LETTER REPORT

Oconee Pressurized Thermal Shock (PTS) Probabilistic Risk Assessment (PRA)

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Prepared by
A. M. Kolaczkowski [1]
D. W. Whitehead [2]
J. Forester [2]
S. Cooper [3]
D. Bley [4]
J. Wreathall [5]
V. J. Dandini [2]

[1] Science Applications International Corporation
405 Urban St., Suite 400
Lakewood, Colorado 80228

[2] Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185-0744

[3] Formerly Science Applications International Corporation
20201 Century Boulevard
Germantown, MD 20874

[4] Buttonwood Consulting, Inc.
11738 English Mill Ct
Oakton, VA 22124-2253

[5] John Wreathall and Company
4157 MacDuff Way
Dublin, OH 43016

H. W. Woods, NRC Project Manager

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Division of Risk Analysis and Applications
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
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ABSTRACT

One of the potentially most significant challenges to the structural integrity of the reactor pressure vessel (RPV) in a pressurized water reactor (PWR) is posed by a pressurized thermal shock (PTS) event wherein severe cooling of the core occurs together with, or followed by, pressurization.

In the early 1980s the nuclear industry and the Nuclear Regulatory Commission (NRC) staff performed a number of investigations aimed at assessing the risk of vessel failure posed by PTS, and on establishing the limits needed to reduce failures caused by PTS transients to a tolerable level. These efforts led to the publication by the Staff of a document [SECY-82-465] that provided the technical basis for subsequent development of what has come to be known as the "PTS Rule" [10CFR50.61].

As PWRs approach the end of their original 40-year operating licenses, and utilities consider requesting 20-year license extensions, compliance with the PTS Rule[10CFR50.61] can become a factor that limits the operational life of the plant. Addressing this issue on a plant-specific basis has consumed considerable resources within both the regulatory and operational communities. Additionally, it is now widely recognized that state of knowledge and data limitations in the early 1980's necessitated a conservative treatment of several key parameters and models used in the probabilistic calculations that provide the technical basis [SECY-82-465] of the current PTS rule [10CFR50.61].

The cost associated with demonstrating and checking compliance with the current PTS screening criteria, the conservatisms known to underlie the screening criteria, and the considerable technical advancements that have occurred in the 20 years since the technical basis for the PTS Rule was established all combined to motivate the NRC Office of Nuclear Regulatory Research to undertake a project aimed at developing the technical basis to support a fundamental revision of the PTS rule and the associated PTS risk and screening criteria.

NUREG-1806, *Technical Basis for Revision of the Pressurized Thermal Shock (PTS) Screening Limit in the PTS Rule (10CFR50.61): Summary Report*, is the main report documenting this latest work. In assessing the current understanding of PTS risk, analyses of the following plants were performed: Oconee 1, Beaver Valley 1, and Palisades.

This report, a companion to NUREG-1806, summarizes the probabilistic risk assessment (PRA) work (only) performed for the Oconee 1 analysis. It does not address the thermal hydraulic or probabilistic fracture mechanics portions of the Oconee 1 study. Other companion reports address these other aspects as well as the other plants.

While this report is meant to be a stand alone document for the PRA portion of the work, it is suggested that it be read in concert with NUREG-1806 to provide a more complete understanding of the work that was performed and its results since it is only in the main NUREG, that the complete picture of the through wall crack frequencies (TWCFs) (including the PRA, TH, and PFM perspectives combined) is provided.

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ACKNOWLEDGMENTS

This study (i.e. the probabilistic risk assessment) was part of a multi-disciplinary team approach that included support from thermal hydraulics (Information Systems Laboratories, Inc.) and probabilistic fracture mechanics (Oak Ridge National Laboratory) to help identify those accident sequences that either did or did not have the potential to be important to pressurized thermal shock (PTS). The willingness of each individual from the two organizations to work in an interactive fashion greatly facilitated this study's work.

In addition, the timely support provided by the staff at Oconee Unit 1was invaluable to this study as it allowed us to consider plant-specific responses to various aspects of the pressurized thermal shock model.

Furthermore, the cooperation provided by members of the Idaho National Engineering and Environmental Laboratory during the transition of the original PTS work to Sandia National Laboratories is gratefully acknowledged.

Finally, special thanks go to our Nuclear Regulatory Commission Project Manager Mr. Hugh W. (Roy) Woods. His diligent efforts to ensure that we had the necessary resources and the time to interact with the other organizations is greatly appreciated.

ACRONYMS AND INITIALISMS

AOP	Abnormal Operating Procedure
ATWS	Anticipated Transient Without Scram
BOP	Balance of Plant
BWST	Borated Water Storage Tank
CBP	Condensate Booster Pump
CCW	Component Cooling Water
CETC	Core Exit Thermal-Couple
CFT	Core Flood Tank
CPF	Conditional Probability of (Vessel) Failure
DC	Direct Current
EFW	Emergency Feedwater
ESDE	Excessive Steam Demand Event
EOC	Error of Commission
EOO	Error of Omission
EOP	Emergency Operating Procedure
HEP	Human Error Probability
HFE	Human Failure Event
HPI	High Pressure Injection
HRA	Human Reliability Analysis
HTC	Heat Transfer Coefficient
HZP	Hot Zero Power
ICS	Integrated Control System
IE	Initiating Event
ISLOCA	Interfacing System Loss of Coolant Accident
LOCA	Loss of Coolant Accident
LLOCA	Large Loss of Coolant Accident
LPI	Low Pressure Injection
MFW/FW	Main Feedwater/Feedwater
MLOCA	Medium Loss of Coolant Accident
MSLB	Main Steam Line Break
MSSRV	Main Steam Safety Relief Valve
NRC	Nuclear Regulatory Commission
OATC	Operator at the Controls
PFM	Probabilistic Fracture Mechanics
PORV	Power (Pilot) Operated Relief Valve
PRA	Probabilistic Risk Assessment
PTS	Pressurized Thermal Shock
PWR	Pressurized Water Reactor
PZR	Pressurizer
RCP	Reactor Coolant Pump
RCS	Reactor Coolant System
RPS	Reactor Protection System
RPV	Reactor Pressure Vessel
SG	Steam Generator
SGTR	Steam Generator Tube Rupture
SRVs	Safety Relief Valves
SSCs	Systems, Structures, and Components

SSRVs	Secondary Steam Relief Valves
TBVs	Turbine Bypass Valves
TCVs	Turbine Control Valves
TH	Thermal-hydraulic
TSVs	Turbine Stop Valves
TT/RT	Turbine Trip/Reactor Trip
TWCF	Through-wall Crack Frequency
UMD	University of Maryland

1. INTRODUCTION

1.1 Summary of the PTS Issue

One of the potentially most significant challenges to the structural integrity of the reactor pressure vessel (RPV) in a pressurized water reactor (PWR) is posed by a pressurized thermal shock (PTS) event wherein severe cooling of the core occurs together with, or followed by, pressurization. Several operational sequences can thermally shock the vessel (either with or without significant internal pressure); these include a break of the main steam line, secondary depressurization through a relief valve, a loss of coolant accident (LOCA), or extended injection of high-pressure water to name just a few. During these events, water level in the primary system is restored since it will have dropped due to contraction resulting from overcooling, and in cases involving a primary system breach (e.g., a LOCA) additional water level drop occurs due to leakage from the primary. The water added is much colder water than that present in the reactor coolant system (RCS). The temperature differential between the nominally ambient temperature emergency coolant water and the operating temperature of a pressurized water reactor (ΔT = 550°F – 60°F = 490°F) produces significant thermal stresses in the thick section steel wall of the RPV. These stresses could be high enough to initiate a running cleavage crack, a crack that could propagate all the way through the vessel.

In the early 1980s the nuclear industry and the Nuclear Regulatory Commission (NRC) staff performed a number of investigations aimed at assessing the risk of vessel failure posed by PTS, and on establishing the limits needed to reduce failures caused by PTS transients to a tolerable level. These efforts led to the publication by the Staff of a document [SECY-82-465] that provided the technical basis for subsequent development of what has come to be known as the “PTS Rule” [10CFR50.61].

As PWRs approach the end of their original 40-year operating licenses, and utilities consider requesting 20-year license extensions, compliance with the PTS Rule[10CFR50.61] can become a factor that limits the operational life of the plant. Addressing this issue on a plant-specific basis has consumed considerable resources within both the regulatory and operational communities. Additionally, it is now widely recognized that state of knowledge and data limitations in the early 1980’s necessitated a conservative treatment of several key parameters and models used in the probabilistic calculations that provide the technical basis [SECY-82-465] of the current PTS rule [10CFR50.61].

The cost associated with demonstrating and checking compliance with the current PTS screening criteria, the conservatisms known to underlie the screening criteria, and the considerable technical advancements that have occurred in the 20 years since the technical basis for the PTS Rule was established all combined to motivate the NRC Office of Nuclear Regulatory Research to undertake a project aimed at developing the technical basis to support a fundamental revision of the PTS rule and the associated PTS risk and screening criteria.

1.2 Overview of the Technical Approach

This project makes use of three main models (shown in Figure 1.1) that, together, allow us to estimate the yearly through-wall crack frequency (TWCF) in a RPV. First a probabilistic risk assessment (PRA) event-tree analysis is performed to define both the sequences of events that are likely to produce a PTS challenge to RPV integrity and to define the frequency with which such sequences can be expected to occur. The sequence definitions are then passed to a thermal-hydraulic (TH) model that estimates the temporal variation of temperature, pressure, and heat-transfer coefficient in the RPV down-comer characteristic of each of the sequence definitions. These pressure, temperature, and heat transfer coefficient histories are passed to a probabilistic fracture mechanics (PFM) model. The PFM model uses the thermal hydraulics output along with other information concerning plant design and materials of construction to estimate the time variation of the driving force to fracture produced by a particular sequence of events. The PFM model compares this estimate of fracture driving force to the fracture toughness, or fracture resistance, of the RPV steel. This comparison allows us to estimate the probability that a particular sequence of events will produce a crack all the way through the reactor pressure vessel wall were that sequence of events to actually occur. The final step in the analysis involves a simple matrix multiplication of these probabilities of through-wall cracking (from the PFM analysis) with the frequency at which a particular event sequence is expected to occur (as defined by the PRA event-tree analysis). This multiplication establishes an estimate of the yearly frequency of through wall cracking (i.e., TWCF) that can be expected for a particular plant after a particular period of operation.

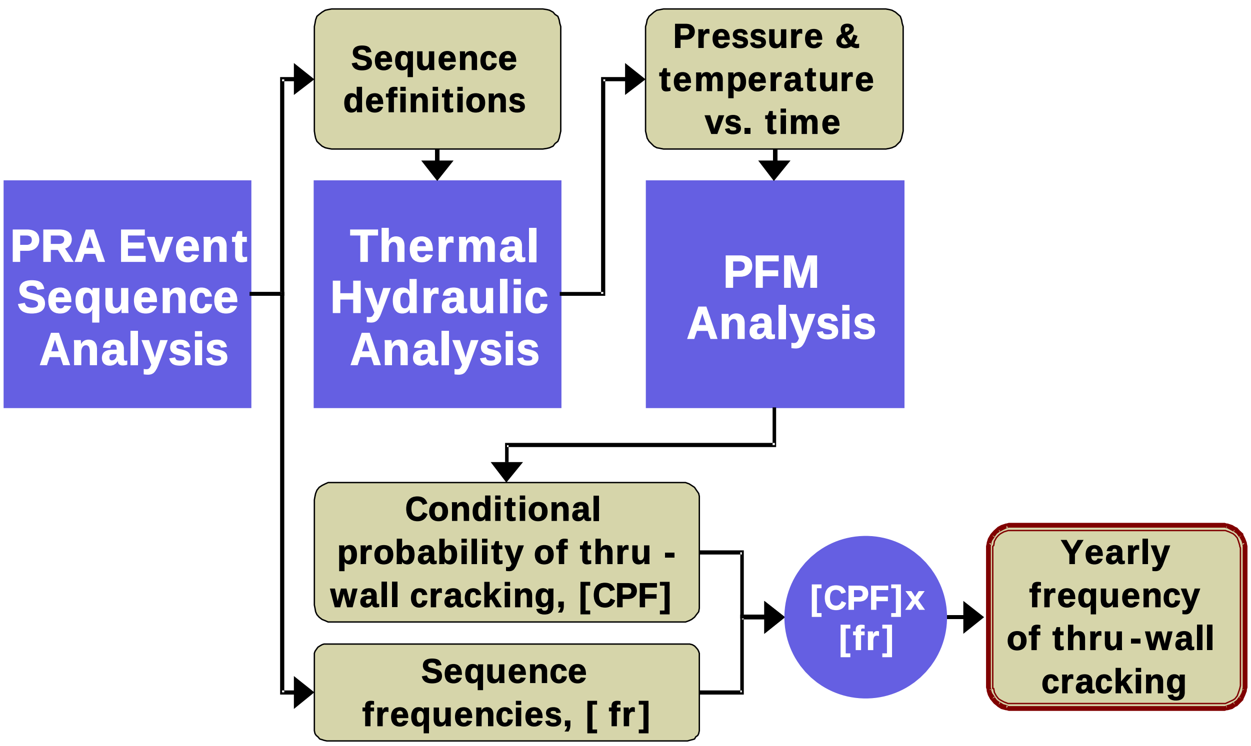

Figure 1.1. Three model approach used in the PTS analyses.

1.3 Purpose of This Report

NUREG-1806, *Technical Basis for Revision of the Pressurized Thermal Shock (PTS) Screening Limit in the PTS Rule (10CFR50.61): Summary Report* [NUREG-1806], is the main report documenting this latest work. In assessing the current understanding of PTS risk, analyses of the following plants were performed: Oconee 1, Beaver Valley 1, and Palisades. These plants were chosen for the following reasons:

- The management and technical staff of these plants actively supported the NRC in this effort by providing access to plant personnel, plant simulators, records of construction, and other information as required.

- One of the plants (Oconee 1) was included in the original PTS studies that provided the basis for 10CFR50.61. We judged it desirable to include this plant in our re-evaluation activities to provide a linkage to past efforts[1].

- Two of the plants (Palisades and Beaver Valley 1) are among the closest plants to the 10CFR50.61 screening limit. Participation of these plants was deemed crucial since, based on our current state of knowledge, they are believed to be most "at risk."

This report is a companion to the engineering summary report [NUREG-1806] and summarizes the PRA work (only) performed for the Oconee 1 analysis. It does not address the thermal hydraulic or probabilistic fracture mechanics portions of the Oconee 1 study. Other companion reports address these other aspects as well as the other plants.

The remainder of this report documents elements of the PRA work performed for the Oconee 1 PTS analysis. First we provide an intentionally brief, high level overview of Oconee design features most relevant to the PTS issue to familiarize the reader with the Oconee plant. The document then generally follows, as applicable, the relevant documentation requirements for the various PRA requirements in the ASME Standard [ASME RA-S-2002] as the means to document the Oconee PTS PRA that was performed for this project. While this report is meant to be a stand alone document for the PRA portion of the work, it is suggested that it be read in concert with NUREG-1806 to provide a more complete understanding of the work that was performed and its results since it is only in the NUREG, that the complete picture of the TWCFs (including the PRA, TH, and PFM perspectives combined) is provided.

[1] Originally the third original PTS plant (Robinson 2) had agreed to participate in this re-evaluation effort, however plant management withdrew its support for these activities mid-way through the project. Subsequently, the management and technical staff of Beaver Valley 1 agreed to participate.

2. RELEVANT OCONEE FEATURES

The occurrence of a significant PTS challenge to the reactor vessel requires (along with material issues) the following:

- a rapid rate of cooling of the primary system,
- continuation of that cooling to a low temperature, and
- maintenance of some level of primary system pressure (the higher the pressure, the greater the concern), or repressurization before significant vessel outer wall cooling occurs.

The original Oconee PTS study [NUREG/CR-3770] served as a good reference and was used to define four functions and related equipment whose status individually or in combination, are particularly relevant to the PTS issue and the above characteristics. These are:

1. Secondary pressure control (because a rapid drop in pressure can cause a rapid cooling in the primary system).

   Relevant Oconee equipment related to potential loss of this function: steam lines [breaks], turbine stop valves (TSVs)[2] and turbine control valves (TCVs), turbine bypass valves (TBVs), and secondary steam relief valves (SSRVs) [potential openings of one or more]. Turbine block valves are available to isolate an uncontrolled release from an open TBV [possible isolation mechanism to regain TBV-caused loss of secondary pressure].

2. Steam generator feed control (because over-feeding can contribute to enhanced cooling of the primary system).

   Relevant Oconee equipment related to potential loss of this function: main feedwater (MFW), condensate, and emergency feedwater (EFW) systems [sources of over-feed].

3. Primary system injection and flow control (because injection can add a cooling effect to the primary system and provides the "cold" water at the downcomer of the RPV, and also can maintain or increase primary system pressure to a relatively high value; the flow characteristics can exacerbate/mitigate flow stagnation).

   Relevant Oconee equipment related to potential loss of this primary system control function: reactor coolant pumps (RCPs) [status dictates forced or natural flow conditions in the RCS], internal vent valves [status dictates degree of mixing of "hot" and "cold" water before reaching the downcomer of the RPV], high pressure injection (HPI)[3] pumps, and the core flood tanks (CFTs) as well as low pressure injection (LPI) pumps [injection sources].

4. Primary system pressure control (beyond that mentioned in "3." above; failures of primary system integrity are of interest because they can cause a cooling effect in the primary system and, depending on the size of the failure, may maintain high primary system pressure depending on injection control).

[2] Note that Oconee has no main steam isolation valves (MSIVs) like most plants. Status of TSVs and TCVs not modeled because of probability considerations (two valves in series must fail to close, plus operator must fail to trip lift oil pump).

[3] Note that Oconee's pumps serve both normal makeup and safety injection functions and can pressurize the primary system to the pressurizer safety valve setpoints.

2. Relevant Oconee Features

Relevant Oconee equipment related to the potential loss of this function: RCS piping [breaks], power-operated relief valve (PORV) and associated block valve [potential opening and reclosing/isolating], pressurizer safety relief valves (SRVs) [potential opening and reclosing], and pressurizer sprays and heaters (although these were later found to have small effects and so were not modeled) [potential cooling/depressurization and heating/repressurization].

5. Other potentially relevant Oconee equipment, because of the interactions with the above equipment, include:

- actuation and protection circuitry associated with the above equipment
- integrated control system (ICS)
- separate EFW control circuitry
- the atmospheric dump valve on each steam generator (SG)[4]
- support systems including cooling water, instrument air, and electric power and instrumentation[5]

It is important to note that support systems were only superficially treated in the original Oconee PTS analysis documented in NUREG/CR-3770. Such superficial treatment of support systems may have two effects of concern:

- NUREG/CR-3770 may have missed some initiators that can make the operator response more complex and potentially induce new human failure events (HFEs) or higher likelihoods of analyzed HFEs, and

- the frequencies of the scenarios included in NUREG/CR-3770 may be optimistic by not explicitly accounting for support system failure contributions to the relevant equipment failures both individually as well as accounting for common dependency effects (i.e., acting like common cause).

The original PTS work for the H. B. Robinson plant, which was performed after the Oconee original analysis and documented separately [NUREG/CR-4183], examined support system effects more rigorously and included their failures subsequent to other initiators and found one support system initiator involving three additional PTS scenarios of concern. It is noted that for Oconee, Table 2.2 and Section 2.2.4 in NUREG/CR-3770 show such possibilities as main feedwater failing "as is" and TBVs failing closed (putting more demand on SSRVs) on loss of air, and TBVs failing 50% open on certain ICS failures, as examples of support system failure effects. Note that a re-designed ICS at Oconee (atypical compared with other Babcock and Wilcox (B&W) plants) may now prevent the 50% TBV open failure mode. Nevertheless, possible support system dependencies are considered more fully in this updated PTS PRA for Oconee[6].

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4 Note that the atmospheric dump valves were not treated in NUREG/CR-3770. Because these are normally not used at Oconee and are chained (i.e., locked shut), we decided to not model in this update analysis.

5 It is assumed that HVAC is not particularly important due to its relatively slow effects on PTS-relevant equipment.

6 While support systems were treated more fully in this analysis (i.e., initiating events and human failure effects), the treatment is still not as extensive as that performed for the updated Beaver Valley and Palisades analyses.

3. INITIATING EVENTS

One of the first tasks associated with the Oconee PTS PRA was the identification of those challenging events (i.e., initiating events) that perturb the normal status of the plant thereby causing an abnormal event such as a transient or loss of coolant accident (LOCA) that subsequently triggers possible sequences of events (called "sequences" or "scenarios"), some of which could result in a PTS challenge. For the identified initiating events, the expected number of occurrences per year (i.e., frequency) of each was also determined since this is a necessary aspect of determining the expected frequency of each PTS challenging scenario.

3.1 Identification Process

The process used to identify initiating events for the Oconee PTS analysis did not start anew but instead made vast use of already existing analyses. In this way, much of the already performed evaluations of possible initiators including losses of support systems, examination of actual Oconee initiating events, interviews with plant personnel, etc. did not have to be performed extensively since much of this type of detail is already included within the existing analyses that were reviewed. Thus the approach to identify initiators primarily involved the following:

- Review of the initial Oconee and H. B. Robinson PTS analyses for relevant Oconee-specific initiators addressed in those studies that could either directly cause loss of one or more of the four functions (e.g., LOCA) or challenge normal operation such that subsequent plant responses could cause an overcooling transient of potential concern (e.g., reactor trip followed by a demanded and then stuck-open TBV).

- Review of actual overcooling events and the associated initiators.

- Review of material from the Oconee PRA [Oconee IPE] focusing on initiators in that study and particularly those that may be relevant to PTS as opposed to core damage, including support system initiators.

- Brainstorming of possible initiators that could cause loss of one or more of the four functions discussed previously including consideration of the above sources and analysis of the effects of each initiator.

NUREG/CR-3770 examines nine classes of initiating events deemed to be relevant (all assuming nominal power level of >45%) because they are judged to sufficiently challenge the functions discussed above. As a point of comparison, the H. B. Robinson PTS report [NUREG/CR-4183] considers many potential relevant initiators and documents 11 relevant initiators. Table 3.1 provides the comparison between the initiators considered in the original Oconee and H.B. Robinson PTS studies.

Note that the H.B. Robinson analysis specifically reviewed and ruled out events involving:

- inadvertent safety injection (SI) or events with similar effects (e.g., loss of heat source to regenerative heat exchanger)

- excessive MFW as an initiator or events with similar effects (e.g., loss of feedwater heaters, initiation of auxiliary feedwater as an initiator)

- spurious pressurizer spray actuation.

3. Initiating Events

Table 3.1. Initiator comparisons for PTS.

NUREG/CR-3770 Oconee PTS	NUREG/CR-4183 H.B.Robinson PTS
1. Reactor/Turbine Trip understood to encompass typical, uncomplicated trips (e.g., turbine trip or inadvertent scram)	1. Reactor/Turbine Trip understood to encompass typical, uncomplicated trips (e.g., turbine trip or inadvertent scram)
2. Excessive MFW event	---- (screened out). May be plant-specific/vendor reason
3. Large Steam Line Break sufficient to depressurize the affected steam generator (SG) to below the EFW actuation setpoint of 725 psi	2. Large Steam Line Break at full power 3. Large Steam Line Break at hot 0% power
4. Small Steam Line Break that is insufficient to depressurize the affected SG to below the EFW actuation setpoint of 725 psi	4. Small Steam Line Break at full power 5. Small Steam Line Break at hot 0% power
5. Loss of MFW event	6. Loss of MFW event
6. Small Break LOCA-1 that is large enough to depressurize the primary system to below the HPI setpoint (1500 psi) but small enough that the primary system can repressurize using HPI to the PORV/SRV setpoints (>2450 psi)	7. Small Break LOCA at full power for which HPI can repressurize the primary system to its shutoff head and includes, for instance, single PORV/SRV openings and reactor coolant pump seal failures 8. Small Break LOCA at hot 0% power
7. Small Break LOCA-2 that is just like small LOCA-1 except it is large enough that the system cannot repressurize using HPI	9. Medium Break LOCA at full power for which HPI cannot keep up and a gradual pressure decrease occurs 10. Medium Break LOCA at hot 0% power
8. Inadvertent Safety Injection (SI)	---- (screened out). May be plant-specific/vendor reason
9. Steam Generator Tube Rupture (SGTR)	11. Steam Generator Tube Rupture (SGTR)

These events were judged to be insufficient challenges for PTS concerns in the H. B. Robinson study. Furthermore, a review was performed of possible support system failures that may contribute to other initiator scenarios or might, by themselves, be initiators that ought to be considered. This review examined:

- loss of component cooling water
- loss of service water
- loss of instrument air
- loss of certain electrical buses.

Based on being able to bound the effects of these losses into the above eleven categories as well as using low frequency arguments, the H. B. Robinson study ruled out support system faults as initiators except for a loss of service water that leads to loss of air that leads to loss of MFW. Three new sequences related to the loss of service water initiator were therefore, also analyzed.

While the two studies came to similar conclusions about the initiators that needed to be examined, noted discrepancies include:

- whether or not excessive feedwater should be considered,
- whether or not inadvertent SI should be considered, and
- the fact that perhaps some hot 0% secondary and primary system LOCAs also need to be considered.

Noteworthy in both studies is the lack of external event considerations (these were not analyzed in the studies). These could be of particular concern because of the additional context and complexity affecting the responses to such events. Of these (e.g., seismic, fire, internal flood, external flood, high winds/tornado, transportation accidents), it would seem that fire and internal flooding (though perhaps also seismic) may be of particular interest due to:

- their relative frequencies and potential to fail equipment (especially electrical) that may cause PTS-relevant failures of ICS, MFW, TBVs, etc.
- the concern about hot shorts caused by fire that may also cause PTS-relevant failures.

External events were treated in the updated Oconee PTS analysis but in a more bounding way than the traditional PRA event tree modeling treatment. The bounding external event approach is discussed in [Kolaczkowski]. Hence, this initiating event analysis and subsequent scenario modeling discussed later only address the internal initiators modeled in the updated Oconee PTS study.

Overcooling events or their potential do occur from time-to-time in the industry, so there is a limited experience base associated with such events [INEEL LER Review]. Review of LERs associated with such events demonstrates that this experience base largely consists of failures to properly control or throttle feed, actual or potential loss of portions of secondary pressure control, as well as other causes but all leading to relatively minor over-cooling situations. Examples include:

- manually overfeeding in an attempt to compensate for a loss of a single MFW pump
- runback equipment failure while the ICS was in manual mode
- discovered potential failure of some main steam safety relief valves (MSSRVs) to close (did not actually occur)
- equipment failure of a steam dump valve thus holding it open
- discovered potential failure of a MFW isolation valve to be able to close (did not actually occur)

- failure associated with a feedwater control valve controller (manual control room control of the valve was used to close the valve)

- discovered inability to close main steam isolation valves (MSIVs) because of disconnected DC power (MSIVs were not actually demanded) during a startup

- loss of control of feedwater control valves during a test at 15% power due to test staff error

- a MSSRV not completely closing during a complicated transient which was remedied by the operators decreasing pressure to reseat the valve

- MFW overfeeding due to an excessive manual bias in the feedwater controllers and a subsequent overfeeding of EFW due to a DC bus fault (all controlled rather quickly by operator action)

- failure of a steam dump valve being used during startup to close upon an upset

- a feedwater demand controller failure which resulted in actual MFW overfeed

- steam generator tube rupture (SGTR) events.

The above suggest that such events as reactor trips complicated by additional failures such as ICS failure, valve failures (e.g., MSSRVs, steam dump valves, etc. failing to close on demand), feedwater anomalies involving overfeeds or losses of feedwater or failure of associated equipment, and SGTRs should be among those scenarios considered for modeling in the Oconee PTS analysis.

Considering the above comparisons and actual events, a few representative and broad categories of initiating events were examined more closely to determine the potential Oconee-specific effects of such events both from a scenario perspective as well as considering potential challenges to the operating crew. This additional information was used to further aid in the final decision as to the initiators to model in the Oconee PTS analysis. Table 3.2 documents this examination.

Given all the information supplied above, and consideration of the Oconee PRA initiators as well as expert judgment, Table 3.3 provides a summary of the considerations used to decide which of the identified candidate initiators would be modeled in the Oconee PTS study. These considerations include thermal-hydraulic effects, frequency, and any particularly challenging operator response effects. Insights into the eventual grouping of initiators are also provided.

3.2 Initiators Modeled in the Oconee PTS Study

Based on the above process, Table 3.4 provides the list of internal initiating events that were modeled in the Oconee PTS study.

3.3 Initiators for Hot Zero Power Conditions

The above initiating event list was specifically generated with “at nominal power” conditions in mind. At hot zero power conditions, the thermal hydraulic response of the plant will generally be worse (i.e.,

Table 3.2. Representative initiators and their potential effects.

Representative Initiators of Interest	Potential Effects
Reactor Trip & other complexities (e.g., involving support system failure)	By itself, not a serious overcooling and significant challenges to operator performance would not seem to exist until multiple failures or unexpected events occur along with the trip. To the extent these additional complexities involve just one function (i.e., primary integrity, secondary feed, secondary pressure, primary flow/pressure), current operator experiences and training would suggest that such events are not extremely different from operator "expectations." However, as the number of individual equipment response problems increases or as multiples of the four functions become troubled, the scenario takes on characteristics of potential serious overcooling and being further beyond operator experience and training, thereby creating a larger mismatch between the event and operator "expectations" and thus increasing the chances of human error during the response. Ways to cause these multiple failures include both multiple independent equipment faults (e.g., PORV demanded and stuck-open along with a stuck-open TBV), as well as common support system or similar common faults affecting multiple equipment (e.g., subsequent ICS failure, instrument air failure, bus failures, loss of power, loss of component cooling water (CCW) causing the need to shutdown RCPs, and fire). Timing of the faults may also change the nature of the challenge such as if equipment first responds as expected and then fails/degrades later (e.g., TBVs properly function at first and then one sticks open later).
Loss of air	This event, whether as an initiator or subsequent to some other initiator, is a relatively infrequent event, with Oconee perhaps having even greater redundancy capability than some other plants [Oconee Visit] [IAS Lesson Plan] [AOP-Loss of Air]. Hence such an event is somewhat "unexpected" and yet its effects can be uniquely detrimental to concerns about PTS. On loss of air, besides some distraction paid to restoring air and other effects, RCS normal letdown closes down and seal injection increases causing pressurizer level and potentially RCS pressure to rise, MFW control valves initially fail "as is" potentially causing over-cooling if/when the plant trips though MFW will likely lose net positive suction head (NPSH) soon afterwards, TBVs fail closed, component cooling pumps could likely trip on closure of return block valve(s) adding further complexity and causing control rod drive heatup and RCP heatup requiring tripping of the RCPs (hence no forced RCS flow). Pending additional failures of backup nitrogen bottles and the extent of the air loss, equipment such as EFW control valves and main steam valves to the turbine-driven EFW as well as other components could be affected, as well as indications of main steam pressure, turbine-driven EFW pump discharge pressure, RCS makeup flow and HPI header pressure; all further adding to the difficulty to determine plant conditions and respond to the event appropriately. Many of these effects potentially can cause overcooling [IAS Lesson Plan] [AOP-Loss of Air].

Table 3.2. Representative initiators and their potential effects.

Representative Initiators of Interest	Potential Effects
ICS failures	This event, whether as an initiator or subsequent to some other initiator, is a moderately frequent event. Oconee has a somewhat atypical system due to recent improvements not made in other B&W plants involving use of more redundancy, automatic switching features, improved power source redundancy, etc. making the system far less susceptible to single failure effects [Oconee Visit] [UFSAR] [ICS Lesson Plan] [AOP-Loss of ICS Power] [Design Spec-ICS]. In spite of this, the fact that ICS controls equipment relevant to the balance of heat generation and heat removal, makes failures within it candidates for inducing PTS conditions. It controls: rod position, MFW flow control valve and pump speed, turbine governor control and bypass valves. Therefore, failures could potentially affect particularly the secondary feed and pressure control functions in an adverse way with respect to PTS. Operator identification of a problem and intervention may be necessary to prevent/mitigate a PTS condition. The complexity of the system and reliance on its auto-protective features may make failures and their effects difficult to predict, identify, and respond to. Some potential concerns include transferring from manual to auto mode if not done correctly (possible feed swings), failure of auto switching features, failure of auto switch to "good" power source (note, upon loss of hand power with a controller in "hand" mode, the control signal goes to 50% which might induce a PTS condition), and loss of all power which fails closed TBVs and causes all demand windows to go to mid-scale (including letdown) as well as failure of all ICS/non-nuclear indications (operator must rely more on post-accident monitoring indications). Resulting effects of various failures could be rather unexpected and potentially difficult to diagnose and respond to so as to prevent or limit the potential for PTS conditions.
Excessive MFW flow (or excessive feedwater cooling); especially at hot 0% power	Transitions at very low power conditions during startup or shutdown represent a time when multiple testing, unusual system configurations, changing system demands, etc. are typical and, hence, plant upsets are relatively likely. These conditions provide potential overcooling of the secondary and unique chances for operator error (or delayed response) in dealing with such upsets. Particularly, if plant conditions are being largely controlled by operator manual intervention, auto feature defenses may not be present or as redundant; hence any potential PTS-inducing upset may require human identification and control. Hence, excessive MFW may be of concern for PTS.

Table 3.2. Representative initiators and their potential effects.

Representative Initiators of Interest	Potential Effects
Steam line breaks (large to small; at power and at hot 0% power)	These are unexpected events (so little to no actual experience) and yet some training is periodically performed on such events thereby providing some familiarity [Oconee Visit] By themselves, they could be significant overcooling events but with no additional complexities, human responses would seem to be relatively straightforward and the nature of the event is easy to identify. However, like the reactor trip discussion above, should additional failures occur especially if they cause problems in controlling other of the four functions (e.g., feed control valve fails to close), then the overcooling situation could become more serious and the operator's ability to control the potential PTS condition can be more difficult and may even make for delayed or inappropriate action. Any plant condition that either causes both steam lines to be affected or make both appear to be the source of the depressurization (e.g., failure of turbine trip) could be troublesome with regard to isolating/restoring the correct steam path. Timely isolation of feed to the affected SG is key to the thermal transient caused by such events.
LOCA (primary)	This is an unexpected or infrequent event (e.g., pipe break, stuck -open PORV) and yet some training is periodically performed resulting in some operator familiarity (although a member of the training staff indicated that isolable LOCAs and very small LOCAs are not trained on very often) [Oconee Visit]. Like the steam line break, with no additional complexities, while the event itself can cause serious overcooling, the human responses would seem to be relatively straightforward and the nature of the event is easy to identify although there may be a tendency to not throttle injection until pressurizer level and subcooling are comfortably high (thereby potentially increasing pressure). However, like the reactor trip discussion above, should additional failures occur especially if they cause problems in controlling other of the four functions (e.g., MSSRV sticks open), then the operator's ability to control the potential PTS condition can be more difficult and may even make for delayed or inappropriate action.

Table 3.3. Considerations for including or excluding initiating events.

Initiator	Thermal-Hydraulic (TH) Considerations	Frequency Considerations	Human Reliability Analysis (HRA) Considerations	Comments
Reactor/Turbine Trip (including co-existing anomalies such as stuck-open valves, feed control failures such as due to ICS malfunction, etc.)	Depending on subsequent failures, over-cooling is possible and could be significant.	Of the order of 1/yr but must have additional equipment or operator failures that cause one or more of following: - secondary depressurization - secondary overfeed - primary leak (e.g., PORV or SRV open) - primary overfeed/ pressurization. Rule out subsequent break as too improbable.	Numerous depending on specific failures.	With the high frequency, this ought to be modeled as its own initiator including being a catch-all for all initiators co-involving complexities such as ICS failures, etc.
Loss of cooling/service water	Tendency is for running equipment to fail over time which more likely causes underfeed/no flow; therefore does not tend towards possible PTS. However, the likely need to shutdown RCPs due to heatup could add to stagnation potential.	In the E-3 to E-4/yr range for initiator which tends to make it less important from a frequency contribution perspective.	More complex event than reactor trip. Operators have other diversions or concerns for heatup and failing of equipment which could delay any overcooling responses.	This is a low frequency initiator yet could increase workload and add to confusion. Will likely need to shutdown RCPs due to heatup which enhances stagnation potential. Loss of component cooling could cause RCP seal failure but this is a small PTS challenge for any reasonable size LOCA. Since loss of air (see below) has a similar frequency, can cause a multiple set of direct effects important to PTS including potential loss of component cooling water, it is felt this initiator can be bounded by modeling the loss of air initiator.

Table 3.3. Considerations for including or excluding initiating events.

Initiator	Thermal-Hydraulic (TH) Considerations	Frequency Considerations	Human Reliability Analysis (HRA) Considerations	Comments
Loss of air	Oconee PTS report indicates loss of air will freeze MFW "as is," close TBVs, which will put more demands on SSRVs which could stick open, among other effects. Too much MFW and stuck-open SSRVs provides a tendency for PTS.	In the ~E-2/yr range so not so low as to be easily dismissed. Other failures may not be necessary to be of concern for PTS.	More complex event than reactor trip. Operators have other diversions or concerns dealing with recovering air which could delay any overcooling responses.	Loss of air will freeze MFW "as is" and close TBVs, which will put more demands on SSRVs which could stick open. Too much MFW (at least until loss of net positive suction) and stuck-open SSRVs provides a tendency for PTS. Additionally, other effects such as loss of component cooling water can further add to the effects of the event (such as needing to shutdown RCPs).
Loss of Electrical Bus(es)/Power	Tendency is for equipment to fail which more likely causes underfeed/no flow; therefore does not tend towards possible PTS.	In the E-2/yr to the E-3/yr range for initiator (bus loss) which tends to make this type of initiator less important though they are included in the PRA. Loss of offsite power (LOSP) is in the 0.01/yr - 0.1/yr range.	More complex event than reactor trip. Operators have other diversions or concerns getting power restored which could delay any overcooling responses.	Loss of power and its subsequent effects could be unique depending on the specific loss. Frequency, especially for loss of offsite power is not so low so that modeling seems worthwhile. Will also model plant-wide loss of 120VAC and 4KV buses that induce trips.
Failure of ICS	Depends on types of failures possible but some could be overcooling concerns.	Initiator may be in the E-1/yr or less range. Recognize that the ICS at Oconee has been recently redesigned making it somewhat atypical of other B&W plants and less susceptible to failures and should not cause TBVs going to 50%.	Failure of auto responses could make plant control difficult and even require operators to take over manual control of feed, etc.	Can be handled as a form of the reactor trip initiator using actual industry experience and subsequent event tree modeling to address the co-existence (along with the trip) of these possible failure modes such as causing overfeeds, etc.

Table 3.3. Considerations for including or excluding initiating events.

Initiator	Thermal-Hydraulic (TH) Considerations	Frequency Considerations	Human Reliability Analysis (HRA) Considerations	Comments
Excessive MFW	This event, by itself, would seem to present a relatively minor PTS challenge but may be more serious at hot 0% power condition.	Seems it would take controller or operator failure, or similar. MFW pumps may tend to trip on low suction pressure and should trip on high SG level. It is believed the level must exceed this high level before being a PTS concern so would need additional failures of this trip and the runback feature.	Seems operator might be able to manually control if condition identified before any significant effect.	While seemingly unlikely to be a serious PTS challenge without other failures, it was decided to capture the unique nature of this event by handling as a form of the reactor trip initiator using actual industry experience and subsequent event tree modeling to address this type of co-existing failure with the trip.
Large steam line break (suggest this be pipe breaks only; stuck-open valves covered under reactor trip)	Potentially serious overcooling may exist before operator can respond.	In the E-3/yr range but considering the TH comment, probably still important. Likely to also cause auto EFW which further worsens cooling.	Operator isolation of the break (if possible) and isolation of feed to the affected SG can be critical as to the seriousness of the event.	Potential fast overcooling and requirement for isolation make this an initiator to be modeled.
Small steam line break (suggest this be pipe breaks only; stuck-open valves covered under reactor trip)	Less cooling effect than large.	In the E-2/yr range.	See above.	See above. The potential differences in rate/degree of overcooling and timing for operator actions suggest this be its own category of initiator, separate from the large breaks.

Table 3.3. Considerations for including or excluding initiating events.

Initiator	Thermal-Hydraulic (TH) Considerations	Frequency Considerations	Human Reliability Analysis (HRA) Considerations	Comments
Loss of MFW	By itself does not tend toward to PTS (is an underfeed). But need to consider other failures such as lack of control of EFW or condensate feed.	In the E-1/yr range or less. Could cause demand on PORV (which could stick-open) pending EFW response.	Could involve controlling EFW or condensate especially in loss of both MFW and EFW.	Based on Oconee specific features from PRA, it is noted that Loss of Main Condenser will likely cause loss of MFW and put additional demands on MSSRVs causing higher potential for stuck-open valve that cannot be isolated. The similar frequency and effects as loss of MFW, the additional MSSRV demands, and the demand for EFW and the potential to overfeed it or overfeed with condensate make loss of main condenser (that should envelope the loss of MFW) a sufficiently unique initiator worthy of being modeled.
Small LOCA-1 (a repressurization possible with HPI)	Primary system cooling occurs, with stagnation and possible repressurization.	In the E-3/yr to the E-4/yr range.	Operator will likely shutdown RCPs. Possible tendency to over feed primary and perhaps repressurize.	Directly causes some overcooling and should be modeled.
Small LOCA-2 (too large for repressurization with HPI)	See above, but the repressurization cannot occur except at somewhat lower pressure (e.g., near CFT dump pressure) depending on the size.	Lower than the above Small LOCA-1 case.	See above but cannot maintain any high repressurization.	As the size differences may matter as to the overcooling rate, and depending on the RCS pressure, different challenges to PTS may exist. LOCAs, as initiators, will need to be modeled into at least a few representative size ranges.
SGTR	By itself, does not seem to present much of a PTS challenge as long as the number and size of tube failures are small. May need other failures.	In the E-2/yr range or a little less. If need other failures, frequency is lower yet.	Seems strong operator tendency to isolate affected SG and/or keep RCS pressure low per EOPs (so less of a PTS concern)	While seemingly unlikely to be a serious PTS challenge without other failures, it was decided to capture the unique nature of this event, especially considering actual SGTR events have involved at least minor overcooling.

Table 3.3. Considerations for including or excluding initiating events.

Initiator	Thermal-Hydraulic (TH) Considerations	Frequency Considerations	Human Reliability Analysis (HRA) Considerations	Comments
Inadvertent SI	By itself, does not seem to present much of a PTS challenge. Seems need other failures. Some TH results show cooling effects should not be significant.	Probably in the E-1 to E-2/yr range. If need other failures, frequency is lower yet.	Seems operator would likely be able to manually control if condition identified, before any significant effect.	Preliminary TH shows low overcooling effects. Does not seem worthy of modeling.

Table 3.4. Oconee PTS study initiators.

Modeling Designator	Description
LOP-3KI	Loss of power at 120 VAC Bus 3KI
LOP-3TC	Loss of power at 4 KV Bus 3TC
LIA	Loss of instrument air
LLOCA	Large LOCA ~6" or greater equivalent diameter
LMC	Loss of main condenser
LOCA	Small LOCA ~1.4" - 2.8" equivalent diameter
LOSP	Loss of offsite power (including possible station blackout)
MLOCA	Medium LOCA ~2.8" - 6" equivalent diameter
RTTT	Reactor trip / turbine trip
SGTR	Steam generator tube rupture
SLB1	Steam line break (small) ~8" or less equivalent diameter
SLB2	Steam line break (large) >~8" equivalent diameter treated as main steam line guillotine rupture

more severe cooling) because of the lack of substantial fission product heat that exists immediately after a trip from nominal power conditions. Further, the early PTS studies support the modeling of overcooling events at hot zero power conditions because of the different plant thermal-hydraulic responses.

After review of recent Oconee experience and discussion with the Oconee staff about the uniqueness (or lack thereof) of hot zero power conditions from an initiator and plant/operator response perspective, it was decided that all of the above initiators would also be modeled for when the plant is at hot zero power conditions when the initiator occurs (i.e., no significant difference was found between full power and hot zero power types of initiators). However, to properly account for the average time per year that the Oconee plant is in this condition, frequency adjustments had to be made to account for this fraction of time as well as other effects on the likelihood of each initiator. This is discussed later in section 3.5 concerning the initiating event frequency assignments.

