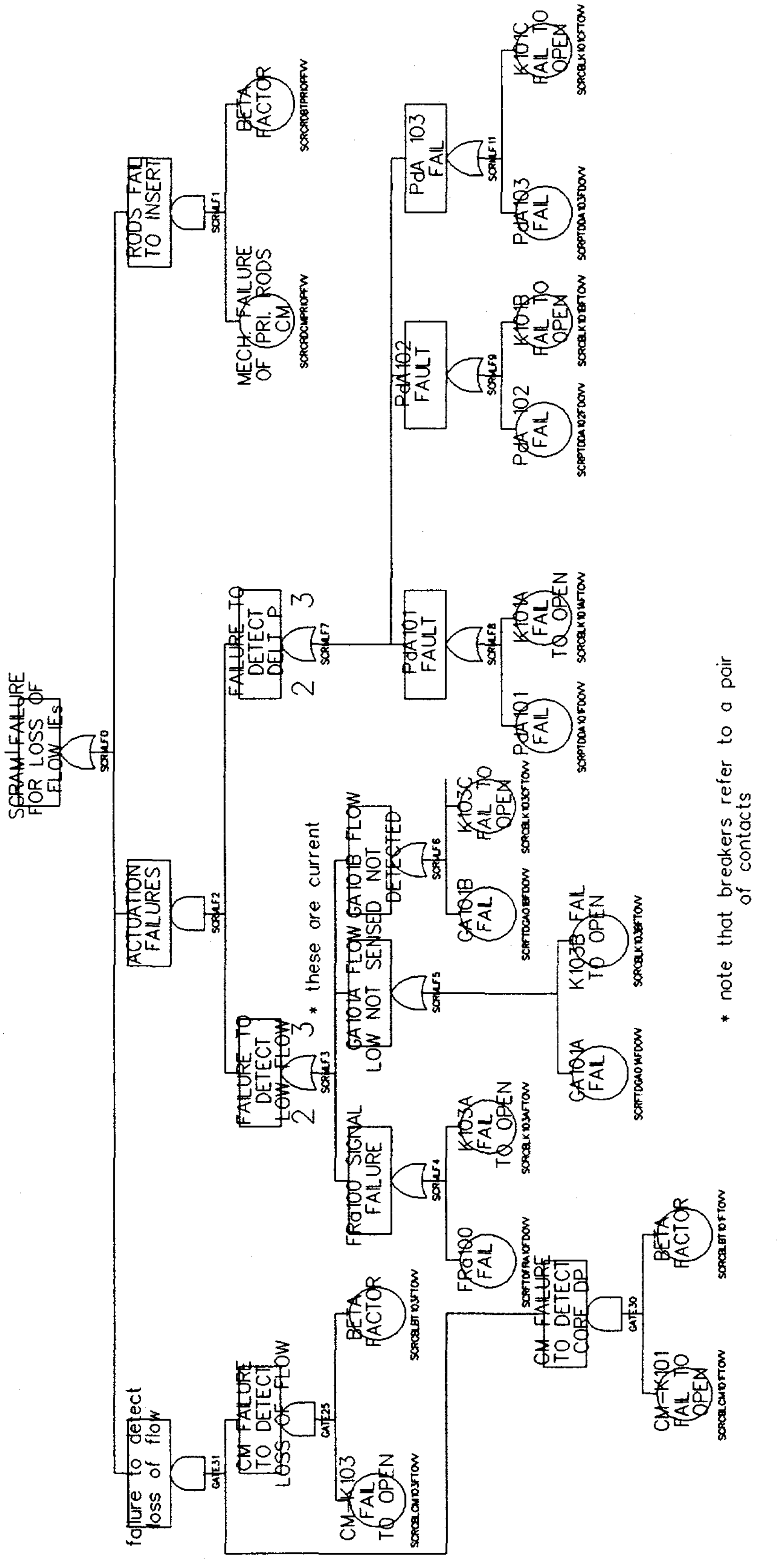
NSS CHANNEL-3 Failure

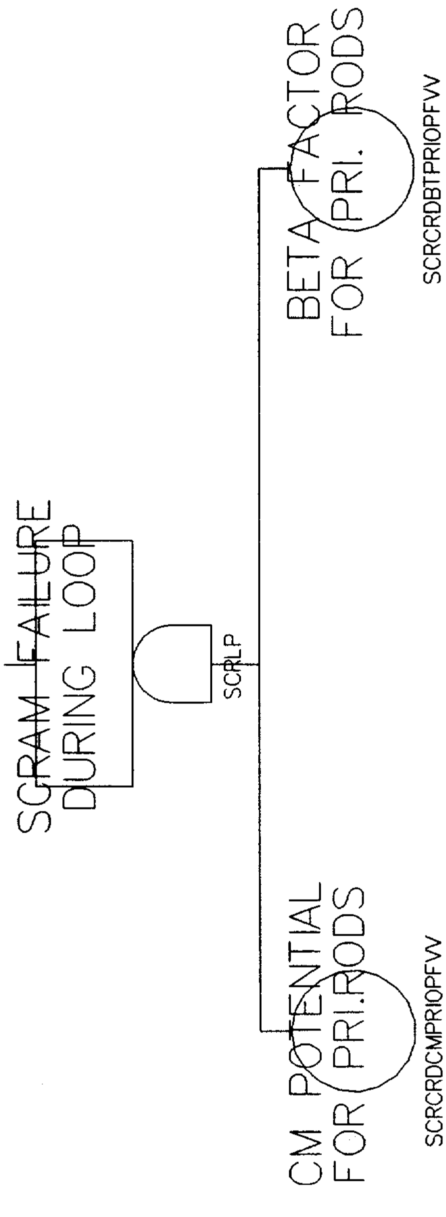


* Low signal Failure Causes auto scram trip

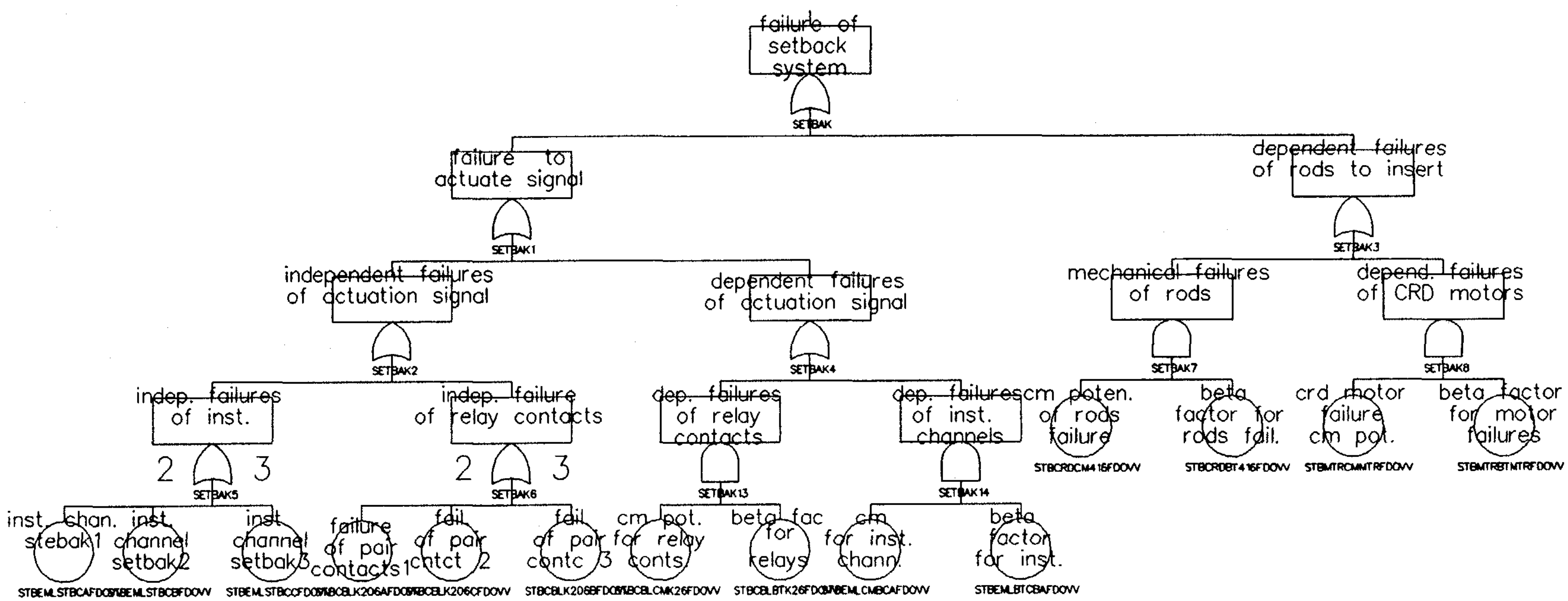
* Also note that breakers are actually a pair of conntacts

SCRMLF0

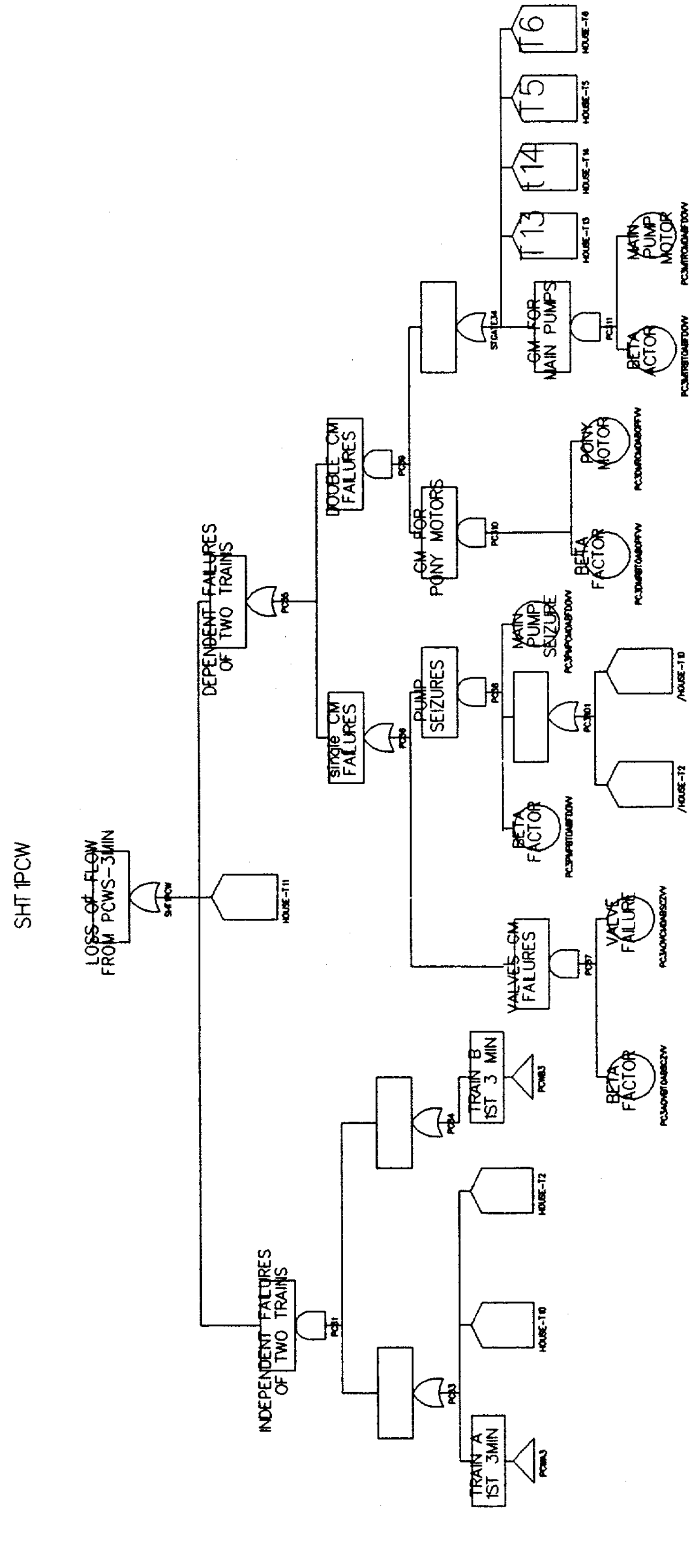

SCRAM FAILURE FOR LOSS OF FLOW IEs
SCRMLF0
failure to detect loss of flow
GATE31
ACTUATION FAILURES
SCRMLF2
RODS FAIL TO INSERT
SCRMLF1
MECH FAILURE OF PRI. RODS CM
SCRCRDCMPRIOPFVV
BETA FACTOR
SCRCRDBTPRIOPFVV
CM FAILURE TO DETECT LOSS OF FLOW
GATE25
CM-K103 FAIL TO OPEN
SCRCBLCM103FTOVV
BETA FACTOR
SCRCBLBT103FTOVV
CM FAILURE TO DETECT CORE DP
GATE30
CM-K101 FAIL TO OPEN
SCRCBLCM101FTOVV
BETA FACTOR
SCRCBLBT101FTOVV
FAILURE TO DETECT LOW FLOW
2 3 *
SCRMLF3
* these are current
FRa100 SIGNAL FAILURE
SCRMLF4
FRa100 FAIL
SCRFTDFRA10FDOVV
K103A FAIL TO OPEN
SCRCBLK103AFTOVV
GA101A FLOW LOW NOT SENSED
SCRMLF5
GA101A FAIL
SCRFTDGA101AFDOVV
K103B FAIL TO OPEN
SCRCBLK103BFTOVV
GA101B FLOW NOT DETECTED
SCRMLF6
GA101B FAIL
SCRFTDGA101BFDOVV
K103C FAIL TO OPEN
SCRCBLK103CFTOVV
FAILURE TO DETECT DELT P
2 3
SCRMLF7
PdA101 FAULT
SCRMLF8
PdA101 FAIL
SCRPTDDA101FDOVV
K101A FAIL TO OPEN
SCRCBLK101AFTOVV
PdA102 FAULT
SCRMLF9
PdA 102 FAIL
SCRPTDDA102FDOVV
K101B FAIL TO OPEN
SCRCBLK101BFTOVV
PdA 103 FAIL
SCRMLF11
PdA103 FAIL
SCRPTDDA103FDOVV
K101C FAIL TO OPEN
SCRCBLK101CFTOVV
* note that breakers refer to a pair of contacts

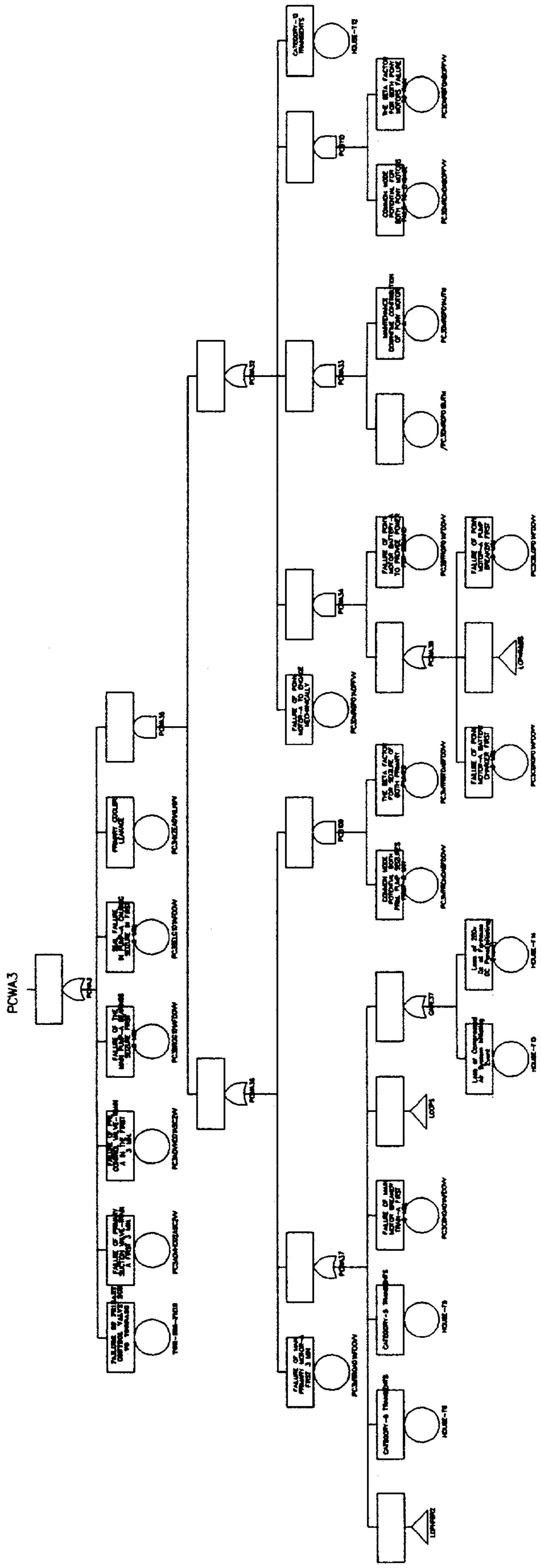

SCRAM FAILURE DURING LOOP
SCRLP
BETA FACTOR FOR PRI. RODS
SCRCRDBTPRIOPFVV
CM POTENTIAL FOR PRI.RODS
SCRCRDCMPRIOPFVV

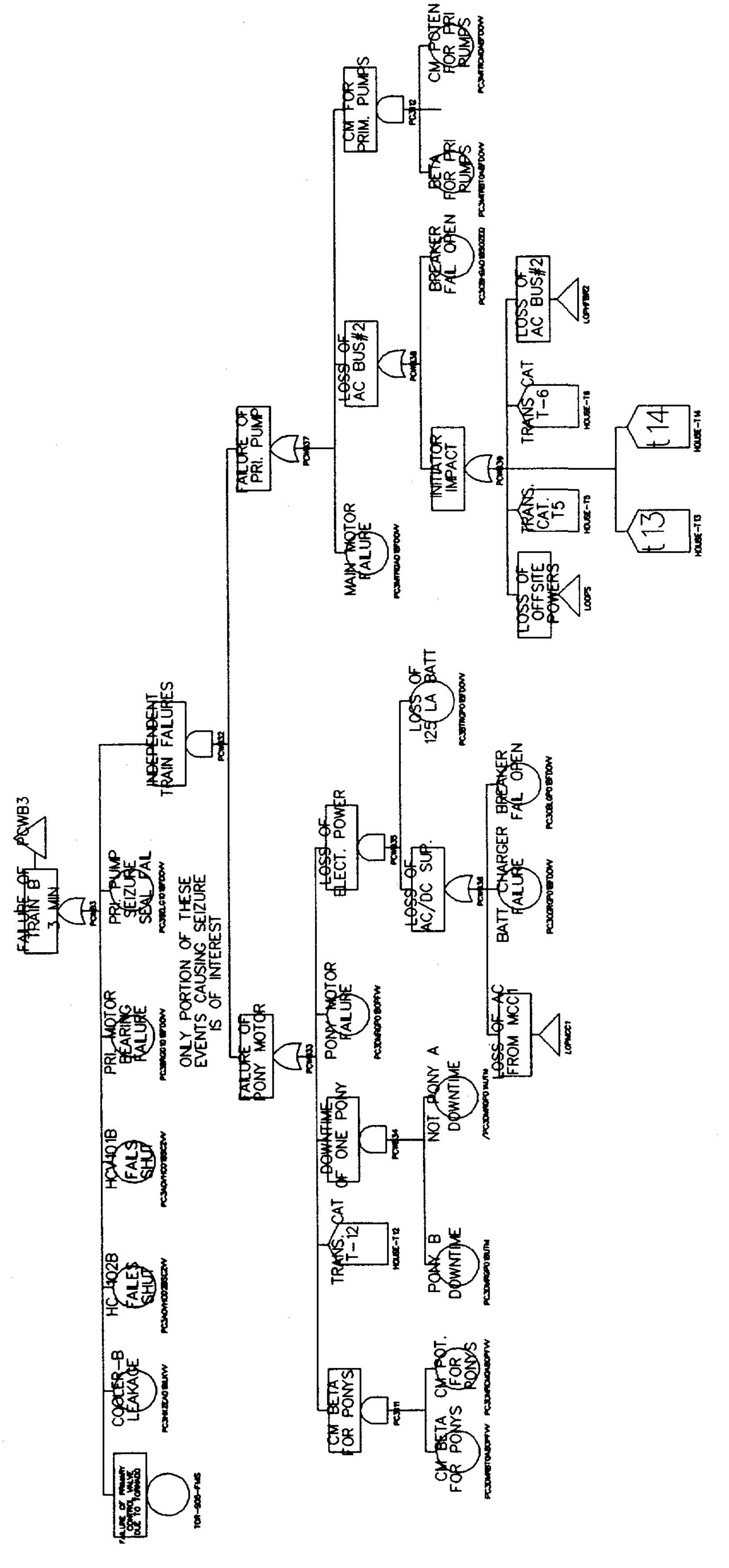
SETBAK

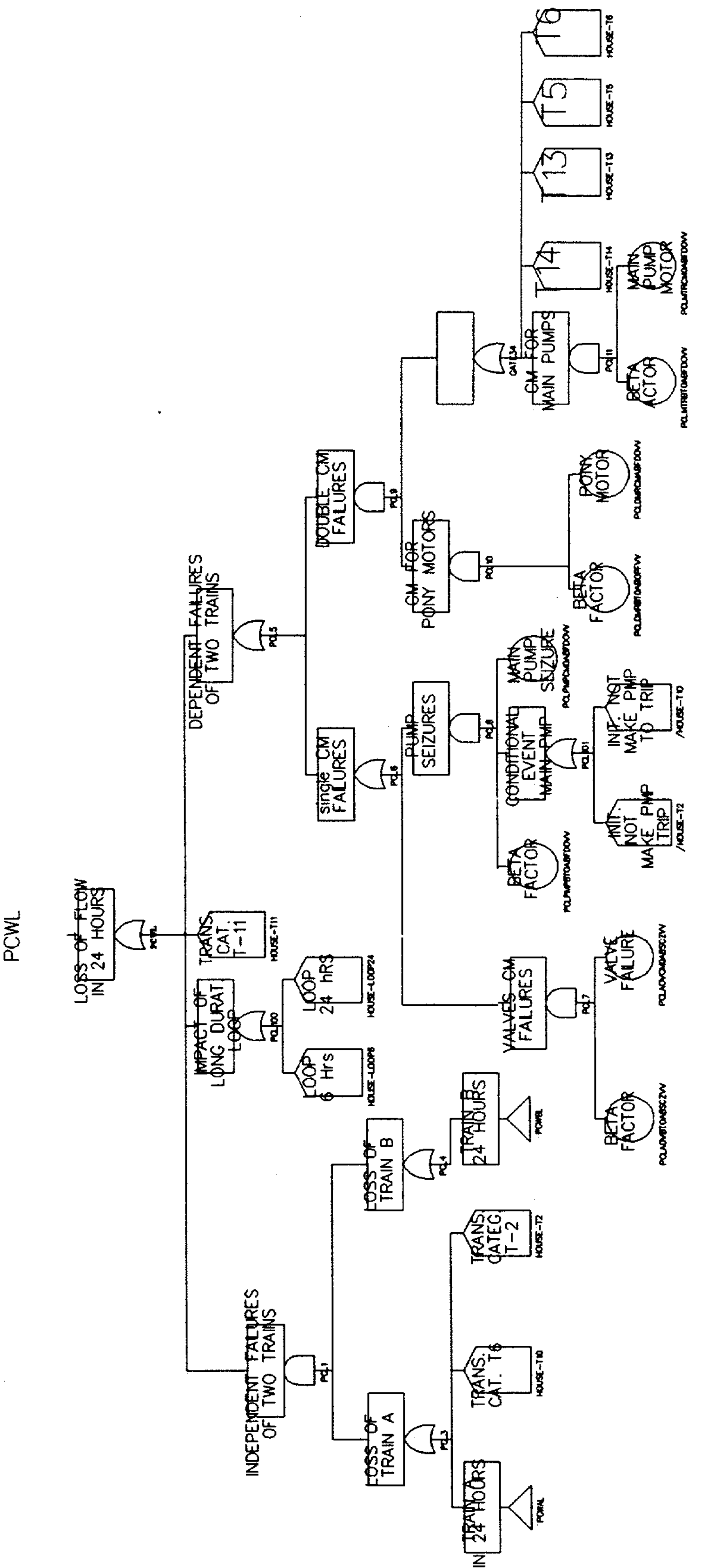

failure of setback system
SETBAK
failure to actuate signal
SETBAK1
dependent failures of rods to insert
SETBAK3
independent failures of actuation signal
SETBAK2
dependent failures of actuation signal
SETBAK4
mechanical failures of rods
SETBAK7
depend. failures of CRD motors
SETBAK8
indep. failures of inst.
SETBAK5
2
3
indep. failure of relay contacts
SETBAK6
2
3
dep. failures of relay contacts
SETBAK13
dep. failures of inst. channels
SETBAK14
cm poten. of rods failure
STBCRDCM416FDOVV
beta factor for rods fail.
STBCRDBT416FDOVV
crd motor failure cm pot.
STBMTRCMMTRFDOVV
beta factor for motor failures
STBMTRBTMTRFDOVV
inst. chan. stebak1
inst. channel setbak2
inst channel setbak3
failure of pair contacts 1
fail of pair cntct 2
fail of pair contc 3
cm pot. for relay conts
beta fac for relays
cm for inst. chann.
beta factor for inst.
STBEMLSTBCBFDOVV
STBEMLSTBCCFDOVV
STBCBLK206CFDOVV
STBEMLCMBCAFDOVV
STBEMLBTCBAFDOVV

Appendix C.2 Primary Cooling Water System

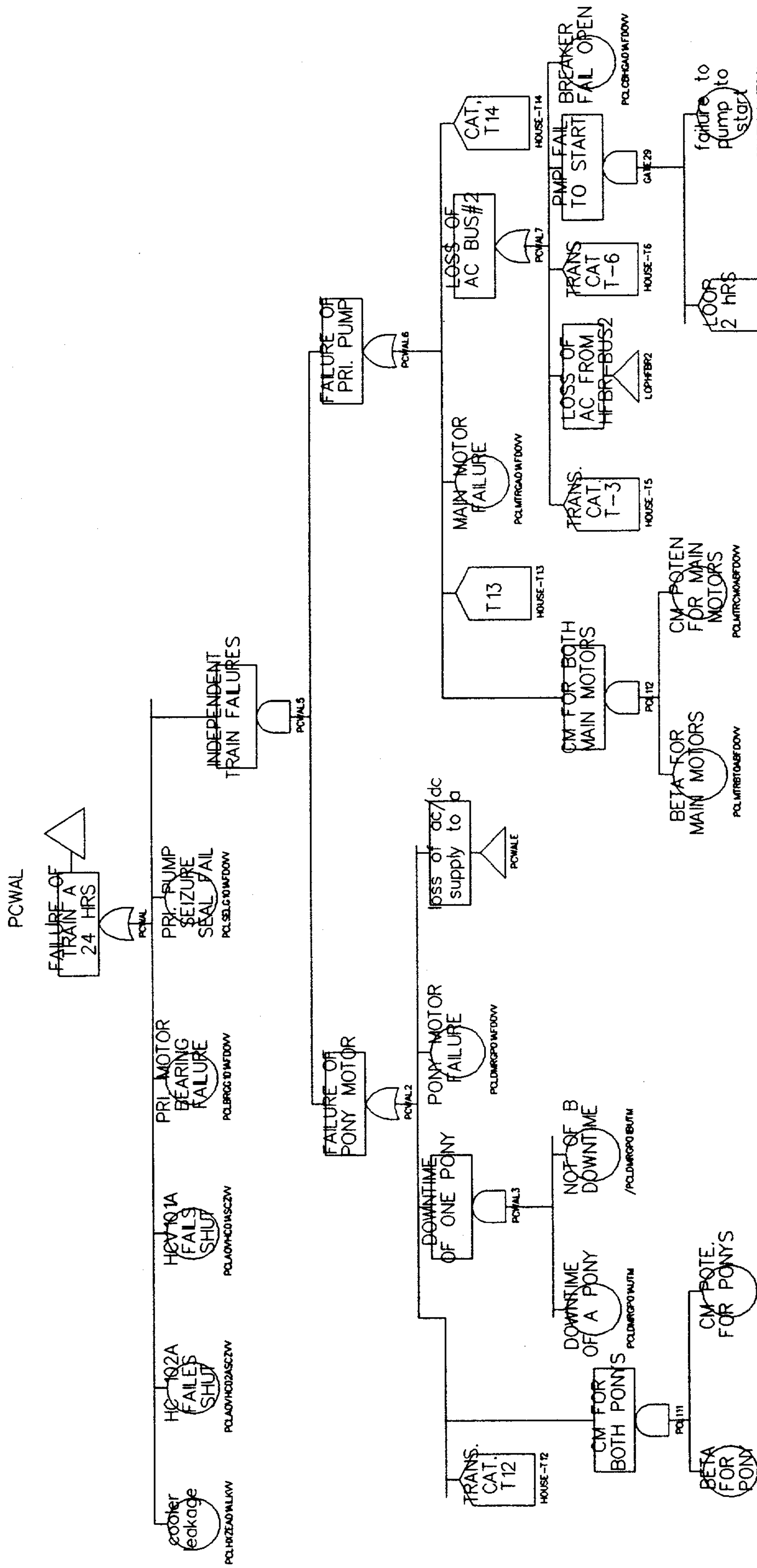

SHT 1PCW
LOSS OF FLOW FROM PCWS-3MIN
INDEPENDENT FAILURES OF TWO TRAINS
TRAIN A 1ST 3MIN
TRAIN B 1ST 3 MIN
DEPENDENT FAILURES OF TWO TRAINS
single CM FAILURES
VALVES CM FAILURES
BETA FACTOR
VALVE FAILURE
PUMP SEIZURES
BETA FACTOR
MAIN PUMP SEIZURE
DOUBLE CM FAILURES
CM FOR PONY MOTORS
BETA FACTOR
PONY MOTOR
CM FOR MAIN PUMPS
BETA FACTOR
MAIN PUMP MOTOR
T13
T14
T5
T6

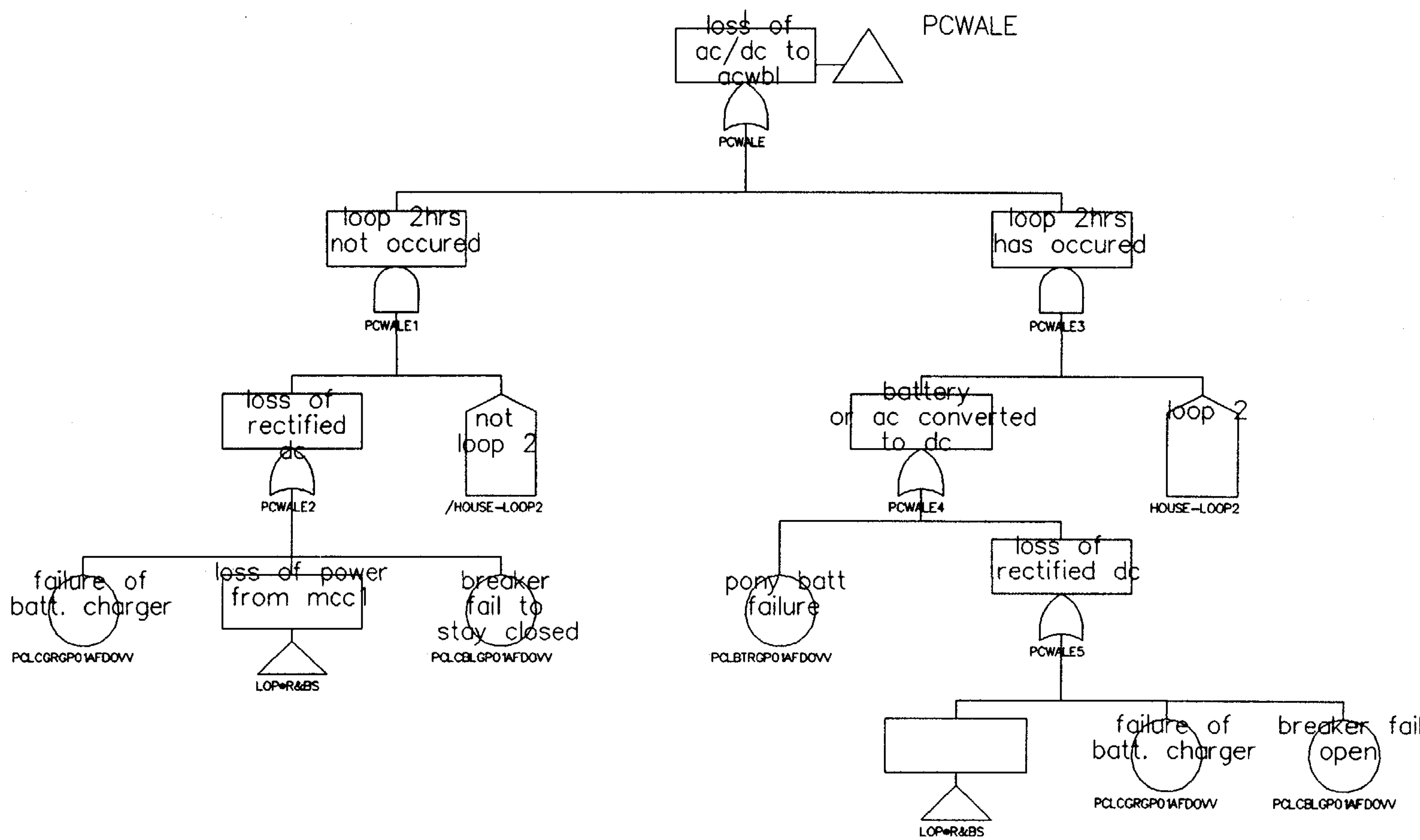

PCWA3


FAILURE OF TRAIN B 3 MIN
PCWB3
FAILURE OF PRIMARY CONTROL VALVE DUE TO TORNADO
COOLER-B LEAKAGE
HC 402B FAILES SHUT
HCV401B FAILS SHUT
PRI. MOTOR BEARING FAILURE
PRI. PUMP SEIZURE SEAL FAIL
ONLY PORTION OF THESE EVENTS CAUSING SEIZURE IS OF INTEREST
INDEPENDENT TRAIN FAILURES
FAILURE OF PONY MOTOR
CM BETA FOR PONYS
CM BETA FOR PONYS
CM POT. FOR PONYS
TRANS. CAT T-12
DOWNTIME OF ONE PONY
PONY B DOWNTIME
NOT PONY A DOWNTIME
PONY MOTOR FAILURE
LOSS OF ELECT. POWER
LOSS OF AC/DC SUP.
LOSS OF AC FROM MCC1
BATT. CHARGER FAILURE
BREAKER FAIL OPEN
LOSS OF 125 LA BATT
FAILURE OF PRI. PUMP
MAIN MOTOR FAILURE
LOSS OF AC BUS#2
INITIATOR IMPACT
LOSS OF OFFSITE POWERS
TRANS. CAT. T5
TRANS CAT T-6
LOSS OF AC BUS#2
t13
t14
BREAKER FAIL OPEN
CM FOR PRIM. PUMPS
BETA FOR PRI PUMPS
CM POTEN FOR PRI PUMPS

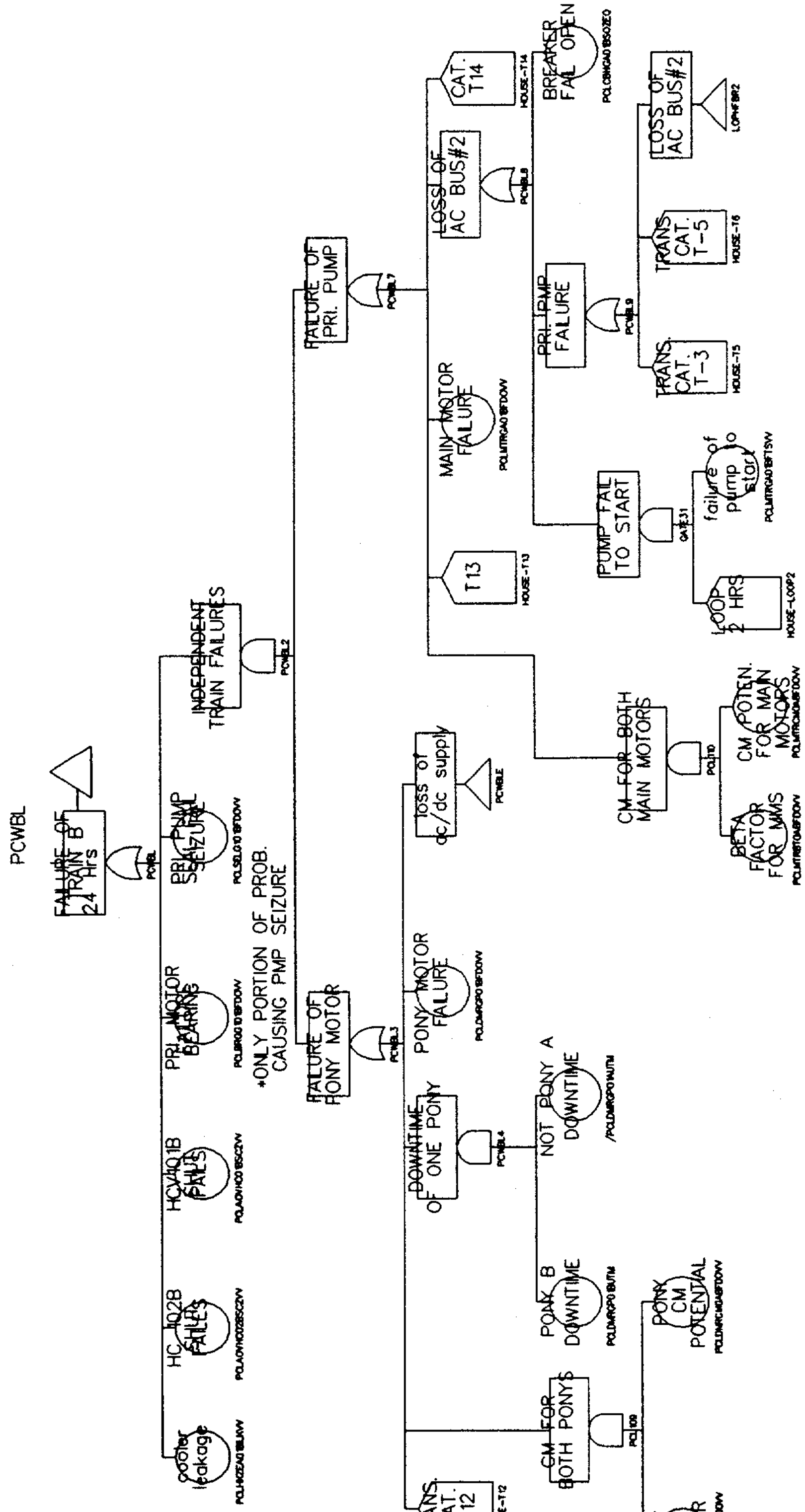


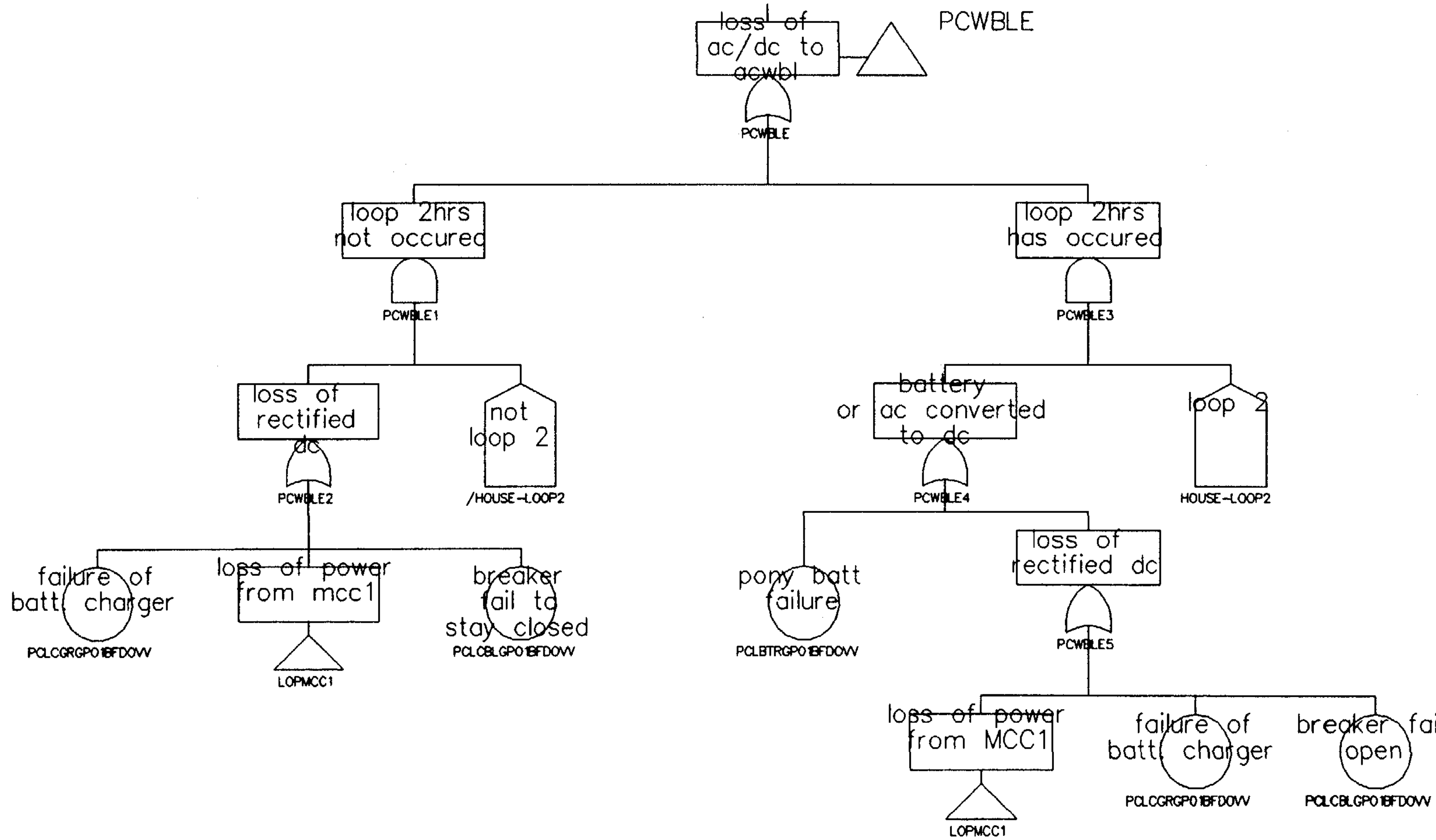
PCWL
LOSS OF FLOW IN 24 HOURS
INDEPENDENT FAILURES OF TWO TRAINS
IMPACT OF LONG DURAT LOOP
TRANS CAT. T-11
DEPENDENT FAILURES OF TWO TRAINS
LOSS OF TRAIN A
LOSS OF TRAIN B
IN TRAIN A 24 HOURS
TRANS. CAT. T6
TRANS CATEG T-2
TRAIN B 24 HOURS
LOOP 6 Hrs
LOOP 24 hRS
single CM FAILURES
DOUBLE CM FAILURES
VALVES CM FAILURES
BETA FACTOR
VALVE FAILURE
PUMP SEIZURES
BETA FACTOR
CONDITIONAL EVENT MAIN PMP
MAIN PUMP SEIZURE
INIT. NOT MAKE PMP TRIP
INIT. NOT MAKE PMP TO TRIP
CM FOR PONY MOTORS
BETA FACTOR
PONY MOTOR
CM FOR MAIN PUMPS
BETA ACTOR
MAIN PUMP MOTOR
T14
T13
T5
T6


PCWAL
FAILURE OF TRAIN A 24 HRS
PCWAL
PCWALE
cooler leakage
PCLHXZEA01ALKVV
HC 102A FAILES SHUT
PCLAOVHC02ASC2VV
HCV101A FALS SHUT
PCLAOVHC01ASC2VV
PRI. MOTOR BEARING FALURE
PCLBRGC101AFDOVV
PRI. PUMP SEIZURE SEAL FAIL
PCLSELG101AFDOVV
INDEPENDENT TRAIN FALURES
PCWAL5
FAILURE OF PONY MOTOR
PCWAL2
FAILURE OF PRI. PUMP
PCWAL6
TRANS. CAT. T12
HOUSE-T12
CM FOR BOTH PONYS
BETA FOR PONY
PCLDMRBTOABFDOVV
CM POTE. FOR PONYS
PCLDMRCMOABFDOVV
DOWNTIME OF ONE PONY
PCWAL3
DOWNTIME OF A PONY
NOT OF B DOWNTIME
PONY MOTOR FAILURE
loss of ac/dc supply to a
PCWALE
CM FOR BOTH MAIN MOTORS
BETA FOR MAIN MOTORS
PCLMTRBTOABFDOVV
CM POTEN FOR MAIN MOTORS
PCLMTRCMOABFDOVV
T13
HOUSE-T13
MAIN MOTOR FAILURE
PCLMTRGA01AFDOVV
TRANS. CAT. T-3
HOUSE-T5
LOSS OF AC FROM HFBR-BUS2
LOPHFBR2
LOOP 2 hRS
HOUSE-LOOP2
TRANS CAT T-6
HOUSE-T6
LOSS OF AC BUS#2
PCWAL7
PMP FAIL TO START
GATE29
failure to pump to start
PCLMTRGA01AFTSVV
CAT. T14
HOUSE-T14
BREAKER FAIL OPEN
PCLCBHGA01AFDOVV



PCWALE
loss of ac/dc to acwbl
PCWALE
loop 2hrs not occured
PCWALE1
loop 2hrs has occured
PCWALE3
loss of rectified dc
PCWALE2
not loop 2
/HOUSE-LOOP2
battery or ac converted to dc
PCWALE4
loop 2
HOUSE-LOOP2
failure of batt. charger
PCLCGRGP01AFDOVV
loss of power from mcc1
LOP*R&BS
breaker fail to stay closed
PCLCBLGP01AFDOVV
pony batt failure
PCLBTRGP01AFDOVV
loss of rectified dc
PCWALE5
LOP*R&BS
failure of batt. charger
PCLCGRGP01AFDOVV
breaker fail open
PCLCBLGP01AFDOVV

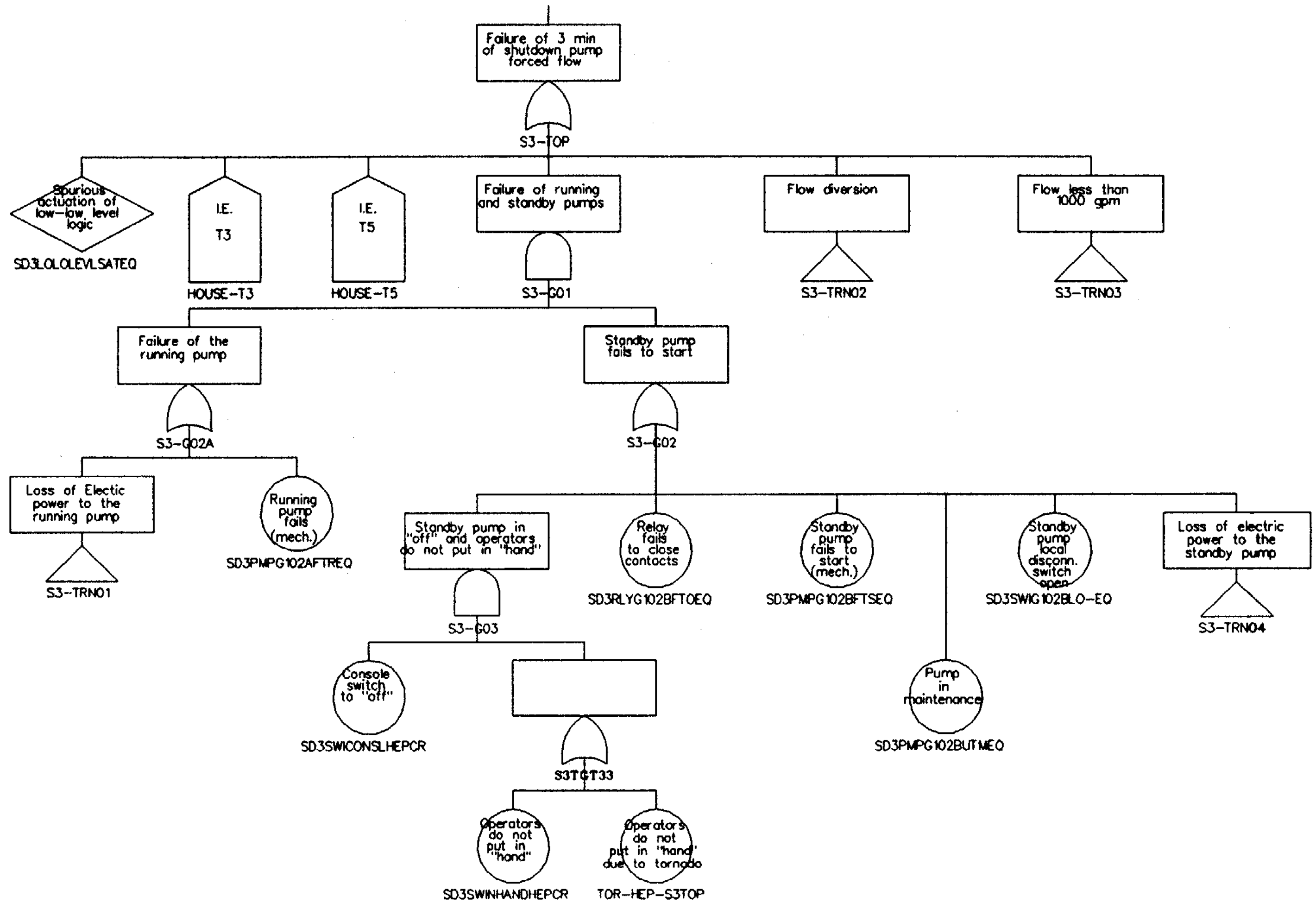

PCWBL
FAILURE OF TRAIN B 24 Hrs
PRI. PUMP SEIZURE
*ONLY PORTION OF PROB. CAUSING PMP SEIZURE
PRI. MOTOR BEARINGS
HCV101B SHUT FAILS
HC 102B SHUT FAILS
cooler leakage
INDEPENDENT TRAIN FAILURES
FAILURE OF PRI. PUMP
FAILURE OF PONY MOTOR
loss of dc/dc supply
PONY MOTOR FAILURE
DOWNTIME OF ONE PONY
NOT PONY A DOWNTIME
PONY B DOWNTIME
CM FOR BOTH PONYS
PONY CM POTENTIAL
PONY BETA FACTOR
TRANS. CAT. T12
CM FOR BOTH MAIN MOTORS
BETA FACTOR FOR MMS
CM POTEN. FOR MAIN MOTORS
MAIN MOTOR FAILURE
T13
LOSS OF AC BUS#2
CAT. T14
BREAKER FAIL OPEN
PRI. PUMP FAILURE
TRANS. CAT. T-3
TRANS. CAT. T-5
PUMP FAIL TO START
failure of pump to start
LOOP 2 HRS


PCWBLE
loss of ac/dc to acwbl
PCWBLE
loop 2hrs not occured
PCWBLE1
loop 2hrs has occured
PCWBLE3
loss of rectified dc
PCWBLE2
not loop 2
/HOUSE-LOOP2
or battery ac converted to dc
PCWBLE4
loop 2
HOUSE-LOOP2
failure of batt charger
PCLCGRGP01BFDOVV
loss of power from mcc1
LOPMCC1
breaker fail to stay closed
PCLCBLGP01BFDOVV
pony batt failure
PCLBTRGP01BFDOVV
loss of rectified dc
PCWBLE5
loss of power from MCC1
LOPMCC1
failure of batt charger
PCLCGRGP01BFDOVV
breaker fail open
PCLCBLGP01BFDOVV

Appendix C.3
Shutdown Cooling Water System Modified for Tornado Initiator

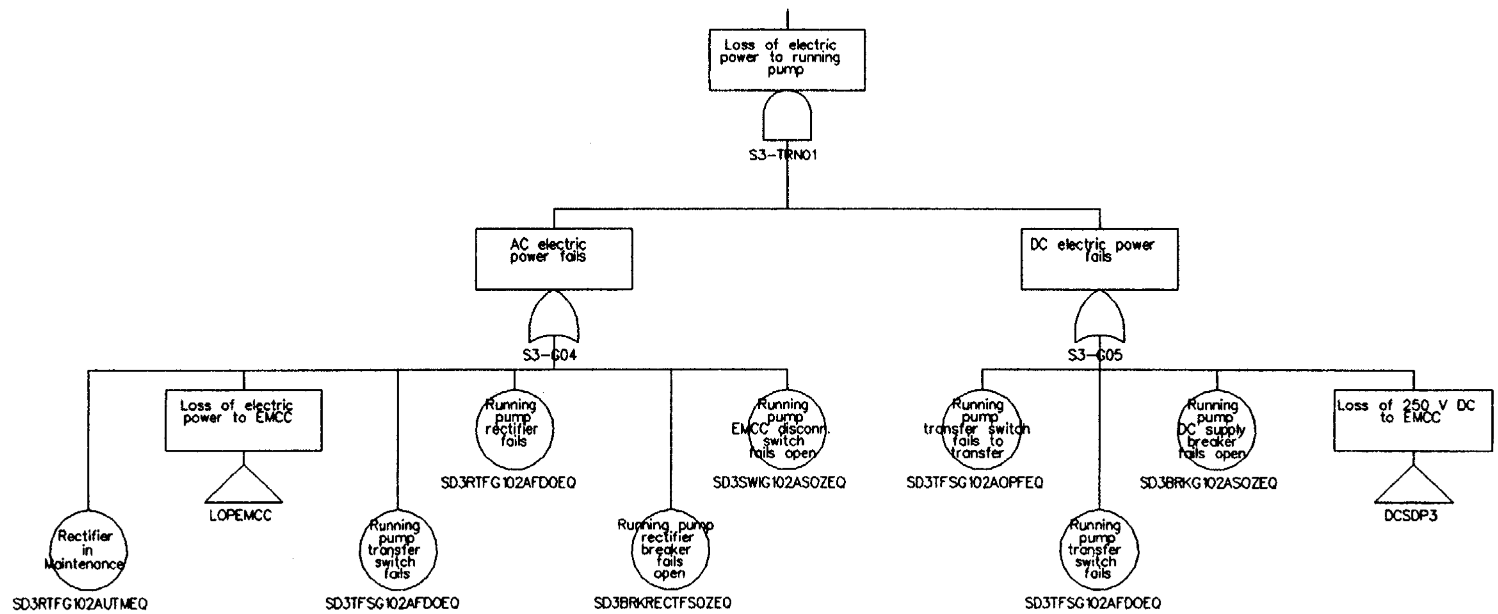
S3 FAULT TREE

Sheet 1 of 6

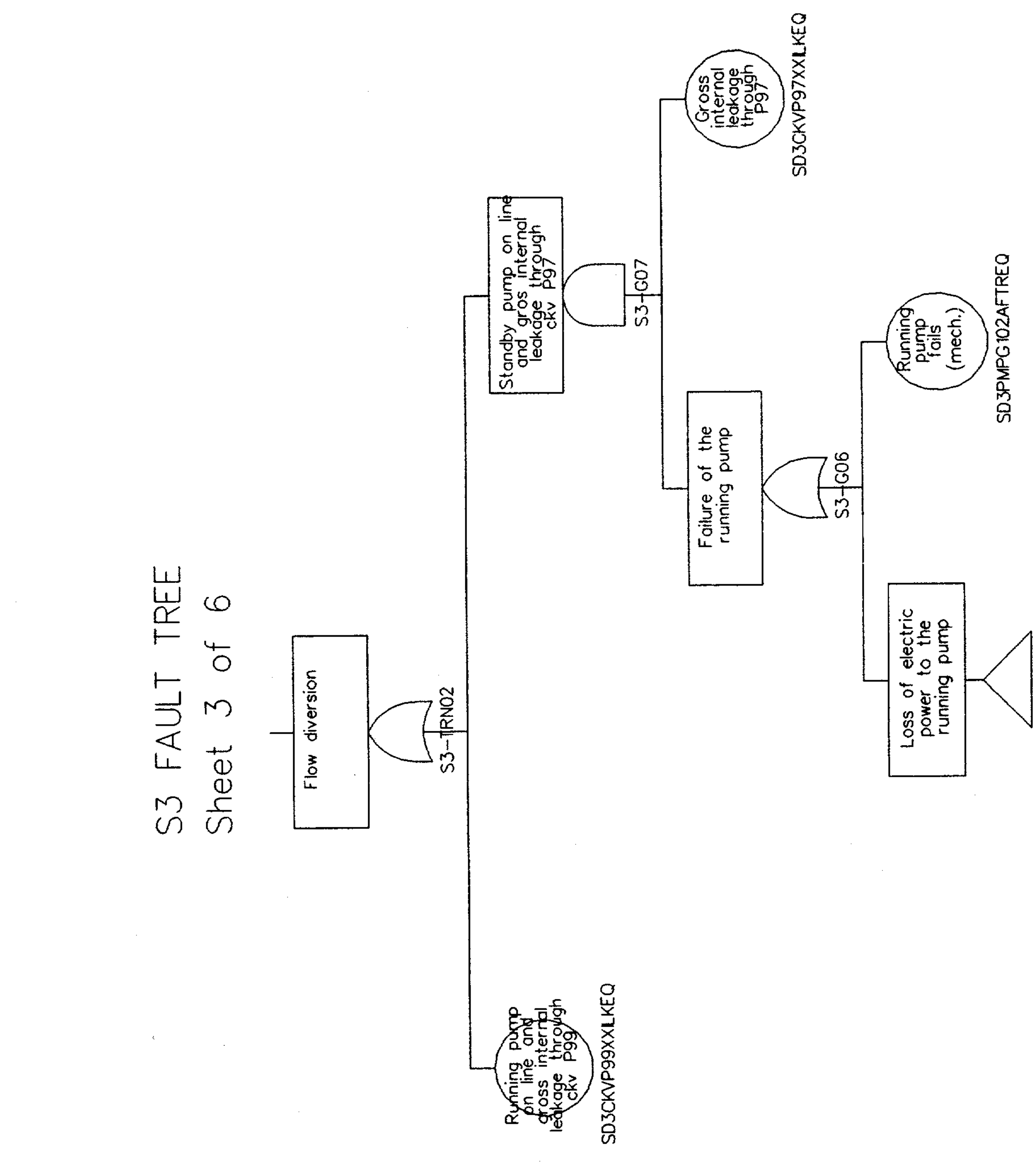


S3 FAULT TREE

Sheet 2 of 6

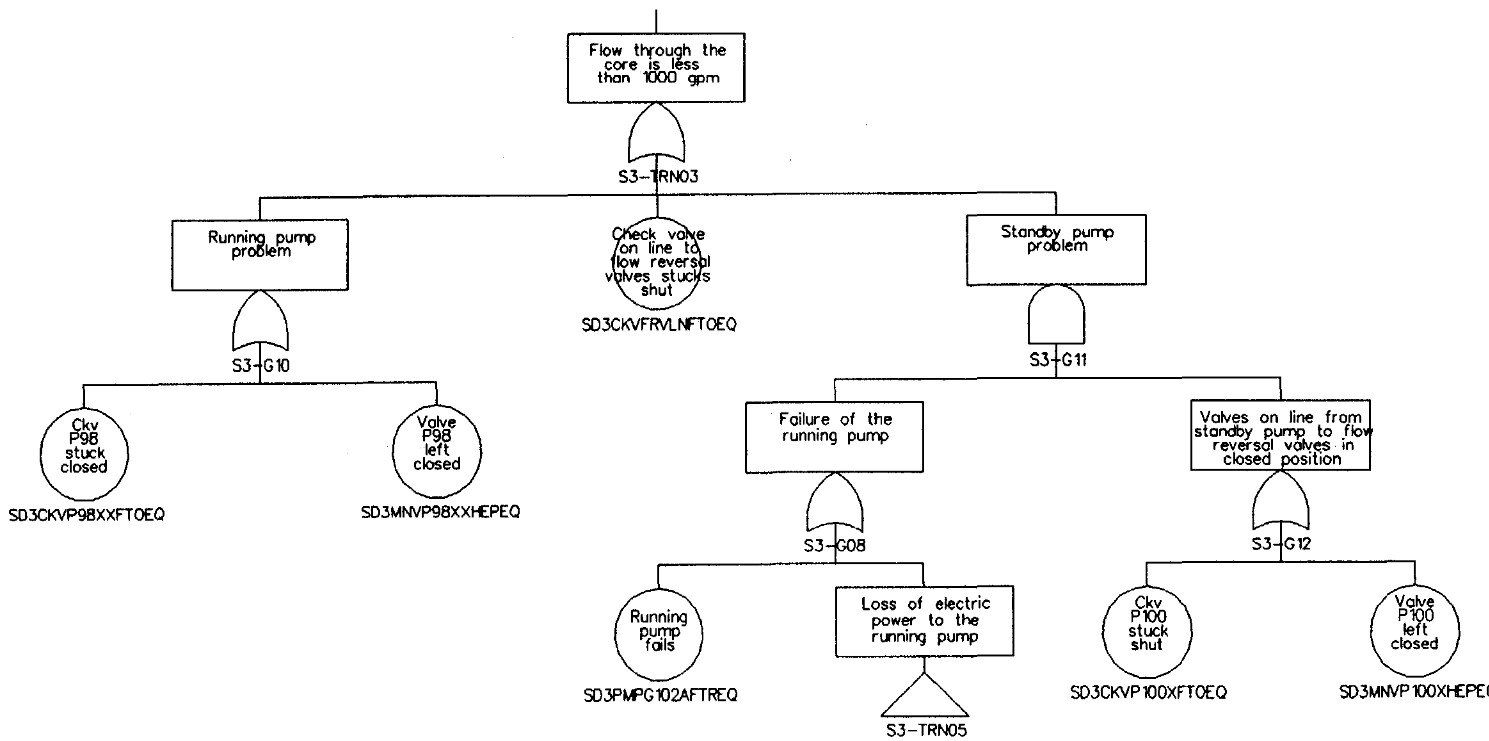


Note: Set House-3min="True"
After done, set it back to "FALSE"


S3 FAULT TREE
Sheet 3 of 6
Flow diversion
S3-TRN02
Running pump on line and gross internal leakage through ckv P99
SD3CKVP99XXLKEQ
Standby pump on line and gros internal leakage through ckv P97
S3-G07
Gross internal leakage through P97
SD3CKVP97XXLKEQ
Failure of the running pump
S3-G06
Running pump fails (mech.)
SD3PMPG102AFTREQ
Loss of electric power to the running pump
S3-TRN05

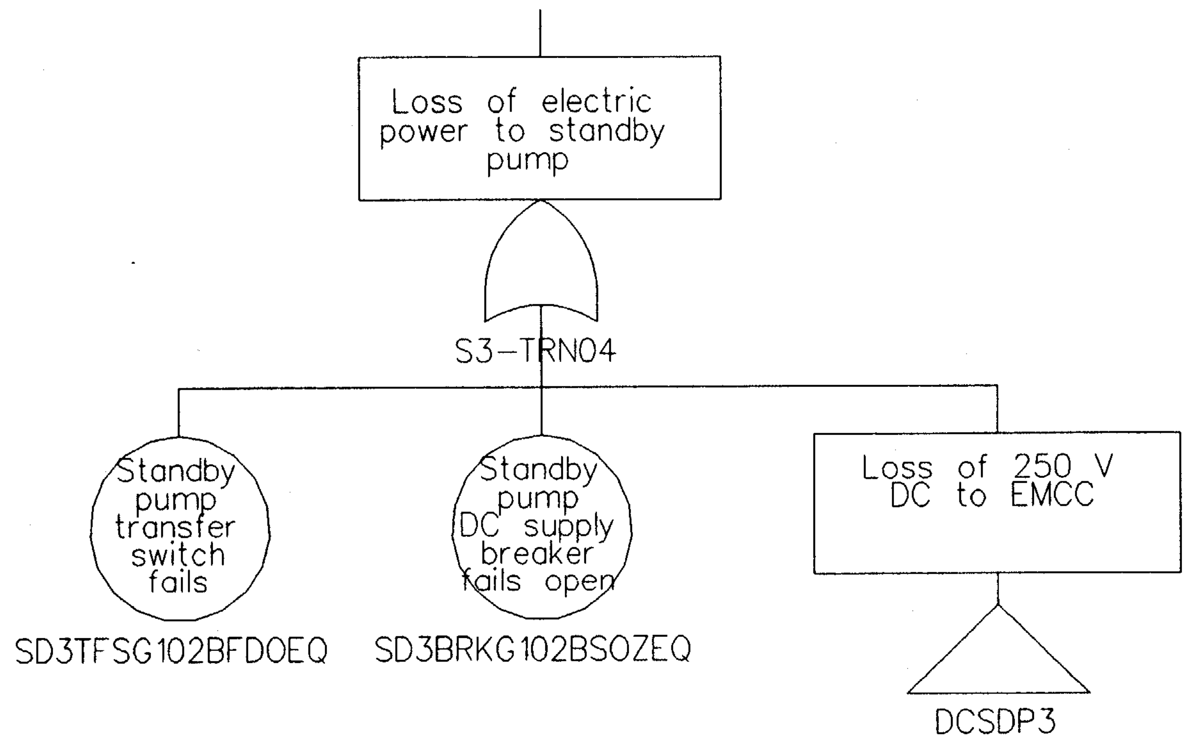
S3 FAULT TREE

Sheet 4 of 6



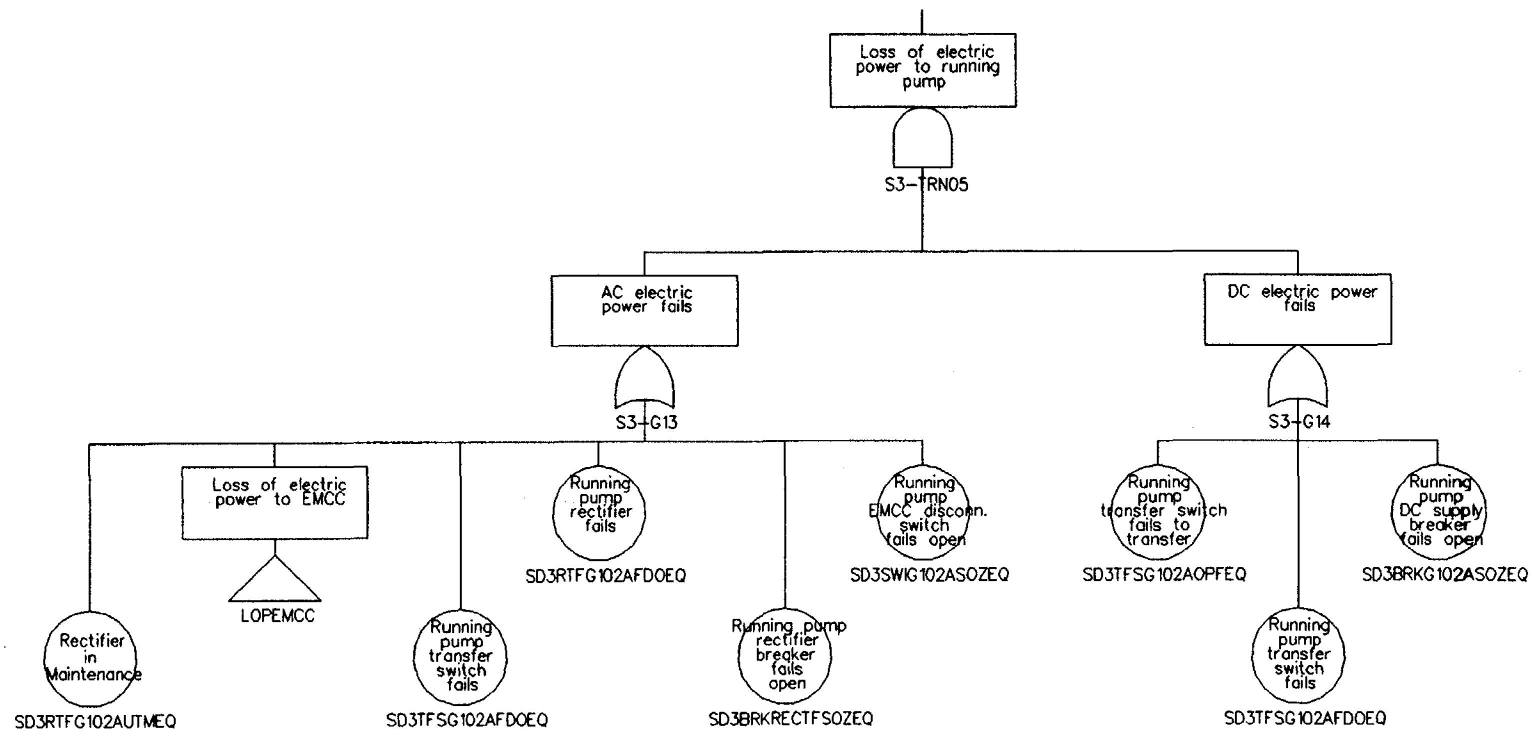
S3 FAULT TREE

Sheet 5 of 6



S3 FAULT TREE

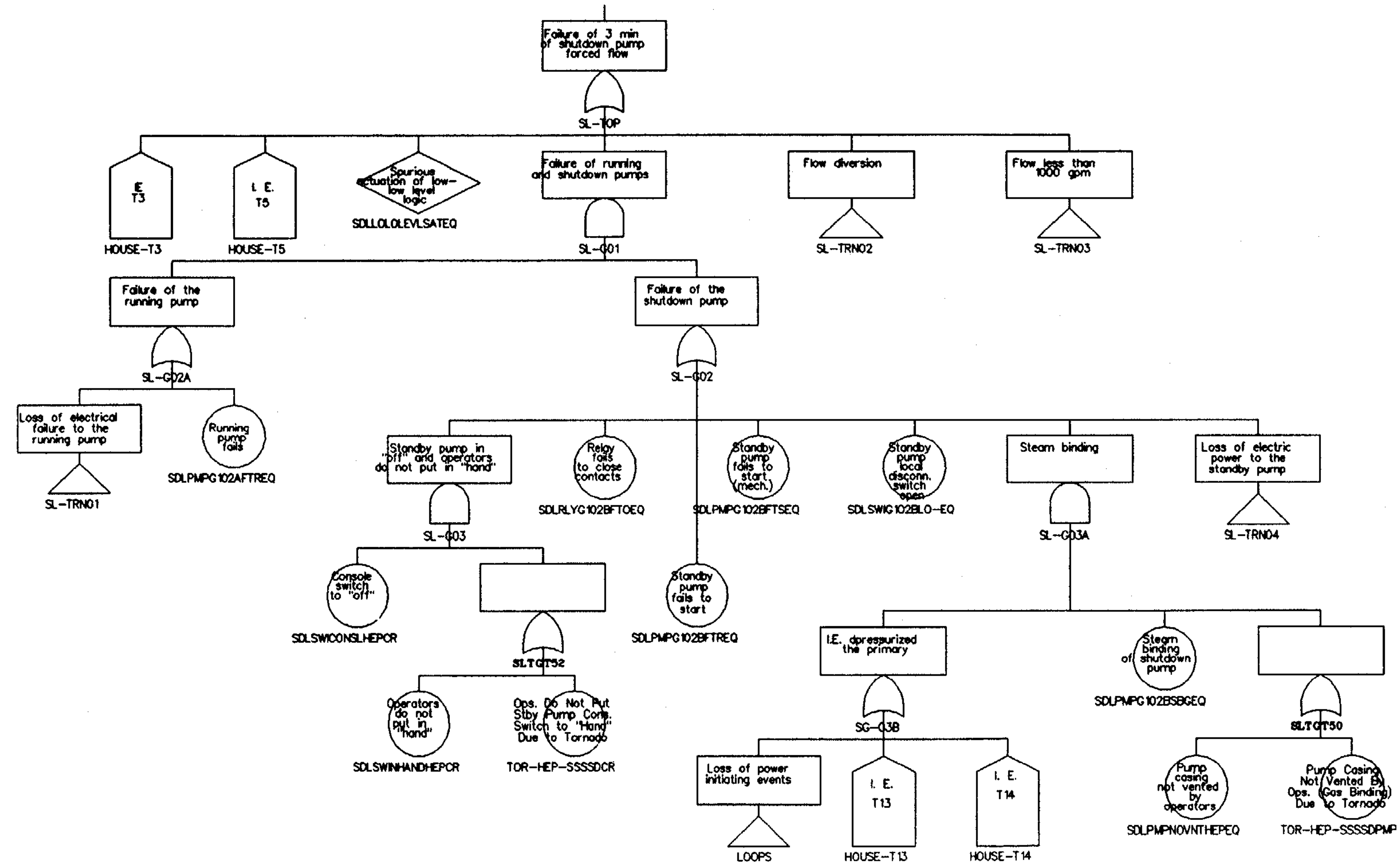
Sheet 6 of 6



This "transfer" is the same as S3-TRN01, except that DCSDP3 is not included since it also causes failure of the standby pump.