3.4 Other Initiator/Scenario Types Considered But Not Modeled

Two general and noteworthy types of scenarios commonly modeled in PRAs were not included in the Oconee PTS analysis; anticipated transients without scram (ATWS) scenarios and interfacing system LOCA (ISLOCA) scenarios. Sequences resulting from such scenarios were not included based on the following considerations. First, ATWS events generally initially begin as a severe under-cooling event (i.e., there is too much power for the heat removal capability) and would likely involve other failures to achieve an overcooling situation even if it were possible to do so. While ISLOCAs, like the LOCAs modeled in the Oconee PTS study, could involve overcooling from the start of the event, significant ISLOCAs are often assumed to fail mitigating equipment in PRAs which ultimately causes an under-cooling event and core damage. Second, with typical ATWS and sizeable (not just small leaks) ISLOCA frequency estimates in the E-5/yr to E-6/yr or even lower range, and with the need for other failures to occur to possibly cause a continuing and serious overcooling situation, sequences involving ATWS or ISLOCAs should not be significant contributors to PTS risk when compared to other modeled scenarios with initiator frequencies commonly in the 1/yr to E-3/yr range and since other LOCAs are already modeled in the PTS study.

3.5 Initiating Event Frequencies

3.5.1 Initiators Except LOCAs

A goal of the PTS work was to provide analyses that, to the extent possible, considered the design differences among the various PWRs studied but could be generically applied to all PWRs within the U.S. To accomplish this, it was decided that the modeling of the potential PTS scenarios for each study would consider specific plant design and operational features but that the data used to quantify basic events in each model (e.g., initiator frequencies) would be based primarily on actual industry-wide experience (i.e., not plant specific). As such, no PTS study is a specific assessment of the PTS risk for the particular plant being analyzed; but instead is a more generic assessment of PTS risk but considering PWRs with similar design and operational features as the plant being studied.

Hence, the initiator frequencies used in the Oconee PTS study are based on actual industry-wide PWR experience. Summaries of the experience from 1987 thru 1998 and the detailed qualitative and statistical analyses of that experience is documented in two reports [NUREG/CR-5750, NUREG/CR-5750-Addendum]. The more up-to-date of these reports [NUREG/CR-5750-Addendum] was used as the source of initiator frequencies for the Oconee PTS study. The reader is referred to these two reports for more information.

Table 3.5 summarizes the frequencies used in the Oconee PTS study based on the above information. The far right column of the table provides a reference to the table within the NUREG/CR-5750-Addendum for each frequency. Examination of the table in the Addendum for each initiator type confirms the initiator frequency values used here.

For the small and large main steam line breaks, a separate analysis was performed by the authors of the Addendum specifically for the purpose of these PTS studies. That analysis is summarized below.

MSLB - Main Steam Line Breaks

MSLB events are segregated into two categories: 8-inch equivalent diameter or less (classified as small), and greater than 8-inch equivalent diameter (classified as large). This distinction is one of analytical convenience and provides two broad groups of breaks to account for the differences in overcooling for different size MSLBs. Although the large MSLB will be defined as anything greater than 8-inch equivalent diameter, it will be characterized as a rupture of the main steam line. The table below summarizes the MSLB events that have occurred in the U.S. PWR operating experience (1987-1998, 667 PWR critical-years).

Steam Line Break Events (U.S. industry wide, 1987-1998).

LER	**NSSS**	**Size**	**Isolated?**	**Rx-Trip**	**RCS Cooldown**
42390030	W	6"	Yes, MSIV	manual	minimal
33691012	CE	8"	Yes, MSIV	manual	minimal
45590010	W	1"	Yes, MSIV	manual	minimal
42596008	W	MFP rupture disk	Yes, MFW	auto	minimal
36889006	CE	14" w/ ADV stuck open	Yes	auto	580ºF to 522ºF
33695032	CE	8"	Yes	manual	minimal
32893001	W	<6"	Yes	manaul	minimal
31898004	CE	2"	Yes, MSIV	manual	minimal
28597003	CE	6" (est.)	Yes	manual	minimal
25587016	CE	<6"	Yes	manual	minimal
27096004	B&W	<6"	Yes	manual	579ºF to 550ºF

Based on this experience, the Small SLB frequency is estimated as (10-events/667-critical-PWR-years). The large SLB frequency is estimated as (1-event/667-critical-PWR-years). Gamma distributions accounting for the uncertainties in these estimates are used and the resulting mean values are shown in Table 3.5.

Table 3.5. Oconee PTS study initiator frequencies (excluding LOCAs).

Modeling Designator	Description	Nominal Power Frequency (per critical year)	Multiplier to Convert to Hot Zero Power Frequency	Data Source for Nominal Power Frequency
LOP-3KI	Loss of power at 120 VAC Bus 3KI	6.3E-3 (plant-wide for all similar buses)	0.02	NUREG/CR-5750-Addendum, Table D-11
LOP-3TC	Loss of power at 4 KV Bus 3TC	1.7E-2 (plant-wide for all similar buses)	0.02	NUREG/CR-5750-Addendum, Table D-11
LIA	Loss of instrument air	4.6E-3	0.02	NUREG/CR-5750-Addendum, Table D-11
LMC	Loss of main condenser	6.7E-2	0.02	NUREG/CR-5750-Addendum, Table D-11
LOSP	Loss of offsite power (including possible station blackout)	3.8E-2	0.02	NUREG/CR-5750-Addendum, Table D-11
RTTT	Reactor trip / turbine trip	0.84	0.2	NUREG/CR-5750-Addendum, Table D-12
SGTR	Steam generator tube rupture	5.2E-3	0.02	NUREG/CR-5750-Addendum, Table D-11
SLB1	Steam line break (small) ~8" or less equivalent diameter	1.4E-2	0.02	See discussion above in Section 3.5.1 of this document
SLB2	Steam line break (large) >~8" equivalent diameter treated as main steam line guillotine rupture	2.2E-3	0.02	See discussion above in Section 3.5.1 of this document

Also shown in Table 3.5 are multipliers used in the Oconee PTS study for converting these frequencies to a per critical year when at hot zero power conditions. To arrive at these multipliers, Oconee experience was reviewed to determine the approximate average time per year that Oconee spends at hot zero power on the way up to or down from full/nominal power conditions. Recent experience shows that this is approximately 1% - 2% of the year. Hence, a 2% multiplier was used in nearly all cases to arrive at an appropriate frequency for each initiator while at hot zero power on a per critical year basis. Thus for example, the initiator frequency used in the Oconee PTS study for LIA (loss of instrument air) while at hot zero power is 4.6E-3/yr x 0.02 = 9.2E-5/yr.

A review of transients that typically occur while at hot zero power suggests that there is no evidence that certain initiators are significantly more prone to occur at hot zero power than at full power except for inadvertent reactor/turbine trips due to transient conditions that arise while purposely changing feedwater and steam conditions along with changing power and other parameters in the plant. While no statistical treatment of this observation was attempted, engineering judgment was used to suggest that reactor/turbine trips seem more likely than would be accounted for by simply using the 2% multiplier. A factor of ten increase in the likelihood of such trips while at hot zero power was assumed resulting in the 20% multiplier shown for that case (RTTT) in Table 3.5.

3.5.2 LOCA Initiators

During Oconee PTS model construction and determination of preliminary results, the LOCA frequencies used in the Oconee PTS study came from the same source as the other initiator frequency data [NUREG/CR-5750-Addendum]. In particular, the frequencies are provided in Table D-11 of the Addendum and are based on information in Appendix J of the Addendum and its predecessor report. Those frequencies are shown in Table 3.6 as the “original” LOCA frequencies used in the Oconee PTS study.

As the Oconee study was nearing completion, a separate effort was underway at NRC to review and revise the LOCA frequencies from NUREG/CR-5750 for use particularly in work associated with 10CFR50.46 but with applicability for other risk-informed applications such as the PTS project. There was a concern that the LOCA frequencies in NUREG/CR-5750 did not account for age-related factors important to deriving the frequencies and an expert elicitation effort at NRC was conducted to account for these adjustments [Mayfield memo].

The results from that elicitation were not entirely appropriate for use in the Oconee PTS study because the elicitation structure and results involved both piping and non-piping causes for the various size breaches. To fit our specific application, we needed only the piping contribution. Since the elicitation had not been formatted in a way to decompose the two parts, it was not possible to directly discern the appropriate frequencies to use for our purposes. A discussion was held with personal associated with the elicitation effort and following affirmation of the differences between the elicitation and our PTS study needs, it was agreed that values approaching 1.5 - 2 times the original LOCA frequencies would be appropriate for the small and medium LOCAs in the PTS study. Further, the elicited value of 7E-6/yr should be used as is for the large LOCA. This agreed upon direction resulted in the revised LOCA frequencies shown in Table 3.6. These are the LOCA frequencies used in the “final results” for the Oconee PTS study.

Table 3.6. Oconee PTS study LOCA initiator frequencies.

Modeling Designator	**Description**	**Nominal Power Frequency**	**Multiplier to Convert to Hot Zero Power Frequency**
LLOCA	Large LOCA ~6" or greater equivalent diameter	*original:* 4E-6 per calendar year (converts to 5E-6 per critical year) *revised:* 7E-6 per critical year	0.02
MLOCA	Medium LOCA ~2.8" - 6" equivalent diameter	*original:* 3E-5 per calendar year (converts to 4E-5 per critical year) *revised:* 6E-5 per critical year	0.02
LOCA	Small LOCA ~1.4" - 2.8" equivalent diameter	*original:* 3.1E-4 per critical year *revised:* 6E-4 per critical year	0.02

4. ACCIDENT SEQUENCE ANALYSIS

This section describes how potentially important pressurized thermal shock (PTS) accident scenarios were identified (i.e., developed) and then grouped (or binned) into thermal-hydraulic (TH) bins. The accident sequence (i.e., event tree) analysis in this study differs from a traditional Level 1 core damage analysis in that, instead of being interested in identifying scenarios that lead to core damage, the objective of the PTS analysis was to identify scenarios comprised of initiating events (IEs), equipment successes and failure, and human actions (or the lack of such) that lead to overcooling conditions where PTS may be important. Thus, for each of the IEs identified in section 3, an event tree was constructed to identify the overcooling scenarios. Once the individual overcooling scenarios were developed, TH bins were constructed by grouping scenarios with similar TH characteristics. This binning process was necessary to reduce the number of FAVOR [NUREG/CR-6855 and Dickson] calculations necessary to estimate reactor vessel through-wall-crack frequency.

4.1 Event Tree Development

Primarily as a result of the review of past PTS analyses [NUREG/CR-3770, WCAP-15156, NUREG/CR-4183, AND NUREG/CR-4022], the event trees in this analysis are based on the status and interactions of four plant functions and their associated systems. These four functions are important to PTS for the following reasons:

- Primary integrity: The status of this function determines, at least in part, the potential RCS pressure which influences the rate of cooldown in some situations and the injection source capability as well as incoming and outgoing flowrates thus influencing the vessel downcomer temperature.

- Secondary pressure: The status of this function determines, at least in part, the pressure and temperature in the RCS since the RCS and the secondary side of the plant are thermal-hydraulically coupled in most types of scenarios. Thus, for instance, a rapid drop in secondary pressure can cause a corresponding rapid cooling of the RCS affecting both the downcomer temperature and potentially the RCS pressure depending on subsequent RCS injection flow and heat removal.

- Secondary feed: The status of this function determines, at least in part, the pressure and temperature in the RCS since the RCS and the secondary side of the plant are thermal-hydraulically coupled in most types of scenarios. Thus, for instance, an overfeeding situation can contribute to enhanced cooling of the RCS affecting both the downcomer temperature and potentially the RCS pressure depending on subsequent RCS injection flow and heat removal.

- Primary pressure/flow: The status of this combination of conditions determines, at least in part, the RCS pressure and flow conditions (forced flow or natural circulation) during the overcooling event as well as the nature of the injection that can add cooling to the vessel wall. The flow characteristics either exacerbate or mitigate flow stagnation which can also affect the downcomer region temperature.

Figure 4.1 presents a function-level event tree depicting these four functions and subsequent general types of sequences treated in this PRA analysis.

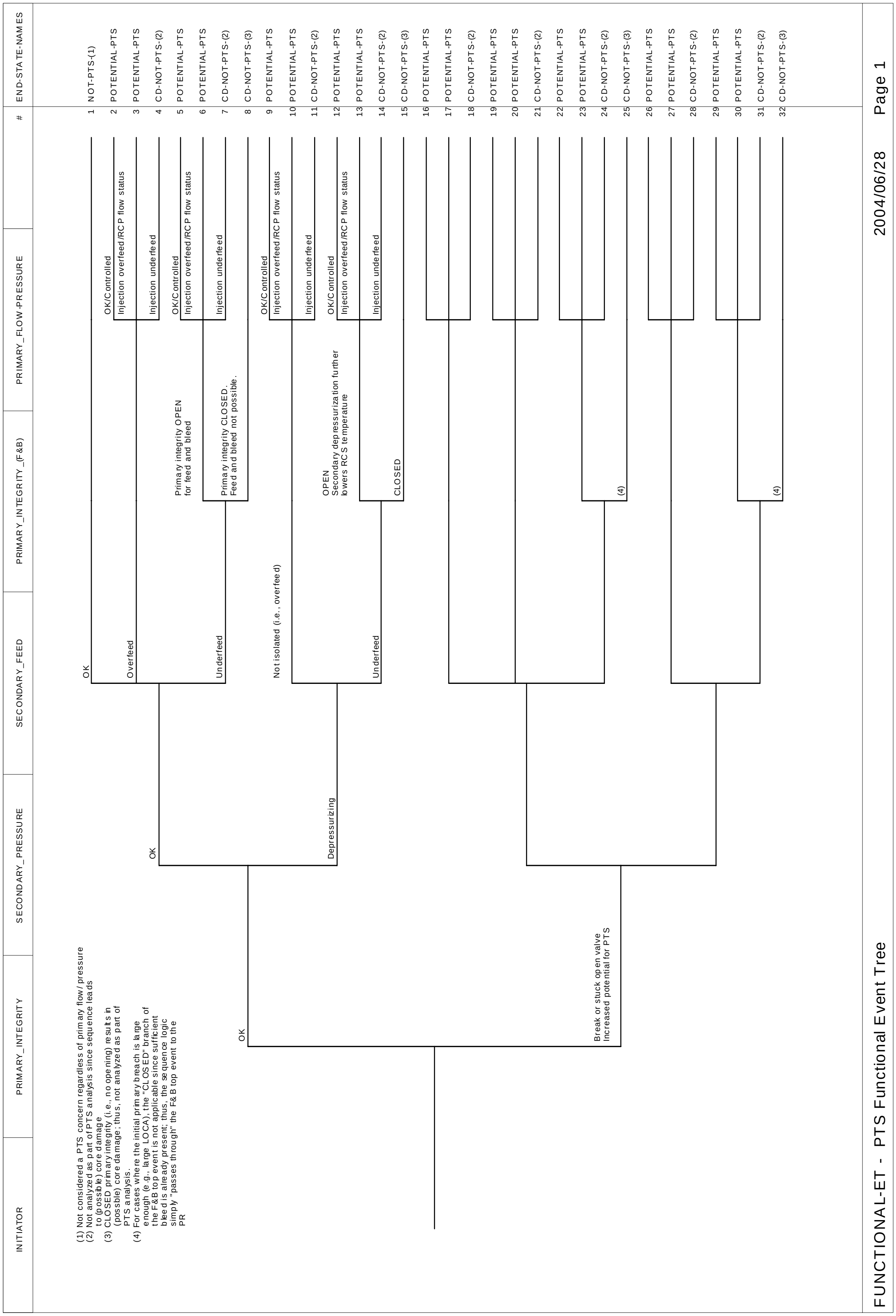

Figure 4.1. Functional event tree.

Development of the system-level event trees used in this analysis required the identification of the relevant Oconee equipment related to the potential loss of the four functions identified in Figure 4.1. For Oconee, the relevant equipment versus function is as follows:

- Primary integrity:
  - RCS piping [different size breaks],
  - power-operated relief valve (PORV) and associated block valve [potential opening and reclosing of PORVs and isolation of block valve],
  - pressurizer safety relief valves (SRVs) [potential opening and reclosing], and
  - pressurizer sprays and heaters (although these were later found to have small effects and so were not modeled) [potential cooling/depressurization and heating/repressurization].
- Secondary pressure:
  - steam lines [different size breaks],
  - turbine stop valves (TSVs)[7] and turbine control valves (TCVs),
  - turbine bypass valves (TBVs) and turbine block valves [possible isolation mechanism to regain TBV-caused loss of secondary pressure], and
  - secondary steam relief valves (SSRVs) [potential openings of one or more].
- Secondary feed:
  - main feedwater (MFW),
  - condensate, and
  - emergency feedwater (EFW) system.
- Primary flow/pressure:
  - reactor coolant pumps (RCPs) [status dictates forced or natural flow conditions in the RCS],
  - internal vent valves [status dictates degree of mixing of “hot” and “cold” water before reaching the downcomer of the RPV[8]],
  - high pressure injection (HPI)[9] pumps and the core flood tanks (CFTs), and
  - low pressure injection (LPI) pumps.

---

[7] Note that Oconee has no main steam isolation valves (MSIVs) like most plants. Status of TSVs and TCVs not modeled because of probability considerations (two valves in series must fail to close, plus operator must fail to trip lift oil pump).

[8] Status of vent valves not quantified as part of model (failure of sufficient number of valves too improbable). Status used in selected TH calculations to account for uncertainty associated with their operation or non operation.

[9] Note that Oconee’s pumps serve both normal makeup and safety injection functions and can pressurize the primary system to the pressurizer safety valve setpoints.

4.2 Event Tree Top Events

4.2.1 Power Model Top Events

With the list of relevant equipment versus function information identified in section 4.1, system-level event trees were developed for each of the initiators identified in Section 3.2. These system-level event trees, including transfer trees, are shown in Figures 4.2 through 4.32. The following sections define the top events included in the system-level event tree used to model each initiating event.

4.2.1.1 3KI Top Events

The top events and the logic structure for the LOP-3KI initiator event tree are shown in Figures 4.2 (initiator tree), 4.18, 4.21, 4.24 (first level transfer trees), 4.19, 4.20, 4.22, 4.23, 4.25, and 4.26 (second level transfer trees).

Top events for Figure 4.2 include:

LOP-3KI: A loss of 120 V ac power at bus 3KI initiating event occurs.

PORV_SRV_SO: The determination of whether a pressurizer PORV or SRV is stuck open. The top branch implies that neither are stuck open, the middle branch represents the case where a PORV is initially stuck open, and the bottom branch represents the case where a SRV is initially stuck open.

PORV_ISO_F: The success or failure of isolating the stuck open PORV. Success implies that the PORV was isolated by closing it or its block valve. Failure implies that the operators failed to close the block valve.

SRV_ISO_F: The determination of whether a stuck open SRV closes by itself. The top branch represents the case where the SRV does reclose. The bottom branch represents the case where it does not.

TBV_SO: The determination of how many TBVs or main steam SRVs (i.e., secondary steam relief valves [SSRVs]) are stuck open. The top branch represents the case where no valves are stuck open. The next three branches represent one, two and four valve(s) stuck open respectively.

TBV_ISO_F: The success or failure of isolating the stuck open TBVs (Note: The main steam SRVs cannot be isolated. The model accounts for the conditional probability that the stuck open valves were main steam SRVs instead of TBVs.). Success implies that the stuck open TBVs were isolated. Failure implies that the operators failed to isolate the TBVs.

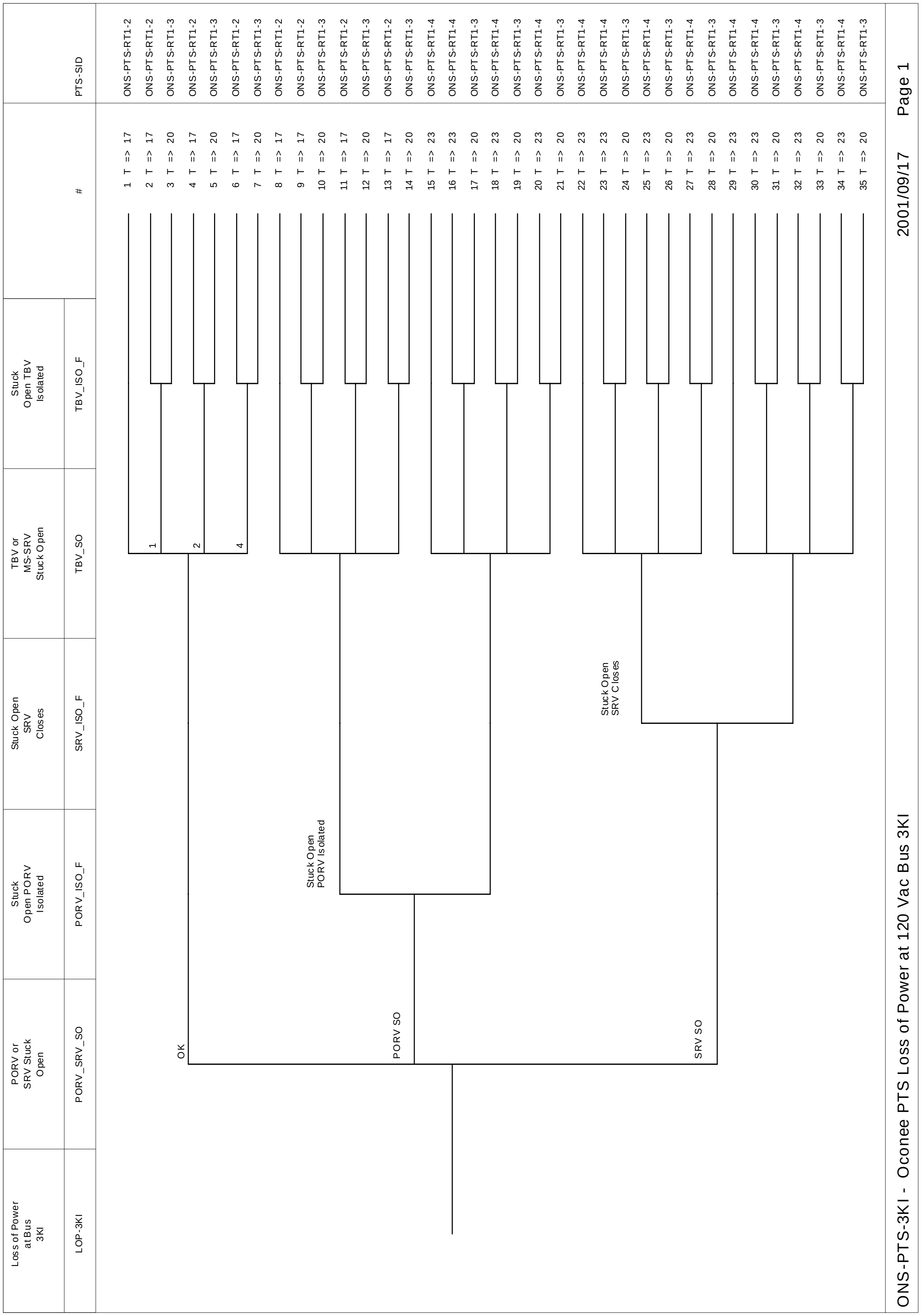

Figure 4.2. Oconee 3KI: loss of power at 120 Vac bus 3KI.

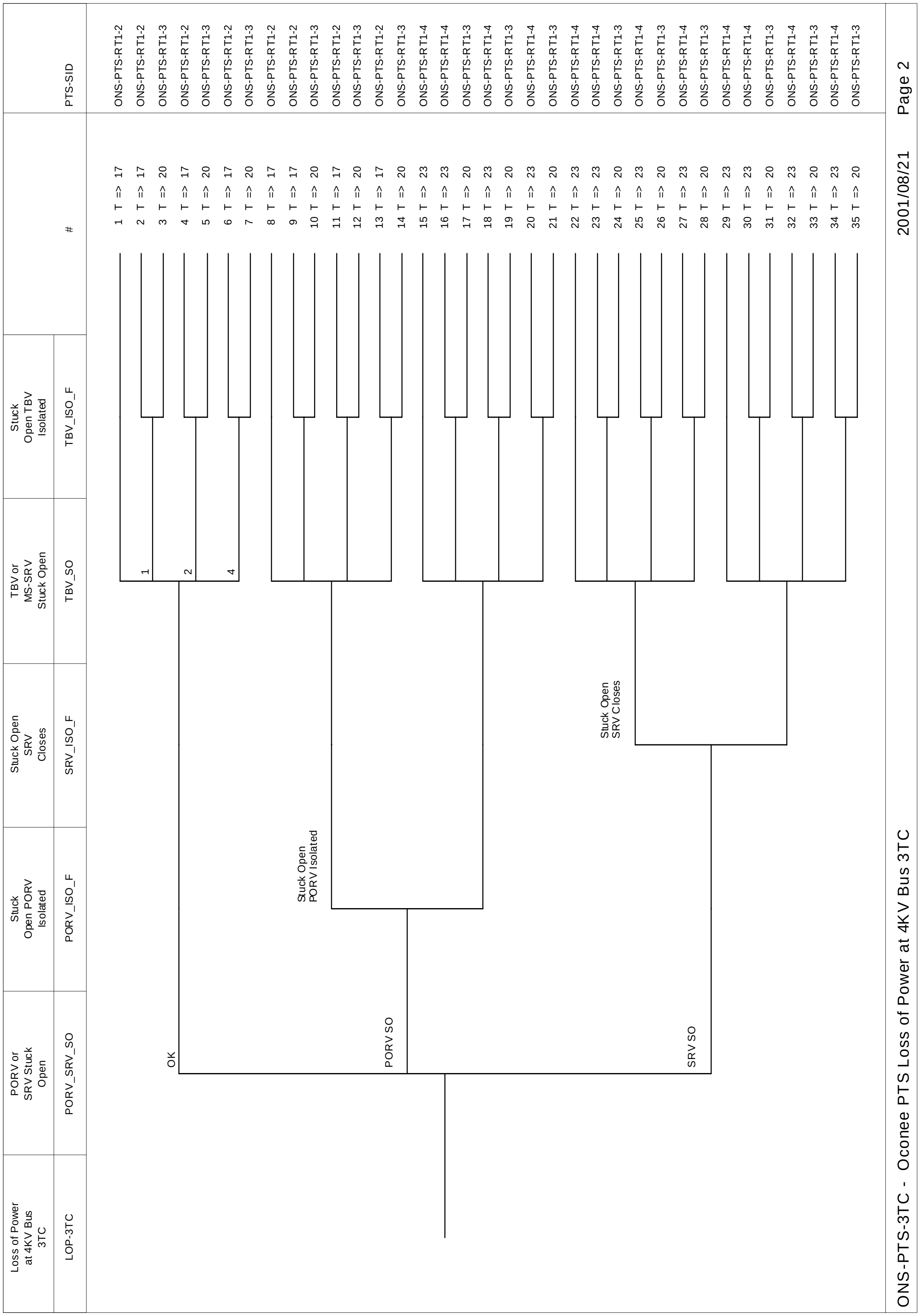

Figure 4.3. Oconee 3TC: loss of power at 4KV bus 3TC.

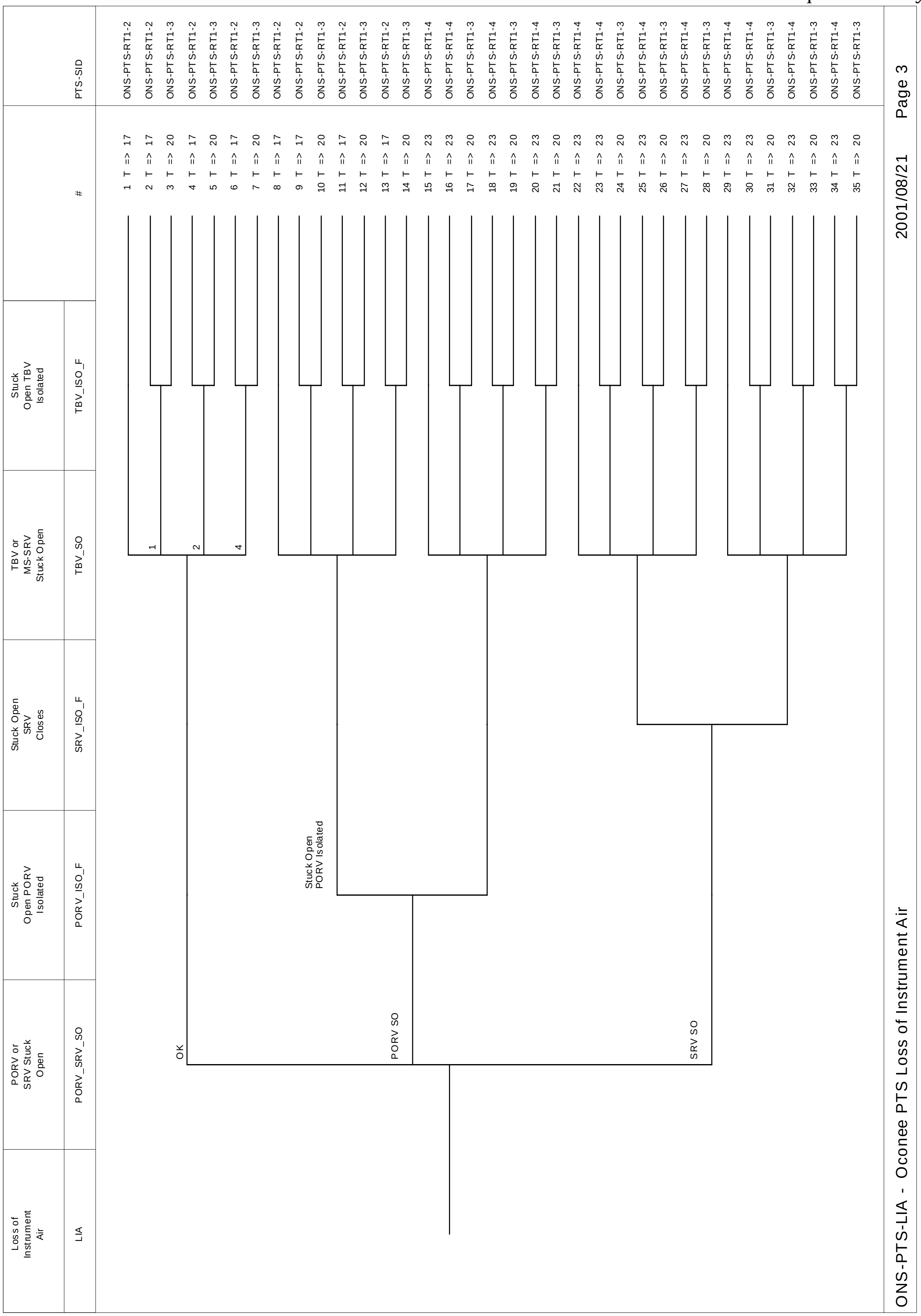

Figure 4.4. Oconee LIA: loss of instrument air.

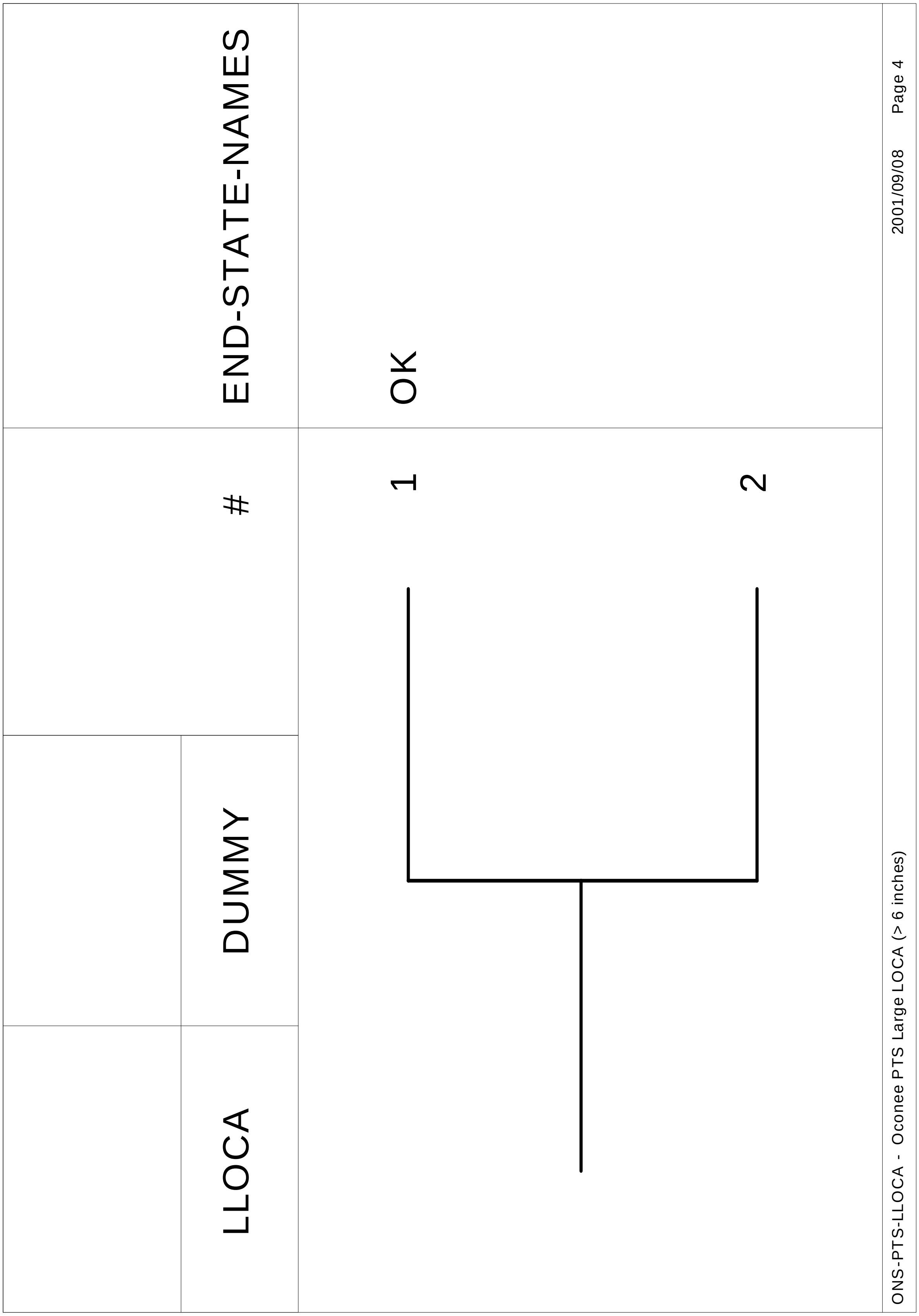

Figure 4.5. Oconee Large LOCA.

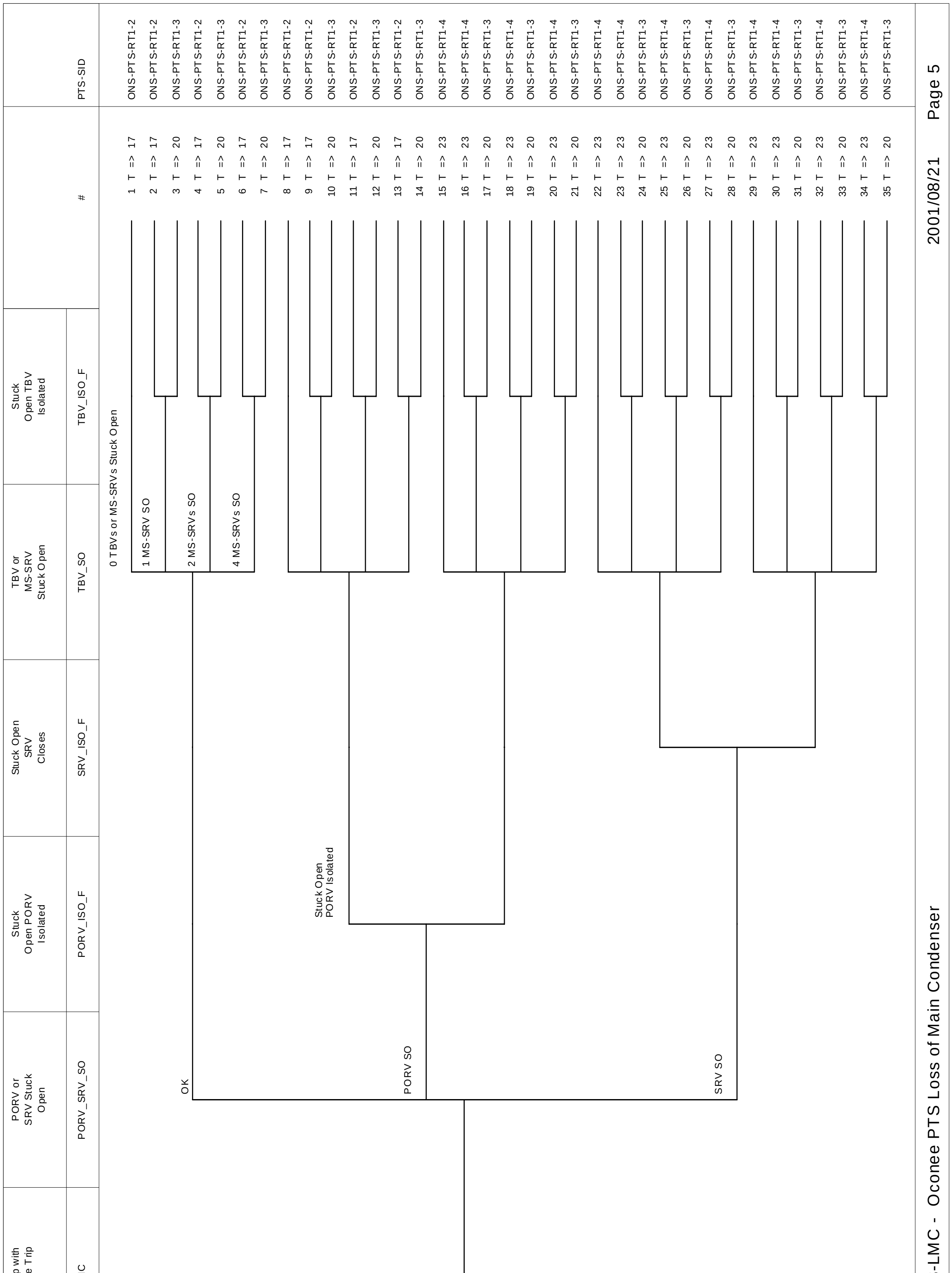

Figure 4.6. Oconee LMC: loss of main condenser.

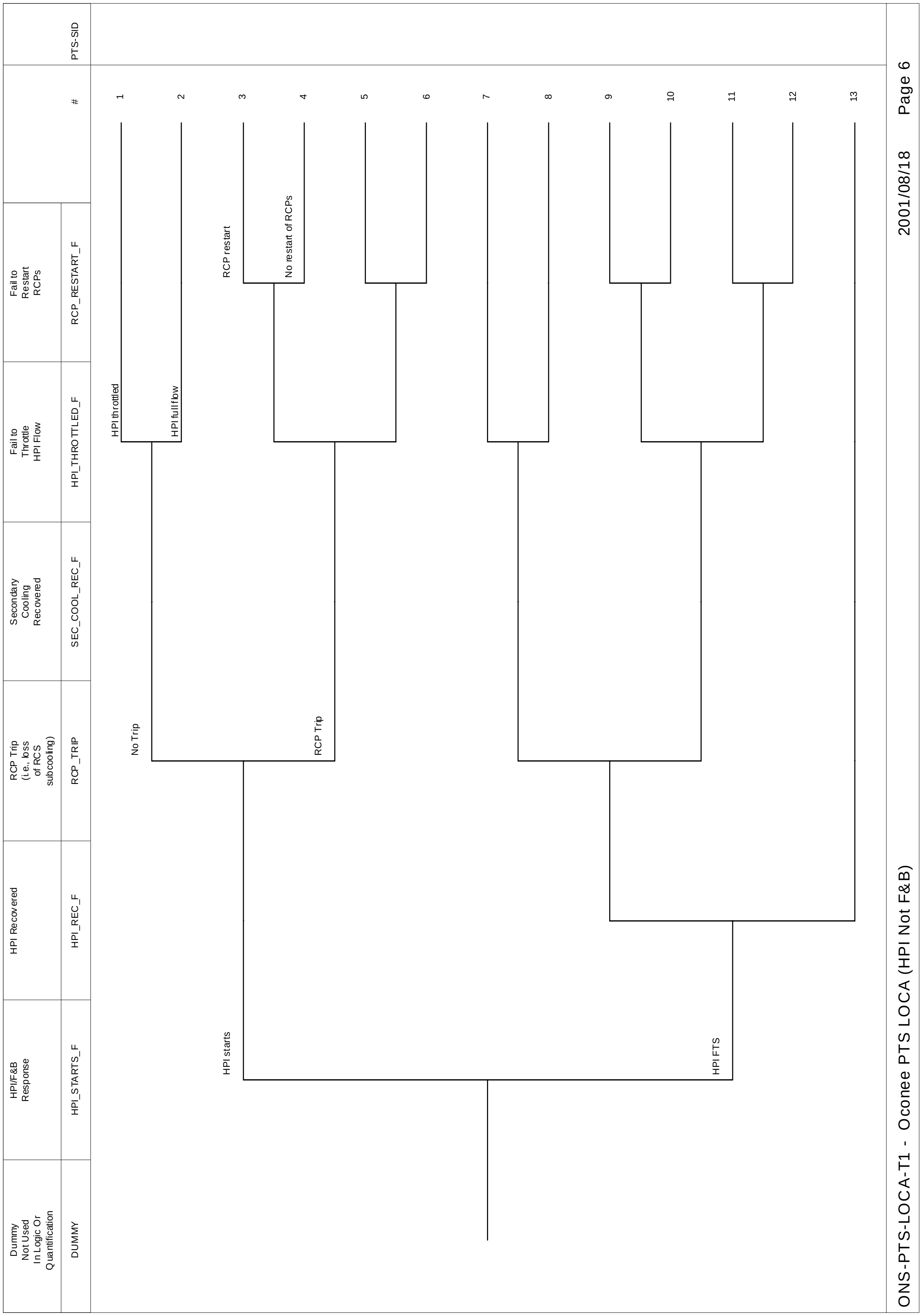

Figure 4.7. Oconee LOCA-T1: LOCA (HPI not F&B).

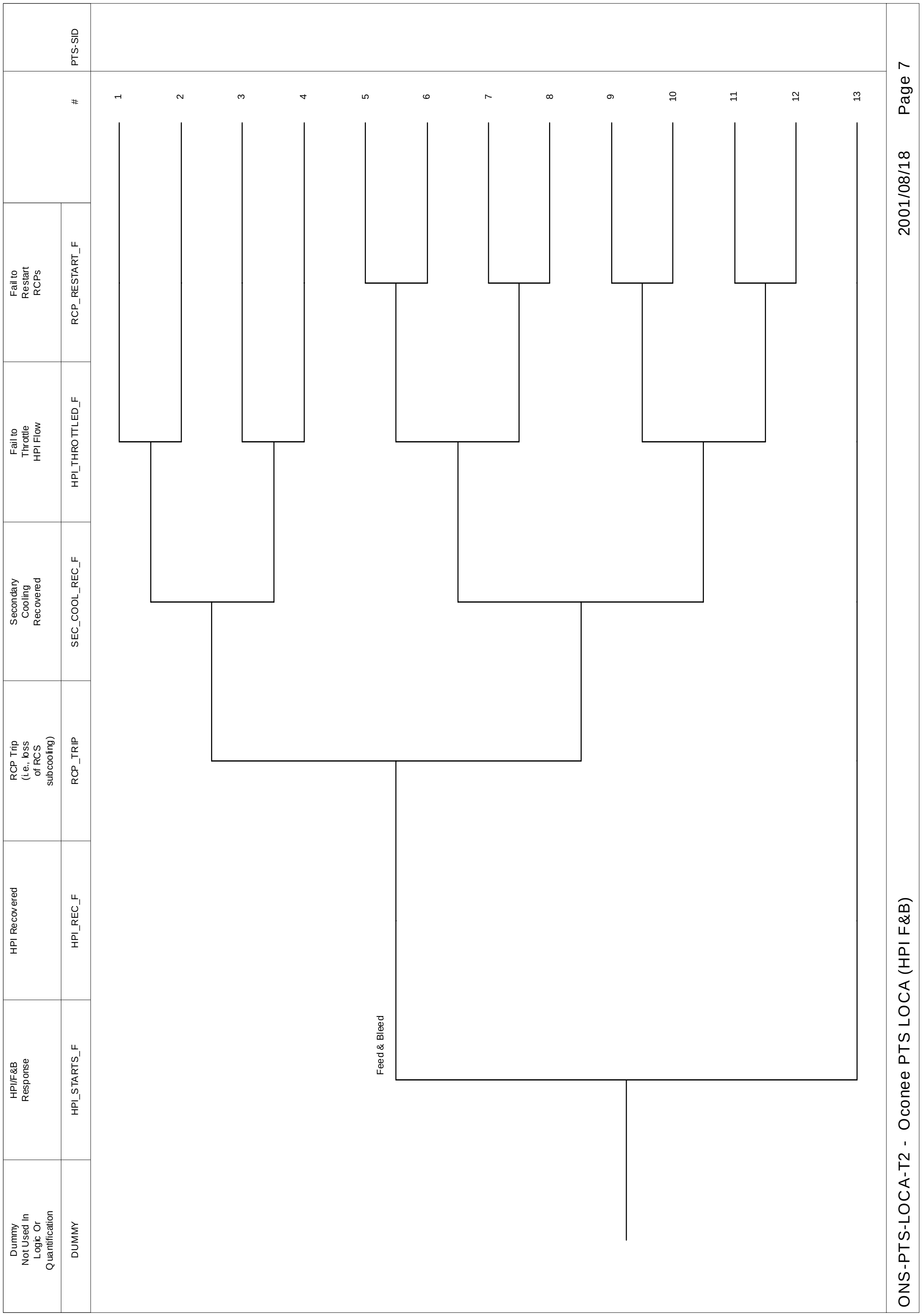

Figure 4.8. Oconee LOCA-T2: LOCA (HPI F&B).