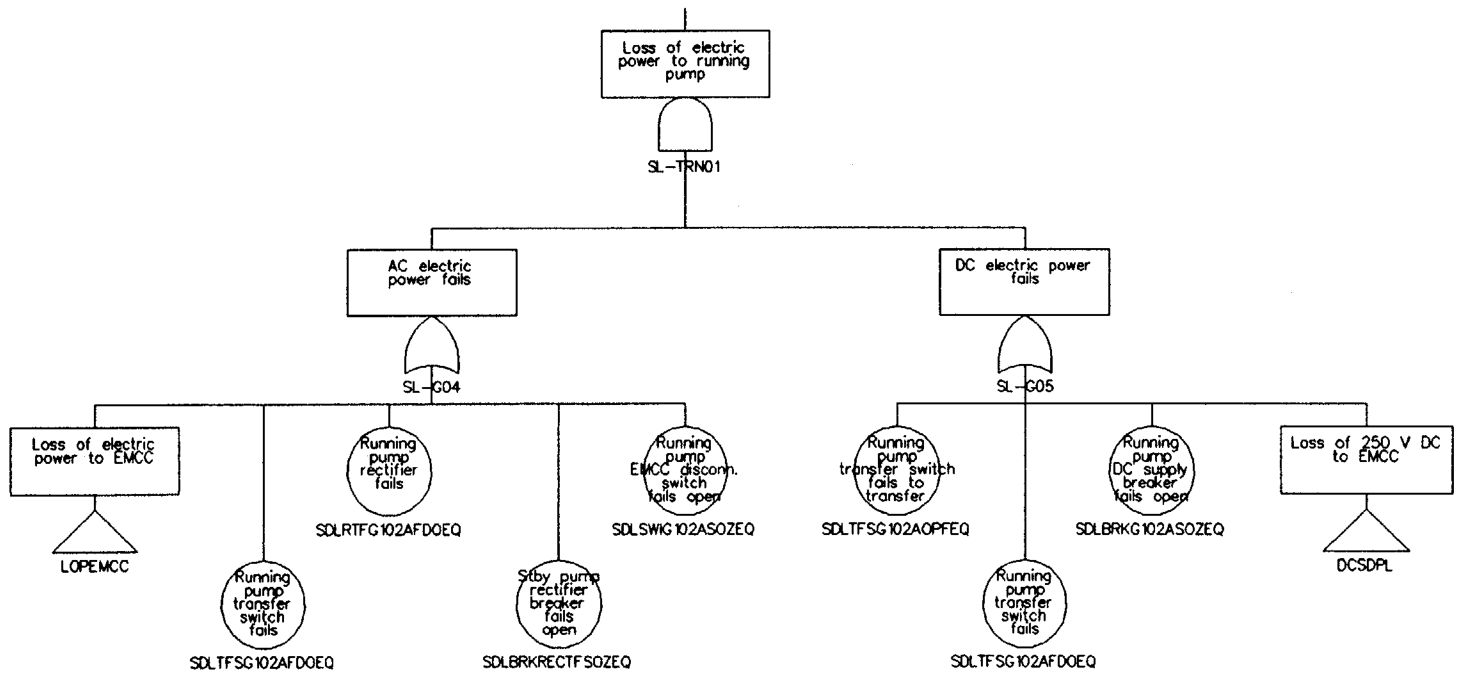
SL FAULT TREE

Sheet 1 of 6



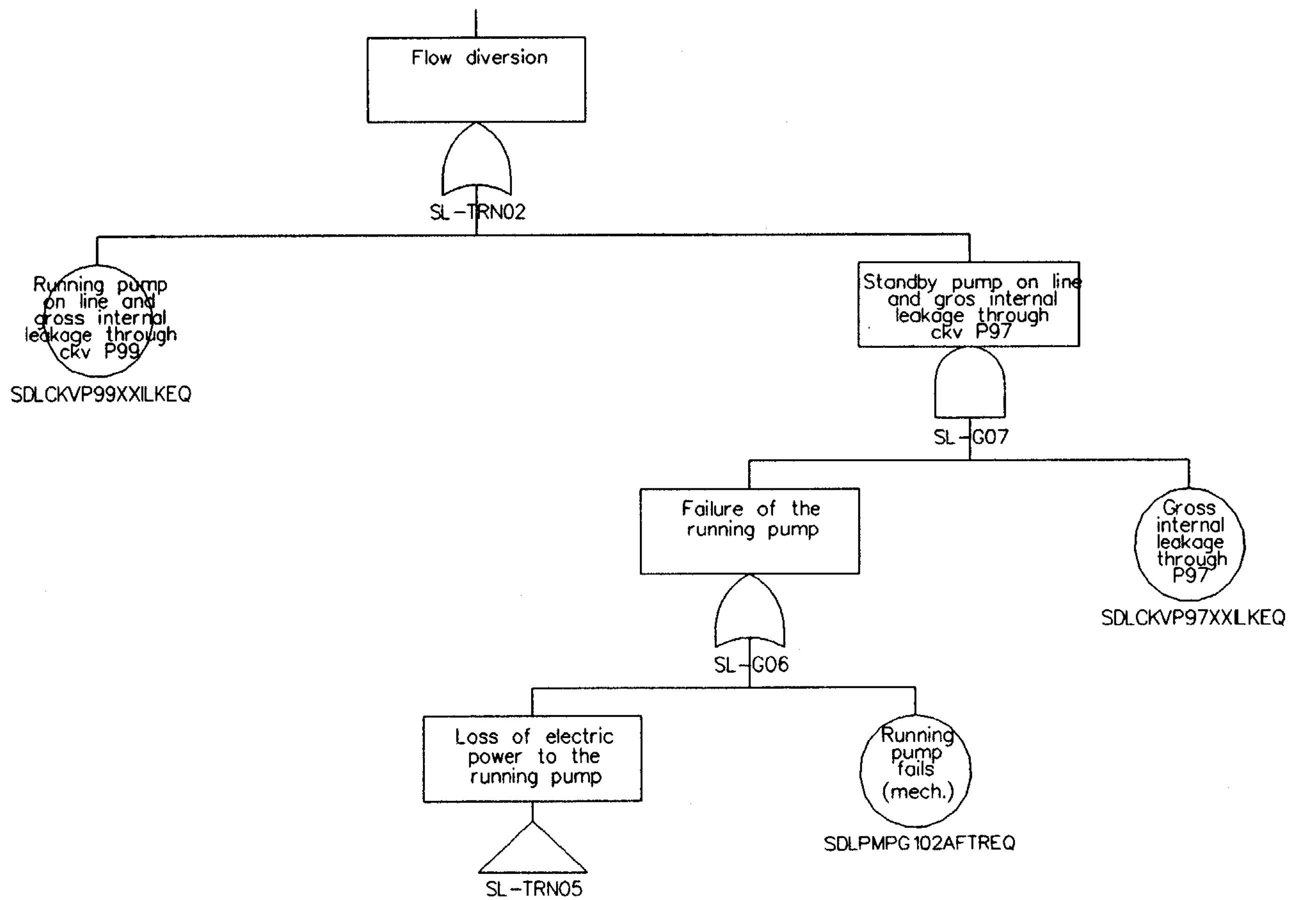
SL FAULT TREE

Sheet 2 of 6

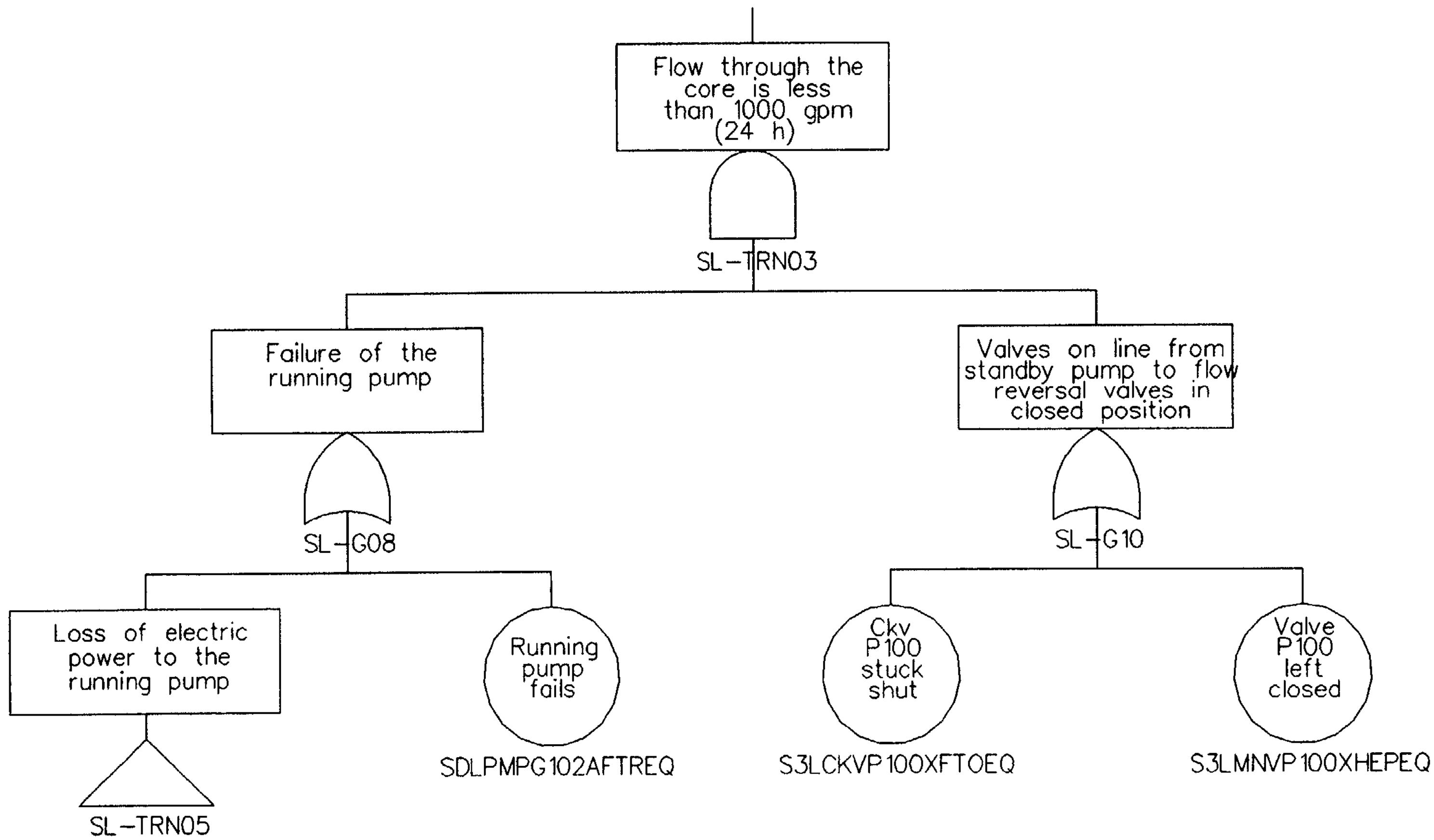


SL FAULT TREE

Sheet 3 of 6

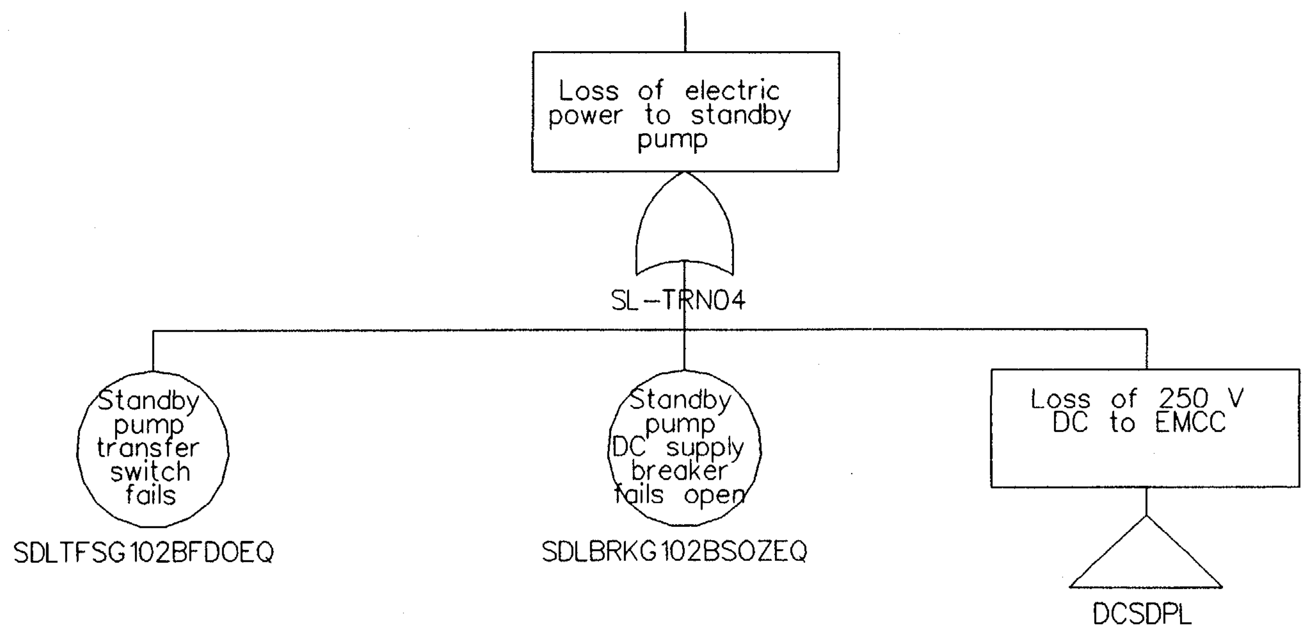


SL FAULT TREE
Sheet 4 of 6



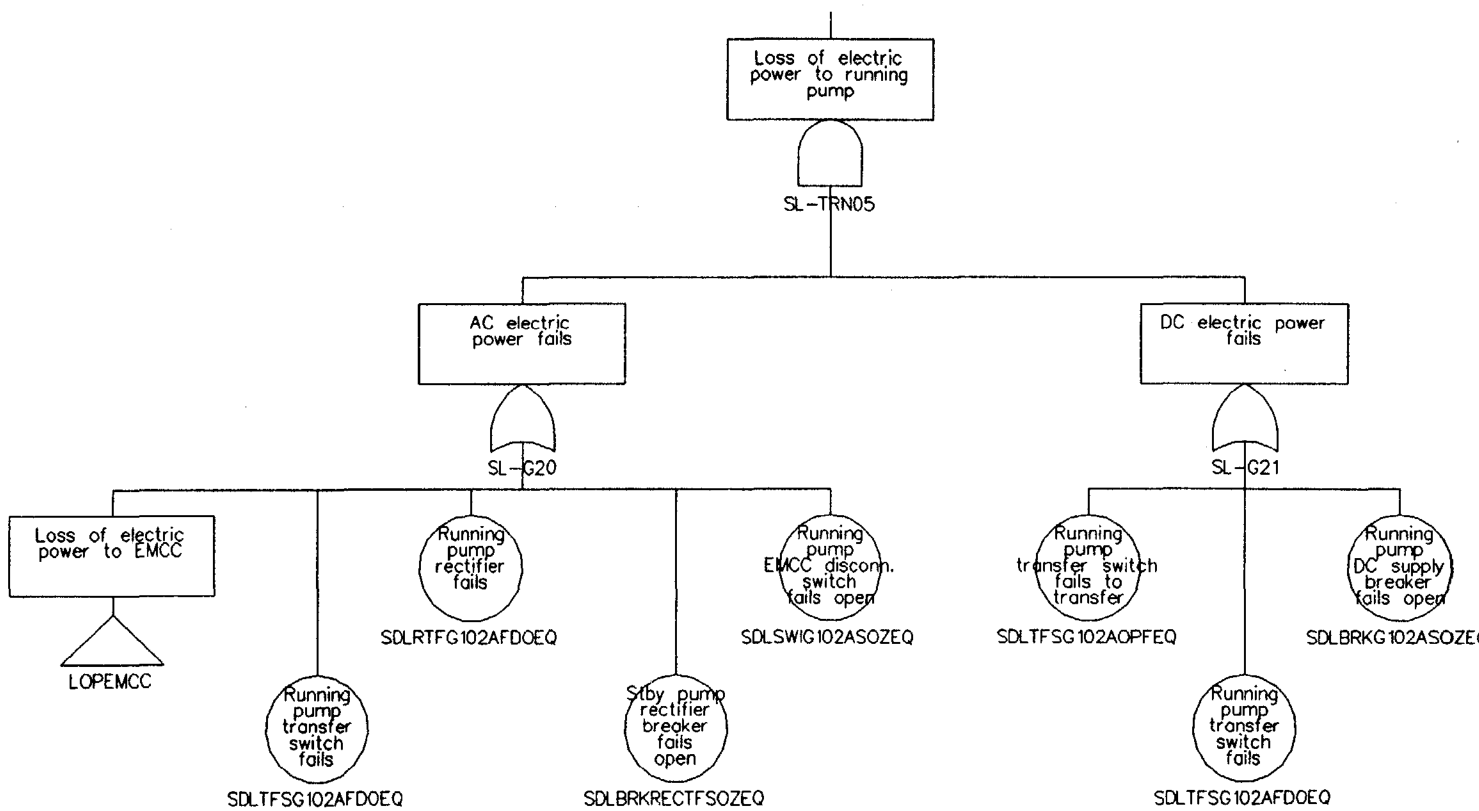
SL FAULT TREE

Sheet 5 of 6



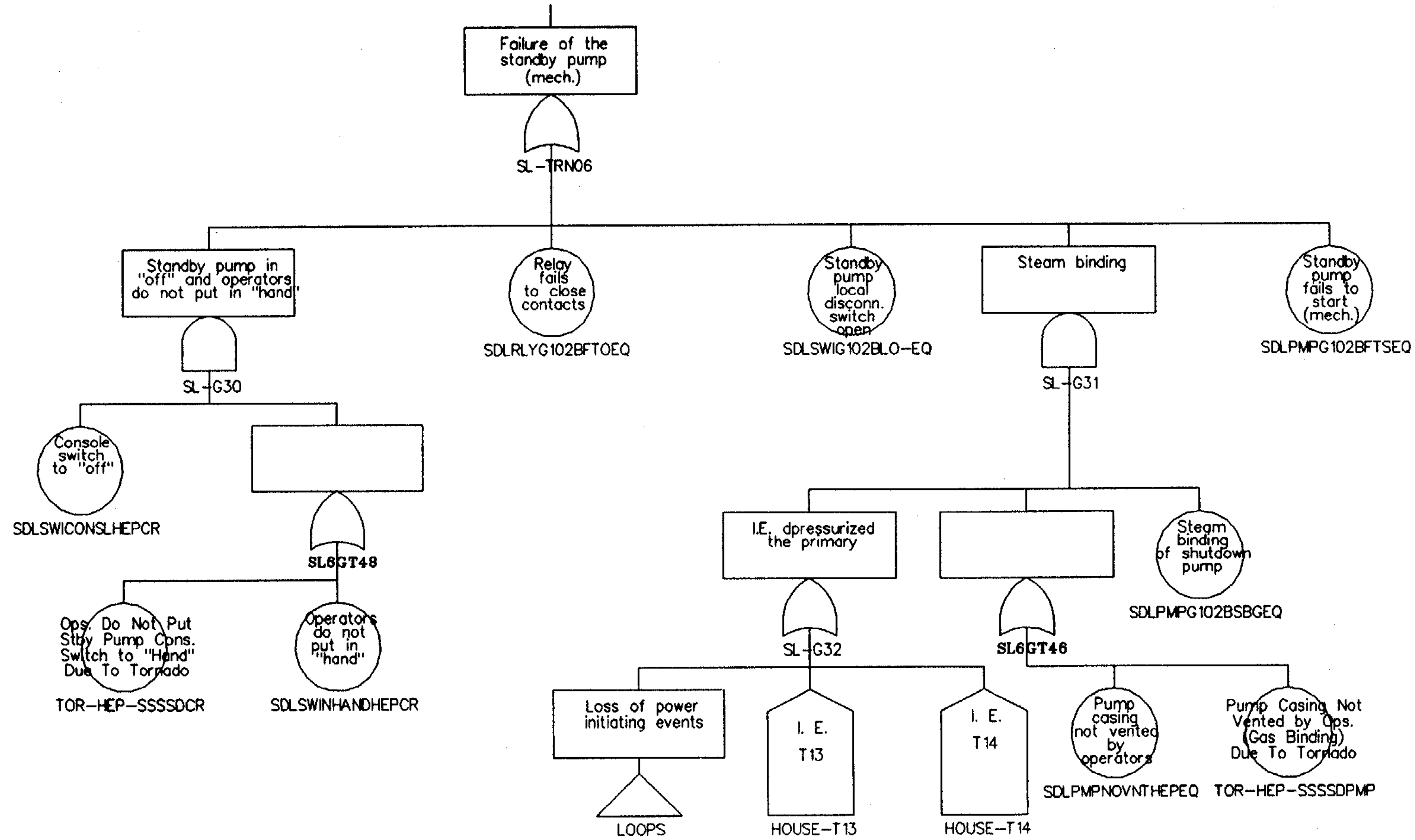
SL FAULT TREE

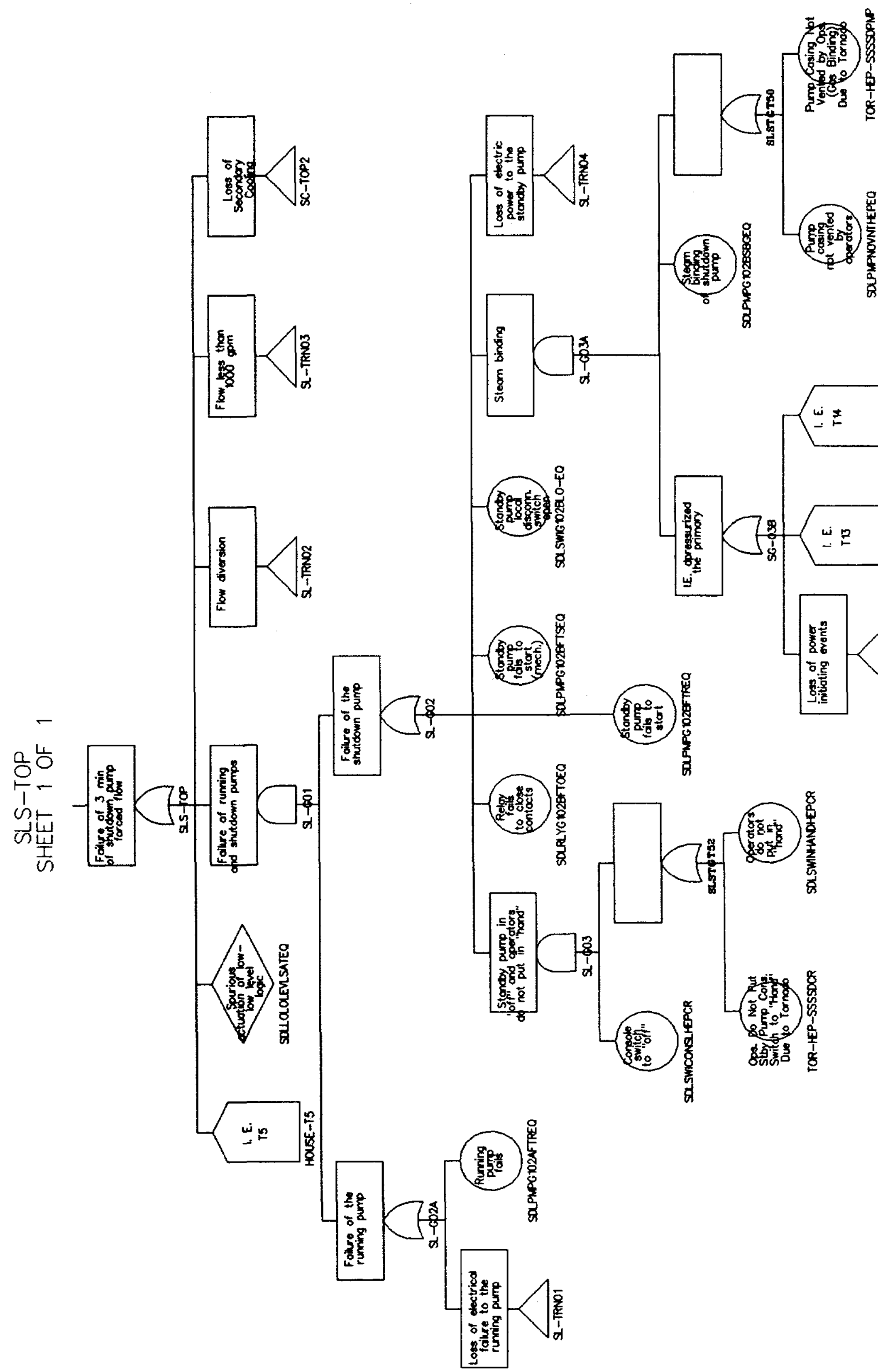
Sheet 6 of 6



SL FAULT TREE

SHEET 6A OF 6A





SLS-TOP
SHEET 1 OF 1
Failure of 3 min of shutdown pump forced flow
SLS-TOP
I. E. T5
HOUSE-T5
Spurious actuation of low-low level logic
SDLLOLOLEVLSATEQ
Failure of running and shutdown pumps
SL-G01
Flow diversion
SL-TRN02
Flow less than 1000 gpm
SL-TRN03
Loss of Secondary Cooling
SC-TOP2
Failure of the running pump
SL-G02A
Running pump fails
SDLPMPG102AFTREQ
Loss of electrical failure to the running pump
SL-TRN01
Failure of the shutdown pump
SL-G02
Standby pump in "off" and operators do not put in "hand"
SL-G03
Console switch to "off"
SDLSWICONSLHEPCR
SLSTGT32
Ops. Do Not Put Stby Pump Cntr. Switch to "Hand" Due to Tornado
TOR-HEP-SSSDOR
Operators do not Put in "hand"
SDLSWIHANDHEPCR
Relay fails to close contacts
SDLRLYG102BFTOEQ
Standby pump fails to start
SDLPMPG102BFTREQ
Standby pump fails to start (mech.)
SDLPMPG102BFTSEQ
Standby pump local disconn. switch open
SDLSWIG102BLO-EQ
Steam binding
SL-G03A
I.E. depressurized the primary
SG-03B
Loss of power initiating events
LOOPS
I. E. T13
HOUSE-T13
I. E. T14
HOUSE-T14
Steam binding of shutdown pump
SDLPMPG102BSBGEQ
SLSTGT50
Pump casing not vented by operators
SDLPMPNOVNTHEPEQ
Pump Casing Not Vented by Ops (Gas Binding) Due to Tornado
TOR-HEP-SSSDPMP
Loss of electric power to the standby pump
SL-TRN04

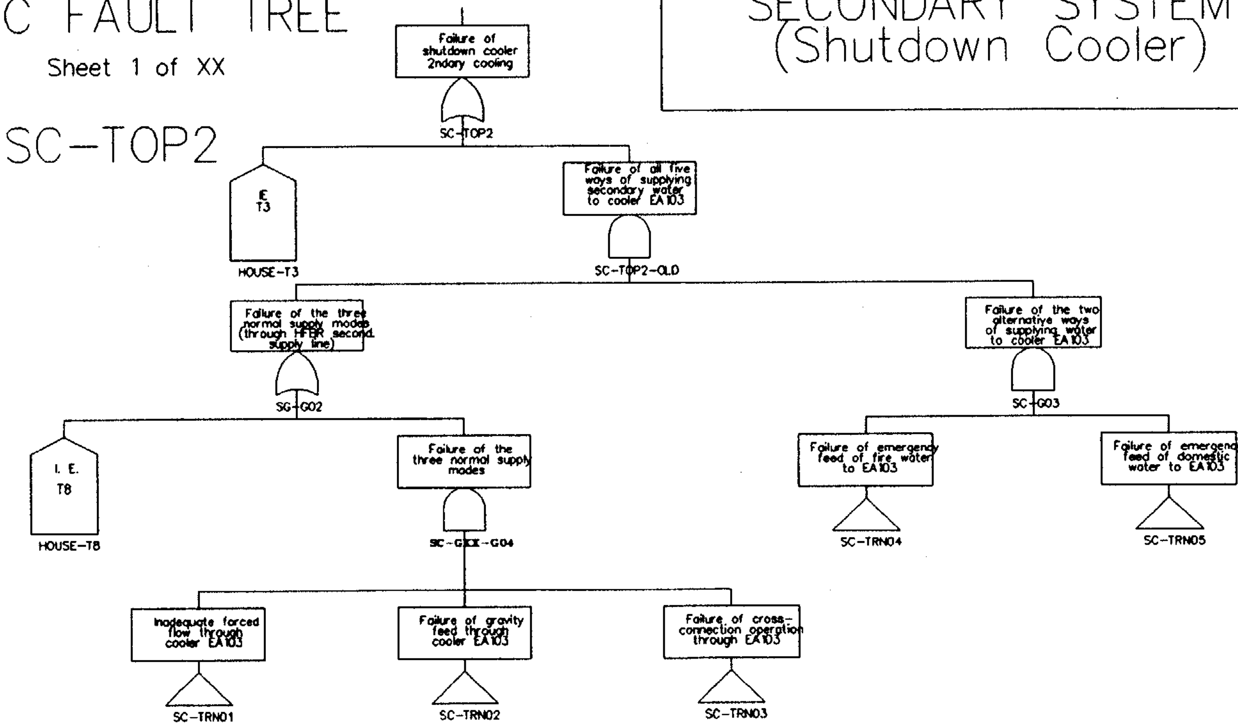
Appendix C.4
Secondary Cooling Water System Modified for Tornado Initiator

SC FAULT TREE

Sheet 1 of XX

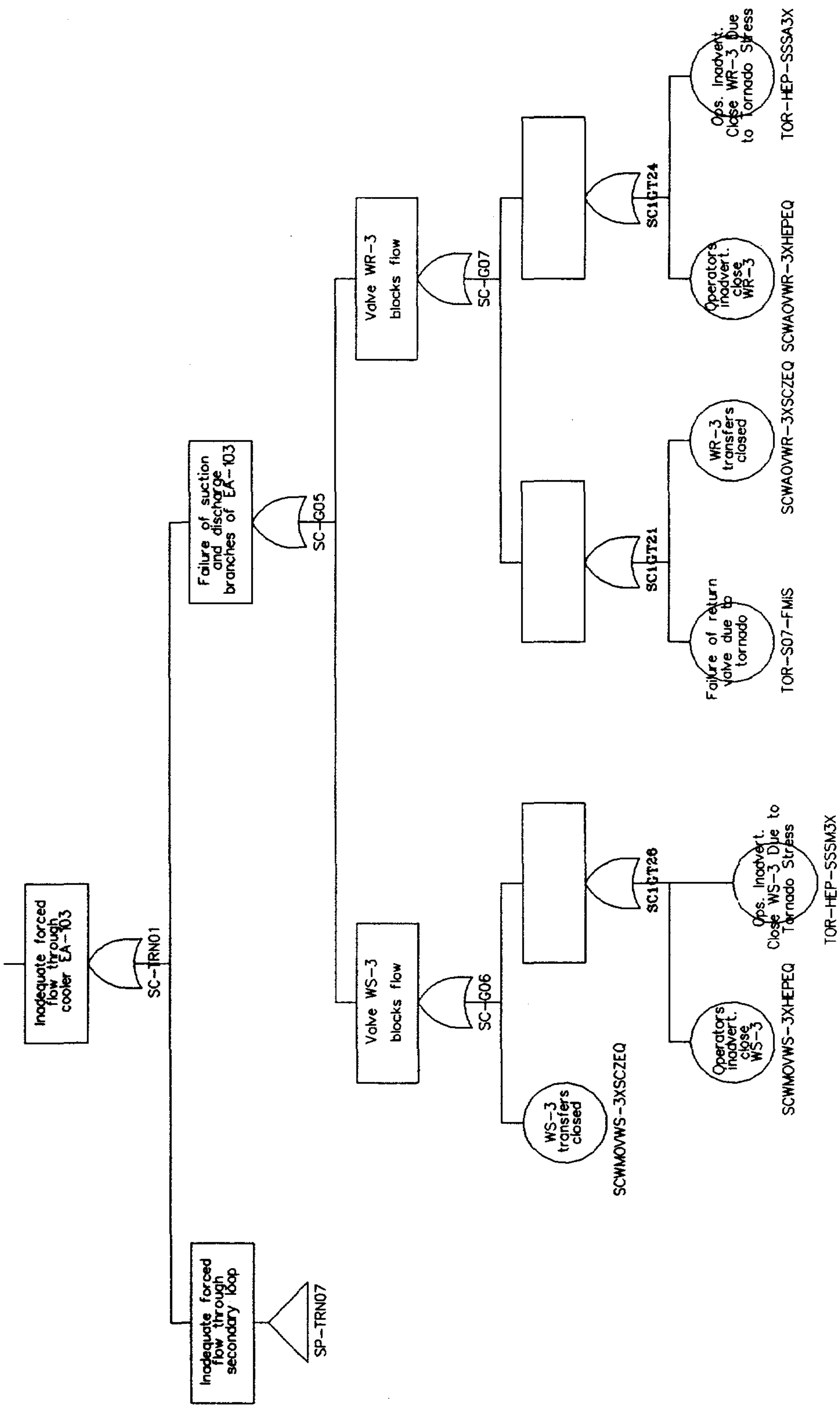
SC–TOP2

SECONDARY SYSTEM (Shutdown Cooler)



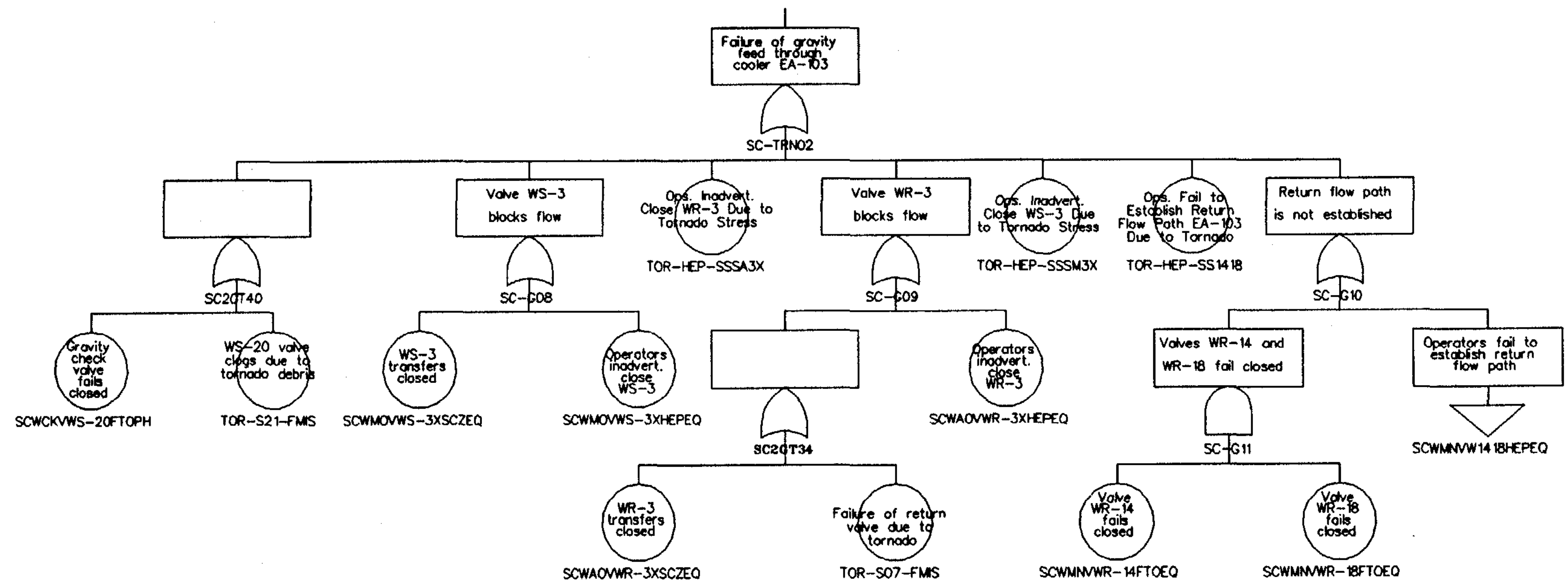
SC FAULT TREE

Sheet 2 of XX

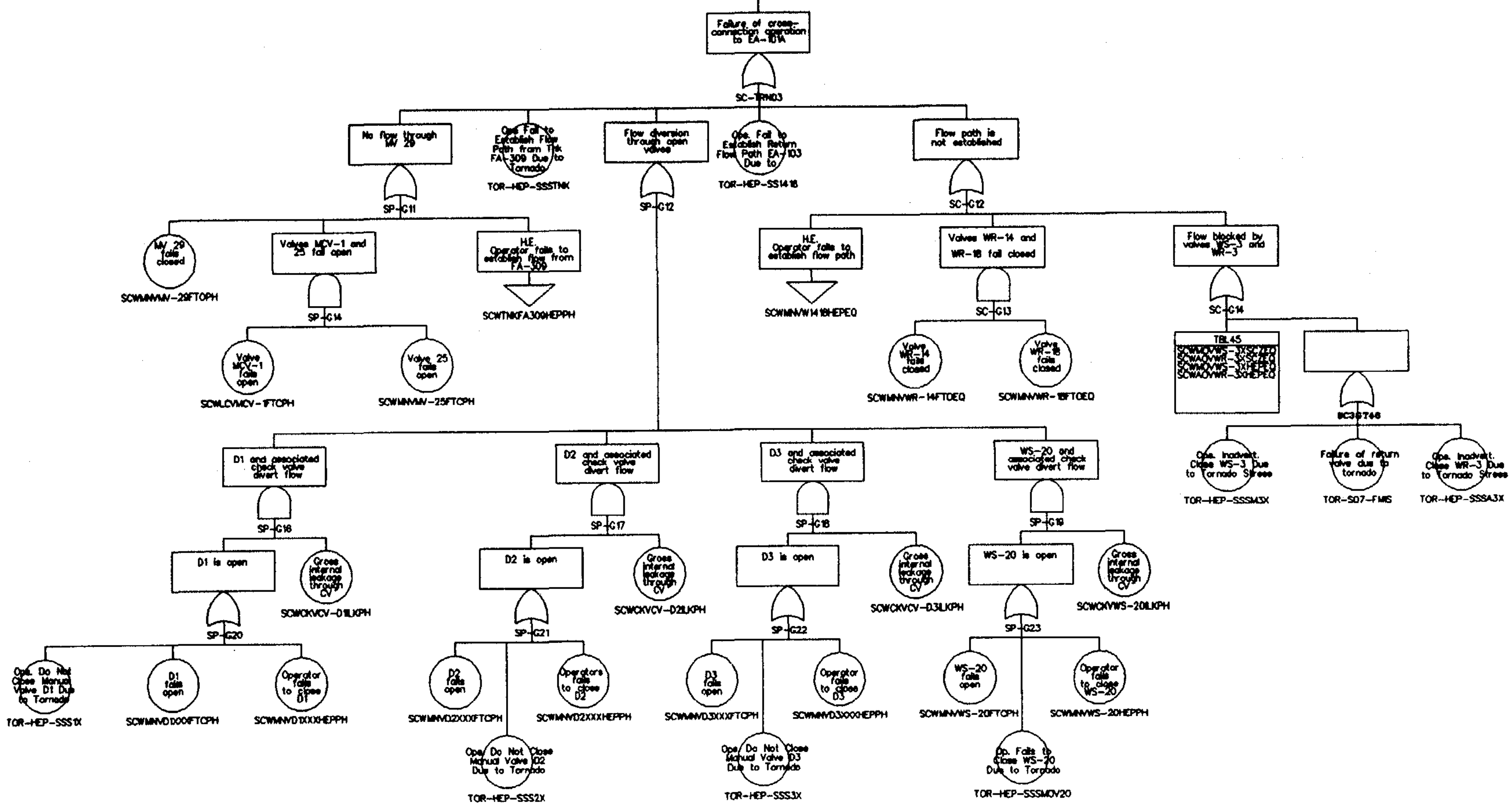


SC FAULT TREE

Sheet 3 of XX

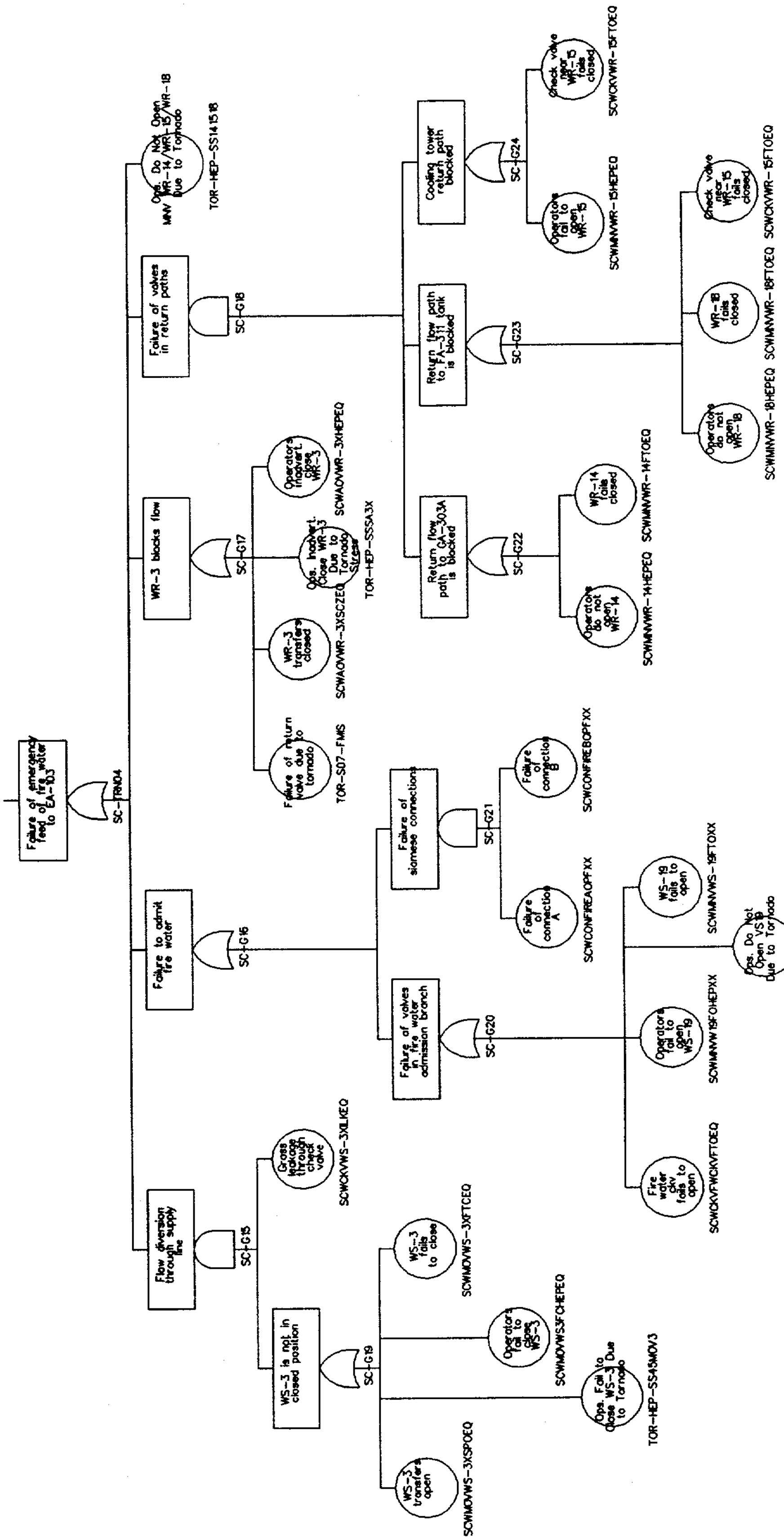


SC FAULT TREE
SC-TRN03
Sheet 4 of XX

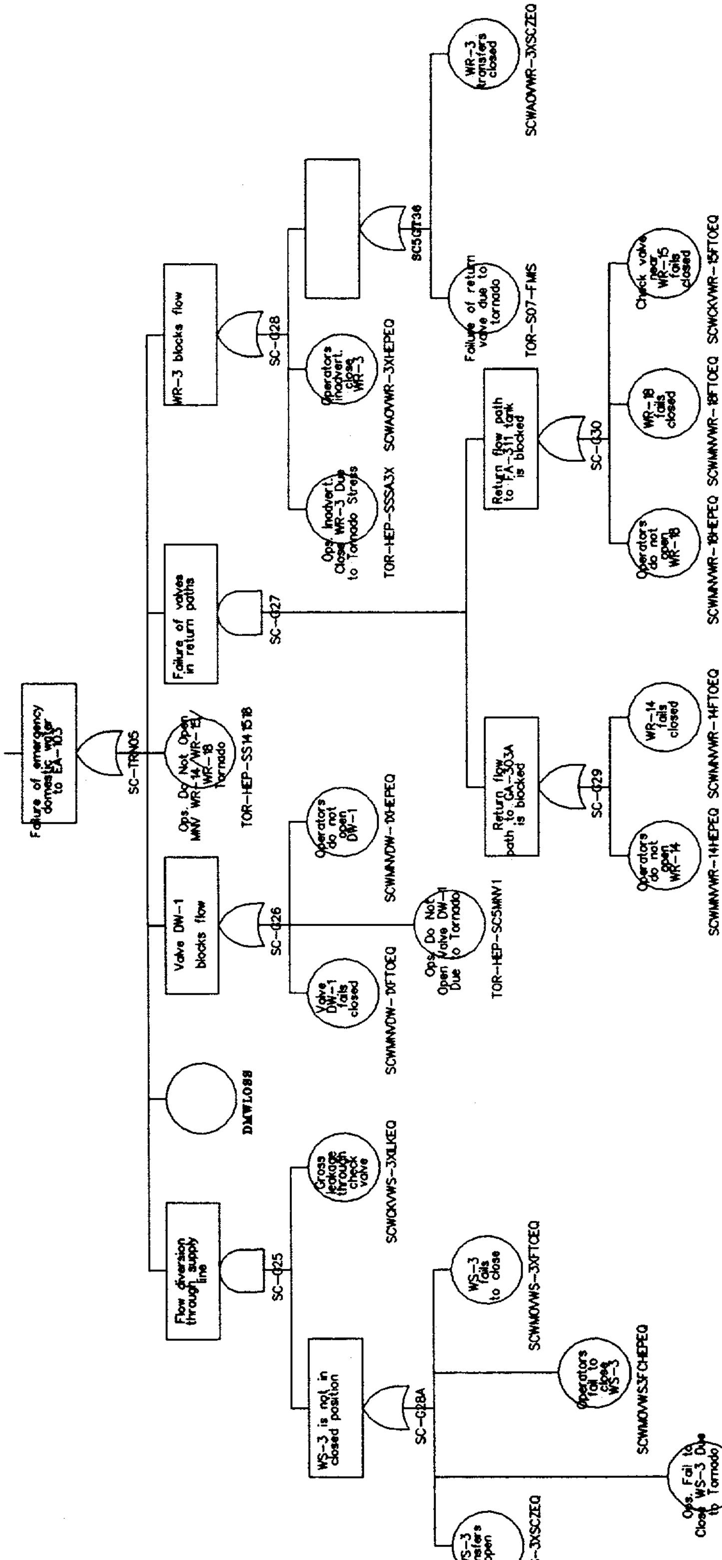


SC FAULT TREE

Sheet 5 of XX



SC FAULT TREE
SHEET 6 OF 6

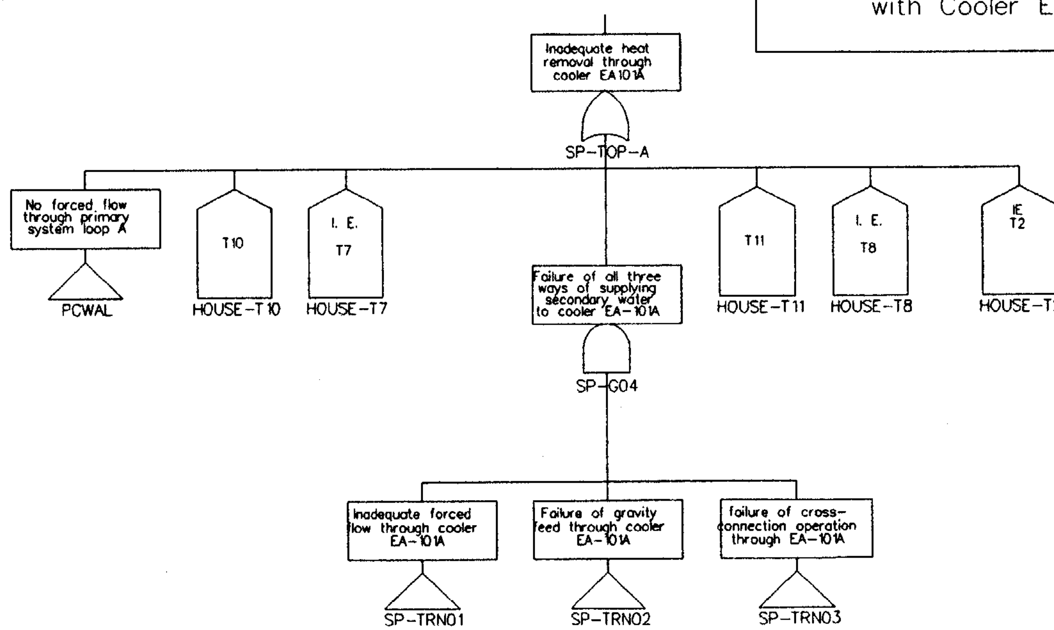


SP FAULT TREE

Sheet 1 of 13

SECONDARY SYSTEM

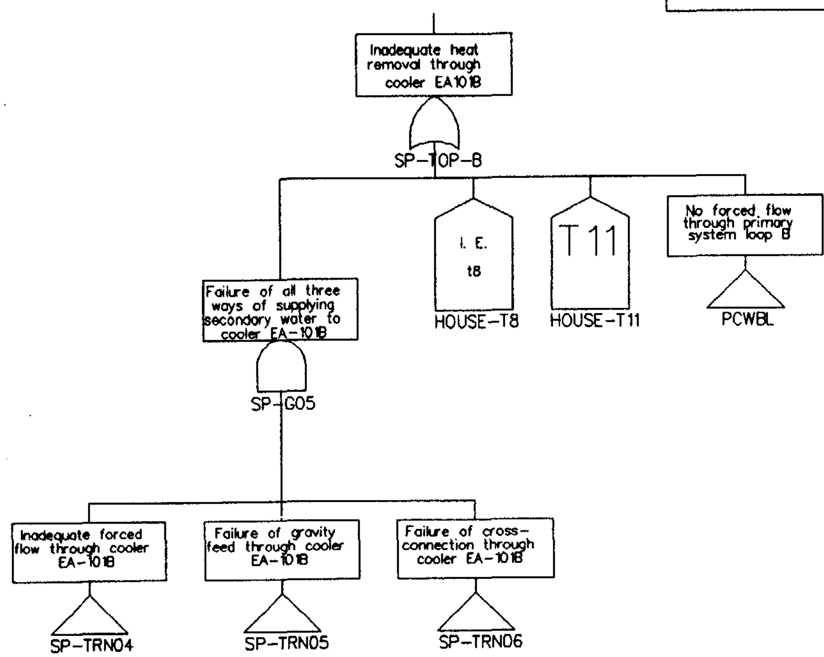
with Cooler EA-101A



SP FAULT TREE

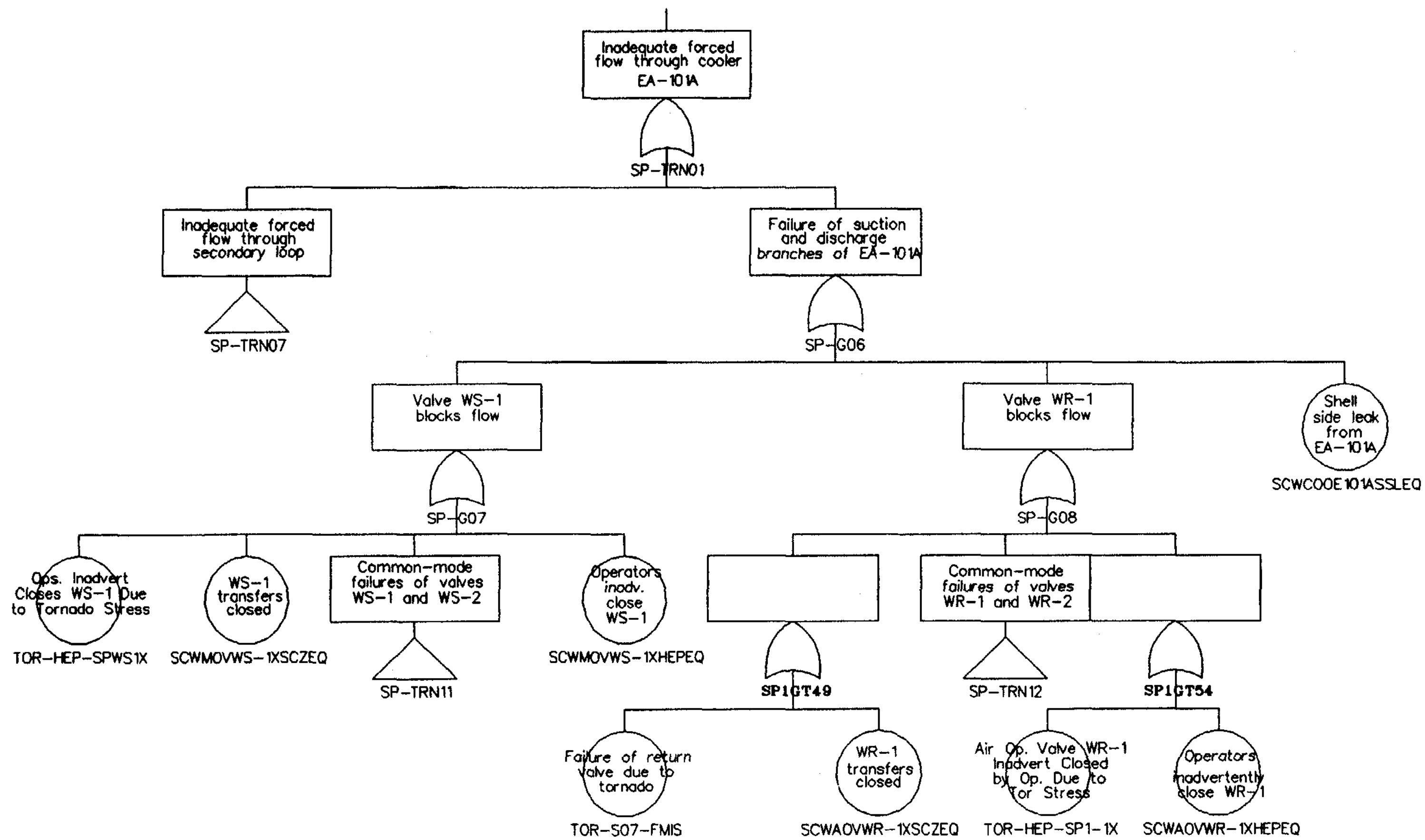
Sheet 1 of 13

SECONDARY SYSTEM
PRIMARY COOLER B



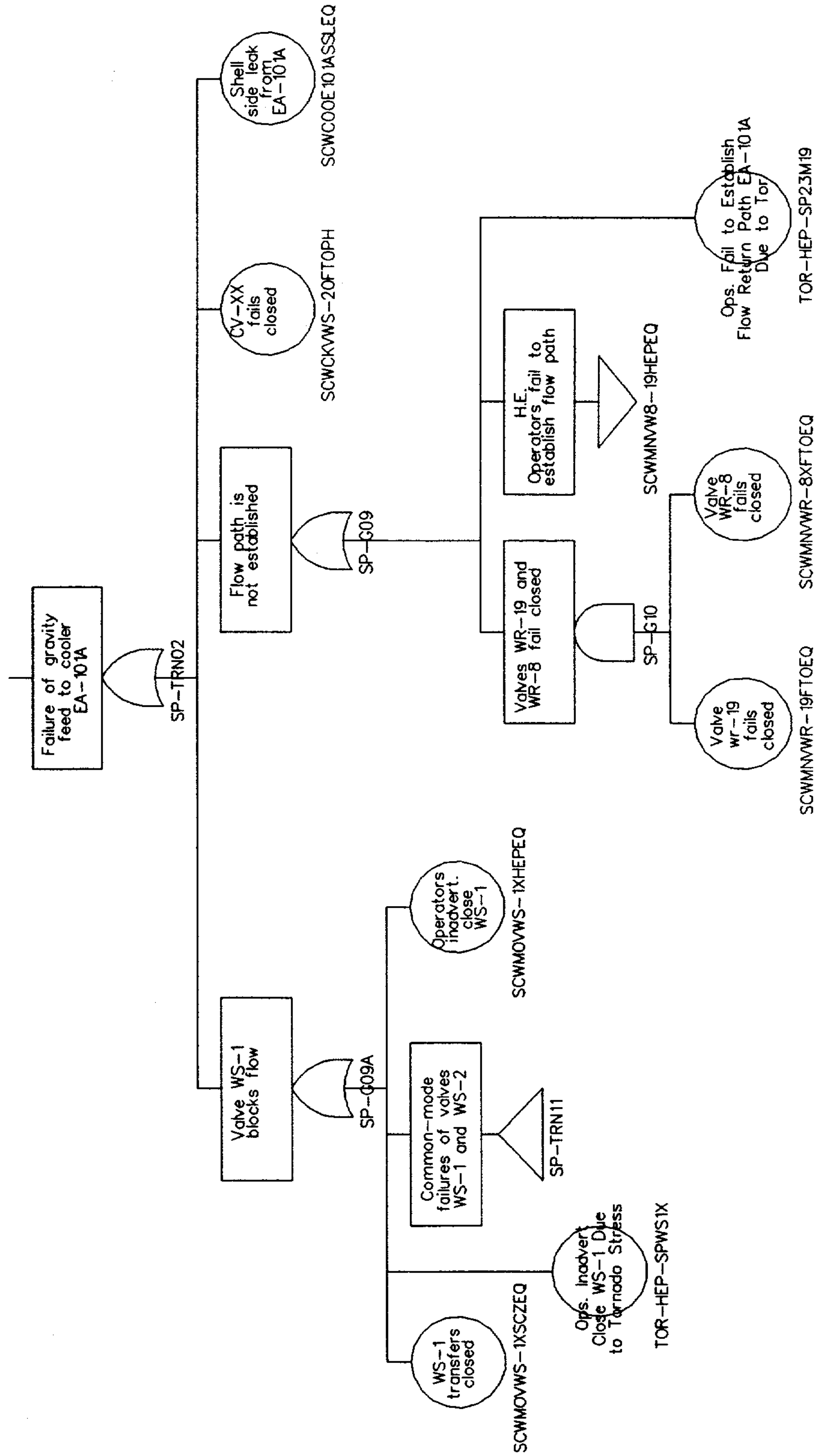
SP FAULT TREE

Sheet 2 of 13



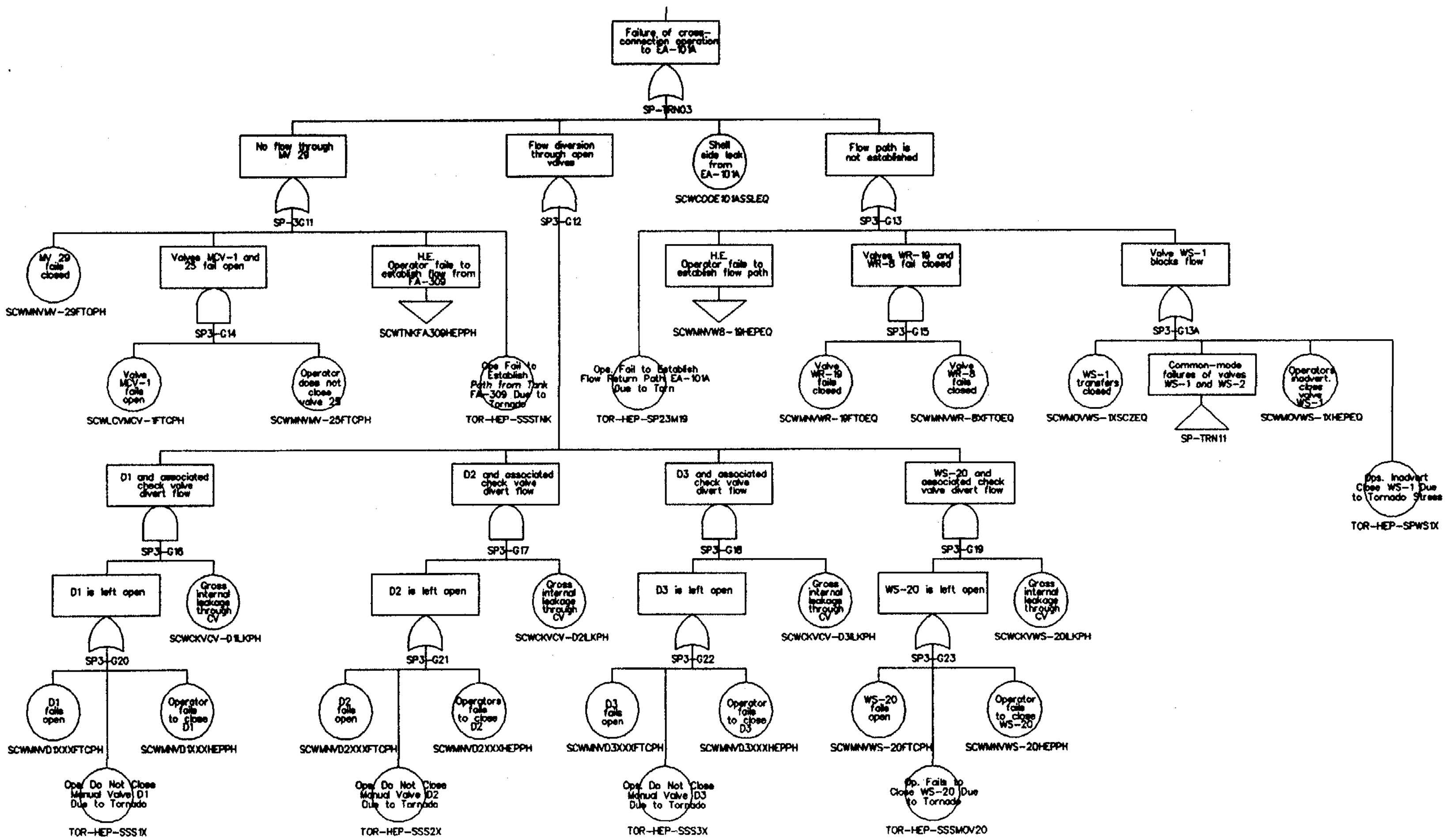
SP FAULT TREE

Sheet 3 of 13



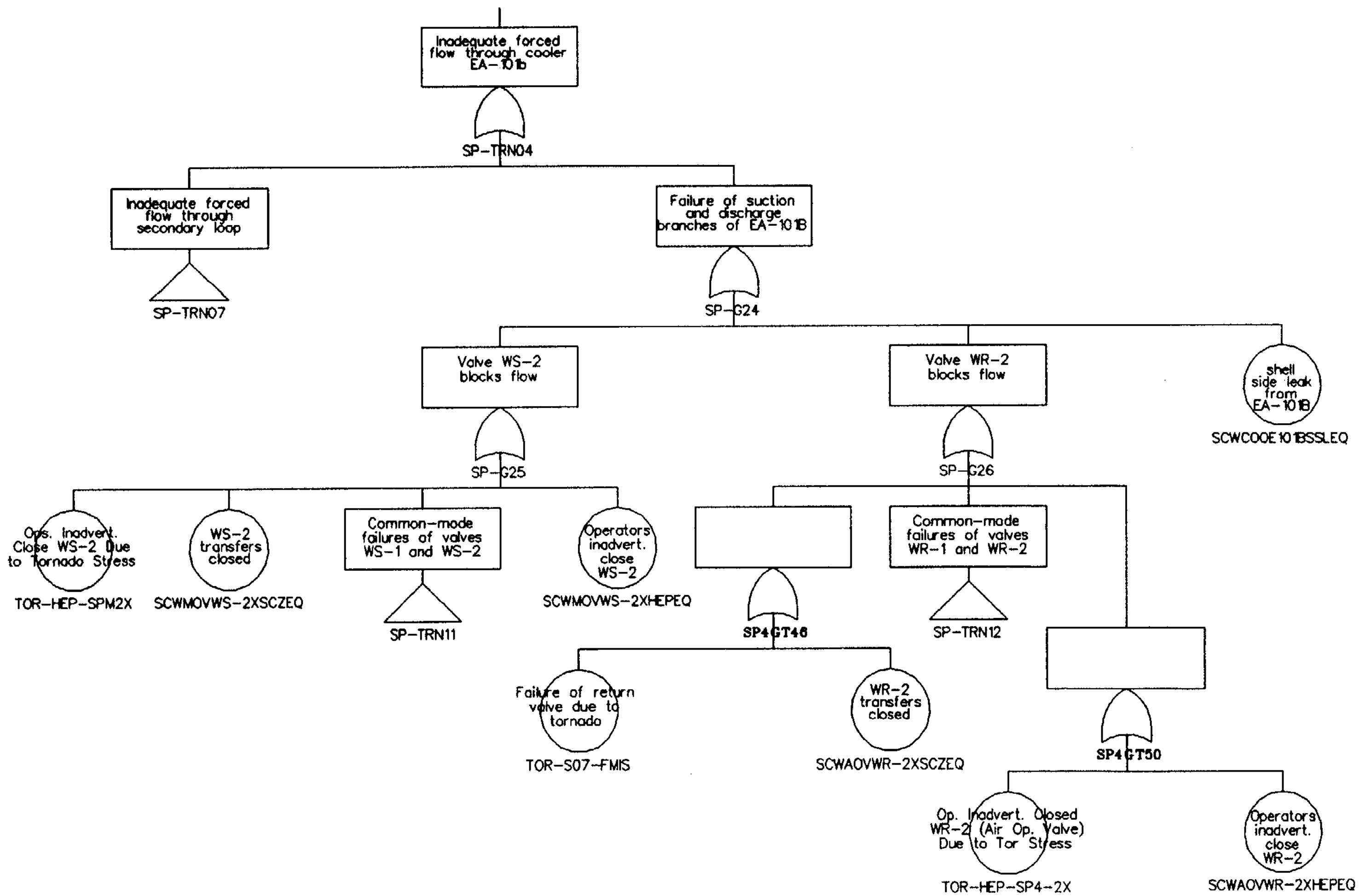
SP FAULT TREE

Sheet 4 of 13



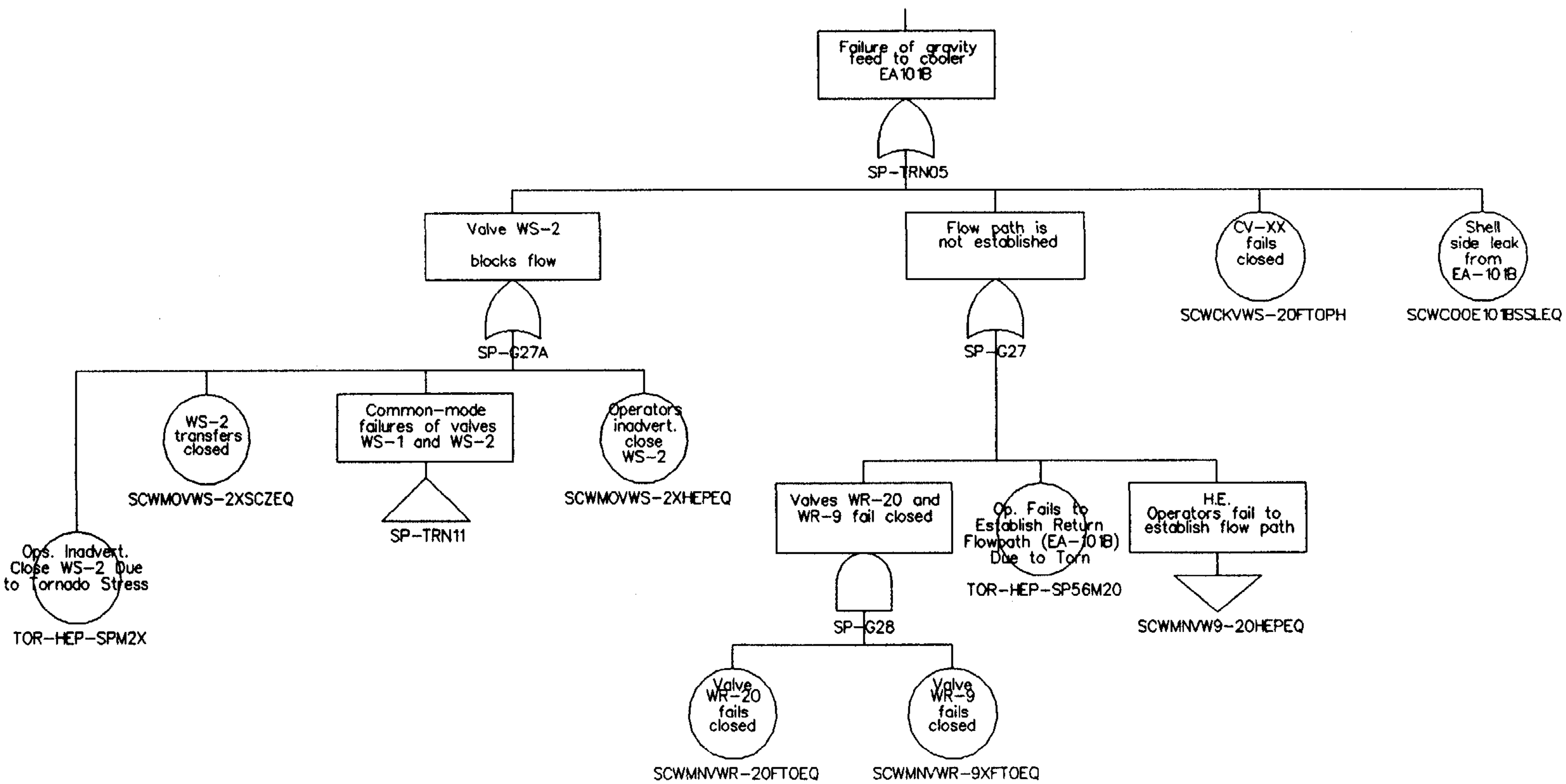
SP FAULT TREE

Sheet 5 of 13



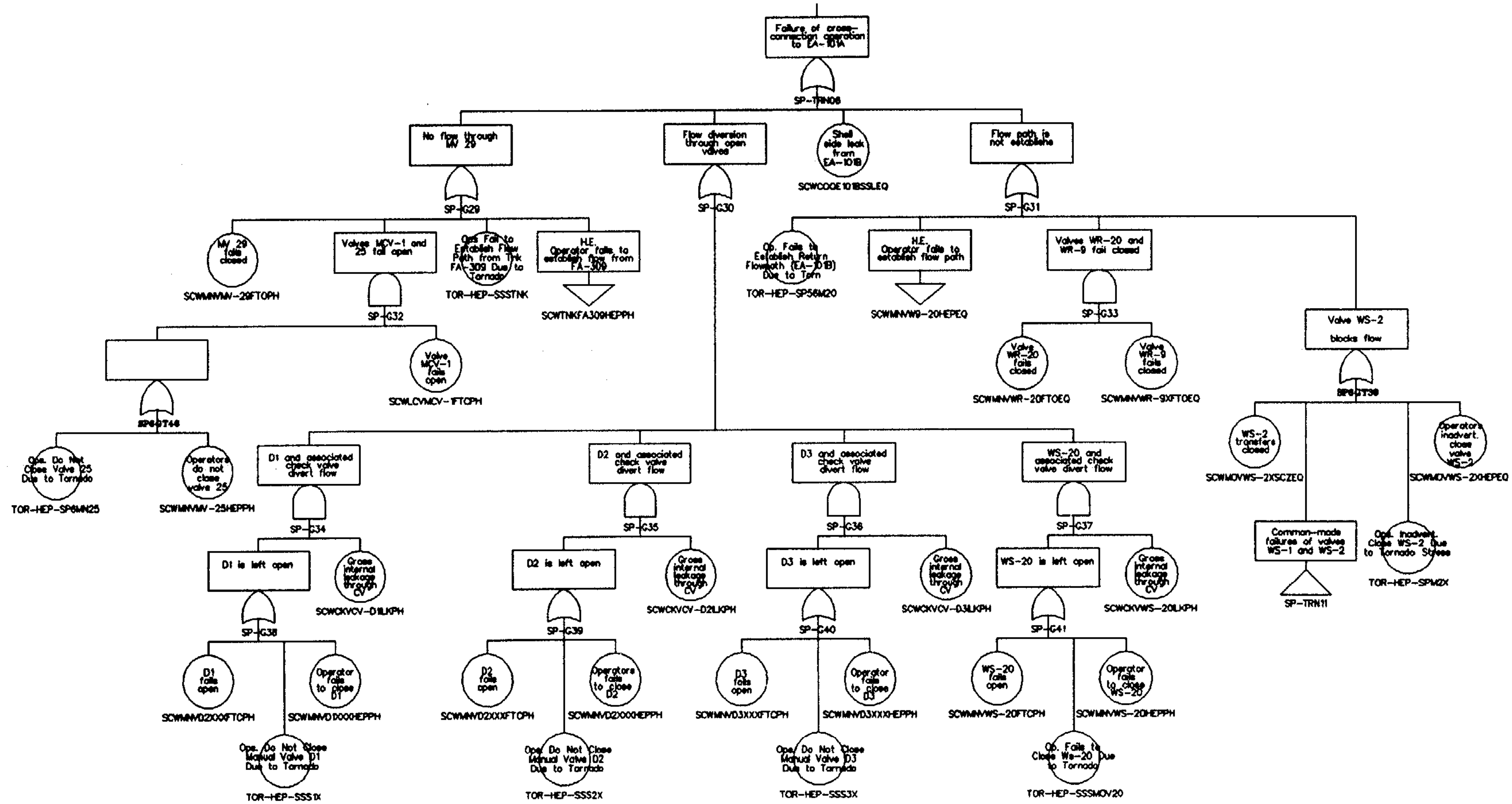
SP FAULT TREE

Sheet 6 of 13



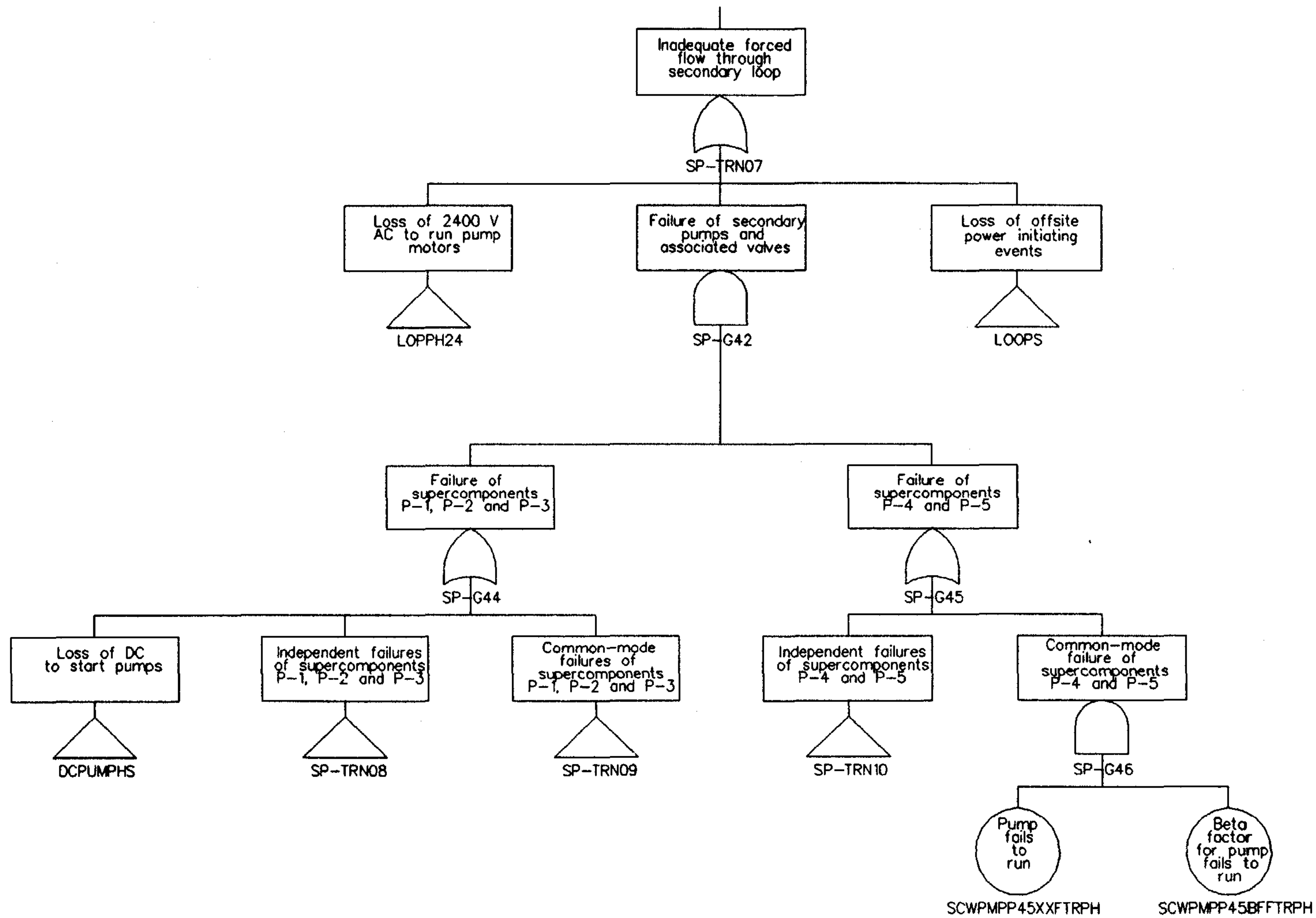
SP FAULT TREE

Sheet 7 of 13



SP FAULT TREE

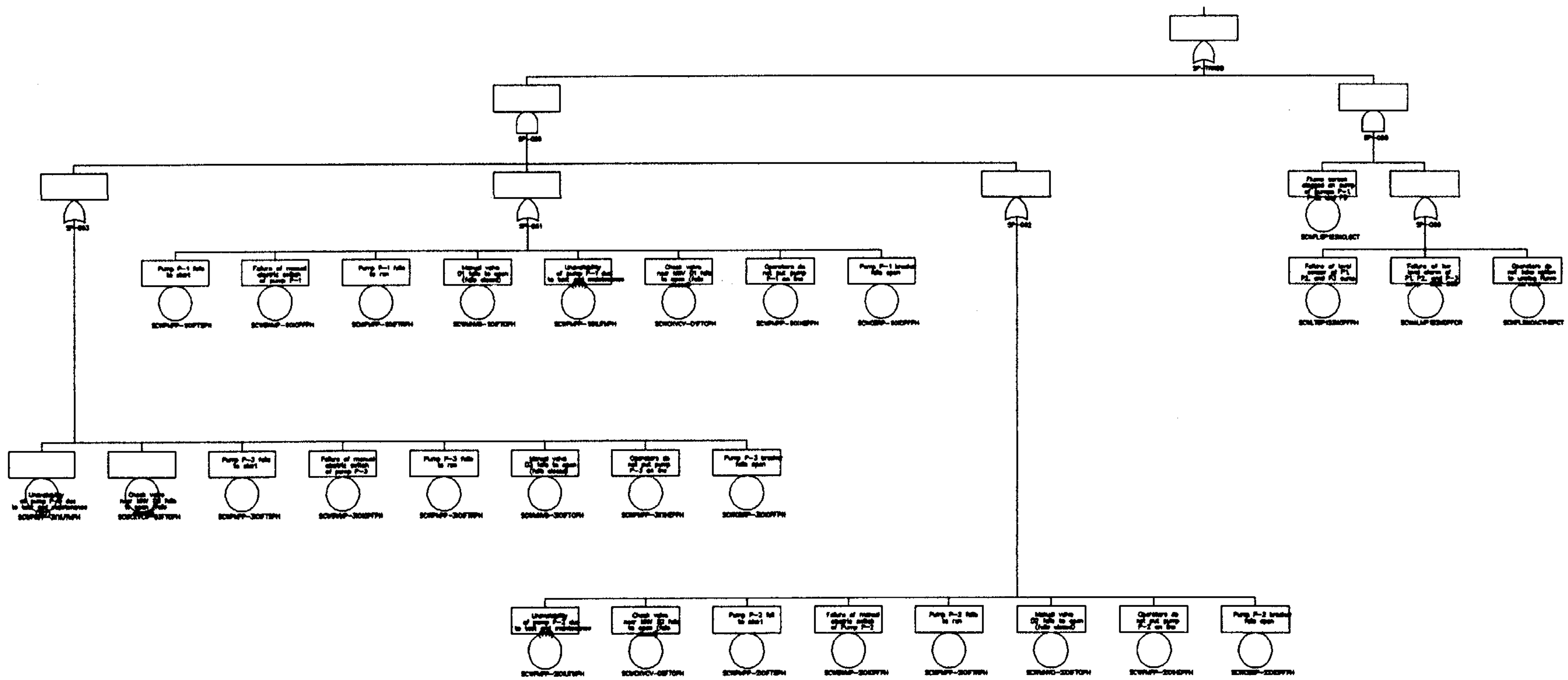
Sheet 8 of 13



SP-TRN08

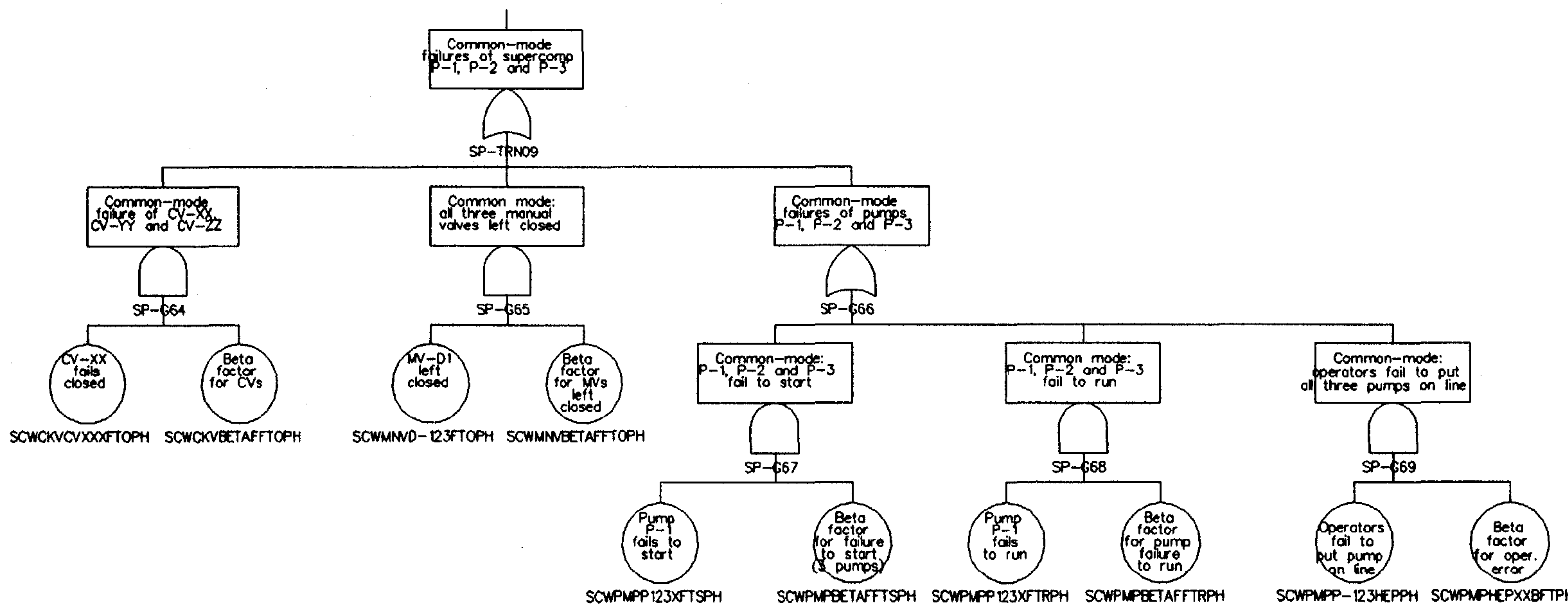
SP FAULT TREE

Sheet 9 of 13



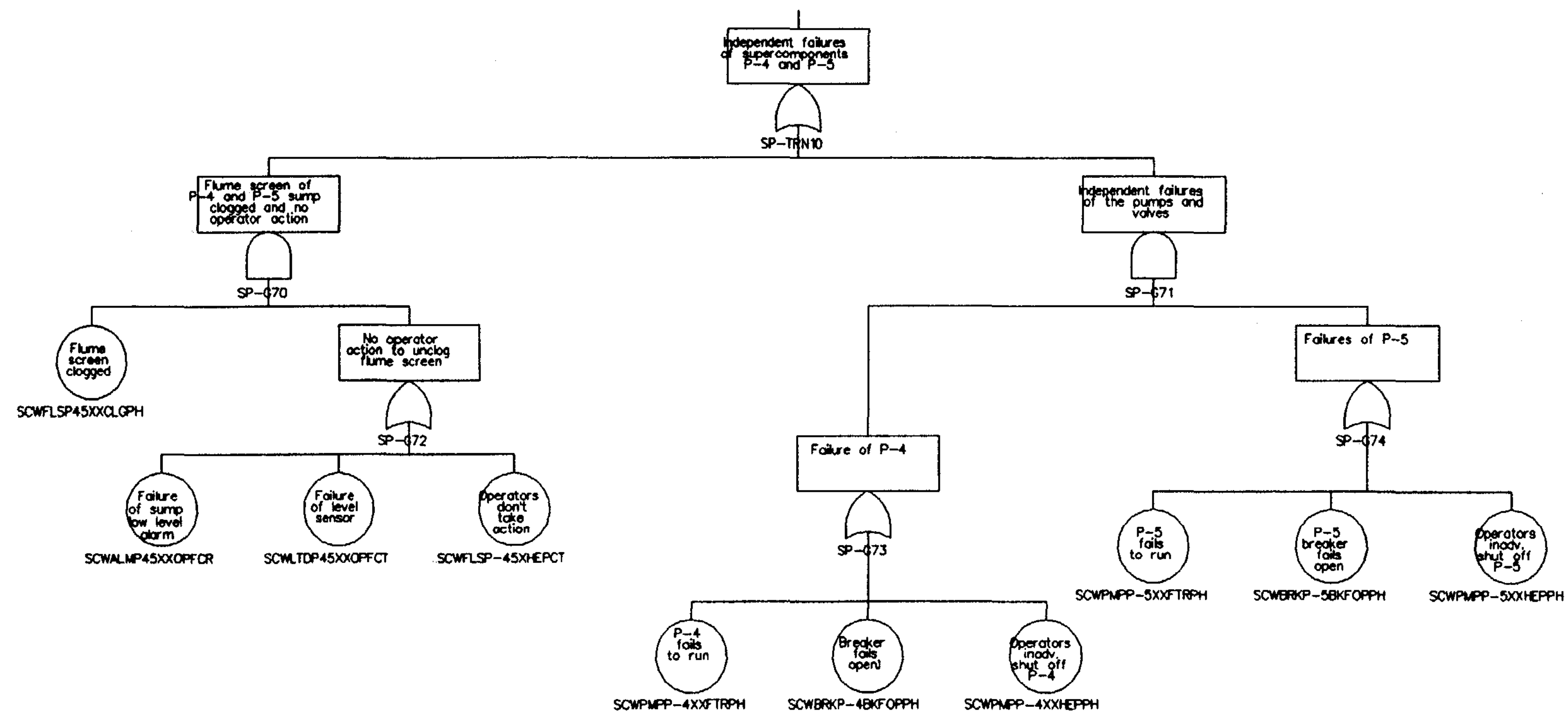
SP FAULT TREE

Sheet 10 of 13



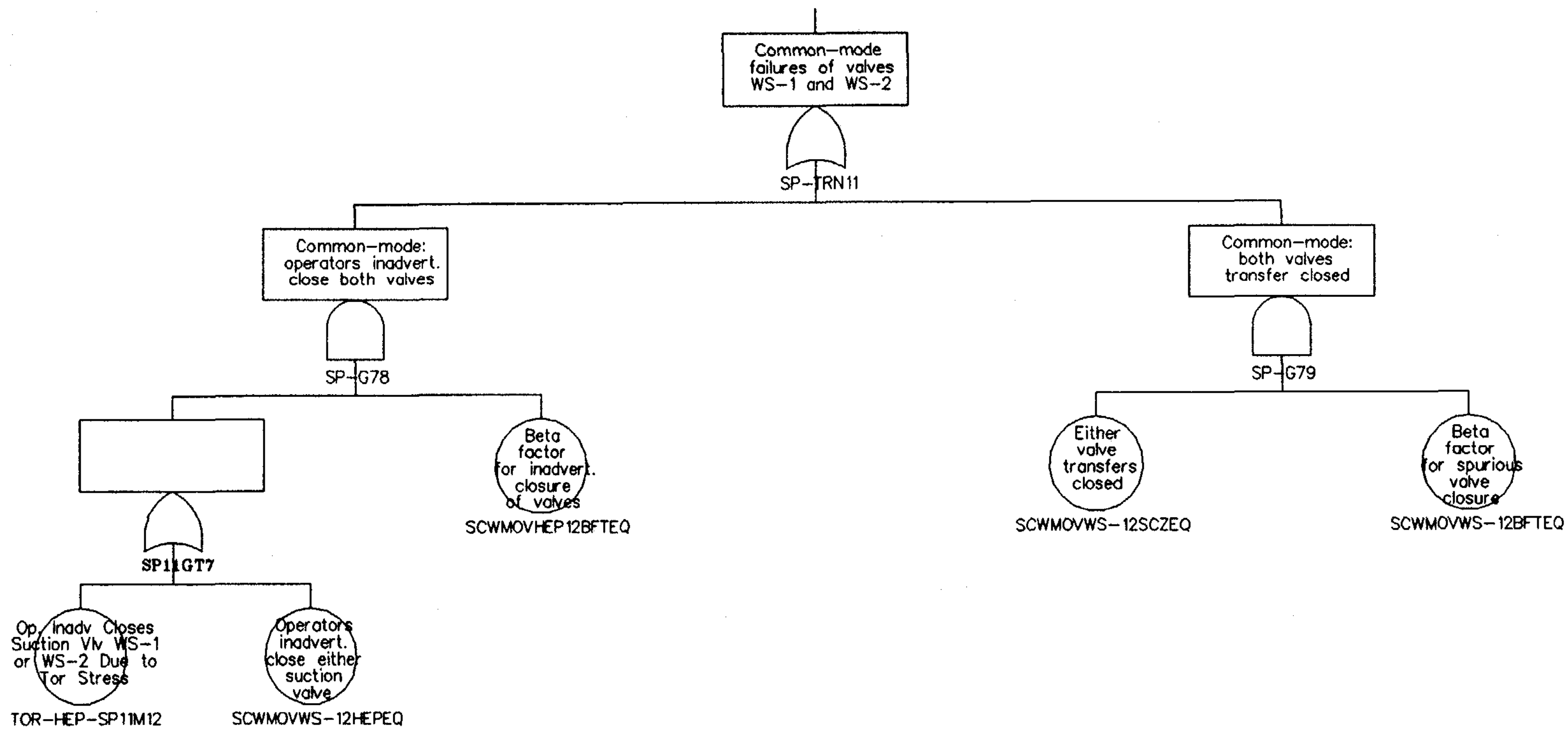
SP FAULT TREE

Sheet 11 of 13



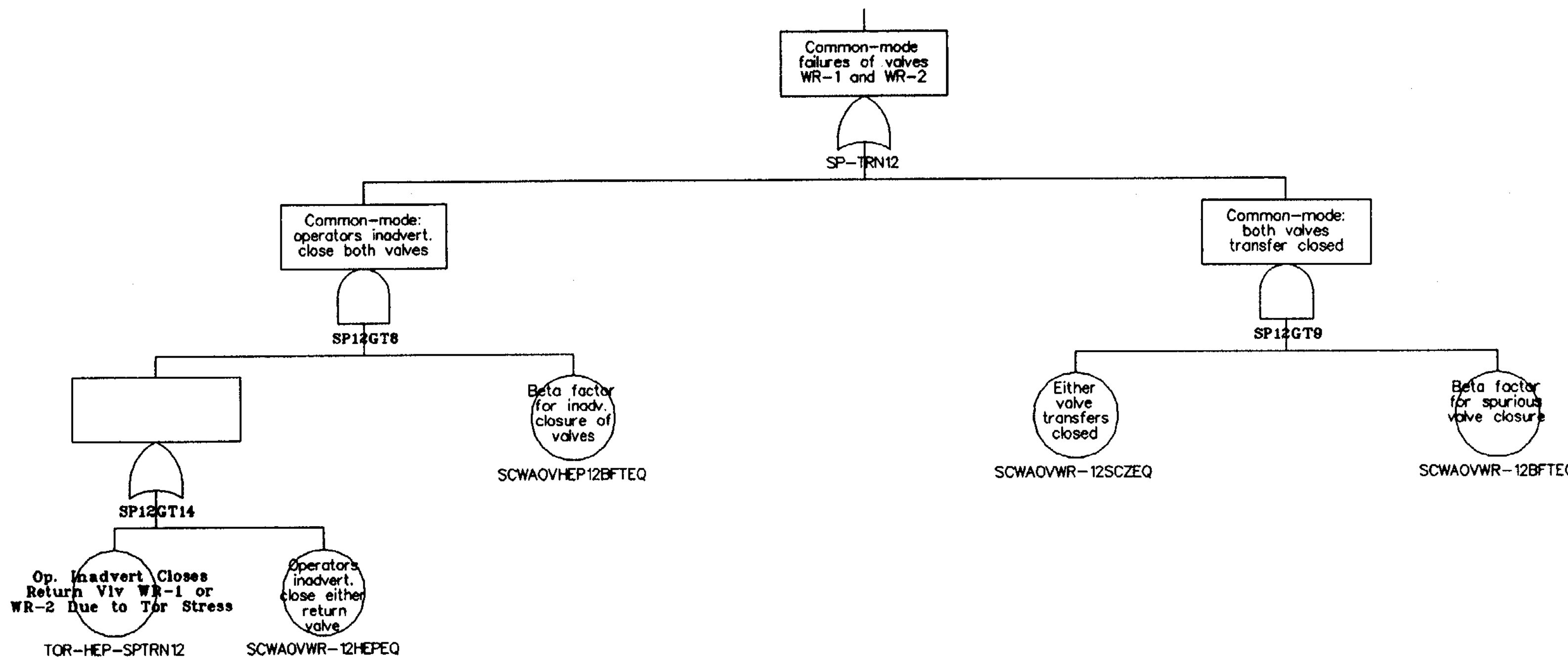
SP FAULT TREE

Sheet 12 of 13

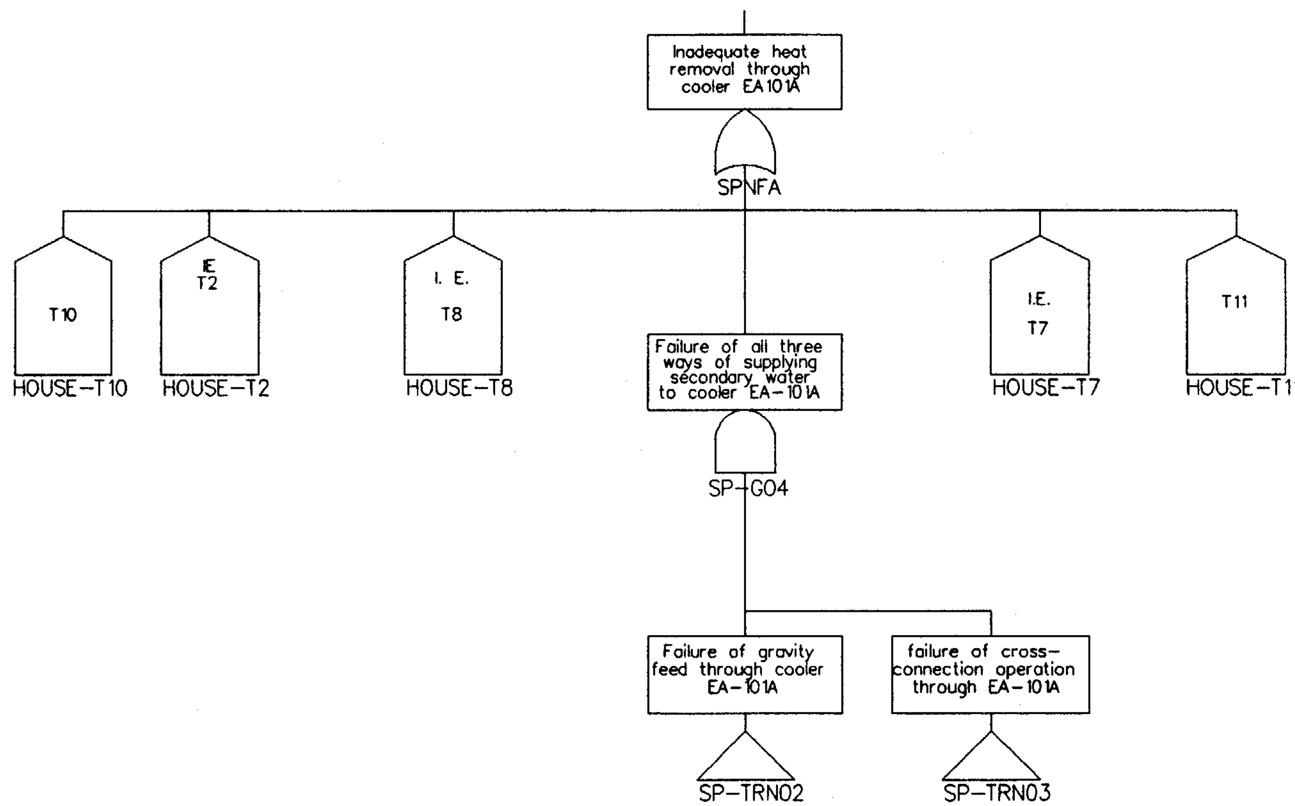


SP FAULT TREE

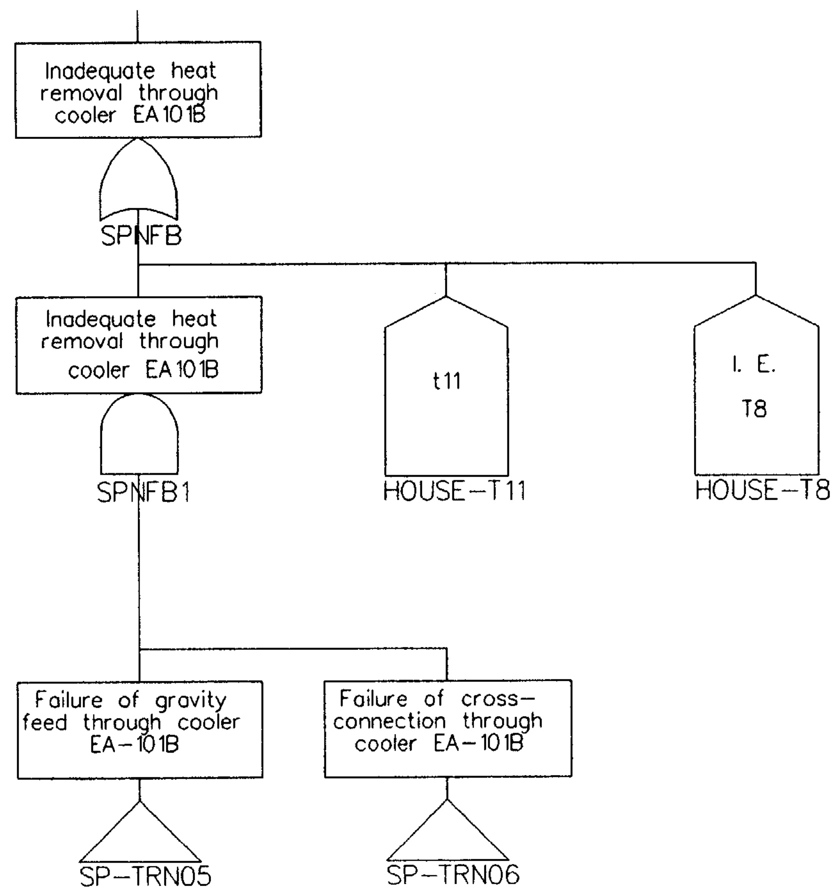
Sheet 13 of 13



SPNFA TRANSFER (for Steam Condensing)



SPNFB TRANSFER (for Steam Condensing)



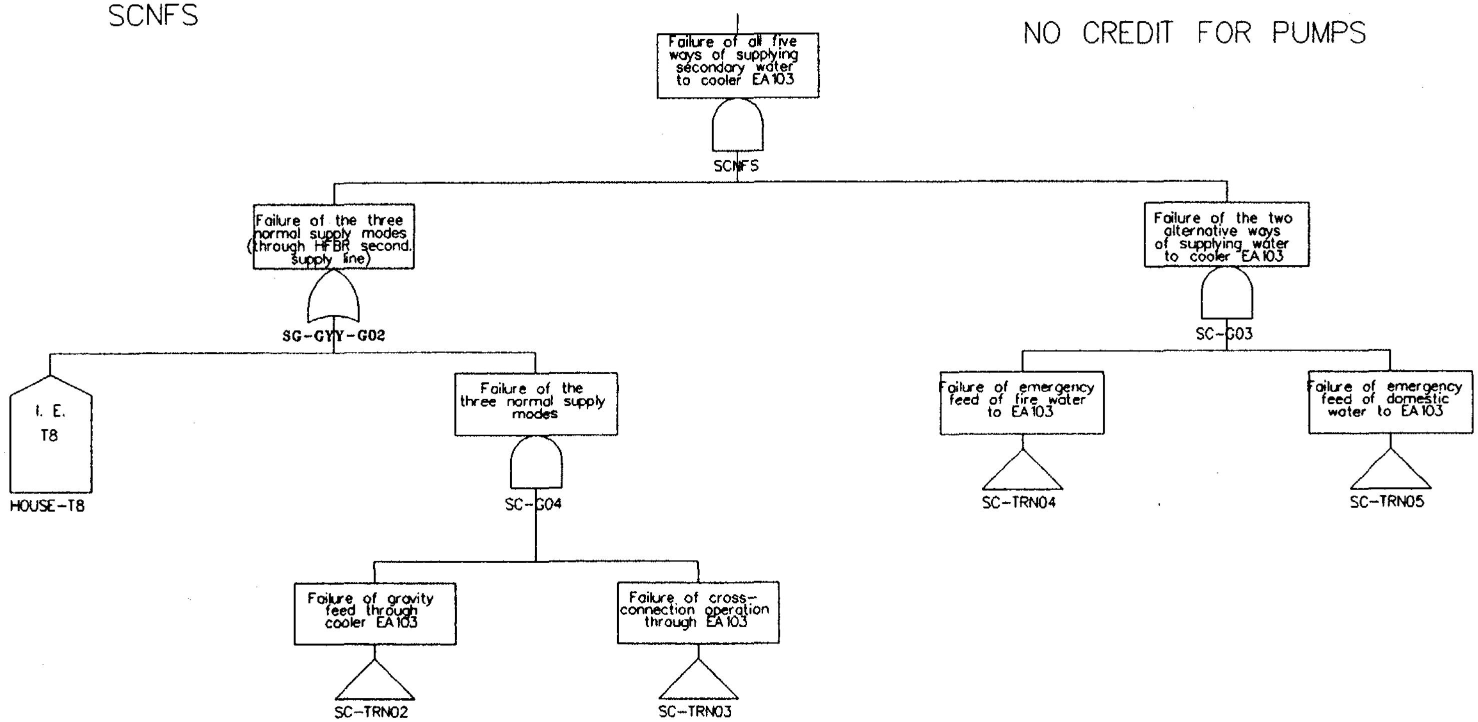
SC FAULT TREE

Sheet 1 of XX

SCNFS

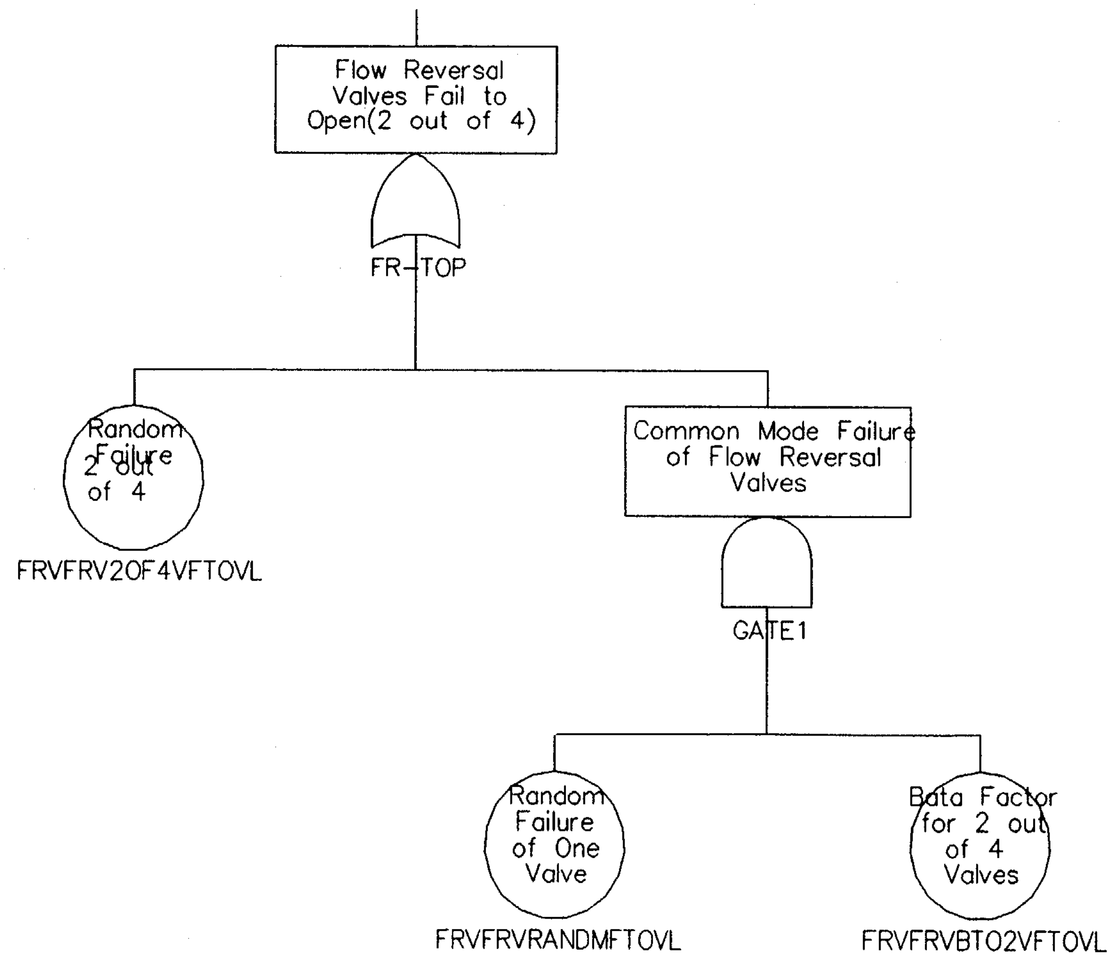
SECONDARY SYSTEM
(Shutdown Cooler)

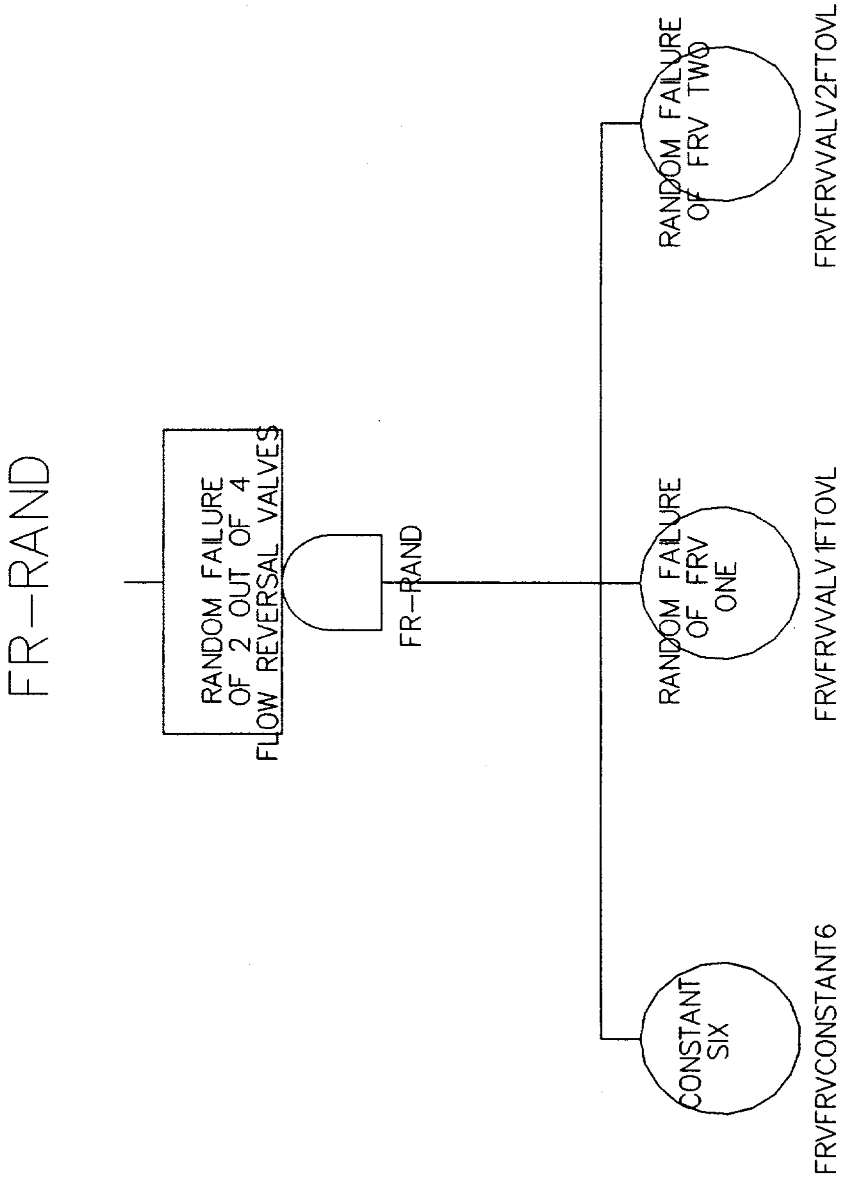
NO CREDIT FOR PUMPS



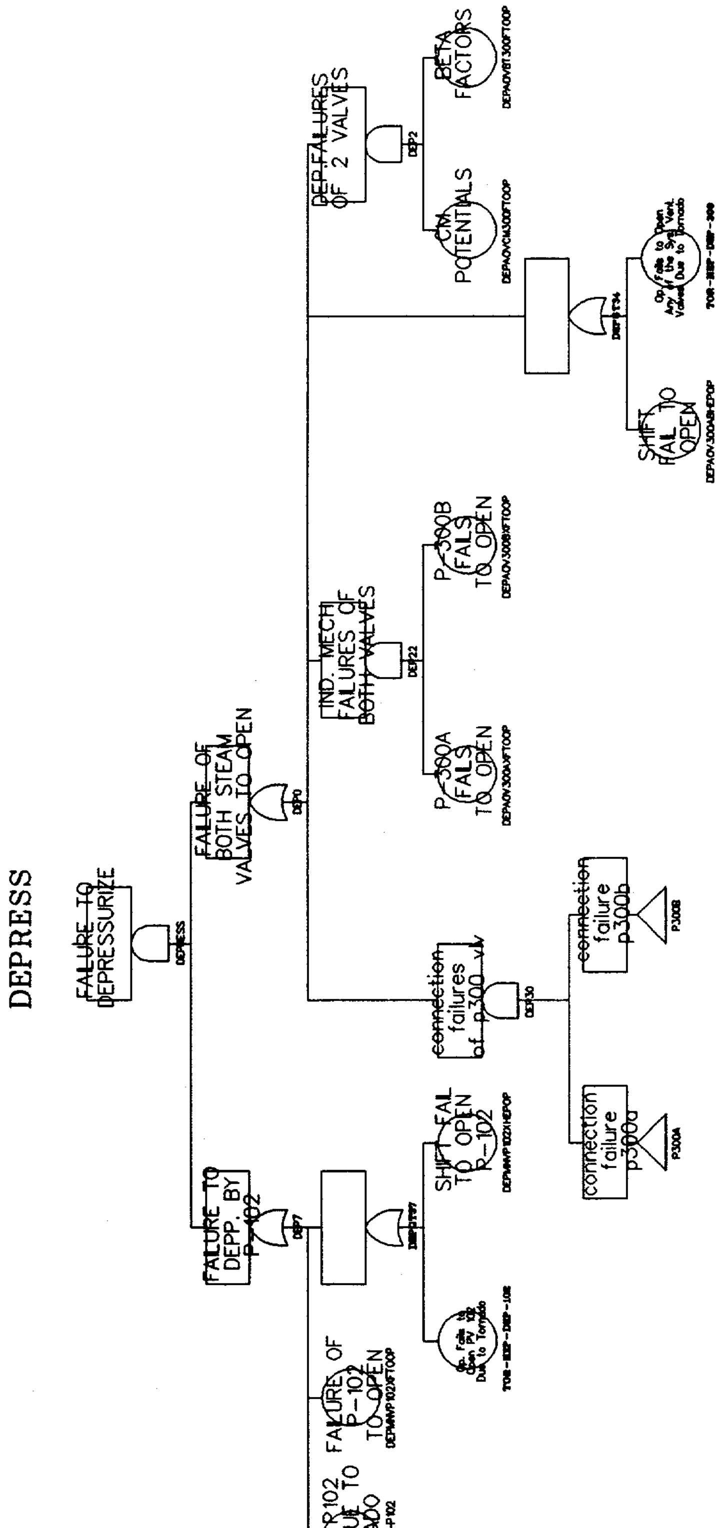
Appendix C.5 Flow Reversal Valves

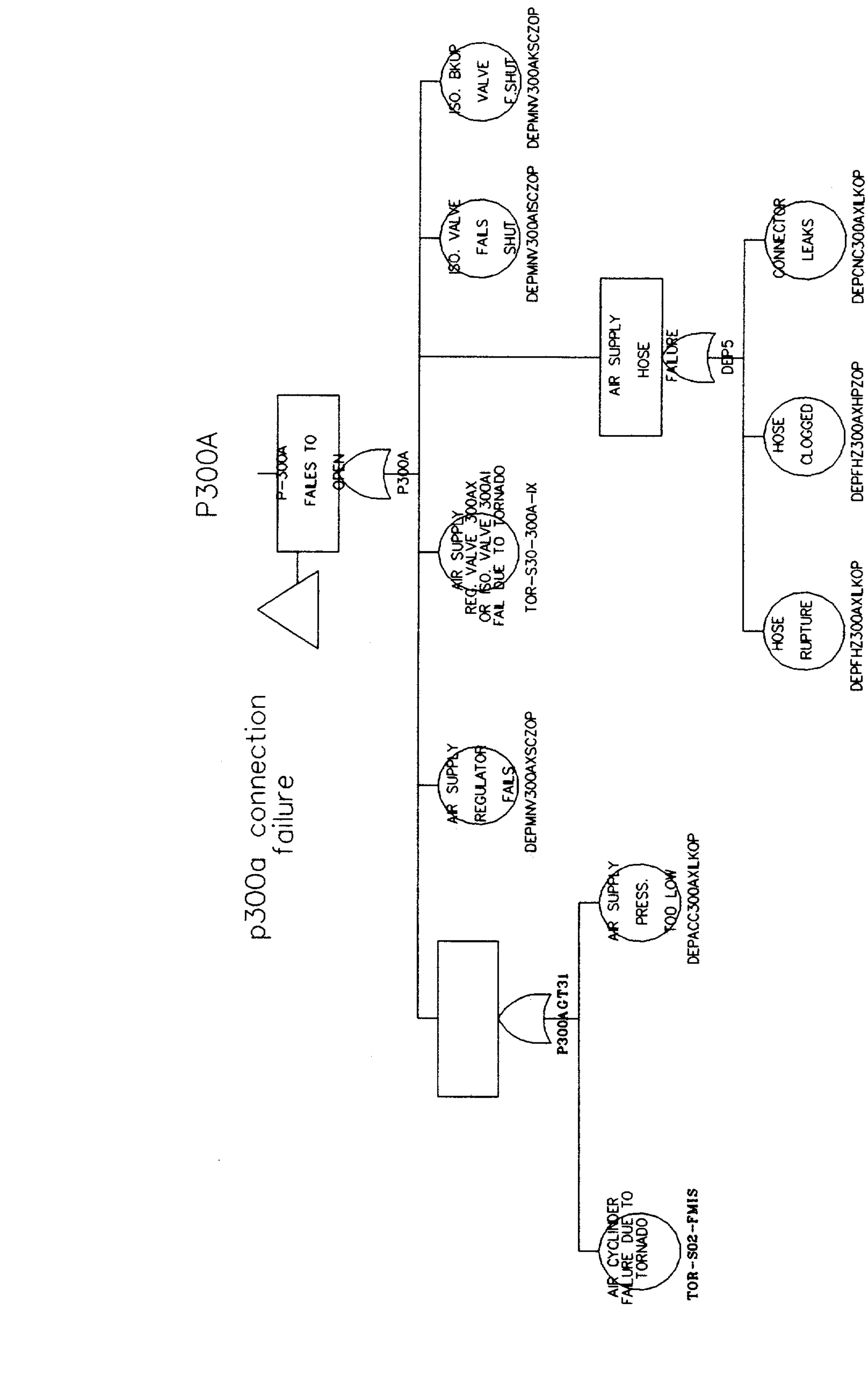
FR—TOP

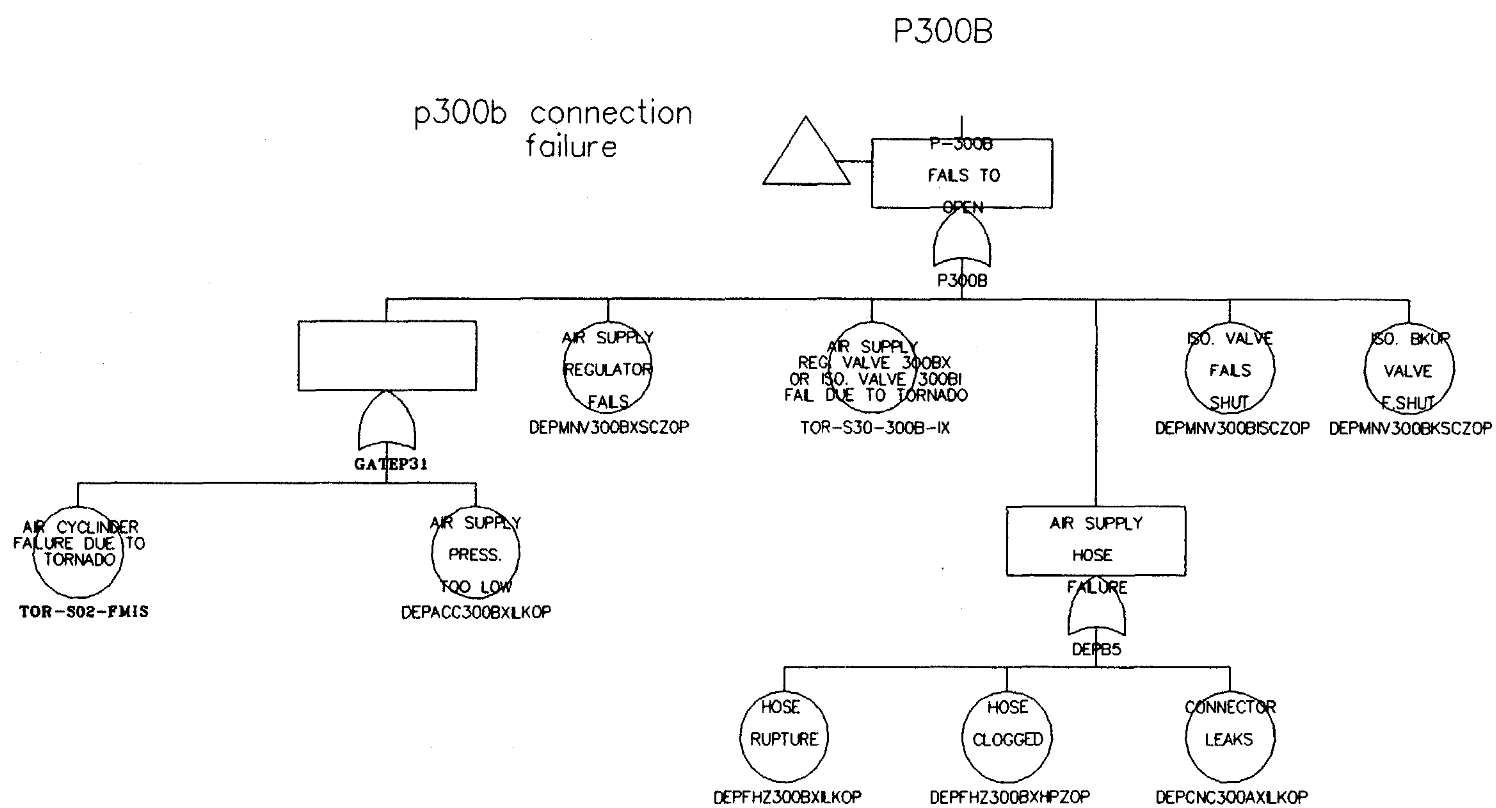

Flow Reversal Valves Fail to Open(2 out of 4)
FR-TOP
Random Failure 2 out of 4
FRVFRV2OF4VFTOVL
Common Mode Failure of Flow Reversal Valves
GATE1
Random Failure of One Valve
FRVFRVRANDMFTOVL
Bata Factor for 2 out of 4 Valves
FRVFRVBTO2VFTOVL


FR-RAND
RANDOM FAILURE OF 2 OUT OF 4 FLOW REVERSAL VALVES
FR-RAND
CONSTANT SIX
FRVFRVCONSTANT6
RANDOM FAILURE OF FRV ONE
FRVFRVVALV1FTOVL
RANDOM FAILURE OF FRV TWO
FRVFRVVALV2FTOVL

Appendix C.6
Depressurization System Modified for Tornado Initiator

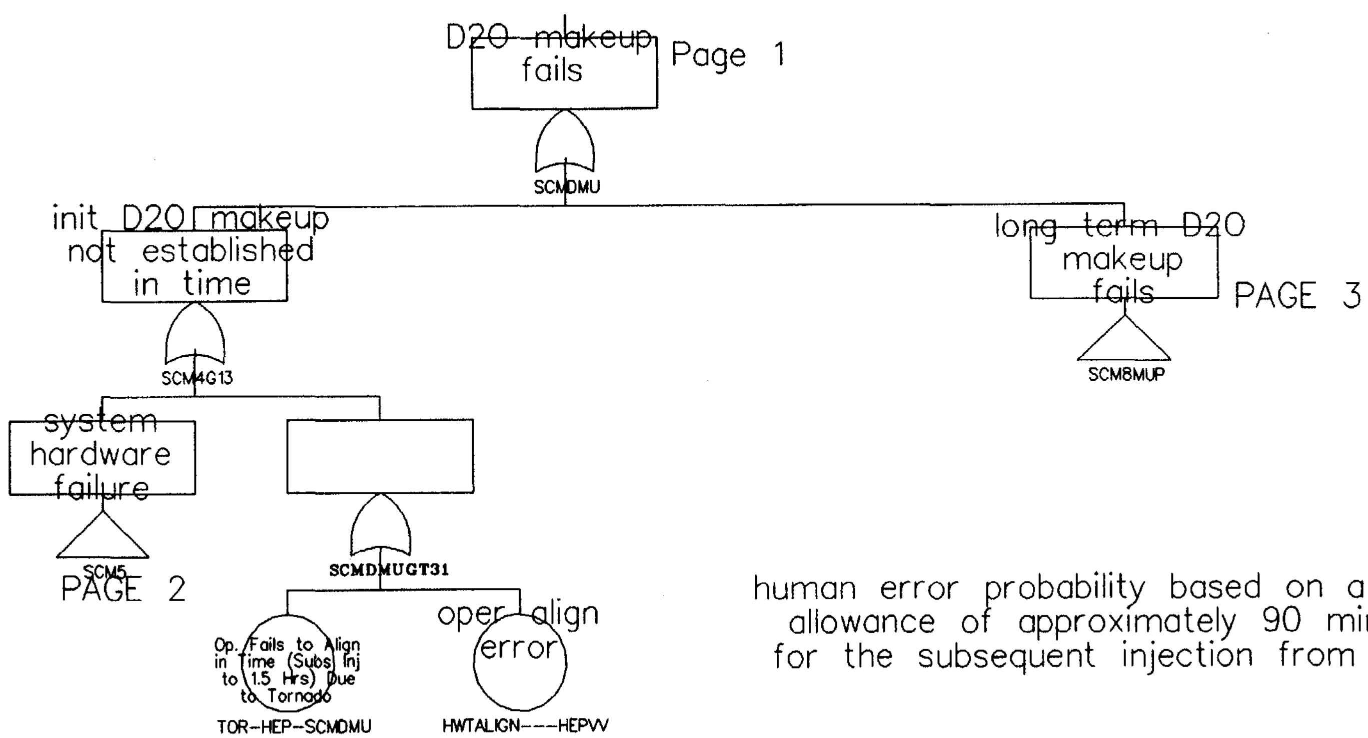

DEPRESS
FAILURE TO DEPRESSURIZE
DEPRESS
FAILURE TO DEPP. BY P-102
DEP7
FAILURE OF BOTH STEAM VALVES TO OPEN
DEP0
VALVE P102 FAILS DUE TO TORNADO
TOR-S30-P102
FAILURE OF P-102 TO OPEN
SHIFT FAIL TO OPEN P-102
connection failures of p300 vlv
DEP30
connection failure p300a
P300A
connection failure p300b
P300B
IND. MECH FAILURES OF BOTH VALVES
DEP22
P-300A FAILS TO OPEN
P-300B FAILS TO OPEN
SHIFT FAIL TO OPEN
DEP FAILURES OF 2 VALVES
DEP2
CM POTENTIALS
BETA FACTORS


P300A
p300a connection failure
P-300A FAILES TO OPEN
P300A
ISO. BKUP VALVE F.SHUT
DEPMNV300AKSCZOP
ISO. VALVE FAILS SHUT
DEPMNV300AISCZOP
AIR SUPPLY HOSE FAILURE
DEP5
CONNECTOR LEAKS
DEPCNC300AXLKOP
HOSE CLOGGED
DEPFHZ300AXHPZOP
HOSE RUPTURE
DEPFHZ300AXLKOP
AIR SUPPLY REG. VALVE 300AX OR ISO. VALVE 300AI FAIL DUE TO TORNADO
TOR-S30-300A-IX
AIR SUPPLY REGULATOR FAILS
DEPMNV300AXSCZOP
P300ACT31
AIR SUPPLY PRESS. TOO LOW
DEPACC300AXLKOP
AIR CYCLINDER FAILURE DUE TO TORNADO
TOR-S02-FMIS

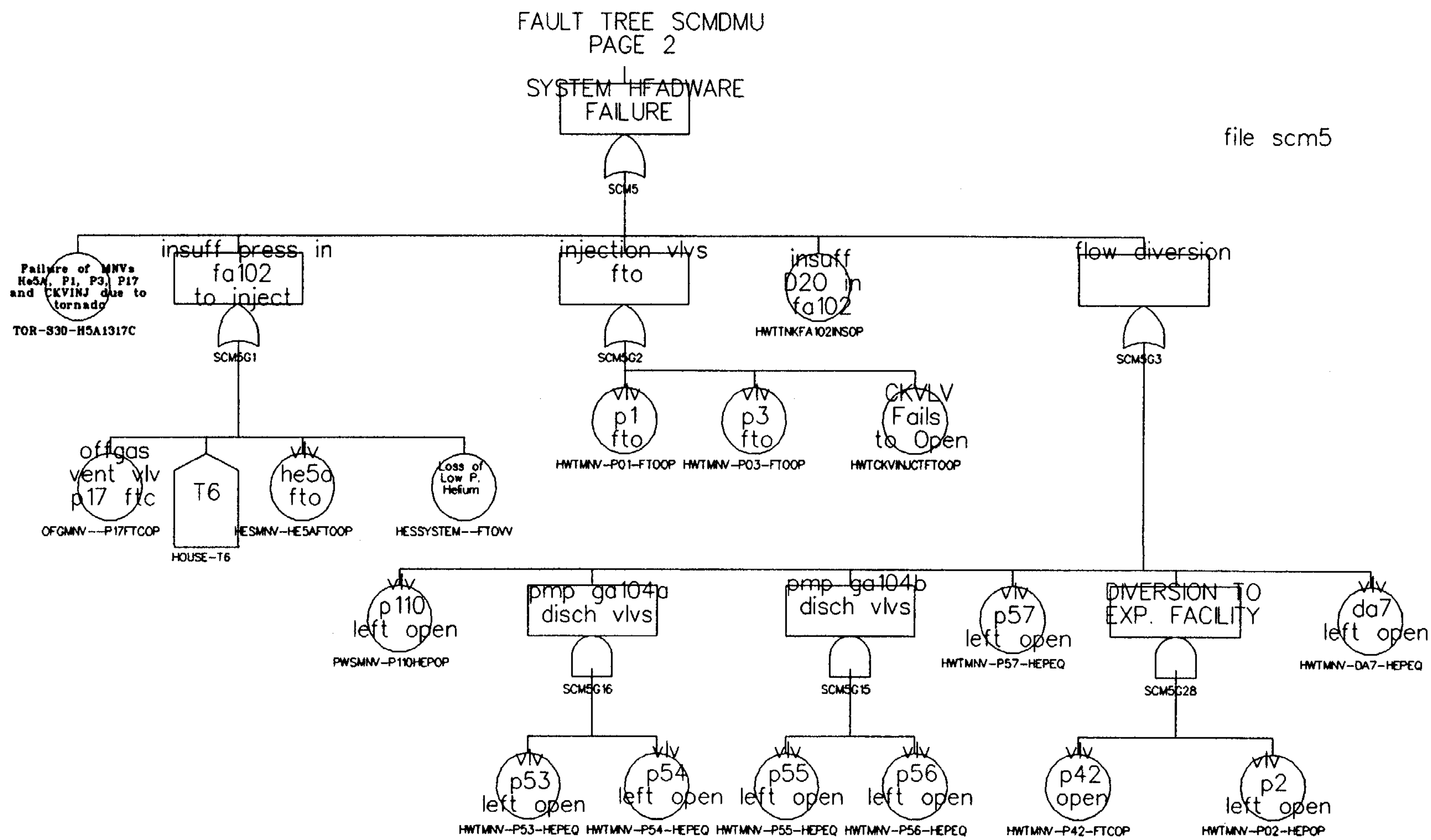

P300B
p300b connection failure
P-300B FALS TO OPEN
P300B
AIR SUPPLY REGULATOR FALS
DEPMNV300BXSCZOP
AIR SUPPLY REG VALVE 300BX OR ISO. VALVE 300BI FAIL DUE TO TORNADO
TOR-S30-300B-IX
ISO. VALVE FALS SHUT
DEPMNV300BISCZOP
ISO. BKUP VALVE F.SHUT
DEPMNV300BKSCZOP
GATEP31
AIR CYCLINDER FALURE DUE TO TORNADO
TOR-S02-FMIS
AIR SUPPLY PRESS. TOO LOW
DEPACC300BXLKOP
AIR SUPPLY HOSE FALURE
DEPB5
HOSE RUPTURE
DEPFHZ300BXLKOP
HOSE CLOGGED
DEPFHZ300BXHPZOP
CONNECTOR LEAKS
DEPCNC300AXLKOP

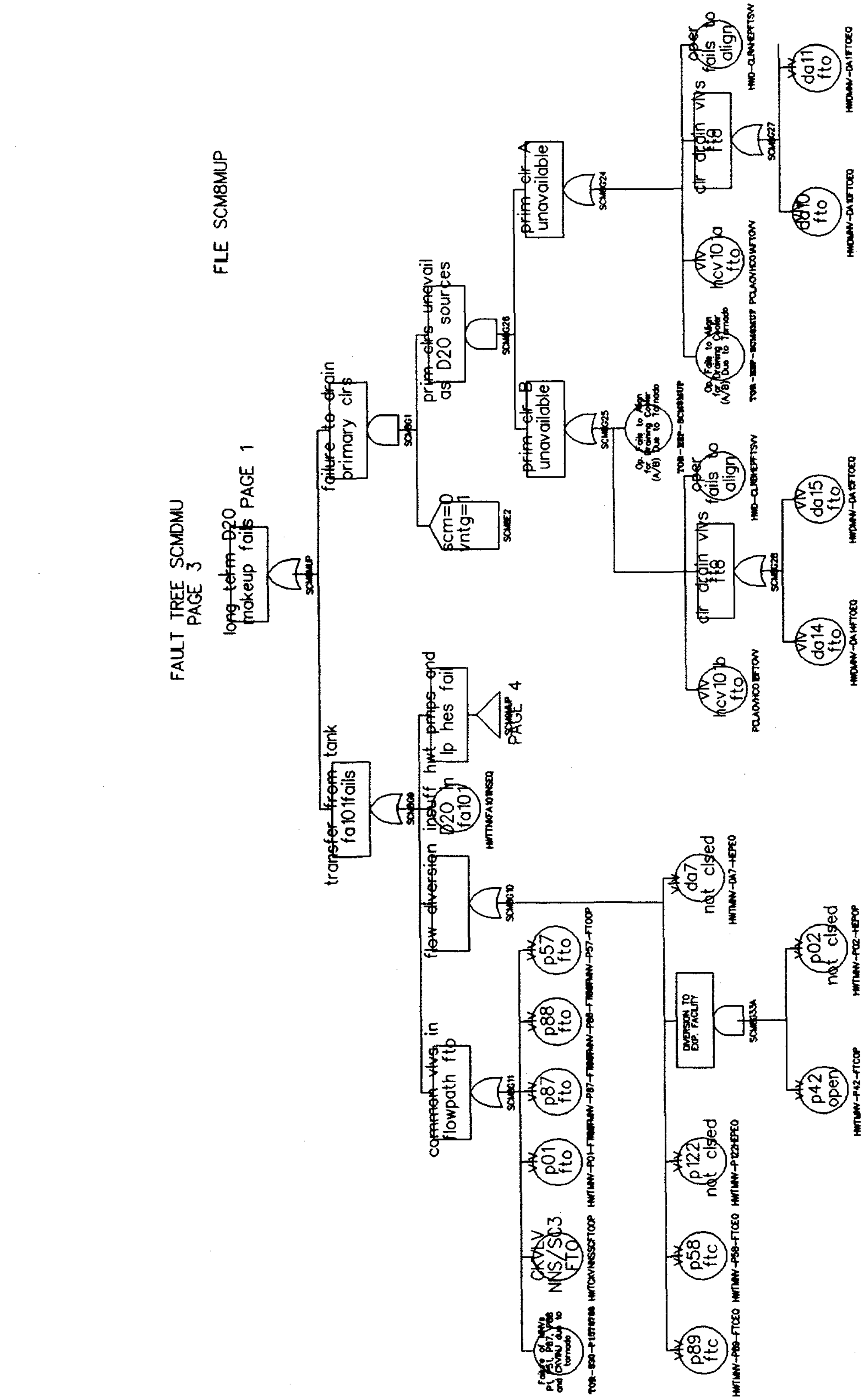
Appendix C.7
Steam Condensing and D_2O Makeup System Modified for Tornado Initiator

FAULT TREE SCMDMU
PAGE 1



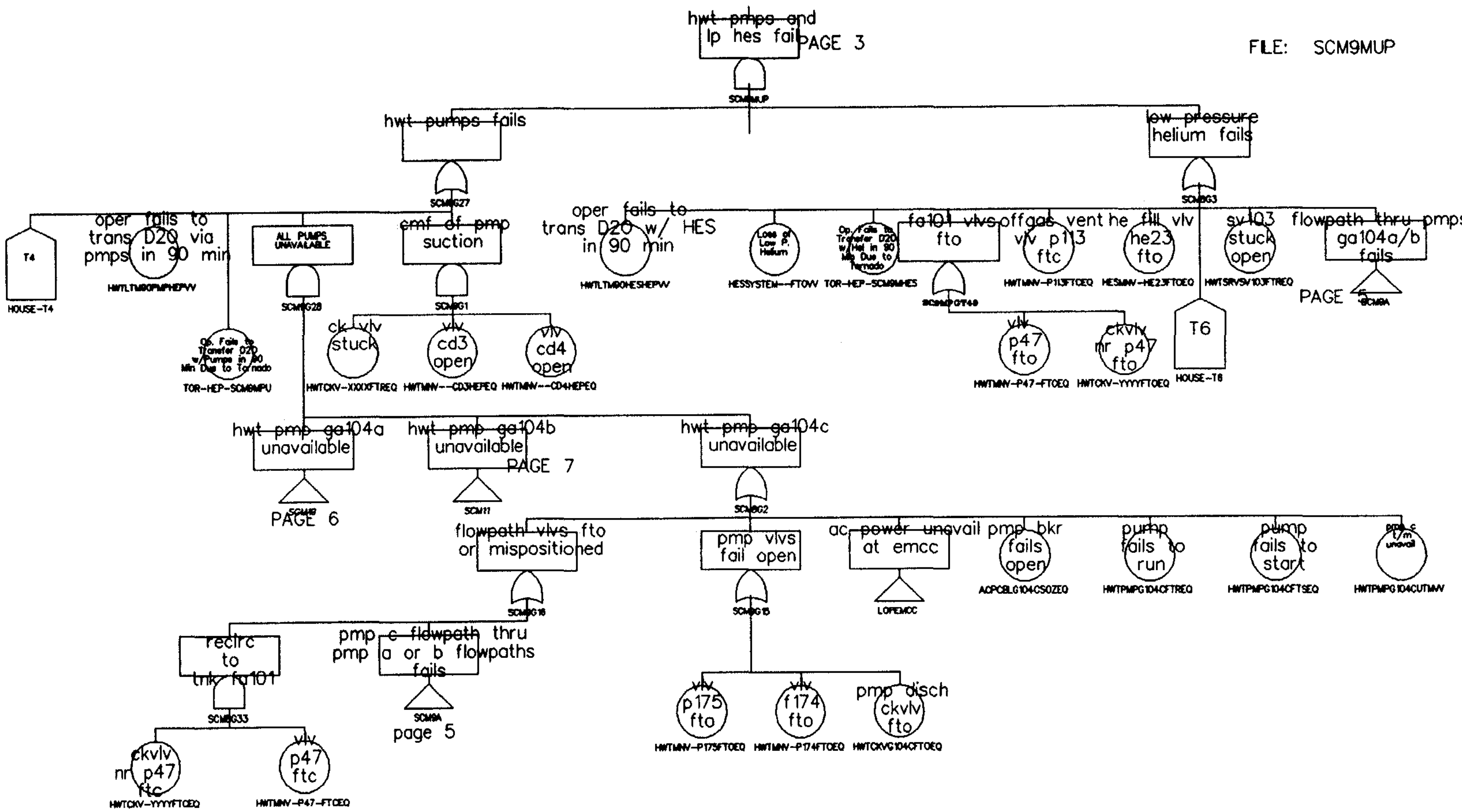
human error probability based on a time allowance of approximately 90 minutes for the subsequent injection from fa102


FAULT TREE SCMDMU
PAGE 2
file scm5
SYSTEM HFADWARE FAILURE
SCM5
Failure of MNVs He5A, P1, P3, P17 and CKVINJ due to tornado
TOR-S30-H5A1317C
insuff press in fa102 to inject
SCM5G1
offgas vent vlv p17 ftc
OFGMNV--P17FTCOP
T6
HOUSE-T6
vlv he5a fto
HESMNV-HE5AFTOOP
Loss of Low P. Helium
HESSYSTEM--FTOVV
injection vlvs fto
SCM5G2
vlv p1 fto
HWTMNV-P01-FTOOP
vlv p3 fto
HWTMNV-P03-FTOOP
CKVLV Fails to Open
HWTCKVINJCTFTOOP
insuff D20 in fa102
HWTTNKFA102INSOP
flow diversion
SCM5G3
vlv p110 left open
PWSMNV-P110HEPOP
pmp ga104a disch vlvs
SCM5G16
vlv p53 left open
HWTMNV-P53-HEPEQ
vlv p54 left open
HWTMNV-P54-HEPEQ
pmp ga104b disch vlvs
SCM5G15
vlv p55 left open
HWTMNV-P55-HEPEQ
vlv p56 left open
HWTMNV-P56-HEPEQ
vlv p57 left open
HWTMNV-P57-HEPEQ
DIVERSION TO EXP. FACILITY
SCM5G28
vlv p42 open
HWTMNV-P42-FTCOP
vlv p2 left open
HWTMNV-P02-HEPOP
vlv da7 left open
HWTMNV-DA7-HEPEQ


FAULT TREE SCMDMU
PAGE 3
FILE SCM8MUP
long term D20 makeup fails PAGE 1
transfer from tank fa101fails
failure to drain primary clrs
scm=0 vntg=1
prim clrs unavail as D20 sources
prim clr B unavailable
prim clr A unavailable
clr drain vlvs fto
oper fails to align
vlv hcv10 b fto
vlv da14 fto
vlv da15 fto
vlv hcv10 a fto
vlv da10 fto
vlv da11 fto
flow diversion
insuff D20 in fa101
hwt pmps and lp hes fail
PAGE 4
common vlvs in flowpath fto
CKVLV NNS/SC3 FTO
vlv p01 fto
vlv p87 fto
vlv p88 fto
vlv p57 fto
vlv da7 not clsed
vlv p89 ftc
vlv p58 ftc
vlv p122 not clsed
DIVERSION TO EXP. FACILITY
vlv p42 open
vlv p02 not clsed