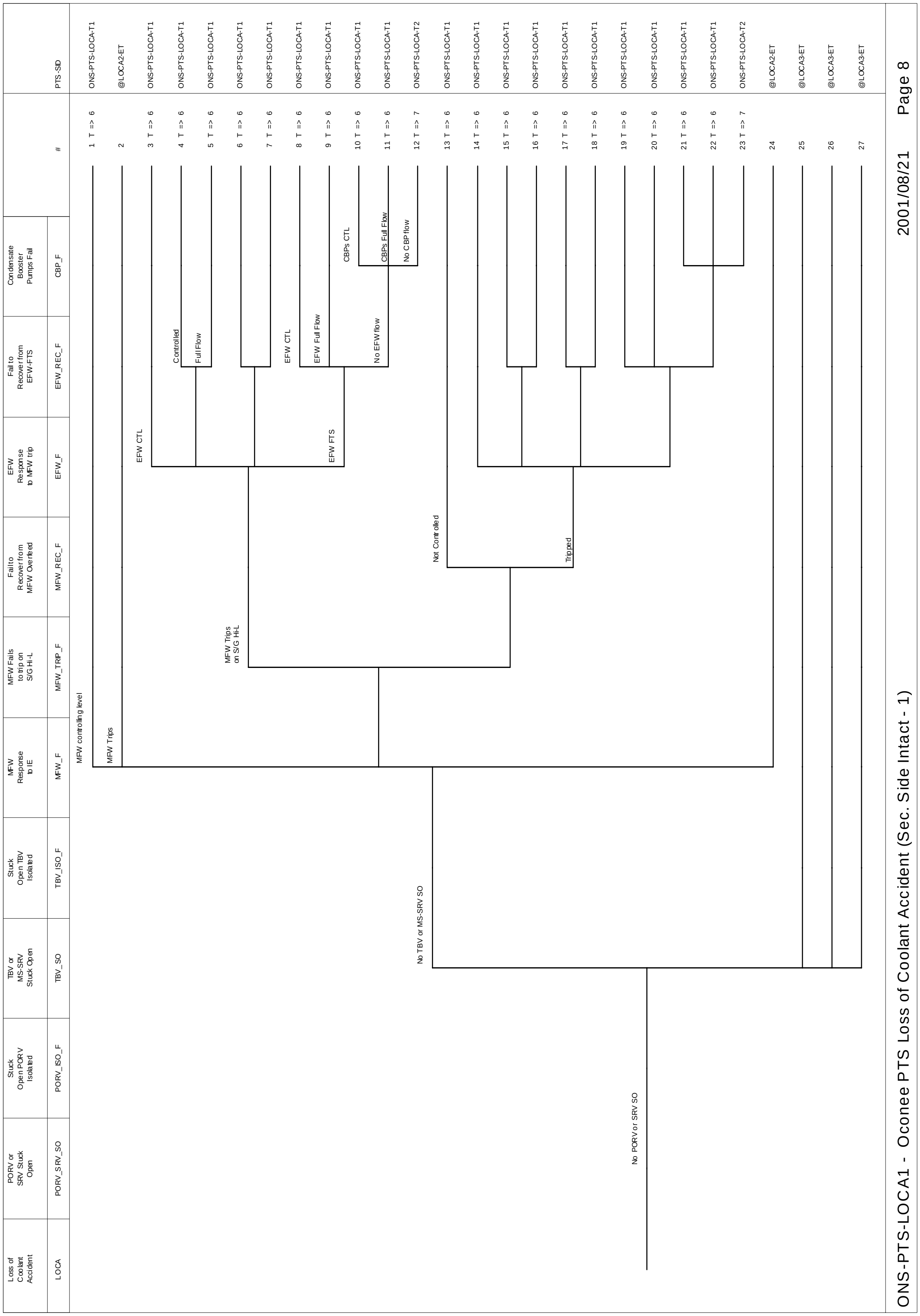

Figure 4.9. Oconee LOCA1: loss of coolant accident (sec. Side intact - 1).

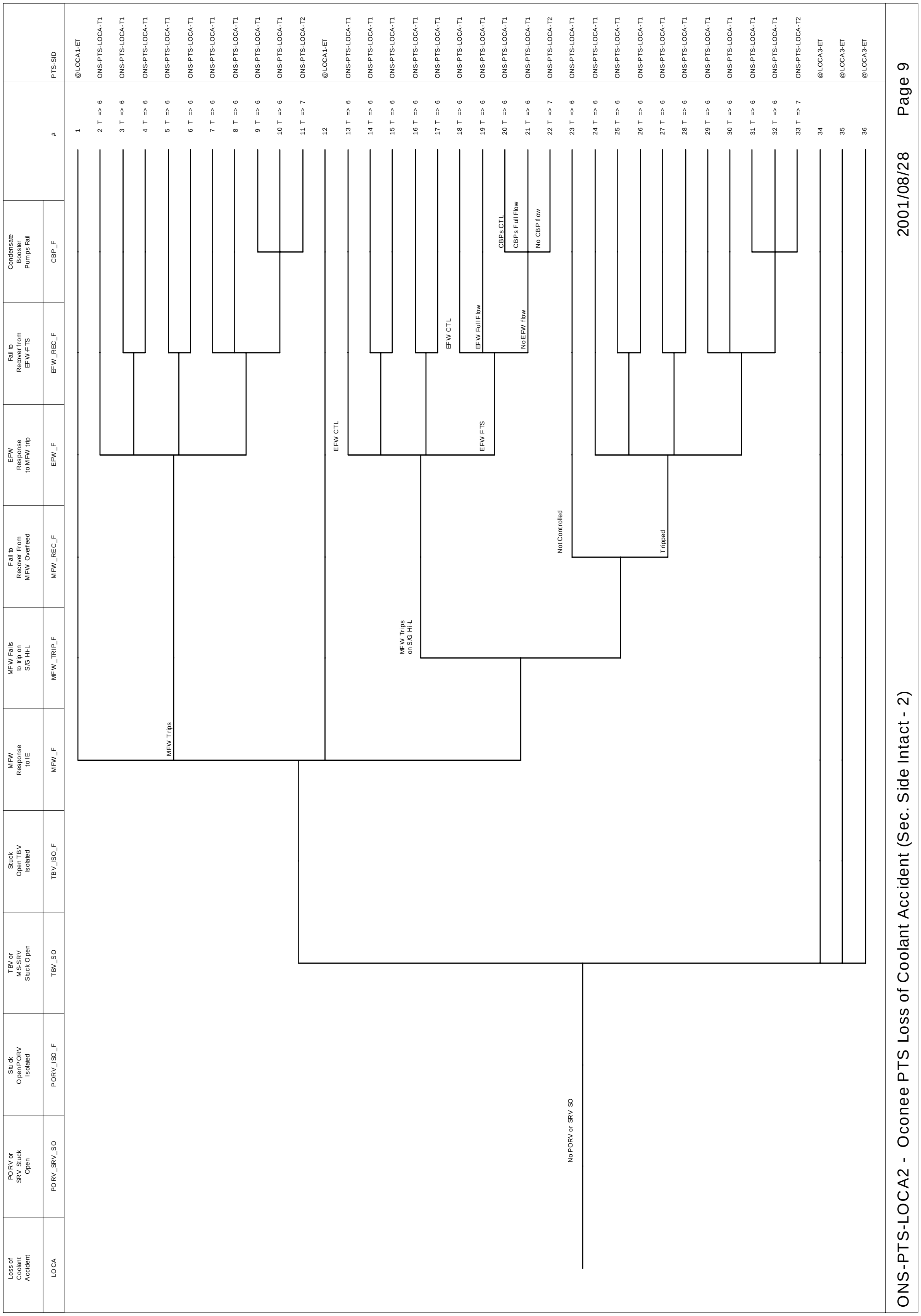

Figure 4.10. Oconee LOCA2: loss of coolant accident (sec. side intact - 2).

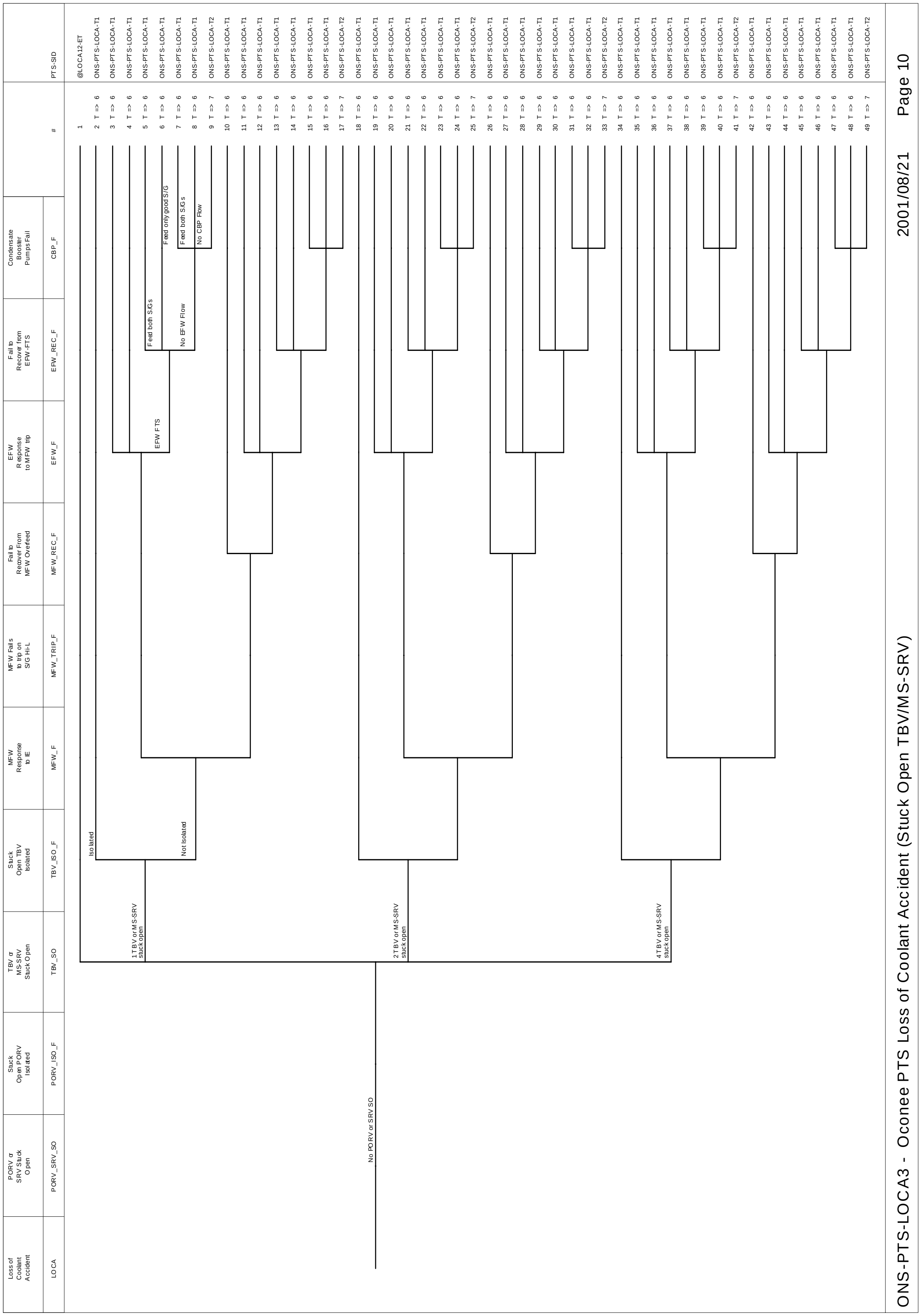

Figure 4.11. Oconee LOCA3: loss of coolant accident (stuck open TBV/MS-SRV).

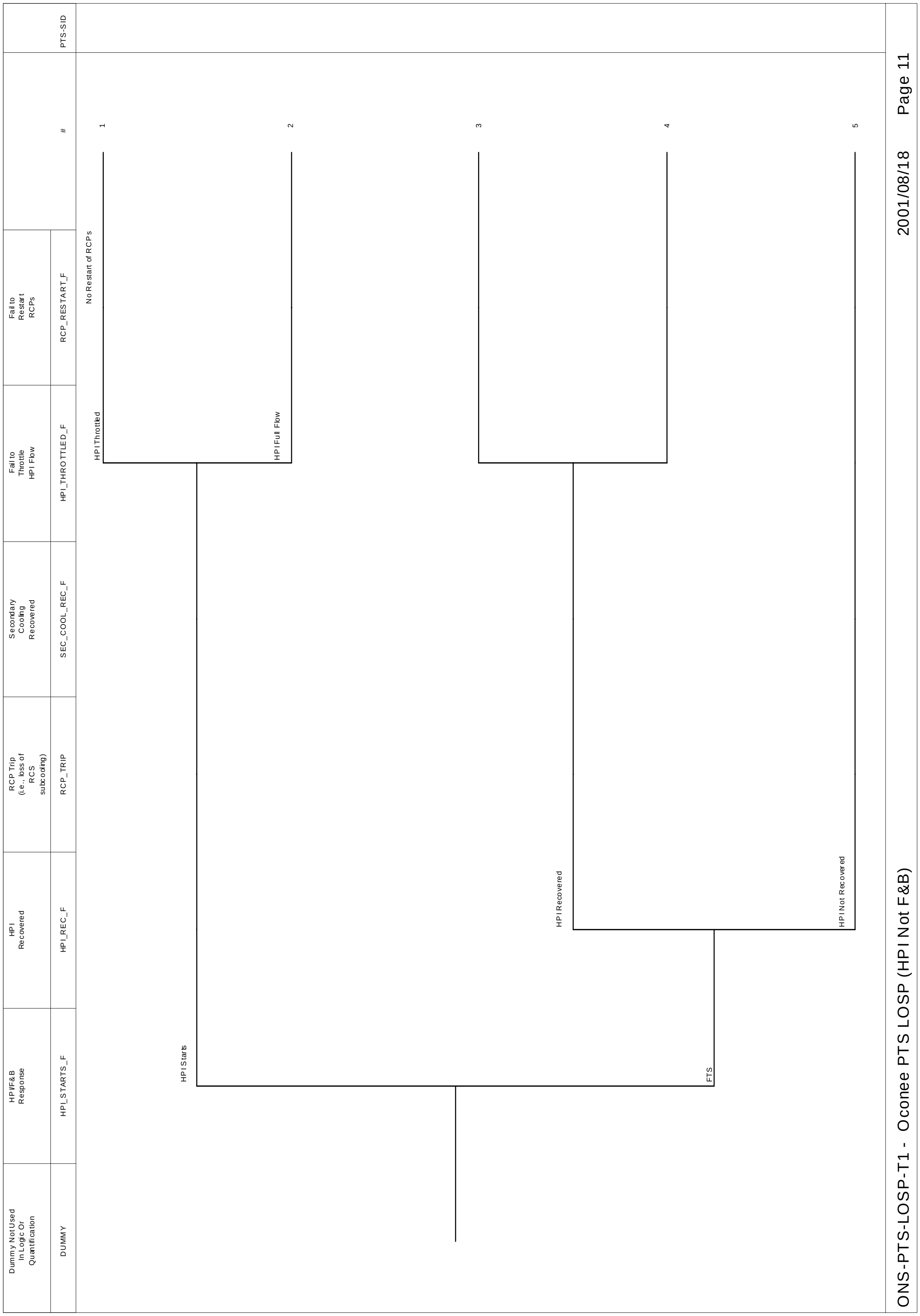

Figure 4.12. Oconee LOSP-T1: LOSP (HPI not F&B).

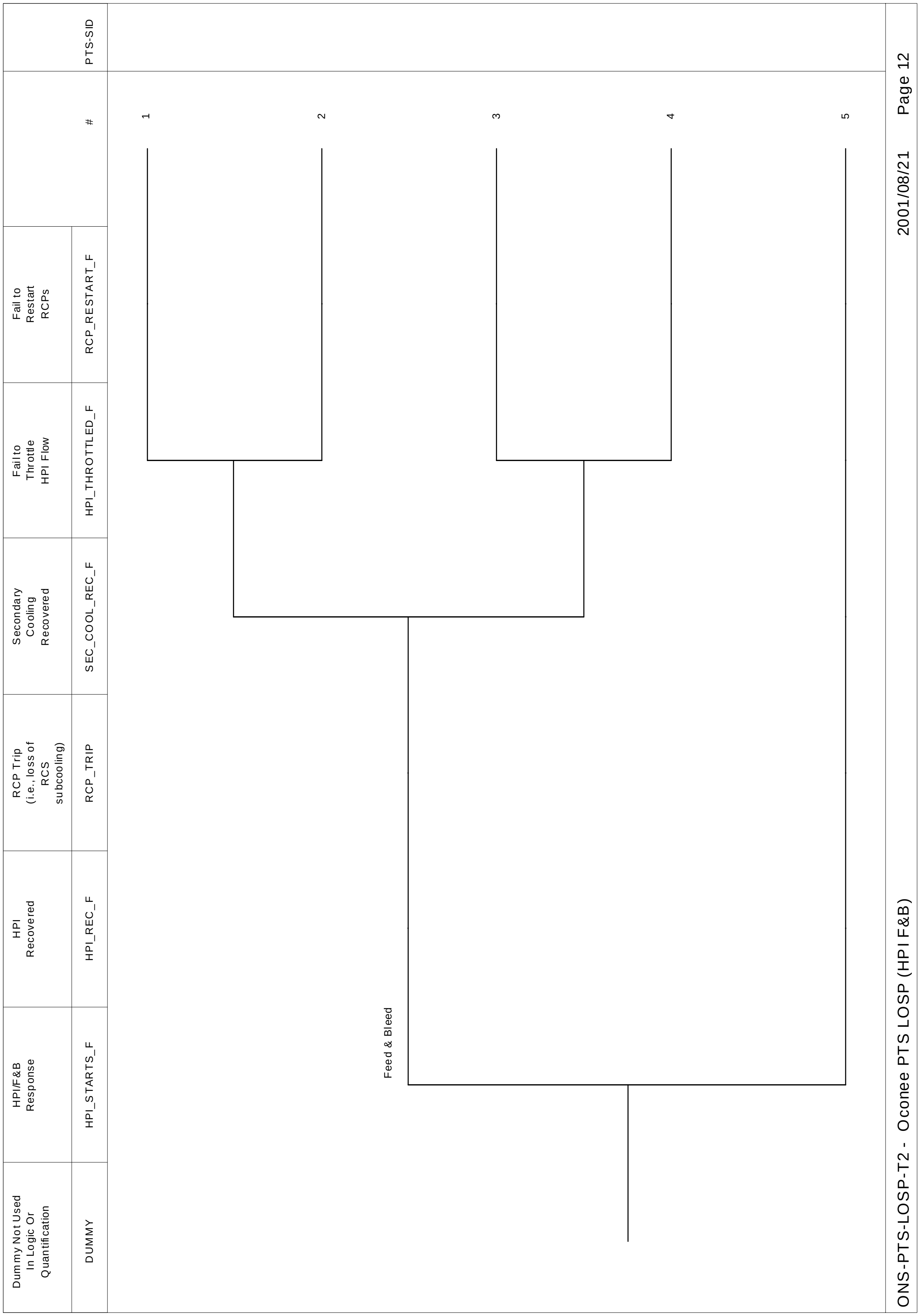

Figure 4.13. Oconee LOSP-T2: LOSP (HPI F&B).

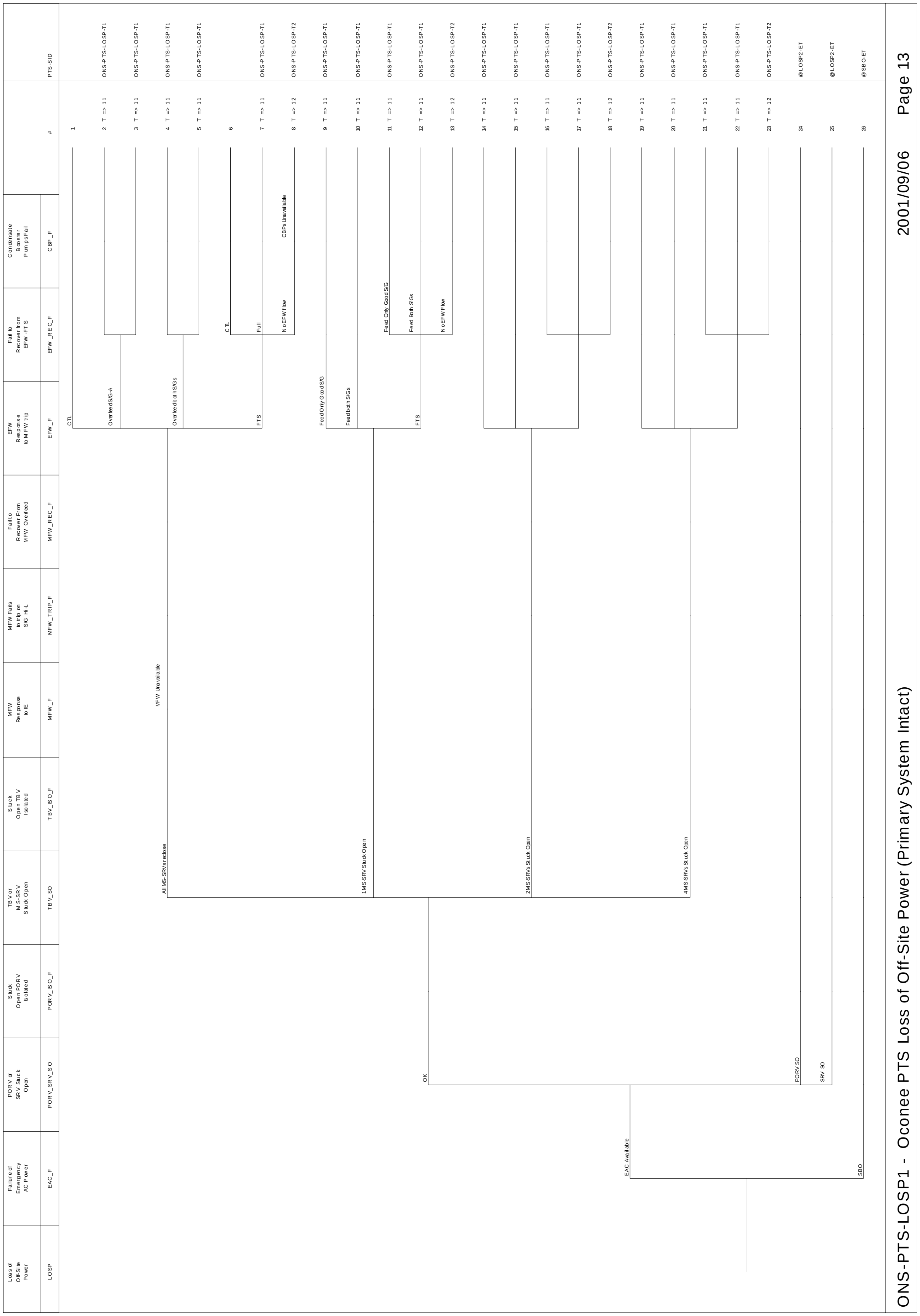

Figure 4.14. Oconee LOSP1: loss of offsite power (primary system intact).

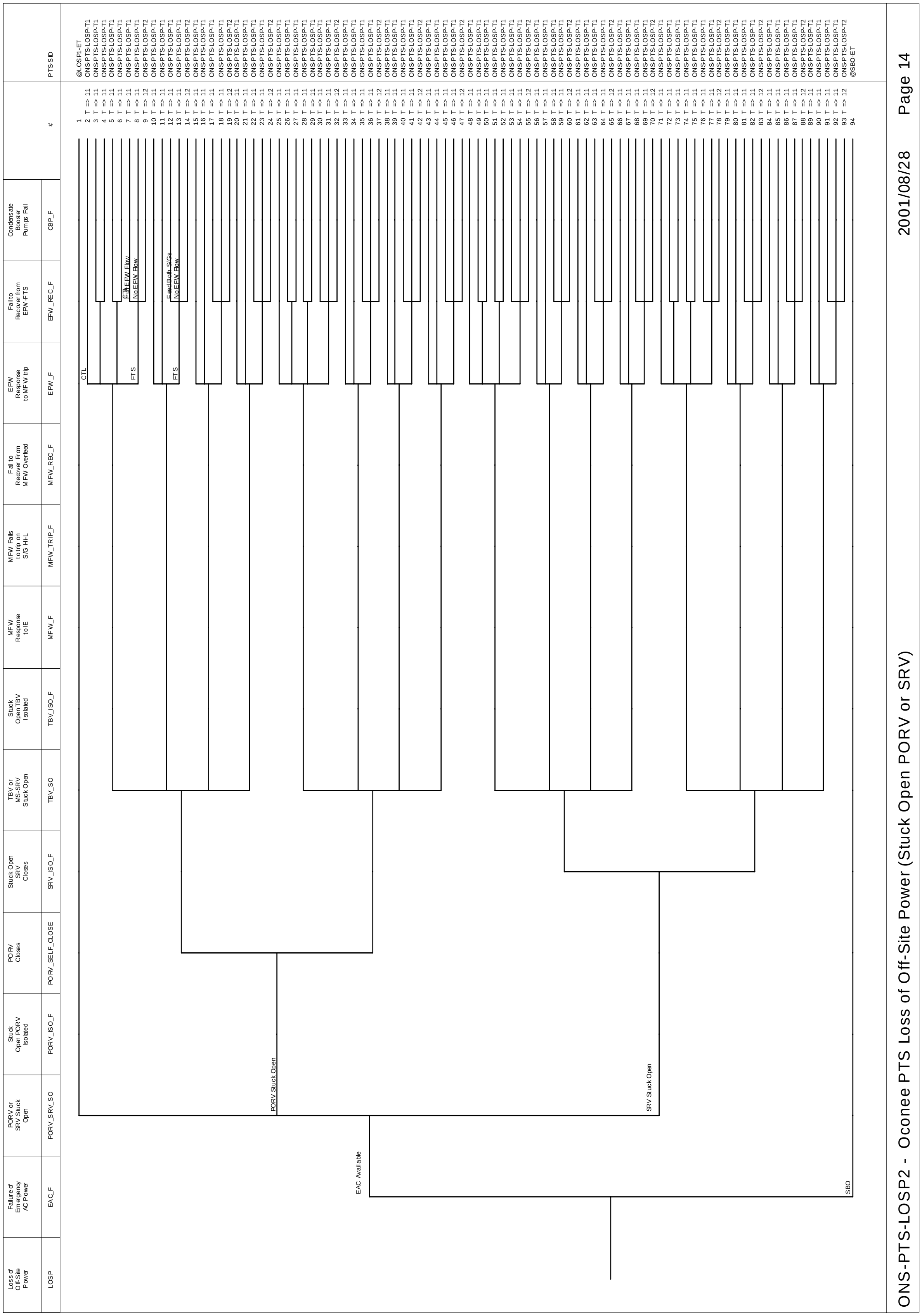

Figure 4.15. Oconee LOSP2: loss of offsite power (stuck open PORV or SRV).

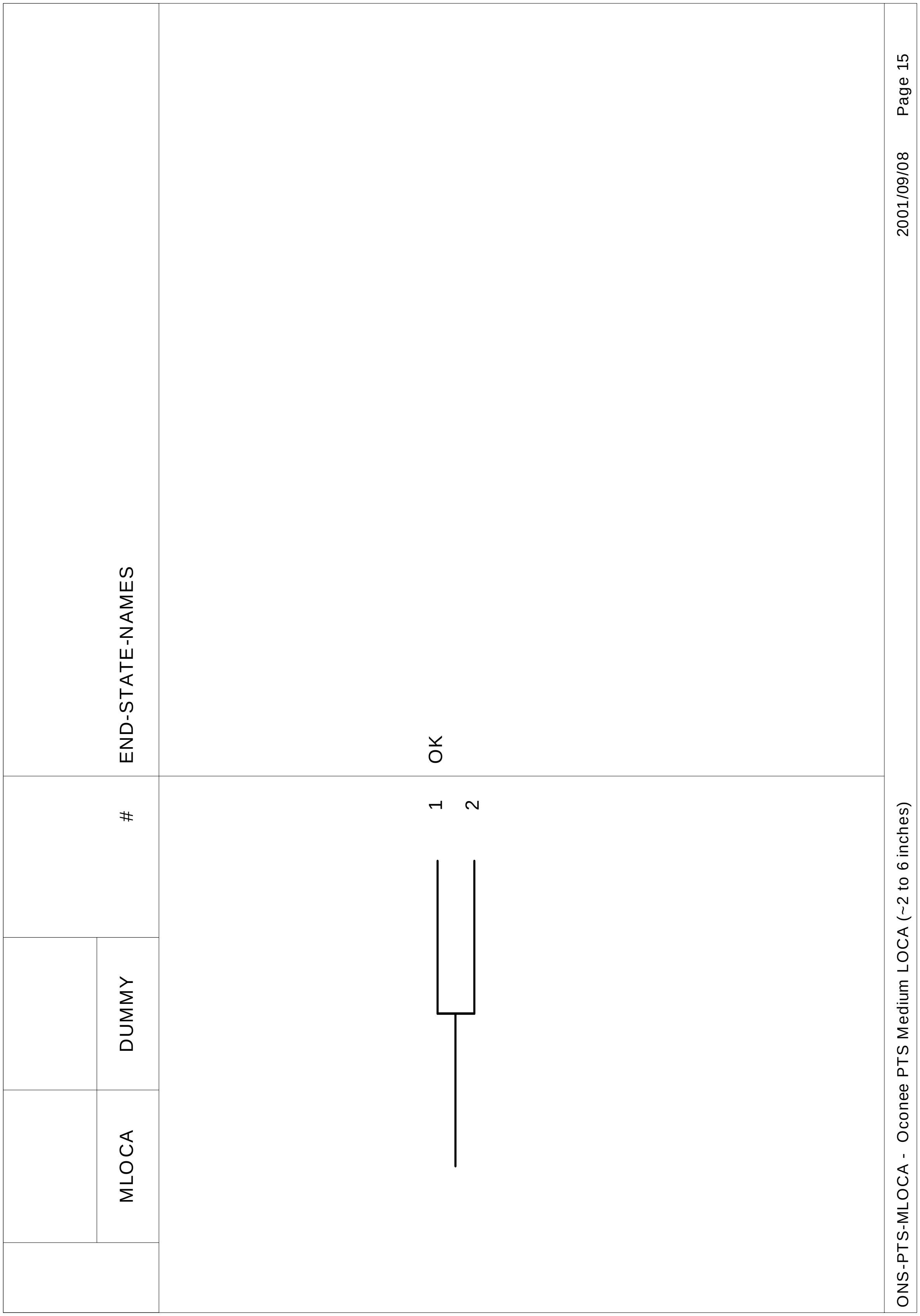

Figure 4.16. Oconee MLOCA: medium LOCA.

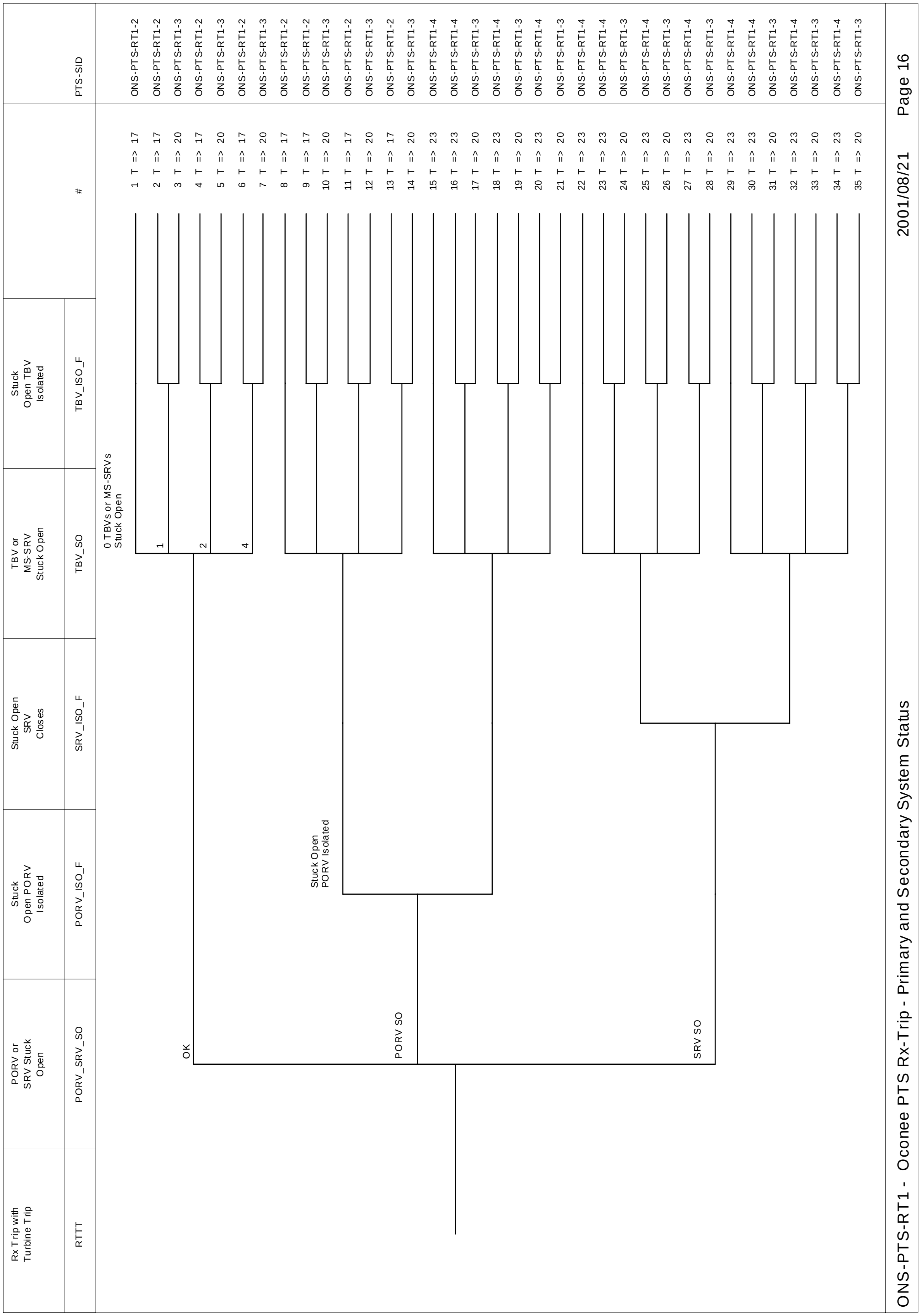

Figure 4.17. Oconee RT1: reactor trip - primary and secondary system status.

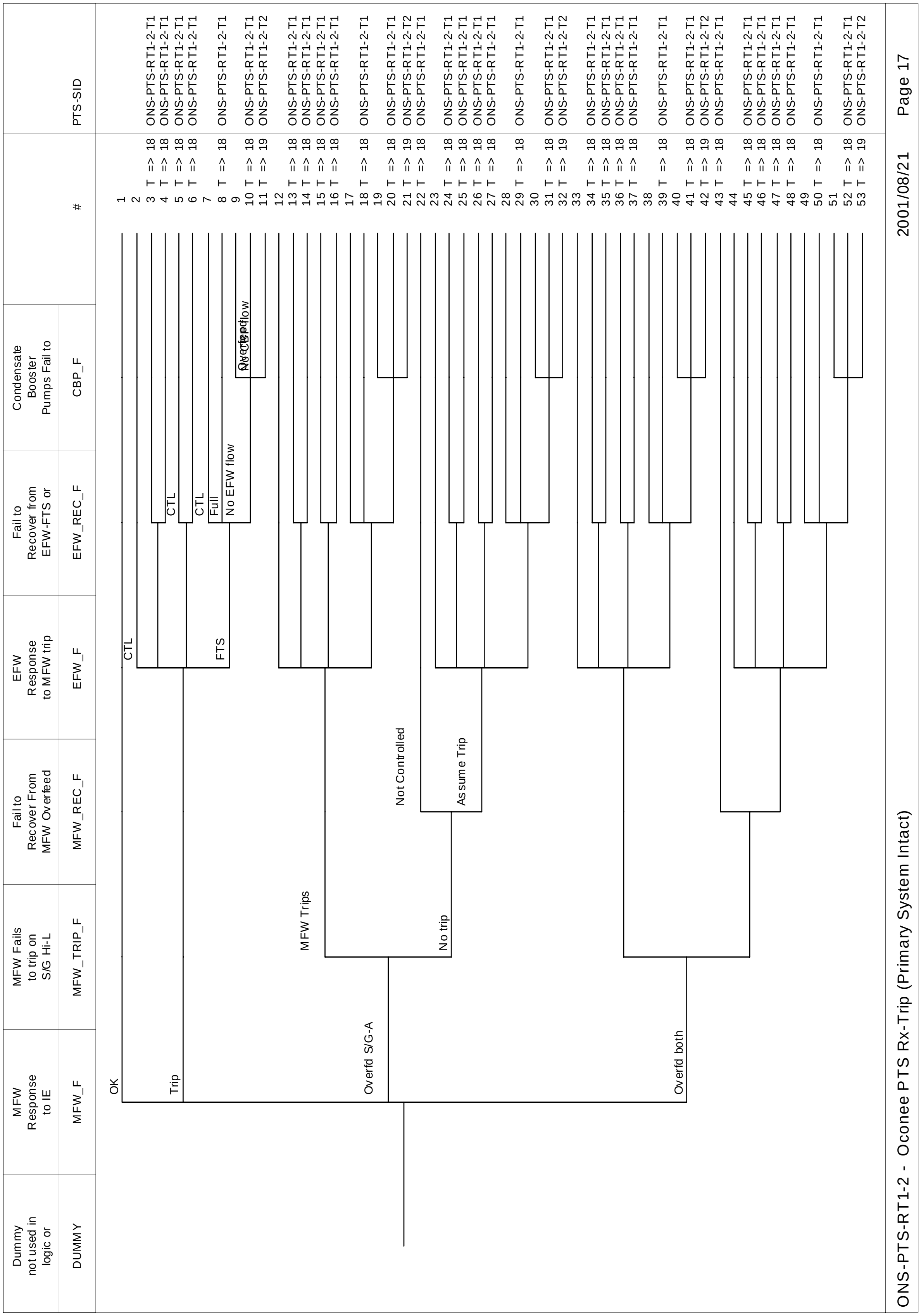

Figure 4.18. Oconee RT1-2: reactor trip (primary system intact).

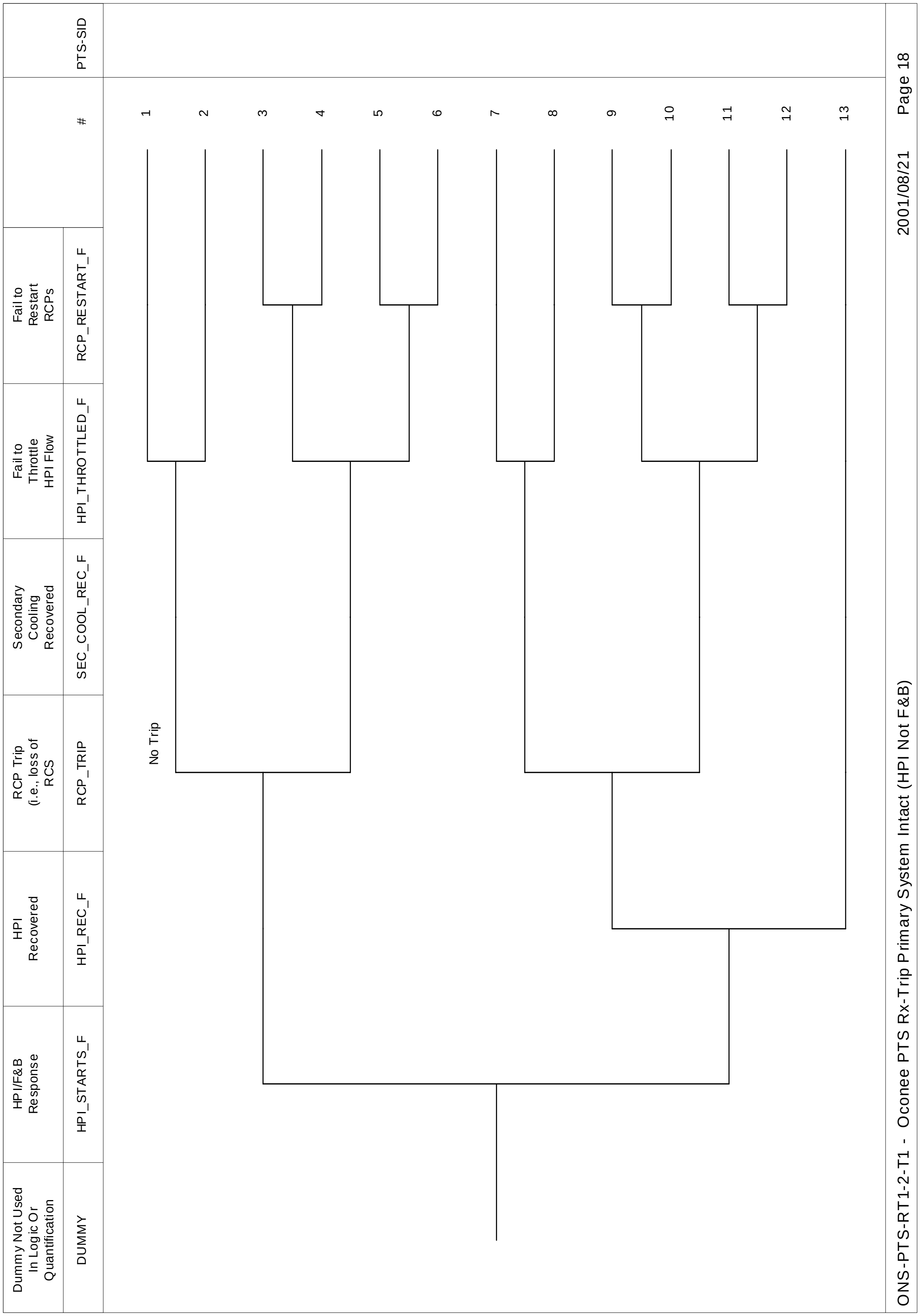

Figure 4.19. Oconee RT1-2-T1: reactor trip primary system intact (HPI not F&B).