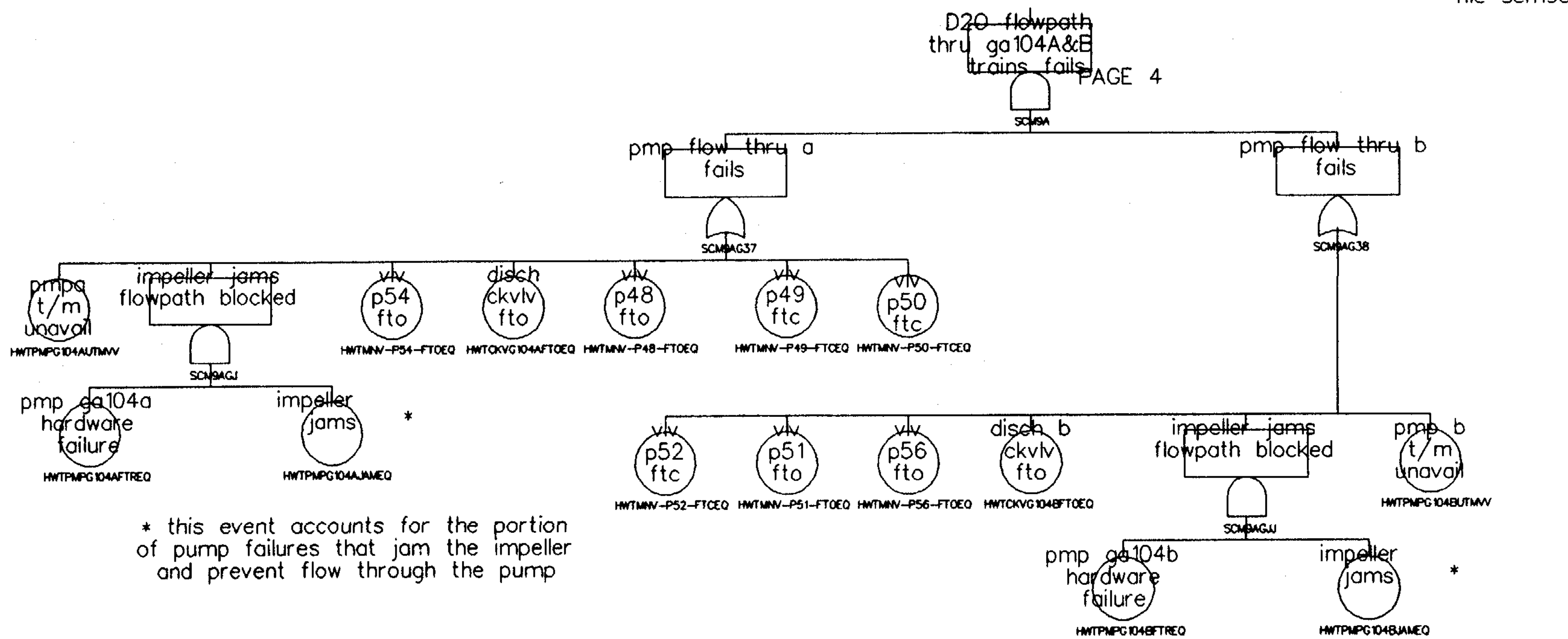
FAULT TREE SCMDMU
PAGE 4

FILE: SCM9MUP

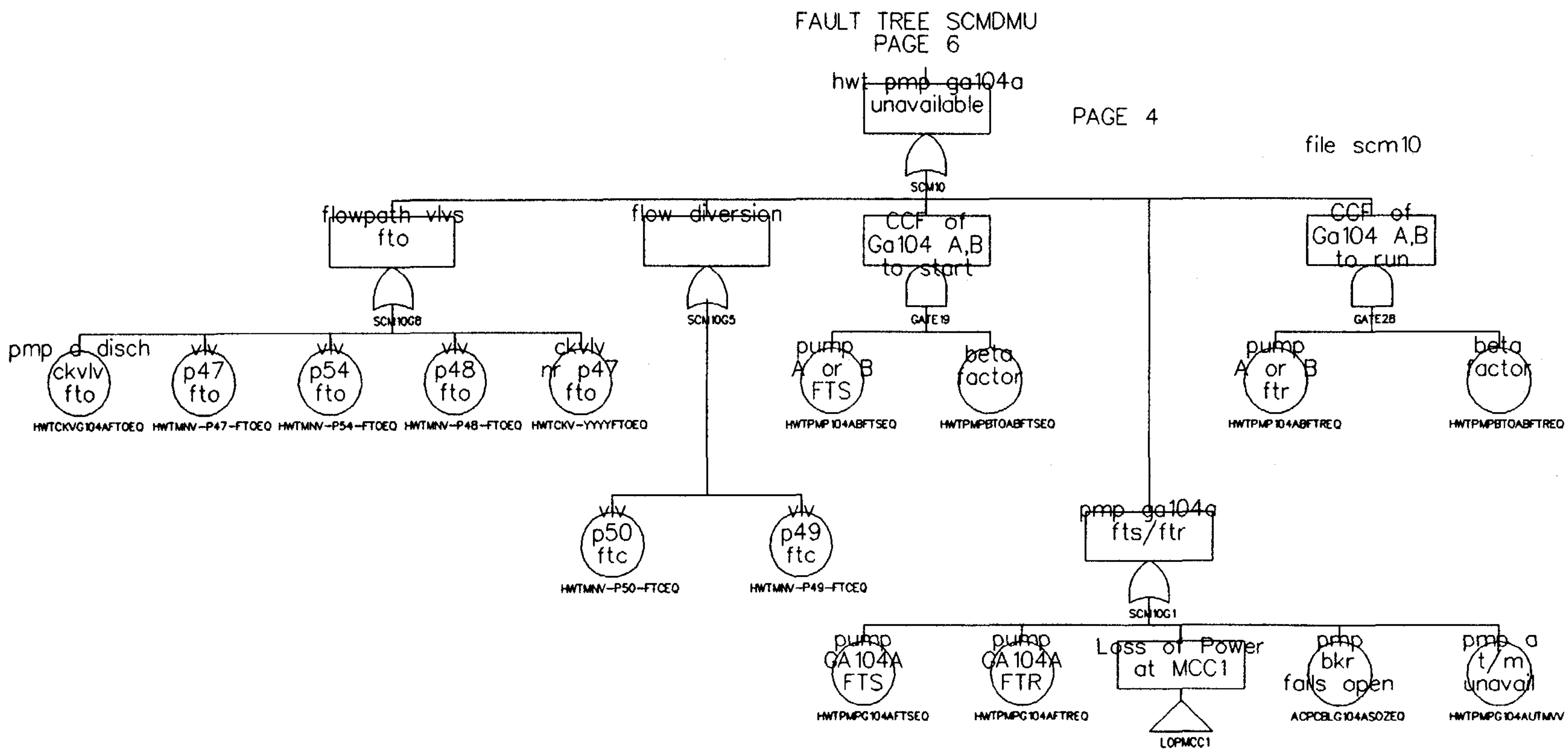


FAULT TREE SCMDMU
PAGE 5

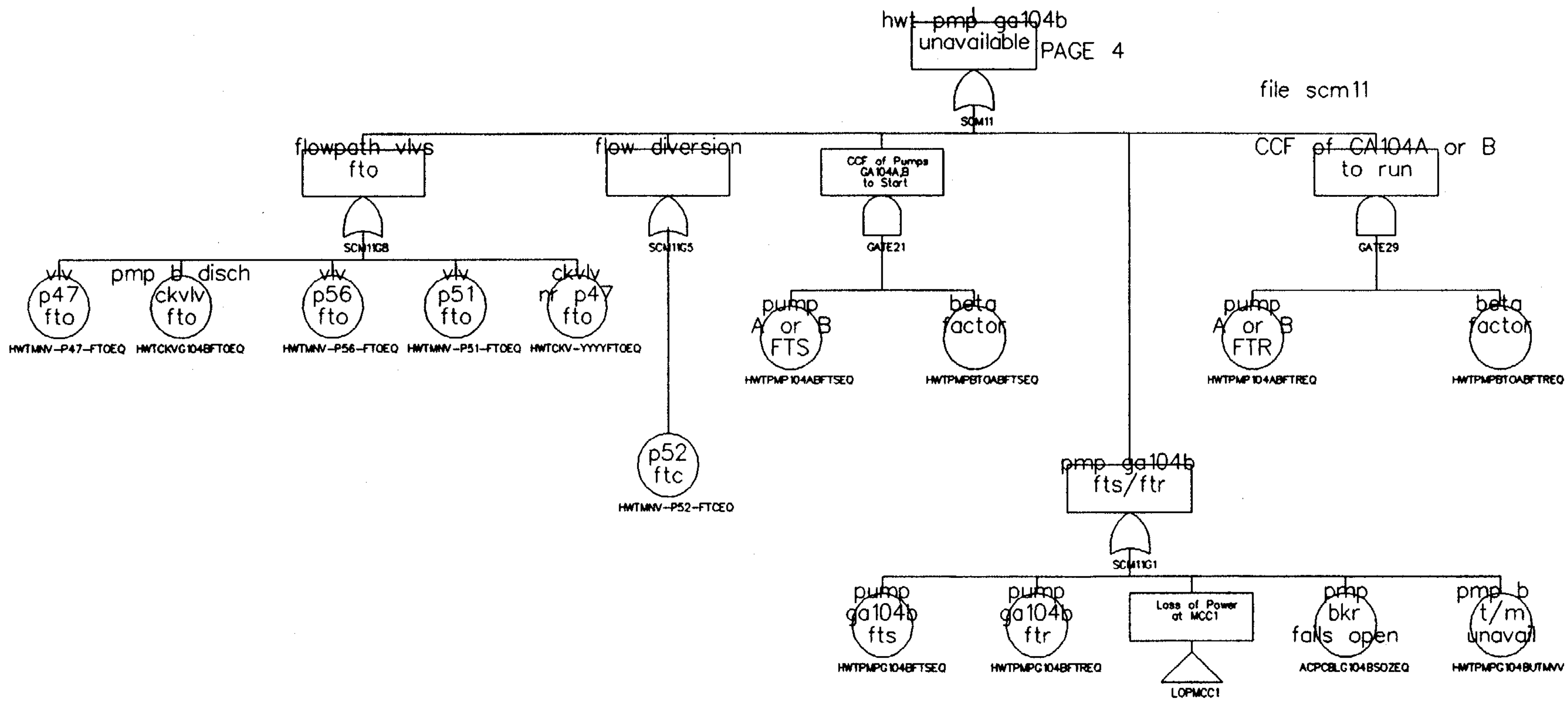
file scm9a

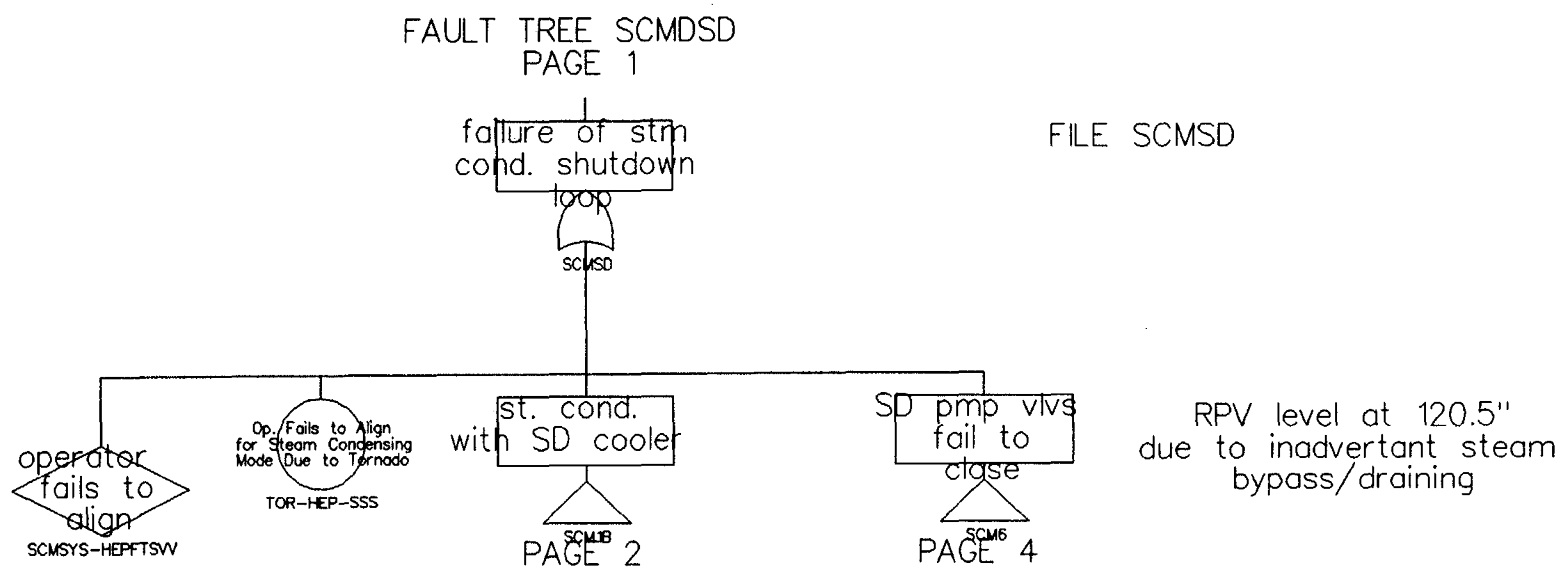


* this event accounts for the portion of pump failures that jam the impeller and prevent flow through the pump


FAULT TREE SCMDMU
PAGE 6
hwt pmp ga104a unavailable
PAGE 4
file scm10
SCM10
flowpath vlvs fto
SCM10G8
flow diversion
SCM10G5
CCF of Ga104 A,B to start
GATE19
CCF of Ga104 A,B to run
GATE28
pmp d disch ckvlv fto
HWTCKVG104AFTOEQ
vlv p47 fto
HWTMNV-P47-FTOEQ
vlv p54 fto
HWTMNV-P54-FTOEQ
vlv p48 fto
HWTMNV-P48-FTOEQ
ckvlv nr p47 fto
HWTCKV-YYYYFTOEQ
pump A or B FTS
HWTPMP104ABFTSEQ
beta factor
HWTPMPBTOABFTSEQ
pump A or B ftr
HWTPMP104ABFTREQ
beta factor
HWTPMPBTOABFTREQ
vlv p50 ftc
HWTMNV-P50-FTCEQ
vlv p49 ftc
HWTMNV-P49-FTCEQ
pmp ga104a fts/ftr
SCM10G1
pump GA104A FTS
HWTPMPG104AFTSEQ
pump GA104A FTR
HWTPMPG104AFTREQ
Loss of Power at MCC1
LOPMCC1
pmp bkr fails open
ACPCBLG104ASOZEQ
pmp a t/m unavail
HWTPMPG104AUTMVV

FAULT TREE SCMDMU
PAGE 7

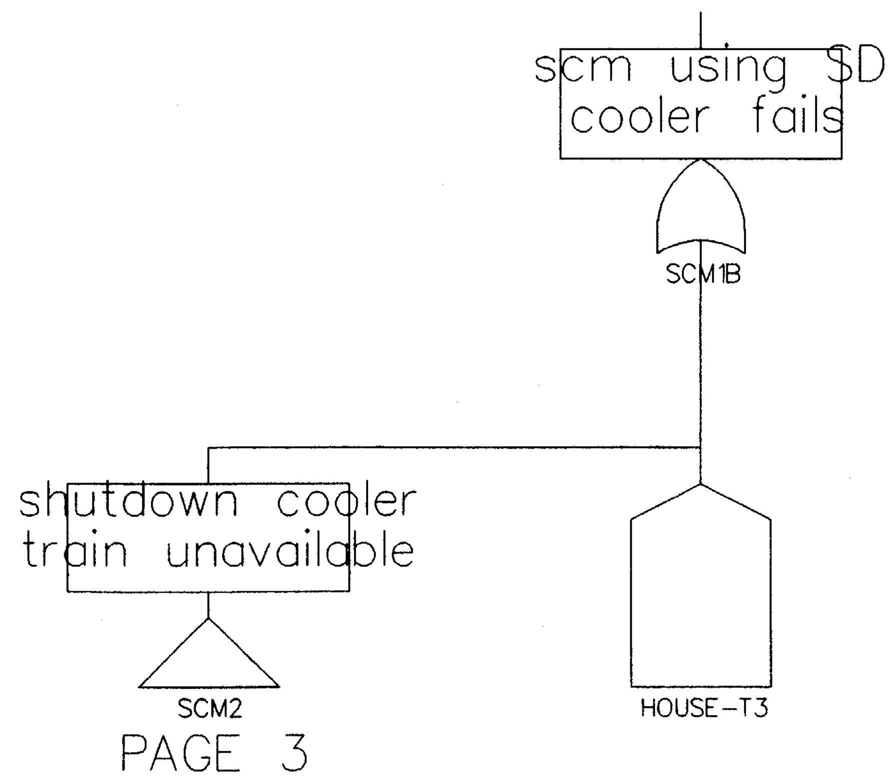




FAULT TREE SCMDSD
PAGE 1
failure of stm cond. shutdown loop
SCMSD
operator fails to align
SCMSYS-HEPFTSVV
Op. Fails to Align for Steam Condensing Mode Due to Tornado
TOR-HEP-SSS
st. cond. with SD cooler
SCM1B
PAGE 2
SD pmp vlvs fail to close
SCM6
PAGE 4
FILE SCMSD
RPV level at 120.5" due to inadvertant steam bypass/draining

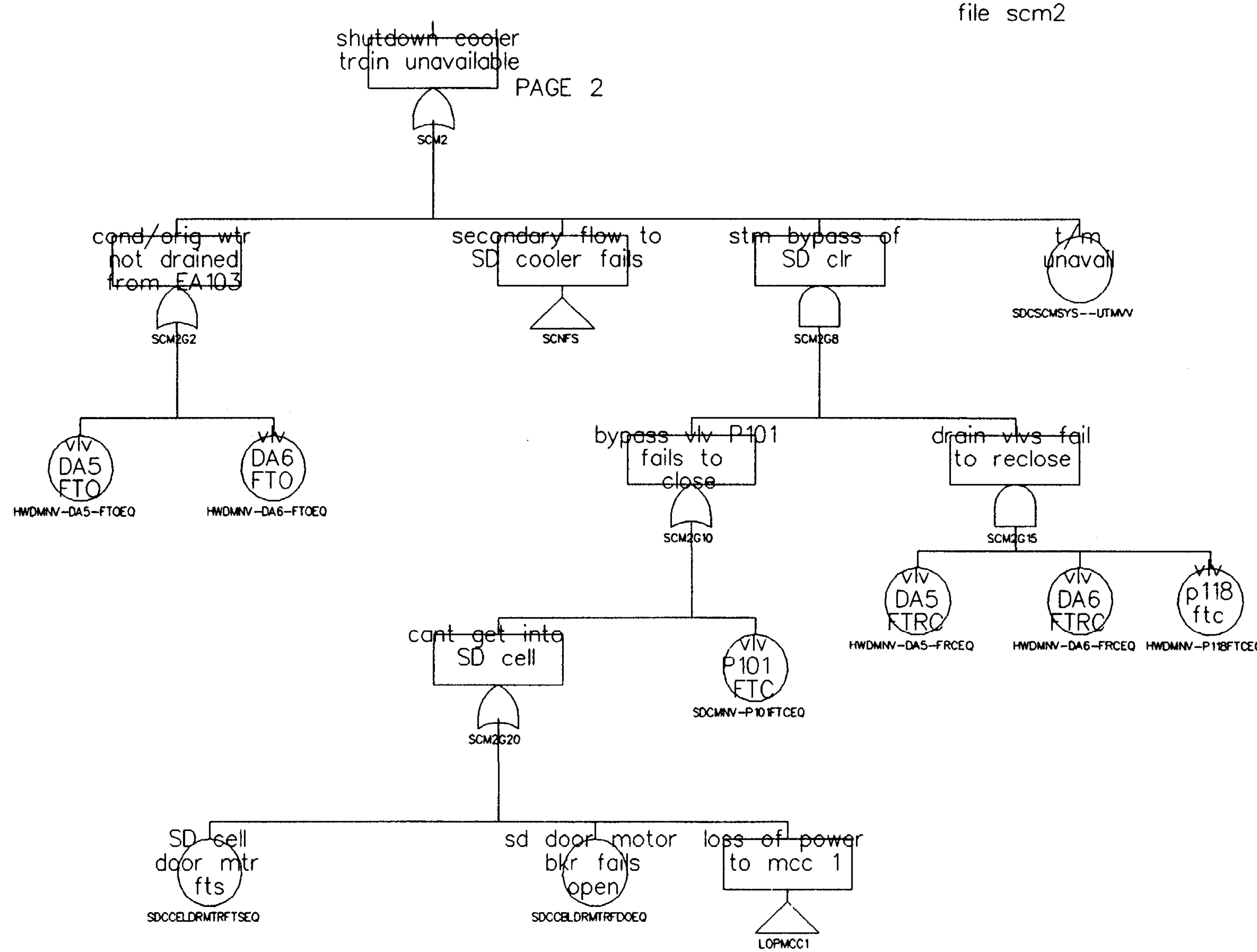
FAULT TREE SCMSD
PAGE 2

file scm 1b



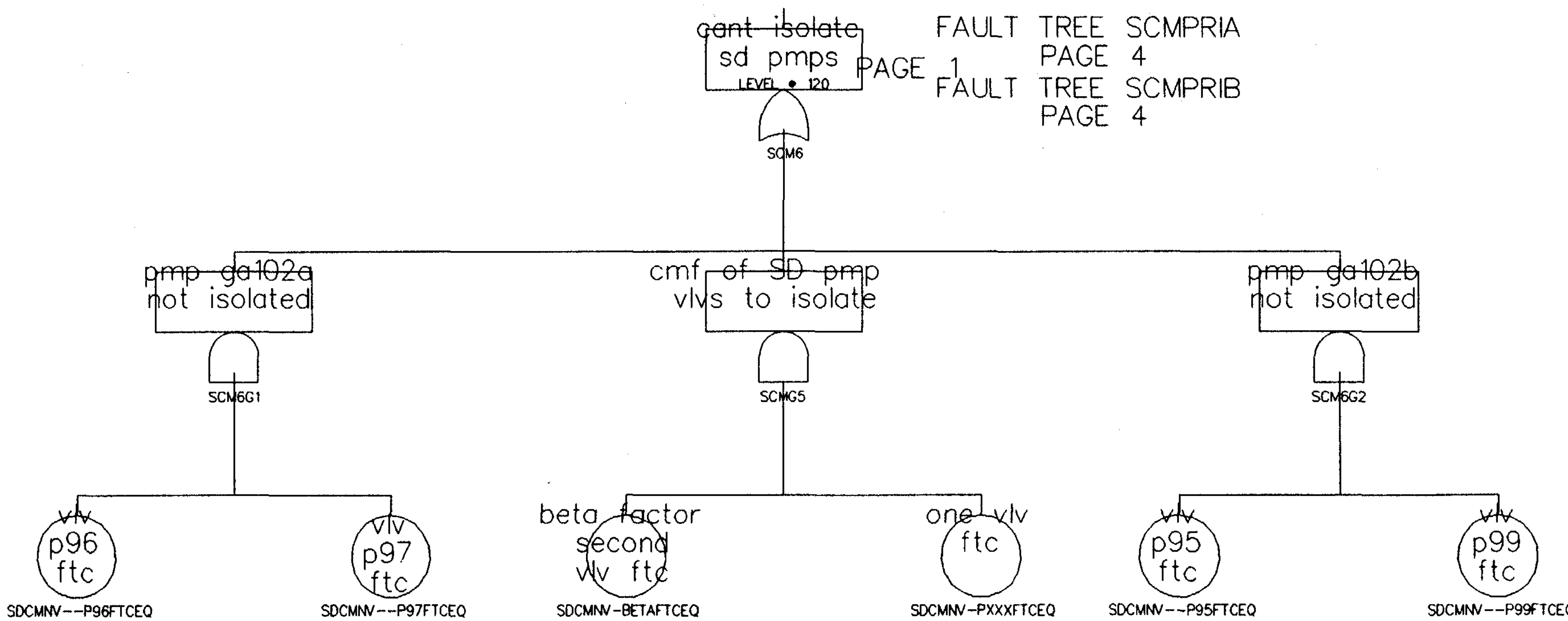
FAULT TREE SCMSD
PAGE 3

file scm2



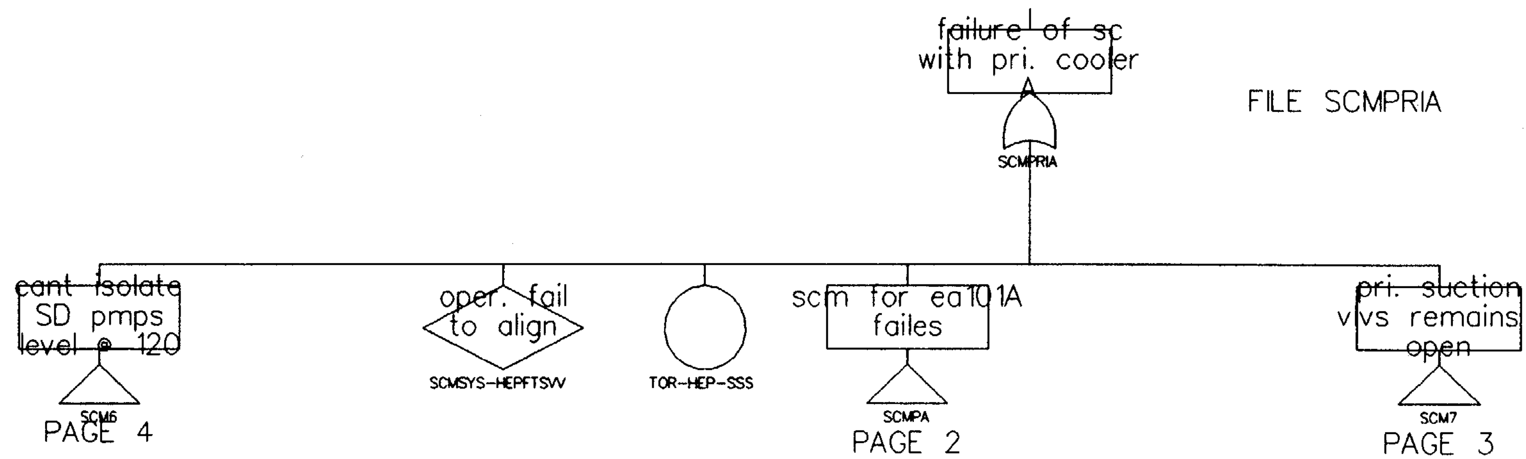
FAULT TREE SCMSD
PAGE 4

file scm6



FAULT TREE SCMPRIA
PAGE 1

FILE SCMPRIA



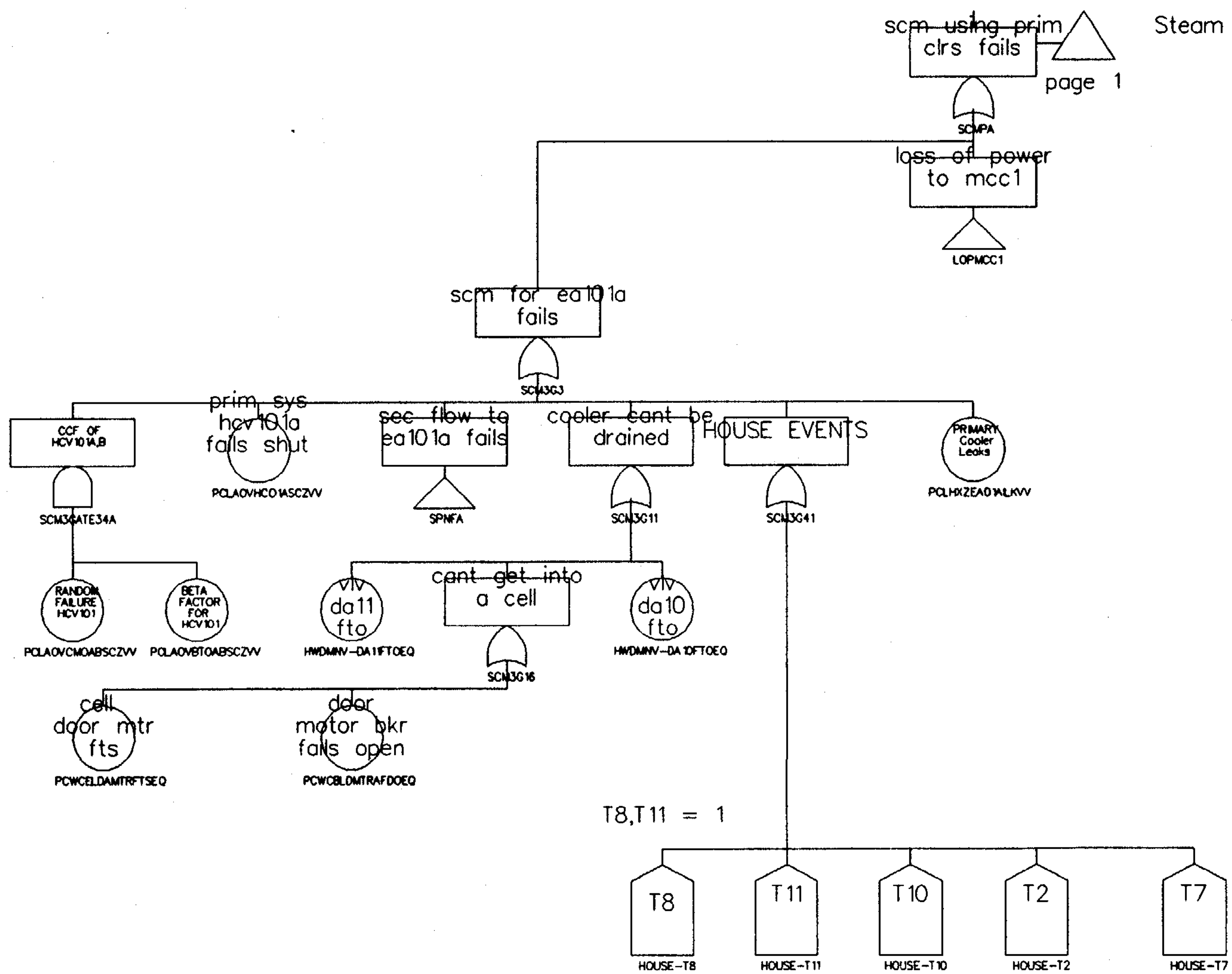
since SCM using the shutdown cooler
is the preferred alignment,
a failure to isolate the SD pumps is
assumed to fail all steam condensing

RPV level at 120.5"
causes steam bypass
(inad. draining)

FAULT TREE SCMPRIA
PAGE 2

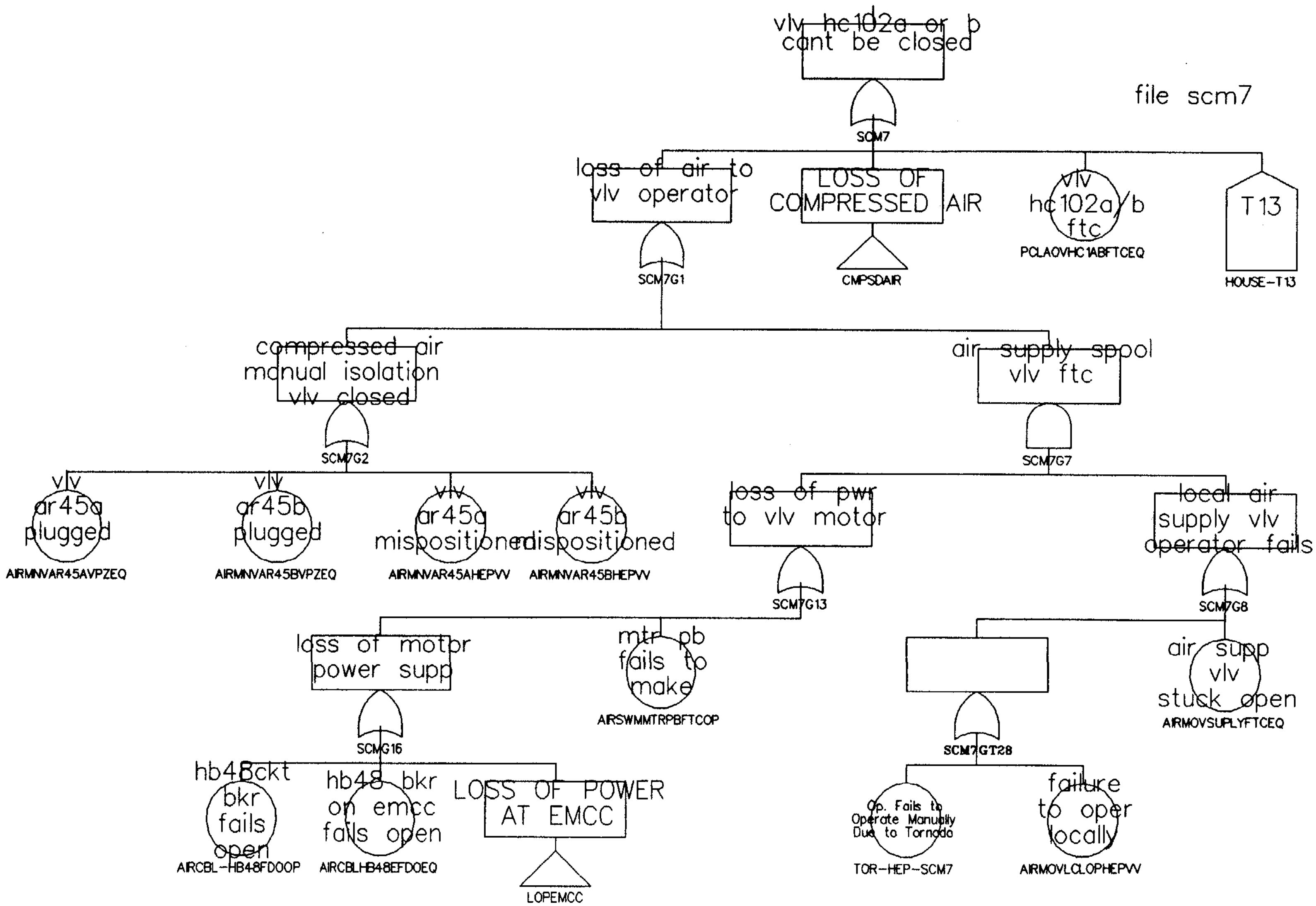
Steam Condensing with Primary loop A

FILE SCMPA



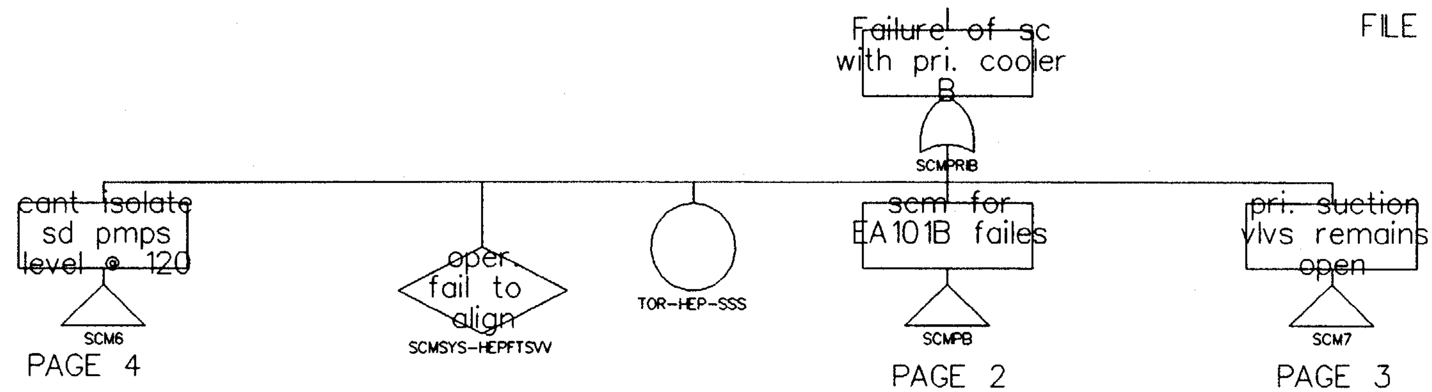
FAULT TREE SCMPRIA,SCMPRIB
PAGE 3

file scm7



FAULT TREE SCMPRIB
PAGE 1

FILE SCMPRIB

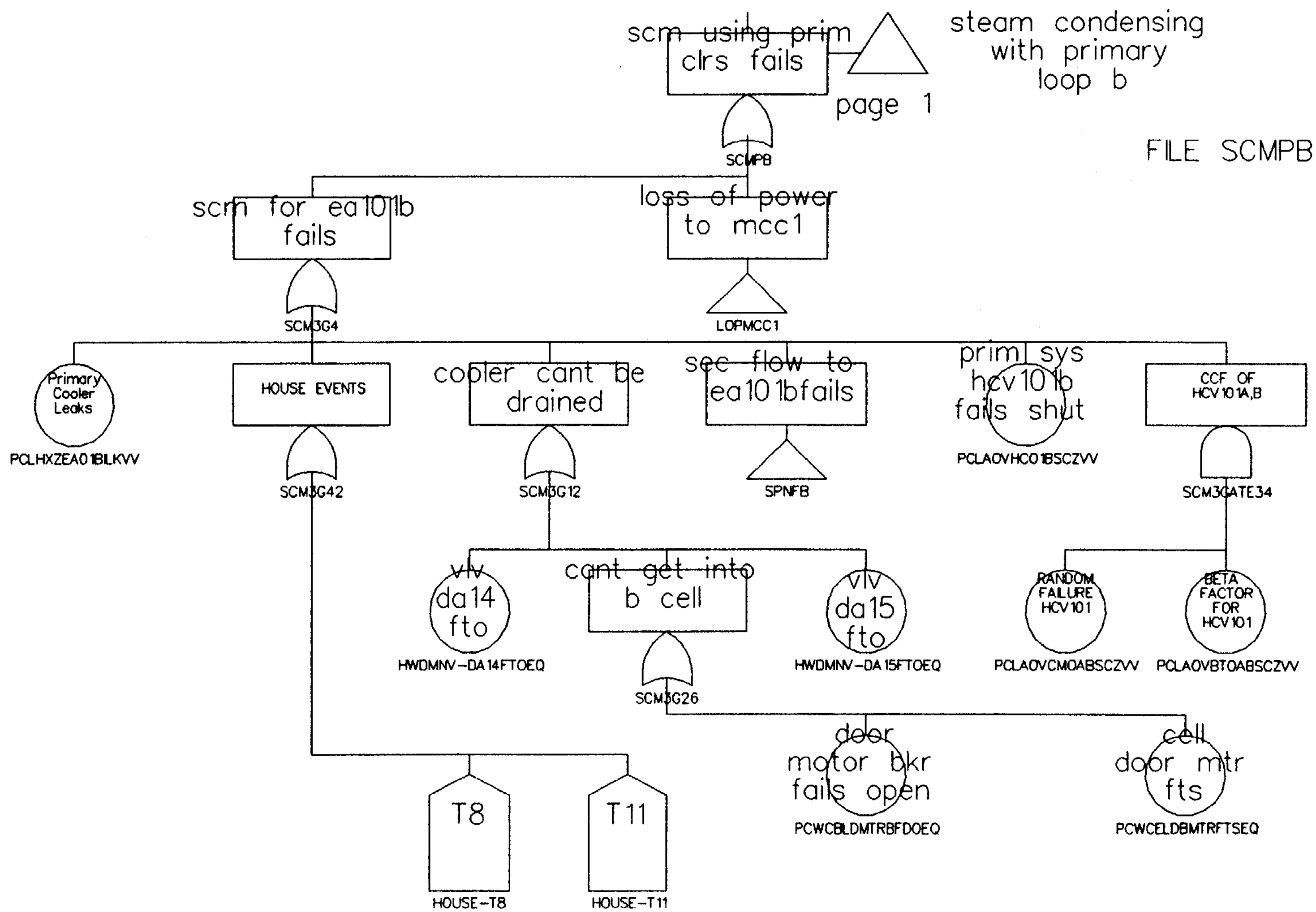


since SCM with the shutdown
cooler is the preferred alignment
a failure to isolate the SD pmps
is assumed to fail all steam condensing

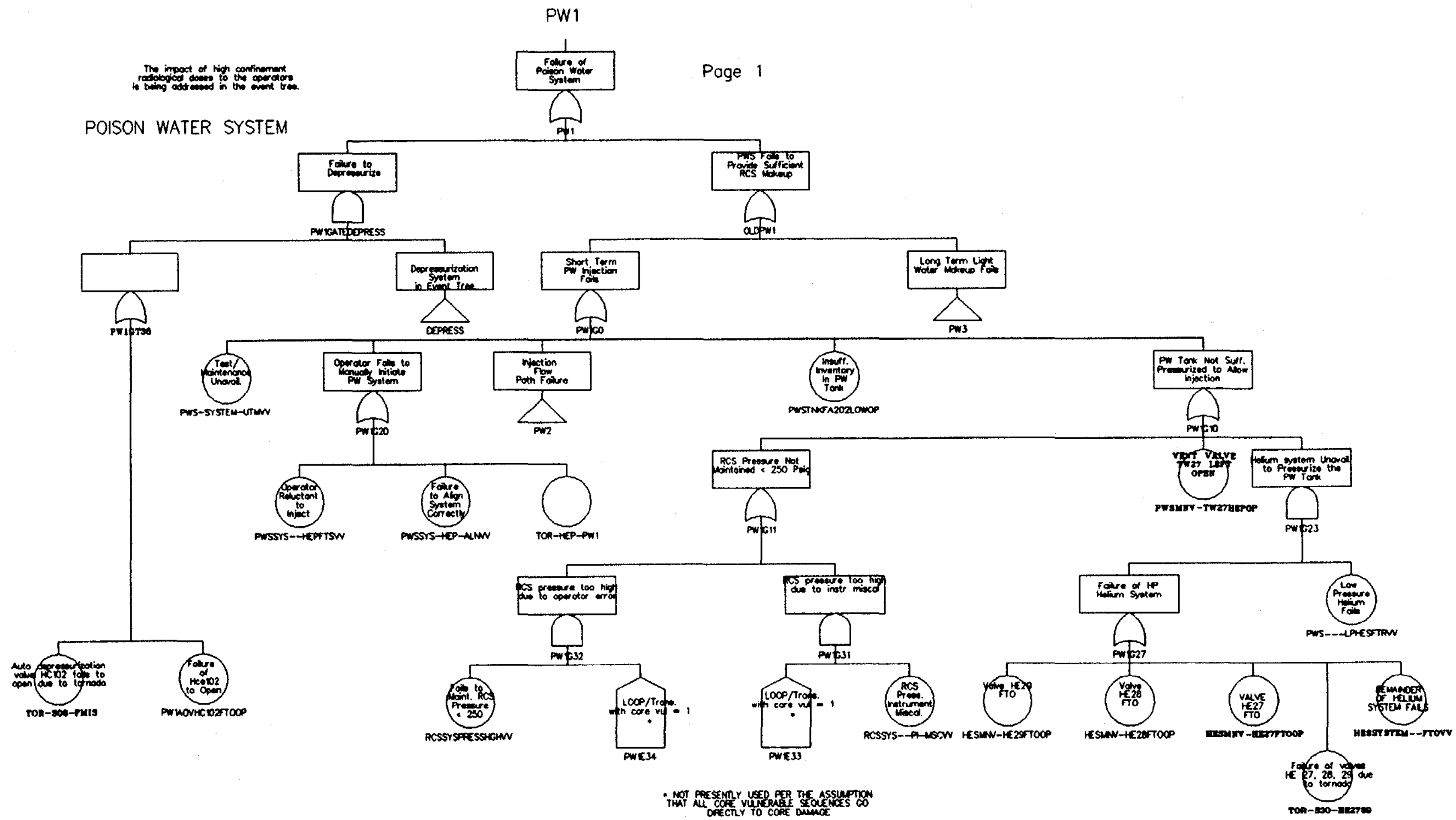
RPV level at 120.5" causes stm
bypass (inadvertant draining)

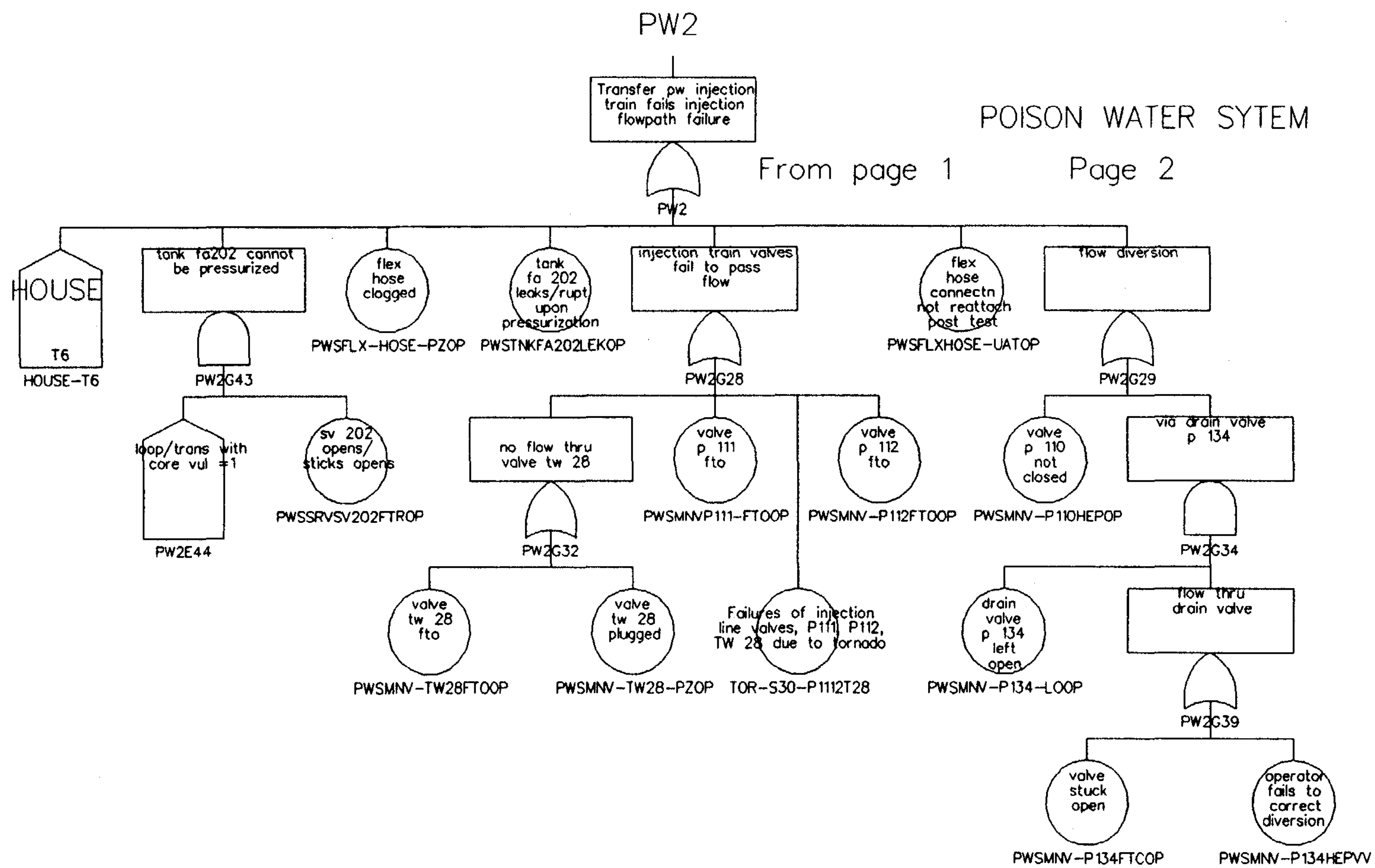
FAULT TREE SCMPRIB

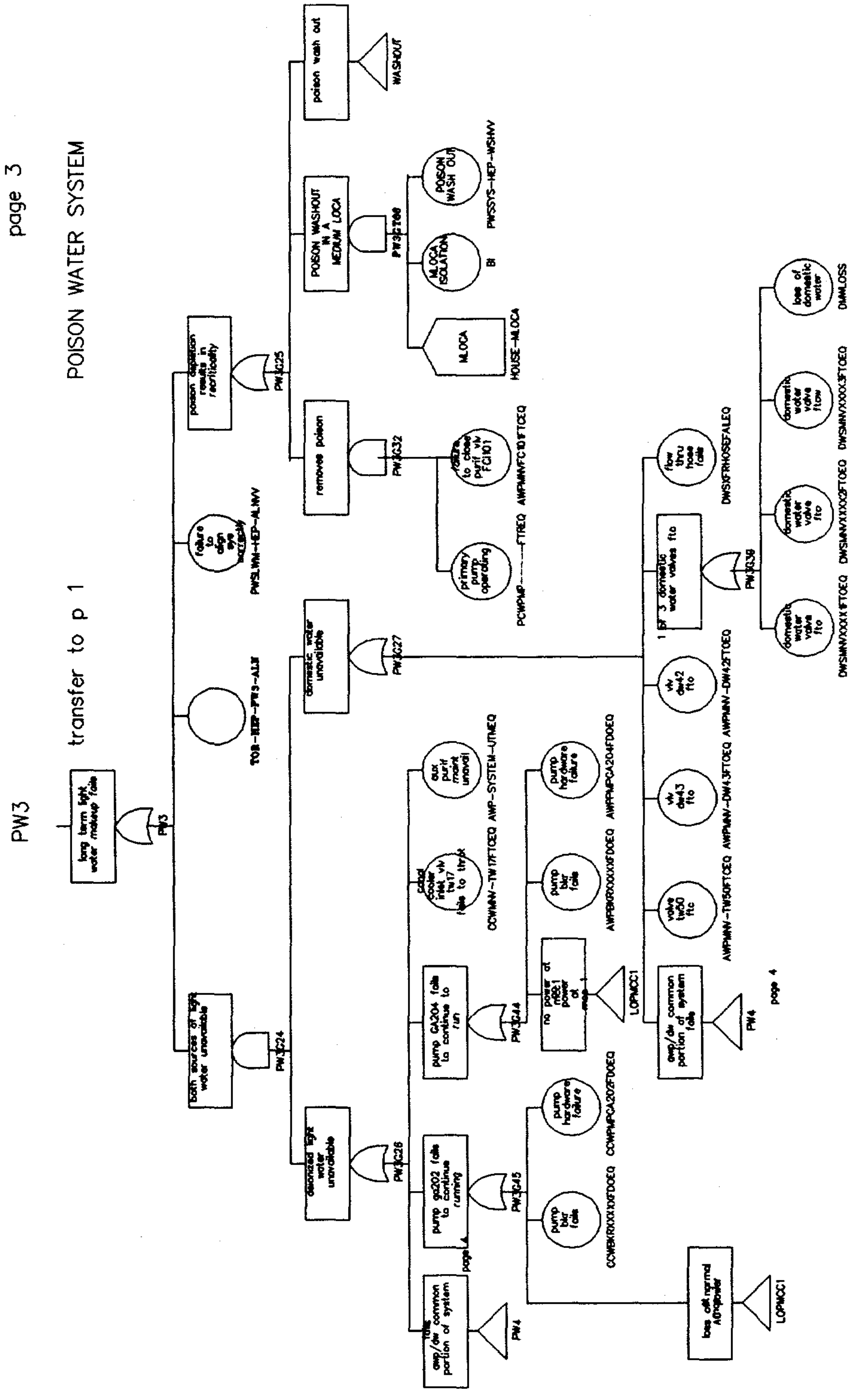
PAGE 2



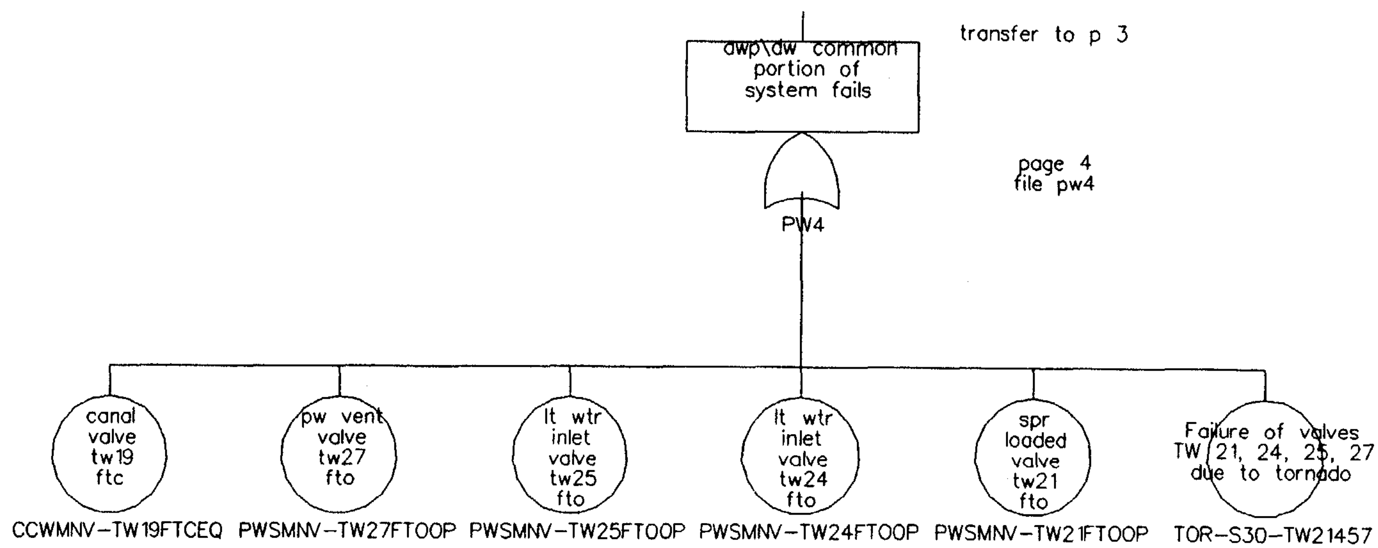
Appendix C.8
Poison Water System Modified for Tornado Initiator


PW1
Page 1
The impact of high confinement radiological doses to the operators is being addressed in the event tree.
POISON WATER SYSTEM
Failure of Poison Water System
PW1
Failure to Depressurize
PWS Fails to Provide Sufficient RCS Makeup
PW1GATEDEPRESS
OLDPW1
PW1GT38
Depressurization System in Event Tree
DEPRESS
Short Term PW Injection Fails
Long Term Light Water Makeup Fails
PW3
PW1G0
Test/ Maintenance Unavail.
PWS-SYSTEM-UTMVV
Operator Fails to Manually Initiate PW System
PW1G20
Injection Flow Path Failure
PW2
Insuff. Inventory in PW Tank
PWSTNKFA202LOWOP
PW Tank Not Suff. Pressurized to Allow Injection
PW1G10
Operator Reluctant to Inject
PWSSYS--HEPFTSVV
Failure to Align System Correctly
PWSSYS-HEP-ALNVV
TOR-HEP-PW1
RCS Pressure Not Maintained < 250 Psig
PW1G11
VENT VALVE TW27 LEFT OPEN
PWSMNV-TW27HEPOP
Helium system Unavail. to Pressurize the PW Tank
PW1G23
RCS pressure too high due to operator error
PW1G32
RCS pressure too high due to instr miscal
PW1G31
Failure of HP Helium System
PW1G27
Low Pressure Helium Fails
PWS---LPHESFTRVV
Auto depressurization valve HC102 fails to open due to tornado
TOR-S06-FMIS
Failure of Hce102 to Open
PW1AOVHC102FTOOP
Fails to Maint. RCS Pressure < 250
RCSSYSPRESSHGHVV
LOOP/Trans. with core vul = 1 *
PW1E34
LOOP/Trans. with core vul = 1 *
PW1E33
RCS Press. Instrument Miscal.
RCSSYS--PI-MSCVV
Valve HE29 FTO
HESMNV-HE29FTOOP
Valve HE28 FTO
HESMNV-HE28FTOOP
VALVE HE27 FTO
HESMNV-HE27FTOOP
REMAINDER OF HELIUM SYSTEM FAILS
HESSYSTEM--FTOVV
Failure of valves HE 27, 28, 29 due to tornado
TOR-S30-HE2789
* NOT PRESENTLY USED PER THE ASSUMPTION THAT ALL CORE VULNERABLE SEQUENCES GO DIRECTLY TO CORE DAMAGE

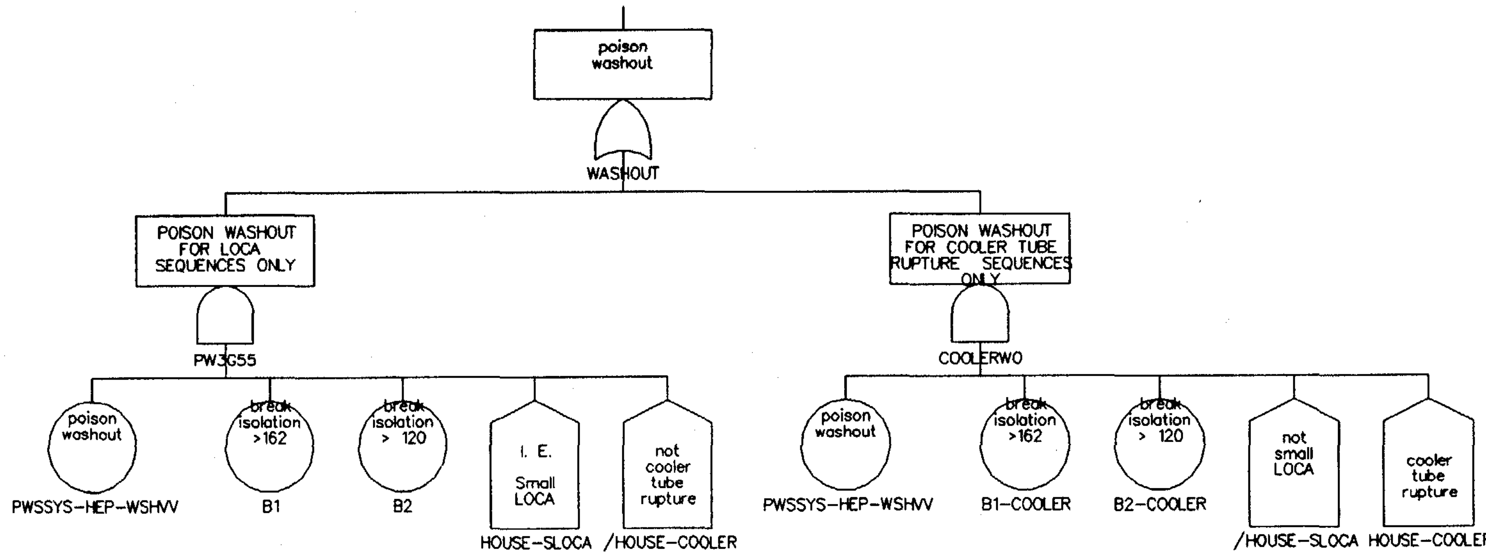

PW2
Transfer pw injection train fails injection flowpath failure
POISON WATER SYTEM
From page 1
Page 2
PW2
HOUSE
T6
HOUSE-T6
tank fa202 cannot be pressurized
PW2G43
loop/trans with core vul #1
PW2E44
sv 202 opens/ sticks opens
PWSSRVSV202FTROP
flex hose clogged
PWSFLX-HOSE-PZOP
tank fa 202 leaks/rupt upon pressurization
PWSTNKFA202LEKOP
injection train valves fail to pass flow
PW2G28
no flow thru valve tw 28
PW2G32
valve tw 28 fto
PWSMNV-TW28FTOOP
valve tw 28 plugged
PWSMNV-TW28-PZOP
valve p 111 fto
PWSMNVP111-FTOOP
Failures of injection line valves, P111, P112, TW 28 due to tornado
TOR-S30-P1112T28
valve p 112 fto
PWSMNV-P112FTOOP
flex hose connectn not reattach post test
PWSFLXHOSE-UATOP
flow diversion
PW2G29
valve p 110 not closed
PWSMNV-P110HEPOP
via drain valve p 134
PW2G34
drain valve p 134 left open
PWSMNV-P134-LOOP
flow thru drain valve
PW2G39
valve stuck open
PWSMNV-P134FTCOP
operator fails to correct diversion
PWSMNV-P134HEPVV


PW3
transfer to p 1
page 3
POISON WATER SYSTEM
long term light water makeup fails
both sources of light water unavailable
deionized light water unavailable
domestic water unavailable
poison depletion results in recriticality
remove poison
POISON WASHOUT IN A MEDIUM LOCA
poison wash out
WASHOUT
MLOCA
HOUSE-MLOCA
MLOCA ISOLATION
POISON WASH OUT
PWSSYS-HEP-WSHV
primary pump operating
pump ga202 fails to continue running
pump GA204 fails to continue to run
pump bkr fails
pump hardware failure
aux purif maint unavail
AWP-SYSTEM-UTMEQ
awp/dw common portion of system fails
PW4
page 4
LOPMCC1
loss off normal AC power
flow thru hose fails
DWSXFRHOSEFALEQ
1 of 3 domestic water valves fto
domestic water valve fto
loss of domestic water
DWMLOSS

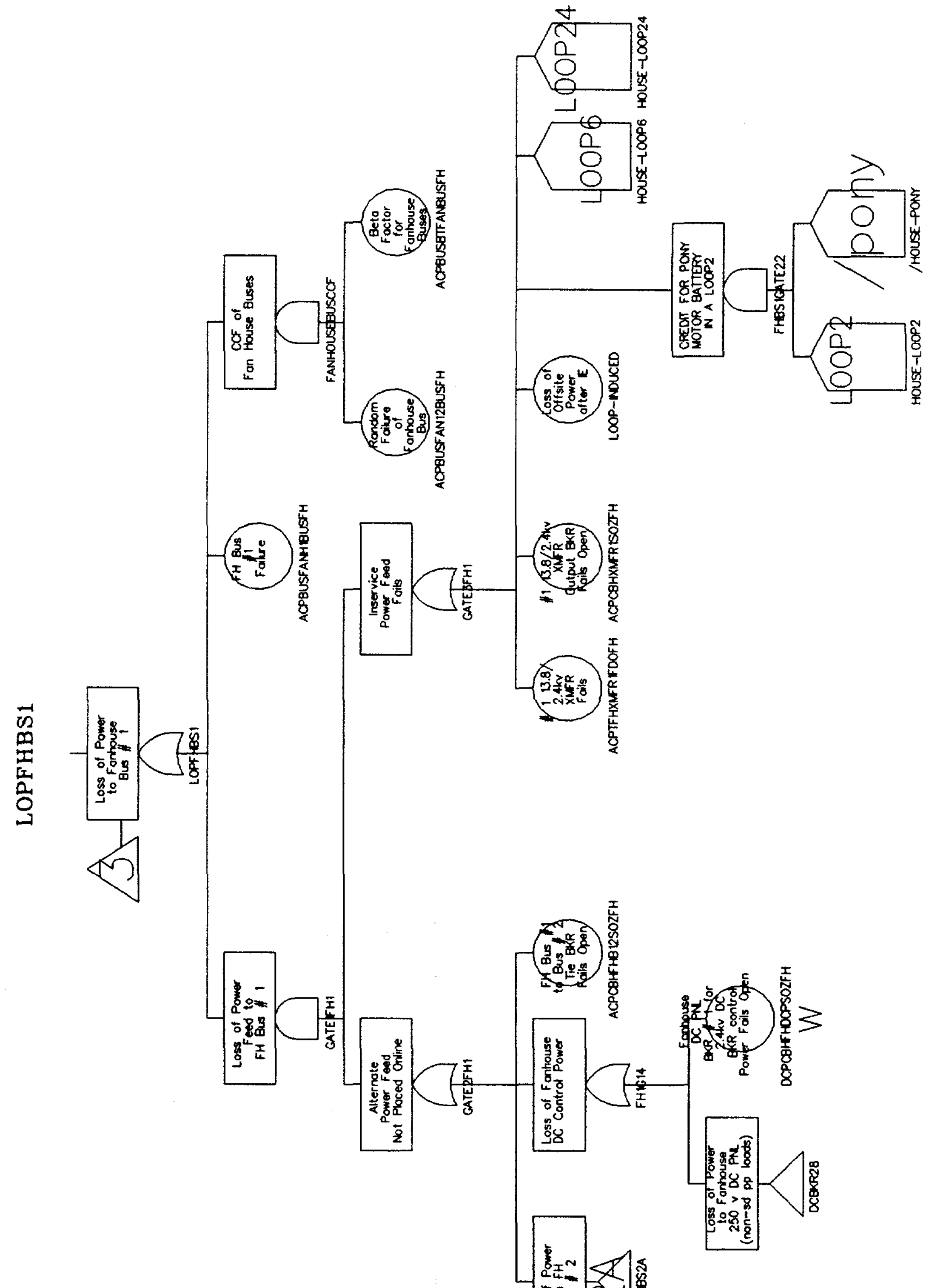
POISON WATER SYSTEM

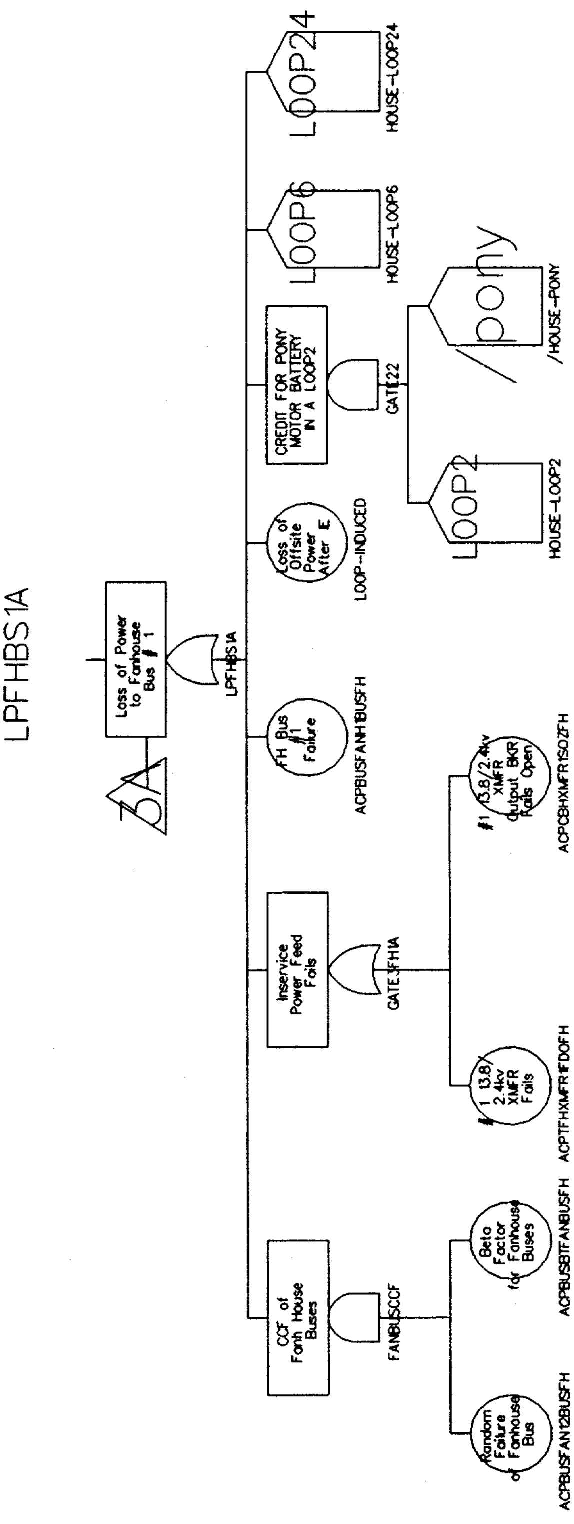


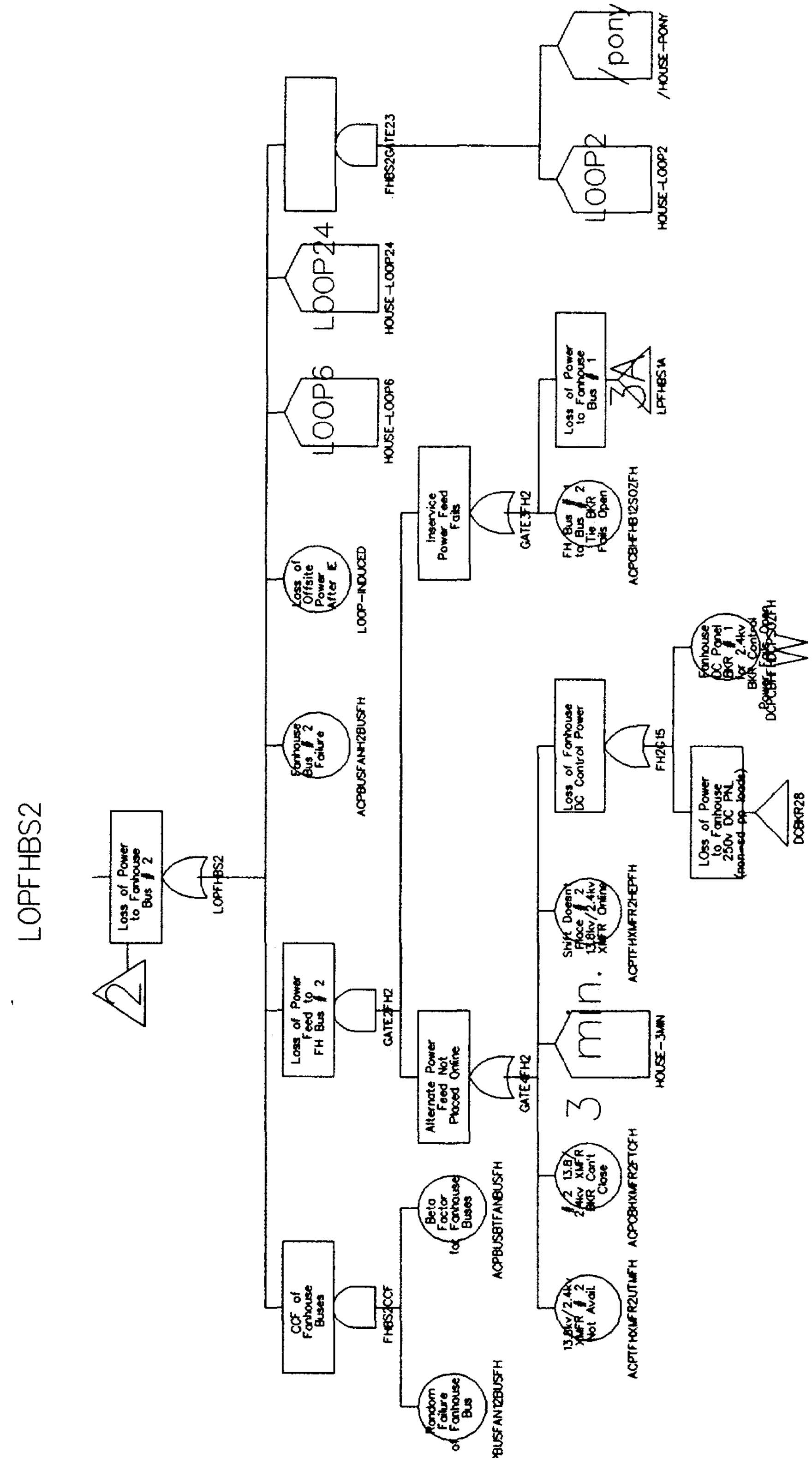
POISON WATER SYSTEM



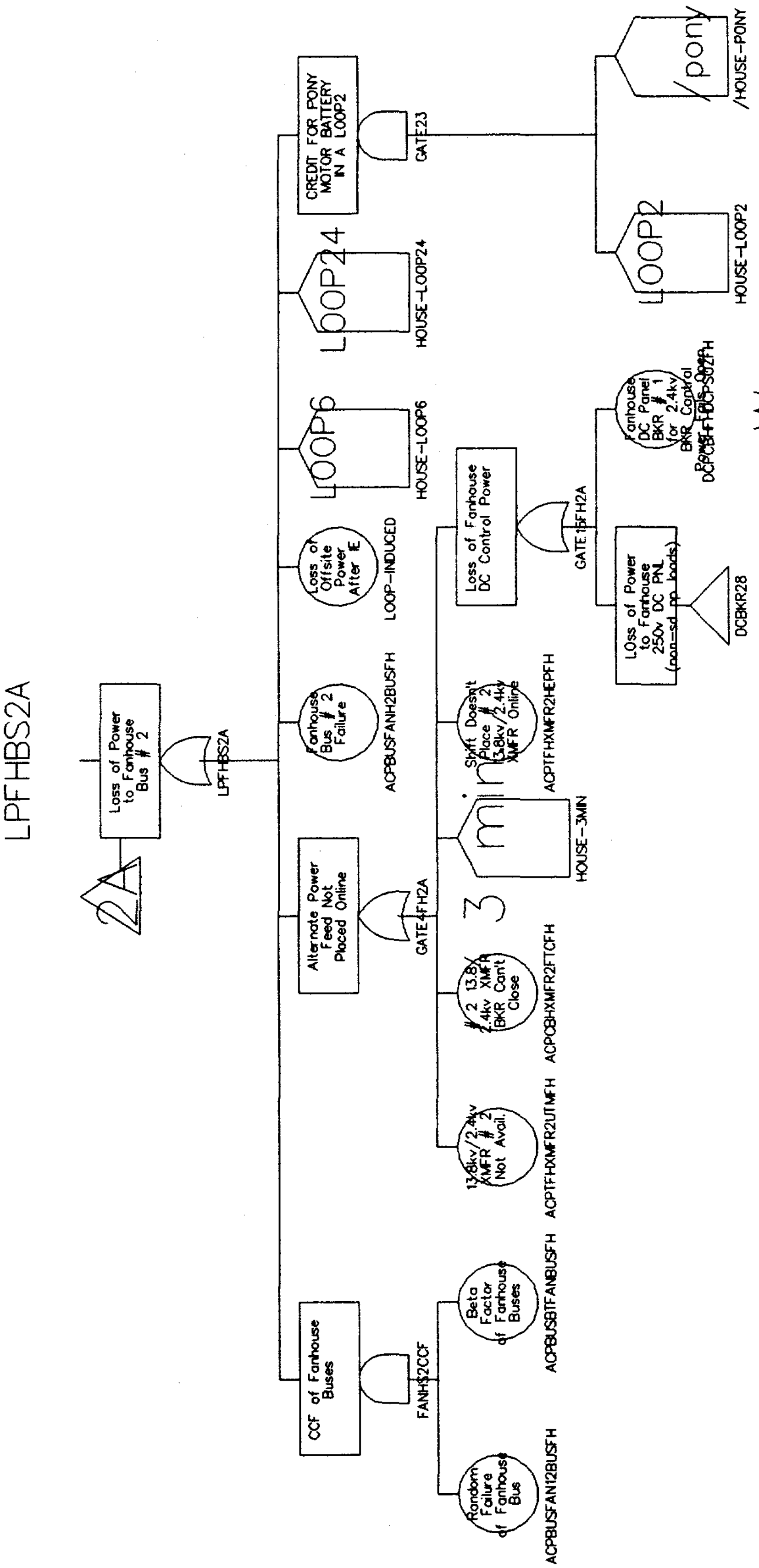
Appendix C.9
AC Power System Modified for Tornado Initiator