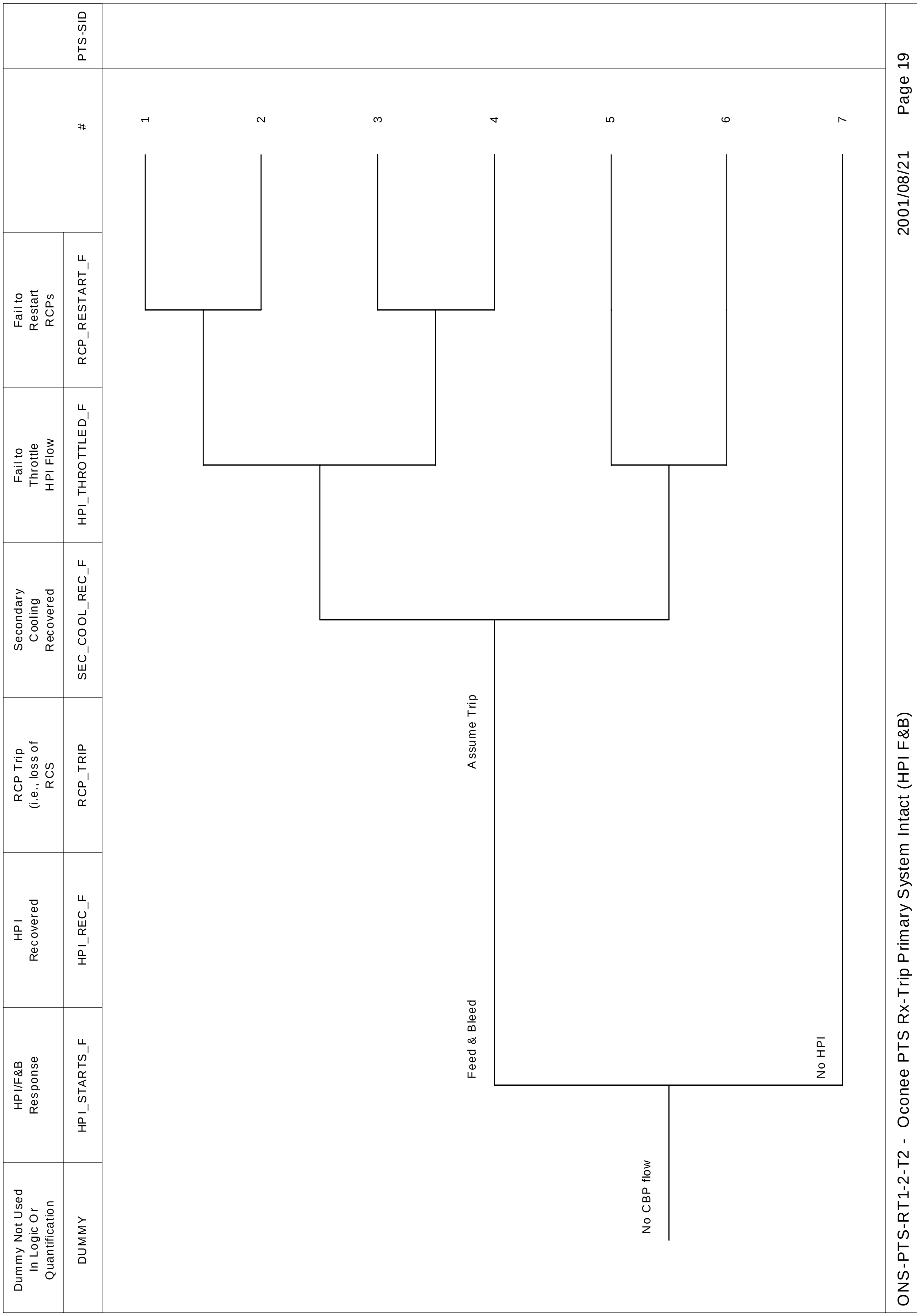

Figure 4.20. Oconee RT1-T2: reactor trip primary system intact (HPI F&B).

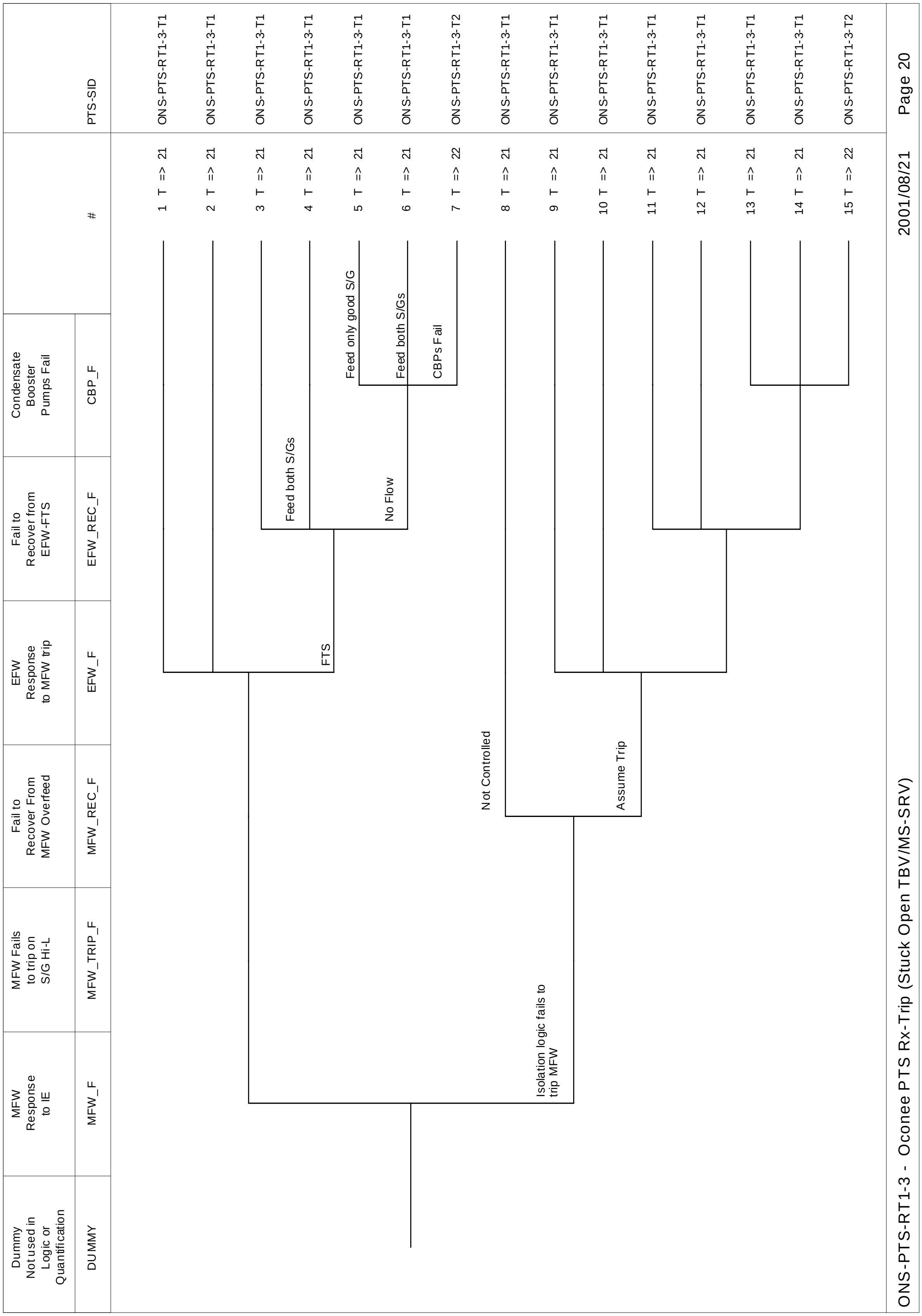

Figure 4.21. Oconee RT1-3: reactor trip (stuck open TBV/MS-SRV).

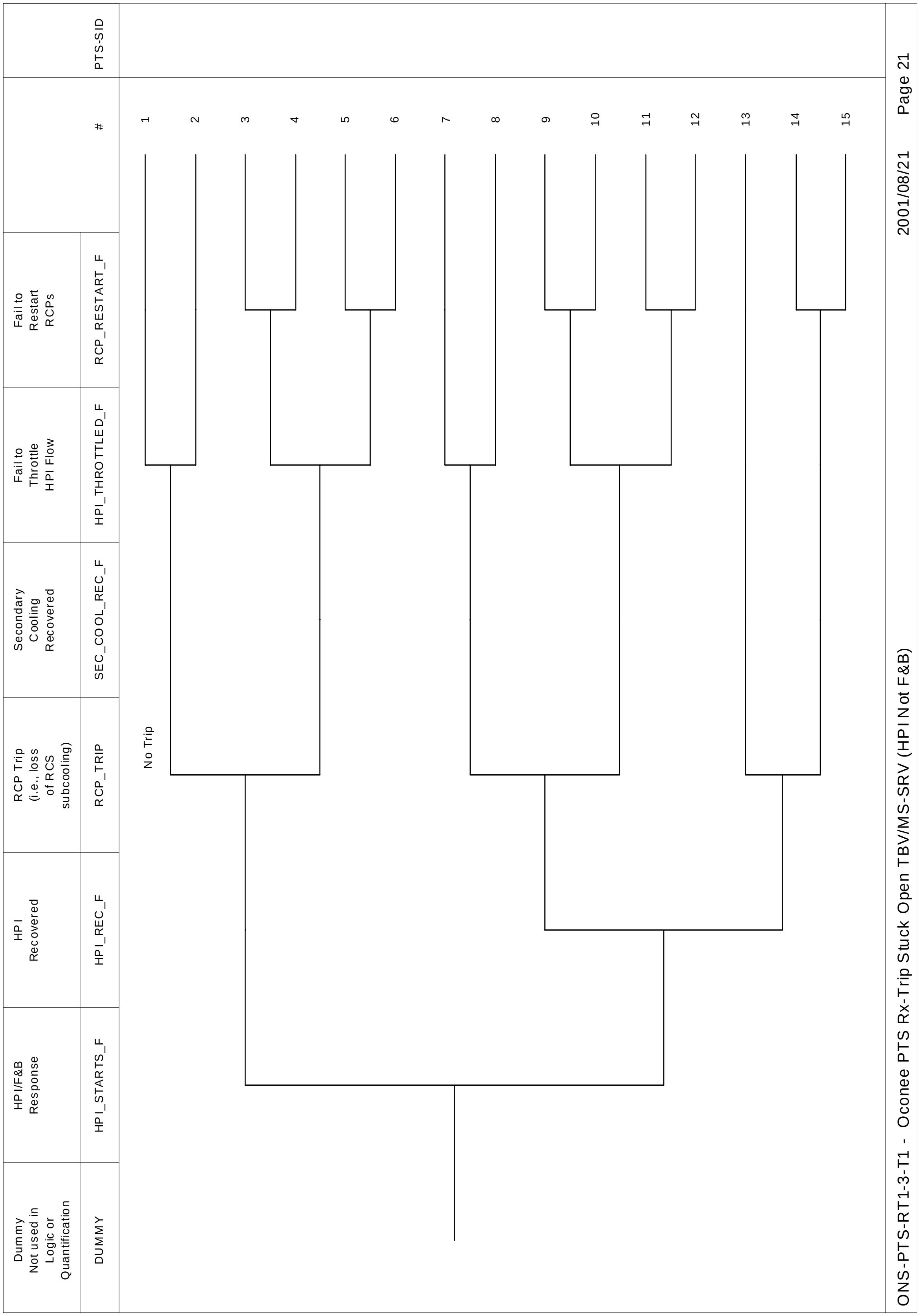

Figure 4.22. Oconee RT1–3-T1: reactor trip stuck open TBV/MS-SRV (HPI not F&B).

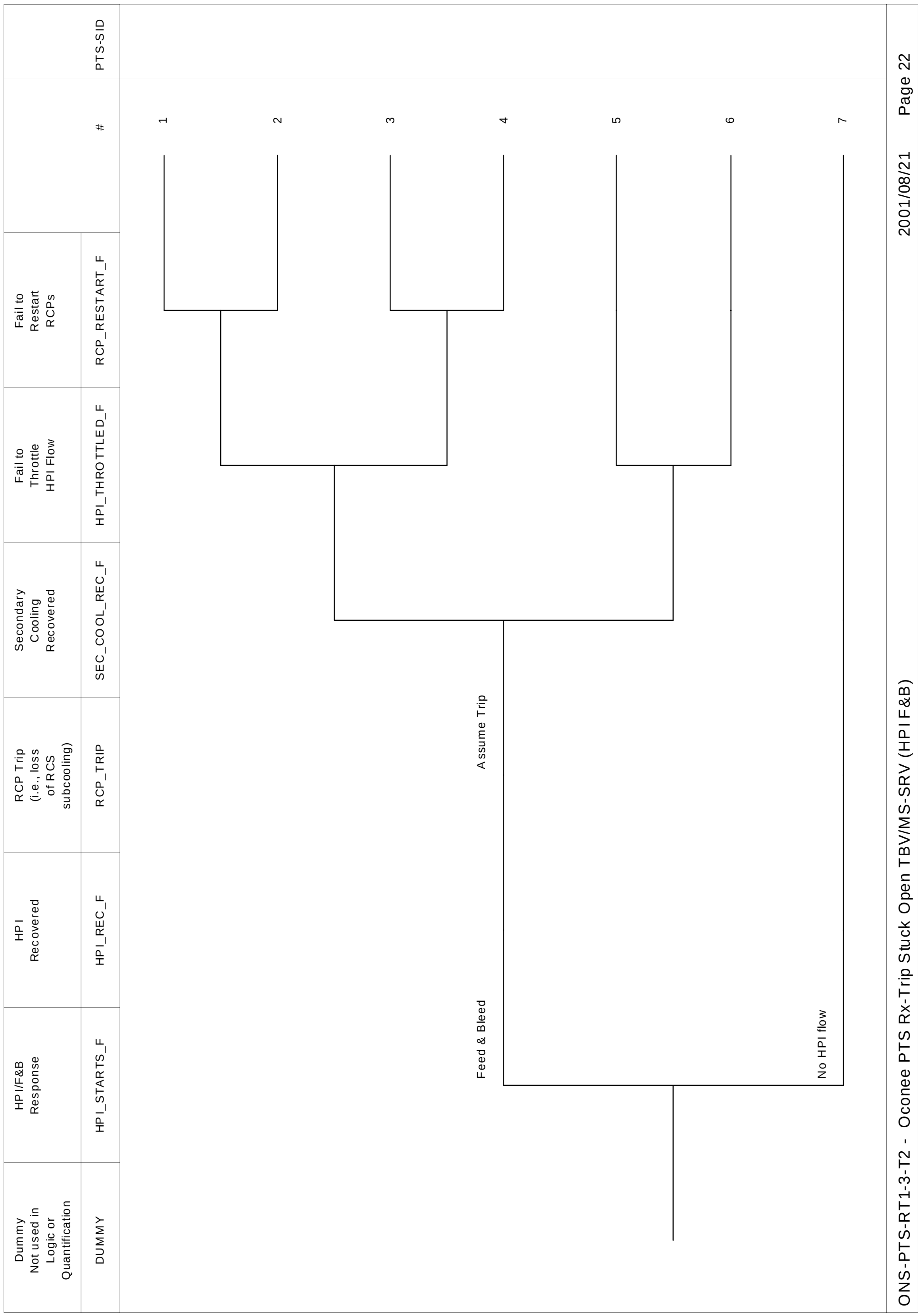

Figure 4.23. Oconee RT1–3-T2: reactor trip stuck open TBV/MS-SRV (HPI F&B).

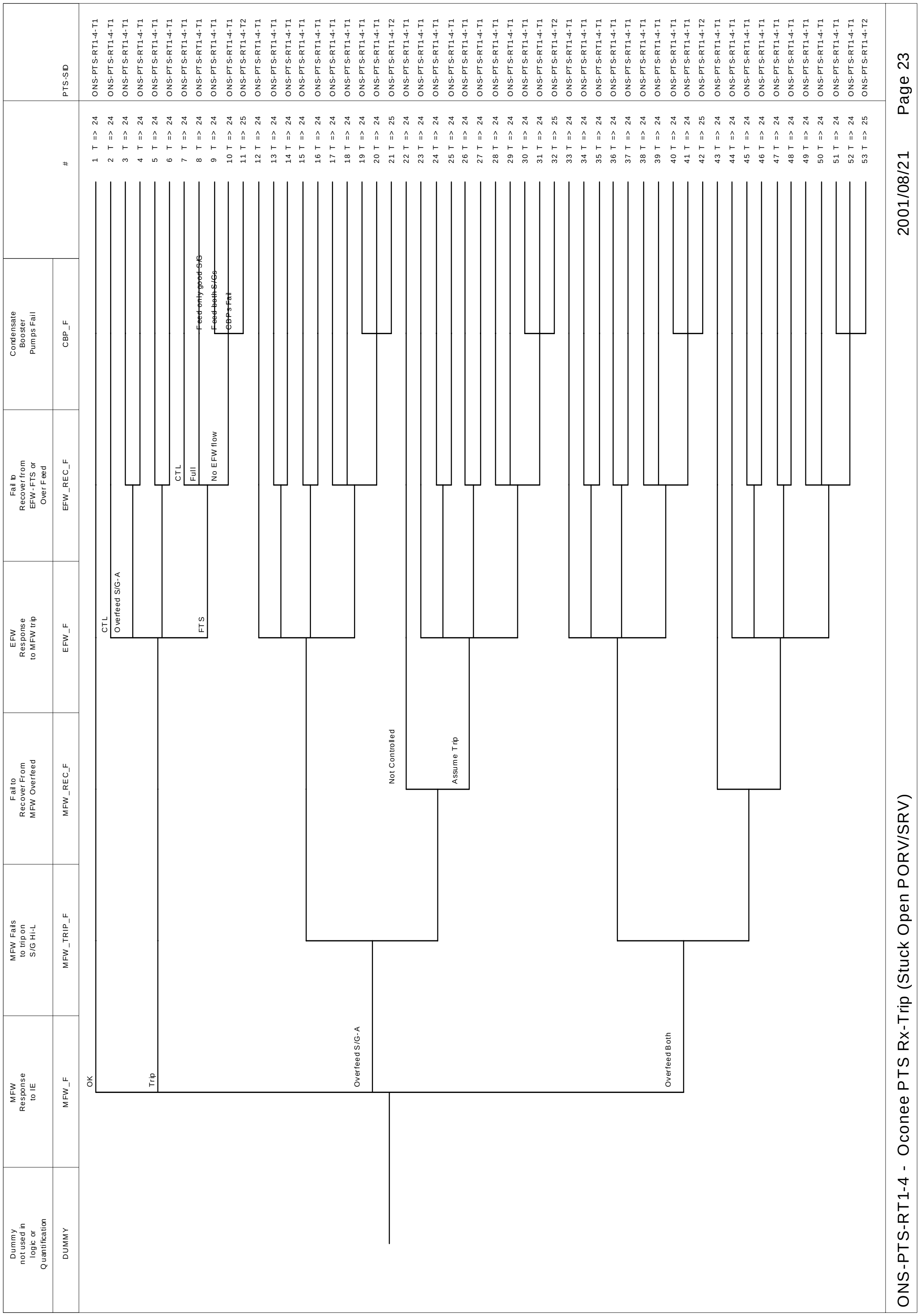

Figure 4.24. Oconee RT1–4: reactor trip (stuck open PORV/SRV).

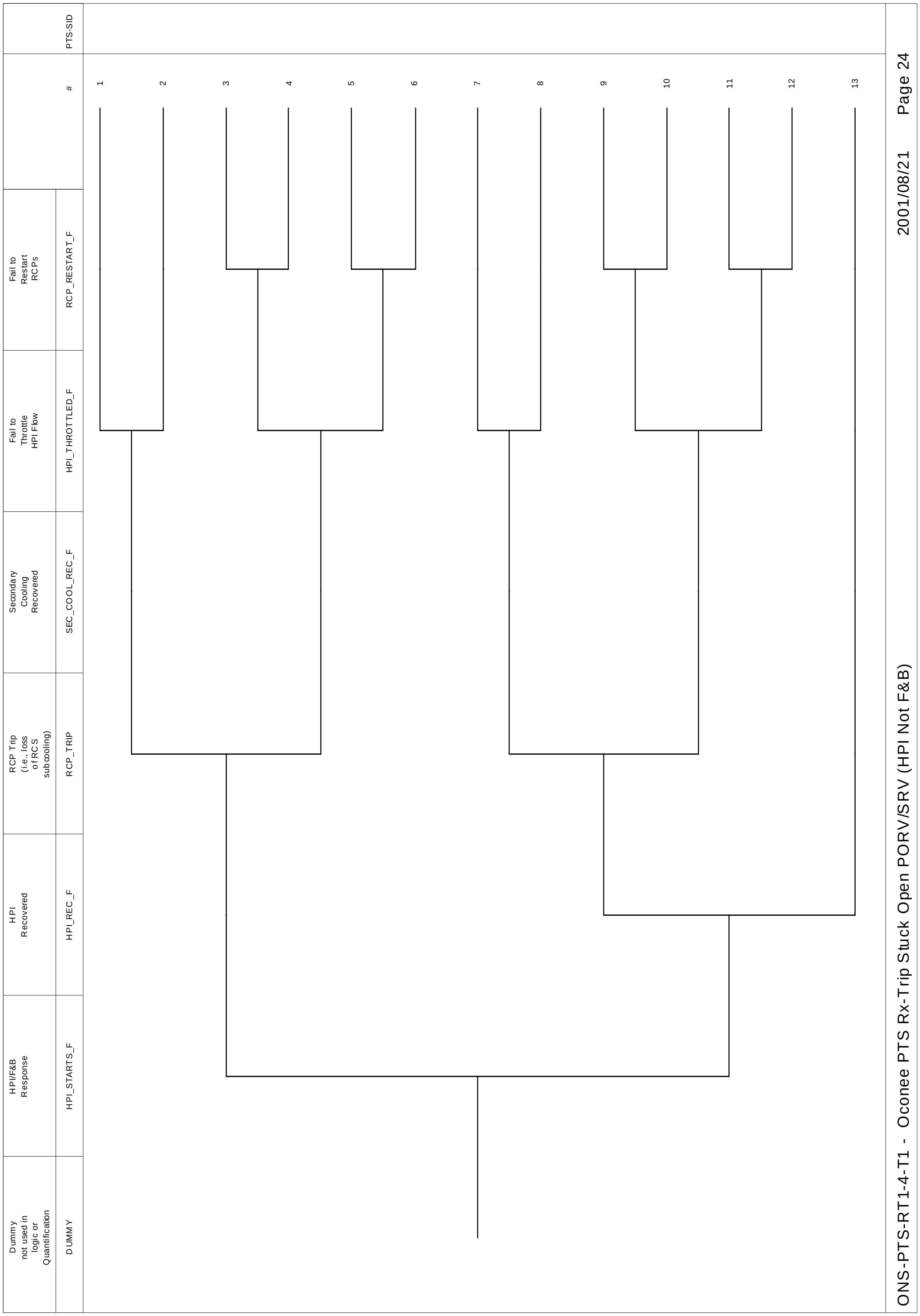

Figure 4.25. Oconee RT1–4-T1: reactor trip stuck open PORV/SRV (HPI not F&B).

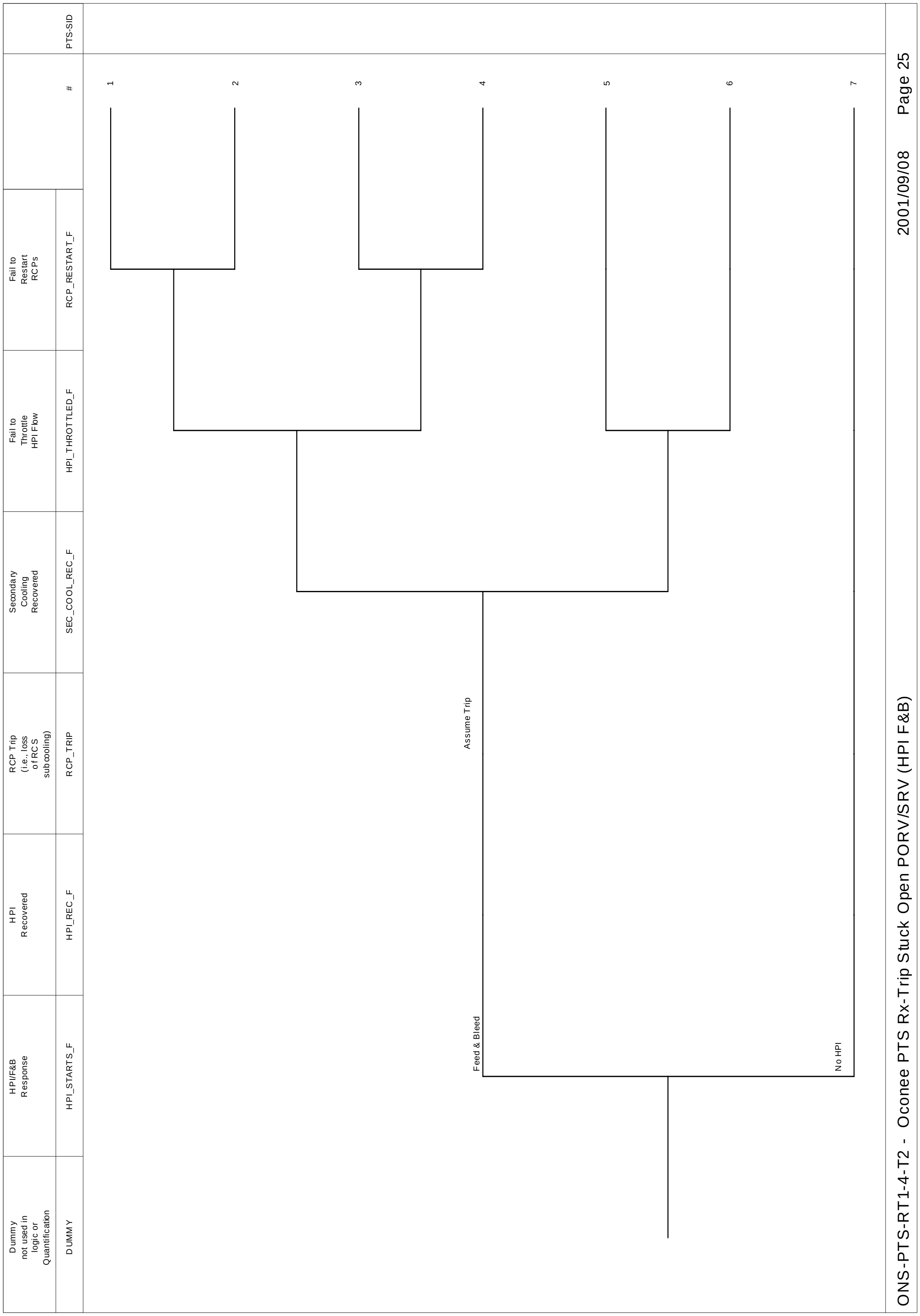

Figure 4.26. Oconee RT1-4-T2: reactor trip stuck open PORV/SRV (HPI F&B).

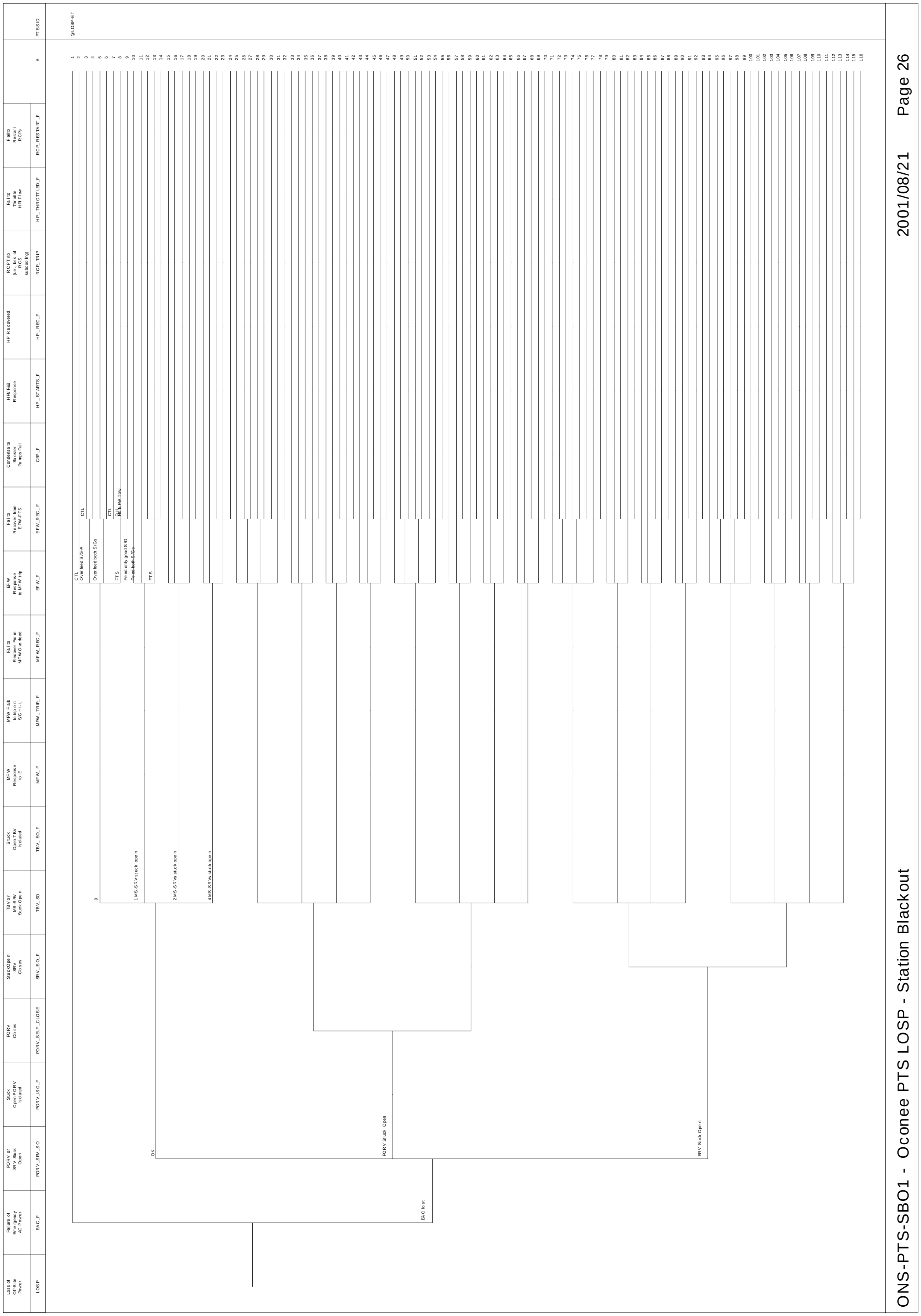

Figure 4.27. Oconee SBO1: LOSP station blackout.

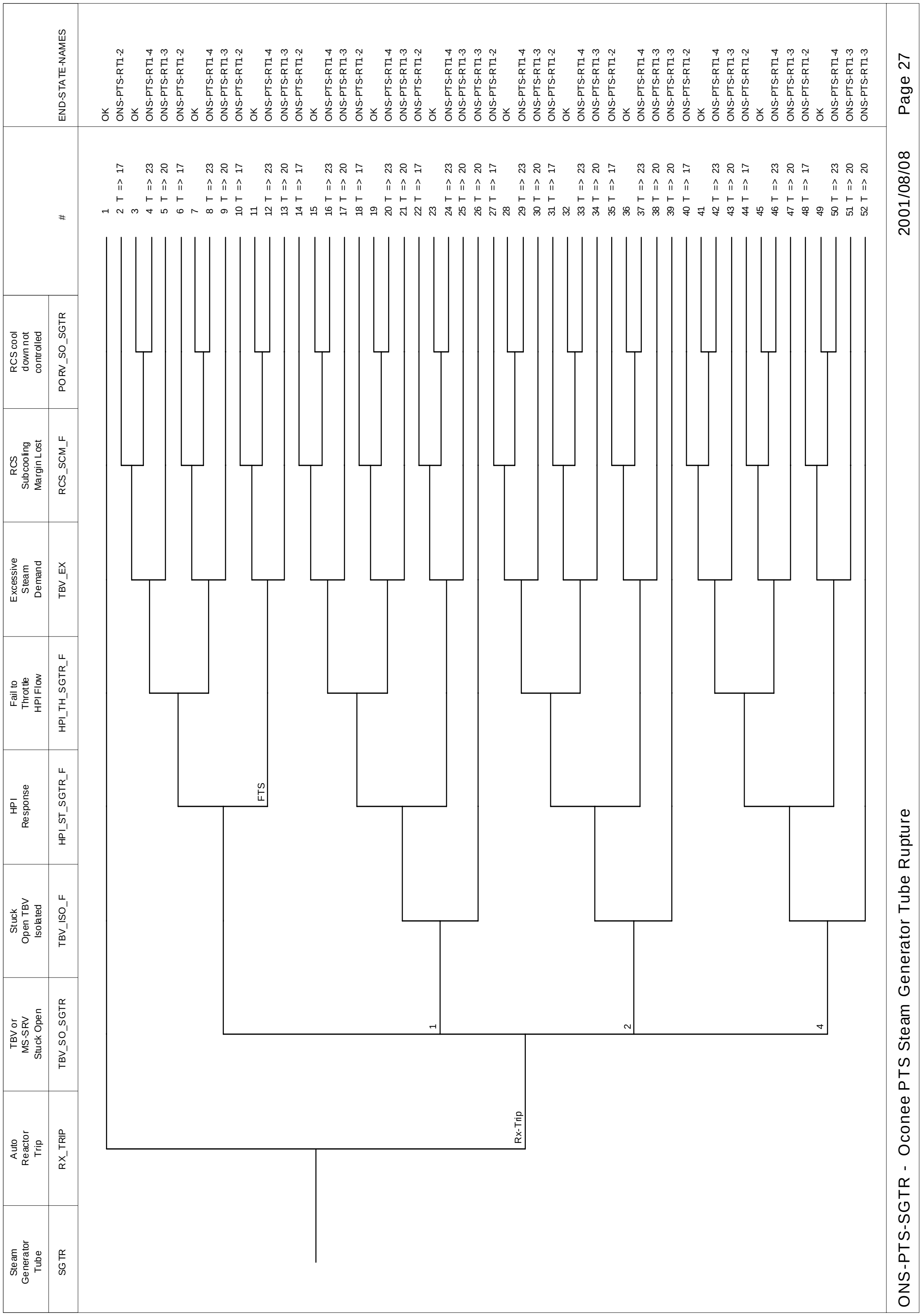

Figure 4.28. Oconee SGTR: steam generator tube rupture.

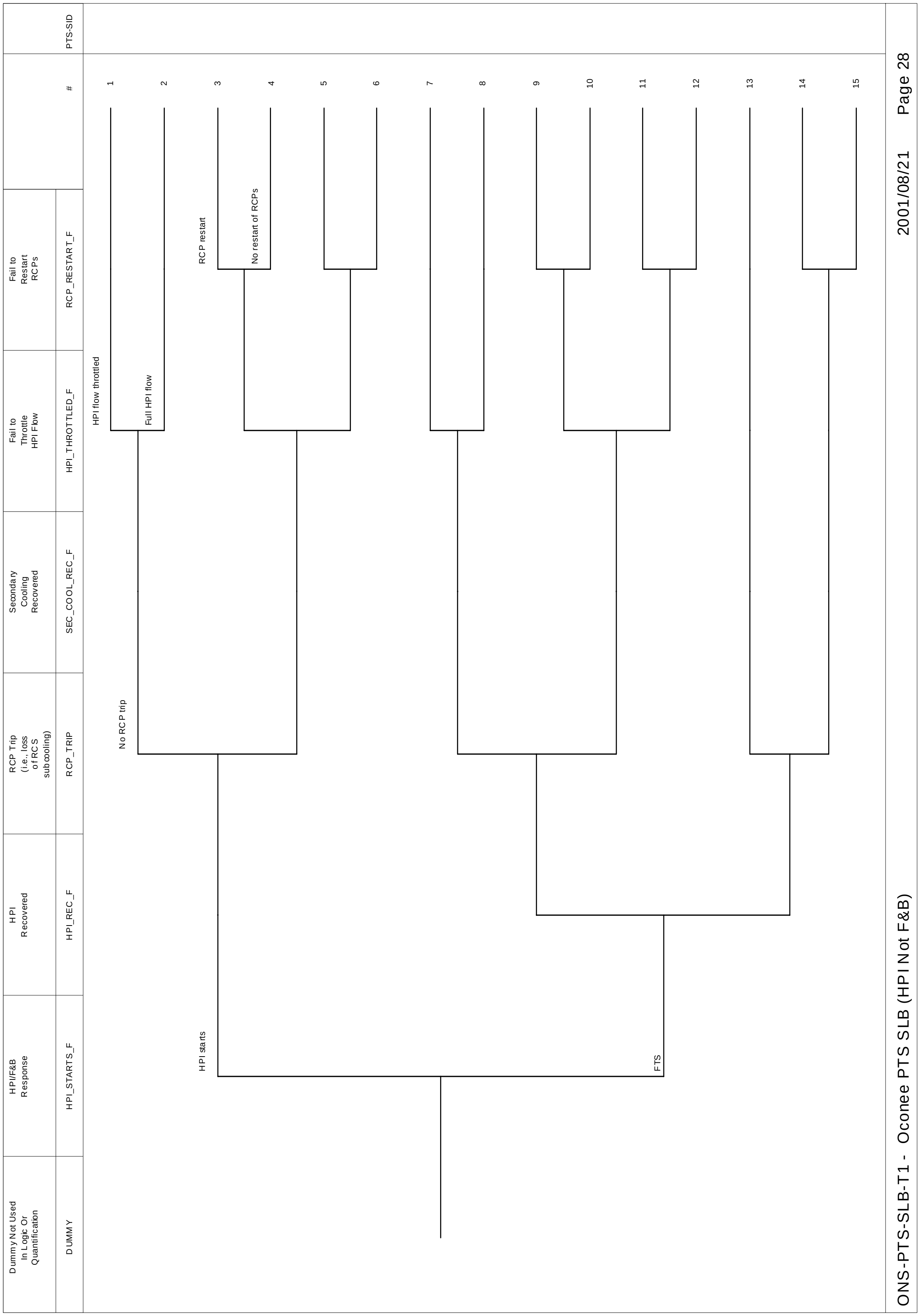

Figure 4.29. Oconee SLB-T1: steam line break (HPI not F&B).

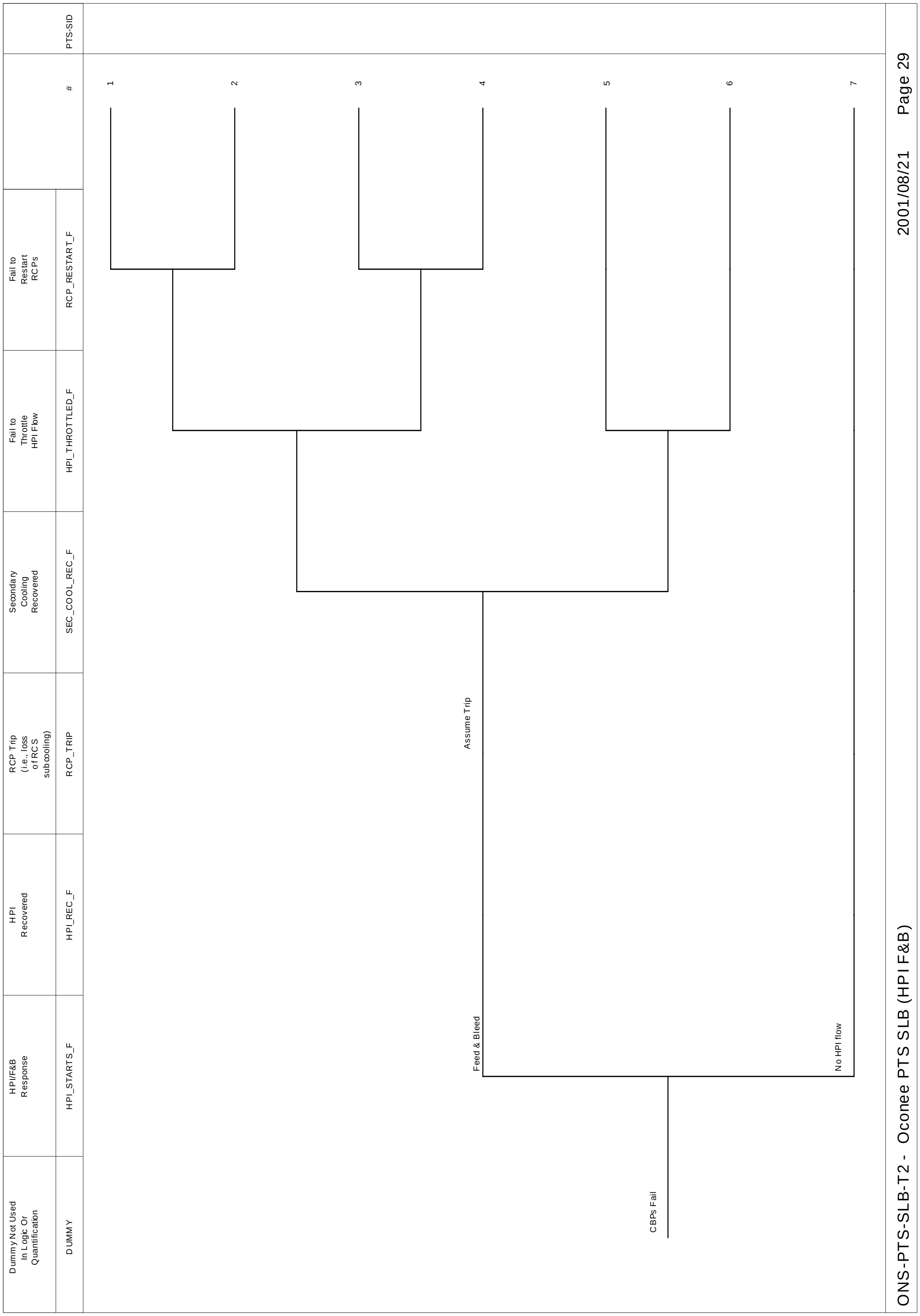

Figure 4.30. Oconee SLB-T2: steam line break (HPI F&B).

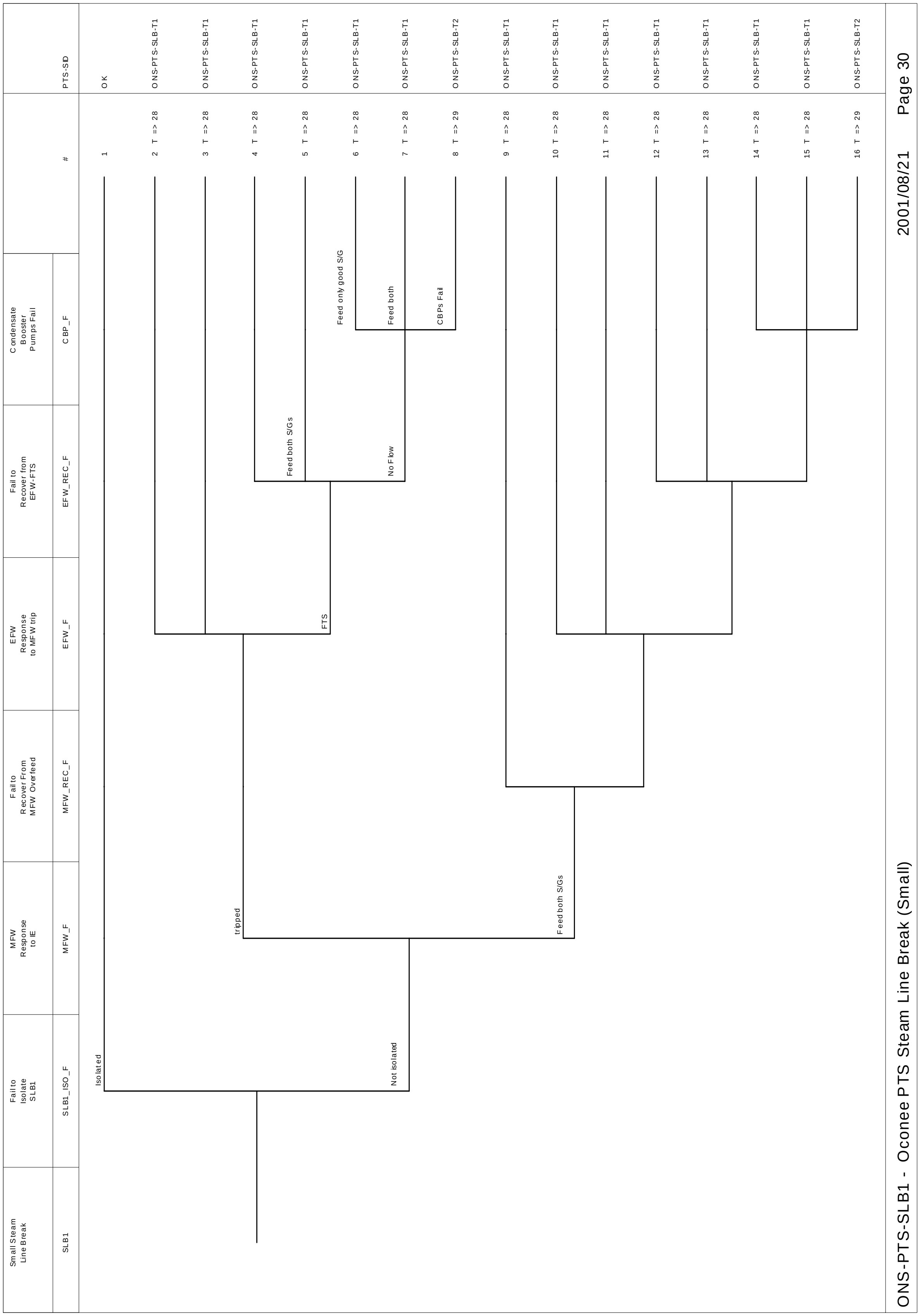

Figure 4.31. Oconee SLB1: steam line break (small).

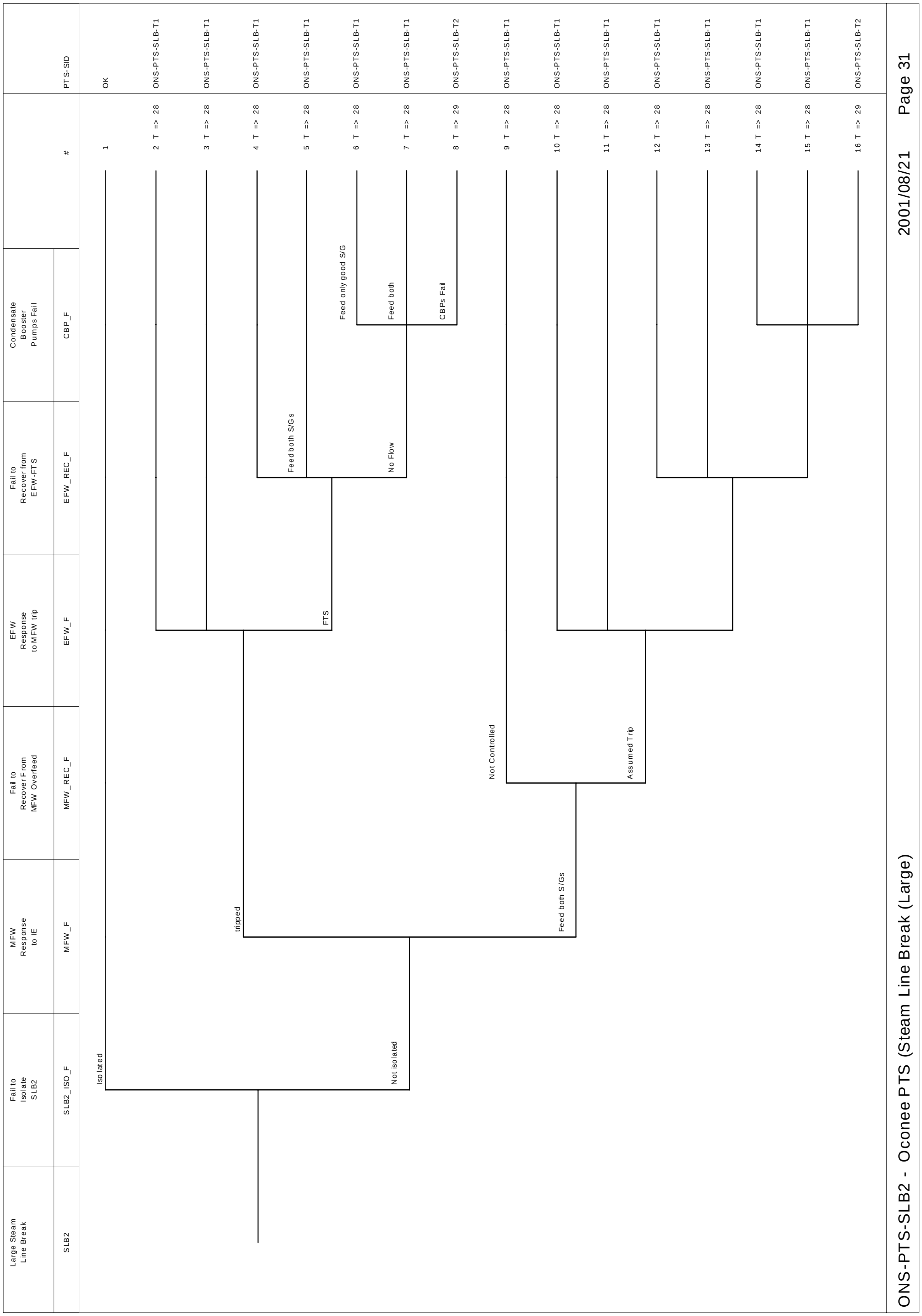

Figure 4.32. Oconee SLB2: steam line break (large).

The top events for Figure 4.18 include:

MFW_F: The determination of MFW response to the initiating event. The top branch represents the case where MFW successfully operates (does a runback) to remove decay heat, maintaining appropriate temperature and pressure. The second branch represents the case where MFW trips, necessitating use of the EFW to remove decay heat. The third branch represents the case of overfeeding one steam generator. The fourth branch represents the case of overfeeding both steam generators.

MFW_TRIP_F: The success or failure of the high steam generator level trip for MFW. Success implies that MFW tripped. Failure implies that MFW did not trip.

MFW_REC_F: The success or failure of controlling (i.e., recovering from) a MFW overfeed event. The top branch implies that the operators fail to control (i.e., fail to trip) MFW, resulting in overfeed by MFW. The bottom branch implies that the operators control (i.e., trip) MFW, terminating the overfeed by MFW.

EFW_F: The determination of EFW response given a demand for EFW. The top branch represents the case where EFW successfully operates to remove decay heat, maintaining appropriate temperature and pressure. The second branch represents the case where EFW overfeeds one steam generator. The third branch represents the case where EFW overfeeds both steam generators. The fourth branch represents the case where EFW fails to start.

EFW_REC_F: The success or failure of recovering from EFW overfeed or EFW fail-to-start. For the two cases where EFW overfeed has occurred, the top branch represents operators regaining control of the overfeed situation, and the bottom branch represents the case where operators do not regain control of EFW. For the case where EFW failed to start, the top (i.e., first) branch represents the case where the EFW is recovered and the operators control flow to the steam generator(s). The middle (i.e., second) branch represents the case where EFW is recovered but the operators do not control flow to the steam generator(s). The bottom (i.e., third) branch represents the case where EFW is not recovered.

CBP_F: The determination of condensate booster pump (CBP) response given a demand for CBP. The top branch represents the case where the operators successfully depressurize the steam generator(s) so that the CBPs can inject, the CBPs successfully operated to remove decay heat, and the operators successfully control injection by the CBPs to prevent overfeeding of a steam generator (i.e., they feed only the good steam generator if one steam generator is faulted). The middle branch represents the case where the operators successfully depressurize the steam generator(s) so that the CBPs can inject, the CBPs work, but operators fail to control flow from the pump(s) (i.e., they feed both steam generators). The bottom branch represents the case where the operators fail to depressurize the steam generator(s) or the CBPs fail to work.

Top events for Figure 4.21 are the same as for Figure 4.18 except for the following:

MFW_F: The success or failure of the main steam line break isolation logic to trip MFW. Success implies that MFW was tripped. Failure implies that MFW was not tripped.

EFW_F: The determination of EFW response given a demand for EFW. The top branch represents the case where EFW starts and feed to a faulted (i.e., bad) steam generator is isolated. The middle branch represents the case where EFW starts but feed to a faulted steam generator is not isolated. The bottom branch represents the case where EFW fails to start.

Top events for Figure 4.24 are the same as for Figure 4.18.

Top events for Figure 4.19 are as follows:

HPI_STARTS_F: The success or failure of high pressure injection. Success implies that injection with high pressure water occurs. Failure implies no injection of high pressure water.

HPI_REC_F: Recovery of high pressure injection given initial failure. Success implies that high pressure injection is recovered. Failure implies that it was not recovered.

RCP_TRIP: The determination of whether the RCPs trip. Success implies the pumps did not trip. Failure implies tripping of the pumps.

SEC_COOL_REC_F: Recovery of secondary cooling. Success implies that secondary cooling is recovered. Failure implies that it is not recovered.

HPI_THROTTLED_F: The determination of whether high pressure injection is throttled to control pressure. Success implies the operators successfully throttled injection to control pressure. Failure implies the operators did not throttle injection; thus, pressure was not controlled.

RCP_RESTART_F: The determination of whether the RCPs are restarted. Success implies the restart of a RCP. Failure implies no RCP restarted.

Top events for Figures 4.20, 4.22, 4.23, 4.25, and 4.26 are the same as for Figure 4.19.

4.2.1.2 3TC Top Events

The top events and the logic structure for the LOP-3TC initiator event tree are shown in Figures 4.3 (initiator tree), 4.18, 4.21, 4.24 (first level transfer trees), 4.19, 4.20, 4.22, 4.23, 4.25, and 4.26 (second level transfer trees).

The top events for Figure 4.3 are the same as for Figure 4.2 except the first event (i.e., the initiator) becomes

LOP-3TC: A loss of 4KV bus 3TC.

See section 4.2.1 for a listing of the remaining events.

Top events for Figures 4.18, 4.21, 4.24, 4.19, 4.20, 4.22, 4.23, 4.25, and 4.26 are described in section 4.2.1.

4.2.1.3 LIA Top Events

The top events and the logic structure for the LIA initiator event tree are shown in Figures 4.4 (initiator tree), 4.18, 4.21, 4.24 (first level transfer trees), 4.19, 4.20, 4.22, 4.23, 4.25, and 4.26 (second level transfer trees).

The top events for Figure 4.4 are the same as for Figure 4.2 except the first event (i.e., the initiator) becomes

LIA: A loss of instrument air.

See section 4.2.1 for a listing of the remaining events.

Top events for Figures 4.18, 4.21, 4.24, 4.19, 4.20, 4.22, 4.23, 4.25, and 4.26 are described in section 4.2.1.

4.2.1.4 LLOCA Top Events

The top event and the logic structure for the LLOCA initiator event tree are shown in Figure 4.5. The LLOCA event tree includes:

LLOCA: A large LOCA.

DUMMY: A “dummy” top event.

This DUMMY top event allows SAPHIRE [SAPHIRE], the PRA computer code, to generate the sequence logic for the one potential PTS relevant sequence included in the LLOCA initiating event model (i.e., a “sequence” consisting solely of the initiating event.).

4.2.1.5 LMC Top Events

The top events and the logic structure for the LMC initiator event tree are shown in Figures 4.6 (initiator tree), 4.18, 4.21, 4.24 (first level transfer trees), 4.19, 4.20, 4.22, 4.23, 4.25, and 4.26 (second level transfer trees).

The top events for Figure 4.6 are the same as for Figure 4.2 except the first event (i.e., the initiator) becomes

LMC: A loss of main condenser.

See section 4.2.1 for a listing of the remaining events.

Top events for Figures 4.18, 4.21, 4.24, 4.19, 4.20, 4.22, 4.23, 4.25, and 4.26 are described in section 4.2.1.

4.2.1.6 LOCA Top Events

The top events and the logic structure for the LOCA initiator event tree are shown in Figures 4.9, 4.10, 4.11 (initiator trees), 4.7, and 4.8 (transfer trees).

Top events for Figure 4.9 include:

LOCA: A small LOCA.

PORV_SRV_SO: The determination of whether a pressurizer PORV or SRV is stuck open. This event is assumed to be not relevant for a LOCA initiating event.

PORV_ISO_F: The success or failure of isolating the stuck open PORV. This event is assumed to be not relevant for a LOCA initiating event.

TBV_SO: The determination of how many TBVs or main steam SRVs (i.e., SSRVs) are stuck open. The top branch represents the case where no valves are stuck open. The next three branches are not actually used in the model. They simply indicate further model development on Figure 4.11.

TBV_ISO_F: The success or failure of isolating the stuck open TBVs (Note: The main steam SRVs cannot be isolated). This top event is not asked since this figure deals with the case where no TBVs or SSRVs were stuck open.

MFW_F: The determination of MFW response to the initiating event. The top branch represents the case where MFW successfully operates (does a runback) to remove decay heat, maintaining appropriate temperature and pressure. The second branch represents the case where MFW trips, necessitating use of the EFW to remove decay heat. (Note: This logic developed in Figure 4.10.) The third branch represents the case of overfeeding one steam generator. The fourth branch represents the case of overfeeding both steam generators. (Note: This logic developed in Figure 4.10.)

MFW_TRIP_F: The success or failure of the high steam generator level trip for MFW. Success implies that MFW tripped. Failure implies that MFW did not trip.

MFW_REC_F: The success or failure of controlling (i.e., recovering from) a MFW overfeed event. The top branch implies that the operators fail to control (i.e., fail to trip) MFW, resulting in overfeed by MFW. The bottom branch implies that the operators control (i.e., trip) MFW, terminating the overfeed by MFW.

EFW_F: The determination of EFW response given a demand for EFW. The top branch represents the case where EFW successfully operates to remove decay heat, maintaining appropriate temperature and pressure. The second branch represents the case where EFW overfeeds one steam generator. The third branch represents the case where EFW overfeeds both steam generators. The fourth branch represents the case where EFW fails to start.

EFW_REC_F: The success or failure of recovering from EFW overfeed or EFW fail-to-start. For the two cases where EFW overfeed has occurred, the top branch represents operators regaining control of the overfeed situation, and the bottom branch represents the case where operators do not regain control EFW. For the case where EFW failed to start, the top (i.e., first) branch represents the case where the EFW is recovered and the operators control flow to the steam generator(s). The middle (i.e., second) branch represents the case where EFW is recovered but the operators do not control flow to the steam generator(s). The bottom (i.e., third) branch represents the case where EFW is not recovered.

CBP_F: The determination of condensate booster pump (CBP) response given a demand for CBP. The top branch represents the case where the operators successfully depressurize the steam generator(s) so that the CBPs can inject, the CBPs successfully operated to remove decay heat, and the operators successfully control injection by the CBPs to prevent overfeeding of a steam generator (i.e., they feed only the good steam generator if one steam generator is faulted). The middle branch represents the case where the operators successfully depressurize the steam generator(s) so that the CBPs can inject, the CBPs work, but operators fail to control flow from the pump(s) (i.e., they feed both steam generators). The bottom branch represents the case where the operators fail to depressurize the steam generator(s) or the CBPs fail to work.

Top events for Figure 4.10 are the same as for Figure 4.9 except for the following:

MFW_F: The determination of MFW response to the initiating event. The top branch represents the case where MFW successfully operates (does a runback) to remove decay heat, maintaining appropriate temperature and pressure. (Note: This logic developed in Figure 4.9.) The second branch represents the case where MFW trips, necessitating use of the EFW to remove decay heat. The third branch represents the case of overfeeding one steam generator. (Note: This logic developed in Figure 4.9.) The fourth branch represents the case of overfeeding both steam generators.

Top events for Figure 4.11 are the same as for Figure 4.9 except for the following:

TBV_SO: The determination of how many TBVs or main steam SRVs (i.e., SSRVs) are stuck open. The top branch represents the case where no valves are stuck open. The next three branches represent one, two and four valve(s) stuck open respectively.

TBV_ISO_F: The success or failure of isolating the stuck open TBVs (Note: The main steam SRVs cannot be isolated. The model accounts for the conditional probability that the stuck open valves were main steam SRVs instead of TBVs.). Success implies that the stuck open TBVs were isolated. Failure implies that the operators failed to isolate the TBVs.

MFW_F: The success or failure of the main steam line break isolation logic to trip MFW. Success implies that MFW was tripped. Failure implies that MFW was not tripped.

MFW_TRIP_F: The success or failure of the high steam generator level trip for MFW. Success implies that MFW tripped. Failure implies that MFW did not trip. Top event not asked (conservative assumption).

EFW_F: The determination of EFW response given a demand for EFW. The top branch represents the case where EFW starts and feed to faulted (i.e., bad) steam generator is isolated. The middle branch represents the case where EFW starts but feed to faulted steam generator is not isolated. The bottom branch represents the case where EFW fails to start.

EFW_REC_F: The success or failure of recovering from EFW fail-to-start. The top (i.e., first) branch represents the case where the EFW is recovered and the operators control flow to the steam generator(s). The middle (i.e., second) branch represents the case where EFW is recovered but the operators do not control flow to the steam generator(s). The bottom (i.e., third) branch represents the case where EFW is not recovered.

Top events for Figures 4.7 and 4.8 are the same as for Figure 4.19. See section 4.2.1 for a listing of the events.

4.2.1.7 LOSP Top Events

The top events and the logic structure for the LOSP initiator event tree are shown in Figures 4.14, 4.15, 4.27 (initiator trees), 4.12, and 4.13 (transfer trees).

Top events for Figure 4.14 include:

LOSP: A loss of offsite power.

EAC_F: The success or failure of emergency AC power. The top branch implies emergency AC power available. The bottom branch implies it is not. Logic development for the bottom branch is shown in Figure 4.27.

PORV_SRV_SO: The determination of whether a pressurizer PORV or SRV is stuck open. The top branch implies that neither are stuck open, the middle branch represents the case where a PORV is initially stuck open, and the bottom branch represents the case where a SRV is initially stuck open. Logic development for the middle and bottom branches is shown in Figure 4.15

PORV_ISO_F: The success or failure of isolating the stuck open PORV. Success implies that the PORV was isolated by closing it or its block valve. Failure implies that the operators failed to close the PORV or the block valve. Top event not asked since Figure 4.14 develops logic for case where no PORV or SRV is stuck open.

TBV_SO: The determination of how many TBVs or main steam SRVs (i.e., SSRVs) are stuck open. The top branch represents the case where no valves are stuck open. The next three branches represent one, two and four valve(s) stuck open respectively.

TBV_ISO_F: The success or failure of isolating the stuck open TBVs (Note: The main steam SRVs cannot be isolated). This top event not asked. Analysis assumed TBV could not be isolated under loss of power condition.

MFW_F: The determination of MFW response to the initiating event. Top event not asked since MFW not available given LOSP.

MFW_TRIP_F: The success or failure of the high steam generator level trip for MFW. Top event not asked since MFW not available given LOSP.

MFW_REC_F: The success or failure of controlling (i.e., recovering from) a MFW overfeed event. Top event not asked since MFW not available given LOSP.

EFW_F: The determination of EFW response given a demand for EFW. Two cases are analyzed.

Case 1 represents the situation where no TBVs or SSRVs are stuck open. For this case, the top branch represents the case where EFW successfully operates to remove decay heat, maintaining appropriate temperature and pressure. The second branch represents the case where EFW overfeeds one steam generator. The third branch represents the case where EFW overfeeds both steam generators. The fourth branch represents the case where EFW fails to start.

Case 2 represents the situation when at least one TBV or SSRV is stuck open. For this case, the top branch represents the case where EFW starts and feed to a faulted (i.e., bad) steam generator is isolated. The middle branch represents the case where EFW starts but feed to a faulted steam generator is not isolated. The bottom branch represents the case where EFW fails to start

EFW_REC_F: The success or failure of recovering from EFW overfeed or EFW fail-to-start. For the two cases where EFW overfeed has occurred, the top branch represents operators regaining control of the overfeed situation, and the bottom branch represents the case where operators do not regain control EFW. For the case where EFW failed to start, the top (i.e., first) branch represents the case where the EFW is recovered and the operators control flow to the steam generator(s). The middle (i.e., second) branch represents the case where EFW is recovered but the operators do not control flow to the steam generator(s). The bottom (i.e., third) branch represents the case where EFW is not recovered.

CBP_F: The determination of condensate booster pump (CBP) response given a demand for CBP. Top event not asked since CBP not available given LOSP.

Top events for Figure 4.15 are the same as for Figure 4.14 except for the following:

PORV_SRV_SO: The determination of whether a pressurizer PORV or SRV is stuck open. The top branch implies that neither are stuck open, the middle branch represents the case where a PORV is initially stuck open, and the bottom branch represents the case where a SRV is initially stuck open. Logic development for the top branch is shown in Figure 4.14.

PORV_SELF_CLOSE: The determination of whether a stuck open PORV closes by itself. The top branch represents the case where the PORV does reclose. The bottom branch represents the case where it does not.

SRV_ISO_F: The determination of whether a stuck open SRV closes by itself. The top branch represents the case where the SRV does reclose. The bottom branch represents the case where it does not.

Top events for Figure 4.27 are the same as for Figure 4.15 except for the following:

EAC_F The success or failure of emergency AC power. The bottom branch represents the case where emergency AC power is lost.

PORV_SRV_SO: The determination of whether a pressurizer PORV or SRV is stuck open. The top branch implies that neither are stuck open, the middle branch represents the case where a PORV is initially stuck open, and the bottom branch represents the case where a SRV is initially stuck open.

HPI_STARTS_F: The success or failure of high pressure injection. Top event not asked because of blackout conditions.

HPI_REC_F: Recovery of high pressure injection given initial failure. Top event not asked because of blackout conditions.

RCP_TRIP: The determination of whether the RCPs trip. Top event not asked because of RCPs tripped on LOSP.

HPI_THROTTLED_F: The determination of whether high pressure injection is throttled to control pressure. Top event not asked because of HPI does not work during blackout conditions.

RCP_RESTART_F: The determination of whether the RCPs are restarted. Top event not asked because blackout conditions prevent restart of RCPs.

Top events for Figures 4.12 and 4.13 are the same as for Figure 4.19. See section 4.2.1 for a listing of the events.

4.2.1.8 MLOCA Top Events

The top event and the logic structure for the MLOCA initiator event tree are shown in Figure 4.16. The MLOCA event tree includes:

MLOCA: A medium LOCA.

DUMMY: A “dummy” top event.

This DUMMY top event allows SAPHIRE to generate the sequence logic for the one potential PTS relevant sequence included in the LLOCA initiating event model (i.e., a “sequence” consisting solely of the initiating event.).

4.2.1.9 RT1 Top Events

The top events and the logic structure for the RTTT initiator event tree are shown in Figures 4.17 (initiator tree), 4.18, 4.21, 4.24 (first level transfer trees), 4.19, 4.20, 4.22, 4.23, 4.25, and 4.26 (second level transfer trees).

The top events for Figure 4.17 are the same as for Figure 4.2 except the first event (i.e., the initiator) becomes

RTTT: A reactor trip with turbine trip.

See section 4.2.1 for a listing of the remaining events.

Top events for Figures 4.18, 4.21, 4.24, 4.19, 4.20, 4.22, 4.23, 4.25, and 4.26 are described in section 4.2.1.

4.2.1.10 SGTR Top Events

The top events and the logic structure for the SGTR initiator event tree are shown in Figures 4.28 (initiator tree), 4.18, 4.21, 4.24 (first level transfer trees), 4.19, 4.20, 4.22, 4.23, 4.25, and 4.26 (second level transfer trees).

The top events for Figure 4.28 are as follows:

SGTR:	Steam generator tube rupture.
RX_TRIP:	The determination of whether an automatic reactor trip occurred. The top branch implies the automatic trip did not occur. The bottom branch implies that it did.
TBV_SO_SGTR:	The determination of how many TBVs or main steam SRVs (i.e., SSRVs) are stuck open given a SGTR initiator. The top branch represents the case where no valves are stuck open. The next three branches represent one, two and four valve(s) stuck open respectively.
TBV_ISO_F:	The success or failure of isolating the stuck open TBVs (Note: The main steam SRVs cannot be isolated. The model accounts for the conditional probability that the stuck open valves were main steam SRVs instead of TBVs.). Success implies that the stuck open TBVs were isolated. Failure implies that the operators failed to isolate the TBVs.
HPI_ST_SGTR_F:	The success or failure of high pressure injection. Success implies that injection with high pressure water occurs. Failure implies no injection of high pressure water.
HPI_TH_SGTR_F:	The determination of whether high pressure injection is throttled to control pressure. Success implies the operators successfully throttled injection to control pressure. Failure implies the operators did not throttle injection; thus, pressure was not controlled.
TBV_EX:	The determination of whether an excessive steam demand is induced (i.e., a TBV sticks open) during SGTR motivated depressurization. The top branch implies excessive steam demand did not occur. The bottom branch implies it did.
RCS_SCM_F:	The determination of whether operators lose reactor coolant system subcooling margin during a SGTR event. Top branch implies the operators did not lose subcooling margin. The bottom branch implies they did loose subcooling margin.
PORV_SO_SGTR:	The determination of whether a PORV sticks open when used to depressurize RCS during a SGTR event. The top branch implies the PORV did not stick open. The bottom branch implies it did.

Top events for Figures 4.18, 4.21, 4.24, 4.19, 4.20, 4.22, 4.23, 4.25, and 4.26 are described in section 4.2.1

4.2.1.11 SLB1 Top Events

The top events and the logic structure for the SLB1 initiator event tree are shown in Figures 4.31 (initiator tree), 4.29, and 4.30 (transfer trees).

The top events for Figure 4.31 are as follows:

SLB1: Small steam line break

SLB1_ISO_F: The success or failure of isolating the small steam line break. Success implies the break was isolated. Failure implies the break was not isolated.

MFW_F: The success or failure of the main steam line break isolation logic to trip MFW. Success implies that MFW was tripped. Failure implies that the MFW was not tripped.

MFW_REC_F: The success or failure of controlling (i.e., recovering from) a MFW overfeed event. The top branch implies that the operators fail to control (i.e., fail to trip) MFW, resulting in overfeed by MFW. The bottom branch implies that the operators control (i.e., trip) MFW, terminating the overfeed by MFW.

EFW_F: The determination of EFW response given a demand for EFW. The top branch represents the case where EFW starts and feed to a faulted (i.e., bad) steam generator is isolated. The middle branch represents the case where EFW starts but feed to a faulted steam generator is not isolated. The bottom branch represents the case where EFW fails to start.

EFW_REC_F: The success or failure of recovering from EFW fail-to-start. The top branch represents the case where the EFW is recovered and the operators control flow to the steam generator(s). The middle branch represents the case where EFW is recovered but the operators do not control flow to the steam generator(s). The bottom branch represents the case where EFW is not recovered.

CBP_F: The determination of condensate booster pump (CBP) response given a demand for CBP. The top branch represents the case where the operators successfully depressurize the steam generator(s) so that the CBPs can inject, the CBPs successfully operated to remove decay heat, and the operators successfully control injection by the CBPs to prevent overfeeding of a steam generator (i.e., they feed only the good steam generator if one steam generator is faulted). The middle branch represents the case where the operators successfully depressurize the steam generator(s) so that the CBPs can inject, the CBPs work, but operators fail to control flow from the pump(s) (i.e., they feed both steam generators). The bottom branch represents the case where the operators fail to depressurize the steam generator(s) or the CBPs fail to work.

Top events for Figure 4.29 are the same as for Figure 4.19 and are described in section 4.2.1

Top events for Figure 4.30 are the same as for Figure 4.29.

4.2.1.12 SLB2 Top Events

The top events and the logic structure for the SLB2 initiator event tree are shown in Figures 4.32 (initiator tree), 4.29, and 4.30 (transfer trees).

The top events for Figure 4.32 are the same as Figure 4.31 except the first two events become

SLB2: Large steam line break.

SLB2_ISO_F: The success or failure of isolating the large steam line break. Success implies the break was isolated. Failure implies the break was not isolated.

See section 4.2.11 for a listing of the remaining events.

Top events for Figures 4.29 and 4.30 are described in section 4.2.11.

4.2.2 Event Tree Top Events for Oconee Hot Zero Power (HZP) Model

With the list of relevant equipment versus function information identified in section 4.1, system-level event trees were developed for each of the initiators identified in section 3.3. These system-level event trees, including transfer trees, are shown in Figures 4.33 through 4.63. The top events included in the system-level event trees used to model each HZP initiating event are the same as those used in the corresponding power event trees, with the addition of one other top event to each of the initiator trees. This top event is a multiplier to convert the power frequency to an HZP frequency and is described in section 3.5. Two different events were used. They include:

HZP-FRACTION: Conversion factor to convert power frequency to HZP frequency. Its value is 0.02.

HZP-MULTIPLIER: Conversion factor to convert power frequency to HZP frequency. Its value is 0.2.

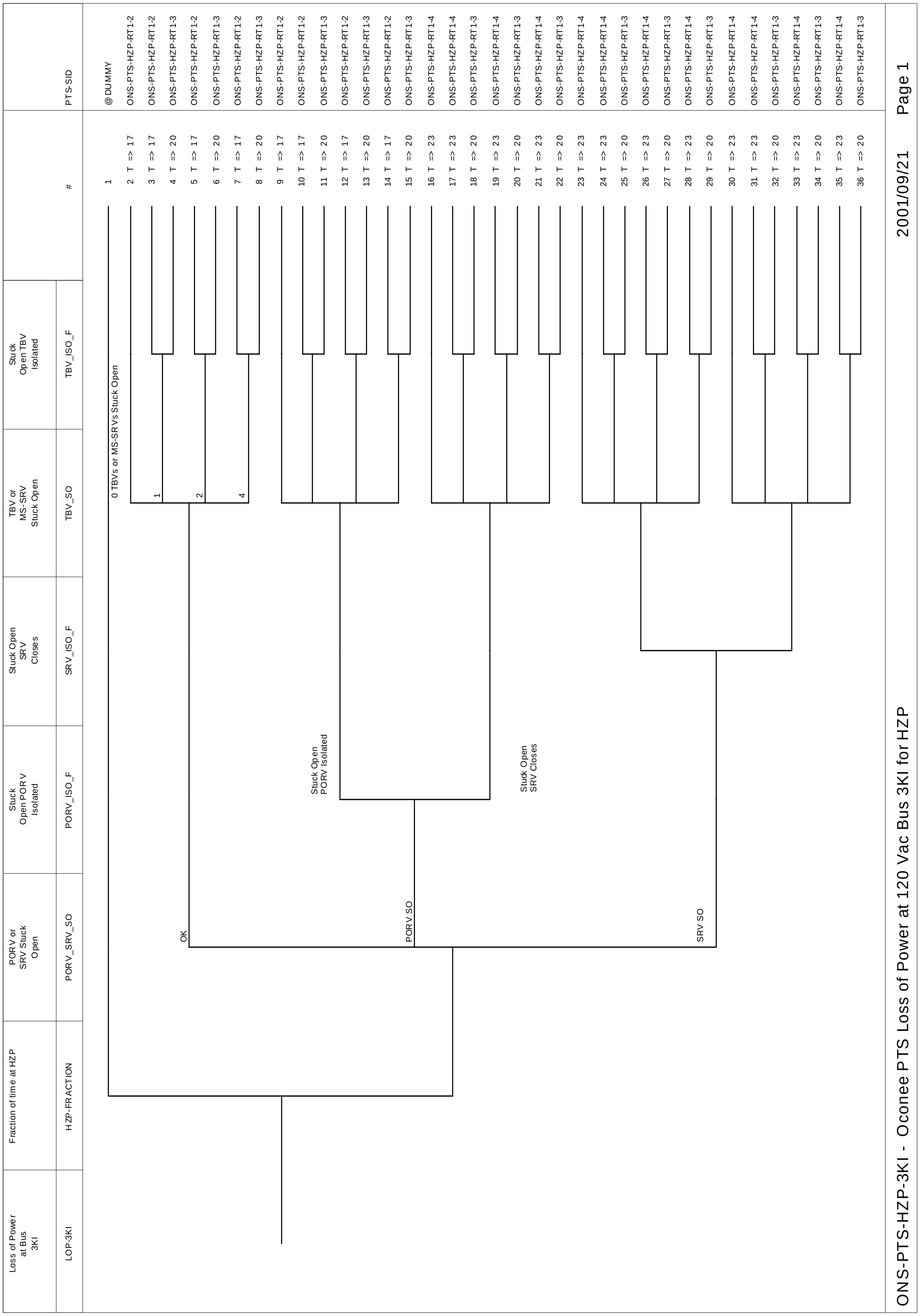

Figure 4.33. Oconee HZP-3KI: loss of power at 120 V ac bus 3KI.

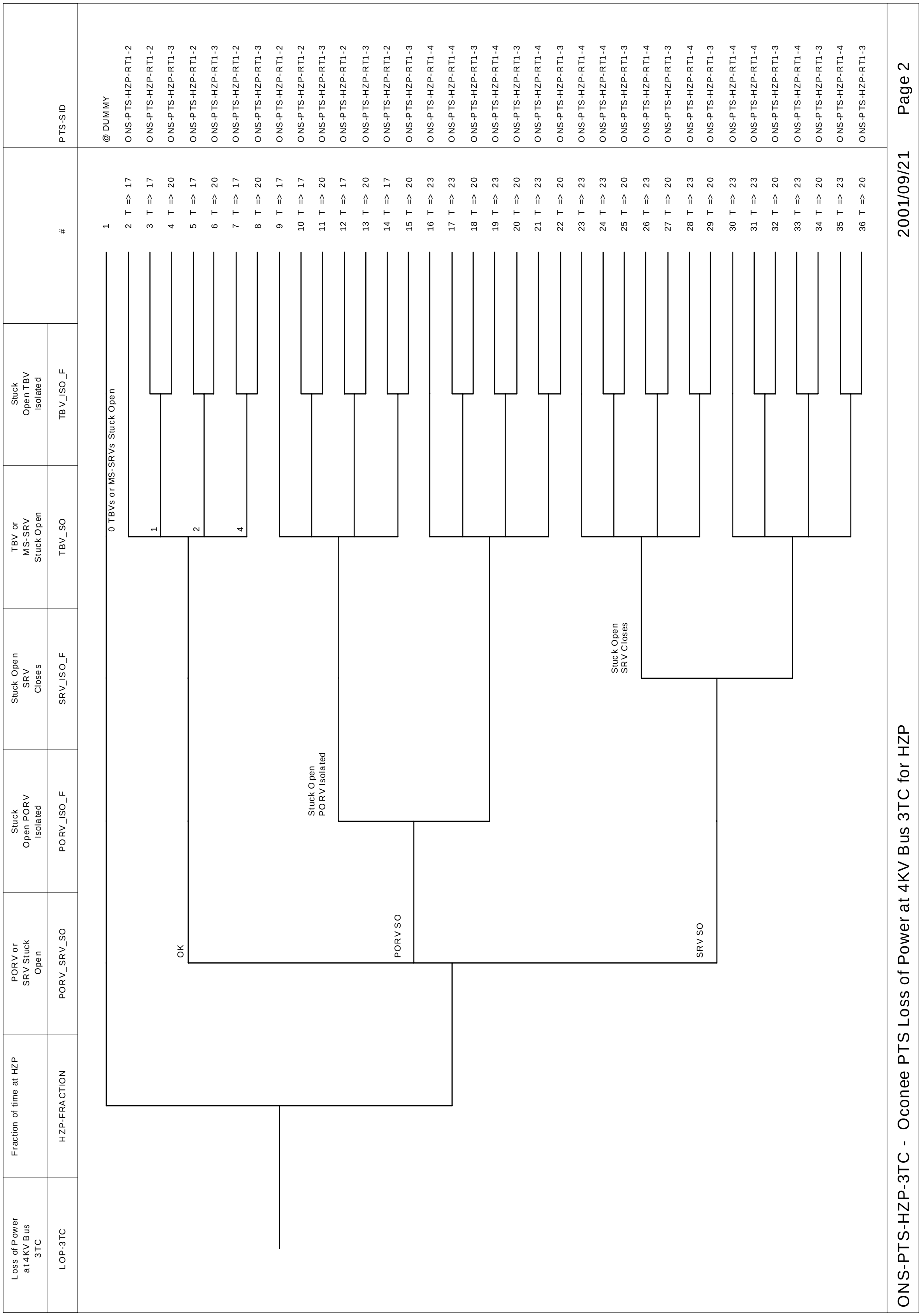

Figure 4.34. Oconee HZP-3TC: loss of power at 4KV bus 3TC.

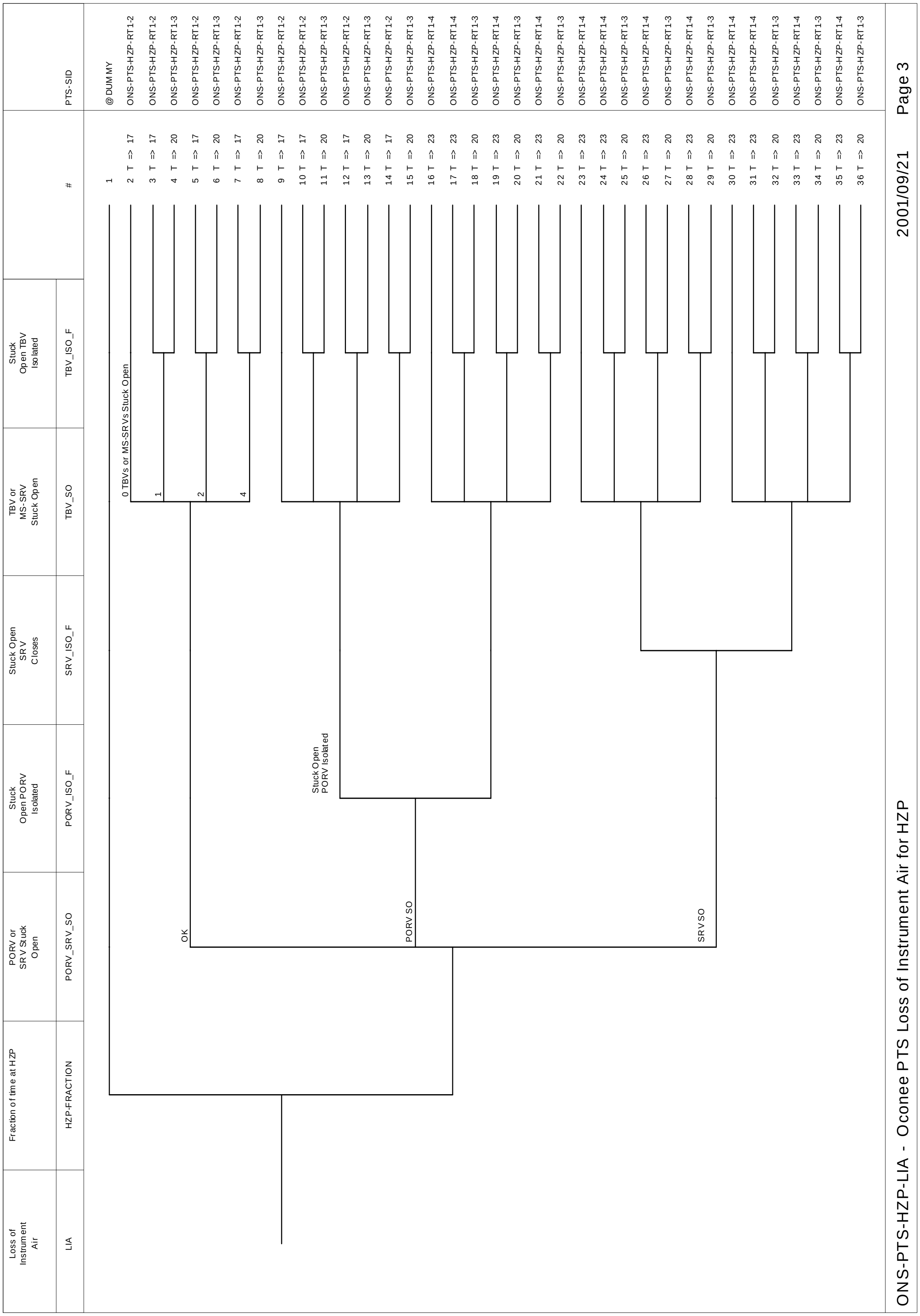

Figure 4.35. Oconee HZP-LIA: loss of instrument air.

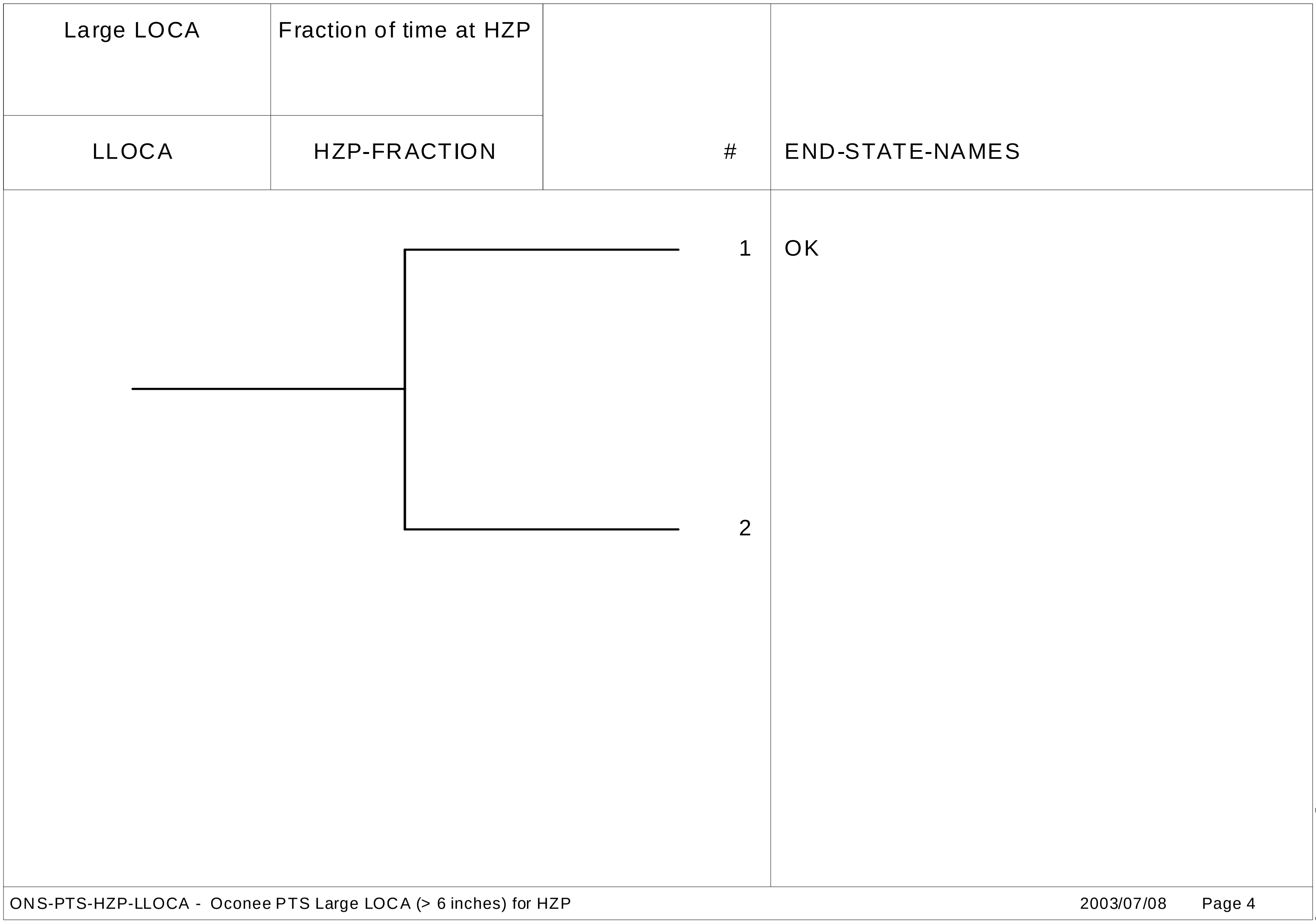

Figure 4.36. Oconee HZP-Large LOCA.