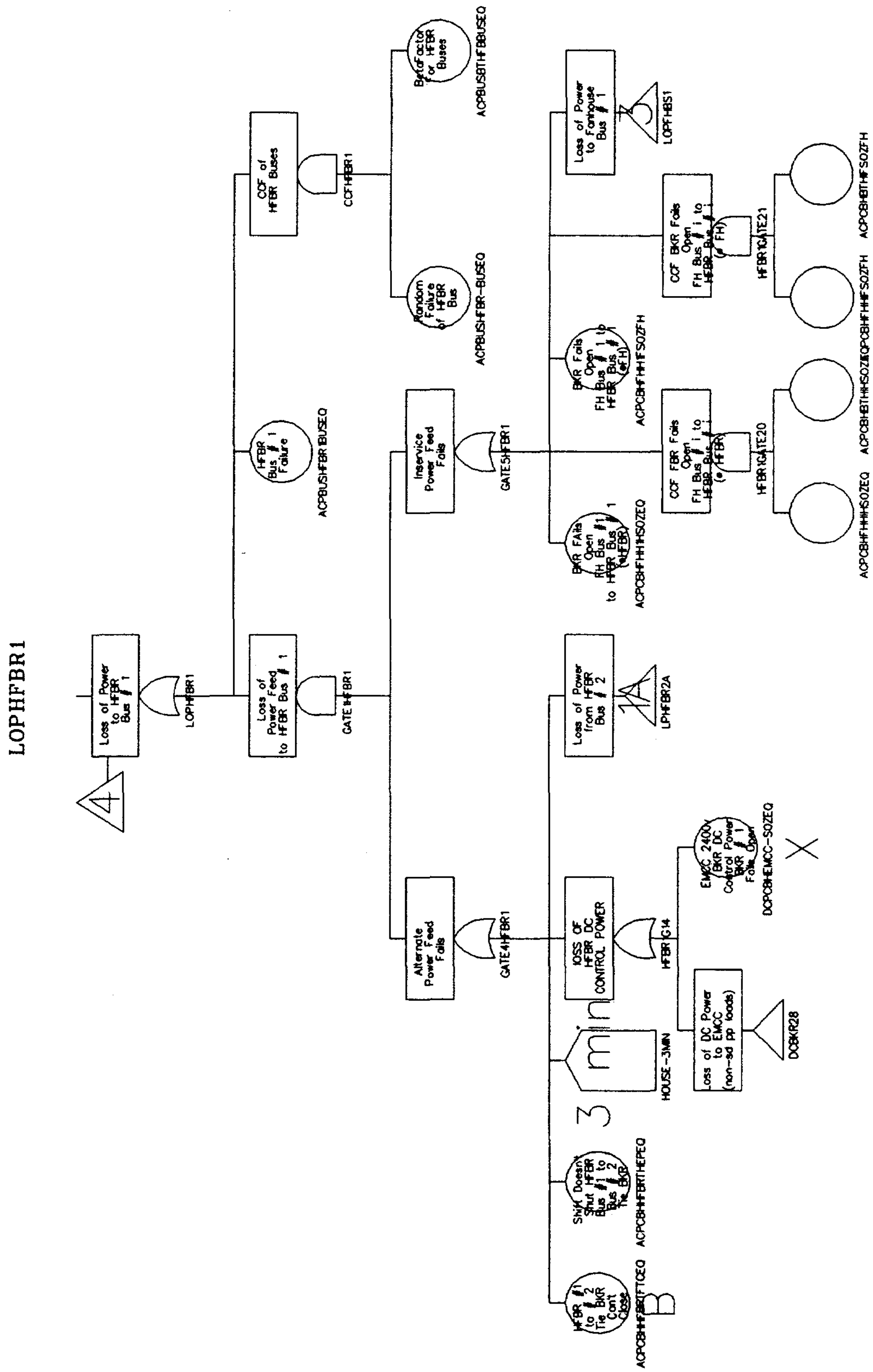

LOPFHBS1
5
Loss of Power to Fanhouse Bus # 1
LOPFHBS1
Loss of Power Feed to FH Bus # 1
GATEAFH1
FH Bus #1 Failure
ACPBUSFANH1BUSFH
CCF of Fan House Buses
FANHOUSEBUSCCF
Random Failure of Fanhouse Bus
ACPBUSFAN12BUSFH
Beta Factor for Fanhouse Buses
ACPBUSBTFANBUSFH
Alternate Power Feed Not Placed Online
GATEDFH1
Inservice Power Feed Fails
GATEBFH1
Loss of Power from FH Bus # 2
2A
LPFHBS2A
Loss of Fanhouse DC Control Power
FH1C14
FH Bus #1 to Bus # 2 Tie BKR Fails Open
ACPCBHFHB12SOZFH
#1 13.8/2.4kv XMFR Fails
ACPTFHXMFR1FDOFH
#1 13.8/2.4kv XMFR Output BKR Fails Open
ACPCBHXMFR1SOZFH
Loss of Offsite Power after IE
LOOP-INDUCED
LOOP6
HOUSE-LOOP6
LOOP24
HOUSE-LOOP24
Fanhouse DC PNL BKR #1 for 2.4kv DC BKR control Power Fails Open
DCPCBHFHDCPSOZFH
W
Loss of Power to Fanhouse 250 v DC PNL (non-sd pp loads)
DCBKR28
CREDIT FOR PONY MOTOR BATTERY IN A LOOP2
FHBS1GATE22
LOOP2
HOUSE-LOOP2
/pony
/HOUSE-PONY


LPFHBS1A
3A
Loss of Power to Fanhouse Bus # 1
LPFHBS1A
CCF of Fanh House Buses
FANBUSCCF
Random Failure of Fanhouse Bus
ACPBUSFAN12BUSFH
Beta Factor for Fanhouse Buses
ACPBUSBTFANBUSFH
Inservice Power Feed Fails
GATE3FH1A
1 13.8/ 2.4kv XMFR Fails
ACPTFHXMFR1FDOFH
#1 13.8/2.4kv XMFR Output BKR Fails Open
ACPCBHXMFR1SOZFH
FH Bus #1 Failure
ACPBUSFANH1BUSFH
Loss of Offsite Power After IE
LOOP-INDUCED
CREDIT FOR PONY MOTOR BATTERY IN A LOOP2
GATE22
LOOP2
HOUSE-LOOP2
/pony
/HOUSE-PONY
LOOP6
HOUSE-LOOP6
LOOP24
HOUSE-LOOP24

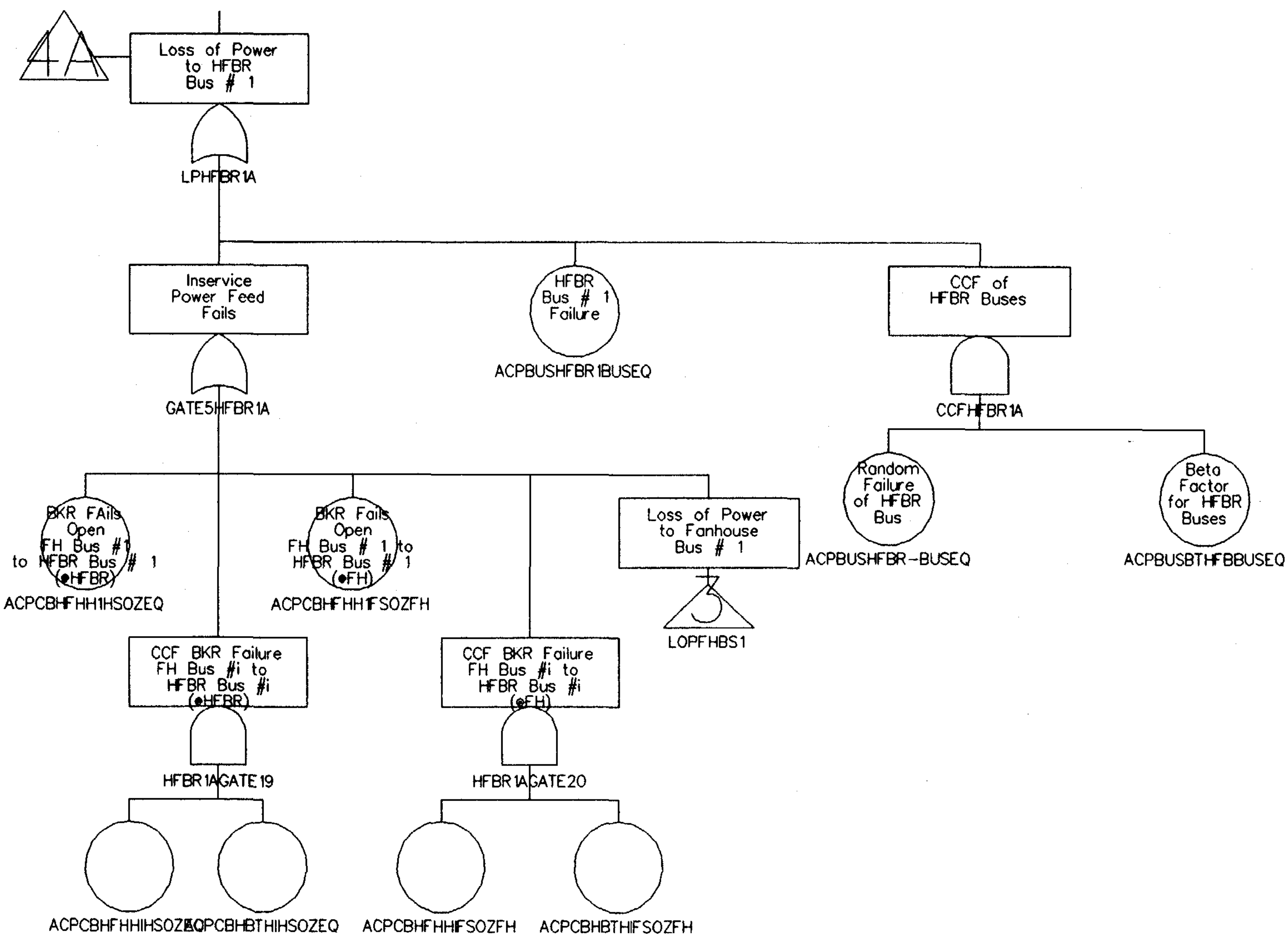


LOPFHBS2
Loss of Power to Fanhouse Bus # 2
LOPFHBS2
CCF of Fanhouse Buses
FHBS2CCF
Random Failure of Fanhouse Bus
ACPBUSFAN12BUSFH
Beta Factor for Fanhouse Buses
ACPBUSBTFANBUSFH
Loss of Power Feed to FH Bus # 2
GATE2FH2
Alternate Power Feed Not Placed Online
GATE4FH2
13.8kv/2.4kv XMFR # 2 Not Avail.
ACPTFHXMFR2UTMFH
2 2.4kv 13.8/ XMFR BKR Can't Close
ACPCBHXMFR2FTCFH
3 min.
HOUSE-3MIN
Shift Doesn't Place # 2 13.8kv/2.4kv XMFR Online
ACPTFHXMFR2HEPFH
Loss of Fanhouse DC Control Power
FH2G15
Loss of Power to Fanhouse 250v DC PNL
DCBKR28
Fanhouse DC Panel BKR # 1 for 2.4kv BKR Control Power Fails Open
DCPCBHFDCP5OZFH
Inservice Power Feed Fails
GATE3FH2
FH Bus # 2 to Bus # 1 Tie BKR Fails Open
ACPCBHFHB12SOZFH
Loss of Power to Fanhouse Bus # 1
LPFHBS1A
Fanhouse Bus # 2 Failure
ACPBUSFANH2BUSFH
Loss of Offsite Power After E
LOOP-INDUCED
LOOP6
HOUSE-LOOP6
LOOP24
HOUSE-LOOP24
FHBS2GATE23
LOOP2
HOUSE-LOOP2
/pony
/HOUSE-PONY


LPFHBS2A
2A
Loss of Power to Fanhouse Bus # 2
LPFHBS2A
CCF of Fanhouse Buses
FANHS2CCF
Random Failure of Fanhouse Bus
ACPBUSFAN12BUSFH
Beta Factor of Fanhouse Buses
ACPBUSBTFANBUSFH
Alternate Power Feed Not Placed Online
GATE4FH2A
13.8kv/2.4kv XMFR # 2 Not Avail.
ACPTFHXMFR2UTMFH
2 13.8/2.4kv XMFR BKR Can't Close
ACPCBHXMFR2FTCFH
3min
HOUSE-3MIN
Shift Doesn't Place # 2 13.8kv/2.4kv XMFR Online
ACPTFHXMFR2HEPFH
Loss of Fanhouse DC Control Power
GATE15FH2A
LOss of Power to Fanhouse 250v DC PNL (non-sd pp loads)
DCBKR28
Fanhouse DC Panel BKR # 1 for 2.4kv BKR Control Power Fails Open
W
Fanhouse Bus # 2 Failure
ACPBUSFANH2BUSFH
Loss of Offsite Power After IE
LOOP-INDUCED
LOOP6
HOUSE-LOOP6
LOOP24
HOUSE-LOOP24
CREDIT FOR PONY MOTOR BATTERY IN A LOOP2
GATE23
LOOP2
HOUSE-LOOP2
/pony
/HOUSE-PONY

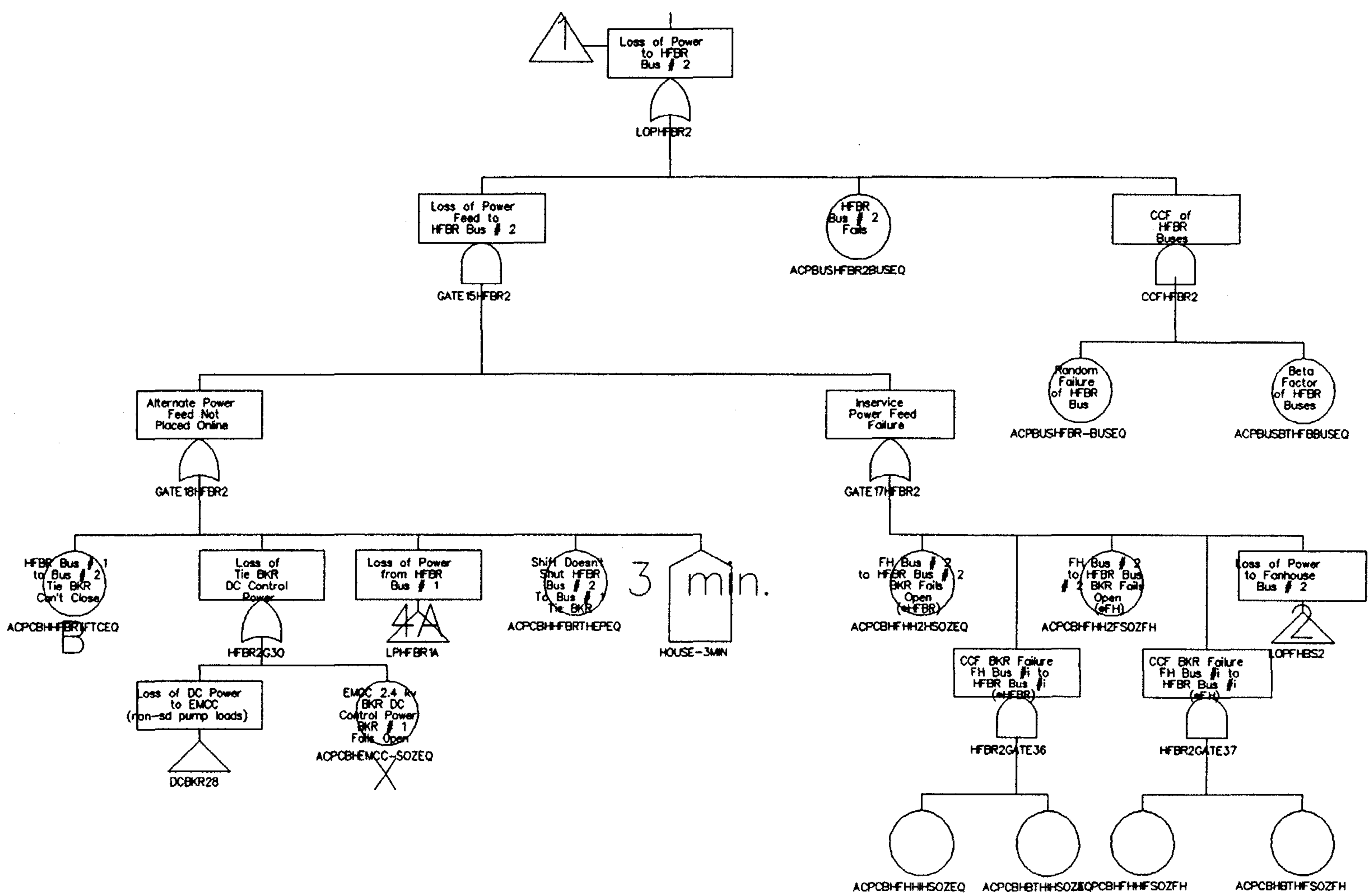

LOPHFBR1
Loss of Power to HFBR Bus # 1
LOPHFBR1
Loss of Power Feed to HFBR Bus # 1
GATE1HFBR1
CCF of HFBR Buses
CCFHFBR1
HFBR Bus # 1 Failure
ACPBUSHFBR1BUSEQ
Random Failure of HFBR Bus
ACPBUSHFBR-BUSEQ
BetaFactor for HFBR Buses
ACPBUSBTHFBBUSEQ
Alternate Power Feed Fails
GATE4HFBR1
Inservice Power Feed Fails
GATE5HFBR1
Loss of Power from HFBR Bus # 2
LPHFBR2A
Loss of Power to Fanhouse Bus # 1
LOPFHBS1
LOSS OF HFBR DC CONTROL POWER
HFBRG14
HOUSE-3MIN
Loss of DC Power to EMCC (non-sd pp loads)
DCBKR28
DCPCBHEMCC-SOZEQ
ACPCBHHFBRTHEPEQ
GATE4HFBR1
HFBR1GATE20
HFBR1GATE21
ACPCBHFHH1HSOZEQ
ACPCBHFHHHFSOZFH

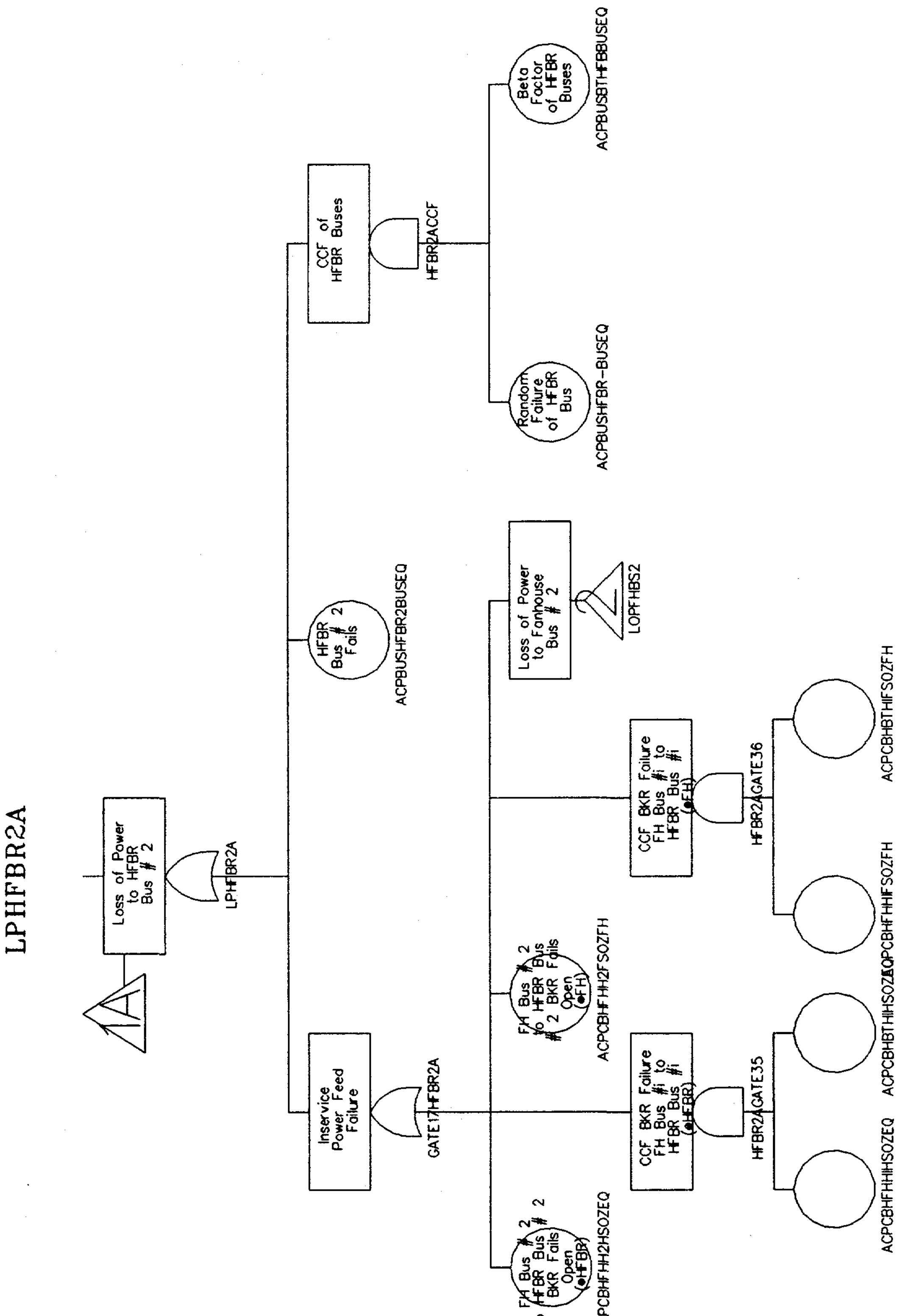
LPHFBR1A



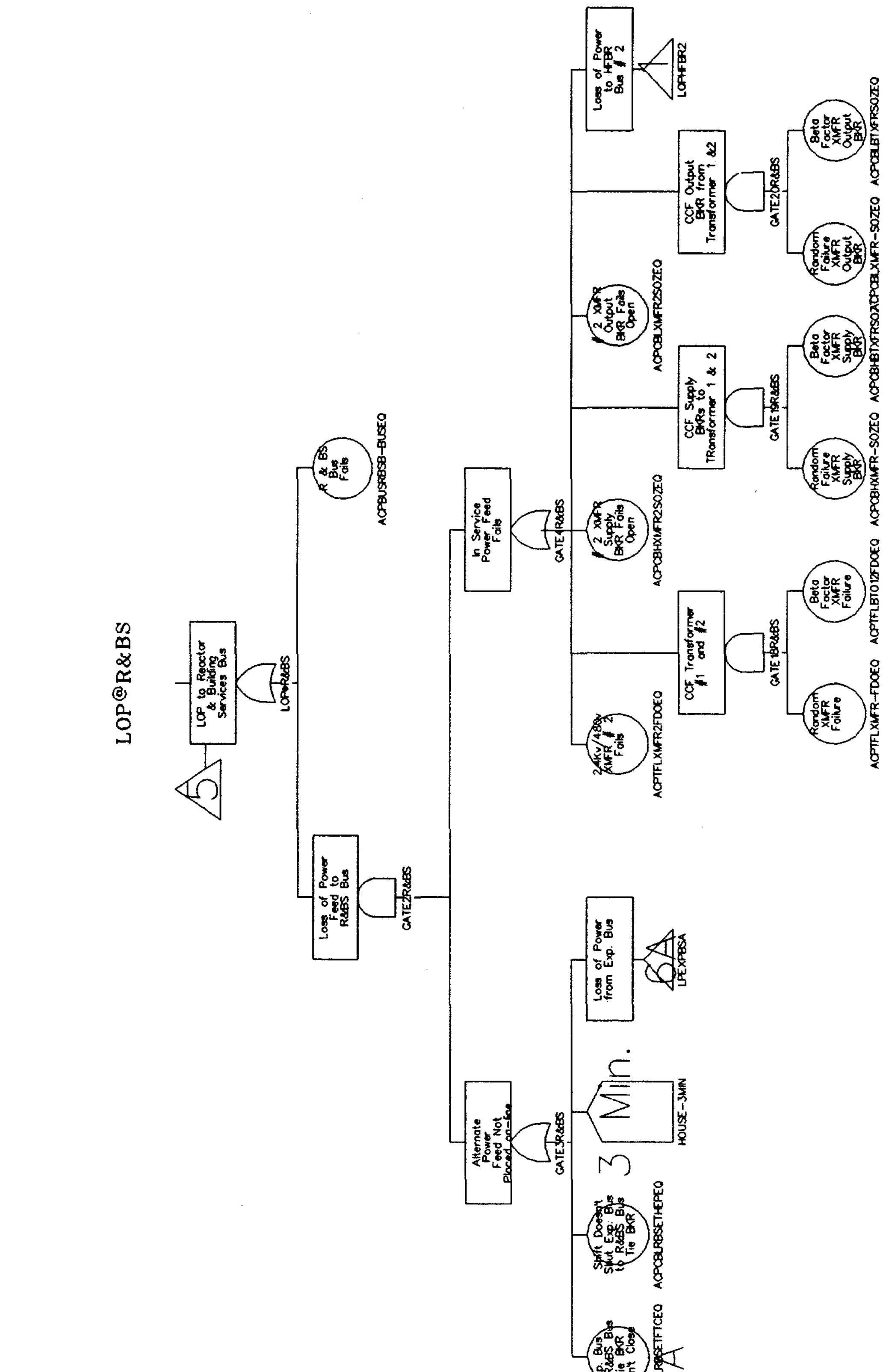
4A
Loss of Power to HFBR Bus # 1
LPHFBR1A
Inservice Power Feed Fails
GATE5HFBR1A
HFBR Bus # 1 Failure
ACPBUSHFBR1BUSEQ
CCF of HFBR Buses
CCFHFBR1A
Random Failure of HFBR Bus
ACPBUSHFBR-BUSEQ
Beta Factor for HFBR Buses
ACPBUSBTHFBBUSEQ
BKR FAils Open FH Bus #1 to HFBR Bus # 1 (●HFBR)
ACPCBHFHH1HSOZEQ
BKR Fails Open FH Bus # 1 to HFBR Bus # 1 (●FH)
ACPCBHFHH1FSOZFH
Loss of Power to Fanhouse Bus # 1
3
LOPFHBS1
CCF BKR Failure FH Bus #i to HFBR Bus #i (●HFBR)
HFBR1AGATE19
CCF BKR Failure FH Bus #i to HFBR Bus #i (●FH)
HFBR1AGATE20
ACPCBHFHHIHSOZEQ
ACPCBHBTHIHSOZEQ
ACPCBHFHHIFSOZFH
ACPCBHBTHIFSOZFH

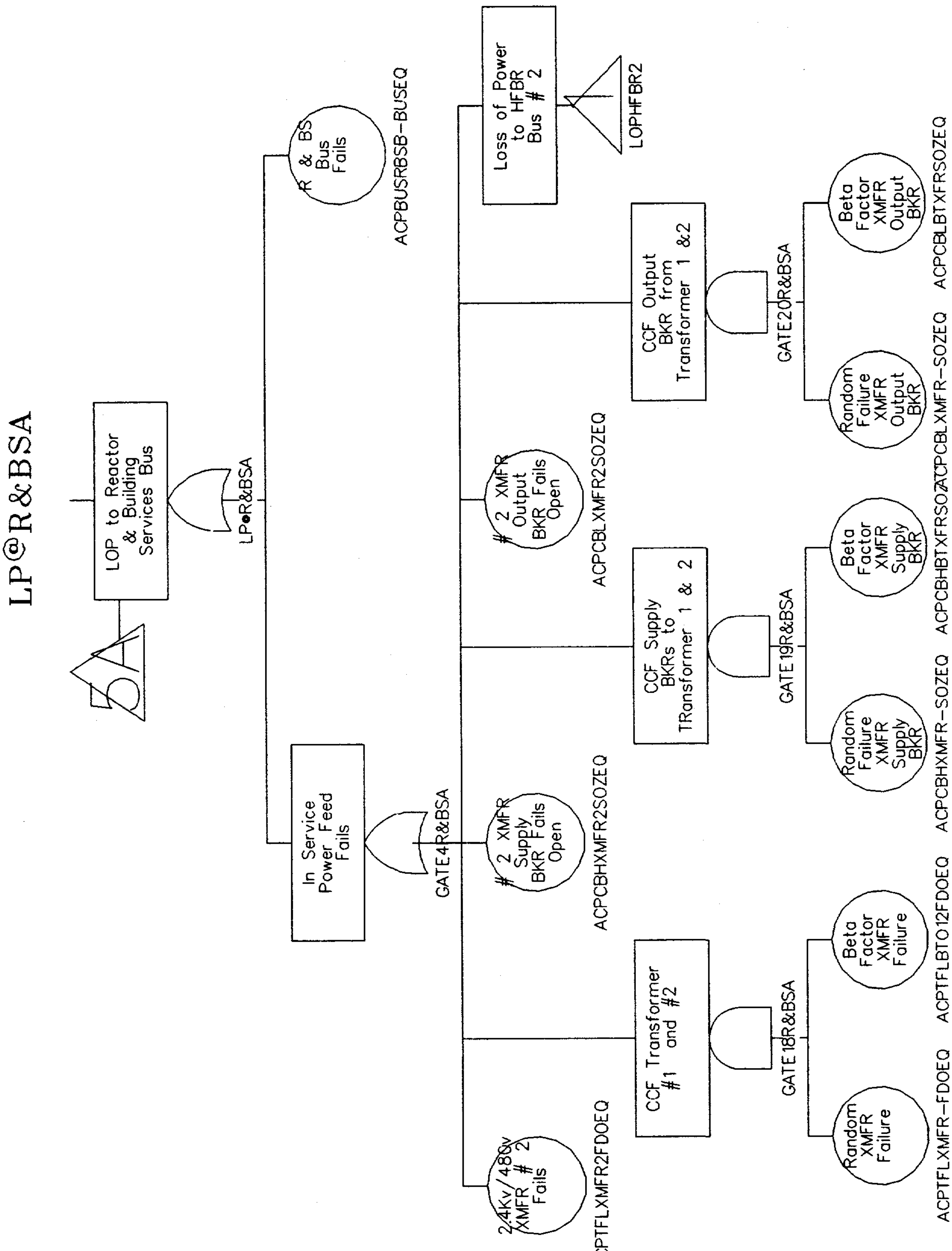
LOPHFBR2

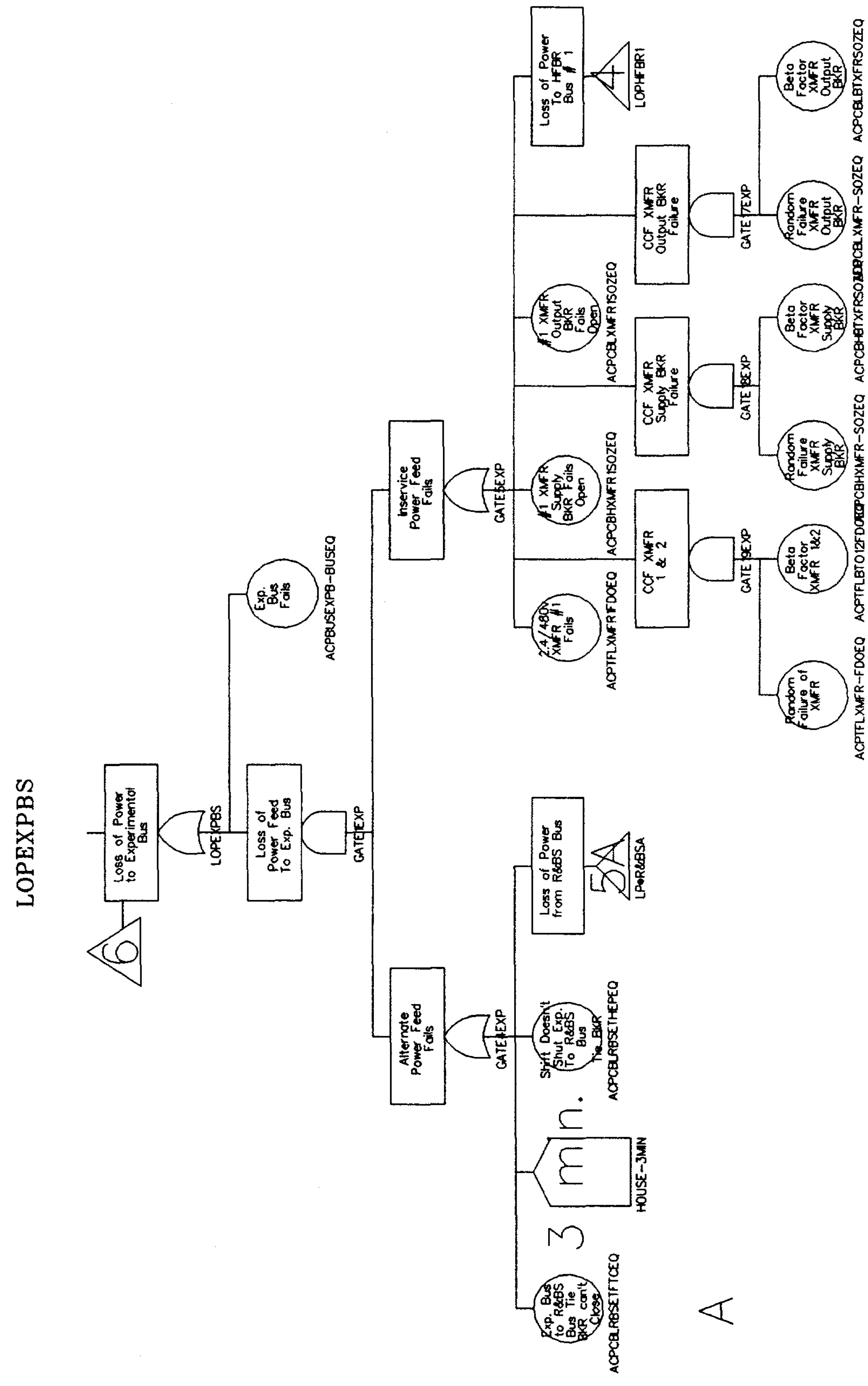

Loss of Power to HFBR Bus # 2
LOPHFBR2
Loss of Power Feed to HFBR Bus # 2
GATE15HFBR2
HFBR Bus # 2 Fails
ACPBUSHFBR2BUSEQ
CCF of HFBR Buses
CCFHFBR2
Random Failure of HFBR Bus
ACPBUSHFBR-BUSEQ
Beta Factor of HFBR Buses
ACPBUSBTHFBBUSEQ
Alternate Power Feed Not Placed Online
GATE18HFBR2
Inservice Power Feed Failure
GATE17HFBR2
HFBR Bus # 1 to Bus # 2 Tie BKR Can't Close
ACPCBHHFBRTFTCEQ
Loss of Tie BKR DC Control Power
HFBR2G30
Loss of Power from HFBR Bus # 1
LPHFBR1A
Shift Doesn't Shut HFBR Bus # 2 To Bus # 1 Tie BKR
ACPCBHHFBRTHEPEQ
3 min.
HOUSE-3MIN
Loss of DC Power to EMCC (non-sd pump loads)
DCBKR28
EMCC 2.4 kv BKR DC Control Power BKR # 1 Fails Open
ACPCBHEMCC-SOZEQ
FH Bus # 2 to HFBR Bus # 2 BKR Fails Open (@HFBR)
ACPCBHFHH2HSOZEQ
FH Bus # 2 to HFBR Bus # 2 BKR Fails Open (@FH)
ACPCBHFHH2FSOZFH
Loss of Power to Fanhouse Bus # 2
LOPFHBS2
CCF BKR Failure FH Bus #i to HFBR Bus #i (@HFBR)
HFBR2GATE36
CCF BKR Failure FH Bus #i to HFBR Bus #i (@FH)
HFBR2GATE37
ACPCBHFHHHSOZEQ
ACPCBHBTHHSOZEQ
ACPCBHFHHFSOZFH
ACPCBHBTHFSOZFH

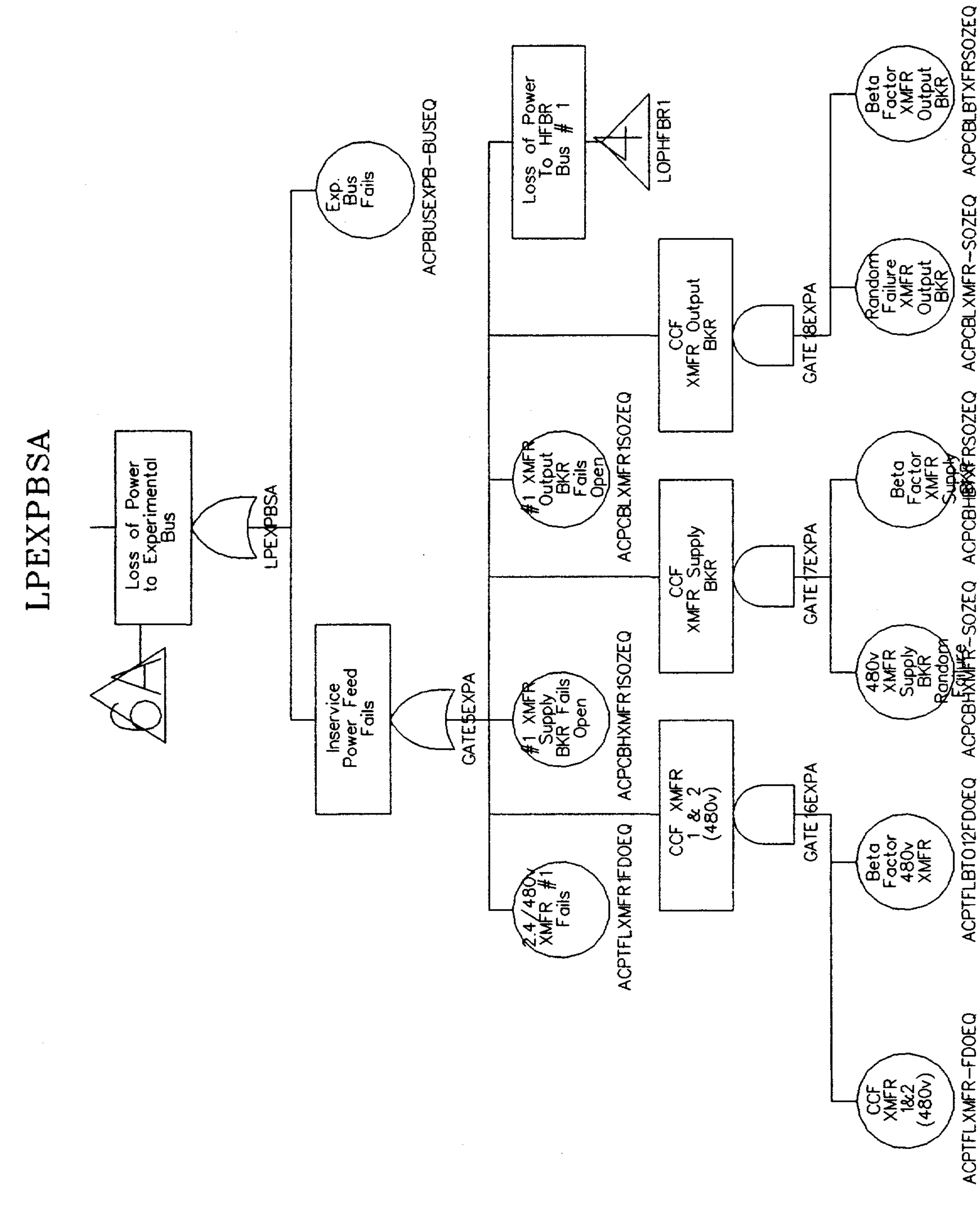


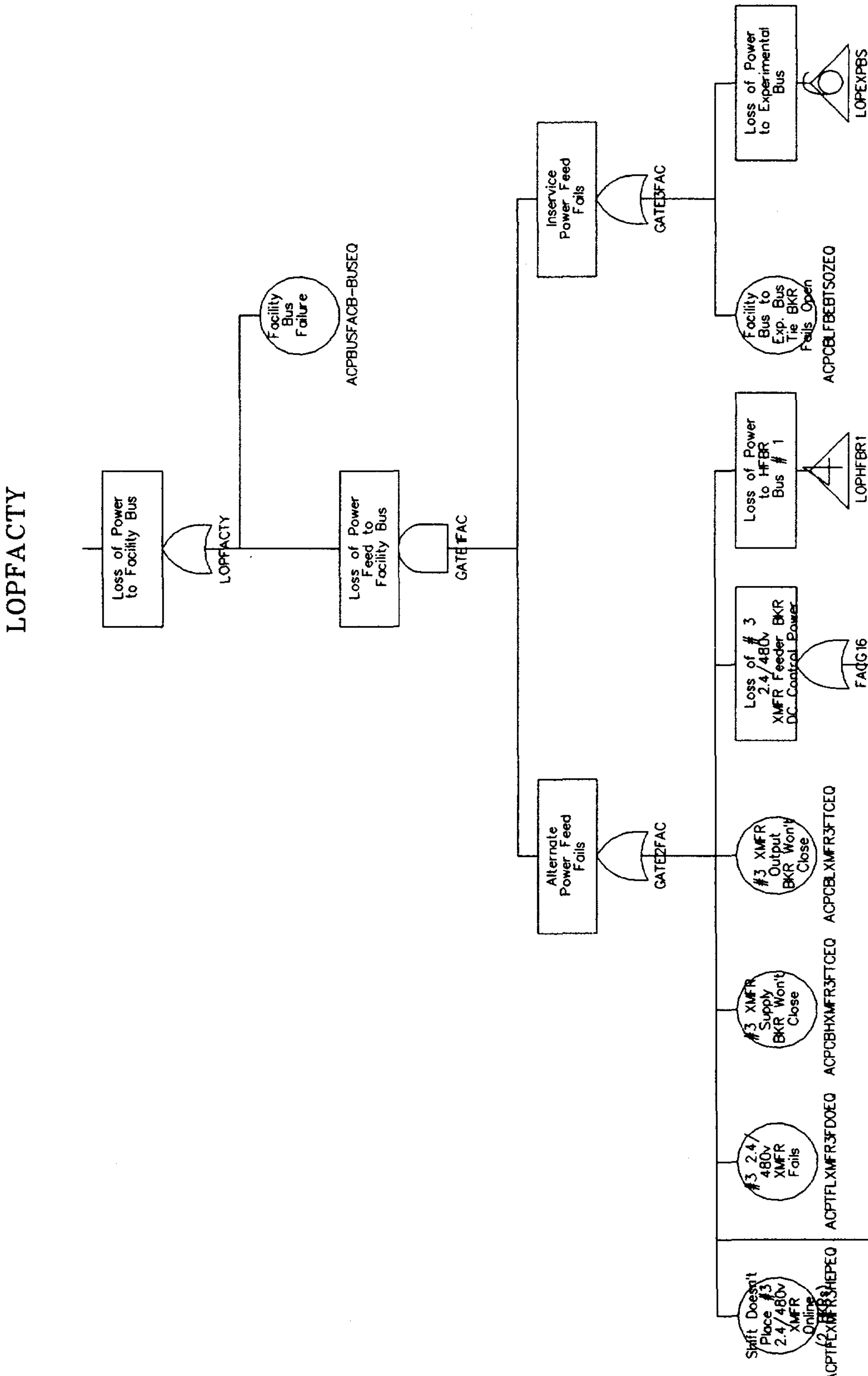
LPHFBR2A
1A
Loss of Power to HFBR Bus # 2
LPHFBR2A
Inservice Power Feed Failure
GATE17HFBR2A
HFBR Bus # 2 Fails
ACPBUSHFBR2BUSEQ
CCF of HFBR Buses
HFBR2ACCF
Random Failure of HFBR Bus
ACPBUSHFBR-BUSEQ
Beta Factor of HFBR Buses
ACPBUSBTHFBBUSEQ
FH Bus # 2 to HFBR Bus # 2 BKR Fails Open (●HFBR)
ACPCBHFHH2HSOZEQ
CCF BKR Failure FH Bus #i to HFBR Bus #i (●HFBR)
HFBR2AGATE35
ACPCBHFHHIHSOZEQ
ACPCBHBTHIHSOZEQ
FH Bus # 2 to HFBR Bus # 2 BKR Fails Open (●FH)
ACPCBHFHH2FSOZFH
CCF BKR Failure FH Bus #i to HFBR Bus #i (●FH)
HFBR2AGATE36
ACPCBHFHHIFSOZFH
ACPCBHBTHIFSOZFH
Loss of Power to Fanhouse Bus # 2
LOPFHBS2


LOP@R&BS
LOP to Reactor & Building Services Bus
LOPR&BS
5
Loss of Power Feed to R&BS Bus
GATE2R&BS
R & BS Bus Fails
ACPBUSRBSB-BUSEQ
Alternate Power Feed Not Placed on-line
GATE3R&BS
Exp. Bus to R&BS Bus Tie BKR Can't Close
ACPCBURBSETFTCEQ
Shift Doesn't Shut Exp. Bus to R&BS Bus Tie BKR
ACPCBURBSETHEPEQ
3 Min.
HOUSE-3MIN
Loss of Power from Exp. Bus
6A
LPEXPBSA
In Service Power Feed Fails
GATE4R&BS
2.4Kv/480v XMFR # 2 Fails
ACPTFLXMFR2FDOEQ
CCF Transformer #1 and #2
GATE18R&BS
Random XMFR Failure
ACPTFLXMFR-FDOEQ
Beta Factor XMFR Failure
ACPTFLBTO12FDOEQ
2 XMFR Supply BKR Fails Open
ACPCBHXMFR2SOZEQ
CCF Supply BKRs to TRansformer 1 & 2
GATE19R&BS
Random Failure XMFR Supply BKR
ACPCBHXMFR-SOZEQ
Beta Factor XMFR Supply BKR
ACPCBHBTXFRSOZEQ
2 XMFR Output BKR Fails Open
ACPCBLXMFR2SOZEQ
CCF Output BKR from Transformer 1 &2
GATE20R&BS
Random Failure XMFR Output BKR
ACPCBLXMFR-SOZEQ
Beta Factor XMFR Output BKR
ACPCBLBTXFRSOZEQ
Loss of Power to HFBR Bus # 2
LOPHFBR2


LP@R&BSA
LOP to Reactor & Building Services Bus
LP●R&BSA
In Service Power Feed Fails
GATE4R&BSA
R & BS Bus Fails
ACPBUSRBSB-BUSEQ
2.4Kv/480v XMFR # 2 Fails
ACPTFLXMFR2FDOEQ
CCF Transformer #1 and #2
GATE18R&BSA
Random XMFR Failure
ACPTFLXMFR-FDOEQ
Beta Factor XMFR Failure
ACPTFLBTO12FDOEQ
2 XMFR Supply BKR Fails Open
ACPCBHXMFR2SOZEQ
CCF Supply BKRs to TRansformer 1 & 2
GATE19R&BSA
Random Failure XMFR Supply BKR
ACPCBHXMFR-SOZEQ
Beta Factor XMFR Supply BKR
ACPCBHBTXFRSOZEQ
2 XMFR Output BKR Fails Open
ACPCBLXMFR2SOZEQ
CCF Output BKR from Transformer 1 &2
GATE20R&BSA
Random Failure XMFR Output BKR
ACPCBLXMFR-SOZEQ
Beta Factor XMFR Output BKR
ACPCBLBTXFRSOZEQ
Loss of Power to HFBR Bus # 2
LOPHFBR2

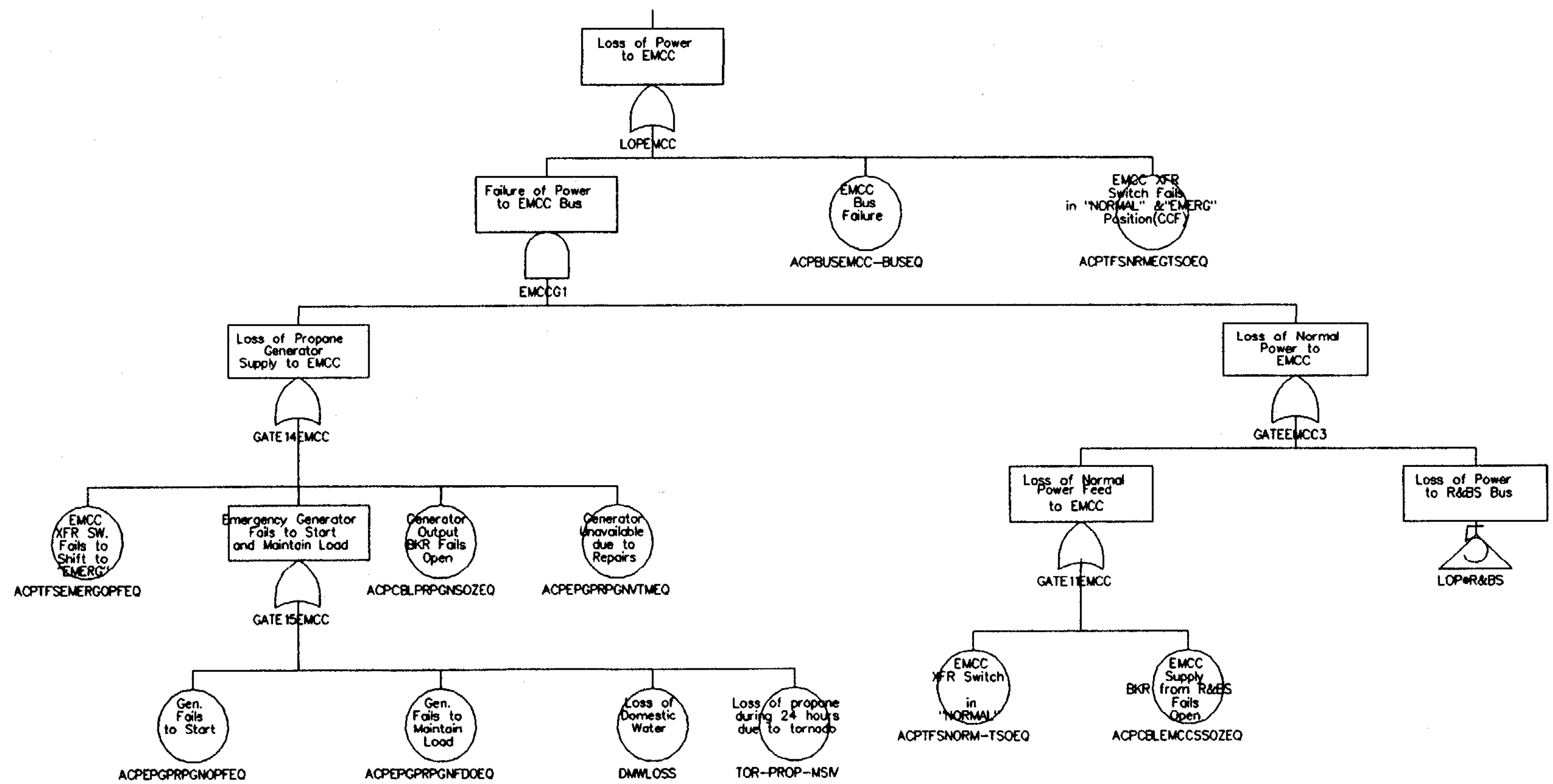

LOPEXPBS
6
Loss of Power to Experimental Bus
LOPEXPBS
Loss of Power Feed To Exp. Bus
GATE1EXP
Exp. Bus Fails
ACPBUSEXPB-BUSEQ
Alternate Power Feed Fails
GATE4EXP
Inservice Power Feed Fails
GATE5EXP
Exp. Bus to R&BS Bus Tie BKR can't Close
ACPCBLRBSETFTCEQ
3 min.
HOUSE-3MIN
Shift Doesn't Shut Exp. To R&BS Bus Tie BKR
ACPCBLRBSETHEPEQ
Loss of Power from R&BS Bus
5A
LP-R&BSA
2.4/480V XMFR #1 Fails
ACPTFLXMFR1FDOEQ
#1 XMFR Supply BKR Fails Open
ACPCBHXMFR1SOZEQ
#1 XMFR Output BKR Fails Open
ACPCBLXMFR1SOZEQ
Loss of Power To HFBR Bus #1
LOPHFBR1
CCF XMFR 1 & 2
GATE9EXP
CCF XMFR Supply BKR Failure
GATE8EXP
CCF XMFR Output BKR Failure
GATE7EXP
Random Failure of XMFR
ACPTFLXMFR-FDOEQ
Beta Factor XMFR 1&2
Random Failure XMFR Supply BKR
ACPCBHXMFR-SOZEQ
Beta Factor XMFR Supply BKR
Random Failure XMFR Output BKR
ACPCBLXMFR-SOZEQ
Beta Factor XMFR Output BKR
ACPCBLBTXFRSOZEQ
A


LPEXPBSA
Loss of Power to Experimental Bus
LPEXPBSA
Inservice Power Feed Fails
GATE5EXPA
Exp. Bus Fails
ACPBUSEXPB-BUSEQ
2.4/480v XMFR #1 Fails
ACPTFLXMFR1FDOEQ
CCF XMFR 1 & 2 (480v)
GATE16EXPA
#1 XMFR Supply BKR Fails Open
ACPCBHXMFR1SOZEQ
CCF XMFR Supply BKR
GATE17EXPA
#1 XMFR Output BKR Fails Open
ACPCBLXMFR1SOZEQ
CCF XMFR Output BKR
GATE18EXPA
Loss of Power To HFBR Bus # 1
LOPHFBR1
CCF XMFR 1&2 (480v)
ACPTFLXMFR-FDOEQ
Beta Factor 480v XMFR
ACPTFLBTO12FDOEQ
480v XMFR Supply BKR Random Failure
ACPCBHXMFR-SOZEQ
Beta Factor XMFR Supply BKR
ACPCBHBTXFRSOZEQ
Random Failure XMFR Output BKR
ACPCBLXMFR-SOZEQ
Beta Factor XMFR Output BKR
ACPCBLBTXFRSOZEQ

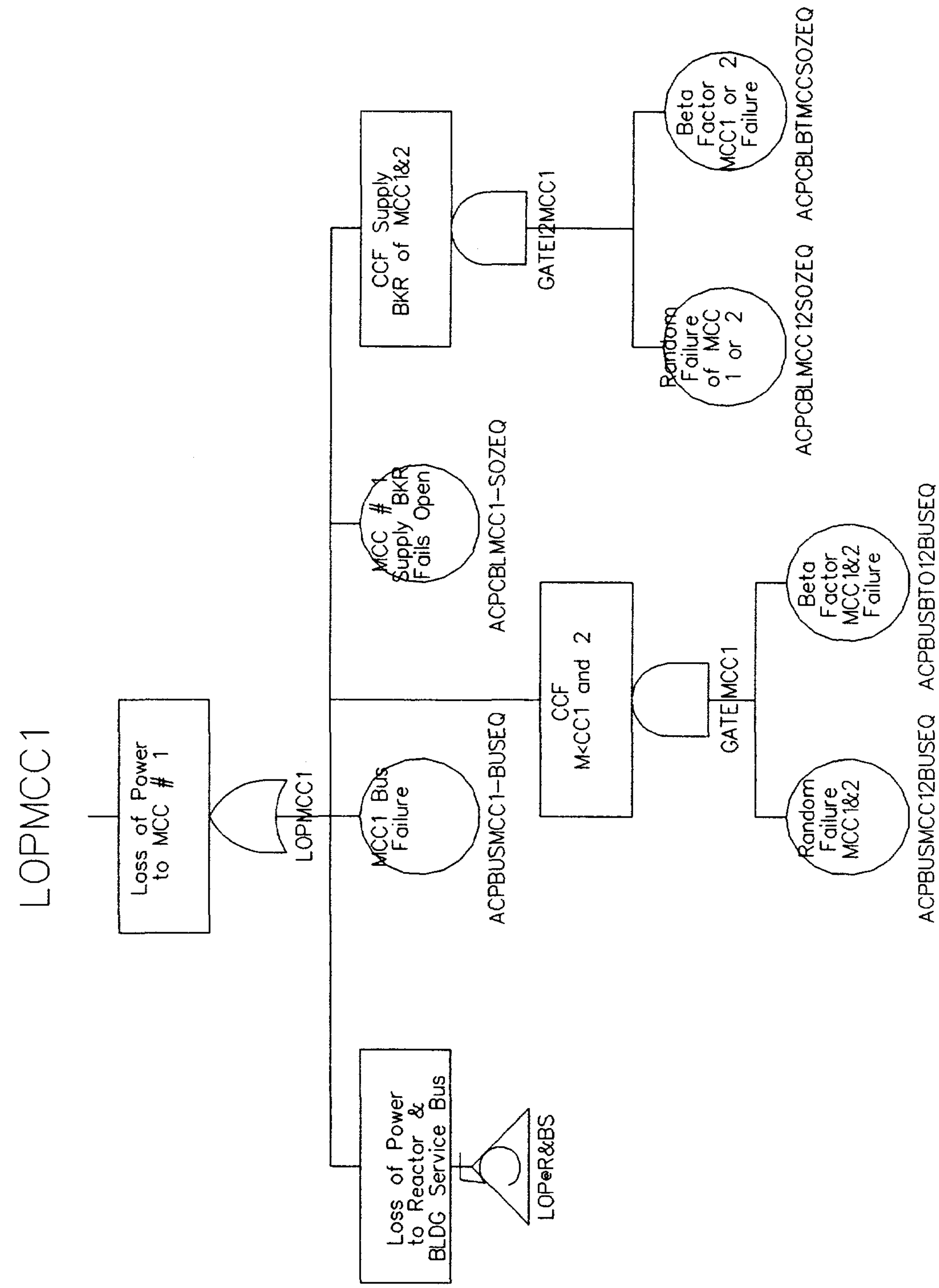


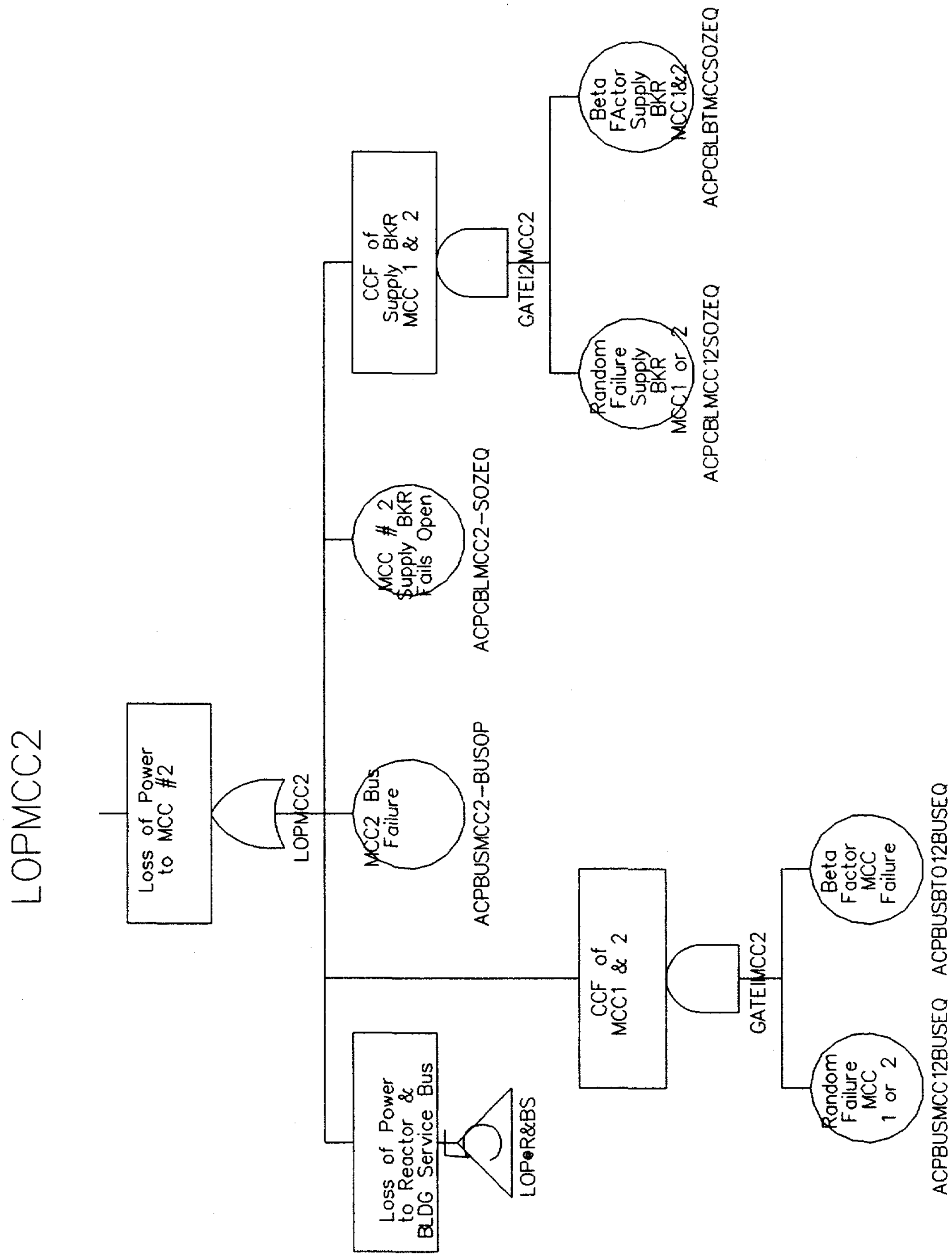
LOPFACTY
Loss of Power to Facility Bus
LOPFACTY
Facility Bus Failure
ACPBUSFACB-BUSEQ
Loss of Power Feed to Facility Bus
GATE1FAC
Alternate Power Feed Fails
GATE2FAC
Inservice Power Feed Fails
GATE3FAC
Facility Bus to Exp. Bus Tie BKR Fails Open
ACPCBLFBEBTSOZEQ
Loss of Power to Experimental Bus
LOPEXPBS
Shift Doesn't Place #3 2.4/480v XMFR Online (2 BKRs)
ACPTFLXMFR3HEPEQ
3 min.
HOUSE-3MIN
#3 2.4/480v XMFR Fails
ACPTFLXMFR3FDOEQ
#3 XMFR Supply BKR Won't Close
ACPCBHXMFR3FTCEQ
#3 XMFR Output BKR Won't Close
ACPCBLXMFR3FTCEQ
Loss of # 3 2.4/480v XMFR Feeder BKR DC Control Power
FACG16
Loss of DC Power to EMCC (non-sd pump loads)
DCBKR28
EMCC 2400v BKR DC Control Power BKR # 1 Fails Open
DCPCBHEMCC-SOZEQ
Loss of Power to HFBR Bus # 1
LOPHFBR1

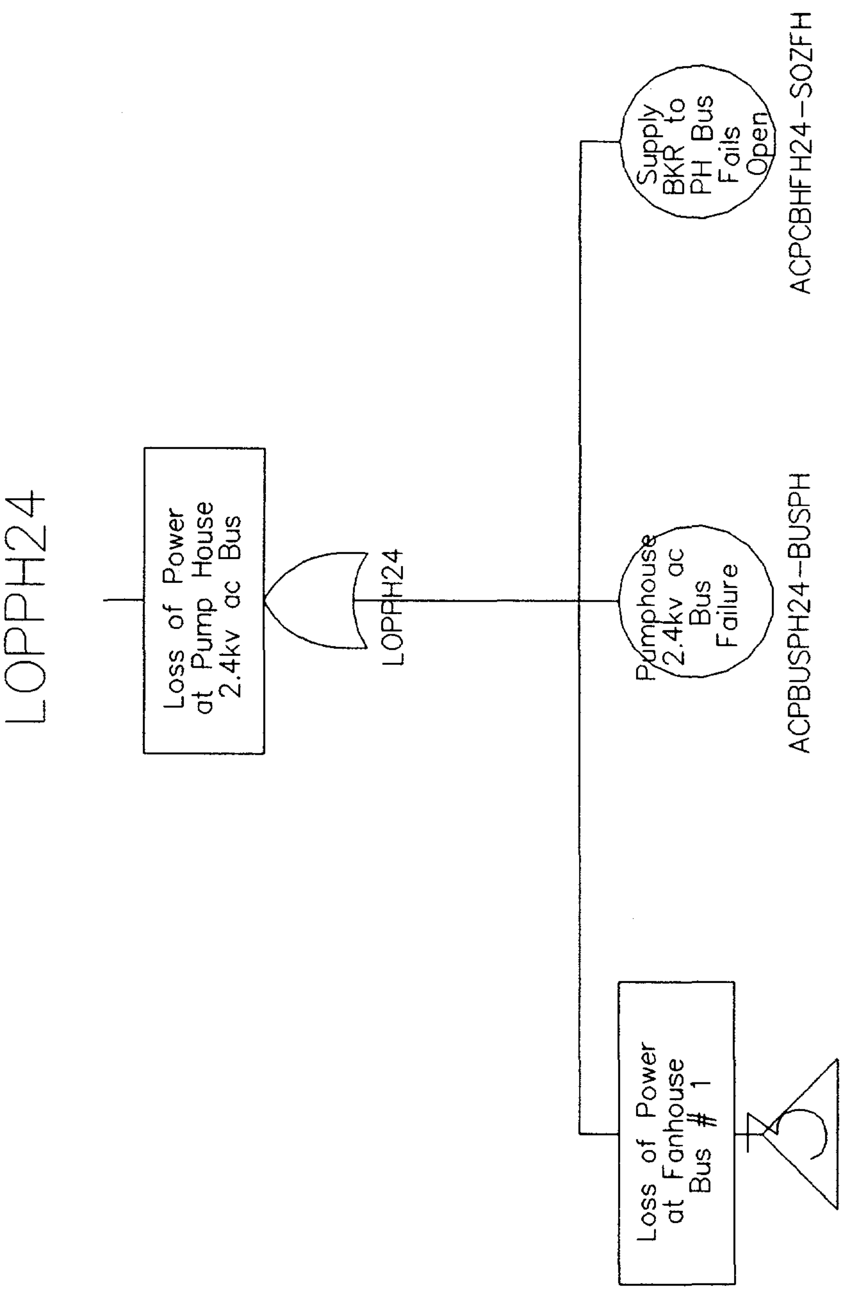
LOPEMCC

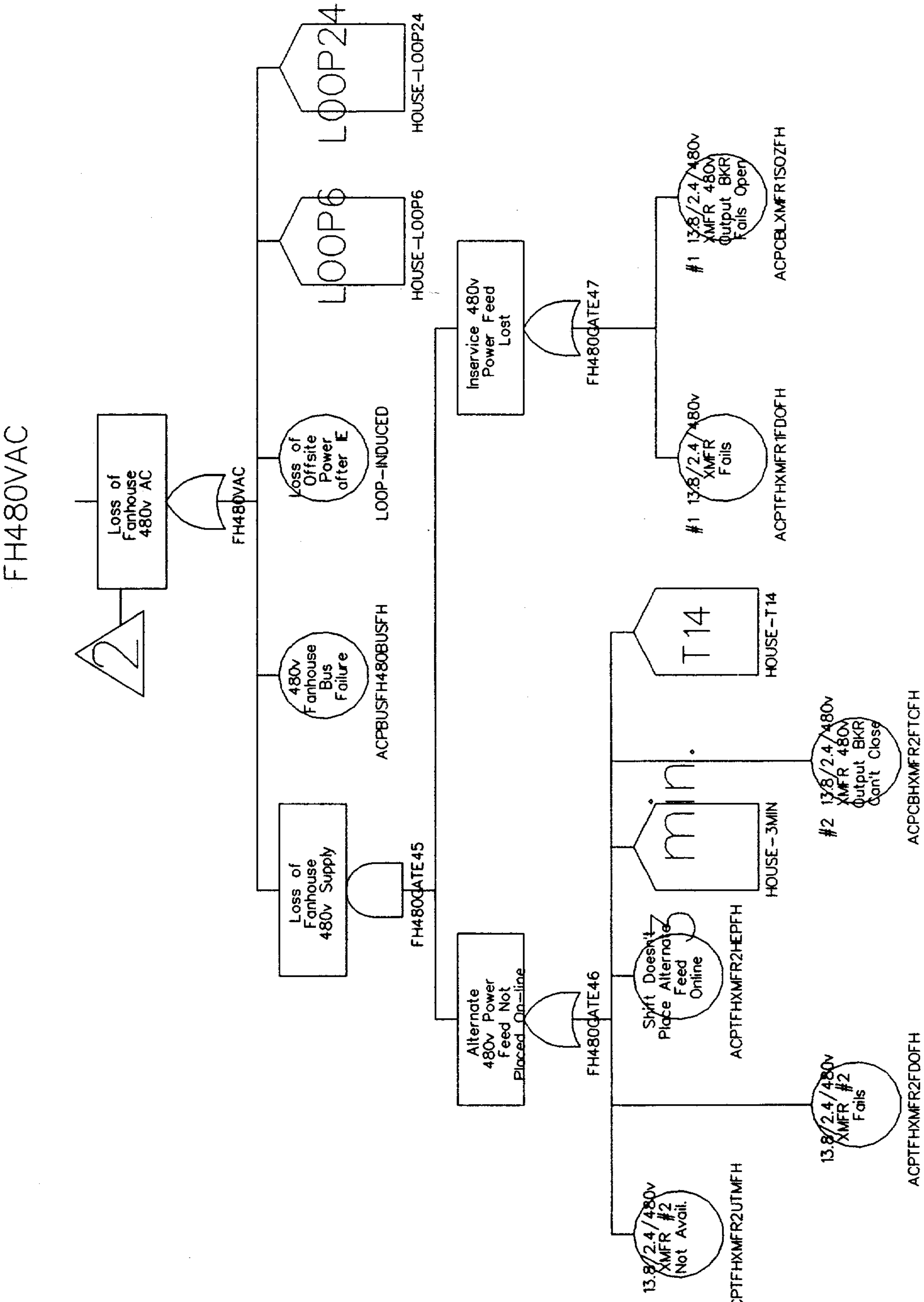


* No Credit Was Taken for Portable Generator

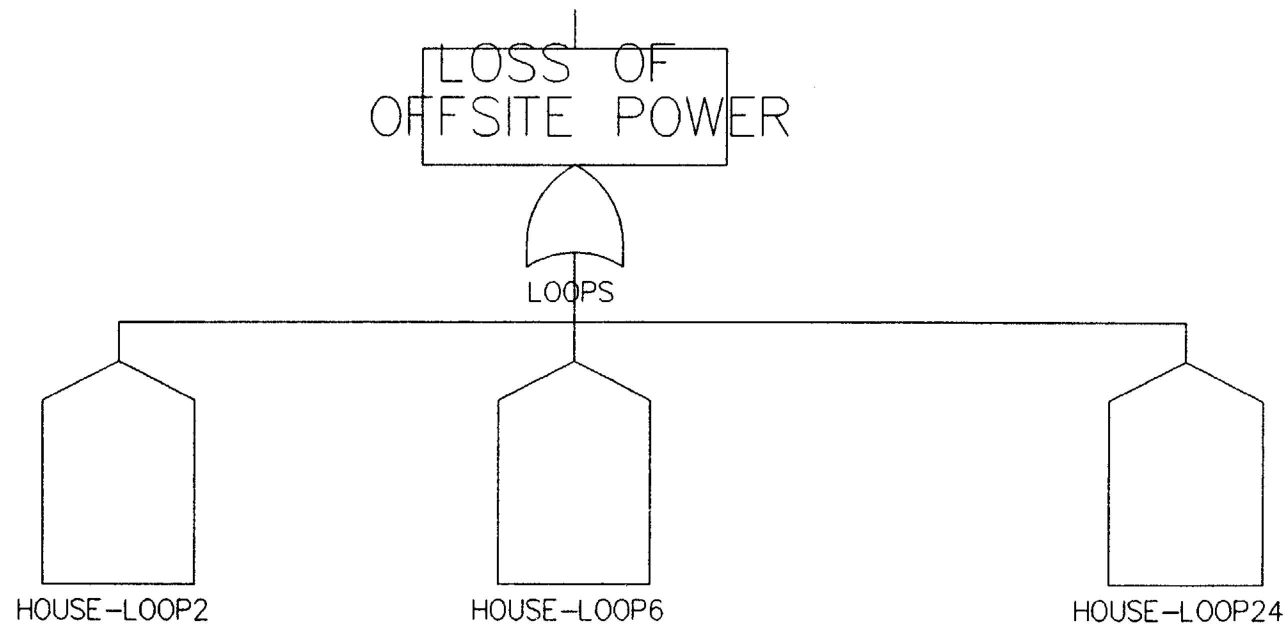

LOPMCC1
Loss of Power to MCC # 1
LOPMCC1
Loss of Power to Reactor & BLDG Service Bus
LOP@R&BS
MCC1 Bus Failure
ACPBUSMCC1-BUSEQ
CCF MCC1 and 2
GATEMCC1
Random Failure MCC1&2
ACPBUSMCC12BUSEQ
Beta Factor MCC1&2 Failure
ACPBUSBTO12BUSEQ
MCC # 1 Supply BKR Fails Open
ACPCBLMCC1-SOZEQ
CCF Supply BKR of MCC1&2
GATE12MCC1
Random Failure of MCC 1 or 2
ACPCBLMCC12SOZEQ
Beta Factor MCC1 or 2 Failure
ACPCBLBTMCCSOZEQ