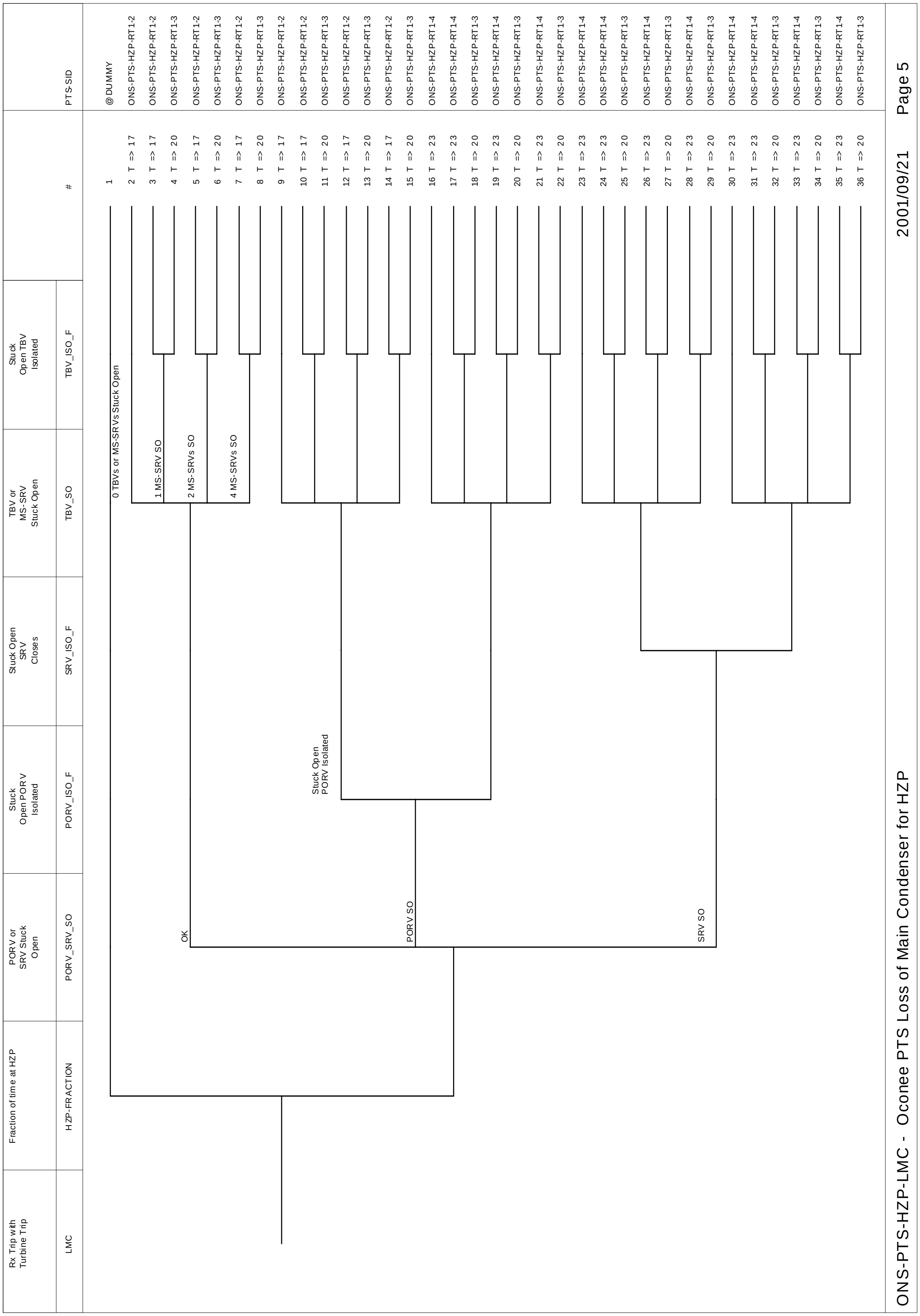

Figure 4.37. Oconee HZP-LMC: loss of main condenser.

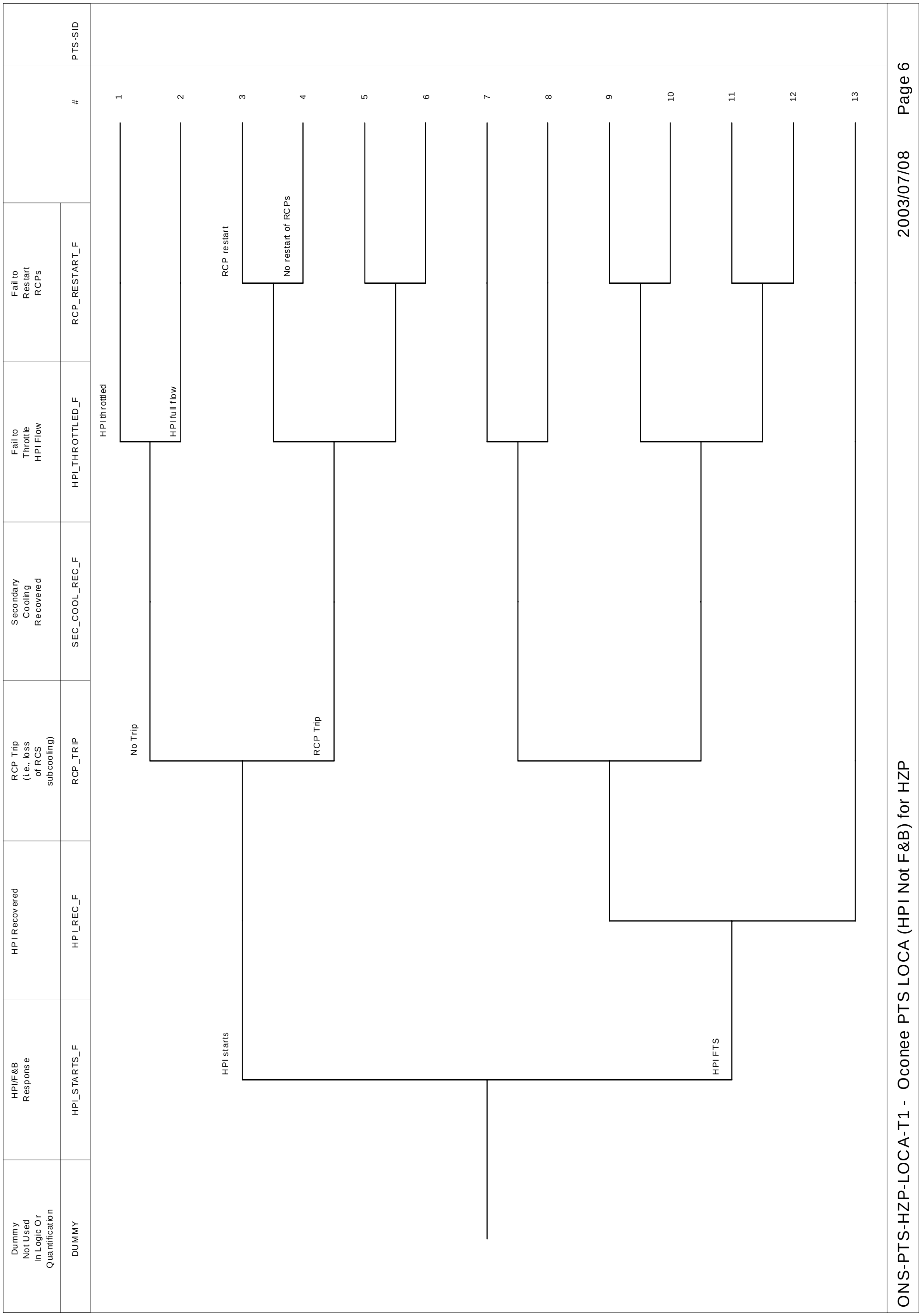

Figure 4.38. Oconee HZP-LOCA-T1: LOCA (HPI not F&B).

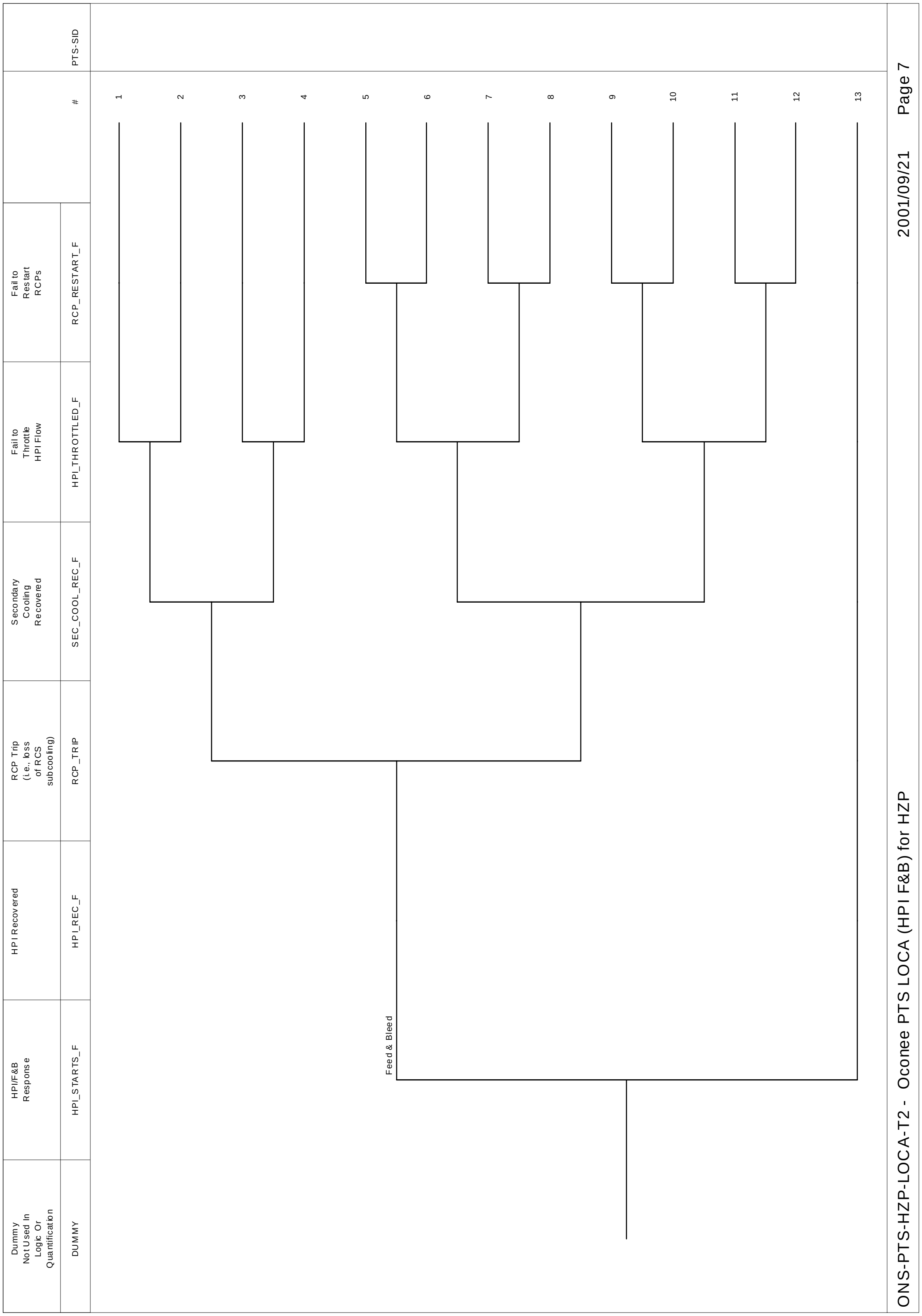

Figure 4.39. Oconee HZP-LOCA-T2: LOCA (HPI F&B).

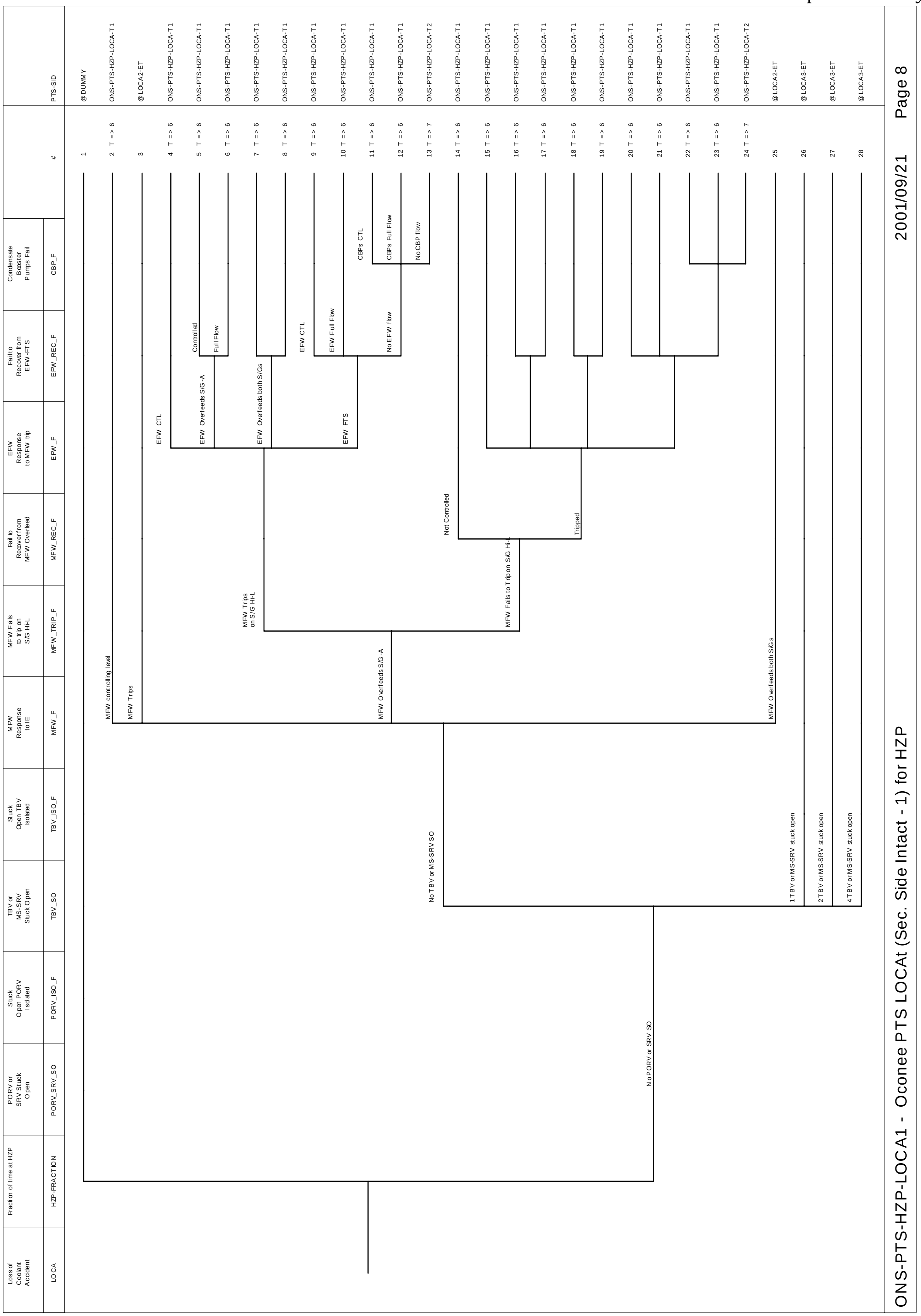

Figure 4.40. Oconee HZP-LOCA1: loss of coolant accident (sec. side intact - 1).

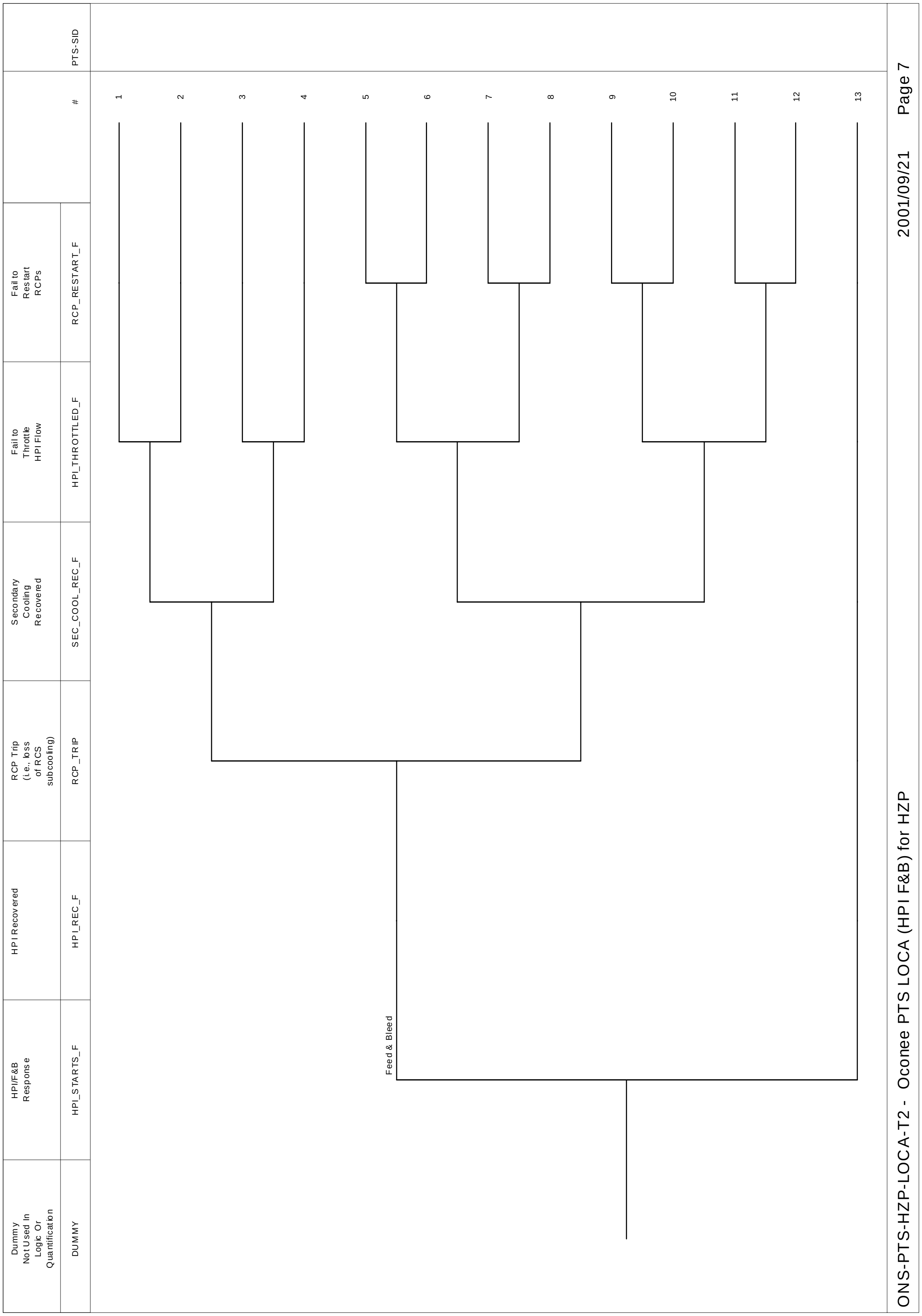

Figure 4.41. Oconee HZP-LOCA2: losss of coolant accident (sec. side intact - 2).

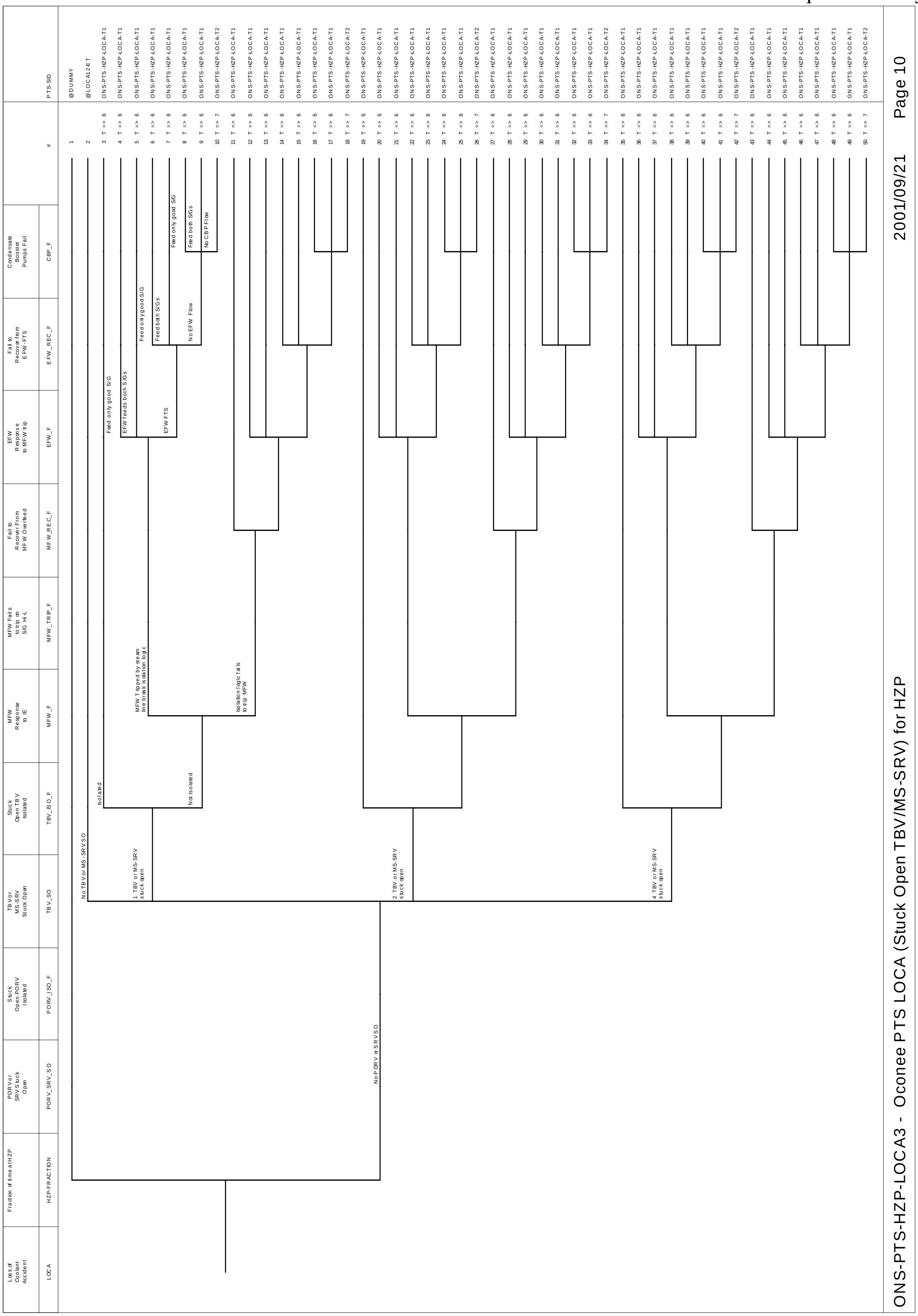

Figure 4.42. Oconee HZP-LOCA3: loss of coolant accident (stuck open TBV/MS-SRV).

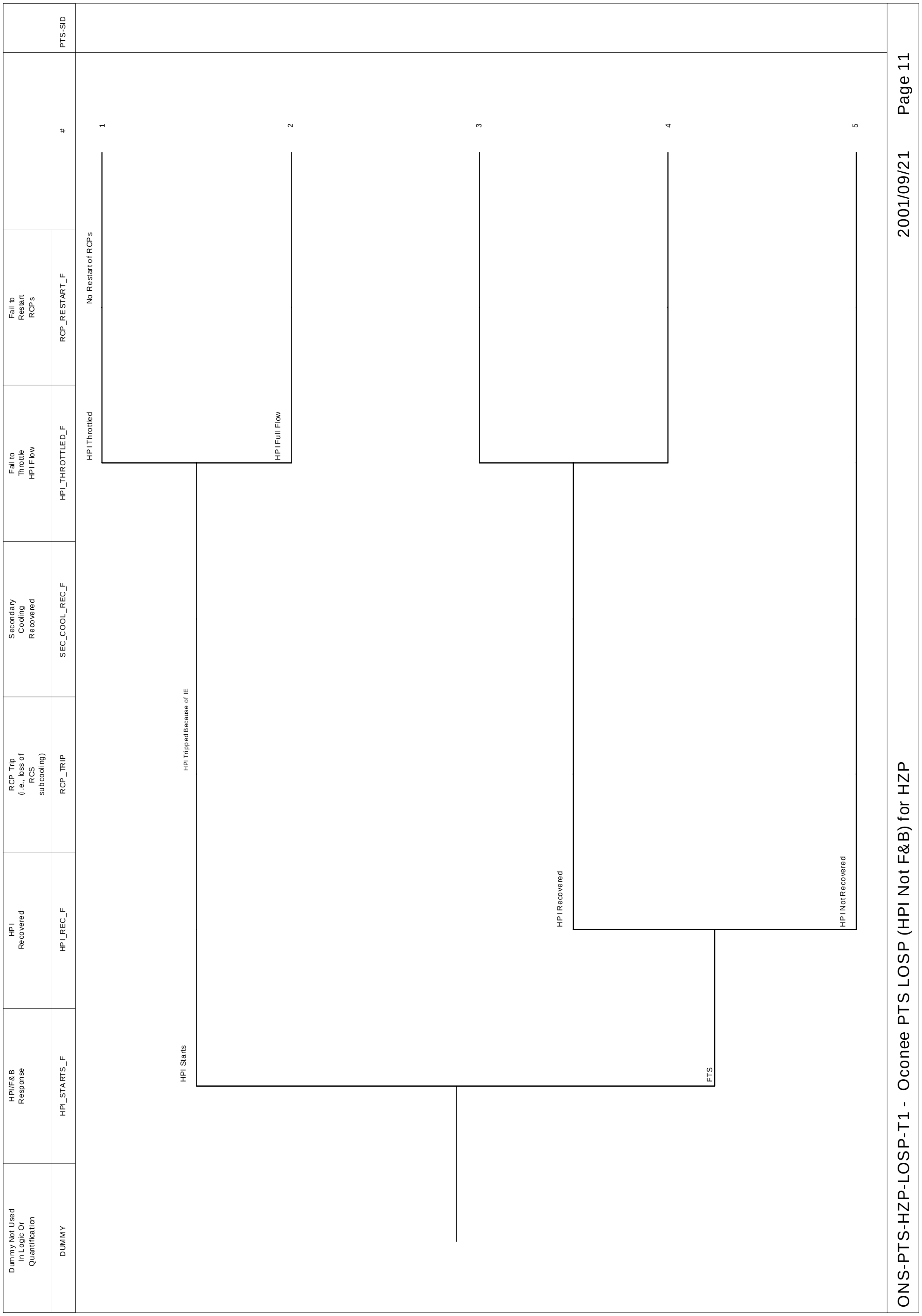

Figure 4.43. Oconee HZP-LOSP-T1: LOSP (HPI not F&B).

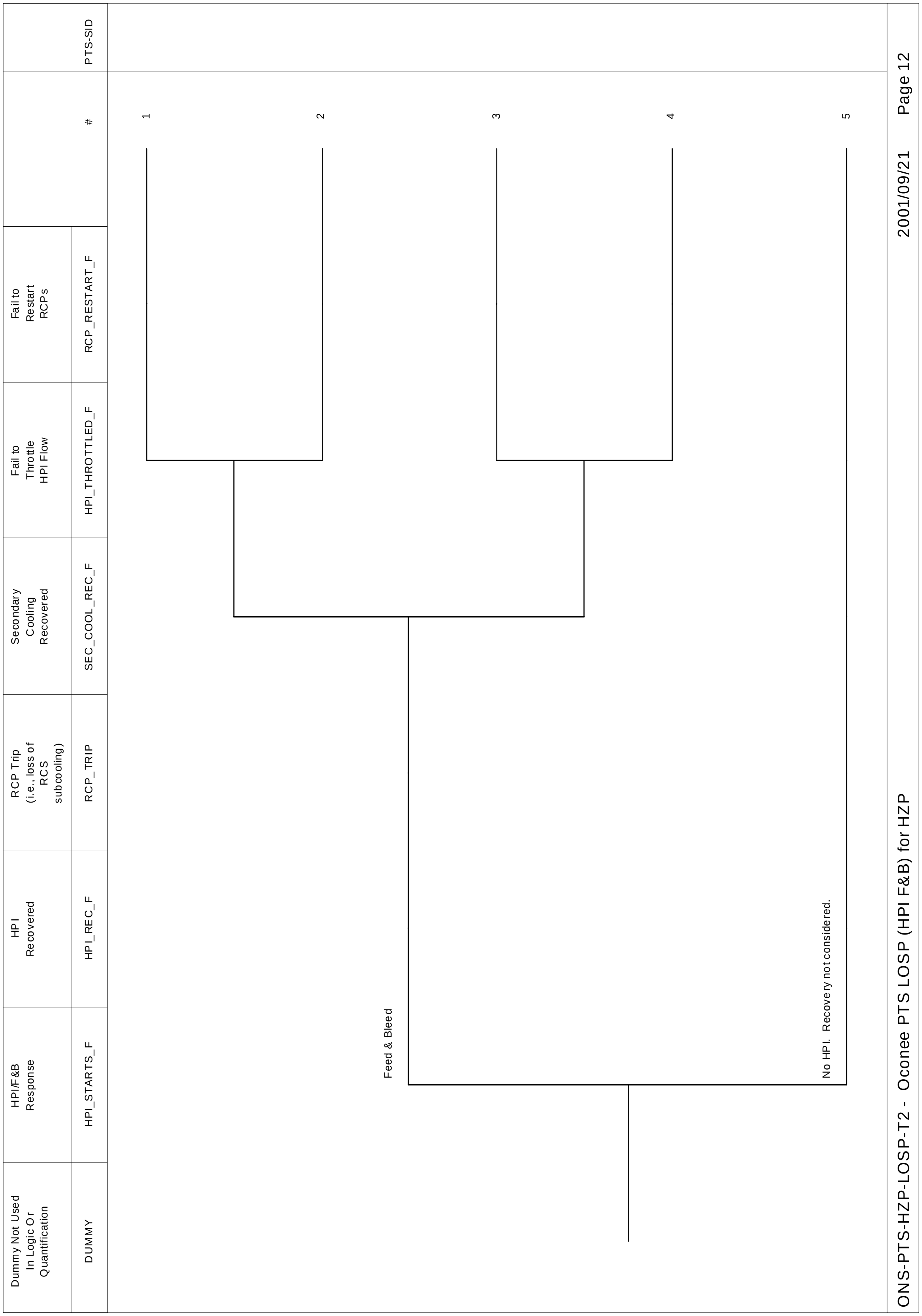

Figure 4.44. Oconee HZP-LOSP-T2: LOSP (HPI F&B).

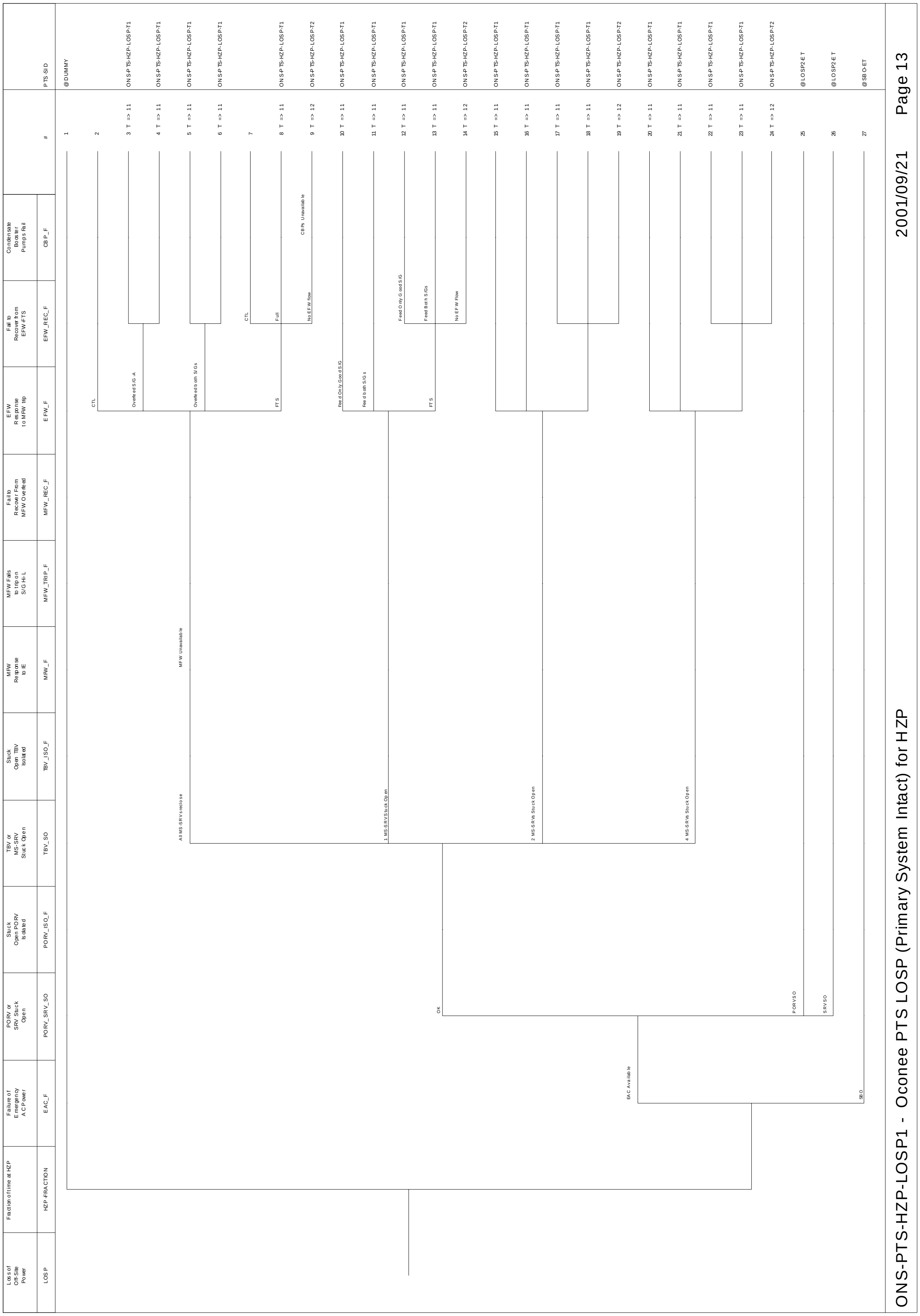

Figure 4.45. Oconee HZP-LOSP1: loss of offsite power (primary system intact).

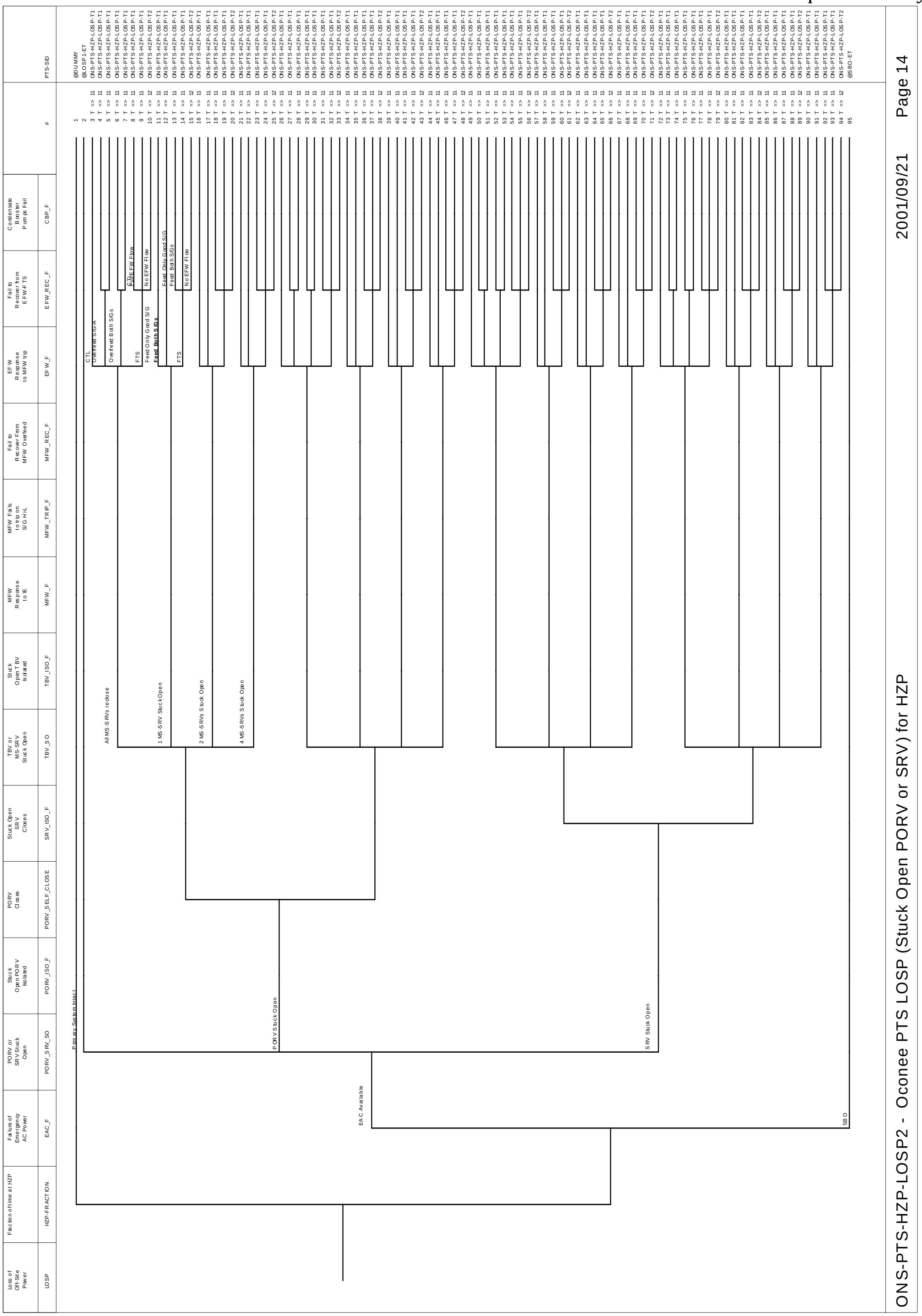

Figure 4.46. Oconee HZP-LOSP2: loss of offsite power (stuck open PORV or SRV).

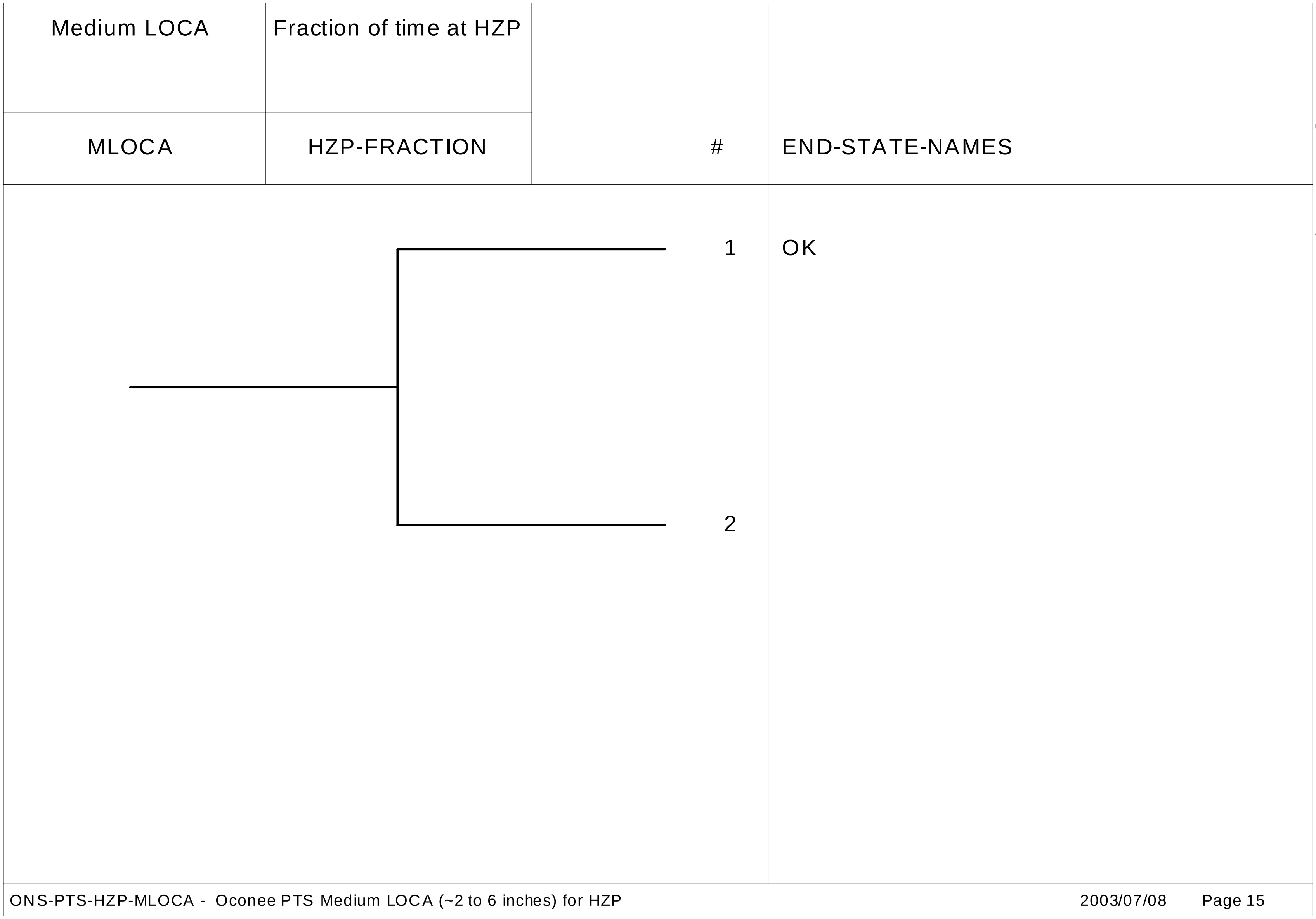

Figure 4.47. Oconee HZP-MLOCA: medium LOCA.

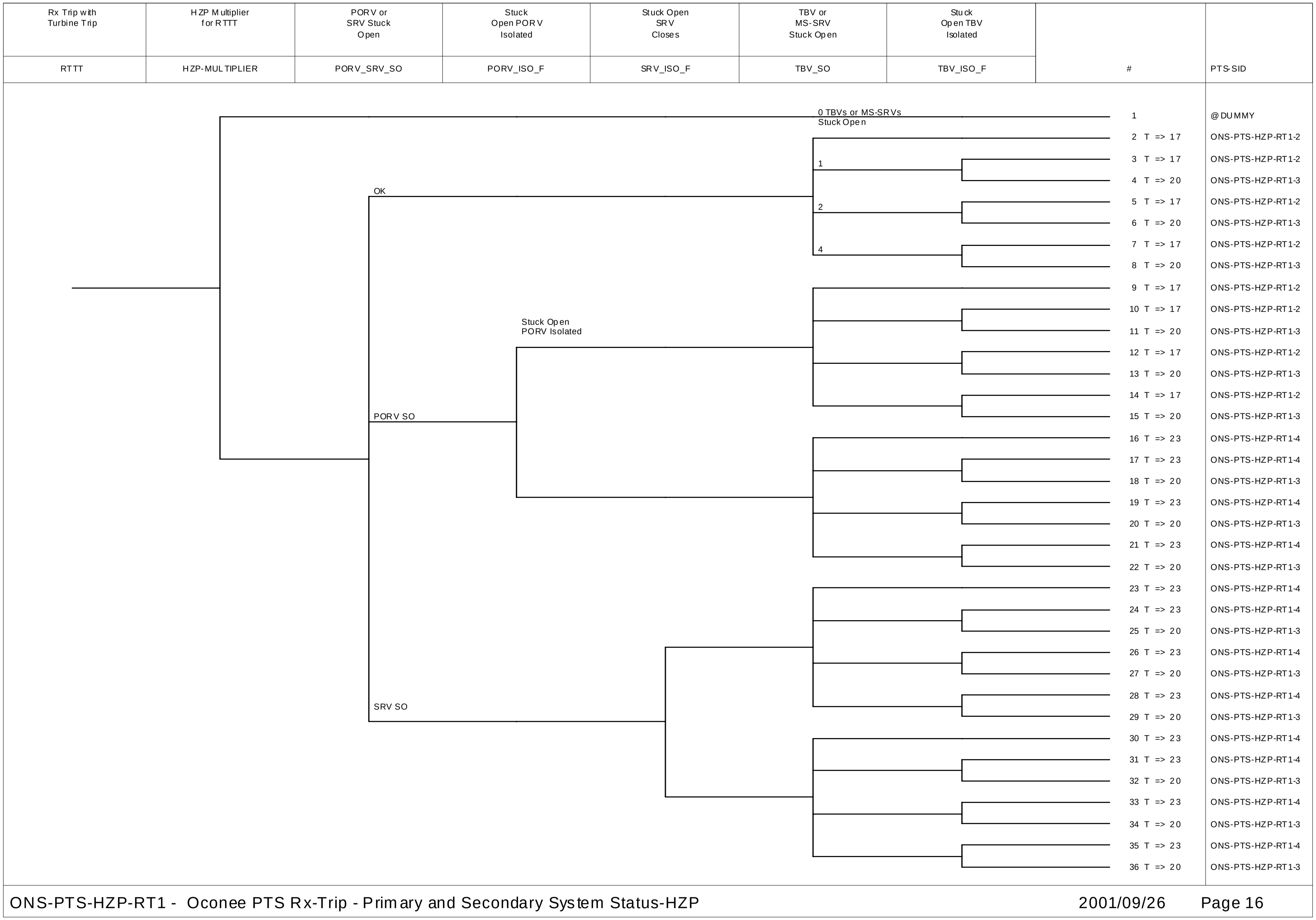

Figure 4.48. Oconee HZP-RT1: reactor trip - primary and secondary system status.