LOPMCC2
Loss of Power to MCC #2
LOPMCC2
Loss of Power to Reactor & BLDG Service Bus
LOP•R&BS
CCF of MCC1 & 2
GATE1MCC2
Random Failure MCC 1 or 2
ACPBUSMCC12BUSEQ
Beta Factor MCC Failure
ACPBUSBTO12BUSEQ
MCC2 Bus Failure
ACPBUSMCC2-BUSOP
MCC # 2 Supply BKR Fails Open
ACPCBLMCC2-SOZEQ
CCF of Supply BKR MCC 1 & 2
GATE12MCC2
Random Failure Supply BKR MCC1 or 2
ACPCBLMCC12SOZEQ
Beta FActor Supply BKR MCC1&2
ACPCBLBTMCCSOZEQ

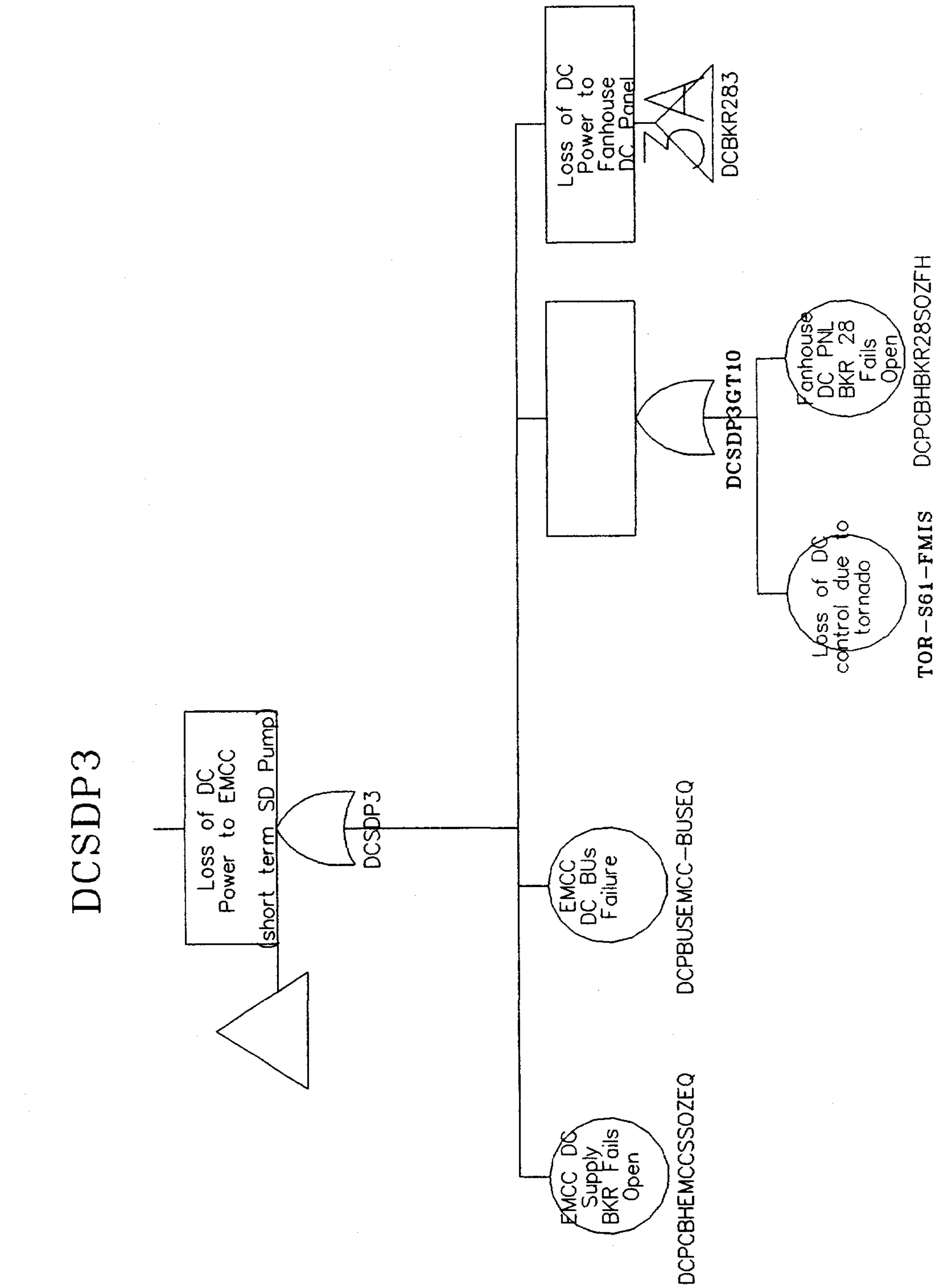

LOPPH24
Loss of Power at Pump House 2.4kv ac Bus
LOPPH24
Loss of Power at Fanhouse Bus # 1
LOPFHBS1
Pumphouse 2.4kv ac Bus Failure
ACPBUSPH24-BUSPH
Supply BKR to PH Bus Fails Open
ACPCBHFH24-SOZFH


FH480VAC
2
Loss of Fanhouse 480v AC
FH480VAC
Loss of Fanhouse 480v Supply
FH480GATE45
480v Fanhouse Bus Failure
ACPBUSFH480BUSFH
Loss of Offsite Power after IE
LOOP-INDUCED
LOOP6
HOUSE-LOOP6
LOOP24
HOUSE-LOOP24
Inservice 480v Power Feed Lost
FH480GATE47
#1 13.8/2.4/480v XMFR Fails
ACPTFHXMFR1FDOFH
#1 13.8/2.4/480v XMFR 480v Output BKR Fails Open
ACPCBLXMFR1SOZFH
Alternate 480v Power Feed Not Placed On-line
FH480GATE46
13.8/2.4/480v XMFR #2 Not Avail.
ACPTFHXMFR2UTMFH
13.8/2.4/480v XMFR #2 Fails
ACPTFHXMFR2FDOFH
Shift Doesn't Place Alternate Feed Online
ACPTFHXMFR2HEPFH
3 min.
HOUSE-3MIN
#2 13.8/2.4/480v XMFR 480v Output BKR Can't Close
ACPCBHXMFR2FTCFH
T14
HOUSE-T14

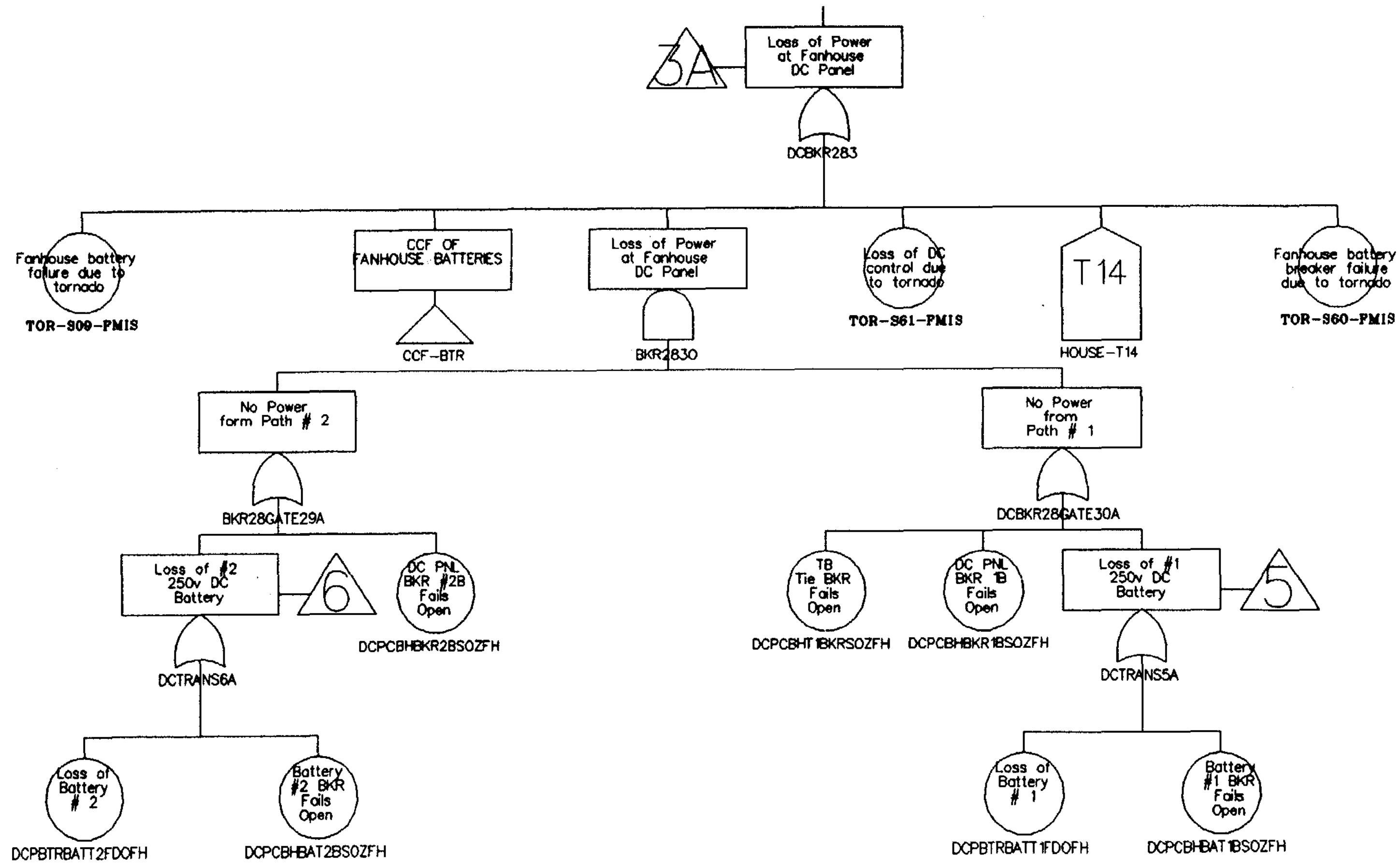
LOOPS


LOSS OF
OFFSITE POWER
LOOPS
HOUSE-LOOP2
HOUSE-LOOP6
HOUSE-LOOP24

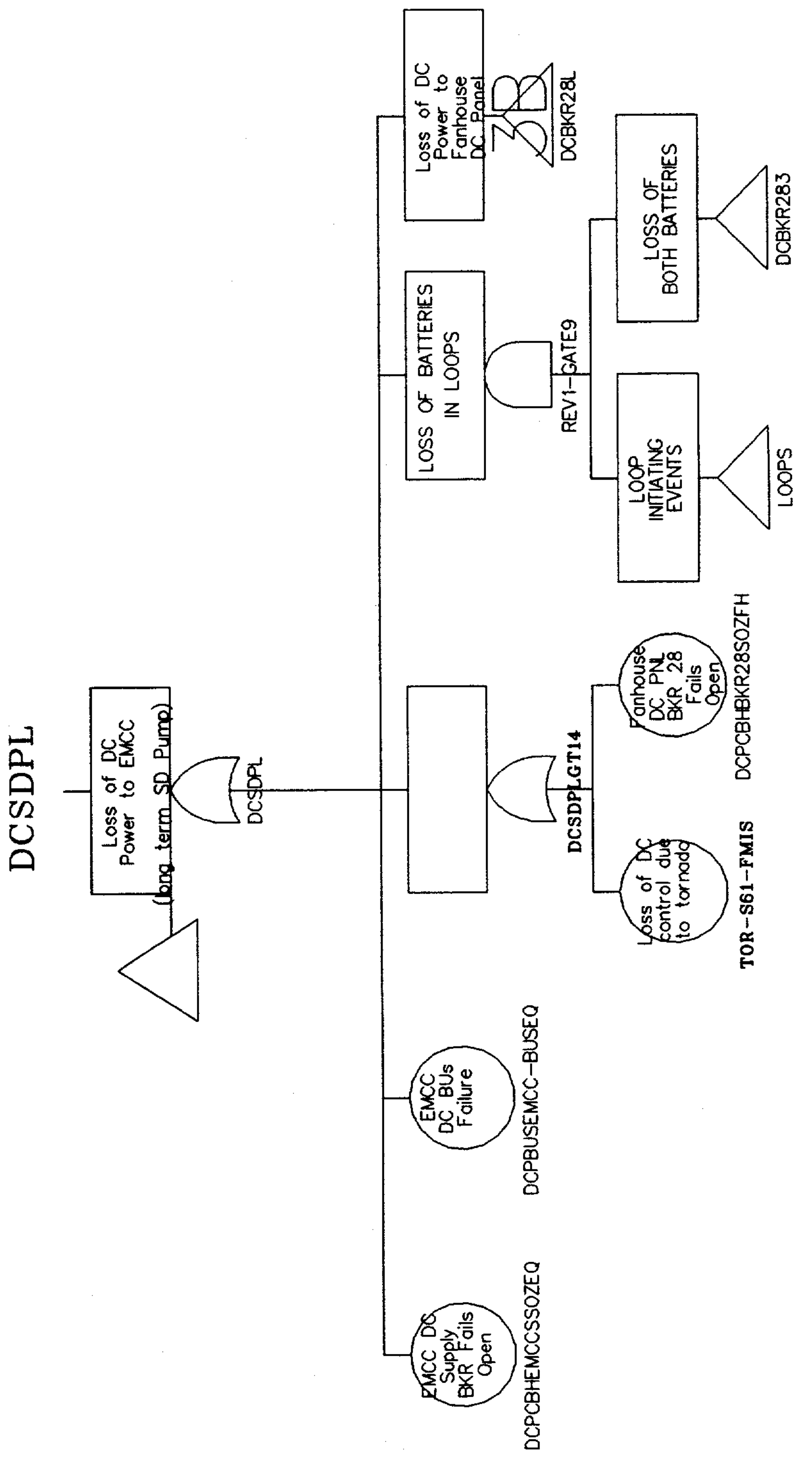
Appendix C.10
DC Power System Modified for Tornado Initiator

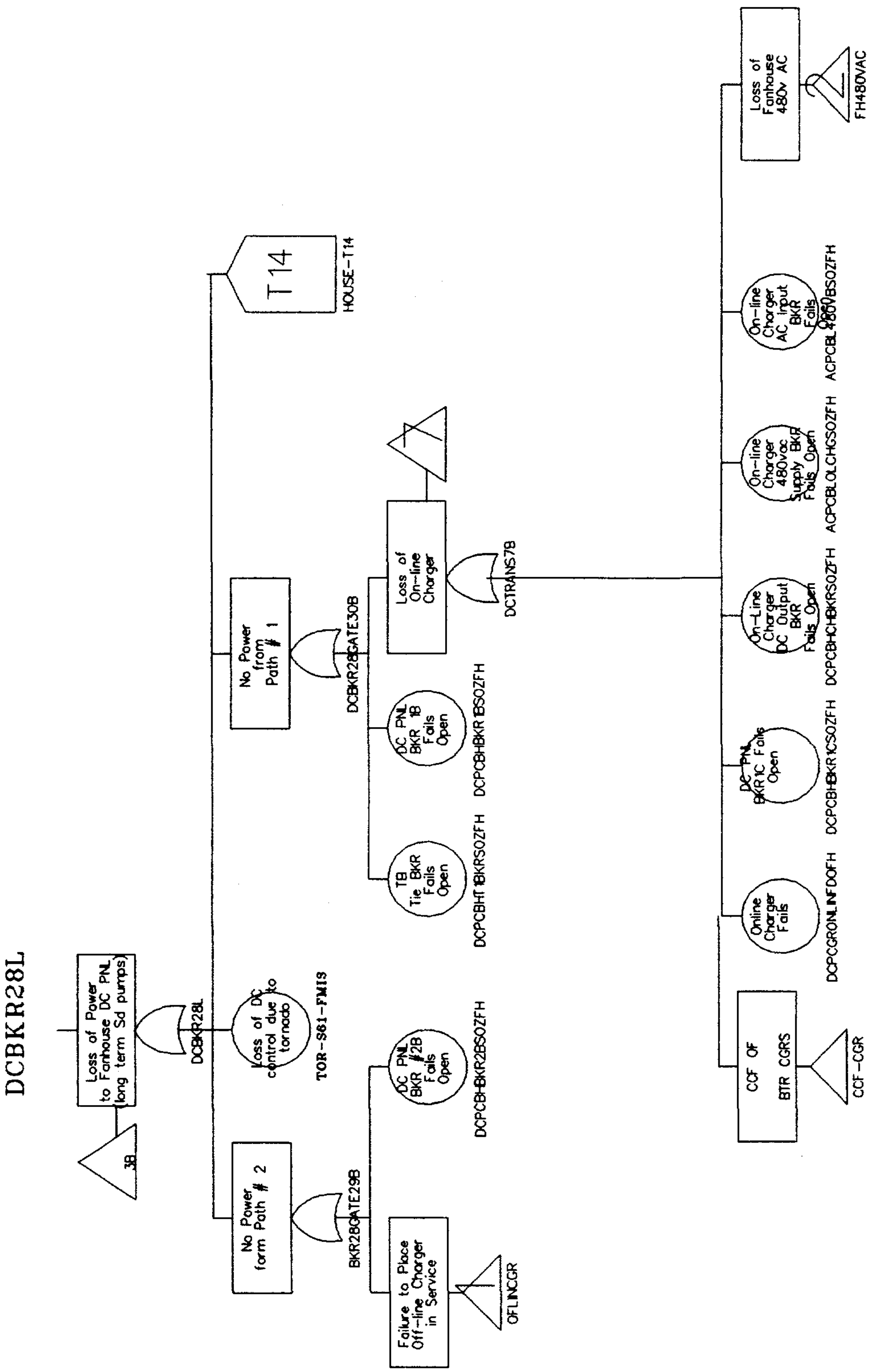

DCSDP3
Loss of DC Power to EMCC (short term SD Pump)
DCSDP3
EMCC DC Supply BKR Fails Open
DCPCBHEMCCSSOZEQ
EMCC DC BUs Failure
DCPBUSEMCC-BUSEQ
DCSDP3GT10
Loss of DC control due to tornado
TOR-S61-FMIS
Fanhouse DC PNL BKR 28 Fails Open
DCPCBHBKR28SOZFH
Loss of DC Power to Fanhouse DC Panel
DCBKR283

DCBKR283

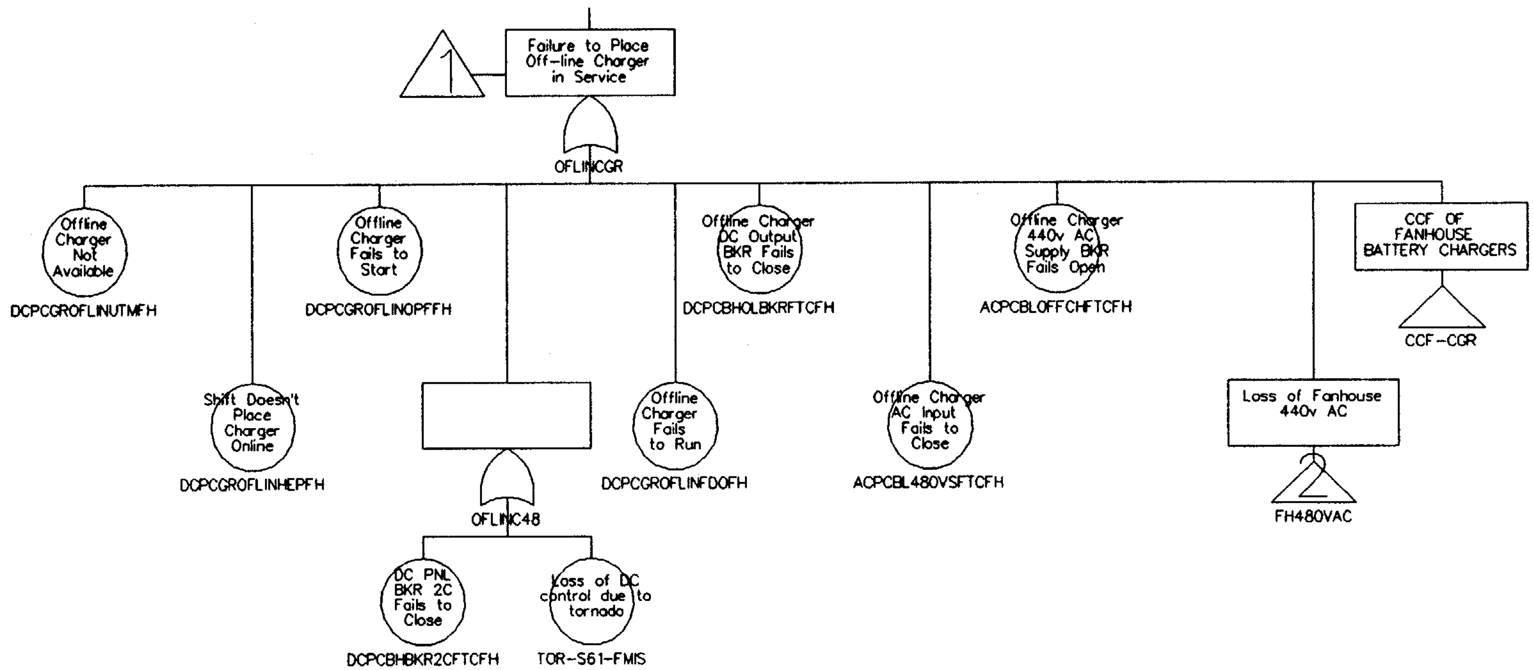


3A
Loss of Power at Fanhouse DC Panel
DCBKR283
Fanhouse battery failure due to tornado
TOR-S09-PMIS
CCF OF FANHOUSE BATTERIES
CCF-BTR
Loss of Power at Fanhouse DC Panel
BKR2830
Loss of DC control due to tornado
TOR-S61-PMIS
T14
HOUSE-T14
Fanhouse battery breaker failure due to tornado
TOR-S60-PMIS
No Power form Path # 2
BKR28GATE29A
Loss of #2 250v DC Battery
6
DC PNL BKR #2B Fails Open
DCPCBHBKR2BSOZFH
DCTRANS6A
Loss of Battery # 2
DCPBTRBATT2FDOFH
Battery #2 BKR Fails Open
DCPCBHBAT2BSOZFH
No Power from Path # 1
DCBKR28GATE30A
TB Tie BKR Fails Open
DCPCBHT1BKRSOZFH
DC PNL BKR 1B Fails Open
DCPCBHBKR1BSOZFH
Loss of #1 250v DC Battery
5
DCTRANS5A
Loss of Battery # 1
DCPBTRBATT1FDOFH
Battery #1 BKR Fails Open
DCPCBHBAT1BSOZFH

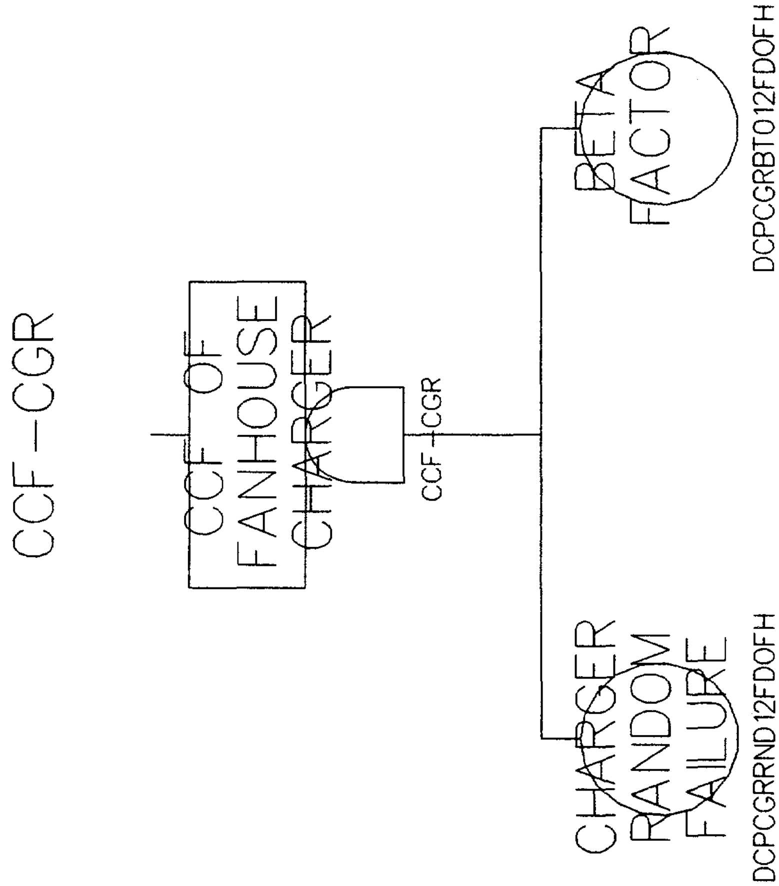

DCSDPL
Loss of DC Power to EMCC (long term SD Pump)
DCSDPL
EMCC DC Supply BKR Fails Open
DCPCBHEMCCSSOZEQ
EMCC DC BUs Failure
DCPBUSEMCC-BUSEQ
DCSDPLGT14
Loss of DC control due to tornado
TOR-S61-FMIS
Fanhouse DC PNL BKR 28 Fails Open
DCPCBHBKR28SOZFH
LOSS OF BATTERIES IN LOOPS
REV1-GATE9
LOOP INITIATING EVENTS
LOOPS
LOSS OF BOTH BATTERIES
DCBKR283
Loss of DC Power to Fanhouse DC Panel
DCBKR28L

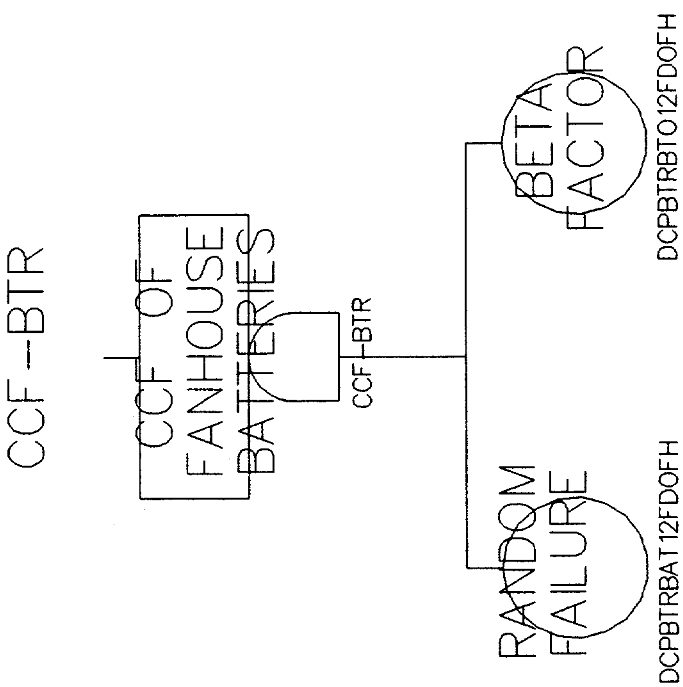

DCBKR28L
Loss of Power to Fanhouse DC PNL (long term Sd pumps)
3B
DCBKR28L
No Power form Path # 2
BKR28GATE29B
Failure to Place Off-line Charger in Service
OFLINCGR
DC PNL BKR #2B Fails Open
DCPCBHBKR2BSOZFH
Loss of DC control due to tornado
TOR-S61-FMIS
No Power from Path # 1
DCBKR28GATE30B
TB Tie BKR Fails Open
DCPCBHT1BKRSOZFH
DC PNL BKR 1B Fails Open
DCPCBHBKR1BSOZFH
Loss of On-line Charger
DCTRANS7B
T14
HOUSE-T14
CCF OF BTR CGRS
CCF-CGR
Online Charger Fails
DCPCGRONLINFDOFH
DC PNL BKR1C Fails Open
DCPCBHBKR1CSOZFH
On-Line Charger DC Output BKR Fails Open
DCPCBHCHBKRSOZFH
On-line Charger 480vac Supply BKR Fails Open
ACPCBL0LCHGSOZFH
On-line Charger AC Input BKR Fails Open
ACPCBL480VBSOZFH
Loss of Fanhouse 480v AC
FH480VAC

OFLINCGR

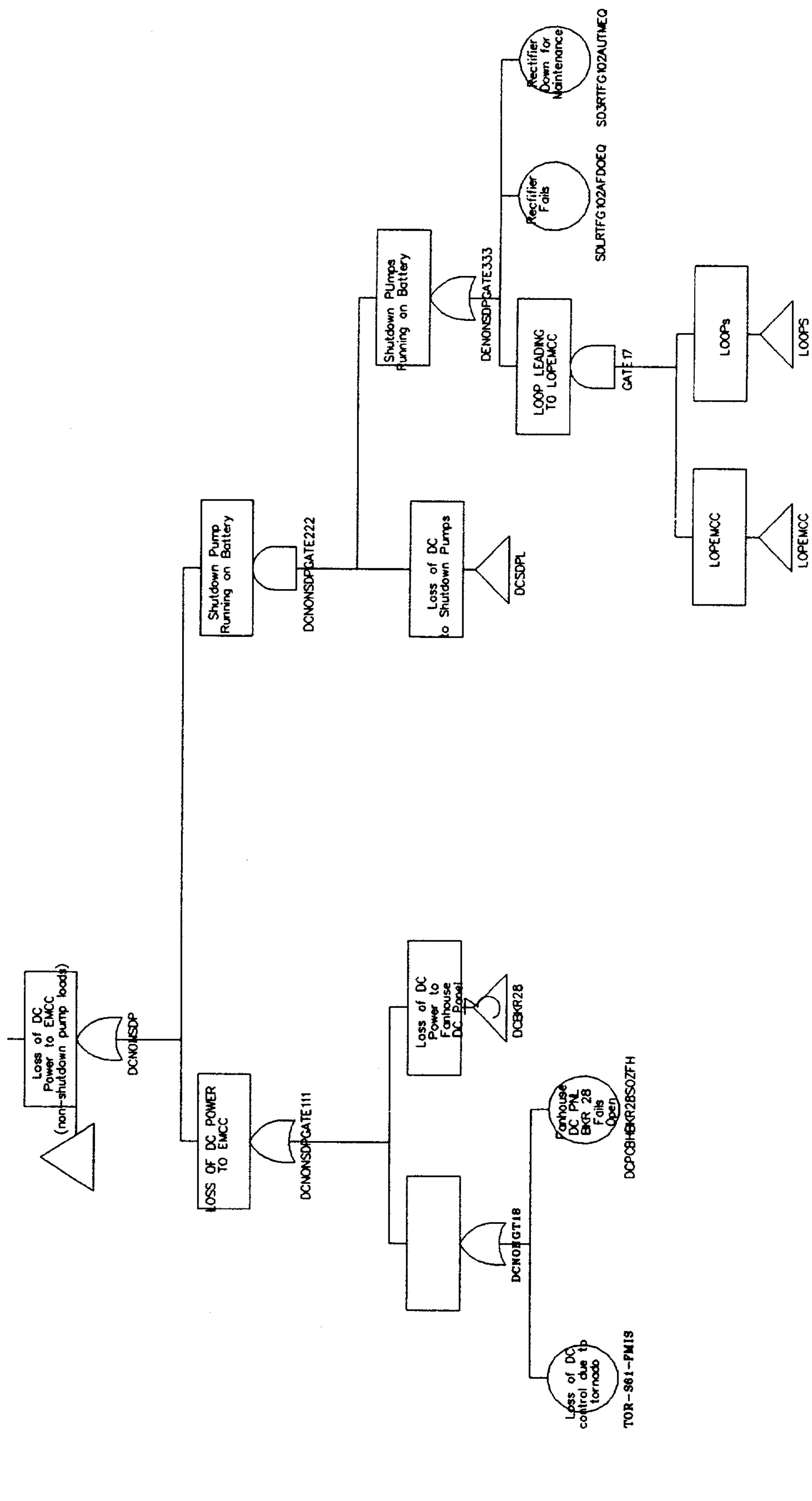


1
Failure to Place Off-line Charger in Service
OFLINCGR
Offline Charger Not Available
DCPCGROFLINUTMFH
Shift Doesn't Place Charger Online
DCPCGROFLINHEPFH
Offline Charger Fails to Start
DCPCGROFLINOPFFH
OFLINC48
DC PNL BKR 2C Fails to Close
DCPCBHBKR2CFTCFH
Loss of DC control due to tornado
TOR-S61-FMIS
Offline Charger Fails to Run
DCPCGROFLINFDOFH
Offline Charger DC Output BKR Fails to Close
DCPCBHOLBKRFTCFH
Offline Charger AC Input Fails to Close
ACPCBL480VSFTCFH
Offline Charger 440v AC Supply BKR Fails Open
ACPCBLOFFCHFTCFH
Loss of Fanhouse 440v AC
2
FH480VAC
CCF OF FANHOUSE BATTERY CHARGERS
CCF-CGR

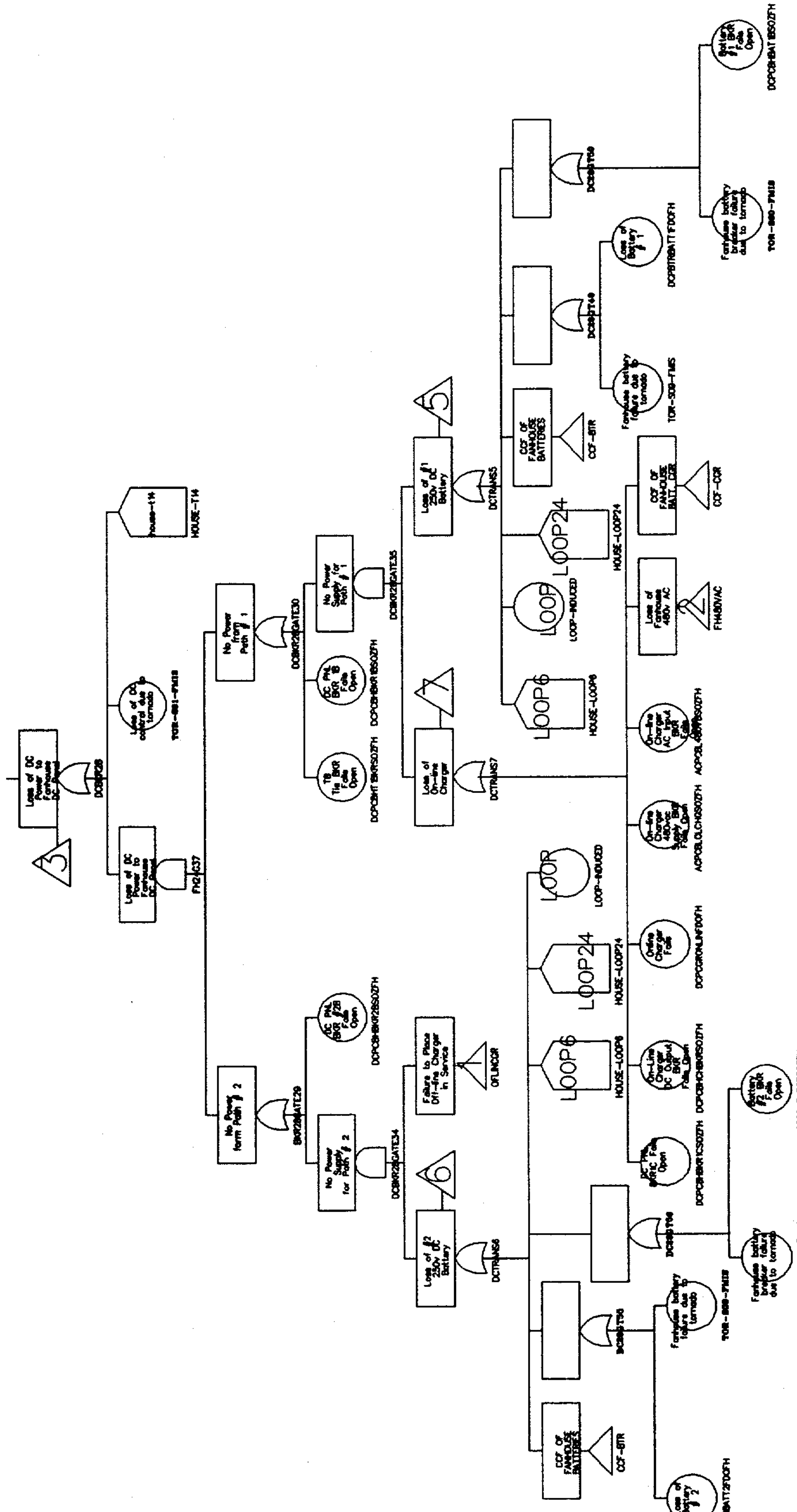

CCF –CGR
CCF OF FANHOUSE CHARGER
CCF-CGR
CHARGER RANDOM FAILURE
DCPCGRRND12FDOFH
BETA FACTOR
DCPCGRBT012FDOFH


CCF -BTR
CCF OF
FANHOUSE
BATTERIES
CCF-BTR
RANDOM
FAILURE
DCPBTRBAT12FDOFH
BETA
FACTOR
DCPBTRBTO12FDOFH

DCNONSDP

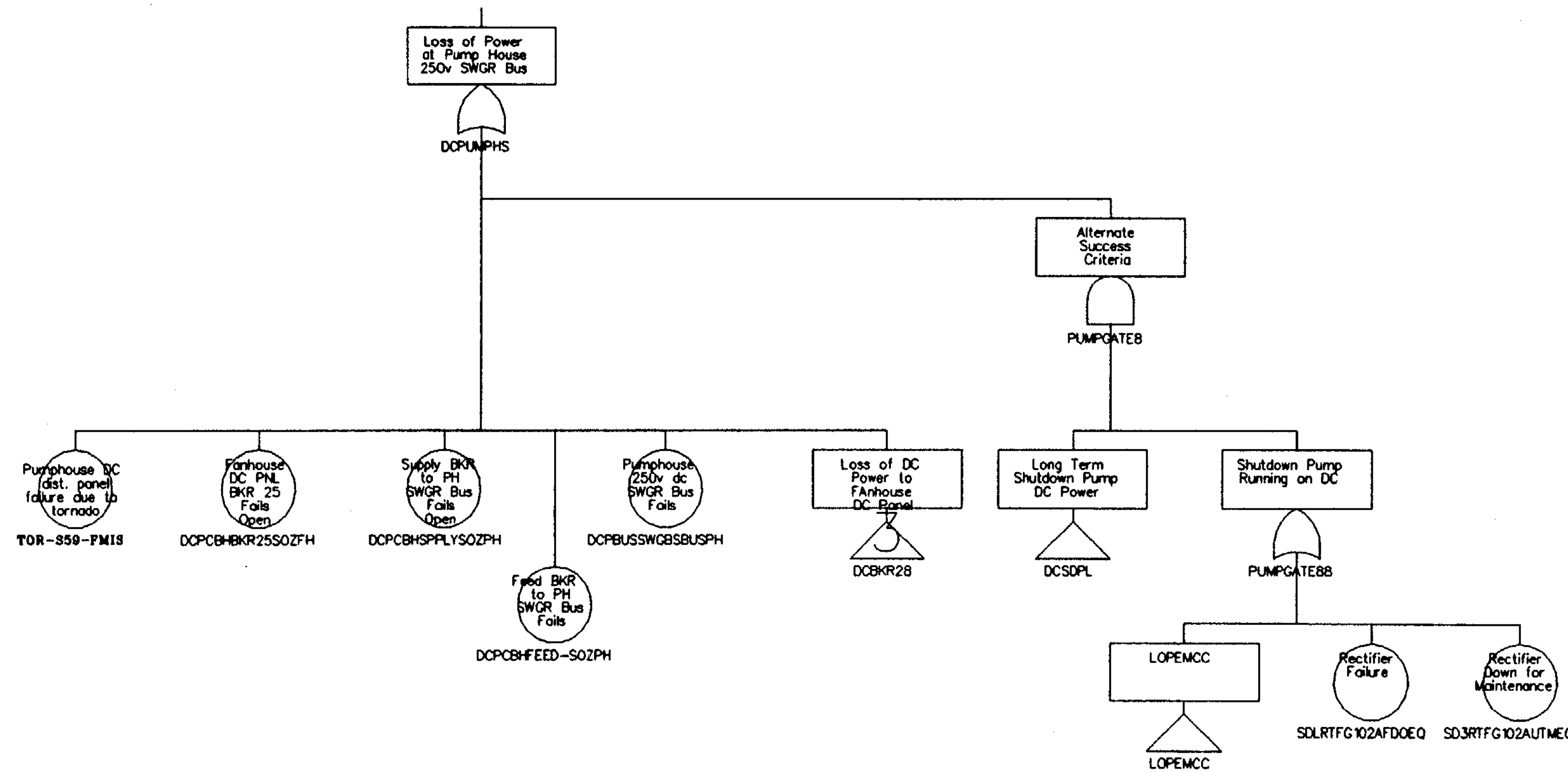

Loss of DC Power to EMCC (non-shutdown pump loads)
DCNONSDP
LOSS OF DC POWER TO EMCC
DCNONSDPGATE111
Shutdown Pump Running on Battery
DCNONSDPGATE222
Loss of DC Power to Fanhouse DC Panel
DCBKR28
DCNONGT18
Fanhouse DC PNL BKR 28 Fails Open
DCPCBHBKR28SOZFH
Loss of DC control due to tornado
TOR-S61-PMIS
Loss of DC to Shutdown Pumps
DCSDPL
Shutdown PUmps Running on Battery
DENONSDPGATE333
Rectifier Fails
SDLRTFG102AFDOEQ
Rectifier Down for Maintenance
SD3RTFG102AUTMEQ
LOOP LEADING TO LOPEMCC
GATE17
LOOPs
LOOPS
LOPEMCC
LOPEMCC

DCBKR28



Loss of DC Power to Fanhouse DC Panel
Loss of DC control due to tornado
HOUSE-T14
No Power form Path # 2
No Power from Path # 1
No Power Supply for Path # 2
No Power Supply for Path # 1
Failure to Place Off-line Charger in Service
OFLINCGR
Loss of #2 250v DC Battery
Loss of #1 250v DC Battery
Loss of On-line Charger
DCTRANS5
DCTRANS6
DCTRANS7
CCF OF FANHOUSE BATTERIES
CCF-BTR
CCF OF FANHOUSE BATT. CGR
CCF-CGR
Loss of Fanhouse 480v AC
FH480VAC
LOOP6
LOOP24
LOOP
HOUSE-LOOP6
HOUSE-LOOP24
LOOP-INDUCED
Online Charger Fails
Fanhouse battery failure due to tornado
Fanhouse battery breaker failure due to tornado

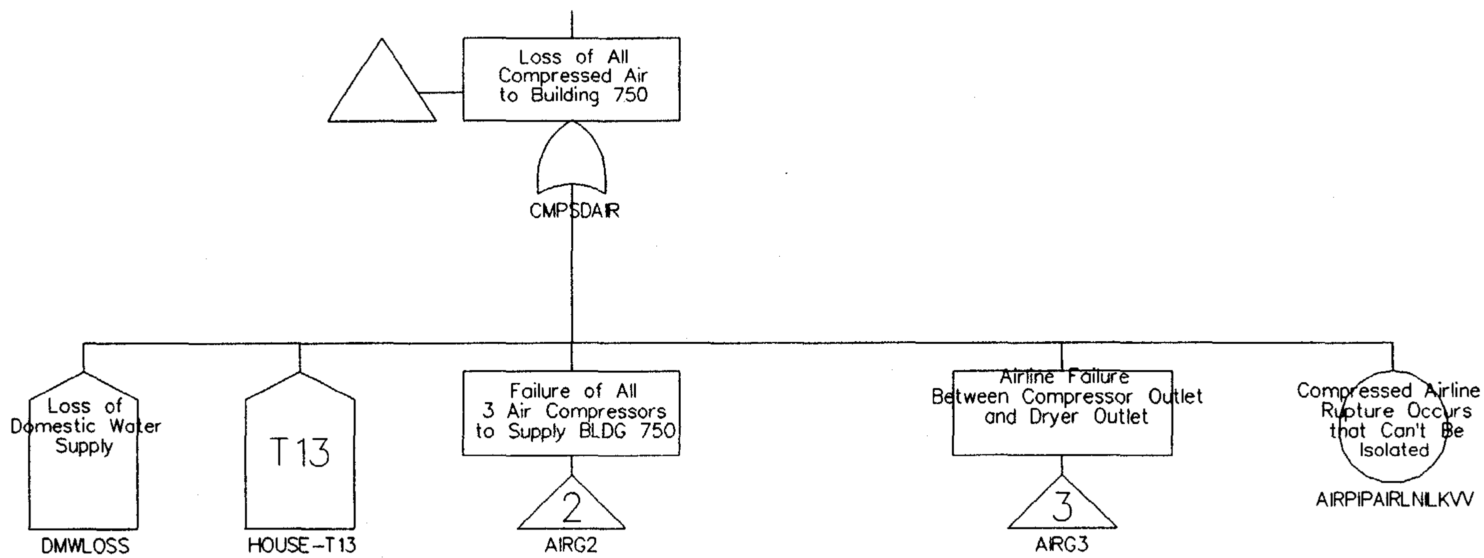
DCPUMPHS

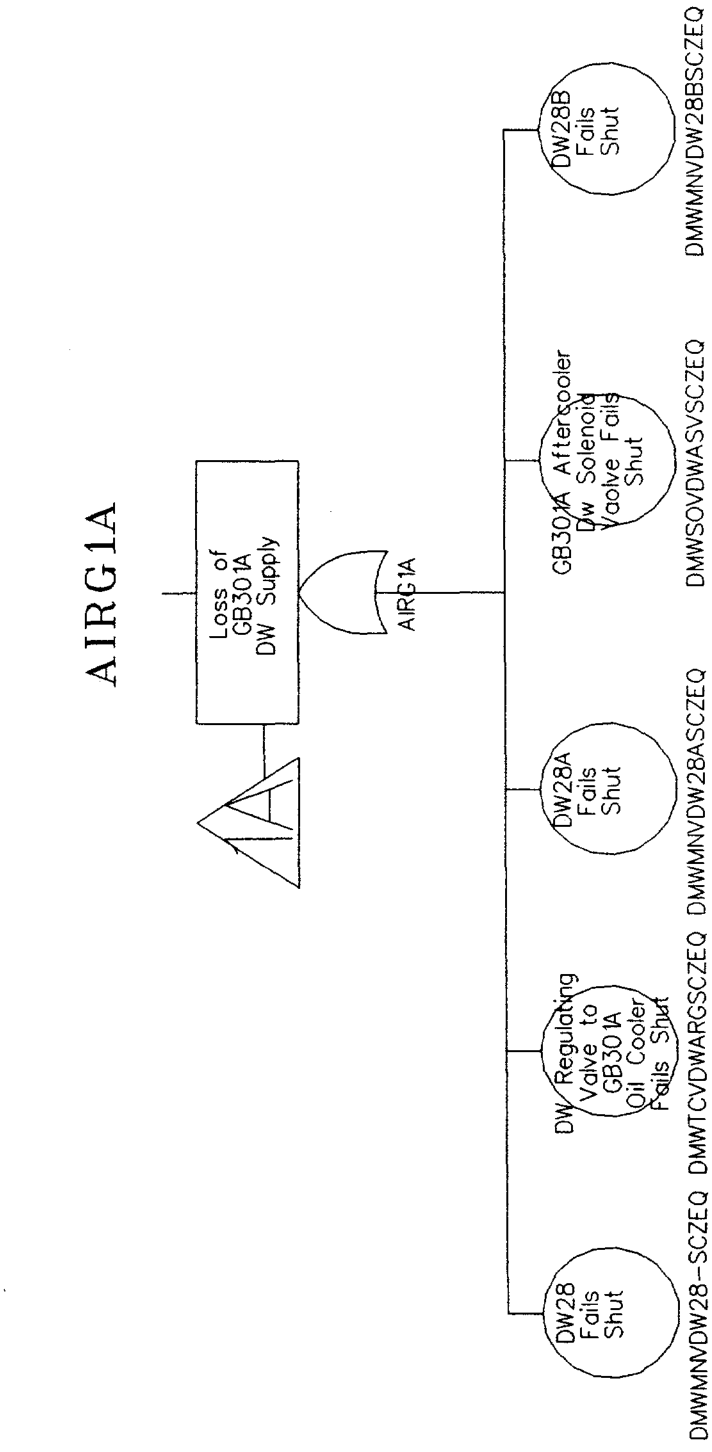


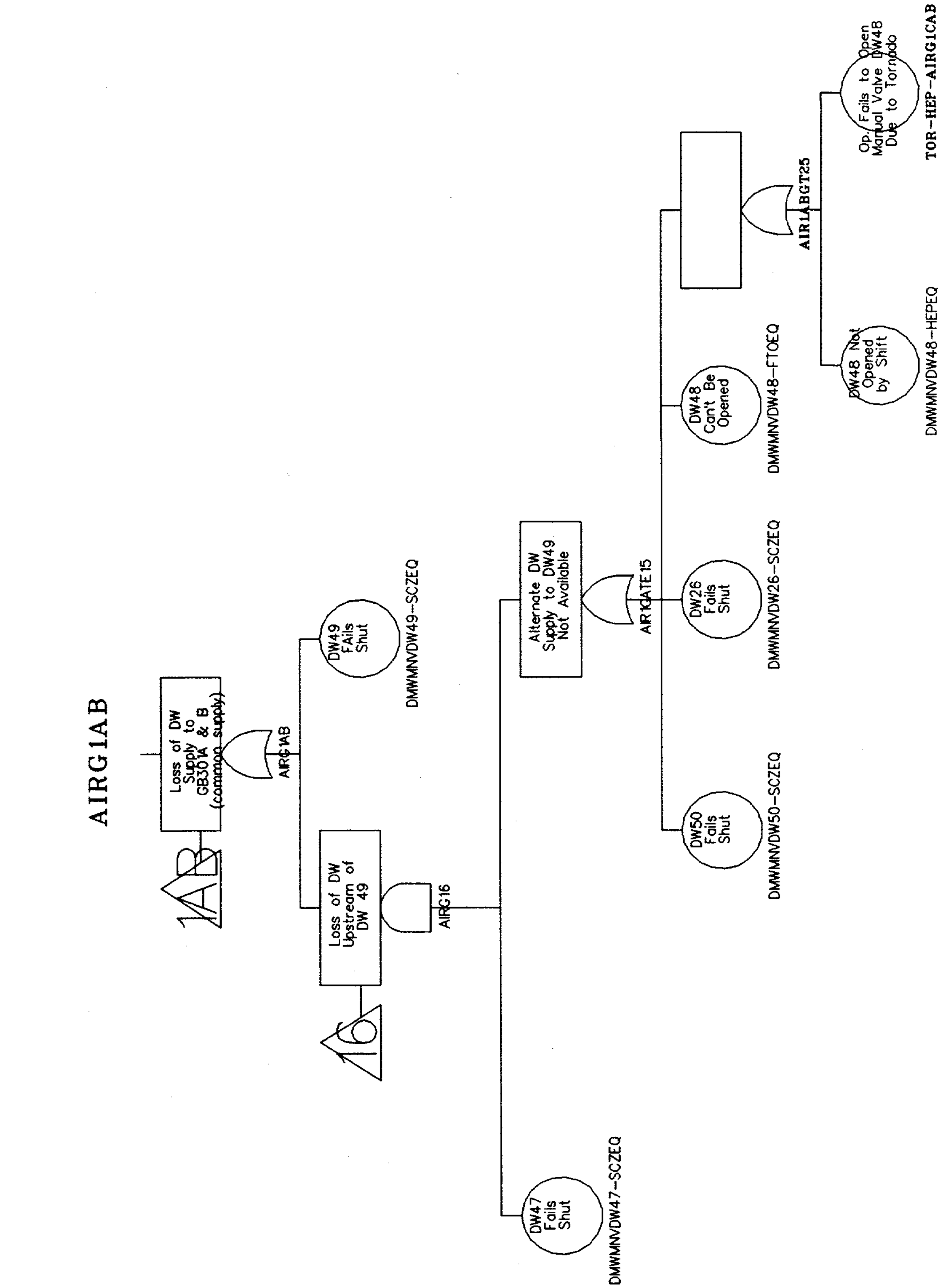
Loss of Power at Pump House 250v SWGR Bus
DCPUMPHS
Alternate Success Criteria
PUMPGATE8
Pumphouse DC dist. panel failure due to tornado
TOR-S59-FMIS
Fanhouse DC PNL BKR 25 Fails Open
DCPCBHBKR25SOZFH
Supply BKR to PH SWGR Bus Fails Open
DCPCBHSPPLYSOZPH
Feed BKR to PH SWGR Bus Fails
DCPCBHFEED-SOZPH
Pumphouse 250v dc SWGR Bus Fails
DCPBUSSWGBSBUSPH
Loss of DC Power to FAnhouse DC Panel
3
DCBKR28
Long Term Shutdown Pump DC Power
DCSDPL
Shutdown Pump Running on DC
PUMPGATE88
LOPEMCC
LOPEMCC
Rectifier Failure
SDLRTFG102AFDOEQ
Rectifier Down for Maintenance
SD3RTFG102AUTMEQ

Appendix C.11
Compressed Air System Modified for Tornado Initiator

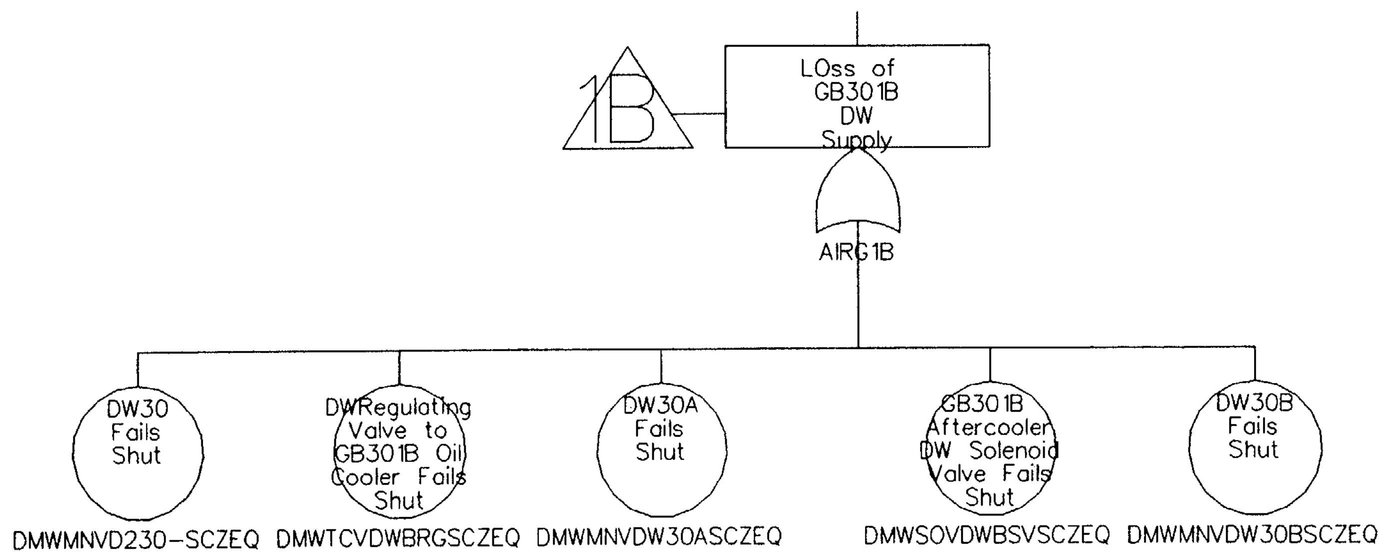
COMPRESSED AIR SYSTEM
CMPSDAIR




AIRG1A
Loss of GB301A DW Supply
AIRG1A
DW28 Fails Shut
DMWMNVDW28-SCZEQ
DW Regulating Valve to GB301A Oil Cooler Fails Shut
DMWTCVDWARGSCZEQ
DW28A Fails Shut
DMWMNVDW28ASCZEQ
GB301A Aftercooler Dw Solenoid Vaolve Fails Shut
DMWSOVDWASVSCZEQ
DW28B Fails Shut
DMWMNVDW28BSCZEQ

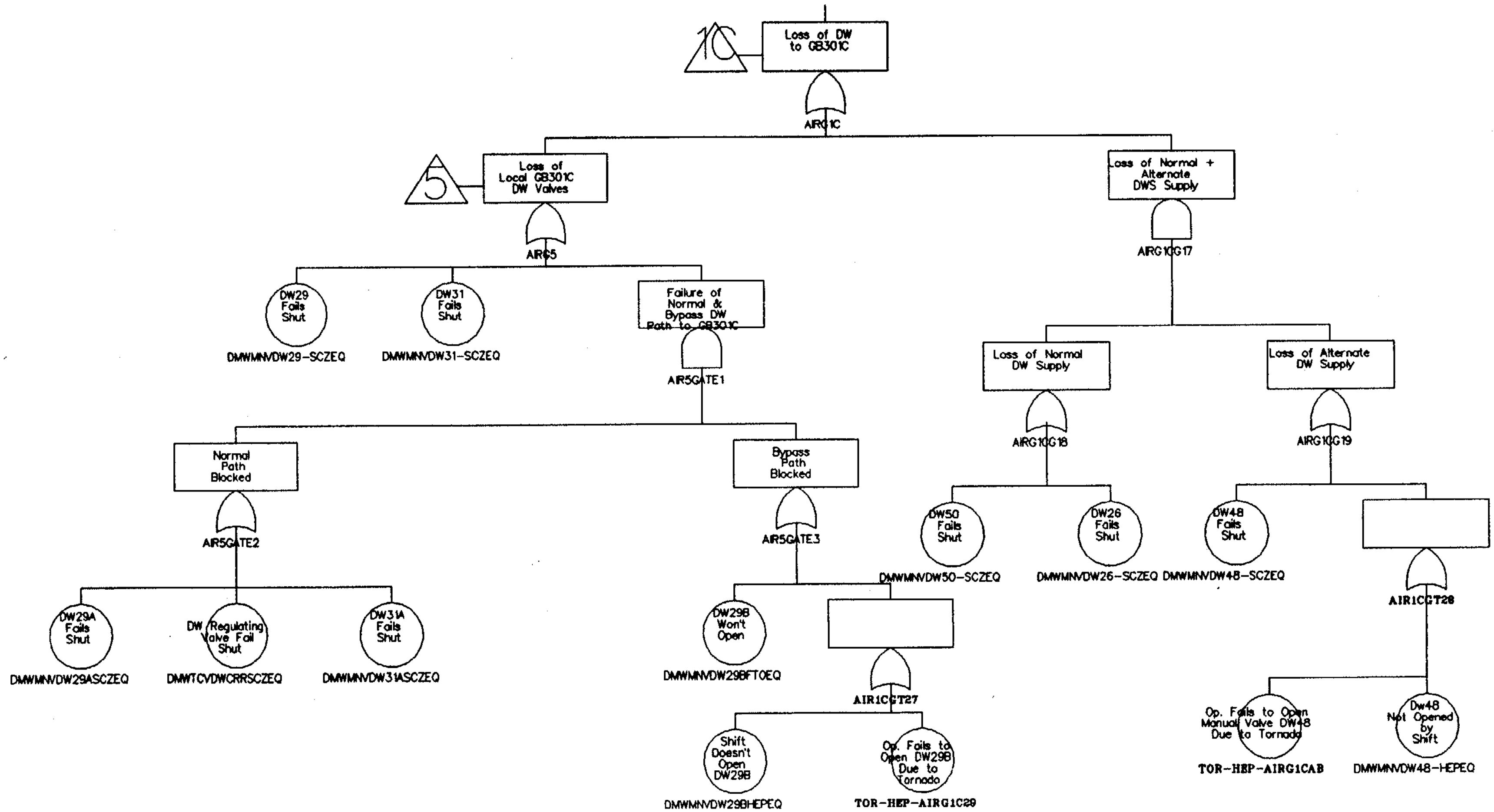

AIRG1AB
1AB
Loss of DW Supply to GB301A & B (common supply)
AIRG1AB
DW49 FAils Shut
DMWMNVDW49-SCZEQ
16
Loss of DW Upstream of DW 49
AIRG16
Alternate DW Supply to DW49 Not Available
AIR1GATE15
DW47 Fails Shut
DMWMNVDW47-SCZEQ
DW50 Fails Shut
DMWMNVDW50-SCZEQ
DW26 Fails Shut
DMWMNVDW26-SCZEQ
DW48 Can't Be Opened
DMWMNVDW48-FTOEQ
AIR1ABGT25
DW48 Not Opened by Shift
DMWMNVDW48-HEPEQ
Op. Fails to Open Manual Valve DW48 Due to Tornado
TOR-HEP-AIRG1CAB

AIRG1B



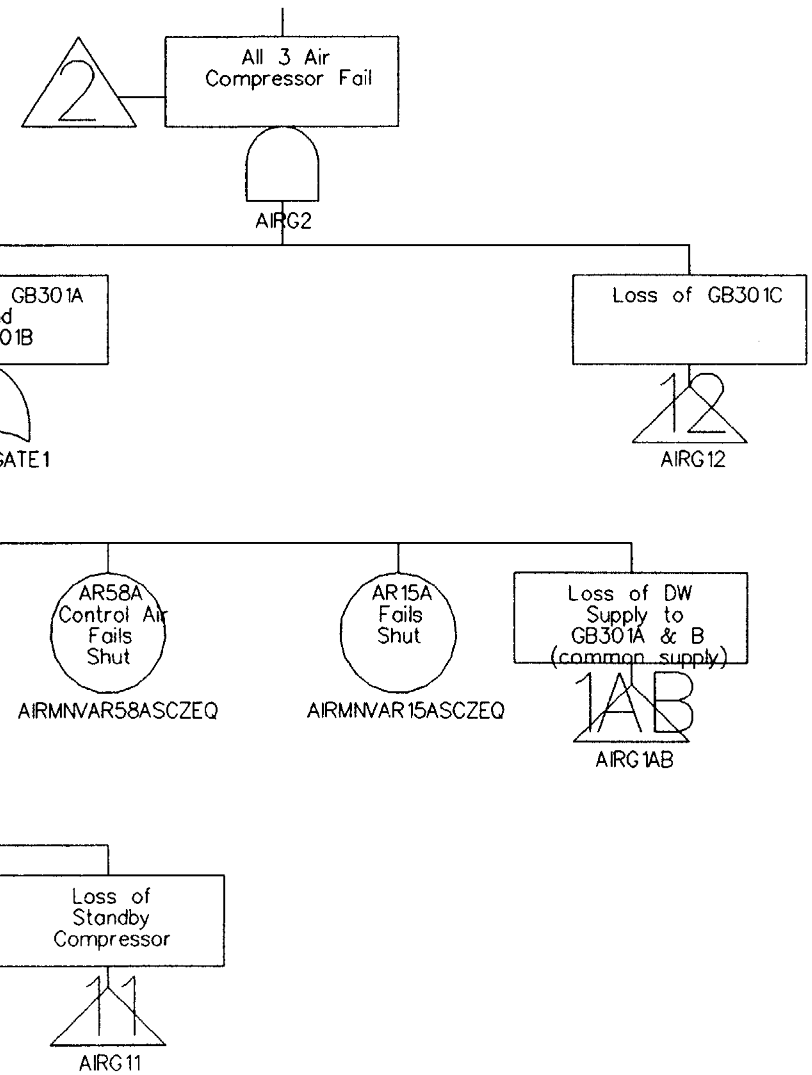
LOss of GB301B DW Supply
1B
AIRG1B
DW30 Fails Shut
DMWMNVD230-SCZEQ
DWRegulating Valve to GB301B Oil Cooler Fails Shut
DMWTCVDWBRGSCZEQ
DW30A Fails Shut
DMWMNVDW30ASCZEQ
GB301B Aftercooler DW Solenoid Valve Fails Shut
DMWSOVDWBSVSCZEQ
DW30B Fails Shut
DMWMNVDW30BSCZEQ

AIRG1C



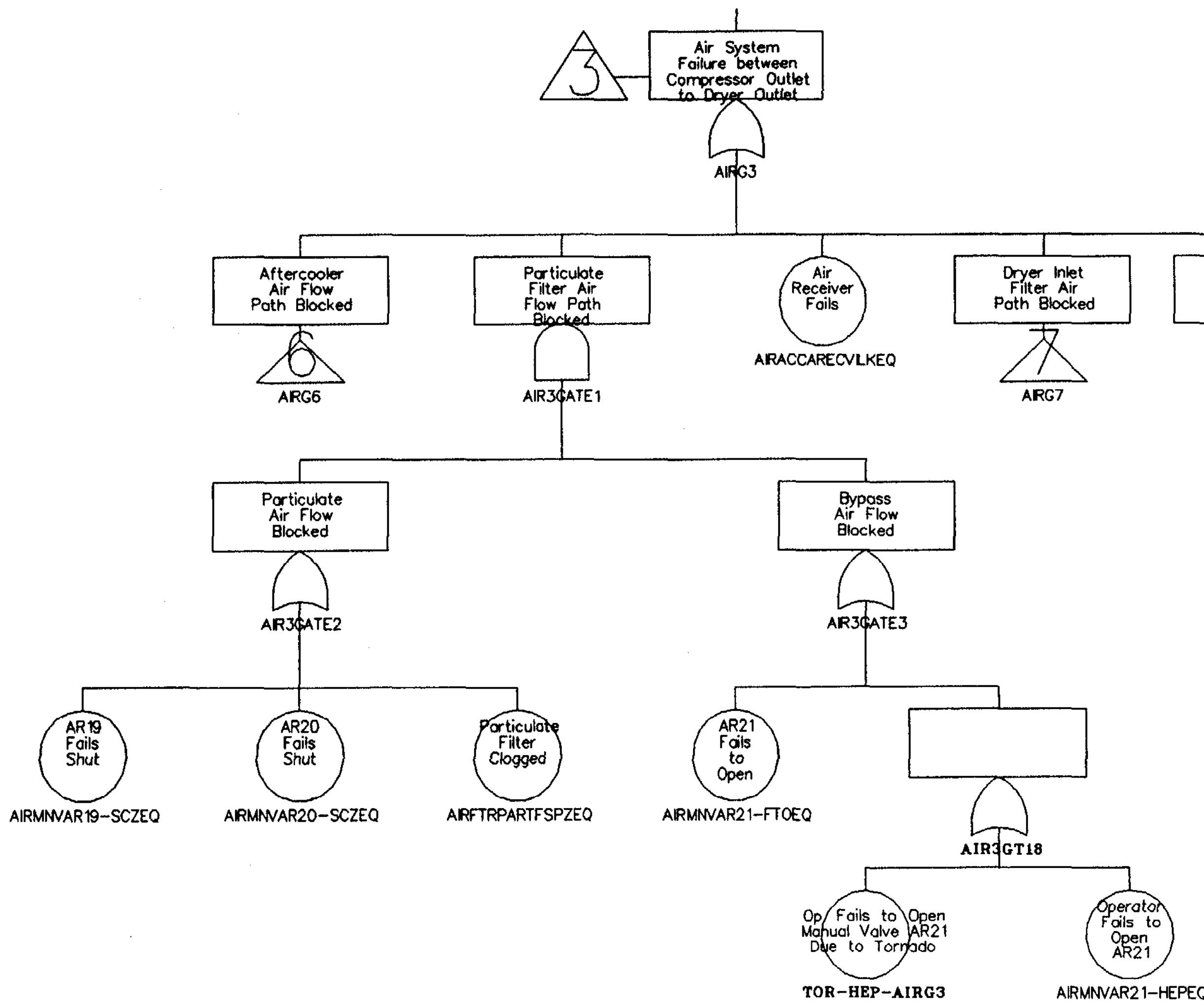
Loss of DW to GB301C
1C
AIRG1C
Loss of Local GB301C DW Valves
5
AIRG5
Loss of Normal + Alternate DWS Supply
AIRG10G17
DW29 Fails Shut
DMWMNVDW29-SCZEQ
DW31 Fails Shut
DMWMNVDW31-SCZEQ
Failure of Normal & Bypass DW Path to GB301C
AIR5GATE1
Normal Path Blocked
AIR5GATE2
DW29A Fails Shut
DMWMNVDW29ASCZEQ
DW Regulating Valve Fail Shut
DMWTCVDWCRRSCZEQ
DW31A Fails Shut
DMWMNVDW31ASCZEQ
Bypass Path Blocked
AIR5GATE3
DW29B Won't Open
DMWMNVDW29BFTOEQ
AIR1CGT27
Shift Doesn't Open DW29B
DMWMNVDW29BHEPEQ
Op. Fails to Open DW29B Due to Tornado
TOR-HEP-AIRG1C29
Loss of Normal DW Supply
AIRG10G18
DW50 Fails Shut
DMWMNVDW50-SCZEQ
DW26 Fails Shut
DMWMNVDW26-SCZEQ
Loss of Alternate DW Supply
AIRG10G19
DW48 Fails Shut
DMWMNVDW48-SCZEQ
AIR1CGT28
Op. Fails to Open Manual Valve DW48 Due to Tornado
TOR-HEP-AIRG1CAB
Dw48 Not Opened by Shift
DMWMNVDW48-HEPEQ

AIRG2

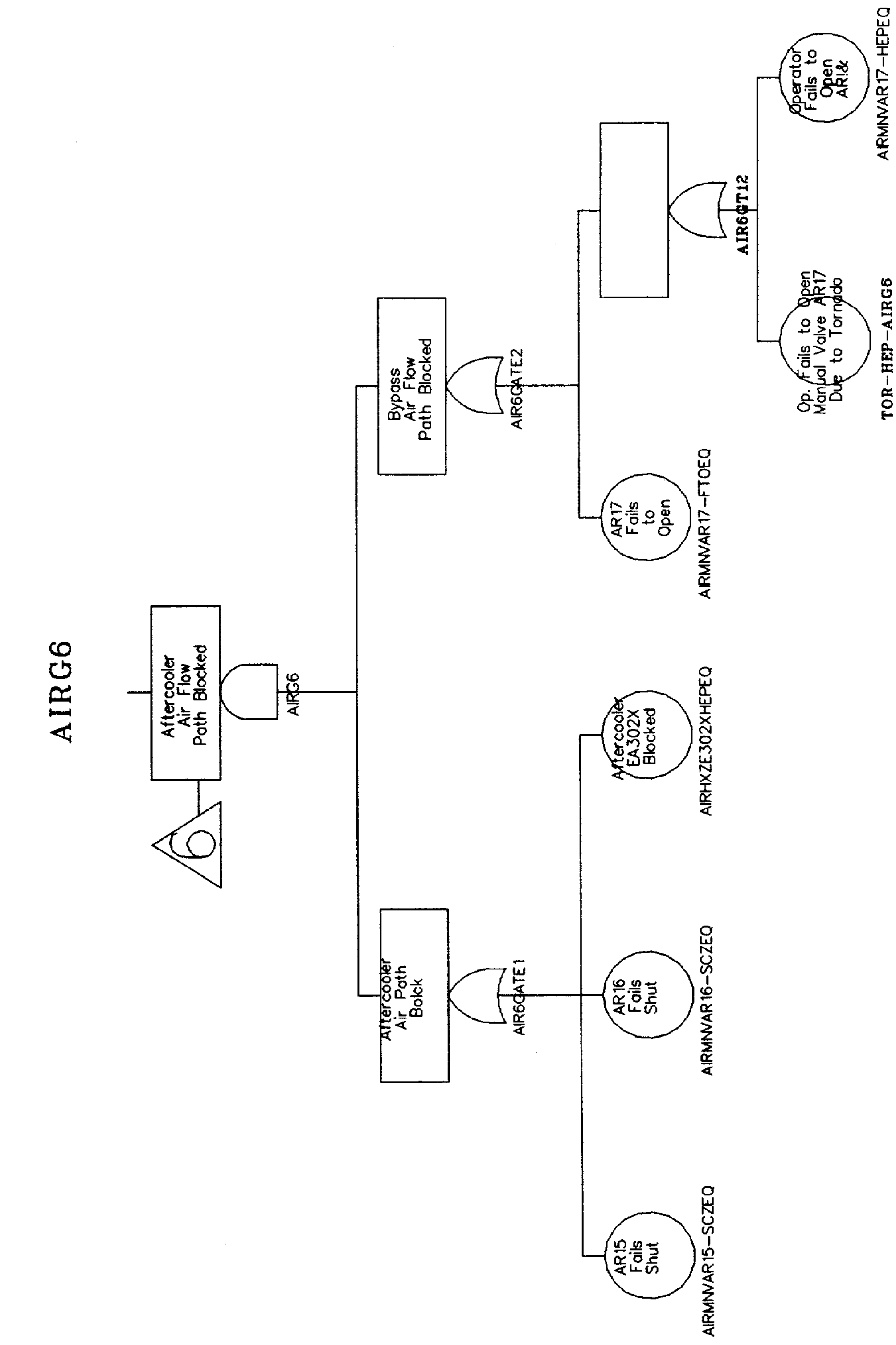


All 3 Air Compressor Fail
2
AIRG2
Loss of GB301A And GB301B
AIR2GATE1
Loss of GB301C
12
AIRG12
Loss of Both Compressors
AIR2GATE3
AR58A Control Air Fails Shut
AIRMNVAR58ASCZEQ
AR15A Fails Shut
AIRMNVAR15ASCZEQ
Loss of DW Supply to GB301A & B (common supply)
1AB
AIRG1AB
Loss of "RUN" Compressor
10
AIRG10
Loss of Standby Compressor
11
AIRG11

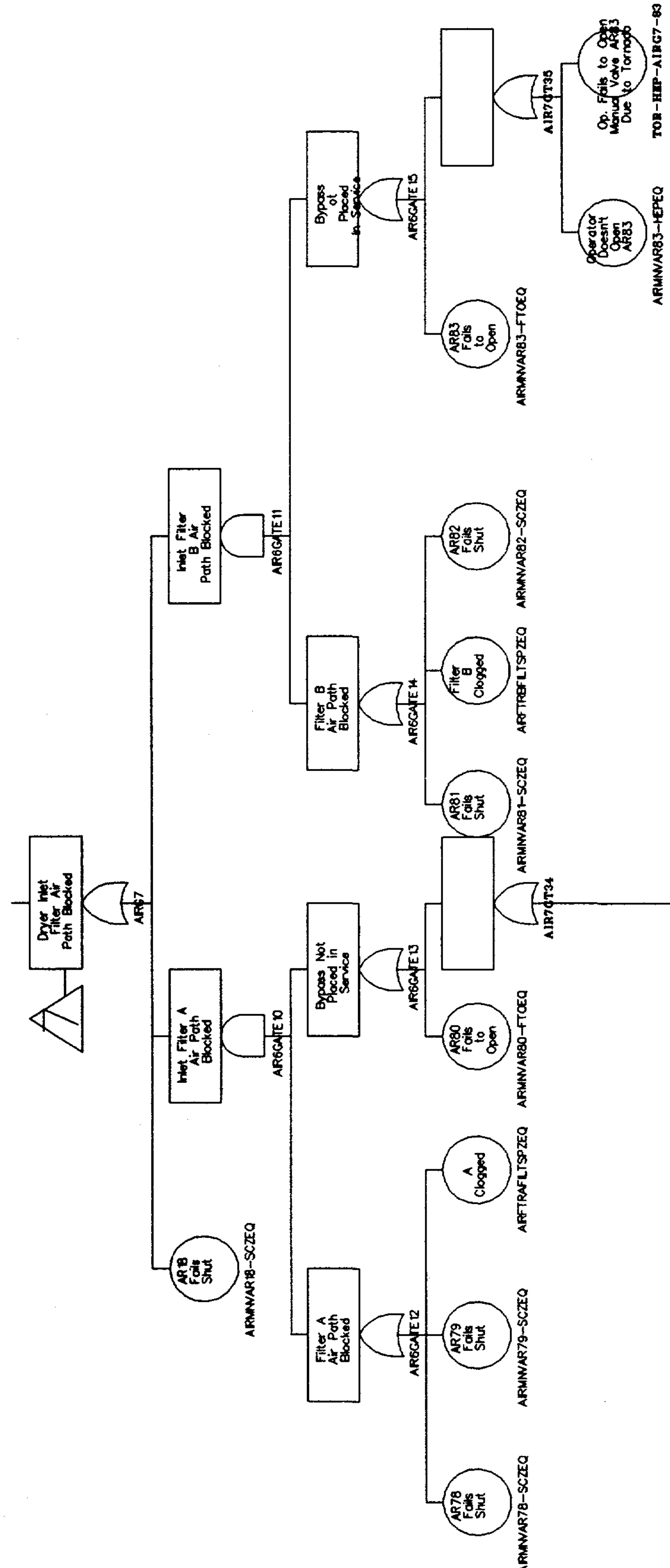
AIRG3



3
Air System Failure between Compressor Outlet to Dryer Outlet
AIRG3
Aftercooler Air Flow Path Blocked
6
AIRG6
Particulate Filter Air Flow Path Blocked
AIR3GATE1
Air Receiver Fails
AIRACCARECVLKEQ
Dryer Inlet Filter Air Path Blocked
7
AIRG7
Dryer Outlet Filter Air Path Blocked
8
AIRG8
Dryer Fails
9
AIRG9
Particulate Air Flow Blocked
AIR3GATE2
Bypass Air Flow Blocked
AIR3GATE3
AR19 Fails Shut
AIRMNVAR19-SCZEQ
AR20 Fails Shut
AIRMNVAR20-SCZEQ
Particulate Filter Clogged
AIRFTRPARTFSPZEQ
AR21 Fails to Open
AIRMNVAR21-FTOEQ
AIR3GT18
Op Fails to Open Manual Valve AR21 Due to Tornado
TOR-HEP-AIRG3
Operator Fails to Open AR21
AIRMNVAR21-HEPEQ

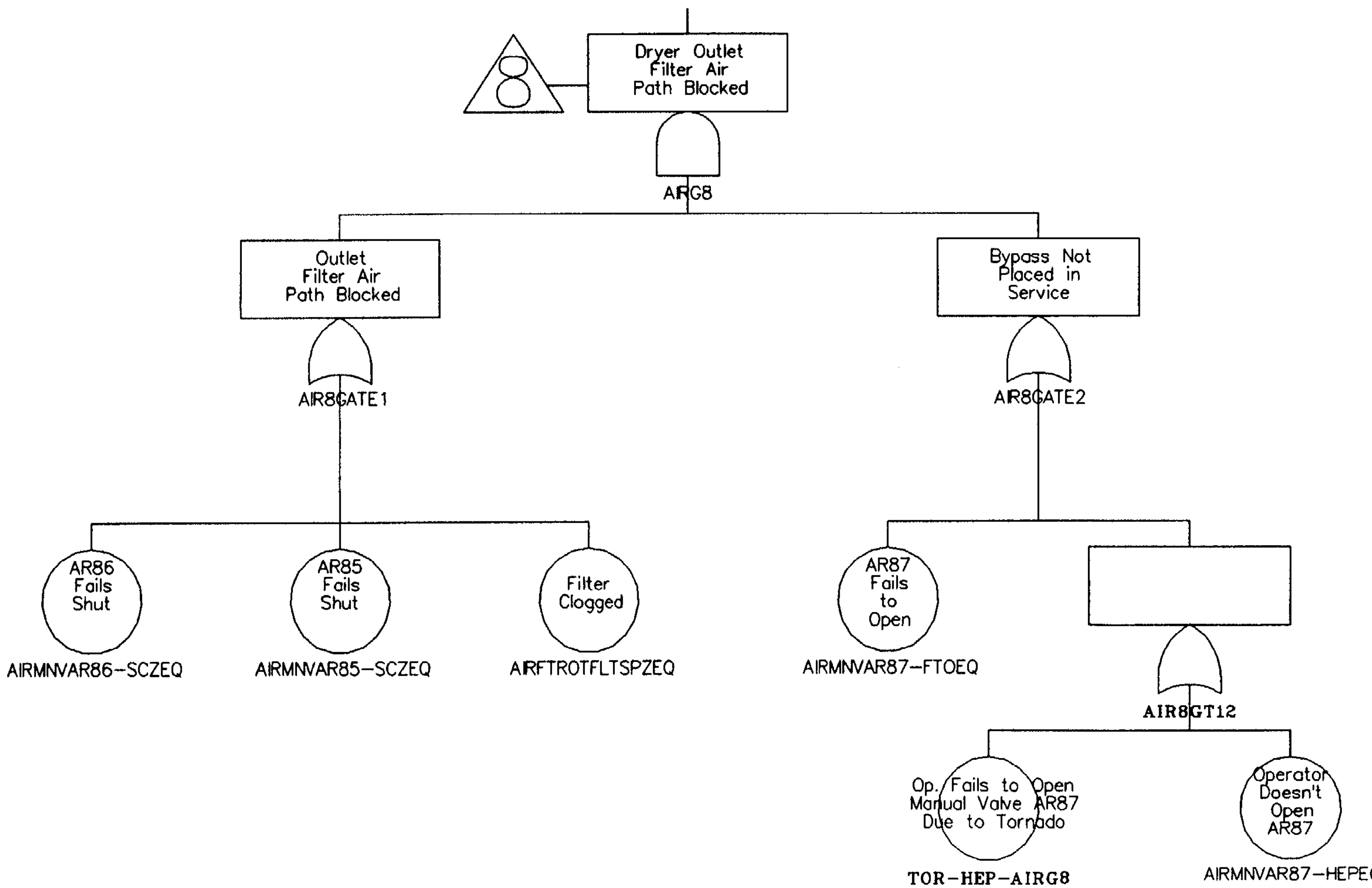

AIRG6
Aftercooler Air Flow Path Blocked
AIRG6
Aftercooler Air Path Bolck
AIR6GATE1
Bypass Air Flow Path Blocked
AIR6GATE2
AR15 Fails Shut
AIRMNVAR15-SCZEQ
AR16 Fails Shut
AIRMNVAR16-SCZEQ
Aftercooler EA302X Blocked
AIRHXZE302XHEPEQ
AR17 Fails to Open
AIRMNVAR17-FTOEQ
AIR6GT12
Op. Fails to Open Manual Valve AR17 Due to Tornado
TOR-HEP-AIRG6
Operator Fails to Open ARI&
AIRMNVAR17-HEPEQ

AIRG7

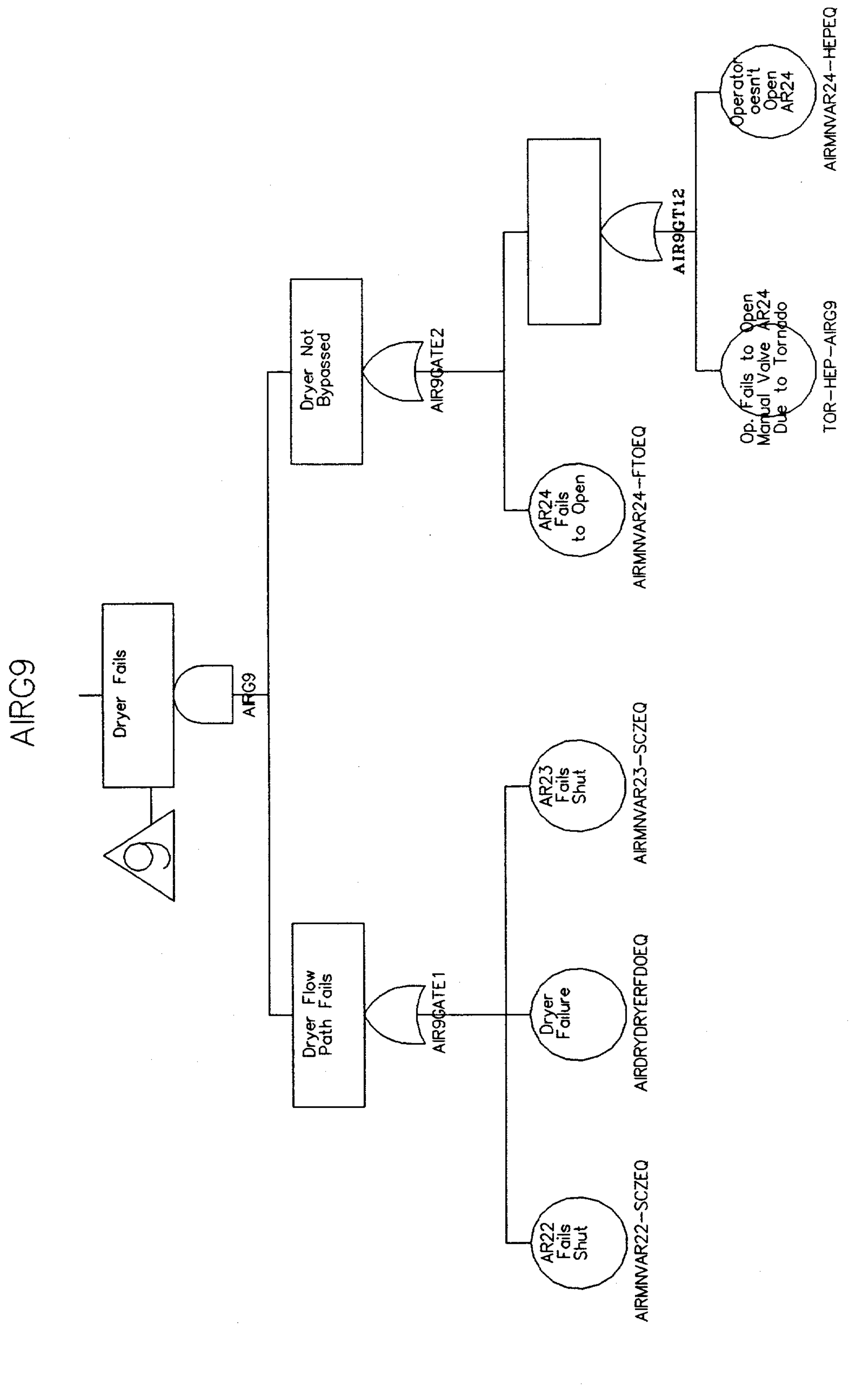


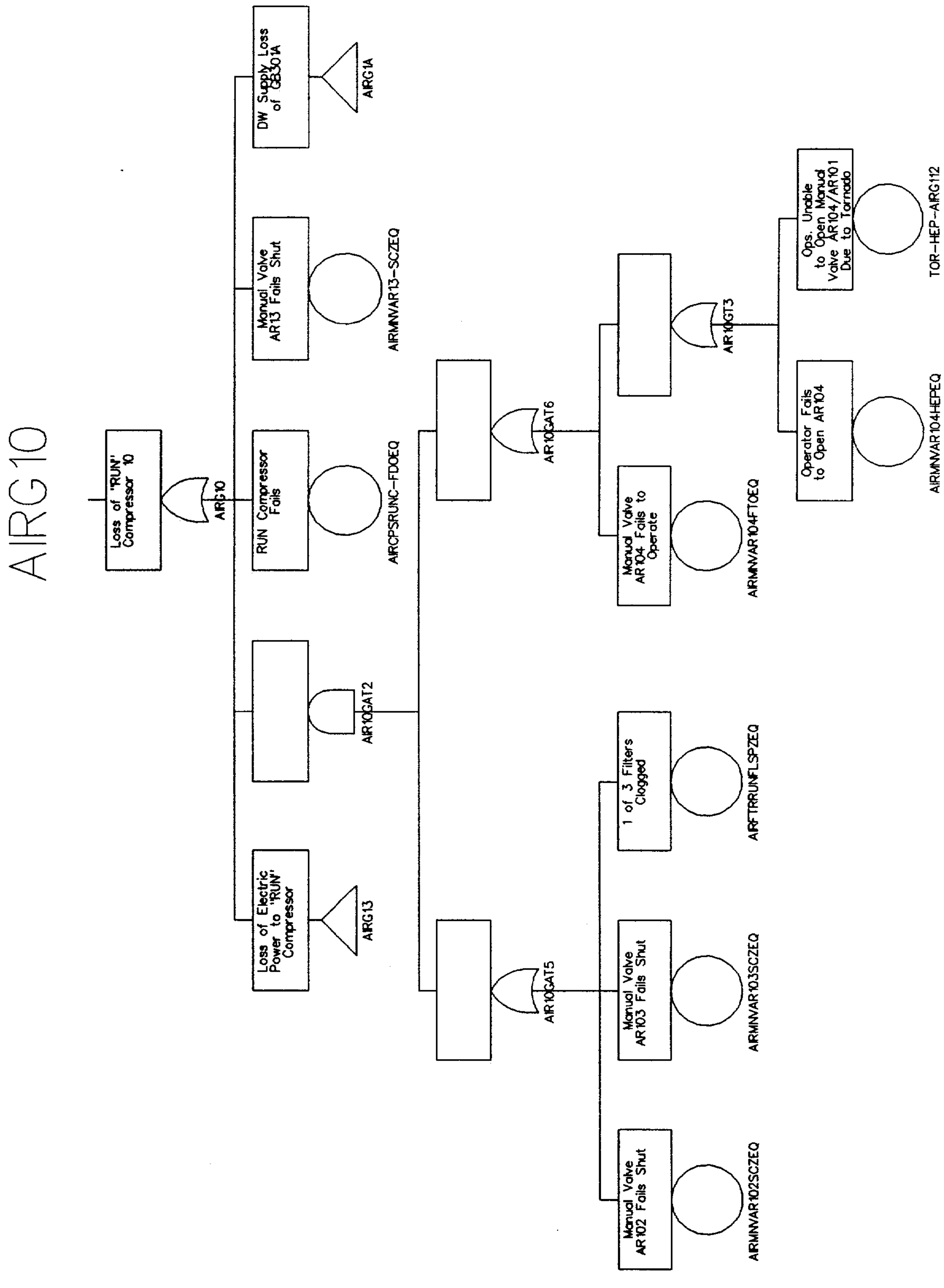
Dryer Inlet Filter Air Path Blocked
AIRG7
Inlet Filter A Air Path Blocked
AIR6GATE10
Inlet Filter B Air Path Blocked
AIR6GATE11
AR18 Fails Shut
AIRMNVAR18-SCZEQ
Filter A Air Path Blocked
AIR6GATE12
Bypass Not Placed in Service
AIR6GATE13
Filter B Air Path Blocked
AIR6GATE14
Bypass ot Placed In Service
AIR6GATE15
AR78 Fails Shut
AIRMNVAR78-SCZEQ
AR79 Fails Shut
AIRMNVAR79-SCZEQ
A Clogged
ARFTRAFLTSPZEQ
AR80 Fails to Open
AIRMNVAR80-FTOEQ
AIR7GT34
AR81 Fails Shut
AIRMNVAR81-SCZEQ
Filter B Clogged
ARFTRBFLTSPZEQ
AR82 Fails Shut
AIRMNVAR82-SCZEQ
AR83 Fails to Open
AIRMNVAR83-FTOEQ
AIR7GT35
Operator Doesn't Open AR80
AIRMNVAR80-HEPEQ
Op. Fails to Open Manual Valve AR80 Due to Tornado
TOR-HEP-AIRG7-80
Operator Doesn't Open AR83
AIRMNVAR83-HEPEQ
Op. Fails to Open Manual Valve AR83 Due to Tornado
TOR-HEP-AIRG7-83

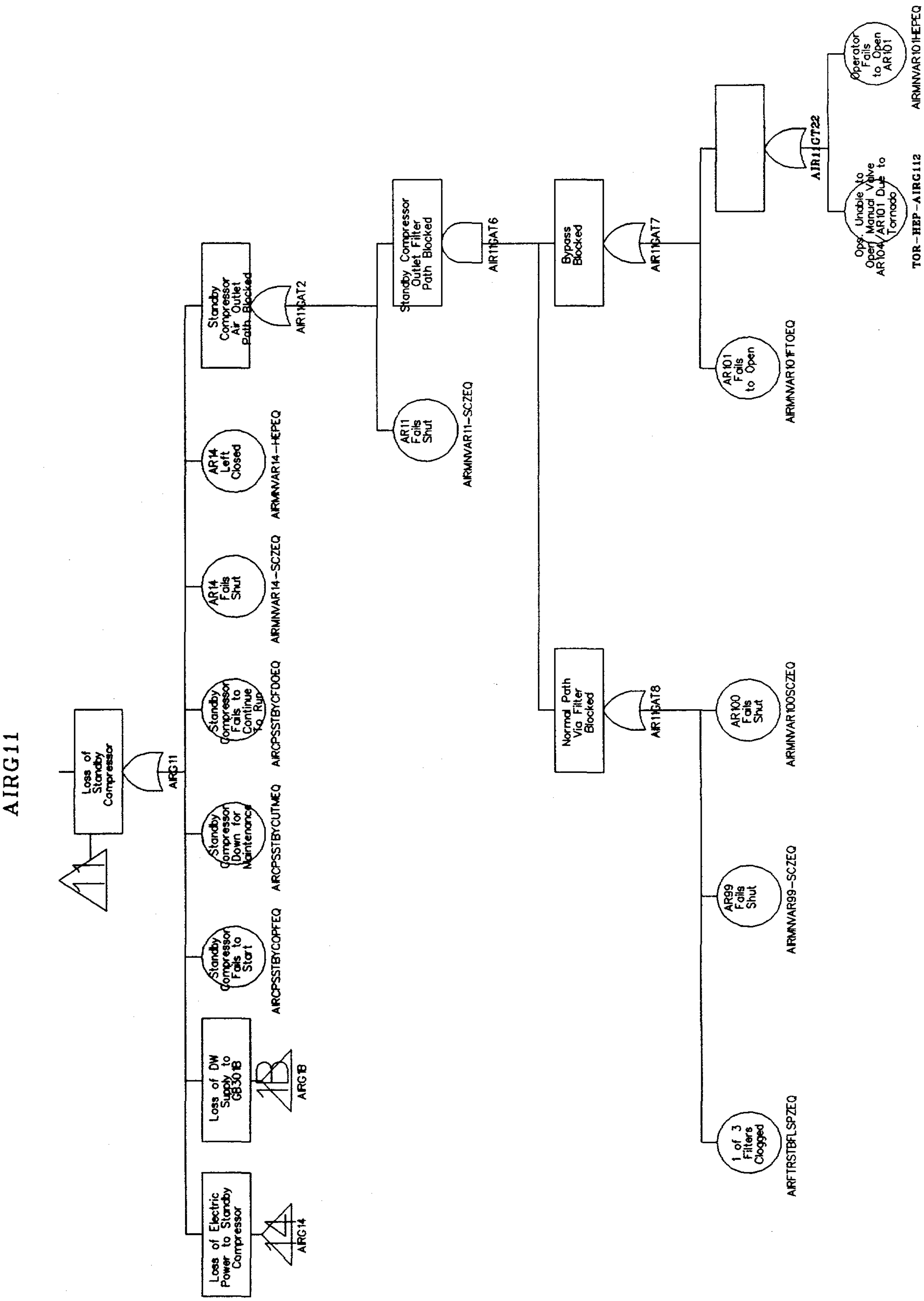
AIRG8

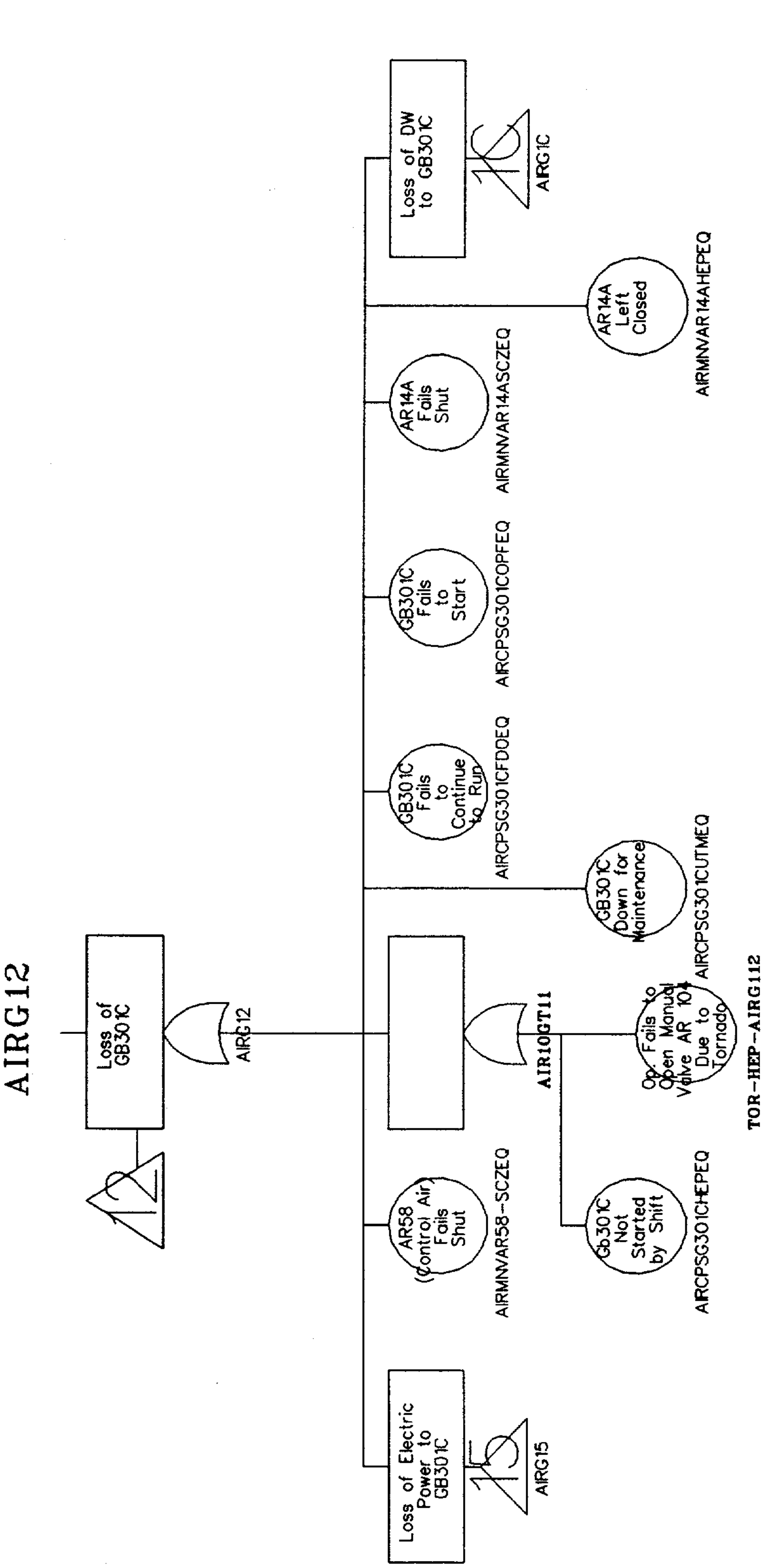


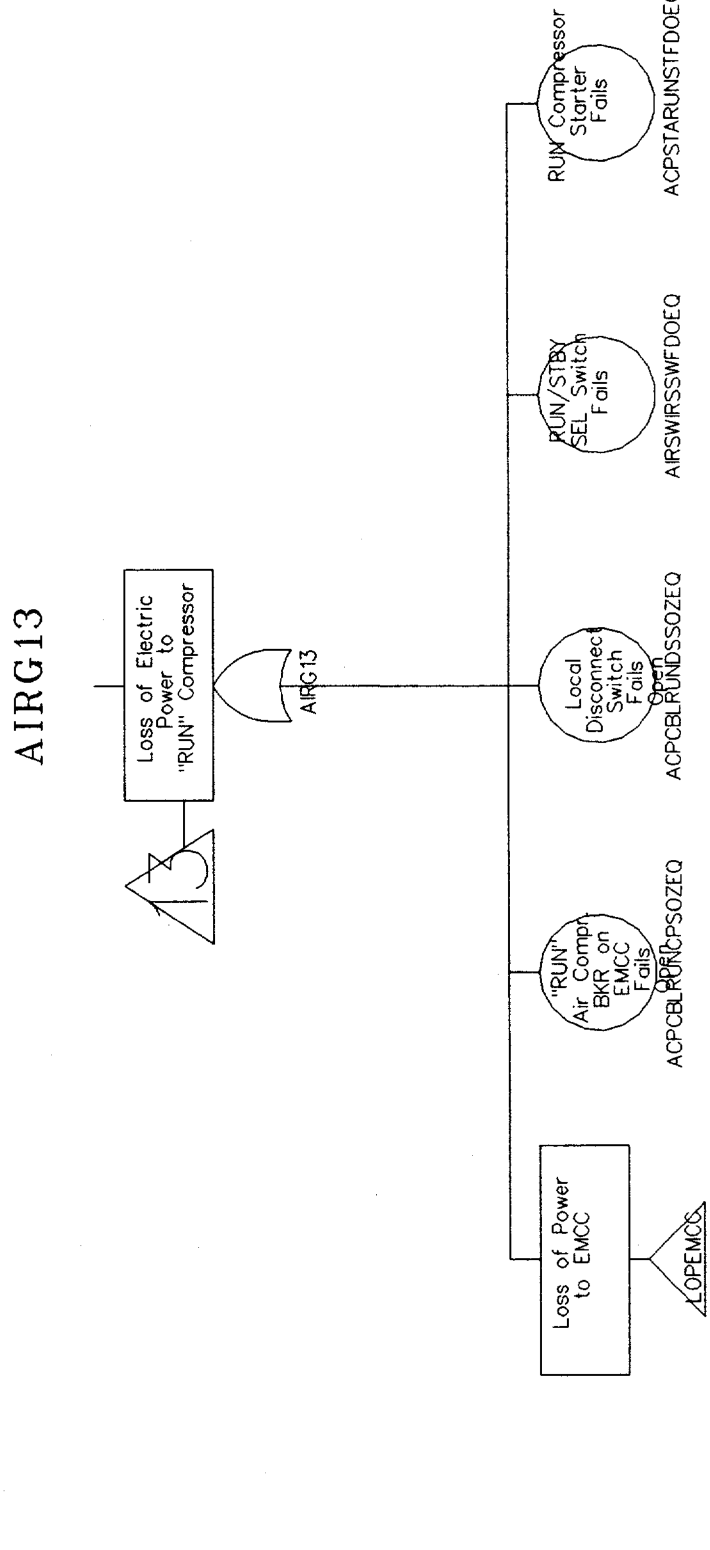
Dryer Outlet Filter Air Path Blocked
8
AIRG8
Outlet Filter Air Path Blocked
Bypass Not Placed in Service
AIR8GATE1
AIR8GATE2
AR86 Fails Shut
AIRMNVAR86-SCZEQ
AR85 Fails Shut
AIRMNVAR85-SCZEQ
Filter Clogged
AIRFTROTFLTSPZEQ
AR87 Fails to Open
AIRMNVAR87-FTOEQ
AIR8GT12
Op. Fails to Open Manual Valve AR87 Due to Tornado
TOR-HEP-AIRG8
Operator Doesn't Open AR87
AIRMNVAR87-HEPEQ

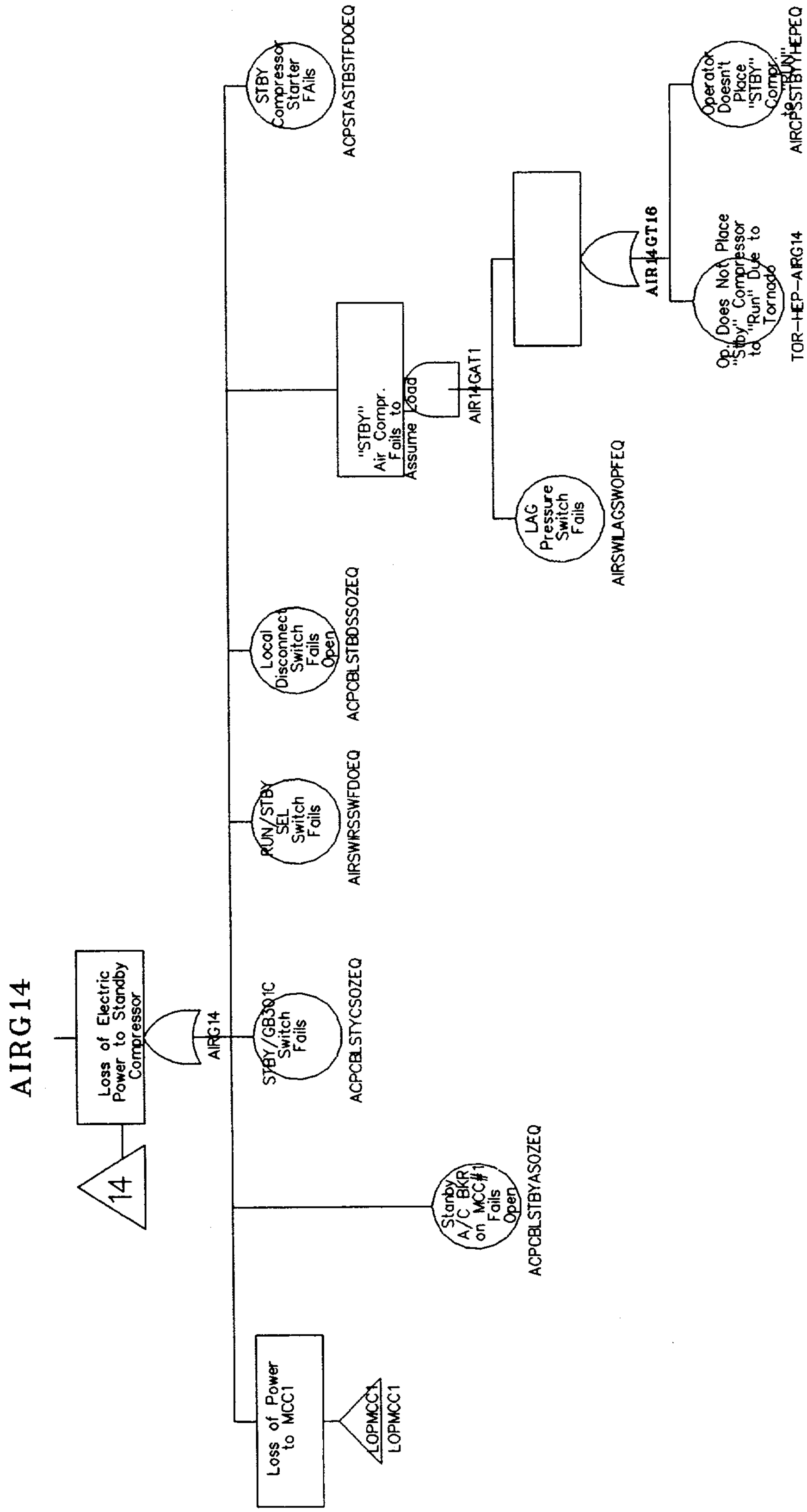

AIRG9
9
Dryer Fails
AIRG9
Dryer Flow Path Fails
AIR9GATE1
Dryer Not Bypassed
AIR9GATE2
AR22 Fails Shut
AIRMNVAR22-SCZEQ
Dryer Failure
AIRDRYDRYERFDOEQ
AR23 Fails Shut
AIRMNVAR23-SCZEQ
AR24 Fails to Open
AIRMNVAR24-FTOEQ
AIR9GT12
Op. Fails to Open Manual Valve AR24 Due to Tornado
TOR-HEP-AIRG9
Operator oesn't Open AR24
AIRMNVAR24-HEPEQ

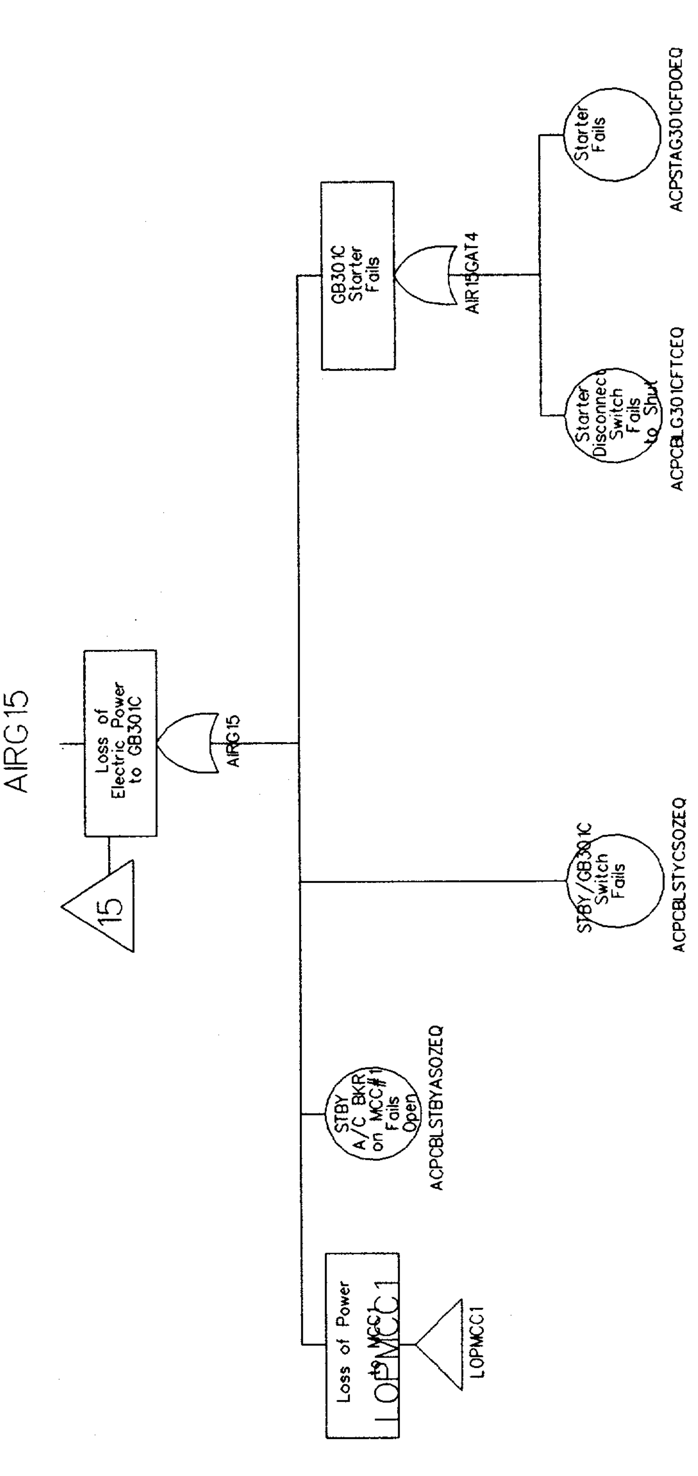

AIRG10
Loss of "RUN" Compressor 10
AIR10
Loss of Electric Power to "RUN" Compressor
AIRG13
AIR10GAT2
RUN Compressor Fails
AIRCPSRUNC-FDOEQ
Manual Valve AR13 Fails Shut
AIRMNVAR13-SCZEQ
DW Supply Loss of GB301A
AIRG1A
AIR10GAT5
AIR10GAT6
Manual Valve AR102 Fails Shut
AIRMNVAR102SCZEQ
Manual Valve AR103 Fails Shut
AIRMNVAR103SCZEQ
1 of 3 Filters Clogged
AIRFTRRUNFLSPZEQ
Manual Valve AR104 Fails to Operate
AIRMNVAR104FTOEQ
AIR10GT3
Operator Fails to Open AR104
AIRMNVAR104HEPEQ
Ops. Unable to Open Manual Valve AR104/AR101 Due to Tornado
TOR-HEP-AIRG112


AIRG11
Loss of Standby Compressor
AIRG11
Loss of Electric Power to Standby Compressor
ARG14
Loss of DW Supply to GB301B
ARG1B
Standby Compressor Fails to Start
AIRCPSSTBYCOPFEQ
Standby Compressor Down for Maintenance
AIRCPSSTBYCUTMEQ
Standby Compressor Fails to Continue To Run
AIRCPSSTBYCFDOEQ
AR14 Fails Shut
AIRMNVAR14-SCZEQ
AR14 Left Closed
AIRMNVAR14-HEPEQ
Standby Compressor Air Outlet Path Blocked
AIR11GAT2
AR11 Fails Shut
AIRMNVAR11-SCZEQ
Standby Compressor Outlet Filter Path Blocked
AIR11GAT6
Normal Path Via Filter Blocked
AIR11GAT8
1 of 3 Filters Clogged
AIRFTRSTBFLSPZEQ
AR99 Fails Shut
AIRMNVAR99-SCZEQ
AR100 Fails Shut
AIRMNVAR100SCZEQ
Bypass Blocked
AIR11GAT7
AR101 Fails to Open
AIRMNVAR101FTOEQ
AIR11GT22
Ops. Unable to Open Manual Valve AR104/AR101 Due to Tornado
TOR-HEP-AIRG112
Operator Fails to Open AR101
AIRMNVAR101HEPEQ


AIRG12
Loss of GB301C
AIRG12
Loss of Electric Power to GB301C
AIRG15
AR58 (Control Air) Fails Shut
AIRMNVAR58--SCZEQ
Gb301C Not Started by Shift
AIRCPSG301CHEPEQ
AIR10GT11
Op. Fails to Open Manual Valve AR 104 Due to Tornado
TOR-HEP-AIRG112
GB301C Down for Maintenance
AIRCPSG301CUTMEQ
GB301C Fails to Continue to Run
AIRCPSG301CFDOEQ
GB301C Fails to Start
AIRCPSG301COPFEQ
AR14A Fails Shut
AIRMNVAR14ASCZEQ
AR14A Left Closed
AIRMNVAR14AHEPEQ
Loss of DW to GB301C
AIRG1C


AIRG13
Loss of Electric Power to "RUN" Compressor
13
AIRG13
Loss of Power to EMCC
LOPEMCC
LOPEMCC
"RUN" Air Compr BKR on EMCC Fails Open
ACPCBLRUNCPSOZEQ
Local Disconnect Switch Fails Open
ACPCBLRUNDSSOZEQ
RUN/STBY SEL Switch Fails
AIRSWIRSSWFDOEQ
RUN Compressor Starter Fails
ACPSTARUNSTFDOEQ


AIRG14
Loss of Electric Power to Standby Compressor
14
AIRG14
Loss of Power to MCC1
LOPMCC1
LOPMCC1
Standby A/C BKR on MCC#1 Fails Open
ACPCBLSTBYASOZEQ
STBY/GB301C Switch Fails
ACPCBLSTYCSOZEQ
RUN/STBY SEL Switch Fails
AIRSWIRSSWFDOEQ
Local Disconnect Switch Fails Open
ACPCBLSTBDSSOZEQ
"STBY" Air Compr. Fails to Assume Load
AIR14GAT1
LAG Pressure Switch Fails
AIRSWILAGSWOPFEQ
AIR14GT16
Op. Does Not Place "Stby" Compressor to "Run" Due to Tornado
TOR-HEP-AIRG14
Operator Doesn't Place "STBY" Compr. to "RUN"
AIRCPSSTBYHEPEQ
STBY Compressor Starter FAils
ACPSTASTBSTFDOEQ


AIRG15
Loss of Electric Power to GB301C
AIRG15
15
GB301C Starter Fails
AIR15GAT4
Starter Disconnect Switch Fails to Shut
ACPCBLG301CFTCEQ
Starter Fails
ACPSTAG301CFDOEQ
STBY/GB301C Switch Fails
ACPCBLSTYCSOZEQ
STBY A/C BKR on MCC#1 Fails Open
ACPCBLSTBYASOZEQ
Loss of Power to MCC1
LOPMCC1
LOPMCC1

APPENDIX D

Logic of the Tornado Induced LOOP24 Event Tree

D.1 Explanation of Top Events (Failure of Indicated Systems) for the Logic of the Tornado Induced LOOP24 Event Tree

D.2 Logic of the Tornado Induced LOOP24 Event Tree

APPENDIX D.1
Explanation of Top Events (Failure of Indicated System) for the Logic of the Tornado Induced LOOP24 Event Tree

Table D.1 Explanation of Top Events (Failure of Indicated Systems) for the Logic of the Tornado Induced LOOP24 Event Tree

SCRLP:	Scram or setback system
SHT1PCW:	Primary cooling water, first 3 min
S3-TOP:	Shutdown cooling, first 3 min
SL-TOP	Shutdown cooling, long term
SPNFA, SPNFB:	Secondary cooling through primary cooler A or B, steam condensing mode
SC-TOP2:	Secondary cooling through the shutdown cooler
FR-TOP:	Flow reversal valves
DEPRESS:	Depressurization system
SCMDMU:	Heavy water makeup
SCMSD:	Steam condensing, shutdown cooler
PW1:	Poison water system

Appendix D.2
Logic of the Tornado Induced LOOP24 Event Tree

Sequence Name	System	System	System
Event Tree Name: LOOP24			
3	/SCRLP	/SHT1PCW	/SL-TOP
	/SPNFA	/SPNFB	SC-TOP2
	/FR-TOP	/DEPRESS	/SCMDMU
	PW1		
5	/SCRLP	/SHT1PCW	/SL-TOP
	/SPNFA	/SPNFB	SC-TOP2
	/FR-TOP	/DEPRESS	SCMDMU
	PW1		
7	/SCRLP	/SHT1PCW	/SL-TOP
	/SPNFA	/SPNFB	SC-TOP2
	/FR-TOP	DEPRESS	PW1
8	/SCRLP	/SHT1PCW	/SL-TOP
	/SPNFA	/SPNFB	SC-TOP2
	FR-TOP		
11	/SCRLP	/SHT1PCW	/SL-TOP
	/SPNFA	SPNFB	SC-TOP2
	/FR-TOP	/DEPRESS	/SCMDMU
	PW1		
13	/SCRLP	/SHT1PCW	/SL-TOP
	/SPNFA	SPNFB	SC-TOP2
	/FR-TOP	/DEPRESS	SCMDMU
	PW1		
15	/SCRLP	/SHT1PCW	/SL-TOP
	/SPNFA	SPNFB	SC-TOP2
	/FR-TOP	DEPRESS	PW1
16	/SCRLP	/SHT1PCW	/SL-TOP
	/SPNFA	SPNFB	SC-TOP2
	FR-TOP		
19	/SCRLP	/SHT1PCW	/SL-TOP
	SPNFA	/SPNFB	SC-TOP2
	/FR-TOP	/DEPRESS	/SCMDMU
	PW1		
21	/SCRLP	/SHT1PCW	/SL-TOP
	SPNFA	/SPNFB	SC-TOP2
	/FR-TOP	/DEPRESS	SCMDMU
	PW1		
23	/SCRLP	/SHT1PCW	/SL-TOP
	SPNFA	/SPNFB	SC-TOP2
	/FR-TOP	DEPRESS	PW1
24	/SCRLP	/SHT1PCW	/SL-TOP
	SPNFA	/SPNFB	SC-TOP2
	FR-TOP		
27	/SCRLP	/SHT1PCW	/SL-TOP
	SPNFA	SPNFB	SC-TOP2
	/FR-TOP	/DEPRESS	PW1

29	/SCRLP	/SHT1PCW	/SL-TOP
	SPNFA	SPNFB	SC-TOP2
	/FR-TOP	DEPRESS	PW1
30	/SCRLP	/SHT1PCW	/SL-TOP
	SPNFA	SPNFB	SC-TOP2
	FR-TOP		
33	/SCRLP	/SHT1PCW	SL-TOP
	/SPNFA	/SPNFB	/SC-TOP2
	/FR-TOP	/DEPRESS	/SCMDMU
	SCMSD	PW1	
35	/SCRLP	/SHT1PCW	SL-TOP
	/SPNFA	/SPNFB	/SC-TOP2
	/FR-TOP	/DEPRESS	SCMDMU
	PW1		
37	/SCRLP	/SHT1PCW	SL-TOP
	/SPNFA	/SPNFB	/SC-TOP2
	/FR-TOP	DEPRESS	PW1
38	/SCRLP	/SHT1PCW	SL-TOP
	/SPNFA	/SPNFB	/SC-TOP2
	FR-TOP		
40	/SCRLP	/SHT1PCW	SL-TOP
	/SPNFA	/SPNFB	SC-TOP2
	/FR-TOP	/DEPRESS	/SCMDMU
	PW1		
42	/SCRLP	/SHT1PCW	SL-TOP
	/SPNFA	/SPNFB	SC-TOP2
	/FR-TOP	/DEPRESS	SCMDMU
	PW1		
44	/SCRLP	/SHT1PCW	SL-TOP
	/SPNFA	/SPNFB	SC-TOP2
	/FR-TOP	DEPRESS	PW1
45	/SCRLP	/SHT1PCW	SL-TOP
	/SPNFA	/SPNFB	SC-TOP2
	FR-TOP		
48	/SCRLP	/SHT1PCW	SL-TOP
	/SPNFA	SPNFB	/SC-TOP2
	/FR-TOP	/DEPRESS	/SCMDMU
	SCMSD	PW1	
50	/SCRLP	/SHT1PCW	SL-TOP
	/SPNFA	SPNFB	/SC-TOP2
	/FR-TOP	/DEPRESS	SCMDMU
	PW1		
52	/SCRLP	/SHT1PCW	SL-TOP
	/SPNFA	SPNFB	/SC-TOP2
	/FR-TOP	DEPRESS	PW1
53	/SCRLP	/SHT1PCW	SL-TOP

	/SPNFA	SPNFB	/SC-TOP2
	FR-TOP		
55	/SCRLP	/SHT1PCW	SL-TOP
	/SPNFA	SPNFB	SC-TOP2
	/FR-TOP	/DEPRESS	/SCMDMU
	PW1		
57	/SCRLP	/SHT1PCW	SL-TOP
	/SPNFA	SPNFB	SC-TOP2
	/FR-TOP	/DEPRESS	SCMDMU
	PW1		
59	/SCRLP	/SHT1PCW	SL-TOP
	/SPNFA	SPNFB	SC-TOP2
	/FR-TOP	DEPRESS	PW1
60	/SCRLP	/SHT1PCW	SL-TOP
	/SPNFA	SPNFB	SC-TOP2
	FR-TOP		
63	/SCRLP	/SHT1PCW	SL-TOP
	SPNFA	/SPNFB	/SC-TOP2
	/FR-TOP	/DEPRESS	/SCMDMU
	SCMSD	PW1	
65	/SCRLP	/SHT1PCW	SL-TOP
	SPNFA	/SPNFB	/SC-TOP2
	/FR-TOP	/DEPRESS	SCMDMU
	PW1		
67	/SCRLP	/SHT1PCW	SL-TOP
	SPNFA	/SPNFB	/SC-TOP2
	/FR-TOP	DEPRESS	PW1
68	/SCRLP	/SHT1PCW	SL-TOP
	SPNFA	/SPNFB	/SC-TOP2
	FR-TOP		
70	/SCRLP	/SHT1PCW	SC-TOP
	SPNFA	/SPNFB	SC-TOP2
	/FR-TOP	/DEPRESS	/SCMDMU
	PW1		
72	/SCRLP	/SHT1PCW	SL-TOP
	SPNFA	/SPNFB	SC-TOP2
	/FR-TOP	/DEPRESS	SCMDMU
	PW1		
74	/SCRLP	/SHT1PCW	SL-TOP
	SPNFA	/SPNFB	SC-TOP2
	/FR-TOP	DEPRESS	PW1
75	/SCRLP	/SHT1PCW	SL-TOP
	SPNFA	/SPNFB	SC-TOP2
	FR-TOP		
78	/SCRLP	/SHT1PCW	SL-TOP
	SPNFA	SPNFB	/SC-TOP2
	/FR-TOP	/DEPRESS	/SCMDMU

	SCMSD	PW1	
80	/SCRLP	/SHT1PCW	SL-TOP
	SPNFA	SPNFB	/SC-TOP2
	/FR-TOP	/DEPRESS	SCMDMU
	PW1		
82	/SCRLP	/SHT1PCW	SL-TOP
	SPNFA	SPNFB	/SC-TOP2
	/FR-TOP	DEPRESS	PW1
83	/SCRLP	/SHT1PCW	SL-TOP
	SPNFA	SPNFB	/SC-TOP2
	FR-TOP		
85	/SCRLP	/SHT1PCW	SL-TOP
	SPNFA	SPNFB	SC-TOP2
	PW1		
88	/SCRLP	SHT1PCW	/S3-TOP
	/SL-TOP	/SPNFA	/SPNFB
	SC-TOP2	/FR-TOP	/DEPRESS
	/SCMDMU	PW1	
90	/SCRLP	SHT1PCW	/S3-TOP
	/SL-TOP	/SPNFA	/SPNFB
	SC-TOP2	/FR-TOP	/DEPRESS
	SCMDMU	PW1	
92	/SCRLP	SHT1PCW	/S3-TOP
	/SL-TOP	/SPNFA	/SPNFB
	SC-TOP2	/FR-TOP	DEPRESS
	PW1		
93	/SCRLP	SHT1PCW	/S3-TOP
	/SL-TOP	/SPNFA	/SPNFB
	SC-TOP2	FR-TOP	
96	/SCRLP	SHT1PCW	/S3-TOP
	/SL-TOP	/SPNFA	SPNFB
	SC-TOP2	/FR-TOP	/DEPRESS
	/SCMDMU	PW1	
98	/SCRLP	SHT1PCW	/S3-TOP
	/SL-TOP	/SPNFA	SPNFB
	SC-TOP2	/FR-TOP	/DEPRESS
	SCMDMU	PW1	
100	/SCRLP	SHT1PCW	/S3-TOP
	/SL-TOP	/SPNFA	SPNFB
	SC-TOP2	/FR-TOP	DEPRESS
	PW1		
101	/SCRLP	SHT1PCW	/S3-TOP
	/SL-TOP	/SPNFA	SPNFB
	SC-TOP2	FR-TOP	
104	/SCRLP	SHT1PCW	/S3-TOP
	/SL-TOP	SPNFA	/SPNFB
	SC-TOP2	/FR-TOP	/DEPRESS

	/SCMDMU	PW1	
106	/SCRLP	SHT1PCW	/S3-TOP
	/SL-TOP	SPNFA	/SPNFB
	SC-TOP2	/FR-TOP	/DEPRESS
	SCMDMU	PW1	
108	/SCRLP	SHT1PCW	/S3-TOP
	/SL-TOP	SPNFA	/SPNFB
	SC-TOP2	/FR-TOP	DEPRESS
	PW1		
109	/SCRLP	SHT1PCW	/S3-TOP
	/SL-TOP	SPNFA	/SPNFB
	SC-TOP2	FR-TOP	
112	/SCRLP	SHT1PCW	/S3-TOP
	/SL-TOP	SPNFA	SPNFB
	SC-TOP2	/FR-TOP	/DEPRESS
	PW1		
114	/SCRLP	SHT1PCW	/S3-TOP
	/SL-TOP	SPNFA	SPNFB
	SC-TOP2	/FR-TOP	DEPRESS
	PW1		
115	/SCRLP	SHT1PCW	/S3-TOP
	/SL-TOP	SPNFA	SPNFB
	SC-TOP2	FR-TOP	
118	/SCRLP	SHT1PCW	/S3-TOP
	SL-TOP	/SPNFA	/SPNFB
	/SC-TOP2	/FR-TOP	/DEPRESS
	/SCMDMU	SCMSD	PW1
120	/SCRLP	SHT1PCW	/S3-TOP
	SL-TOP	/SPNFA	/SPNFB
	/SC-TOP2	/FR-TOP	/DEPRESS
	SCMDMU	PW1	
122	/SCRLP	SHT1PCW	/S3-TOP
	SL-TOP	/SPNFA	/SPNFB
	/SC-TOP2	/FR-TOP	DEPRESS
	PW1		
123	/SCRLP	SHT1PCW	/S3-TOP
	SL-TOP	/SPNFA	/SPNFB
	/SC-TOP2	FR-TOP	
125	/SCRLP	SHT1PCW	/S3-TOP
	SL-TOP	/SPNFA	/SPNFB
	SC-TOP2	/FR-TOP	/DEPRESS
	/SCMDMU	PW1	
127	/SCRLP	SHT1PCW	/S3-TOP
	SL-TOP	/SPNFA	/SPNFB
	SC-TOP2	/FR-TOP	/DEPRESS
	SCMDMU	PW1	
129	/SCRLP	SHT1PCW	/S3-TOP

	SL-TOP	/SPNFA	/SPNFB
	SC-TOP2	/FR-TOP	DEPRESS
	PW1		
130	/SCRLP	SHT1PCW	/S3-TOP
	SL-TOP	/SPNFA	/SPNFB
	SC-TOP2	FR-TOP	
133	/SCRLP	SHT1PCW	/S3-TOP
	SL-TOP	/SPNFA	SPNFB
	/SC-TOP2	/FR-TOP	/DEPRESS
	/SCMDMU	SCMSD	PW1
135	/SCRLP	SHT1PCW	/S3-TOP
	SL-TOP	/SPNFA	SPNFB
	/SC-TOP2	/FR-TOP	/DEPRESS
	SCMDMU	PW1	
137	/SCRLP	SHT1PCW	/S3-TOP
	SL-TOP	/SPNFA	SPNFB
	/SC-TOP2	/FR-TOP	DEPRESS
	PW1		
138	/SCRLP	SHT1PCW	/S3-TOP
	SL-TOP	/SPNFA	SPNFB
	/SC-TOP2	FR-TOP	
140	/SCRLP	SHT1PCW	/S3-TOP
	SL-TOP	/SPNFA	SPNFB
	SC-TOP2	/FR-TOP	/DEPRESS
	/SCMDMU	PW1	
142	/SCRLP	SHT1PCW	/S3-TOP
	SL-TOP	/SPNFA	SPNFB
	SC-TOP2	/FR-TOP	/DEPRESS
	SCMDMU	PW1	
144	/SCRLP	SHT1PCW	/S3-TOP
	SL-TOP	/SPNFA	SPNFB
	SC-TOP2	/FR-TOP	DEPRESS
	PW1		
145	/SCRLP	SHT1PCW	/S3-TOP
	SL-TOP	/SPNFA	SPNFB
	SC-TOP2	FR-TOP	
148	/SCRLP	SHT1PCW	/S3-TOP
	SL-TOP	SPNFA	/SPNFB
	/SC-TOP2	/FR-TOP	/DEPRESS
	/SCMDMU	SCMSD	PW1
150	/SCRLP	SHT1PCW	/S3-TOP
	SL-TOP	SPNFA	/SPNFB
	/SC-TOP2	/FR-TOP	/DEPRESS
	SCMDMU	PW1	
152	/SCRLP	SHT1PCW	/S3-TOP
	SL-TOP	SPNFA	/SPNFB
	/SC-TOP2	/FR-TOP	DEPRESS
	PW1		

153	/SCRLP	SHT1PCW	/S3-TOP
	SL-TOP	SPNFA	/SPNFB
	/SC-TOP2	FR-TOP	
155	/SCRLP	SHT1PCW	/S3-TOP
	SL-TOP	SPNFA	/SPNFB
	SC-TOP2	/FR-TOP	/DEPRESS
	/SCMDMU	PW1	
157	/SCRLP	SHT1PCW	/S3-TOP
	SL-TOP	SPNFA	/SPNFB
	SC-TOP2	/FR-TOP	/DEPRESS
	SCMDMU	PW1	
159	/SCRLP	SHT1PCW	/S3-TOP
	SL-TOP	SPNFA	/SPNFB
	SC-TOP2	/FR-TOP	DEPRESS
	PW1		
160	/SCRLP	SHT1PCW	/S3-TOP
	SL-TOP	SPNFA	/SPNFB
	SC-TOP2	FR-TOP	
163	/SCRLP	SHT1PCW	/S3-TOP
	SL-TOP	SPNFA	SPNFB
	/SC-TOP2	/FR-TOP	/DEPRESS
	/SCMDMU	SCMSD	PW1
165	/SCRLP	SHT1PCW	/S3-TOP
	SL-TOP	SPNFA	SPNFB
	/SC-TOP2	/FR-TOP	/DEPRESS
	SCMDMU	PW1	
167	/SCRLP	SHT1PCW	/S3-TOP
	SL-TOP	SPNFA	SPNFB
	/SC-TOP2	/FR-TOP	DEPRESS
	PW1		
168	/SCRLP	SHT1PCW	/S3-TOP
	SL-TOP	SPNFA	SPNFB
	/SC-TOP2	FR-TOP	
170	/SCRLP	SHT1PCW	/S3-TOP
	SL-TOP	SPNFA	SPNFB
	SC-TOP2	PW1	
171	/SCRLP	SHT1PCW	S3-TOP
172	SCRLP		
Sequence Name	System	System	System

APPENDIX E

System Cutsets for Tornado Induced Event Tree

E.1 System Unavailabilities and Availability Lower Bounds

E.2 System Cutsets

E.3 Conditional Probabilities Without and With Correction for Tornado Induced LOOP24 Sequences

Appendix E.1
System Unavailabilities and Availability Lower Bounds

Table E.1 System Unavailabilities & Availability Lower Bounds for the Tornado Induced LOOP24 Event Tree

System (Top Event)	IRRAS Calculated Unavailability	Availability Lower Bound
SCRLP	2.39E-6	1
SHT1PCW	1.56E-1	0.844
S3-TOP	3.05E-2	0.969
SL-TOP	1.40E-1	0.860
SPNFA	9.16E-2	0.908
SPNFB	9.16E-2	0.908
SC-TOP2	1.57E-1	0.843
FR-TOP	3.26E-5	1
DEPRESS	2.45E-1	0.755
SCMDMU	7.51E-1	0.249
SCMSD	2.40E-1	0.760
PW1	8.44E-1	0.156

Appendix E.2
System Cutsets

SYSTEM CUT SETS (QUANTIFICATION) REPORT

Family : HFBR-TOR Analysis : RANDOM

System : SCRLP Case : ALTERNATE

Mincut Upper Bound : 2.394E-006

Cut No.	% Total	% Cut Set	Prob/ Freq.	ALTERNATE CUT SETS
1	100.0	100.0	2.3E-006	SCRCRDBTPRIOPFVV, SCRCRDCMPRIOPFVV

SYSTEM CUT SETS (QUANTIFICATION) REPORT

Family : HFBR-TOR   Analysis : RANDOM

System : SHT1PCW   Case : ALTERNATE

Mincut Upper Bound : 1.560E-001

Cut No.	% Total	% Cut Set	Prob/ Freq.	ALTERNATE CUT SETS
1	100.0	100.0	1.5E-001	TOR-S05-FMIS
2	100.0	0.0	6.3E-005	PC3DMRBT0ABOPFVV, PC3DMRCM0ABOPFVV
3	100.0	0.0	4.5E-006	PC3DMRGP01AOPFVV, PC3DMRGP01BOPFVV
4	100.0	0.0	1.0E-006	PC3BTRGP01AFDOVV, PC3DMRGP01BOPFVV
5	100.0	0.0	1.0E-006	PC3BTRGP01BFDOVV, PC3DMRGP01AOPFVV
6	100.0	0.0	5.7E-007	PC3DMRGP01AOPFVV, /PC3DMRGP01AUTM, PC3DMRGP01BUTM
7	100.0	0.0	5.7E-007	PC3DMRGP01AUTM, PC3DMRGP01BOPFVV, /PC3DMRGP01BUTM
8	100.0	0.0	2.4E-007	PC3BTRGP01AFDOVV, PC3BTRGP01BFDOVV
9	100.0	0.0	1.3E-007	PC3BTRGP01AFDOVV, /PC3DMRGP01AUTM, PC3DMRGP01BUTM
10	100.0	0.0	1.3E-007	PC3BTRGP01BFDOVV, PC3DMRGP01AUTM, /PC3DMRGP01BUTM

SYSTEM CUT SETS (QUANTIFICATION) REPORT

Family : HFBR-TOR   Analysis : RANDOM
System : S3-TOP   Case   : ALTERNATE
Mincut Upper Bound : 3.052E-002

Cut No.	% Total	% Cut Set	Prob/ Freq.	ALTERNATE CUT SETS
1	22.5	22.5	6.8E-003	ACPEPGPRPGNFDOEQ, TOR-S09-FMIS
2	45.1	22.5	6.8E-003	ACPEPGPRPGNFDOEQ, TOR-S60-FMIS
3	67.7	22.5	6.8E-003	ACPEPGPRPGNFDOEQ, TOR-S61-FMIS
4	74.5	6.7	2.0E-003	ACPEPGPRPGNOPFEQ, TOR-S09-FMIS
5	81.2	6.7	2.0E-003	ACPEPGPRPGNOPFEQ, TOR-S60-FMIS
6	88.0	6.7	2.0E-003	ACPEPGPRPGNOPFEQ, TOR-S61-FMIS
7	89.9	1.8	5.6E-004	ACPEPGPRPGNVTMEQ, TOR-S09-FMIS
8	91.7	1.8	5.6E-004	ACPEPGPRPGNVTMEQ, TOR-S60-FMIS
9	93.5	1.8	5.6E-004	ACPEPGPRPGNVTMEQ, TOR-S61-FMIS
10	95.0	1.4	4.5E-004	SD3CKVFRVLNFTOEQ
11	96.5	1.4	4.5E-004	SD3CKVP98XXFTOEQ
12	97.6	1.1	3.4E-004	TOR-PROP-MSIV, TOR-S09-FMIS
13	98.7	1.1	3.4E-004	TOR-PROP-MSIV, TOR-S60-FMIS
14	99.9	1.1	3.4E-004	TOR-PROP-MSIV, TOR-S61-FMIS
15	100.0	0.3	1.0E-004	SD3MNVP98XXHEPEQ
16	100.0	0.1	4.0E-005	ACPEPGPRPGNFDOEQ, DCPCBHBKR28SOZFH
17	100.0	0.1	4.0E-005	ACPEPGPRPGNFDOEQ, DCPCBHEMCCSSOZEQ
18	100.0	0.0	2.8E-005	SD3BRKRECTFSOZEQ, TOR-S09-FMIS
19	100.0	0.0	2.8E-005	SD3BRKRECTFSOZEQ, TOR-S60-FMIS
20	100.0	0.0	2.8E-005	SD3BRKRECTFSOZEQ, TOR-S61-FMIS
21	100.0	0.0	2.1E-005	ACPEPGPRPGNFDOEQ, DCPBTRBAT12FDOFH, DCPBTRBTO12FDOFH
22	100.0	0.0	2.0E-005	ACPTFSEMERGOPFEQ, TOR-S09-FMIS
23	100.0	0.0	2.0E-005	ACPTFSEMERGOPFEQ, TOR-S60-FMIS
24	100.0	0.0	2.0E-005	ACPTFSEMERGOPFEQ, TOR-S61-FMIS
25	100.0	0.0	1.2E-005	ACPEPGPRPGNOPFEQ, DCPCBHBKR28SOZFH
26	100.0	0.0	1.2E-005	ACPEPGPRPGNOPFEQ, DCPCBHEMCCSSOZEQ
27	100.0	0.0	9.4E-006	ACPCBLPRPGNSOZEQ, TOR-S09-FMIS
28	100.0	0.0	9.4E-006	ACPCBLPRPGNSOZEQ, TOR-S60-FMIS
29	100.0	0.0	9.4E-006	ACPCBLPRPGNSOZEQ, TOR-S61-FMIS
30	100.0	0.0	6.4E-006	ACPEPGPRPGNOPFEQ, DCPBTRBAT12FDOFH, DCPBTRBTO12FDOFH
31	100.0	0.0	3.2E-006	ACPEPGPRPGNVTMEQ, DCPCBHBKR28SOZFH
32	100.0	0.0	3.2E-006	ACPEPGPRPGNVTMEQ, DCPCBHEMCCSSOZEQ
33	100.0	0.0	2.0E-006	DCPCBHBKR28SOZFH, TOR-PROP-MSIV
34	100.0	0.0	2.0E-006	DCPCBHEMCCSSOZEQ, TOR-PROP-MSIV
35	100.0	0.0	1.7E-006	ACPEPGPRPGNVTMEQ, DCPBTRBAT12FDOFH, DCPBTRBTO12FDOFH
36	100.0	0.0	1.0E-006	DCPBTRBAT12FDOFH, DCPBTRBTO12FDOFH, TOR-PROP-MSIV
37	100.0	0.0	4.6E-007	ACPEPGPRPGNFDOEQ, DCPBTRBATT1FDOFH, DCPBTRBATT2FDOFH
38	100.0	0.0	3.1E-007	ACPEPGPRPGNFDOEQ, DCPBUSEMCC-BUSEQ
39	100.0	0.0	1.9E-007	ACPBUSEMCC-BUSEQ, TOR-S09-FMIS
40	100.0	0.0	1.9E-007	ACPBUSEMCC-BUSEQ, TOR-S60-FMIS
41	100.0	0.0	1.9E-007	ACPBUSEMCC-BUSEQ, TOR-S61-FMIS
42	100.0	0.0	1.6E-007	ACPTFSNRMEGTSOEQ, TOR-S09-FMIS

SYSTEM CUT SETS (QUANTIFICATION) REPORT

Family : HFBR-TOR   Analysis : RANDOM
System : S3-TOP   Case : ALTERNATE
Mincut Upper Bound : 3.052E-002

Cut No.	% Total	% Cut Set	Prob/ Freq.	ALTERNATE CUT SETS
43	100.0	0.0	1.6E-007	ACPTFSNRMEGTSOEQ, TOR-S60-FMIS
44	100.0	0.0	1.6E-007	ACPTFSNRMEGTSOEQ, TOR-S61-FMIS
45	100.0	0.0	1.6E-007	SD3SWIG102ASOZEQ, TOR-S09-FMIS
46	100.0	0.0	1.6E-007	SD3SWIG102ASOZEQ, TOR-S60-FMIS
47	100.0	0.0	1.6E-007	SD3SWIG102ASOZEQ, TOR-S61-FMIS
48	100.0	0.0	1.6E-007	DCPCBHBKR28SOZFH, SD3BRKRECTFSOZEQ
49	100.0	0.0	1.6E-007	DCPCBHEMCCSSOZEQ, SD3BRKRECTFSOZEQ
50	100.0	0.0	1.4E-007	ACPEPGPRPGNOPFEQ, DCPBTRBATT1FDOFH, DCPBTRBATT2FDOFH
51	100.0	0.0	1.2E-007	ACPTFSEMERGOPFEQ, DCPCBHBKR28SOZFH
52	100.0	0.0	1.2E-007	ACPTFSEMERGOPFEQ, DCPCBHEMCCSSOZEQ
53	100.0	0.0	1.1E-007	ACPEPGPRPGNFDOEQ, SD3BRKG102ASOZEQ, SD3PMPG102BFTSEQ
54	100.0	0.0	1.0E-007	SD3PMPG102AFTREQ, TOR-S09-FMIS
55	100.0	0.0	1.0E-007	SD3PMPG102AFTREQ, TOR-S60-FMIS
56	100.0	0.0	1.0E-007	SD3PMPG102AFTREQ, TOR-S61-FMIS
57	100.0	0.0	9.3E-008	ACPEPGPRPGNOPFEQ, DCPBUSEMCC-BUSEQ
58	100.0	0.0	8.7E-008	DCPBTRBAT12FDOFH, DCPBTRBTO12FDOFH, SD3BRKRECTFSOZEQ
59	100.0	0.0	8.7E-008	ACPEPGPRPGNFDOEQ, DCPBTRBATT1FDOFH, DCPCBHBAT2BSOZFH
60	100.0	0.0	8.7E-008	ACPEPGPRPGNFDOEQ, DCPBTRBATT1FDOFH, DCPCBHBKR2BSOZFH
61	100.0	0.0	8.7E-008	ACPEPGPRPGNFDOEQ, DCPBTRBATT2FDOFH, DCPCBHBAT1BSOZFH
62	100.0	0.0	8.7E-008	ACPEPGPRPGNFDOEQ, DCPBTRBATT2FDOFH, DCPCBHBKR1BSOZFH
63	100.0	0.0	8.7E-008	ACPEPGPRPGNFDOEQ, DCPBTRBATT2FDOFH, DCPCBHT1BKRSOZFH
64	100.0	0.0	8.3E-008	ACPEPGPRPGNFDOEQ, SD3PMPG102BFTSEQ, SD3TFSG102AOPFEQ
65	100.0	0.0	6.4E-008	ACPTFSEMERGOPFEQ, DCPBTRBAT12FDOFH, DCPBTRBTO12FDOFH
66	100.0	0.0	5.5E-008	ACPCBLPRPGNSOZEQ, DCPCBHBKR28SOZFH
67	100.0	0.0	5.5E-008	ACPCBLPRPGNSOZEQ, DCPCBHEMCCSSOZEQ
68	100.0	0.0	4.0E-008	ACPEPGPRPGNFDOEQ, SD3BRKG102ASOZEQ, SD3SWIG102BLO-EQ
69	100.0	0.0	3.7E-008	ACPEPGPRPGNVTMEQ, DCPBTRBATT1FDOFH, DCPBTRBATT2FDOFH
70	100.0	0.0	3.5E-008	SD3LOLOLEVLSATEQ