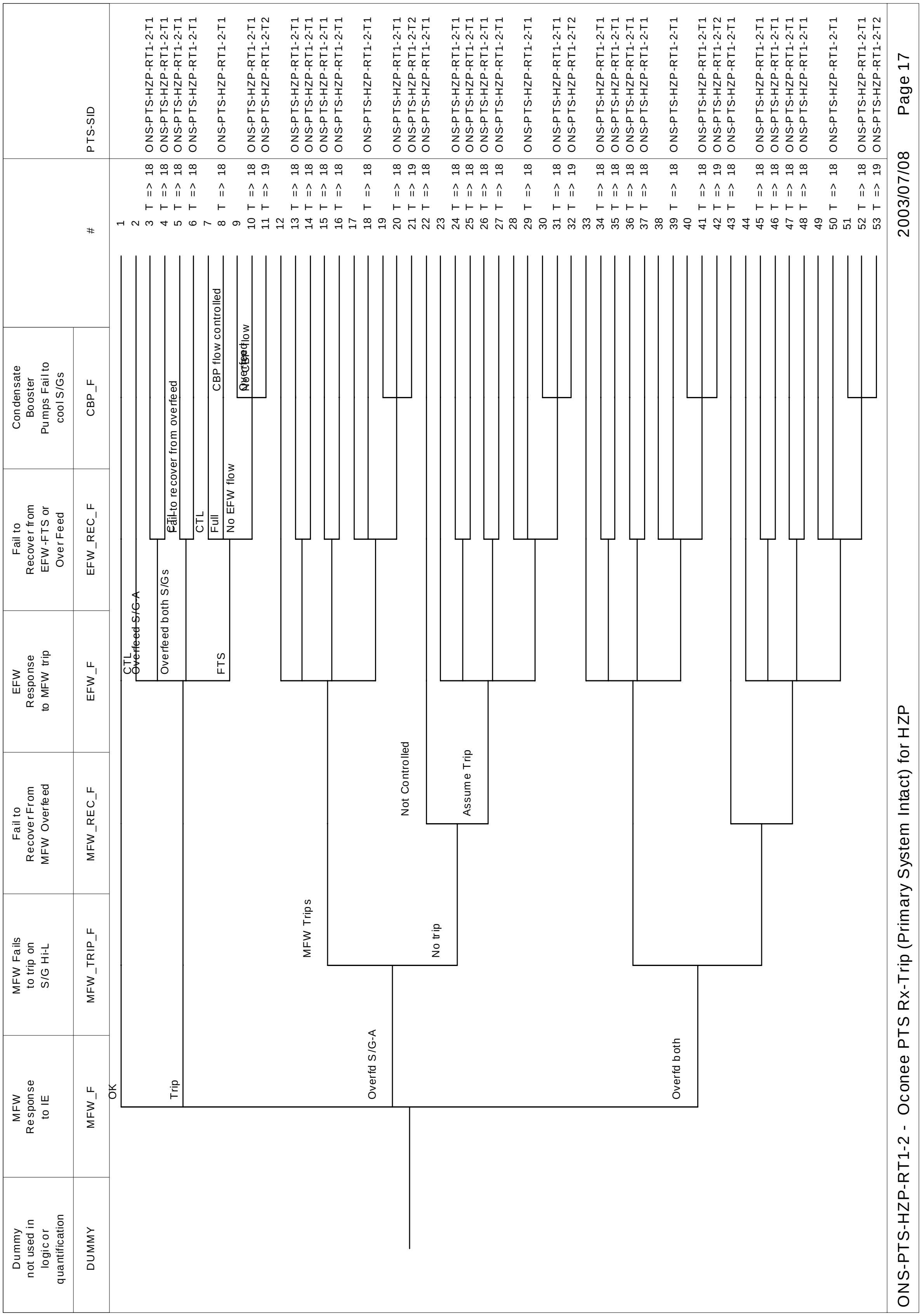

Figure 4.49. Oconee HZP-RT1-2: reactor trip (primary system intact).

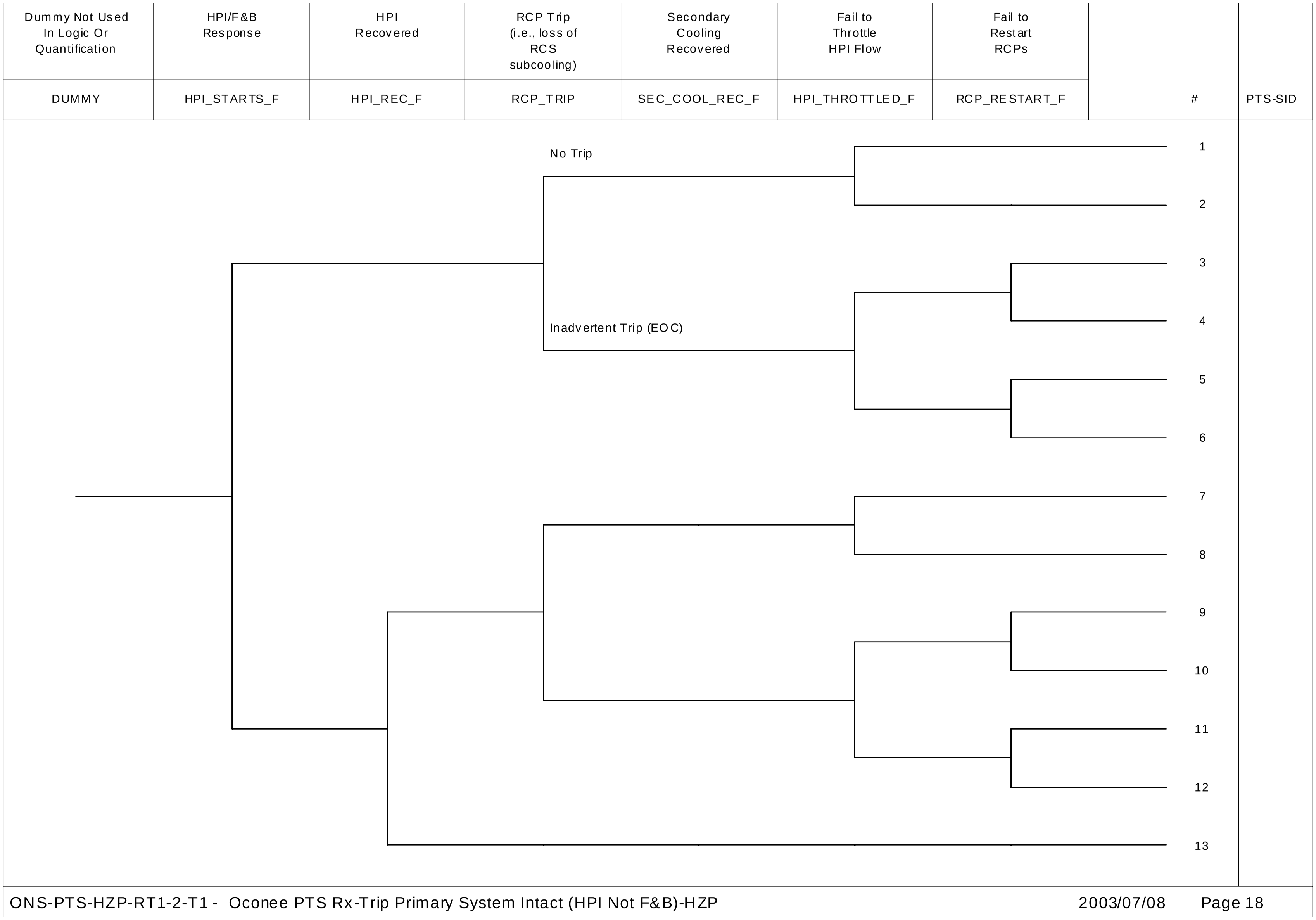

Figure 4.50. Oconee HZP-RT1-2-T1: reactor trip primary system intact (HPI not F&B).

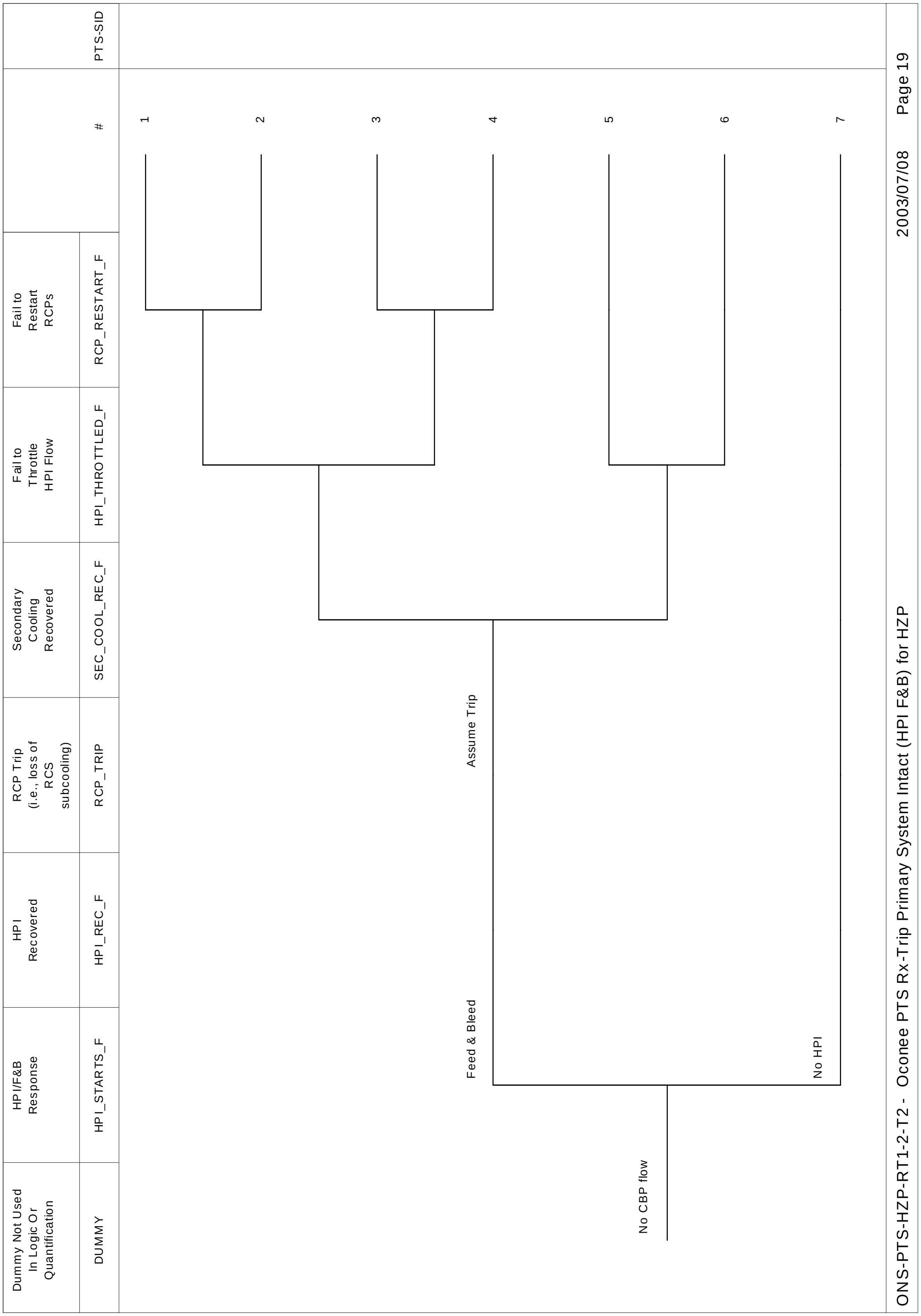

Figure 4.51. Oconee HZP-RT1-T2: reactor trip primary system intact (HPI F&B).

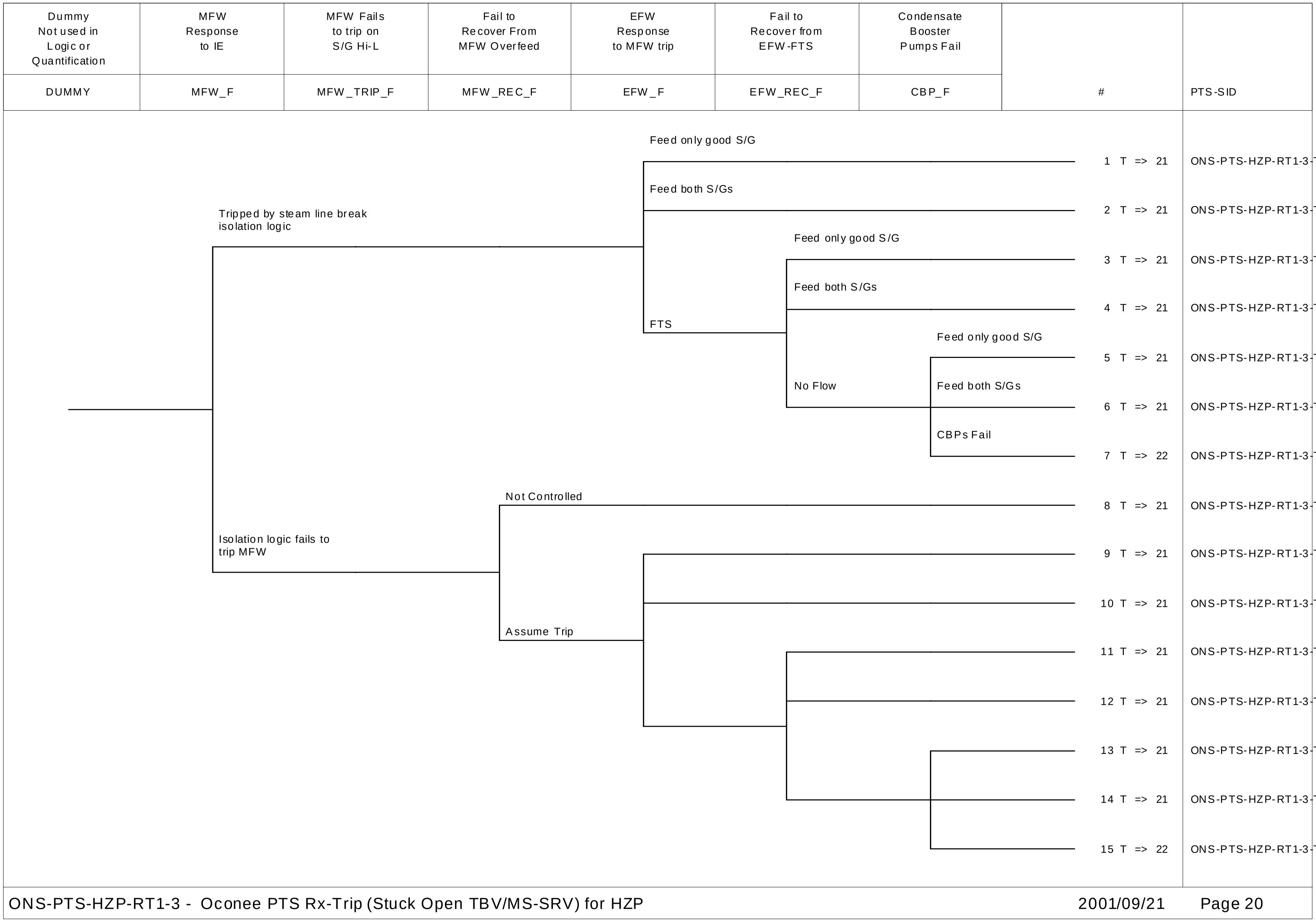

Figure 4.52. Oconee HZP-RT1-3: reactor trip (stuck open TBV/MS-SRV).

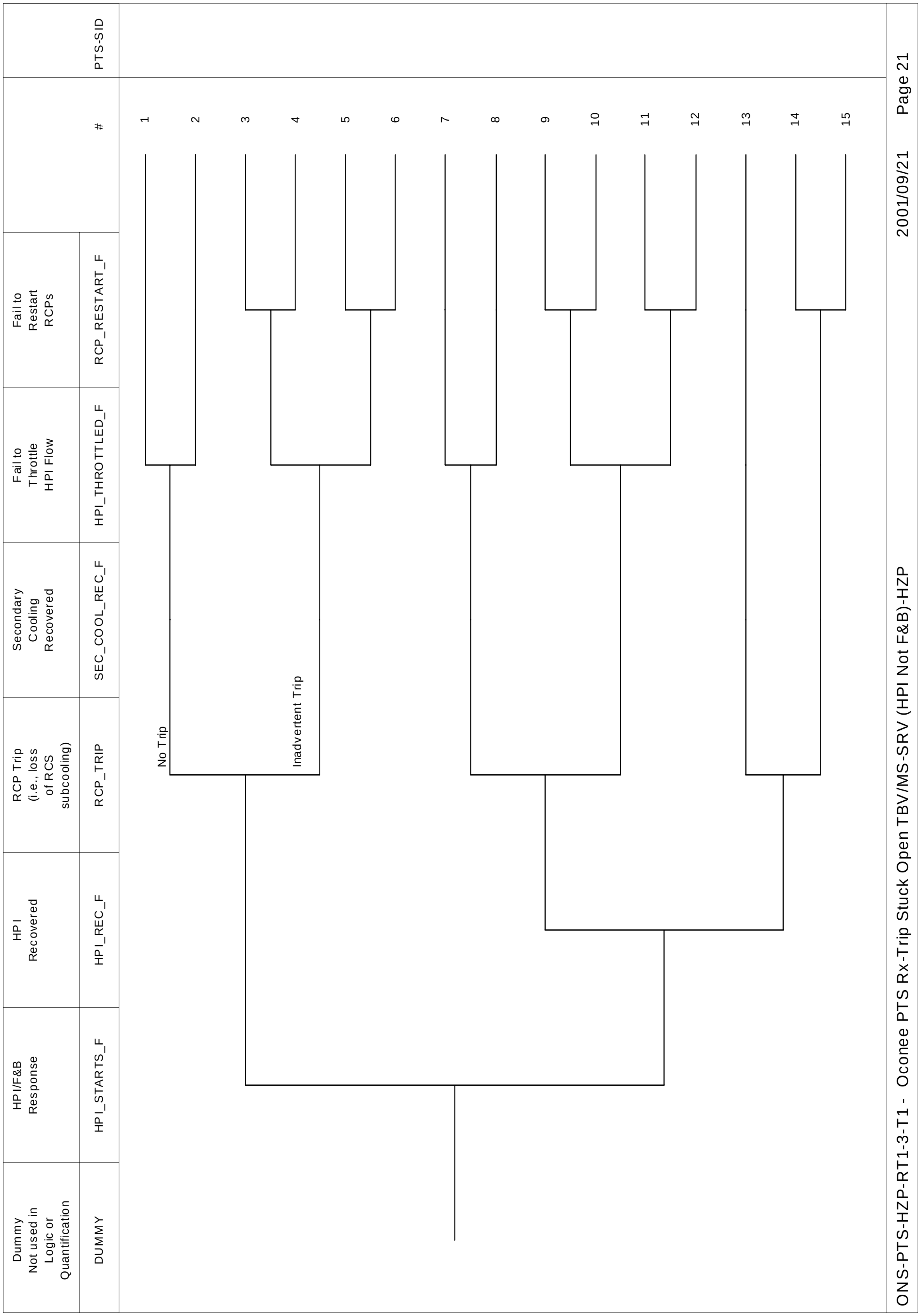

Figure 4.53. Oconee HZP-RT1-3-T1: reactor trip stuck open TBV/MS-SRV (HPI ot F&B).

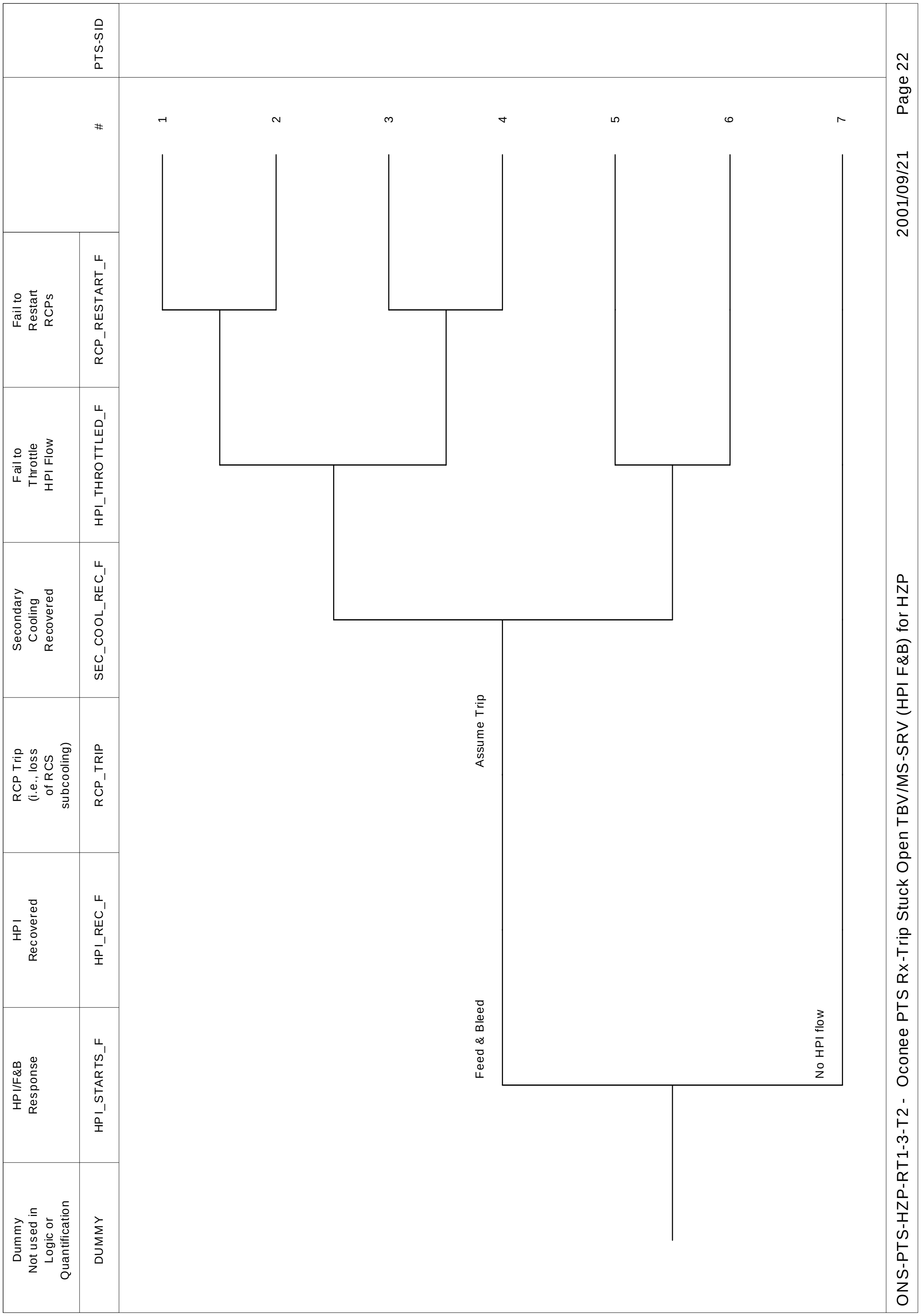

Figure 4.54. Oconee HZP-RT1-3-T2: reactor trip stuck open TBV/MS-SRV (HPI F&B).

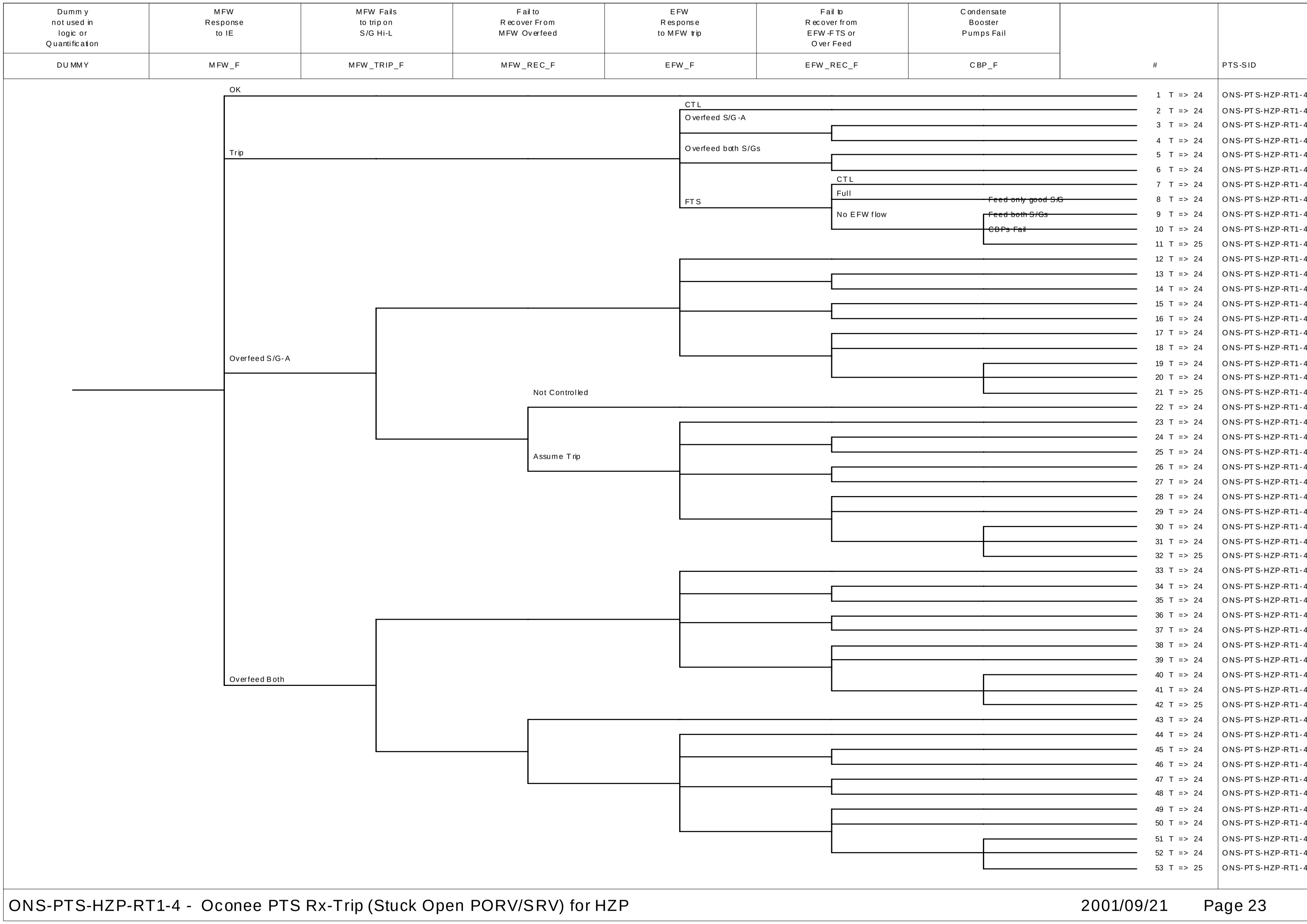

Figure 4.55. Oconee HZP-RT1-4: reactor trip (stuck open PORV/SRV).

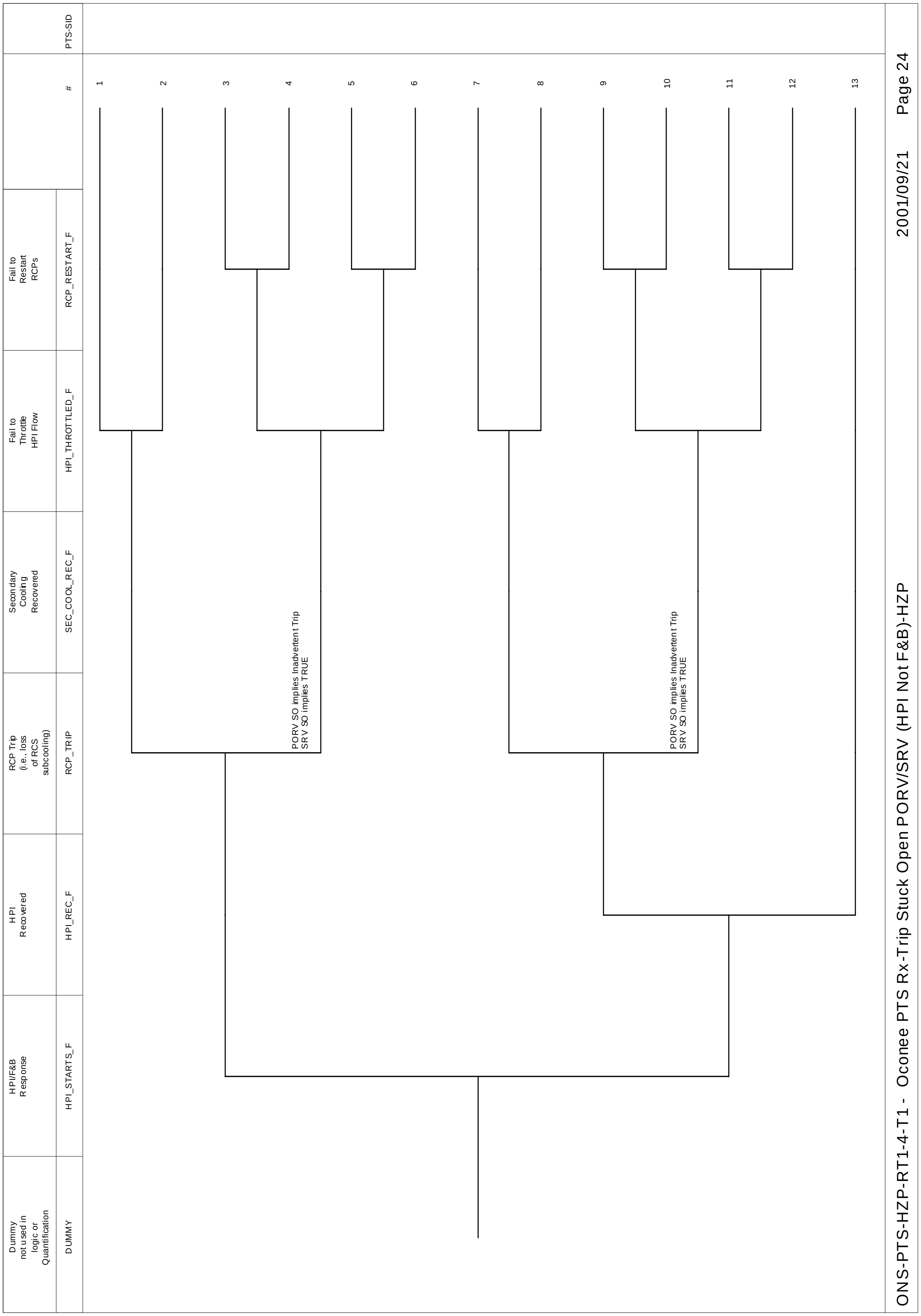

Figure 4.56. Oconee HZP-RT1-4-T1: reactor trip stuck open PORV/SRV (HPI not F&B).

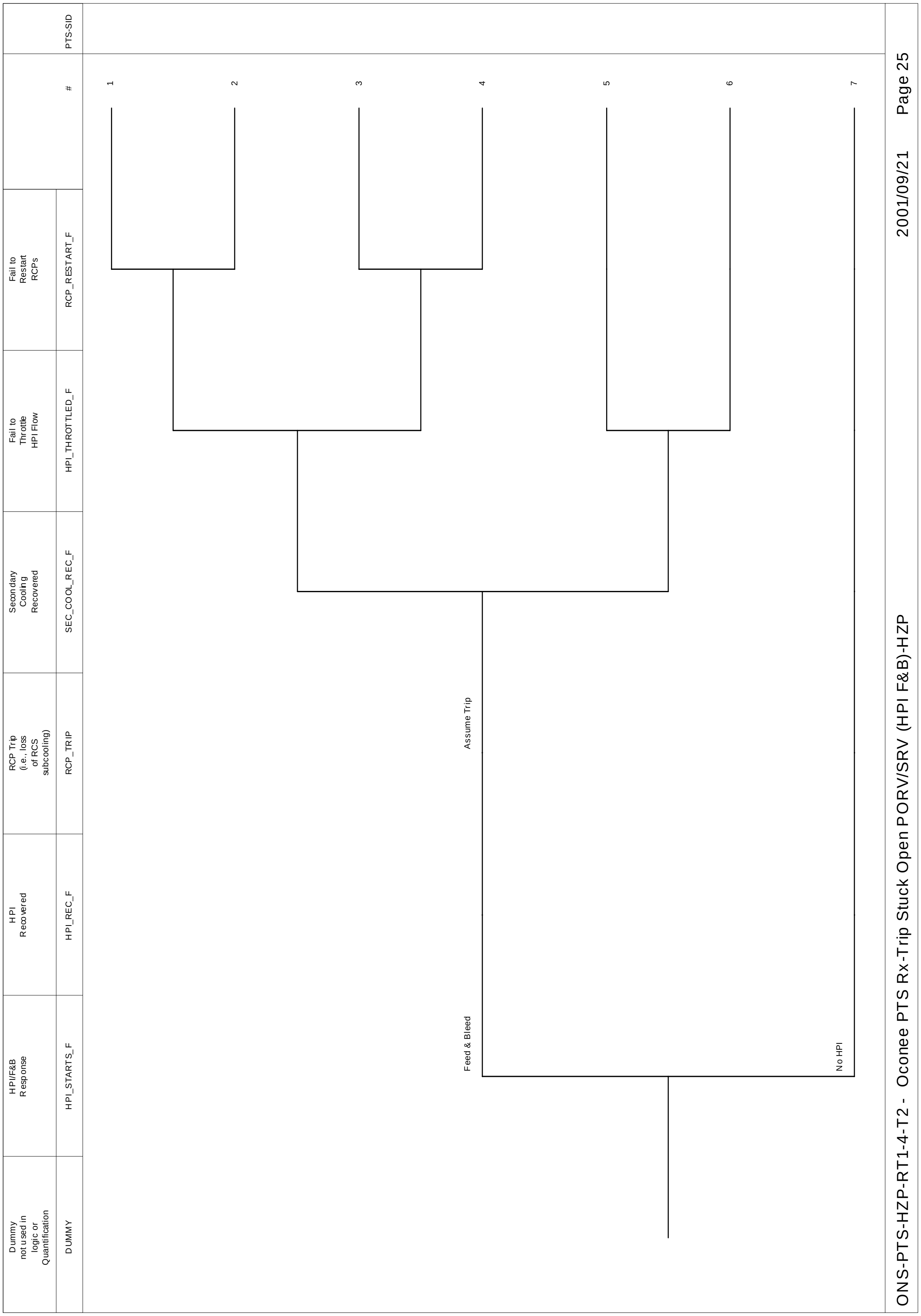

Figure 4.57. Oconee HZP-RT1-4-T2: reactor trip stuck open PORV/SRV (HPI F&B).

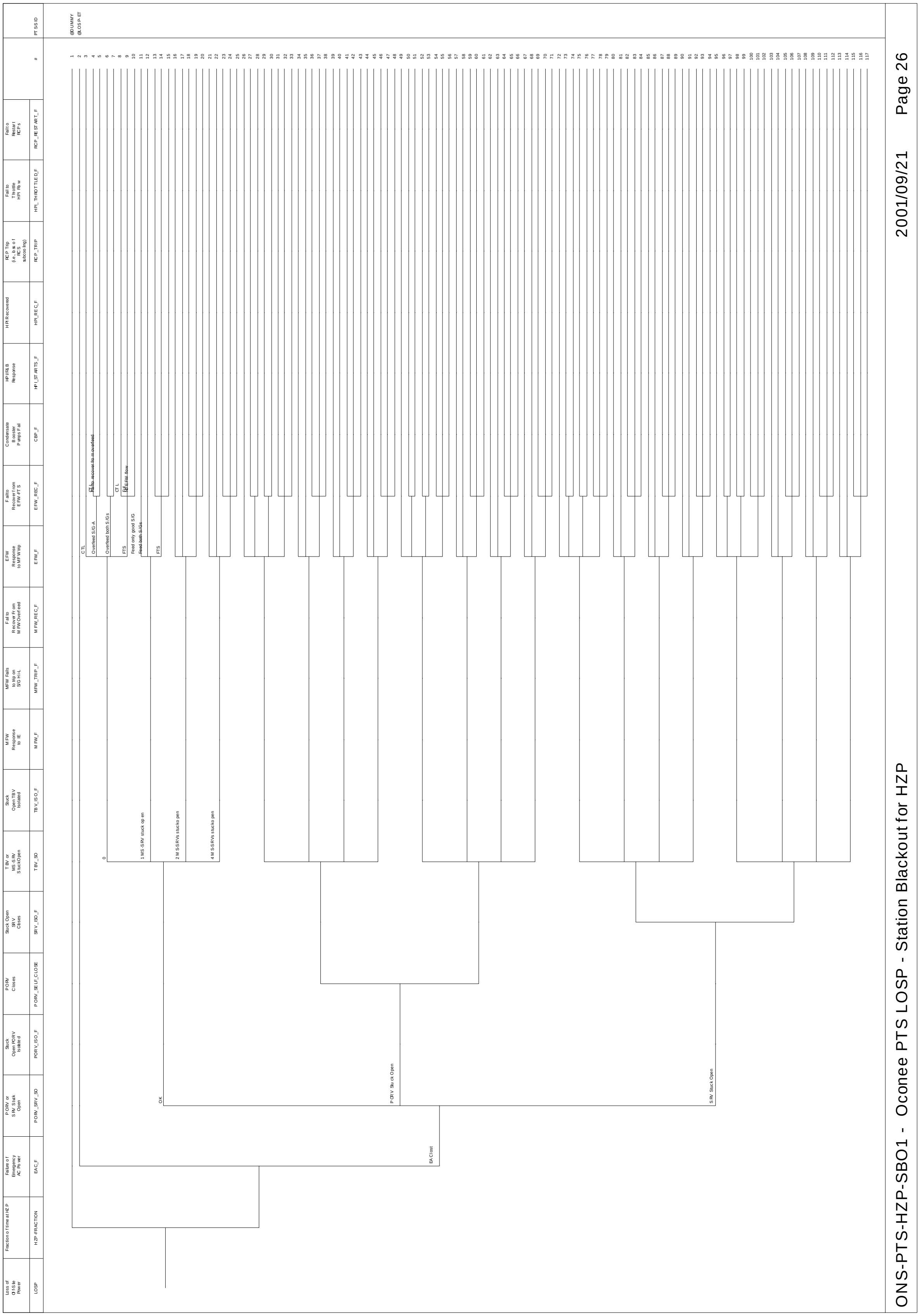

Figure 4.58. Oconee HZP-SBO1: LOSP station blackout.

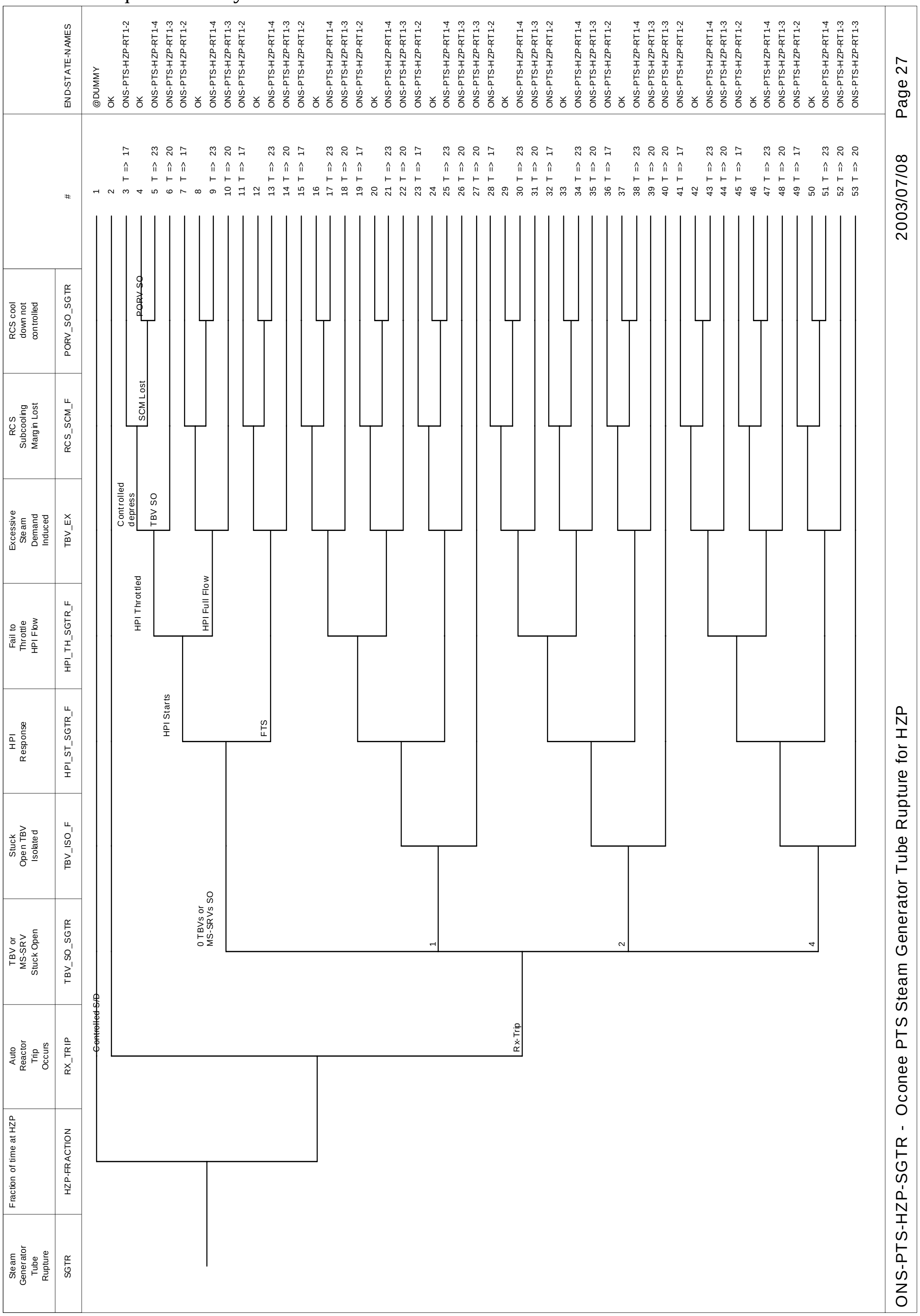

Figure 4.59. Oconee HZP-SGTR: steam generator tube rupture.