SYSTEM CUT SETS (QUANTIFICATION) REPORT

Family : HFBR-TOR   Analysis : RANDOM

System : SL-TOP   Case : ALTERNATE

Mincut Upper Bound : 1.397E-001

Cut No.	% Total	% Cut Set	Prob/ Freq.	ALTERNATE CUT SETS
1	71.4	71.4	9.9E-002	ACPEPGPRPGNFDOEQ
2	92.9	21.4	3.0E-002	ACPEPGPRPGNOPFEQ
3	98.7	5.8	8.1E-003	ACPEPGPRPGNVTMEQ
4	100.0	3.5	5.0E-003	TOR-PROP-MSIV
5	100.0	0.5	7.5E-004	SDLPMPG102AFTREQ
6	100.0	0.2	4.0E-004	SDLBRKRECTFSOZEQ
7	100.0	0.2	3.0E-004	ACPTFSEMERGOPFEQ
8	100.0	0.1	1.3E-004	ACPCBLPRPGNSOZEQ
9	100.0	0.0	1.1E-004	SDLRTFG102AFDOEQ
10	100.0	0.0	1.7E-005	SDLLOLOLEVLSATEQ
11	100.0	0.0	1.3E-005	SDLCKVP99XXILKEQ
12	100.0	0.0	2.7E-006	ACPBUSEMCC-BUSEQ
13	100.0	0.0	2.4E-006	ACPTFSNRMEGTSOEQ
14	100.0	0.0	2.4E-006	SDLSWIG102ASOZEQ
15	100.0	0.0	2.4E-006	SDLTFSG102AFDOEQ
16	100.0	0.0	2.4E-007	DMWLOSS

SYSTEM CUT SETS (QUANTIFICATION) REPORT

Family : HFBR-TOR Analysis : RANDOM

System : SPNFA Case : ALTERNATE

Mincut Upper Bound : 9.161E-002

Cut No.	% Total	% Cut Set	Prob/ Freq.	ALTERNATE CUT SETS
1	98.2	98.2	9.0E-002	TOR-HEP-SP23M19
2	99.3	1.0	1.0E-003	SCWMNVW8-19HEPEQ
3	99.8	0.5	5.0E-004	TOR-HEP-SPWS1X
4	99.9	0.1	1.0E-004	SCWMOVWS-1XHEPEQ
5	100.0	0.0	7.2E-005	SCWCOOE101ASSLEQ
6	100.0	0.0	5.0E-005	SCWMOVHEP12BFTEQ, TOR-HEP-SP11M12
7	100.0	0.0	4.0E-005	SCWCKVWS-20FTOPH, TOR-HEP-SSSTNK
8	100.0	0.0	1.0E-005	SCWMOVHEP12BFTEQ, SCWMOVWS-12HEPEQ
9	100.0	0.0	2.3E-006	SCWMOVWS-1XSCZEQ
10	100.0	0.0	4.5E-007	SCWCKVWS-20FTOPH, SCWTNKFA309HEPPH
11	100.0	0.0	2.3E-007	SCWMOVWS-12BFTEQ, SCWMOVWS-12SCZEQ
12	100.0	0.0	4.5E-008	SCWCKVWS-20FTOPH, SCWMNVMV-29FTOPH

SYSTEM CUT SETS (QUANTIFICATION) REPORT

Family : HFBR-TOR   Analysis : RANDOM

System : SPNFB   Case : ALTERNATE

Mincut Upper Bound : 9.161E-002

Cut No.	% Total	% Cut Set	Prob/ Freq.	ALTERNATE CUT SETS
1	98.2	98.2	9.0E-002	TOR-HEP-SP56M20
2	99.3	1.0	1.0E-003	SCWMNVW9-20HEPEQ
3	99.8	0.5	5.0E-004	TOR-HEP-SPM2X
4	99.9	0.1	1.0E-004	SCWMOVWS-2XHEPEQ
5	100.0	0.0	7.2E-005	SCWCOOE101BSSLEQ
6	100.0	0.0	5.0E-005	SCWMOVHEP12BFTEQ, TOR-HEP-SP11M12
7	100.0	0.0	4.0E-005	SCWCKVWS-20FTOPH, TOR-HEP-SSSTNK
8	100.0	0.0	1.0E-005	SCWMOVHEP12BFTEQ, SCWMOVWS-12HEPEQ
9	100.0	0.0	2.3E-006	SCWMOVWS-2XSCZEQ
10	100.0	0.0	4.5E-007	SCWCKVWS-20FTOPH, SCWTNKFA309HEPPH
11	100.0	0.0	2.3E-007	SCWMOVWS-12BFTEQ, SCWMOVWS-12SCZEQ
12	100.0	0.0	7.5E-008	SCWCKVWS-20FTOPH, SCWLCVMCV-1FTCPH, TOR-HEP-SP6MN25
13	100.0	0.0	4.5E-008	SCWCKVWS-20FTOPH, SCWMNVMV-29FTOPH

SYSTEM CUT SETS (QUANTIFICATION) REPORT

Family : HFBR-TOR Analysis : RANDOM
System : SC-TOP2 Case : ALTERNATE
Mincut Upper Bound : 1.565E-001

Cut No.	% Total	% Cut Set	Prob/ Freq.	ALTERNATE CUT SETS
1	99.6	99.6	1.5E-001	TOR-S07-FMIS
2	100.0	0.3	5.0E-004	TOR-HEP-SSSA3X
3	100.0	0.0	1.0E-004	SCWAOVWR-3XHEPEQ
4	100.0	0.0	4.5E-005	TOR-HEP-SS141518, TOR-HEP-SS1418
5	100.0	0.0	7.0E-006	TOR-HEP-SS141518, TOR-HEP-SSSTNK, TOR-S21-FMIS
6	100.0	0.0	6.4E-006	SCWAOVWR-3XSCZEQ
7	100.0	0.0	5.0E-007	SCWMNVW1418HEPEQ, TOR-HEP-SS141518
8	100.0	0.0	2.5E-007	TOR-HEP-SS141518, TOR-HEP-SSSM3X
9	100.0	0.0	7.8E-008	SCWTNKFA309HEPPH, TOR-HEP-SS141518, TOR-S21-FMIS
10	100.0	0.0	5.0E-008	SCWMOVWS-3XHEPEQ, TOR-HEP-SS141518
11	100.0	0.0	2.2E-008	TOR-HEP-SC4MNV19, TOR-HEP-SC5MNV1, TOR-HEP-SS1418
12	100.0	0.0	2.0E-008	SCWCKVFWCKVFTOEQ, TOR-HEP-SC5MNV1, TOR-HEP-SS1418
13	100.0	0.0	2.0E-008	SCWCKVWS-20FTOPH, TOR-HEP-SS141518, TOR-HEP-SSSTNK

SYSTEM CUT SETS (QUANTIFICATION) REPORT

Family : HFBR-TOR   Analysis : RANDOM

System : FR-TOP   Case : ALTERNATE

Mincut Upper Bound : 3.260E-005

Cut No.	% Total	% Cut Set	Prob/ Freq.	ALTERNATE CUT SETS
1	97.5	97.5	3.1E-005	FRVFRVBTO2VFTOVL, FRVFRVRANDMFTOVL
2	100.0	2.4	8.0E-007	FRVFRV2OF4VFTOVL

SYSTEM CUT SETS (QUANTIFICATION) REPORT

Family : HFBR-TOR   Analysis : RANDOM
System : DEPRESS   Case : ALTERNATE
Mincut Upper Bound : 2.451E-001

Cut No.	% Total	% Cut Set	Prob/ Freq.	ALTERNATE CUT SETS
1	26.7	26.7	6.5E-002	TOR-S30-300A-IX, TOR-S30-300B-IX, TOR-S30-P102
2	52.3	25.6	6.2E-002	TOR-HEP-DEP-300, TOR-S30-P102
3	78.0	25.6	6.2E-002	TOR-S02-FMIS, TOR-S30-P102
4	88.3	10.3	2.5E-002	TOR-HEP-DEP-102, TOR-S30-300A-IX, TOR-S30-300B-IX
5	98.2	9.9	2.4E-002	TOR-HEP-DEP-102, TOR-HEP-DEP-300
6	100.0	9.9	2.4E-002	TOR-HEP-DEP-102, TOR-S02-FMIS
7	100.0	1.6	4.0E-003	DEPAOV300ABHEPOP, TOR-S30-P102
8	100.0	0.6	1.5E-003	DEPAOV300ABHEPOP, TOR-HEP-DEP-102
9	100.0	0.3	8.1E-004	DEPMNVP102XHEPOP, TOR-S30-300A-IX, TOR-S30-300B-IX
10	100.0	0.3	7.8E-004	DEPMNVP102XHEPOP, TOR-HEP-DEP-300
11	100.0	0.3	7.8E-004	DEPMNVP102XHEPOP, TOR-S02-FMIS
12	100.0	0.0	1.5E-004	DEPMNV300AKSCZOP, TOR-S30-300B-IX, TOR-S30-P102
13	100.0	0.0	1.5E-004	DEPMNV300BKSCZOP, TOR-S30-300A-IX, TOR-S30-P102
14	100.0	0.0	6.0E-005	DEPMNV300AKSCZOP, TOR-HEP-DEP-102, TOR-S30-300B-IX
15	100.0	0.0	6.0E-005	DEPMNV300BKSCZOP, TOR-HEP-DEP-102, TOR-S30-300A-IX
16	100.0	0.0	5.0E-005	DEPAOV300ABHEPOP, DEPMNVP102XHEPOP
17	100.0	0.0	3.0E-005	DEPAOVBT300FTOOP, DEPAOVCM300FTOOP, TOR-S30-P102
18	100.0	0.0	1.6E-005	DEPMNV300AISCZOP, TOR-S30-300B-IX, TOR-S30-P102
19	100.0	0.0	1.6E-005	DEPMNV300AXSCZOP, TOR-S30-300B-IX, TOR-S30-P102
20	100.0	0.0	1.6E-005	DEPMNV300BISCZOP, TOR-S30-300A-IX, TOR-S30-P102
21	100.0	0.0	1.6E-005	DEPMNV300BXSCZOP, TOR-S30-300A-IX, TOR-S30-P102
22	100.0	0.0	1.6E-005	DEPCNC300AXILKOP, TOR-S30-P102
23	100.0	0.0	1.5E-005	DEPMNVP102XFTOOP, TOR-S30-300A-IX, TOR-S30-300B-IX
24	100.0	0.0	1.5E-005	DEPMNVP102XFTOOP, TOR-HEP-DEP-300
25	100.0	0.0	1.5E-005	DEPMNVP102XFTOOP, TOR-S02-FMIS
26	100.0	0.0	1.1E-005	DEPAOVBT300FTOOP, DEPAOVCM300FTOOP, TOR-HEP-DEP-102
27	100.0	0.0	6.5E-006	DEPFHZ300AXHPZOP, TOR-S30-300B-IX, TOR-S30-P102
28	100.0	0.0	6.5E-006	DEPFHZ300BXHPZOP, TOR-S30-300A-IX, TOR-S30-P102
29	100.0	0.0	6.2E-006	DEPMNV300AISCZOP, TOR-HEP-DEP-102, TOR-S30-300B-IX
30	100.0	0.0	6.2E-006	DEPMNV300AXSCZOP, TOR-HEP-DEP-102,

SYSTEM CUT SETS (QUANTIFICATION) REPORT

Family : HFBR-TOR   Analysis : RANDOM
System : DEPRESS   Case : ALTERNATE
Mincut Upper Bound : 2.451E-001

Cut No.	% Total	% Cut Set	Prob/ Freq.	ALTERNATE CUT SETS
				TOR-S30-300B-IX
31	100.0	0.0	6.2E-006	DEPMNV300BISCZOP, TOR-HEP-DEP-102, TOR-S30-300A-IX
32	100.0	0.0	6.2E-006	DEPMNV300BXSCZOP, TOR-HEP-DEP-102, TOR-S30-300A-IX
33	100.0	0.0	6.2E-006	DEPCNC300AXILKOP, TOR-HEP-DEP-102
34	100.0	0.0	5.8E-006	DEPFHZ300AXILKOP, TOR-S30-300B-IX, TOR-S30-P102
35	100.0	0.0	5.8E-006	DEPFHZ300BXILKOP, TOR-S30-300A-IX, TOR-S30-P102
36	100.0	0.0	2.5E-006	DEPFHZ300AXHPZOP, TOR-HEP-DEP-102, TOR-S30-300B-IX
37	100.0	0.0	2.5E-006	DEPFHZ300BXHPZOP, TOR-HEP-DEP-102, TOR-S30-300A-IX
38	100.0	0.0	2.2E-006	DEPFHZ300AXILKOP, TOR-HEP-DEP-102, TOR-S30-300B-IX
39	100.0	0.0	2.2E-006	DEPFHZ300BXILKOP, TOR-HEP-DEP-102, TOR-S30-300A-IX
40	100.0	0.0	1.9E-006	DEPMNV300AKSCZOP, DEPMNVP102XHEPOP, TOR-S30-300B-IX
41	100.0	0.0	1.9E-006	DEPMNV300BKSCZOP, DEPMNVP102XHEPOP, TOR-S30-300A-IX
42	100.0	0.0	1.5E-006	DEPACC300AXILKOP, TOR-S30-300B-IX, TOR-S30-P102
43	100.0	0.0	1.5E-006	DEPACC300BXILKOP, TOR-S30-300A-IX, TOR-S30-P102
44	100.0	0.0	9.8E-007	DEPAOV300ABHEPOP, DEPMNVP102XFTOOP
45	100.0	0.0	6.0E-007	DEPACC300AXILKOP, TOR-HEP-DEP-102, TOR-S30-300B-IX
46	100.0	0.0	6.0E-007	DEPACC300BXILKOP, TOR-HEP-DEP-102, TOR-S30-300A-IX
47	100.0	0.0	3.7E-007	DEPAOVBT300FTOOP, DEPAOVCM300FTOOP, DEPMNVP102XHEPOP
48	100.0	0.0	3.7E-007	DEPMNV300AKSCZOP, DEPMNV300BKSCZOP, TOR-S30-P102
49	100.0	0.0	2.3E-007	DEPAOV300AXFTOOP, DEPAOV300BXFTOOP, TOR-S30-P102
50	100.0	0.0	2.0E-007	DEPMNV300AISCZOP, DEPMNVP102XHEPOP, TOR-S30-300B-IX

SYSTEM CUT SETS (QUANTIFICATION) REPORT

Family : HFBR-TOR   Analysis : RANDOM

System : SCMDMU   Case : ALTERNATE

Mincut Upper Bound : 7.510E-001

Cut No.	% Total	% Cut Set	Prob/ Freq.	ALTERNATE CUT SETS
1	53.6	53.6	4.0E-001	TOR-S30-H5A1317C
2	100.0	53.6	4.0E-001	TOR-S30-P1578788
3	100.0	11.9	9.0E-002	TOR-HEP-SCMDMU
4	100.0	11.9	8.9E-002	ACPEPGPRPGNFDOEQ, HWTLTM90HESHEPVV
5	100.0	10.7	8.1E-002	HWTLTM90HESHEPVV, TOR-HEP-SCM9MPU
6	100.0	3.6	2.7E-002	ACPEPGPRPGNOPFEQ, HWTLTM90HESHEPVV
7	100.0	1.3	1.0E-002	HWTALIGN---HEPVV
8	100.0	1.2	8.9E-003	ACPEPGPRPGNFDOEQ, TOR-HEP-SCM9MHES
9	100.0	1.0	8.1E-003	TOR-HEP-SCM9MHES, TOR-HEP-SCM9MPU
10	100.0	0.9	7.3E-003	ACPEPGPRPGNVTMEQ, HWTLTM90HESHEPVV
11	100.0	0.6	4.5E-003	HWTLTM90HESHEPVV, TOR-PROP-MSIV
12	100.0	0.4	3.0E-003	ACPEPGPRPGNFDOEQ, HWTSRVSV103FTREQ
13	100.0	0.3	2.7E-003	HWTLTM90HESHEPVV, HWTPMPG104CFTSEQ
14	100.0	0.3	2.7E-003	ACPEPGPRPGNOPFEQ, TOR-HEP-SCM9MHES
15	100.0	0.3	2.7E-003	HWTSRVSV103FTREQ, TOR-HEP-SCM9MPU
16	100.0	0.1	9.0E-004	HWTLTM90HESHEPVV, HWTLTM90PMPHEPVV
17	100.0	0.1	9.0E-004	ACPEPGPRPGNOPFEQ, HWTSRVSV103FTREQ
18	100.0	0.1	7.3E-004	ACPEPGPRPGNVTMEQ, TOR-HEP-SCM9MHES
19	100.0	0.0	6.7E-004	HWTLTM90HESHEPVV, HWTPMPG104CFTREQ
20	100.0	0.0	4.5E-004	TOR-HEP-SCM9MHES, TOR-PROP-MSIV
21	100.0	0.0	4.5E-004	HWTCKVINJCTFTOOP
22	100.0	0.0	4.5E-004	HWTCKVNNSSCFTOOP
23	100.0	0.0	4.0E-004	HWTCKVG104CFTOEQ, HWTLTM90HESHEPVV
24	100.0	0.0	2.7E-004	HWTPMPG104CFTSEQ, TOR-HEP-SCM9MHES
25	100.0	0.0	2.7E-004	ACPTFSEMERGOPFEQ, HWTLTM90HESHEPVV
26	100.0	0.0	2.4E-004	ACPEPGPRPGNVTMEQ, HWTSRVSV103FTREQ
27	100.0	0.0	2.4E-004	HWTLTM90HESHEPVV, HWTPMPG104CUTMVV
28	100.0	0.0	1.5E-004	HWTSRVSV103FTREQ, TOR-PROP-MSIV
29	100.0	0.0	1.2E-004	ACPCBLG104CSOZEQ, HWTLTM90HESHEPVV
30	100.0	0.0	1.2E-004	ACPCBLPRPGNSOZEQ, HWTLTM90HESHEPVV
31	100.0	0.0	1.0E-004	HESMNV-HE5AFTOOP
32	100.0	0.0	1.0E-004	HWTMNV-P01-FTOOP
33	100.0	0.0	1.0E-004	HWTMNV-P03-FTOOP
34	100.0	0.0	1.0E-004	HWTMNV-P57-FTOOP
35	100.0	0.0	1.0E-004	HWTMNV-P58-FTCEQ
36	100.0	0.0	1.0E-004	HWTMNV-P87-FTOOP
37	100.0	0.0	1.0E-004	HWTMNV-P88-FTOOP
38	100.0	0.0	1.0E-004	HWTMNV-P89-FTCEQ
39	100.0	0.0	1.0E-004	OFGMNV--P17FTCOP
40	100.0	0.0	9.2E-005	HWTPMPG104CFTSEQ, HWTSRVSV103FTREQ
41	100.0	0.0	9.0E-005	HWTLTM90PMPHEPVV, TOR-HEP-SCM9MHES
42	100.0	0.0	9.0E-005	HWTLTM90HESHEPVV, HWTMNV-P174FTOEQ
43	100.0	0.0	9.0E-005	HWTLTM90HESHEPVV, HWTMNV-P175FTOEQ
44	100.0	0.0	6.7E-005	HWTPMPG104CFTREQ, TOR-HEP-SCM9MHES
45	100.0	0.0	4.4E-005	ACPEPGPRPGNFDOEQ, HWTCKV-YYYYFTOEQ
46	100.0	0.0	4.0E-005	HWTCKV-YYYYFTOEQ, TOR-HEP-SCM9MPU
47	100.0	0.0	4.0E-005	HWTCKVG104CFTOEQ, TOR-HEP-SCM9MHES

SYSTEM CUT SETS (QUANTIFICATION) REPORT

Family : HFBR-TOR   Analysis : RANDOM

System : SCMDMU   Case : ALTERNATE

Mincut Upper Bound : 7.510E-001

Cut No.	% Total	% Cut Set	Prob/ Freq.	ALTERNATE CUT SETS
48	100.0	0.0	3.0E-005	HWTLTM90PMPHEPVV, HWTSRVSV103FTREQ
49	100.0	0.0	2.7E-005	ACPTFSEMERGOPFEQ, TOR-HEP-SCM9MHES
50	100.0	0.0	2.4E-005	HWTPMPG104CUTMVV, TOR-HEP-SCM9MHES

SYSTEM CUT SETS (QUANTIFICATION) REPORT

Family : HFBR-TOR   Analysis : RANDOM

System : SCMSD   Case : ALTERNATE

Mincut Upper Bound : 2.403E-001

Cut No.	% Total	% Cut Set	Prob/ Freq.	ALTERNATE CUT SETS
1	64.9	64.9	1.5E-001	TOR-S07-FMIS
2	100.0	37.4	9.0E-002	TOR-HEP-SSS
3	100.0	4.1	1.0E-002	SCMSYS-HEPFTSVV
4	100.0	0.2	5.0E-004	TOR-HEP-SSSA3X
5	100.0	0.0	1.0E-004	HWDMNV-DA5-FTOEQ
6	100.0	0.0	1.0E-004	HWDMNV-DA6-FTOEQ
7	100.0	0.0	1.0E-004	SCWAOVWR-3XHEPEQ
8	100.0	0.0	4.5E-005	TOR-HEP-SS141518, TOR-HEP-SS1418
9	100.0	0.0	1.0E-005	SDCMNV-BETAFTCEQ, SDCMNV-PXXXFTCEQ
10	100.0	0.0	7.0E-006	TOR-HEP-SS141518, TOR-HEP-SSSTNK, TOR-S21-FMIS
11	100.0	0.0	6.4E-006	SCWAOVWR-3XSCZEQ
12	100.0	0.0	5.0E-007	SCWMNVW1418HEPEQ, TOR-HEP-SS141518
13	100.0	0.0	2.5E-007	TOR-HEP-SS141518, TOR-HEP-SSSM3X
14	100.0	0.0	7.8E-008	SCWTNKFA309HEPPH, TOR-HEP-SS141518, TOR-S21-FMIS
15	100.0	0.0	5.0E-008	SCWMOVWS-3XHEPEQ, TOR-HEP-SS141518
16	100.0	0.0	2.2E-008	TOR-HEP-SC4MNV19, TOR-HEP-SC5MNV1, TOR-HEP-SS1418
17	100.0	0.0	2.0E-008	SCWCKVFWCKVFTOEQ, TOR-HEP-SC5MNV1, TOR-HEP-SS1418
18	100.0	0.0	2.0E-008	SCWCKVWS-20FTOPH, TOR-HEP-SS141518, TOR-HEP-SSSTNK

SYSTEM CUT SETS (QUANTIFICATION) REPORT

Family : HFBR-TOR   Analysis : RANDOM
System : PW1   Case : ALTERNATE

Mincut Upper Bound : 8.439E-001

Cut No.	% Total	% Cut Set	Prob/ Freq.	ALTERNATE CUT SETS
1	47.7	47.7	4.0E-001	TOR-S30-P1112T28
2	95.5	47.7	4.0E-001	TOR-S30-TW21457
3	100.0	46.8	3.9E-001	PWS---LPHESFTRVV, TOR-S30-HE2789
4	100.0	10.6	9.0E-002	TOR-HEP-PW1
5	100.0	10.6	9.0E-002	TOR-HEP-PW3-ALN
6	100.0	3.1	2.6E-002	TOR-S06-FMIS, TOR-S30-300A-IX, TOR-S30-300B-IX, TOR-S30-P102
7	100.0	3.0	2.5E-002	TOR-HEP-DEP-300, TOR-S06-FMIS, TOR-S30-P102
8	100.0	3.0	2.5E-002	TOR-S02-FMIS, TOR-S06-FMIS, TOR-S30-P102
9	100.0	1.2	1.0E-002	TOR-HEP-DEP-102, TOR-S06-FMIS, TOR-S30-300A-IX, TOR-S30-300B-IX
10	100.0	1.1	1.0E-002	PWSLWM-HEP-ALNVV
11	100.0	1.1	1.0E-002	PWSSYS-HEP-ALNVV
12	100.0	1.1	9.8E-003	TOR-HEP-DEP-102, TOR-HEP-DEP-300, TOR-S06-FMIS
13	100.0	1.1	9.8E-003	TOR-HEP-DEP-102, TOR-S02-FMIS, TOR-S06-FMIS
14	100.0	0.1	1.6E-003	DEPAOV300ABHEPOP, TOR-S06-FMIS, TOR-S30-P102
15	100.0	0.1	1.0E-003	DWSXFRHOSEFAILEQ
16	100.0	0.0	6.2E-004	DEPAOV300ABHEPOP, TOR-HEP-DEP-102, TOR-S06-FMIS
17	100.0	0.0	3.2E-004	DEPMNVP102XHEPOP, TOR-S06-FMIS, TOR-S30-300A-IX, TOR-S30-300B-IX
18	100.0	0.0	3.1E-004	DEPMNVP102XHEPOP, TOR-HEP-DEP-300, TOR-S06-FMIS
19	100.0	0.0	3.1E-004	DEPMNVP102XHEPOP, TOR-S02-FMIS, TOR-S06-FMIS
20	100.0	0.0	1.0E-004	AWPMNV-DW42FTOEQ
21	100.0	0.0	1.0E-004	AWPMNV-DW43FTOEQ
22	100.0	0.0	1.0E-004	AWPMNV-TW50FTCEQ
23	100.0	0.0	1.0E-004	CCWMNV-TW19FTCEQ
24	100.0	0.0	1.0E-004	DWSMNVXXXX1FTOEQ
25	100.0	0.0	1.0E-004	DWSMNVXXXX2FTOEQ
26	100.0	0.0	1.0E-004	DWSMNVXXXX3FTOEQ
27	100.0	0.0	1.0E-004	PWSMNV-P112FTOOP
28	100.0	0.0	1.0E-004	PWSMNV-TW21FTOOP
29	100.0	0.0	1.0E-004	PWSMNV-TW24FTOOP
30	100.0	0.0	1.0E-004	PWSMNV-TW25FTOOP
31	100.0	0.0	1.0E-004	PWSMNV-TW27FTOOP
32	100.0	0.0	1.0E-004	PWSMNV-TW28FTOOP
33	100.0	0.0	1.0E-004	PWSMNVP111-FTOOP
34	100.0	0.0	9.8E-005	HESMNV-HE27FTOOP, PWS---LPHESFTRVV
35	100.0	0.0	9.8E-005	HESMNV-HE28FTOOP, PWS---LPHESFTRVV
36	100.0	0.0	9.8E-005	HESMNV-HE29FTOOP, PWS---LPHESFTRVV
37	100.0	0.0	6.8E-005	PW1AOVHC102FTOOP, TOR-S30-300A-IX, TOR-S30-300B-IX, TOR-S30-P102
38	100.0	0.0	6.6E-005	PW1AOVHC102FTOOP, TOR-HEP-DEP-300, TOR-S30-P102
39	100.0	0.0	6.6E-005	PW1AOVHC102FTOOP, TOR-S02-FMIS, TOR-S30-P102

SYSTEM CUT SETS (QUANTIFICATION) REPORT

Family : HFBR-TOR Analysis : RANDOM

System : PW1 Case : ALTERNATE

Mincut Upper Bound : 8.439E-001

Cut No.	% Total	% Cut Set	Prob/ Freq.	ALTERNATE CUT SETS
40	100.0	0.0	6.2E-005	DEPMNV300AKSCZOP, TOR-S06-FMIS, TOR-S30-300B-IX, TOR-S30-P102
41	100.0	0.0	6.2E-005	DEPMNV300BKSCZOP, TOR-S06-FMIS, TOR-S30-300A-IX, TOR-S30-P102
42	100.0	0.0	4.0E-005	PWSFLX-HOSE-PZOP
43	100.0	0.0	4.0E-005	PWSMNV-TW28-PZOP
44	100.0	0.0	2.6E-005	PW1AOVHC102FTOOP, TOR-HEP-DEP-102, TOR-S30-300A-IX, TOR-S30-300B-IX
45	100.0	0.0	2.5E-005	PW1AOVHC102FTOOP, TOR-HEP-DEP-102, TOR-HEP-DEP-300
46	100.0	0.0	2.5E-005	PW1AOVHC102FTOOP, TOR-HEP-DEP-102, TOR-S02-FMIS
47	100.0	0.0	2.4E-005	DEPMNV300AKSCZOP, TOR-HEP-DEP-102, TOR-S06-FMIS, TOR-S30-300B-IX
48	100.0	0.0	2.4E-005	DEPMNV300BKSCZOP, TOR-HEP-DEP-102, TOR-S06-FMIS, TOR-S30-300A-IX
49	100.0	0.0	2.0E-005	DEPAOV300ABHEPOP, DEPMNVP102XHEPOP, TOR-S06-FMIS
50	100.0	0.0	1.2E-005	DEPAOVBT300FTOOP, DEPAOVCM300FTOOP, TOR-S06-FMIS, TOR-S30-P102

Appendix E.3
Conditional Probabilities Without and With Correction for Tornado Induced LOOP24 Sequences

Correction is defined as: multiplication by the product of the availabilities of successful top events. (Successful top events for each sequence are listed in Appendix D.2.)

Table E.3 Conditional Probabilities Without and With Correction for Tornado Induced LOOP24 Sequences

Sequence #	Cond. Probability w/o Correction*	Cond. Probability w. Correction*
3	2.024E-1	2.271E-2
5	2.000E-1	8.974E-2
7	7.473E-2	4.470E-2
8	5.102E-6	3.052E-6
11	2.000E-2	2.466E-3
13	2.008E-2	9.899E-3
15	7.083E-3	4.656E-3
16	4.578E-7	3.010E-7
19	2.000E-2	2.466E-3
21	2.008E-2	9.899E-3
23	7.083E-3	4.614E-3
24	4.578E-7	3.010E-7
27	1.868E-3	1.012E-3
29	6.558E-4	4.738E-4
30	4.018E-8	2.903E-8
33	2.016E-2	2.210E-3
35	3.251E-1	1.425E-1
37	6.917E-2	4.042E-2
38	4.687E-6	2.738E-6
40	3.138E-2	4.092E-3
42	5.933E-2	3.095E-2
44	1.115E-2	7.756E-3
45	7.217E-7	5.020E-7
48	1.862E-3	2.242E-4
50	3.513E-2	1.692E-2

* Truncation Value: 10E-8

Table E.3 (continued)

Sequence #	Cond. Probability w/o Correction*	Cond. Probability w. Correction*
52	6.538E-3	4.198E-3
53	4.091E-7	2.627E-7
55	2.912E-3	5.629E-4
57	5.580E-3	3.199E-3
59	1.021E-3	7.805E-4
60	5.797E-8	4.431E-8
63	1.862E-3	2.242E-4
65	3.513E-2	1.692E-2
67	6.538E-3	4.198E-3
68	4.091E-7	2.627E-7
70	2.912E-3	4.173E-4
72	5.580E-3	3.200E-3
74	1.021E-3	7.805E-4
75	5.797E-8	4.431E-8
78	1.714E-4	2.268E-5
80	3.303E-3	1.748E-3
82	6.016E-4	4.245E-4
83	2.571E-8	1.814E-8
85	2.900E-4	2.436E-4
88	3.388E-2	4.388E-3
90	3.397E-2	1.760E-2
92	1.203E-2	8.310E-3
93	7.935E-7	5.481E-7
96	3.142E-3	4.471E-4

* Truncation Value: 10E-8

Table E.3 (continued)

Sequence #	Cond. Probability w/o Correction*	Cond. Probability w. Correction*
98	3.157E-3	1.797E-3
100	1.107E-3	8.403E-4
101	6.965E-8	5.287E-8
104	3.142E-3	4.471E-4
106	3.157E-3	1.797E-3
108	1.107E-3	8.403E-4
109	6.965E-8	5.287E-8
112	2.915E-4	1.824E-4
114	1.012E-4	8.442E-5
115	--	--
118	3.171E-3	4.011E-4
120	5.912E-2	2.992E-2
122	1.111E-2	7.496E-3
123	7.217E-7	4.869E-7
125	4.954E-3	7.461E-4
127	9.486E-3	5.714E-3
129	1.745E-3	1.402E-3
130	1.004E-7	8.065E-8
133	2.902E-4	4.034E-5
135	5.560E-3	3.092E-3
137	1.019E-3	7.556E-4
138	5.797E-8	4.298E-8
140	4.543E-4	7.519E-5
142	8.693E-4	5.755E-4

* Truncation Value: 10E-8

Table E.3 (continued)

Sequence #	Cond. Probability w/o Correction*	Cond. Probability w. Correction*
144	1.573E-4	1.388E-4
145	--	--
148	2.902E-4	4.034E-5
150	5.560E-3	3.092E-3
152	1.019E-3	7.556E-4
153	5.797E-8	4.298E-8
155	4.543E-4	7.519E-5
157	8.693E-4	5.755E-4
159	1.573E-4	1.388E-4
160	--	--
163	2.618E-5	4.000E-6
165	5.128E-4	3.133E-4
167	9.138E-5	7.446E-5
168	--	--
170	4.446E-5	4.313E-5
171	4.815E-3	4.815E-3
172	2.394E-6	2.394E-6

* Truncation Value: 10E-8

APPENDIX F

Important Sequence Cutsets for Tornado Induced Event Tree Sequences Ranked 1-10

SEQUENCE CUT SETS (QUANTIFICATION) REPORT

Family : HFBR-TOR　　Sequence : 035　　**Rank 1**
Analysis : RANDOM　　Event Tree : LOOP24
Case : ALTERNATE　　Init. Event : IE-LOOP24
Mincut Upper Bound : 3.251E-001

Cut No.	% Total	% Cut Set	Prob/ Freq.	ALTERNATE CUT SETS
1	11.1	11.1	3.6E-002	ACPEPGPRPGNFDOEQ, HWTLTM90HESHEPVV, TOR-S30-P1112T28
2	22.2	11.1	3.6E-002	ACPEPGPRPGNFDOEQ, HWTLTM90HESHEPVV, TOR-S30-TW21457
3	33.1	10.9	3.5E-002	ACPEPGPRPGNFDOEQ, HWTLTM90HESHEPVV, PWS---LPHESFTRVV, TOR-S30-HE2789
4	38.1	4.9	1.6E-002	ACPEPGPRPGNFDOEQ, TOR-S30-H5A1317C, TOR-S30-P1112T28
5	43.1	4.9	1.6E-002	ACPEPGPRPGNFDOEQ, TOR-S30-H5A1317C, TOR-S30-TW21457
6	48.1	4.9	1.6E-002	ACPEPGPRPGNFDOEQ, TOR-S30-P1112T28, TOR-S30-P1578788
7	53.1	4.9	1.6E-002	ACPEPGPRPGNFDOEQ, TOR-S30-P1578788, TOR-S30-TW21457
8	58.0	4.8	1.5E-002	ACPEPGPRPGNFDOEQ, PWS---LPHESFTRVV, TOR-S30-H5A1317C, TOR-S30-HE2789
9	62.9	4.8	1.5E-002	ACPEPGPRPGNFDOEQ, PWS---LPHESFTRVV, TOR-S30-HE2789, TOR-S30-P1578788
10	66.2	3.3	1.0E-002	ACPEPGPRPGNOPFEQ, HWTLTM90HESHEPVV, TOR-S30-P1112T28
11	69.6	3.3	1.0E-002	ACPEPGPRPGNOPFEQ, HWTLTM90HESHEPVV, TOR-S30-TW21457
12	72.8	3.2	1.0E-002	ACPEPGPRPGNOPFEQ, HWTLTM90HESHEPVV, PWS---LPHESFTRVV, TOR-S30-HE2789
13	75.3	2.4	8.0E-003	ACPEPGPRPGNFDOEQ, HWTLTM90HESHEPVV, TOR-HEP-PW1
14	77.8	2.4	8.0E-003	ACPEPGPRPGNFDOEQ, HWTLTM90HESHEPVV, TOR-HEP-PW3-ALN
15	79.3	1.5	4.8E-003	ACPEPGPRPGNOPFEQ, TOR-S30-H5A1317C, TOR-S30-P1112T28
16	80.8	1.5	4.8E-003	ACPEPGPRPGNOPFEQ, TOR-S30-H5A1317C, TOR-S30-TW21457
17	82.3	1.5	4.8E-003	ACPEPGPRPGNOPFEQ, TOR-S30-P1112T28, TOR-S30-P1578788
18	83.8	1.5	4.8E-003	ACPEPGPRPGNOPFEQ, TOR-S30-P1578788, TOR-S30-TW21457
19	85.3	1.4	4.7E-003	ACPEPGPRPGNOPFEQ, PWS---LPHESFTRVV, TOR-S30-H5A1317C, TOR-S30-HE2789
20	86.8	1.4	4.7E-003	ACPEPGPRPGNOPFEQ, PWS---LPHESFTRVV, TOR-S30-HE2789, TOR-S30-P1578788

SEQUENCE CUT SETS (QUANTIFICATION) REPORT

Rank 2

Family : HFBR-TOR   Sequence : 005
Analysis : RANDOM   Event Tree : LOOP24
Case : ALTERNATE   Init. Event : IE-LOOP24
Mincut Upper Bound : 2.000E-001

Cut No.	% Total	% Cut Set	Prob/ Freq.	ALTERNATE CUT SETS
1	12.6	12.6	2.5E-002	TOR-S07-FMIS, TOR-S30-H5A1317C, TOR-S30-P1112T28
2	25.3	12.6	2.5E-002	TOR-S07-FMIS, TOR-S30-H5A1317C, TOR-S30-TW21457
3	38.0	12.6	2.5E-002	TOR-S07-FMIS, TOR-S30-P1112T28, TOR-S30-P1578788
4	50.6	12.6	2.5E-002	TOR-S07-FMIS, TOR-S30-P1578788, TOR-S30-TW21457
5	63.0	12.4	2.4E-002	PWS---LPHESFTRVV, TOR-S07-FMIS, TOR-S30-H5A1317C, TOR-S30-HE2789
6	75.5	12.4	2.4E-002	PWS---LPHESFTRVV, TOR-S07-FMIS, TOR-S30-HE2789, TOR-S30-P1578788
7	78.3	2.8	5.6E-003	TOR-HEP-PW1, TOR-S07-FMIS, TOR-S30-H5A1317C
8	81.1	2.8	5.6E-003	TOR-HEP-PW1, TOR-S07-FMIS, TOR-S30-P1578788
9	83.9	2.8	5.6E-003	TOR-HEP-PW3-ALN, TOR-S07-FMIS, TOR-S30-H5A1317C
10	86.8	2.8	5.6E-003	TOR-HEP-PW3-ALN, TOR-S07-FMIS, TOR-S30-P1578788
11	89.6	2.8	5.6E-003	TOR-HEP-SCMDMU, TOR-S07-FMIS, TOR-S30-P1112T28
12	92.4	2.8	5.6E-003	TOR-HEP-SCMDMU, TOR-S07-FMIS, TOR-S30-TW21457
13	95.2	2.7	5.5E-003	PWS---LPHESFTRVV, TOR-HEP-SCMDMU, TOR-S07-FMIS, TOR-S30-HE2789
14	97.7	2.5	5.0E-003	HWTLTM90HESHEPVV, TOR-HEP-SCM9MPU, TOR-S07-FMIS, TOR-S30-P1112T28
15	100.0	2.5	5.0E-003	HWTLTM90HESHEPVV, TOR-HEP-SCM9MPU, TOR-S07-FMIS, TOR-S30-TW21457
16	100.0	2.5	4.9E-003	HWTLTM90HESHEPVV, PWS---LPHESFTRVV, TOR-HEP-SCM9MPU, TOR-S07-FMIS, TOR-S30-HE2789
17	100.0	0.6	1.2E-003	TOR-HEP-PW1, TOR-HEP-SCMDMU, TOR-S07-FMIS
18	100.0	0.6	1.2E-003	TOR-HEP-PW3-ALN, TOR-HEP-SCMDMU, TOR-S07-FMIS
19	100.0	0.5	1.1E-003	HWTLTM90HESHEPVV, TOR-HEP-PW1, TOR-HEP-SCM9MPU, TOR-S07-FMIS
20	100.0	0.5	1.1E-003	HWTLTM90HESHEPVV, TOR-HEP-PW3-ALN, TOR-HEP-SCM9MPU, TOR-S07-FMIS

SEQUENCE CUT SETS (QUANTIFICATION) REPORT

Rank 3

Family : HFBR-TOR Sequence : 007
Analysis : RANDOM Event Tree : LOOP24
Case : ALTERNATE Init. Event : IE-LOOP24
Mincut Upper Bound : 7.473E-002

Cut No.	% Total	% Cut Set	Prob/ Freq.	ALTERNATE CUT SETS
1	5.5	5.5	4.1E-003	TOR-S06-FMIS, TOR-S07-FMIS, TOR-S30-300A-IX, TOR-S30-300B-IX, TOR-S30-P102
2	11.0	5.5	4.1E-003	TOR-S07-FMIS, TOR-S30-300A-IX, TOR-S30-300B-IX, TOR-S30-P102, TOR-S30-P1112T28
3	16.5	5.5	4.1E-003	TOR-S07-FMIS, TOR-S30-300A-IX, TOR-S30-300B-IX, TOR-S30-P102, TOR-S30-TW21457
4	21.9	5.4	4.0E-003	PWS---LPHESFTRVV, TOR-S07-FMIS, TOR-S30-300A-IX, TOR-S30-300B-IX, TOR-S30-HE2789, TOR-S30-P102
5	27.2	5.2	3.9E-003	TOR-HEP-DEP-300, TOR-S06-FMIS, TOR-S07-FMIS, TOR-S30-P102
6	32.4	5.2	3.9E-003	TOR-HEP-DEP-300, TOR-S07-FMIS, TOR-S30-P102, TOR-S30-P1112T28
7	37.7	5.2	3.9E-003	TOR-HEP-DEP-300, TOR-S07-FMIS, TOR-S30-P102, TOR-S30-TW21457
8	43.0	5.2	3.9E-003	TOR-S02-FMIS, TOR-S06-FMIS, TOR-S07-FMIS, TOR-S30-P102
9	48.3	5.2	3.9E-003	TOR-S02-FMIS, TOR-S07-FMIS, TOR-S30-P102, TOR-S30-P1112T28
10	53.6	5.2	3.9E-003	TOR-S02-FMIS, TOR-S07-FMIS, TOR-S30-P102, TOR-S30-TW21457
11	58.8	5.1	3.8E-003	PWS---LPHESFTRVV, TOR-HEP-DEP-300, TOR-S07-FMIS, TOR-S30-HE2789, TOR-S30-P102
12	64.0	5.1	3.8E-003	PWS---LPHESFTRVV, TOR-S02-FMIS, TOR-S07-FMIS, TOR-S30-HE2789, TOR-S30-P102
13	66.1	2.1	1.5E-003	TOR-HEP-DEP-102, TOR-S06-FMIS, TOR-S07-FMIS, TOR-S30-300A-IX, TOR-S30-300B-IX
14	68.2	2.1	1.5E-003	TOR-HEP-DEP-102, TOR-S07-FMIS, TOR-S30-300A-IX, TOR-S30-300B-IX, TOR-S30-P1112T28
15	70.4	2.1	1.5E-003	TOR-HEP-DEP-102, TOR-S07-FMIS, TOR-S30-300A-IX, TOR-S30-300B-IX, TOR-S30-TW21457
16	72.5	2.0	1.5E-003	PWS---LPHESFTRVV, TOR-HEP-DEP-102, TOR-S07-FMIS, TOR-S30-300A-IX, TOR-S30-300B-IX, TOR-S30-HE2789
17	74.5	2.0	1.5E-003	TOR-HEP-DEP-102, TOR-HEP-DEP-300, TOR-S06-FMIS, TOR-S07-FMIS
18	76.5	2.0	1.5E-003	TOR-HEP-DEP-102, TOR-HEP-DEP-300, TOR-S07-FMIS, TOR-S30-P1112T28
19	78.6	2.0	1.5E-003	TOR-HEP-DEP-102, TOR-HEP-DEP-300, TOR-S07-FMIS, TOR-S30-TW21457
20	80.6	2.0	1.5E-003	TOR-HEP-DEP-102, TOR-S02-FMIS, TOR-S06-FMIS, TOR-S07-FMIS

SEQUENCE CUT SETS (QUANTIFICATION) REPORT

Rank 4

Family : HFBR-TOR Sequence : 037
Analysis : RANDOM Event Tree : LOOP24
Case : ALTERNATE Init. Event : IE-LOOP24
Mincut Upper Bound : 6.917E-002

Cut No.	% Total	% Cut Set	Prob/ Freq.	ALTERNATE CUT SETS
1	3.8	3.8	2.6E-003	ACPEPGPRPGNFDOEQ, TOR-S06-FMIS, TOR-S30-300A-IX, TOR-S30-300B-IX, TOR-S30-P102
2	7.6	3.8	2.6E-003	ACPEPGPRPGNFDOEQ, TOR-S30-300A-IX, TOR-S30-300B-IX, TOR-S30-P102, TOR-S30-P1112T28
3	11.4	3.8	2.6E-003	ACPEPGPRPGNFDOEQ, TOR-S30-300A-IX, TOR-S30-300B-IX, TOR-S30-P102, TOR-S30-TW21457
4	15.1	3.7	2.5E-003	ACPEPGPRPGNFDOEQ, PWS---LPHESFTRVV, TOR-S30-300A-IX, TOR-S30-300B-IX, TOR-S30-HE2789, TOR-S30-P102
5	18.8	3.6	2.5E-003	ACPEPGPRPGNFDOEQ, TOR-HEP-DEP-300, TOR-S06-FMIS, TOR-S30-P102
6	22.4	3.6	2.5E-003	ACPEPGPRPGNFDOEQ, TOR-HEP-DEP-300, TOR-S30-P102, TOR-S30-P1112T28
7	26.1	3.6	2.5E-003	ACPEPGPRPGNFDOEQ, TOR-HEP-DEP-300, TOR-S30-P102, TOR-S30-TW21457
8	29.7	3.6	2.5E-003	ACPEPGPRPGNFDOEQ, TOR-S02-FMIS, TOR-S06-FMIS, TOR-S30-P102
9	33.4	3.6	2.5E-003	ACPEPGPRPGNFDOEQ, TOR-S02-FMIS, TOR-S30-P102, TOR-S30-P1112T28
10	37.0	3.6	2.5E-003	ACPEPGPRPGNFDOEQ, TOR-S02-FMIS, TOR-S30-P102, TOR-S30-TW21457
11	40.6	3.5	2.4E-003	ACPEPGPRPGNFDOEQ, PWS---LPHESFTRVV, TOR-HEP-DEP-300, TOR-S30-HE2789, TOR-S30-P102
12	44.2	3.5	2.4E-003	ACPEPGPRPGNFDOEQ, PWS---LPHESFTRVV, TOR-S02-FMIS, TOR-S30-HE2789, TOR-S30-P102
13	45.7	1.4	1.0E-003	ACPEPGPRPGNFDOEQ, TOR-HEP-DEP-102, TOR-S06-FMIS, TOR-S30-300A-IX, TOR-S30-300B-IX
14	47.2	1.4	1.0E-003	ACPEPGPRPGNFDOEQ, TOR-HEP-DEP-102, TOR-S30-300A-IX, TOR-S30-300B-IX, TOR-S30-P1112T28
15	48.6	1.4	1.0E-003	ACPEPGPRPGNFDOEQ, TOR-HEP-DEP-102, TOR-S30-300A-IX, TOR-S30-300B-IX, TOR-S30-TW21457
16	50.1	1.4	9.9E-004	ACPEPGPRPGNFDOEQ, PWS---LPHESFTRVV, TOR-HEP-DEP-102, TOR-S30-300A-IX, TOR-S30-300B-IX, TOR-S30-HE2789
17	51.5	1.4	9.7E-004	ACPEPGPRPGNFDOEQ, TOR-HEP-DEP-102, TOR-HEP-DEP-300, TOR-S06-FMIS
18	52.9	1.4	9.7E-004	ACPEPGPRPGNFDOEQ, TOR-HEP-DEP-102, TOR-HEP-DEP-300, TOR-S30-P1112T28
19	54.3	1.4	9.7E-004	ACPEPGPRPGNFDOEQ, TOR-HEP-DEP-102, TOR-HEP-DEP-300, TOR-S30-TW21457
20	55.7	1.4	9.7E-004	ACPEPGPRPGNFDOEQ, TOR-HEP-DEP-102, TOR-S02-FMIS, TOR-S06-FMIS

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SEQUENCE CUT SETS (QUANTIFICATION) REPORT

Rank 5

Family : HFBR-TOR   Sequence : 042
Analysis : RANDOM   Event Tree : LOOP24
Case : ALTERNATE   Init. Event : IE-LOOP24
Mincut Upper Bound : 5.933E-002

Cut No.	% Total	% Cut Set	Prob/ Freq.	ALTERNATE CUT SETS
1	9.5	9.5	5.6E-003	ACPEPGPRPGNFDOEQ, HWTLTM90HESHEPVV, TOR-S07-FMIS, TOR-S30-P1112T28
2	19.0	9.5	5.6E-003	ACPEPGPRPGNFDOEQ, HWTLTM90HESHEPVV, TOR-S07-FMIS, TOR-S30-TW21457
3	28.3	9.3	5.5E-003	ACPEPGPRPGNFDOEQ, HWTLTM90HESHEPVV, PWS---LPHESFTRVV, TOR-S07-FMIS, TOR-S30-HE2789
4	32.6	4.2	2.5E-003	ACPEPGPRPGNFDOEQ, TOR-S07-FMIS, TOR-S30-H5A1317C, TOR-S30-P1112T28
5	36.9	4.2	2.5E-003	ACPEPGPRPGNFDOEQ, TOR-S07-FMIS, TOR-S30-H5A1317C, TOR-S30-TW21457
6	41.1	4.2	2.5E-003	ACPEPGPRPGNFDOEQ, TOR-S07-FMIS, TOR-S30-P1112T28, TOR-S30-P1578788
7	45.4	4.2	2.5E-003	ACPEPGPRPGNFDOEQ, TOR-S07-FMIS, TOR-S30-P1578788, TOR-S30-TW21457
8	49.6	4.1	2.4E-003	ACPEPGPRPGNFDOEQ, PWS---LPHESFTRVV, TOR-S07-FMIS, TOR-S30-H5A1317C, TOR-S30-HE2789
9	53.7	4.1	2.4E-003	ACPEPGPRPGNFDOEQ, PWS---LPHESFTRVV, TOR-S07-FMIS, TOR-S30-HE2789, TOR-S30-P1578788
10	56.6	2.8	1.7E-003	ACPEPGPRPGNOPFEQ, HWTLTM90HESHEPVV, TOR-S07-FMIS, TOR-S30-P1112T28
11	59.5	2.8	1.7E-003	ACPEPGPRPGNOPFEQ, HWTLTM90HESHEPVV, TOR-S07-FMIS, TOR-S30-TW21457
12	62.3	2.8	1.6E-003	ACPEPGPRPGNOPFEQ, HWTLTM90HESHEPVV, PWS---LPHESFTRVV, TOR-S07-FMIS, TOR-S30-HE2789
13	64.4	2.1	1.2E-003	ACPEPGPRPGNFDOEQ, HWTLTM90HESHEPVV, TOR-HEP-PW1, TOR-S07-FMIS
14	66.5	2.1	1.2E-003	ACPEPGPRPGNFDOEQ, HWTLTM90HESHEPVV, TOR-HEP-PW3-ALN, TOR-S07-FMIS
15	67.8	1.2	7.6E-004	ACPEPGPRPGNOPFEQ, TOR-S07-FMIS, TOR-S30-H5A1317C, TOR-S30-P1112T28
16	69.1	1.2	7.6E-004	ACPEPGPRPGNOPFEQ, TOR-S07-FMIS, TOR-S30-H5A1317C, TOR-S30-TW21457
17	70.4	1.2	7.6E-004	ACPEPGPRPGNOPFEQ, TOR-S07-FMIS, TOR-S30-P1112T28, TOR-S30-P1578788
18	71.6	1.2	7.6E-004	ACPEPGPRPGNOPFEQ, TOR-S07-FMIS, TOR-S30-P1578788, TOR-S30-TW21457
19	72.9	1.2	7.4E-004	ACPEPGPRPGNOPFEQ, PWS---LPHESFTRVV, TOR-S07-FMIS, TOR-S30-H5A1317C, TOR-S30-HE2789
20	74.2	1.2	7.4E-004	ACPEPGPRPGNOPFEQ, PWS---LPHESFTRVV, TOR-S07-FMIS, TOR-S30-HE2789, TOR-S30-P1578788

SEQUENCE CUT SETS (QUANTIFICATION) REPORT

Rank 6

Family : HFBR-TOR
Analysis : RANDOM
Case : ALTERNATE

Sequence : 120
Event Tree : LOOP24
Init. Event : IE-LOOP24

Mincut Upper Bound : 5.912E-002

Cut No.	% Total	% Cut Set	Prob/ Freq.	ALTERNATE CUT SETS
1	9.5	9.5	5.6E-003	ACPEPGPRPGNFDOEQ, HWTLTM90HESHEPVV, TOR-S05-FMIS, TOR-S30-P1112T28
2	19.1	9.5	5.6E-003	ACPEPGPRPGNFDOEQ, HWTLTM90HESHEPVV, TOR-S05-FMIS, TOR-S30-TW21457
3	28.4	9.3	5.5E-003	ACPEPGPRPGNFDOEQ, HWTLTM90HESHEPVV, PWS---LPHESFTRVV, TOR-S05-FMIS, TOR-S30-HE2789
4	32.7	4.2	2.5E-003	ACPEPGPRPGNFDOEQ, TOR-S05-FMIS, TOR-S30-H5A1317C, TOR-S30-P1112T28
5	37.0	4.2	2.5E-003	ACPEPGPRPGNFDOEQ, TOR-S05-FMIS, TOR-S30-H5A1317C, TOR-S30-TW21457
6	41.3	4.2	2.5E-003	ACPEPGPRPGNFDOEQ, TOR-S05-FMIS, TOR-S30-P1112T28, TOR-S30-P1578788
7	45.5	4.2	2.5E-003	ACPEPGPRPGNFDOEQ, TOR-S05-FMIS, TOR-S30-P1578788, TOR-S30-TW21457
8	49.7	4.1	2.4E-003	ACPEPGPRPGNFDOEQ, PWS---LPHESFTRVV, TOR-S05-FMIS, TOR-S30-H5A1317C, TOR-S30-HE2789
9	53.9	4.1	2.4E-003	ACPEPGPRPGNFDOEQ, PWS---LPHESFTRVV, TOR-S05-FMIS, TOR-S30-HE2789, TOR-S30-P1578788
10	56.8	2.8	1.7E-003	ACPEPGPRPGNOPFEQ, HWTLTM90HESHEPVV, TOR-S05-FMIS, TOR-S30-P1112T28
11	59.7	2.8	1.7E-003	ACPEPGPRPGNOPFEQ, HWTLTM90HESHEPVV, TOR-S05-FMIS, TOR-S30-TW21457
12	62.5	2.8	1.6E-003	ACPEPGPRPGNOPFEQ, HWTLTM90HESHEPVV, PWS---LPHESFTRVV, TOR-S05-FMIS, TOR-S30-HE2789
13	64.6	2.1	1.2E-003	ACPEPGPRPGNFDOEQ, HWTLTM90HESHEPVV, TOR-HEP-PW1, TOR-S05-FMIS
14	66.8	2.1	1.2E-003	ACPEPGPRPGNFDOEQ, HWTLTM90HESHEPVV, TOR-HEP-PW3-ALN, TOR-S05-FMIS
15	68.0	1.2	7.6E-004	ACPEPGPRPGNOPFEQ, TOR-S05-FMIS, TOR-S30-H5A1317C, TOR-S30-P1112T28
16	69.3	1.2	7.6E-004	ACPEPGPRPGNOPFEQ, TOR-S05-FMIS, TOR-S30-H5A1317C, TOR-S30-TW21457
17	70.6	1.2	7.6E-004	ACPEPGPRPGNOPFEQ, TOR-S05-FMIS, TOR-S30-P1112T28, TOR-S30-P1578788
18	71.9	1.2	7.6E-004	ACPEPGPRPGNOPFEQ, TOR-S05-FMIS, TOR-S30-P1578788, TOR-S30-TW21457
19	73.2	1.2	7.4E-004	ACPEPGPRPGNOPFEQ, PWS---LPHESFTRVV, TOR-S05-FMIS, TOR-S30-H5A1317C, TOR-S30-HE2789
20	74.4	1.2	7.4E-004	ACPEPGPRPGNOPFEQ, PWS---LPHESFTRVV, TOR-S05-FMIS, TOR-S30-HE2789, TOR-S30-P1578788

SEQUENCE CUT SETS (QUANTIFICATION) REPORT

Rank 7

Family : HFBR-TOR   Sequence : 003
Analysis : RANDOM   Event Tree : LOOP24
Case : ALTERNATE   Init. Event : IE-LOOP24
Mincut Upper Bound : 2.024E-001

Cut No.	% Total	% Cut Set	Prob/ Freq.	ALTERNATE CUT SETS
1	31.0	31.0	6.2E-002	TOR-S07-FMIS, TOR-S30-P1112T28
2	62.1	31.0	6.2E-002	TOR-S07-FMIS, TOR-S30-TW21457
3	92.5	30.4	6.1E-002	PWS---LPHESFTRVV, TOR-S07-FMIS, TOR-S30-HE2789
4	99.5	6.9	1.4E-002	TOR-HEP-PW1, TOR-S07-FMIS
5	100.0	6.9	1.4E-002	TOR-HEP-PW3-ALN, TOR-S07-FMIS
6	100.0	0.7	1.5E-003	PWSLWM-HEP-ALNVV, TOR-S07-FMIS
7	100.0	0.7	1.5E-003	PWSSYS-HEP-ALNVV, TOR-S07-FMIS
8	100.0	0.1	2.0E-004	TOR-HEP-SSSA3X, TOR-S30-P1112T28
9	100.0	0.1	2.0E-004	TOR-HEP-SSSA3X, TOR-S30-TW21457
10	100.0	0.1	1.9E-004	PWS---LPHESFTRVV, TOR-HEP-SSSA3X, TOR-S30-HE2789
11	100.0	0.0	1.5E-004	DWSXFRHOSEFAILEQ, TOR-S07-FMIS
12	100.0	0.0	4.5E-005	TOR-HEP-PW1, TOR-HEP-SSSA3X
13	100.0	0.0	4.5E-005	TOR-HEP-PW3-ALN, TOR-HEP-SSSA3X
14	100.0	0.0	4.0E-005	SCWAOVWR-3XHEPEQ, TOR-S30-P1112T28
15	100.0	0.0	4.0E-005	SCWAOVWR-3XHEPEQ, TOR-S30-TW21457
16	100.0	0.0	3.9E-005	PWS---LPHESFTRVV, SCWAOVWR-3XHEPEQ, TOR-S30-HE2789
17	100.0	0.0	1.8E-005	TOR-HEP-SS141518, TOR-HEP-SS1418, TOR-S30-P1112T28
18	100.0	0.0	1.8E-005	TOR-HEP-SS141518, TOR-HEP-SS1418, TOR-S30-TW21457
19	100.0	0.0	1.7E-005	PWS---LPHESFTRVV, TOR-HEP-SS141518, TOR-HEP-SS1418, TOR-S30-HE2789
20	100.0	0.0	1.5E-005	AWPMNV-DW42FTOEQ, TOR-S07-FMIS

SEQUENCE CUT SETS (QUANTIFICATION) REPORT

Family : HFBR-TOR   Sequence : 090   Rank 8
Analysis : RANDOM   Event Tree : LOOP24
Case : ALTERNATE   Init. Event : IE-LOOP24
Mincut Upper Bound : 3.397E-002

Cut No.	% Total	% Cut Set	Prob/ Freq.	ALTERNATE CUT SETS
1	11.6	11.6	3.9E-003	TOR-S05-FMIS, TOR-S07-FMIS, TOR-S30-H5A1317C, TOR-S30-P1112T28
2	23.2	11.6	3.9E-003	TOR-S05-FMIS, TOR-S07-FMIS, TOR-S30-H5A1317C, TOR-S30-TW21457
3	34.9	11.6	3.9E-003	TOR-S05-FMIS, TOR-S07-FMIS, TOR-S30-P1112T28, TOR-S30-P1578788
4	46.5	11.6	3.9E-003	TOR-S05-FMIS, TOR-S07-FMIS, TOR-S30-P1578788, TOR-S30-TW21457
5	57.9	11.4	3.8E-003	PWS---LPHESFTRVV, TOR-S05-FMIS, TOR-S07-FMIS, TOR-S30-H5A1317C, TOR-S30-HE2789
6	69.3	11.4	3.8E-003	PWS---LPHESFTRVV, TOR-S05-FMIS, TOR-S07-FMIS, TOR-S30-HE2789, TOR-S30-P1578788
7	71.9	2.6	8.8E-004	TOR-HEP-PW1, TOR-S05-FMIS, TOR-S07-FMIS, TOR-S30-H5A1317C
8	74.5	2.6	8.8E-004	TOR-HEP-PW1, TOR-S05-FMIS, TOR-S07-FMIS, TOR-S30-P1578788
9	77.1	2.6	8.8E-004	TOR-HEP-PW3-ALN, TOR-S05-FMIS, TOR-S07-FMIS, TOR-S30-H5A1317C
10	79.7	2.6	8.8E-004	TOR-HEP-PW3-ALN, TOR-S05-FMIS, TOR-S07-FMIS, TOR-S30-P1578788
11	82.3	2.6	8.8E-004	TOR-HEP-SCMDMU, TOR-S05-FMIS, TOR-S07-FMIS, TOR-S30-P1112T28
12	84.9	2.6	8.8E-004	TOR-HEP-SCMDMU, TOR-S05-FMIS, TOR-S07-FMIS, TOR-S30-TW21457
13	87.4	2.5	8.6E-004	PWS---LPHESFTRVV, TOR-HEP-SCMDMU, TOR-S05-FMIS, TOR-S07-FMIS, TOR-S30-HE2789
14	89.8	2.3	7.9E-004	HWTLTM90HESHEPVV, TOR-HEP-SCM9MPU, TOR-S05-FMIS, TOR-S07-FMIS, TOR-S30-P1112T28
15	92.1	2.3	7.9E-004	HWTLTM90HESHEPVV, TOR-HEP-SCM9MPU, TOR-S05-FMIS, TOR-S07-FMIS, TOR-S30-TW21457
16	94.4	2.2	7.7E-004	HWTLTM90HESHEPVV, PWS---LPHESFTRVV, TOR-HEP-SCM9MPU, TOR-S05-FMIS, TOR-S07-FMIS, TOR-S30-HE2789
17	95.0	0.5	1.9E-004	TOR-HEP-PW1, TOR-HEP-SCMDMU, TOR-S05-FMIS, TOR-S07-FMIS
18	95.6	0.5	1.9E-004	TOR-HEP-PW3-ALN, TOR-HEP-SCMDMU, TOR-S05-FMIS, TOR-S07-FMIS
19	96.1	0.5	1.7E-004	HWTLTM90HESHEPVV, TOR-HEP-PW1, TOR-HEP-SCM9MPU, TOR-S05-FMIS, TOR-S07-FMIS
20	96.6	0.5	1.7E-004	HWTLTM90HESHEPVV, TOR-HEP-PW3-ALN, TOR-HEP-SCM9MPU, TOR-S05-FMIS, TOR-S07-FMIS

SEQUENCE CUT SETS (QUANTIFICATION) REPORT

Rank 9

Family : HFBR-TOR Sequence : 050
Analysis : RANDOM Event Tree : LOOP24
Case : ALTERNATE Init. Event : IE-LOOP24
Mincut Upper Bound : 3.513E-002

Cut No.	% Total	% Cut Set	Prob/ Freq.	ALTERNATE CUT SETS
1	9.2	9.2	3.2E-003	ACPEPGPRPGNFDOEQ, HWTLTM90HESHEPVV, TOR-HEP-SP56M20, TOR-S30-P1112T28
2	18.5	9.2	3.2E-003	ACPEPGPRPGNFDOEQ, HWTLTM90HESHEPVV, TOR-HEP-SP56M20, TOR-S30-TW21457
3	27.6	9.0	3.1E-003	ACPEPGPRPGNFDOEQ, HWTLTM90HESHEPVV, PWS---LPHESFTRVV, TOR-HEP-SP56M20, TOR-S30-HE2789
4	31.8	4.1	1.4E-003	ACPEPGPRPGNFDOEQ, TOR-HEP-SP56M20, TOR-S30-H5A1317C, TOR-S30-P1112T28
5	35.9	4.1	1.4E-003	ACPEPGPRPGNFDOEQ, TOR-HEP-SP56M20, TOR-S30-H5A1317C, TOR-S30-TW21457
6	40.1	4.1	1.4E-003	ACPEPGPRPGNFDOEQ, TOR-HEP-SP56M20, TOR-S30-P1112T28, TOR-S30-P1578788
7	44.2	4.1	1.4E-003	ACPEPGPRPGNFDOEQ, TOR-HEP-SP56M20, TOR-S30-P1578788, TOR-S30-TW21457
8	48.3	4.0	1.4E-003	ACPEPGPRPGNFDOEQ, PWS---LPHESFTRVV, TOR-HEP-SP56M20, TOR-S30-H5A1317C, TOR-S30-HE2789
9	52.4	4.0	1.4E-003	ACPEPGPRPGNFDOEQ, PWS---LPHESFTRVV, TOR-HEP-SP56M20, TOR-S30-HE2789, TOR-S30-P1578788
10	55.1	2.7	9.7E-004	ACPEPGPRPGNOPFEQ, HWTLTM90HESHEPVV, TOR-HEP-SP56M20, TOR-S30-P1112T28
11	57.9	2.7	9.7E-004	ACPEPGPRPGNOPFEQ, HWTLTM90HESHEPVV, TOR-HEP-SP56M20, TOR-S30-TW21457
12	60.7	2.7	9.6E-004	ACPEPGPRPGNOPFEQ, HWTLTM90HESHEPVV, PWS---LPHESFTRVV, TOR-HEP-SP56M20, TOR-S30-HE2789
13	62.7	2.0	7.2E-004	ACPEPGPRPGNFDOEQ, HWTLTM90HESHEPVV, TOR-HEP-PW1, TOR-HEP-SP56M20
14	64.8	2.0	7.2E-004	ACPEPGPRPGNFDOEQ, HWTLTM90HESHEPVV, TOR-HEP-PW3-ALN, TOR-HEP-SP56M20
15	66.1	1.2	4.3E-004	ACPEPGPRPGNOPFEQ, TOR-HEP-SP56M20, TOR-S30-H5A1317C, TOR-S30-P1112T28
16	67.3	1.2	4.3E-004	ACPEPGPRPGNOPFEQ, TOR-HEP-SP56M20, TOR-S30-H5A1317C, TOR-S30-TW21457
17	68.6	1.2	4.3E-004	ACPEPGPRPGNOPFEQ, TOR-HEP-SP56M20, TOR-S30-P1112T28, TOR-S30-P1578788
18	69.8	1.2	4.3E-004	ACPEPGPRPGNOPFEQ, TOR-HEP-SP56M20, TOR-S30-P1578788, TOR-S30-TW21457
19	71.0	1.2	4.3E-004	ACPEPGPRPGNOPFEQ, PWS---LPHESFTRVV, TOR-HEP-SP56M20, TOR-S30-H5A1317C, TOR-S30-HE2789
20	72.2	1.2	4.3E-004	ACPEPGPRPGNOPFEQ, PWS---LPHESFTRVV, TOR-HEP-SP56M20, TOR-S30-HE2789, TOR-S30-P1578788

SEQUENCE CUT SETS (QUANTIFICATION) REPORT

Rank 10

Family : HFBR-TOR   Sequence : 065
Analysis : RANDOM   Event Tree : LOOP24
Case : ALTERNATE   Init. Event : IE-LOOP24

Mincut Upper Bound : 3.513E-002

Cut No.	% Total	% Cut Set	Prob/ Freq.	ALTERNATE CUT SETS
1	9.2	9.2	3.2E-003	ACPEPGPRPGNFDOEQ, HWTLTM90HESHEPVV, TOR-HEP-SP23M19, TOR-S30-P1112T28
2	18.5	9.2	3.2E-003	ACPEPGPRPGNFDOEQ, HWTLTM90HESHEPVV, TOR-HEP-SP23M19, TOR-S30-TW21457
3	27.6	9.0	3.1E-003	ACPEPGPRPGNFDOEQ, HWTLTM90HESHEPVV, PWS---LPHESFTRVV, TOR-HEP-SP23M19, TOR-S30-HE2789
4	31.8	4.1	1.4E-003	ACPEPGPRPGNFDOEQ, TOR-HEP-SP23M19, TOR-S30-H5A1317C, TOR-S30-P1112T28
5	35.9	4.1	1.4E-003	ACPEPGPRPGNFDOEQ, TOR-HEP-SP23M19, TOR-S30-H5A1317C, TOR-S30-TW21457
6	40.1	4.1	1.4E-003	ACPEPGPRPGNFDOEQ, TOR-HEP-SP23M19, TOR-S30-P1112T28, TOR-S30-P1578788
7	44.2	4.1	1.4E-003	ACPEPGPRPGNFDOEQ, TOR-HEP-SP23M19, TOR-S30-P1578788, TOR-S30-TW21457
8	48.3	4.0	1.4E-003	ACPEPGPRPGNFDOEQ, PWS---LPHESFTRVV, TOR-HEP-SP23M19, TOR-S30-H5A1317C, TOR-S30-HE2789
9	52.4	4.0	1.4E-003	ACPEPGPRPGNFDOEQ, PWS---LPHESFTRVV, TOR-HEP-SP23M19, TOR-S30-HE2789, TOR-S30-P1578788
10	55.1	2.7	9.7E-004	ACPEPGPRPGNOPFEQ, HWTLTM90HESHEPVV, TOR-HEP-SP23M19, TOR-S30-P1112T28
11	57.9	2.7	9.7E-004	ACPEPGPRPGNOPFEQ, HWTLTM90HESHEPVV, TOR-HEP-SP23M19, TOR-S30-TW21457
12	60.7	2.7	9.6E-004	ACPEPGPRPGNOPFEQ, HWTLTM90HESHEPVV, PWS---LPHESFTRVV, TOR-HEP-SP23M19, TOR-S30-HE2789
13	62.7	2.0	7.2E-004	ACPEPGPRPGNFDOEQ, HWTLTM90HESHEPVV, TOR-HEP-PW1, TOR-HEP-SP23M19
14	64.8	2.0	7.2E-004	ACPEPGPRPGNFDOEQ, HWTLTM90HESHEPVV, TOR-HEP-PW3-ALN, TOR-HEP-SP23M19
15	66.1	1.2	4.3E-004	ACPEPGPRPGNOPFEQ, TOR-HEP-SP23M19, TOR-S30-H5A1317C, TOR-S30-P1112T28
16	67.3	1.2	4.3E-004	ACPEPGPRPGNOPFEQ, TOR-HEP-SP23M19, TOR-S30-H5A1317C, TOR-S30-TW21457
17	68.6	1.2	4.3E-004	ACPEPGPRPGNOPFEQ, TOR-HEP-SP23M19, TOR-S30-P1112T28, TOR-S30-P1578788
18	69.8	1.2	4.3E-004	ACPEPGPRPGNOPFEQ, TOR-HEP-SP23M19, TOR-S30-P1578788, TOR-S30-TW21457
19	71.0	1.2	4.3E-004	ACPEPGPRPGNOPFEQ, PWS---LPHESFTRVV, TOR-HEP-SP23M19, TOR-S30-H5A1317C, TOR-S30-HE2789
20	72.2	1.2	4.3E-004	ACPEPGPRPGNOPFEQ, PWS---LPHESFTRVV, TOR-HEP-SP23M19, TOR-S30-HE2789, TOR-S30-P1578788