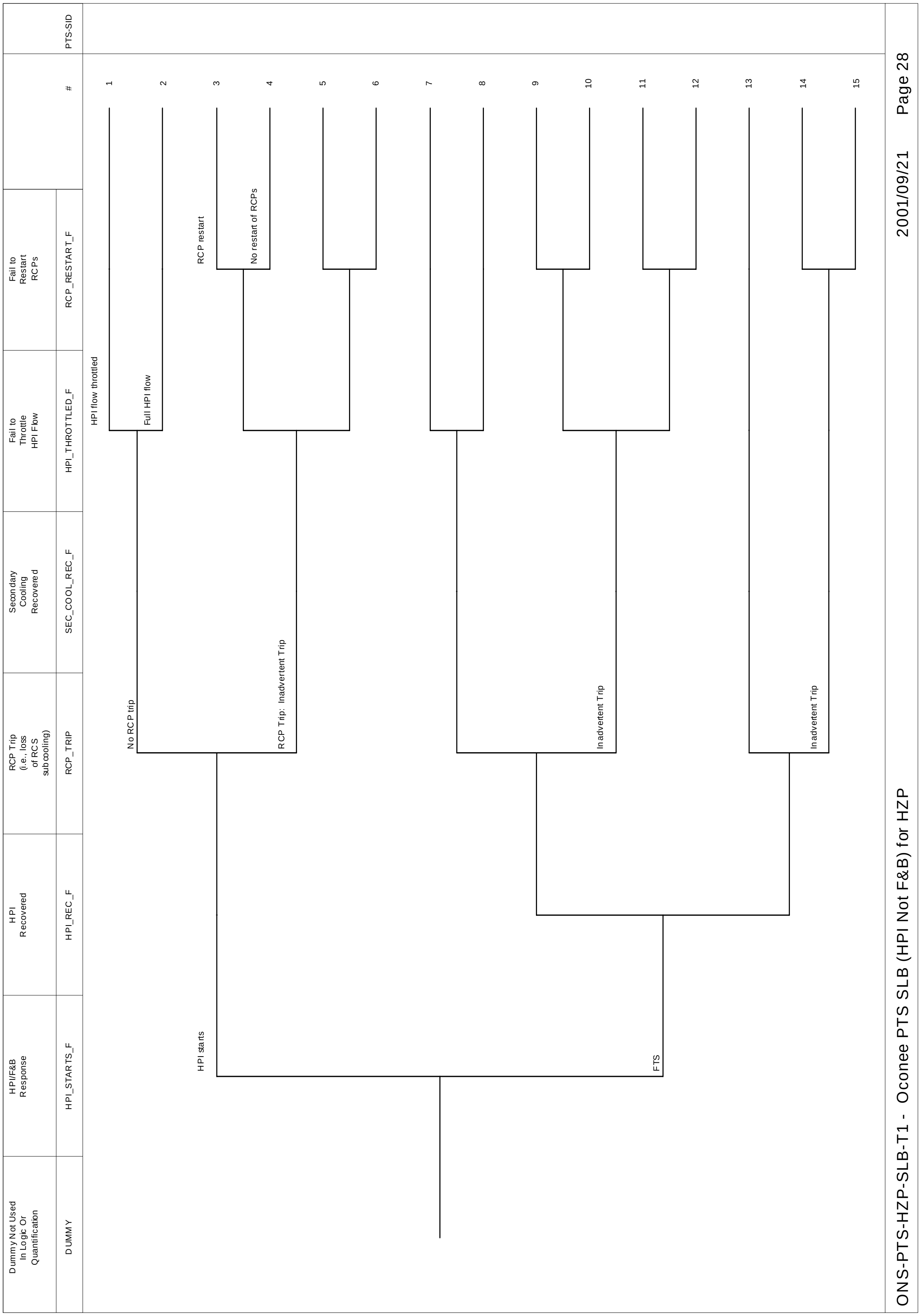

Figure 4.60. Oconee HZP-SLB-T1: steam line break (HPI not F&B).

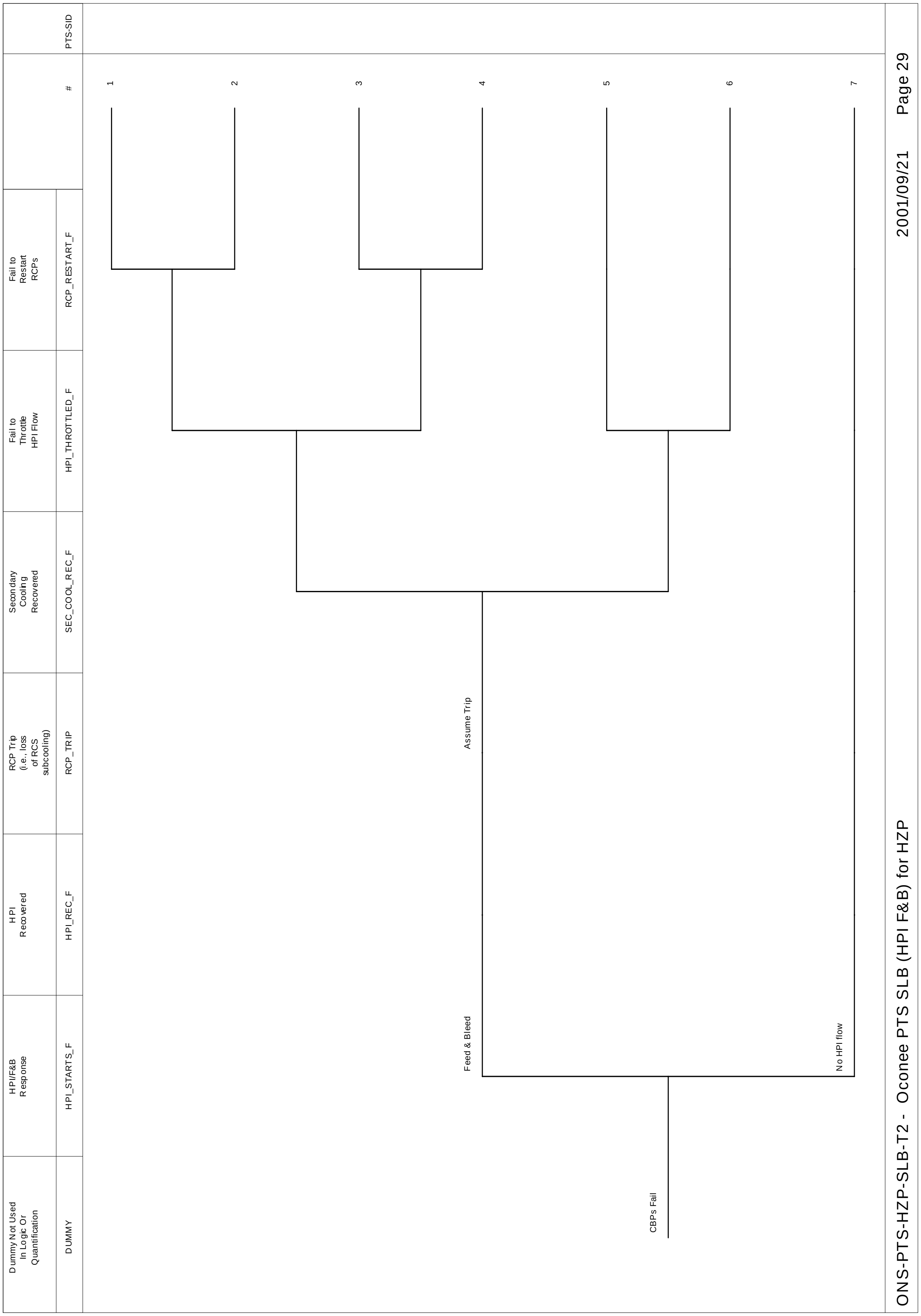

Figure 4.61. Oconee HZP-SLB-T2: steam line break (HPI F&B).

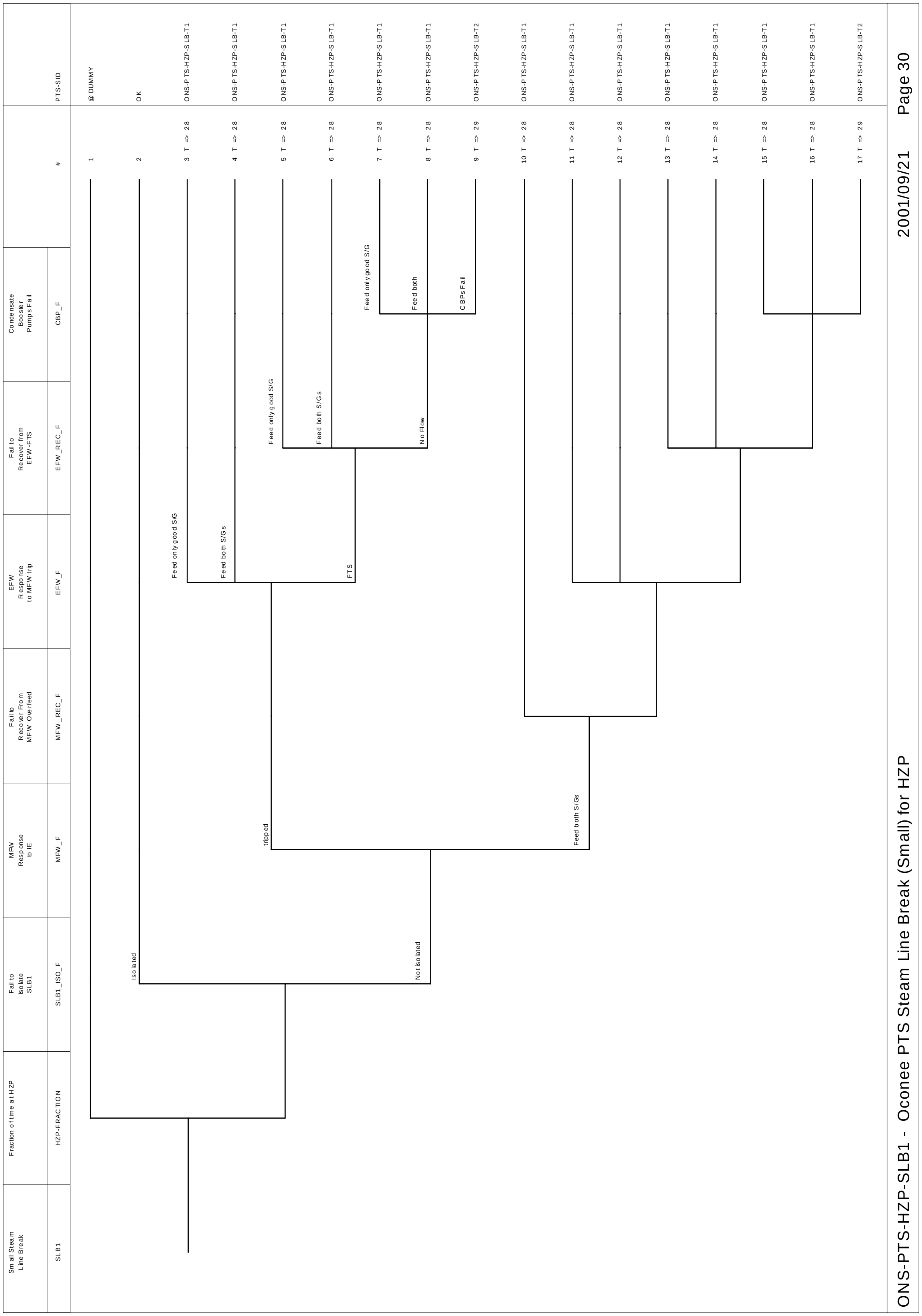

Figure 4.62. Oconee HZP-SLB1: steam line break (small).

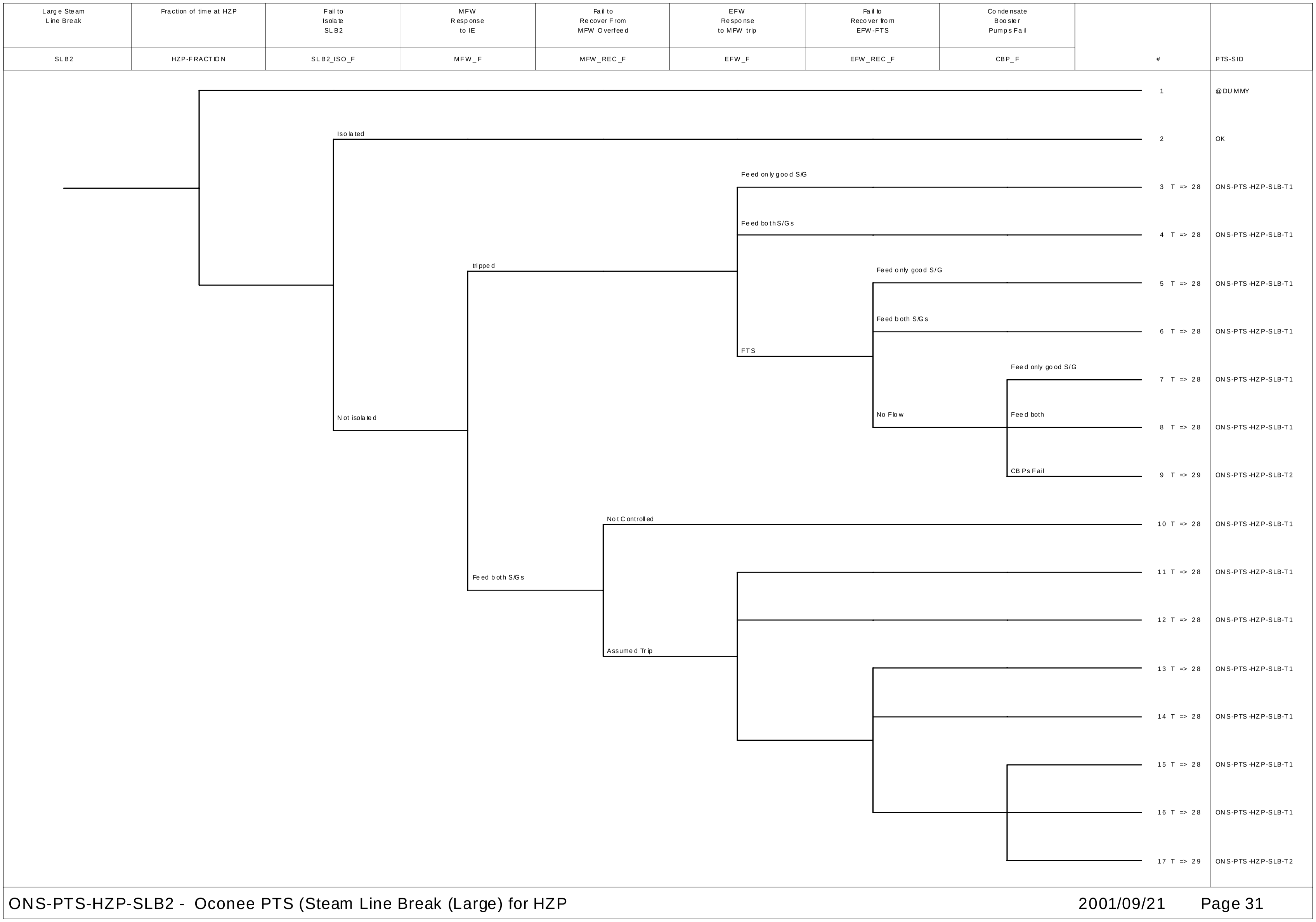

Figure 4.63. Oconee HZP-SLB2: steam line break (large).

4.3 Event Tree Sequence Generation

4.3.1 Power Model Sequence Generation

After developing the power event trees, the logic associated with each path through the trees (i.e., the unique combination of successes and failures) was constructed. SAPHIRE was used to generate this list of sequence logic by employing event tree rules [SAPHIRE]. These rules modified selected top events in the event trees based on the specific path through the trees (i.e., the specific combination of successes and failures) prior to the top event being modified. A single integrated set of event tree rules was developed and used to produce the sequence logic for all event trees. Table 4.1 provides a listing of the rules used to modify event tree top events. The rules employ a sequential "if-then-else" logic structure to test for specific combinations of top events. Application of these rules to the event trees produced the sequence logic for each initiating event. Table 4.2 lists the number of sequences by initiating event produced by this application. As can be seen from Table 4.2, a total of 90,629 sequences was generated. (NOTE: Because so many sequences were generated, the actual logic for each sequence is not reproduced in this report; however, it can be provided in electronic form.) Once the sequence logic was generated, SAPHIRE was used to solve for the minimal cut sets for each sequence. Sequences were solved using no truncation on cut set frequency. (NOTE: As with the sequence logic, the actual cut sets for each sequence are not reproduced in this report; however, they can be provided in electronic form.)

4.3.2 HZP Model Sequence Generation

Using the same approach as described in section 4.3.1, sequence logic was developed for the HZP event trees. Because the only difference between corresponding HZP and power event trees was the top event to convert the power initiating event frequency to HZP frequency (see section 4.2.2), generation of the HZP sequence logic employed the same set of event tree rules as was used to generate the power sequences (see Table 4.1). Since the same rules were used, the number of sequences generated for each of the HZP event trees was the same as generated for the power trees (see Table 4.2). Thus, just as for power, a total of 90,629 HZP sequences was generated and then solved for minimal cut sets. As noted in section 4.3.1, a listing of the generated logic and associated cut sets is not reproduced in this report.

4.4 Thermal-Hydraulic Bin Creation

Given the number of potential PTS sequences generated (181,258), it was necessary to group (i.e., bin) sequences with like characteristics into representative TH cases that could be analyzed in the thermal-hydraulic portions of the PTS study using the RELAP code [NUREG/CR-6858].

Initial bins were constructed by developing event tree partitioning rules in SAPHIRE and then applying these rules to produce the TH bins. Development of the partitioning rules required the analysts to examine the TH information available from preliminary analyses to identify the characteristics that defined the preliminary analyses.

Using this information, the analysts then made judgments as to whether existing TH characteristics could be used to represent new groups of sequences. If the analysts judged that existing characteristics were

Table 4.1. Event tree linkage rules for Oconee power or HZP event trees.

```
|  Rules for ETs
|  Last Modified September 18, 2001
|
|
| List IEs
| LOP-3KI - Loss of Power at bus 3KI
| LOP-3TC - Loss of Power at 4KV bus 3TC
|   Note that IE frequencies are already on a per-plant basis
|   therefore do not need to use (Freq)x3 to account for 3 buses.
| HZP - Rx-Trip with T-Trip at Hot Zero Power
| LIA - Loss of Instrument Air
| LMC - Loss of Main Condenser
| LOCA - Loss of Coolant Accident (PTS relevant) >1.4 & <2.8 inches
|        Used in LOCA1, LOCA2, and LOCA3 trees
| MLOCA - Medium LOCA > 2.8 <= 6 inches
| LLOCA - Large LOCA > 6 inches
| LOSP - Loss of OffSite Power
|        Used in LOSP1, LOSP2, and SBO1 trees
| RTTT - Rx-Trip with Turbine Trip
| SGTR - Steam Generator Tube Rupture
| SLB1 - Small Steam Line Break (<8" - 1 TBV)
| SLB2 - Large Steam Line Break (>8" - Main Steam Line)
|
|
| Rule for PORV_SRV_SO top event.
| Top branch is success (i.e., all valves re-close)
| 1st failure branch is stuck open PORV
| 2nd failure branch is stuck open SRV

if always then
   /PORV_SRV_SO = PORV_SRV_SO-FT;
   PORV_SRV_SO[1] = PORV_SO;
   PORV_SRV_SO[2] = SRV_SO;
endif

| Rule for Isolating a Stuck Open PORV
| If LOSP then cannot close PORV block valve

if always then
   /PORV_ISO_F = PORV_ISO_F-10;
   PORV_ISO_F = PORV_ISO_F-10;
endif
```

Table 4.1. Event tree linkage rules for Oconee power or HZP event trees.

```
| Rule for PORV self closing
| Used for LOSP initiator

if always then
  /PORV_SELF_CLOSE = PORV_SELF_CLOSE;
   PORV_SELF_CLOSE = PORV_SELF_CLOSE;
endif

| Rule for stuck-open SRV reclosing

if always then
  /SRV_ISO_F = SRV_ISO_F;
   SRV_ISO_F = SRV_ISO_F;
endif

| Rule for stuck-open turbine bypass valves (or main steam SRVs)
| Top branch is success (i.e., all valve re-close)
| 1st failure branch is 1 TBV or MS-SRV stuck open
| 2nd failure branch is 2 TBVs or MS-SRVs stuck open
| 3rd failure branch is 4 TBVs or MS-SRVs stuck open

if always then
  /TBV_SO = TBV_SO-FT;
  TBV_SO[1] = TBV_1SO;
  TBV_SO[2] = TBV_2SO;
  TBV_SO[3] = TBV_4SO;
endif

if always then
  /TBV_SO_SGTR = TBV_SO_SGTR-FT;
  TBV_SO_SGTR[1] = TBV_1SO_SGTR;
  TBV_SO_SGTR[2] = TBV_2SO_SGTR;
  TBV_SO_SGTR[3] = TBV_4SO_SGTR;
endif

| TBV_ISO_F
| Rule for isolating stuck open TBV
| if loss of main condenser (LMC) or loss of instrument air (LIA)
| is the initiating event, or all AC power is lost
| then TBVs close
| therefore assume any stuck open valve is
| MS-SRV (not isolatable)
```

Table 4.1. Event tree linkage rules for Oconee power or HZP event trees.

```
if init(LMC) + init(LIA) + EAC_F then
  /TBV_ISO_F = TBV_SO_FI-TRUE;
  TBV_ISO_F = TBV_SO_FI-TRUE;

| The following rules for substituting for TBV_ISO_F combined with
| LOSP as the initiator is NOT needed since question is never asked
| for LOSP sequences since we are uncertain as to whether isolation
| is possible; so we have assumed that it is not possible to isolate.

elsif init(LOSP) * TBV_1SO then
  /TBV_ISO_F = TBV_ISO_F-FT1;
| For TBV_ISO_F-FT1 logic, see fault tree
  TBV_ISO_F = TBV_ISO_F-FT1;
elsif init(LOSP) * TBV_2SO then
  /TBV_ISO_F = TBV_ISO_F-FT2;
| TBV_ISO_F-FT2 logic, see fault tree
  TBV_ISO_F = TBV_ISO_F-FT2;
elsif init(LOSP) * TBV_4SO then
  /TBV_ISO_F = TBV_ISO_F-FT4;
| TBV_ISO_F-FT4 = logic, see fault tree
  TBV_ISO_F = TBV_ISO_F-FT4;

elsif init(LOCA) * TBV_1SO then
  /TBV_ISO_F = TBV_ISO_F-FT3;
| TBV_ISO_F-FT3 = see fault tree
  TBV_ISO_F = TBV_ISO_F-FT3;
elsif init(LOCA) * TBV_2SO then
  /TBV_ISO_F = TBV_ISO_F-FT5;
| TBV_ISO_F-FT5 = see fault tree
  TBV_ISO_F = TBV_ISO_F-FT5;
elsif init(LOCA) * TBV_4SO then
  /TBV_ISO_F = TBV_ISO_F-FT6;
| TBV_ISO_F-FT6 = see fault tree
  TBV_ISO_F = TBV_ISO_F-FT6;

elsif TBV_1SO then
  /TBV_ISO_F = TBV_ISO_F-FT7;
| TBV_ISO_F-FT7 = see fault tree
  TBV_ISO_F = TBV_ISO_F-FT7;
elsif TBV_2SO then
  /TBV_ISO_F = TBV_ISO_F-FT8;
| TBV_ISO_F-FT8 = see fault tree
  TBV_ISO_F = TBV_ISO_F-FT8;
```

Table 4.1. Event tree linkage rules for Oconee power or HZP event trees.

```
elsif TBV_4SO then
  /TBV_ISO_F = TBV_ISO_F-FT9;
| TBV_ISO_F-FT9 = see fault tree
  TBV_ISO_F = TBV_ISO_F-FT9;

|  If SGTR then
elsif TBV_1SO_SGTR then
  /TBV_ISO_F = TBV_ISO_F-FT3;
| TBV_ISO_F-FT3 = see fault tree
  TBV_ISO_F = TBV_ISO_F-FT3;
elsif TBV_2SO_SGTR then
  /TBV_ISO_F = TBV_ISO_F-FT5;
| TBV_ISO_F-FT5 = see fault tree
  TBV_ISO_F = TBV_ISO_F-FT5;
elsif TBV_4SO_SGTR then
  /TBV_ISO_F = TBV_ISO_F-FT6;
| TBV_ISO_F-FT6 = see fault tree
  TBV_ISO_F = TBV_ISO_F-FT6;

endif


| Rules for MFW_F top event.
| if LMC is IE, then MFW trips at time T=0.
| ET currently does not question MFW_F for init(LMC) - assumed tripped
| if LOSP is IE, then MFW trips at time T=0.
| If excessive steam demand (ESD) then MSLB isolate logic should isolate MFW
| If ESD is isolated, assume MFW is isolated
| MFW_ESD_OF = ESD but MFW fails to trip, therefore OverFeed

| Macros for failing to isolate stuck open TBV
TBV_FI = TBV_ISO_F-FT1 + TBV_ISO_F-FT2 + TBV_ISO_F-FT3 + TBV_ISO_F-FT4 + TBV_ISO_F-FT5 +
TBV_ISO_F-FT6 + TBV_ISO_F-FT7 + TBV_ISO_F-FT8 + TBV_ISO_F-FT9 + TBV_EX +
TBV_SO_FI-TRUE;
TBV_I = /TBV_ISO_F-FT1 + /TBV_ISO_F-FT2 + /TBV_ISO_F-FT3 + /TBV_ISO_F-FT4 + /TBV_ISO_F-FT5
+ /TBV_ISO_F-FT6 + /TBV_ISO_F-FT7 + /TBV_ISO_F-FT8 + /TBV_ISO_F-FT9;


if init(LMC) * TBV_FI then
| if LMC then MFW trips, therefore top branch of MFW_F = /MFW_TRIP0-FALSE (compliment of zero)
  /MFW_F = MFW_TRIP0-FALSE;
  MFW_F = MFW_TRIP0-FALSE;
elsif init(SLB1) + init(SLB2) + ((TBV_1SO + TBV_2SO + TBV_4SO + TBV_1SO_SGTR + TBV_2SO_SGTR
+ TBV_4SO_SGTR) * TBV_FI)+ TBV_EX then
```

Table 4.1. Event tree linkage rules for Oconee power or HZP event trees.

```
  /MFW_F = MFW_ESD_OF;
  MFW_F = MFW_ESD_OF;
elsif (TBV_I + /TBV_SO_FI-TRUE) * init(LMC) then
  /MFW_F = MFW_Trip0-TRUE;
  MFW_F[1] = MFW_Trip0-TRUE;
  MFW_F[2] = MFW_OVRFD-FALSE;
  MFW_F[3] = MFW_OVRFD-FALSE;
else
  /MFW_F = MFW_F-FT;
  MFW_F[1] = MFW_Trip0;
  MFW_F[2] = MFW_OVRFD_A;
  MFW_F[3] = MFW_OVRFD_AB;
endif

| Rules for MFW_TRIP_F top event.
| No rules are necessary for this top event.  It is simply
| a data value that does not change.

| Rules for MFW_REC_F top event.
| Case C:  Loss of Instrument Air
| Case B:  Concurrent functional failure
| Case A:  All other events

if init(LIA) then
  /MFW_REC_F = MFW_REC_F-FT-C;
  MFW_REC_F = MFW_REC_F-FT-C;
elsif init(LOCA) + init(SLB1) + init(SLB2) + init(SGTR) + PORV_SO + SRV_SO +
  TBV_1SO + TBV_2SO + TBV_4SO then
  /MFW_REC_F = MFW_REC_F-FT-B;
  MFW_REC_F = MFW_REC_F-FT-B;
else
  /MFW_REC_F = MFW_REC_F-FT-A;
  MFW_REC_F = MFW_REC_F-FT-A;
endif

| Rules for EFW_F top event.
| If all AC power is lost (EAC_F), then MDP trains are lost.
| If steam line break (SLB) circuit actuates, then TDP train is isolated (along with MFW).
| If both EAC_F and SLB then is all EFW unavailable ?

if EAC_F * (init(SLB1) + init(SLB2) + TBV_1SO + TBV_2SO + TBV_4SO) then
| top branch = EFW starts and feed to faulted S/G is isolated
| middle branch = EFW starts but feeds faulted S/G
```

Table 4.1. Event tree linkage rules for Oconee power or HZP event trees.

```
| bottom branch = EFW FTS
/EFW_F = EFW_F-FT2;
| EFW_F-FT2 = EFW_F-FT1 + EFW_SLBSBO_FTS
  EFW_F[1] = EFW_F-FT1;
| EFW_F-FT1 = see fault tree logic
  EFW_F[2] = EFW_SLBSBO_FTS;
elsif EAC_F then
  /EFW_F = EFWTDP_F-FT;
  EFW_F[1] = EFWTDP_OVRFD_A;
  EFW_F[2] = EFWTDP_OVRFD_AB;
  EFW_F[3] = EFWTDP_FTS;
elsif
init(SLB1) +
init(SLB2) +
((TBV_1SO + TBV_1SO_SGTR) * (TBV_ISO_F-FT1 + TBV_ISO_F-FT3 + TBV_ISO_F-FT7) +
(TBV_2SO + TBV_2SO_SGTR) * (TBV_ISO_F-FT2 + TBV_ISO_F-FT5 + TBV_ISO_F-FT8) +
(TBV_4SO + TBV_4SO_SGTR) * (TBV_ISO_F-FT4 + TBV_ISO_F-FT6 + TBV_ISO_F-FT9)) +
TBV_EX +
((TBV_1SO + TBV_2SO + TBV_4SO) * TBV_SO_FI-TRUE) +
(init(LOSP) * (TBV_1SO + TBV_2SO + TBV_4SO))
then
| top branch = EFW starts and feed to faulted S/G is isolated
| middle branch = EFW starts but feeds faulted S/G
| bottom branch = EFW FTS
  /EFW_F = EFW_F-FT4;
| EFW_F-FT4 = see fault tree logic
  EFW_F[1] = EFW_F-FT3;
| EFW_F-FT3 = /EFW_SLB_FTS * EFW_SLB_FI-05a
  EFW_F[2] = EFW_SLB_FTS;
else
  /EFW_F = EFW_F-FT;
  EFW_F[1] = EFW_OVRFD_A;
  EFW_F[2] = EFW_OVRFD_AB;
  EFW_F[3] = EFW_FTS;
endif

|Rule for EFW_REC_F top event.
| If ESD and EFW overfeed then
|   fail to recover flow control = EFW_REC_FL-10b
| If ESD and EFW-FTS then
|   successful manual start but fail to control flow = EFW_REC_FL-10b
|   fail to manually start EFW = EFW_REC_NONE
```

Table 4.1. Event tree linkage rules for Oconee power or HZP event trees.

```
if (init(SLB1) + init(SLB2) + init(LOCA) + init(SGTR) + PORV_SO + SRV_SO +
  TBV_1SO + TBV_2SO + TBV_4SO) * (EFW_OVRFD_A + EFW_OVRFD_AB) then
  /EFW_REC_F = EFW_REC_F-FT-T-B;
  EFW_REC_F = EFW_REC_F-FT-T-B;
elsif init(SLB1) + init(SLB2) + init(LOCA) + init(SGTR) + PORV_SO + SRV_SO +
  TBV_1SO + TBV_2SO + TBV_4SO then
  /EFW_REC_F = EFW_REC_B-FT;
  EFW_REC_F[1] = EFW_REC_F-FT-T-B;
  EFW_REC_F[2] = EFW_REC_NONE;
elsif (init(LOSP) + init(LIA)) * (EFW_OVRFD_A + EFW_OVRFD_AB) then
  /EFW_REC_F = EFW_REC_F-FT-T-E;
  EFW_REC_F = EFW_REC_F-FT-T-E;
elsif init(LOSP) + init(LIA) then
  /EFW_REC_F = EFW_REC_E-FT;
  EFW_REC_F[1] = EFW_REC_F-FT-T-E;
  EFW_REC_F[2] = EFW_REC_NONE;
elsif EFW_OVRFD_A + EFW_OVRFD_AB then
  /EFW_REC_F = EFW_REC_F-FT-T-A;
  EFW_REC_F = EFW_REC_F-FT-T-A;
else
  /EFW_REC_F = EFW_REC_A-FT;
  EFW_REC_F[1] = EFW_REC_F-FT-T-A;
  EFW_REC_F[2] = EFW_REC_NONE;
endif

| Rule for CBP_F top event
| if all AC power is lost (EAC_F) or
| Loss of Main Condenser IE [init(LMC)],
| CBP_F not questioned, assumed unavailable
| CBPs can fail either by not depressurizing S/G (CBP_FTO_DP) or
| CBPs can fail to run (CBP_FTO_FR)

if init(LMC) then
  /CBP_F = CBP_F-TRUE;
  CBP_F[1] = CBP_OVRFD-FALSE;
  CBP_F[2] = CBP_F-TRUE;
else
  /CBP_F = CBP_F-FT2;
| CBP_F-FT2 = CBP_F-FT1 + CBP_OVRFD
  CBP_F[1] = CBP_OVRFD;
  CBP_F[2] = CBP_F-FT1;
| CBP_F-FT1 = CBP_FTO_DP + CBP_FTO_FR
endif
```

Table 4.1. Event tree linkage rules for Oconee power or HZP event trees.

```
| Rule for HPI status in response to SGTR
| Note that this is a different top event than the one below

if init(SGTR) then
   /HPI_ST_SGTR_F = HPI_FTS;
   HPI_ST_SGTR_F = HPI_FTS;
endif


| Rule for HPI_STARTS_F top event
| if all AC power is lost then HPI is unavailable
| if CBPs fail, then no Feedwater, go to Feed & Bleed
| if SGTR then there is a new early HPI event, subsequent HPI event
|   is completely dependent on the initial HPI event.

if CBP_F-FT1 + (init(LMC) * CBP_F-TRUE) then
   /HPI_STARTS_F = HPI_STARTS_F-FT1;
   HPI_STARTS_F = HPI_STARTS_F-FT1;
| HPI STARTS_F-FT1 = HPI_FBHW_F + HPI_FBHA_F
elsif init(SGTR) * (/HPI_FTS + /HPI_ST_SGTR_F) then
   /HPI_STARTS_F = HPI_FTS-FALSE;
   HPI_STARTS_F = HPI_FTS-FALSE;
elsif init(SGTR) * (HPI_FTS + HPI_ST_SGTR_F) then
   /HPI_STARTS_F = HPI_FTS-TRUE;
   HPI_STARTS_F = HPI_FTS-TRUE;
else
   /HPI_STARTS_F = HPI_FTS;
   HPI_STARTS_F = HPI_FTS;
endif

| Rule for HPI_REC_F
| Recovery from initial HPI fail to start - a data value
| Thus no rules needed.

| Rule for RCP_Trip top event
| if LOSP then RCPs are tripped
| if LOCA then RCS subcooling margin is lost (by LOCA definition)
| if PORV is stuck open, estimate probability RCS has lost subcooling margin
| based on review of subcooling curve for TH Case 22 (10%)
| if SRV is stuck open, estimate probability RCS has lost subcooling margin
| based on review of subcooling curve for TH Case 34 (100%)
```

Table 4.1. Event tree linkage rules for Oconee power or HZP event trees.

```
if init(LOSP) + init(LOCA) then
   /RCP_TRIP = RCP_TRIP-TRUE;
   RCP_TRIP = RCP_TRIP-TRUE;
elsif init(SLB1) + init(SLB2) + /PORV_SRV_SO-FT + (PORV_SO * /PORV_ISO_F-10) +
 ((PORV_SO * PORV_ISO_F-10) * ((TBV_1SO * (TBV_ISO_F-FT1 + TBV_ISO_F-FT3 +

TBV_ISO_F-FT7) + (TBV_1SO_SGTR * TBV_ISO_F-FT3)) +
(TBV_2SO * (TBV_ISO_F-FT2 + TBV_ISO_F-FT5 + TBV_ISO_F-FT8) +
(TBV_2SO_SGTR * TBV_ISO_F-FT5)) +
(TBV_4SO * (TBV_ISO_F-FT4 + TBV_ISO_F-FT6 + TBV_ISO_F-FT9) +
(TBV_4SO_SGTR * TBV_ISO_F-FT6)))) then
  /RCP_TRIP = RCP_INADV_TRIP;
  RCP_TRIP = RCP_INADV_TRIP;

elsif PORV_SO * PORV_ISO_F-10 then
   /RCP_TRIP = RCP_TRIP_PORV;
   RCP_TRIP = RCP_TRIP_PORV;
elsif PORV_SO * /PORV_ISO_F then
   /RCP_TRIP = RCP_INADV_TRIP;
   RCP_TRIP = RCP_INADV_TRIP;
elsif SRV_SO then
   /RCP_TRIP = RCP_TRIP_SRV;
   RCP_TRIP = RCP_TRIP_SRV;
endif

| Rule for recovery of secondary cooling (SEC_COOL_REC_F)
if init(LOSP) then
   /SEC_COOL_REC_F = SEC_COOLREC-LOSP;
   SEC_COOL_REC_F = SEC_COOLREC-LOSP;
else
   /SEC_COOL_REC_F = SEC_COOLREC-ALL;
   SEC_COOL_REC_F = SEC_COOLREC-ALL;
endif


| Rule for throttling HPI (HPI_TH_SGTR_F or HPI_THROTTLED_F)
| Case e:
| Case d2:
| Case d1:
| Case c (Combines c1 and c2):
| Case b/a:
| Case SGTR
```

Table 4.1. Event tree linkage rules for Oconee power or HZP event trees.

```
| Case e:

if (init(LOSP) + CBP_F-FT1 + CBP_F-TRUE) *
(/SEC_COOLREC-LOSP + /SEC_COOLREC-ALL) then
  /HPI_THROTTLED_F = HPI_TF_FT-E;
  HPI_THROTTLED_F = HPI_TF_FT-E;

| Case d2:

elsif PORV_SO * /PORV_ISO_F-10 then
  /HPI_THROTTLED_F = HPI_TF_FT-D2;
  HPI_THROTTLED_F = HPI_TF_FT-D2;

| Case d1:

elsif (PORV_SO * /PORV_SELF_CLOSE) + (SRV_SO * /SRV_ISO_F) then
  /HPI_THROTTLED_F = HPI_TF_FT-D1;
  HPI_THROTTLED_F = HPI_TF_FT-D1;

| Case c:

elsif /HPI_REC_F then
  /HPI_THROTTLED_F = HPI_TF_FT-C;
  HPI_THROTTLED_F = HPI_TF_FT-C;

| Case b/a
else
  /HPI_THROTTLED_F = HPI_TF_FT-AB;
  HPI_THROTTLED_F = HPI_TF_FT-AB;
endif

| Case for SGTR

if init(SGTR) then
  /HPI_TH_SGTR_F = HPI_TF_FT-AB;
  HPI_TH_SGTR_F = HPI_TF_FT-AB;
endif


| Rule for RCP_RESTART_F top event
| if LOSP then RCPs are tripped and cannot be restarted
| if LOCA then RCS subcooling margin (SCM) is lost (by LOCA definition) and
```

Table 4.1. Event tree linkage rules for Oconee power or HZP event trees.

```
| RCPs cannot be restarted
| if PORV is stuck open, and HPI successful, then assume SCM has been restored
| if SRV is stuck open, and HPI successful, then assume SCM has been restored

if init(LOSP) + init(LOCA) + RCS_SCM_F + (SRV_SO * SRV_ISO_F) then
   /RCP_RESTART_F = RCP_RF-TRUE;
   RCP_RESTART_F = RCP_RF-TRUE;
else
   /RCP_RESTART_F = RCP_RESTART_F;
   RCP_RESTART_F = RCP_RESTART_F;
endif
```

Table 4.2. Number of power or HZP event tree sequences by initiating event.

Initiating Event	Description	Number of Sequences
LOP-3KI	Loss of power at 120 VAC Bus 3KI	14,779
LOP-3TC	Loss of power at 4 KV Bus 3TC	14,779
LIA	Loss of instrument air	14,779
LLOCA	Large LOCA ~6" or greater equivalent diameter	1
LMC	Loss of main condenser	14,779
LOCA	Small LOCA ~1.4" - 2.8" equivalent diameter	1,313
LOSP	Loss of offsite power (including possible station blackout)	682
MLOCA	Medium LOCA ~2.8" - 6" equivalent diameter	1
RTTT	Reactor trip / turbine trip	14,779
SGTR	Steam generator tube rupture	14,319
SLB1	Steam line break (small) ~8" or less equivalent diameter	209
SLB2	Steam line break (large) >~8" equivalent diameter treated as main steam line guillotine rupture	209
	Total Number of Sequences	90,629

appropriate, either because they matched the examined sequences exactly or because the TH conditions from the new sequences were expected to be similar to but not be worse than the conditions from the existing analysis, then the uniquely-defining characteristics associated with the existing TH analyses were written in an "if-then-else" rule form for application in SAPHIRE. For those cases where the analysts were sufficiently unsure as to the appropriateness of using existing characteristics, new TH characteristics were identified. These new sets of characteristics were discussed with the TH analysts. If after discussion with the T-H analysts it was concluded that the expected TH conditions could be sufficiently different from prior T-H analyses and that the frequency of occurrence of the conditions was such that it could not be "added" to some existing TH bin without being unnecessarily conservative, then a new T-H calculation was identified. The T-H characteristics associated with this new calculation were then written in rule form for subsequent application in SAPHIRE. This iterative process continued until all accident sequence cut sets were each associated with a specific TH bin.

At the conclusion of this initial binning phase, partitioning rules had been developed for each of the initiating event trees. The rules created for the power model are presented in Tables 4.3 through 4.14. (NOTE: The rules for the HZP model are the same as those in Tables 4.3 through 4.14 except that the rule for Bin 35 should partition the sequence cut sets to "TH-35-Y" instead of "TH-35-N.")

After development of the binning rules, each set of rules was applied to their respective initiating-event-specific set of accident sequence cut sets. Once the rules were applied, the cut sets were gathered into the defined bins. This initial gathering created 36 bins containing all of the original accident sequence cut sets. Table 4.15 lists these initial bins for the Power and HZP models and indicates whether the bins are PTS significant or not.

SAPHIRE [SAPHIRE] was then used to update each set of cut sets (i.e., the cut sets in each bin) to truncate all cut sets below 1E-10. After truncation, the remaining cut sets in each bin were examined to determine whether additional binning (or sub-binning) was necessary. Discussions were held among the PRA, TH and PTS project staff to determine which existing TH bins were still adequate and whether additional TH bins should be created to more accurately reflect evolving PTS issues. As a result of the discussions, a new set of rules was constructed for each of the models (i.e., Power and HZP). Table 4.16 lists the rules used to slice (i.e., re-bin) the Power model. Table 4.17 provides the slicing rules for the HZP model.

These rules were used in SAPHIRE to slice the existing cut sets into new bins (i.e., take existing cut sets, modify them if necessary, and store them in new end states [bins]). Tables 4.18 and 4.19 list the bins created by the application of the slicing rules for the Power and HZP models respectively. SAPHIRE was then used to collapse these new bins. This collapsing was done based on the numerical identifier associated with each TH bin (e.g., 08-3KI, 08-3TC, 08-LOCA-1, 08-LOCA-2, 08-LOSP, and 08-RTTT were collapsed into bin 08-P-FINAL). Tables 4.20 and 4.21 list these collapsed bins for the Power and HZP models respectively.

At this point in the TH bin creation process, the Power and HZP models assumed binary logic (e.g., valve fully re-closes or sticks wide open; no in-between states) for all events except for the explicit modeling of the time at which operator actions occur (i.e., failure to take an action is modeled as failure to take that action in multiple discrete times–for example, by 10 min, by 20 min–each with a probability).

Table 4.3. LOP-3KI event tree sequence partitioning rules.

```
| Mapping sequences into T/H bins
| Map LOP-3KI sequences into TH bins
| Last Modified September 14, 2001
|
|Macros
|
M-A = system(/PORV_SRV_SO-FT) * system(/TBV_SO-FT);

M-MFW1 = system(MFW_TRIP0) + system(MFW_OVRFD_A) + system(MFW_OVRFD_AB);

M-TBV1 = system(TBV_1SO) + system(TBV_2SO) + system(TBV_4SO);

M-TBV2 = system(/TBV_ISO_F-FT7);

M-TBV-S = system(/TBV_ISO_F-FT7) + system(/TBV_ISO_F-FT8) + system(/TBV_ISO_F-FT9);

M-B1 = system(/PORV_SRV_SO-FT) * M-TBV-S;

M-EFW1 = system(EFW_OVRFD_A) + system(EFW_OVRFD_AB);

M-TBV-S1 = system(TBV_1SO) * system(/TBV_ISO_F-FT7);

M-TBV-S2 = system(TBV_2SO) * system(/TBV_ISO_F-FT8);

M-TBV-S4 = system(TBV_4SO) * system(/TBV_ISO_F-FT9);

M-B2 = (system(PORV_SO) * system(/PORV_ISO_F-10)) * M-TBV-S;

M-B2F1 = system(PORV_SO) * system(PORV_ISO_F-10) * system(/TBV_SO-FT);

M-B2F = (system(PORV_SO) * system(PORV_ISO_F-10)) * M-TBV-S;

M-C = system(PORV_SO) * system(/PORV_ISO_F-10) * system(/TBV_SO-FT);

| Bin 21

if (init(LOP-3KI) * M-A) * (system(/MFW_F-FT) + (M-MFW1 * system(/EFW_F-FT)) +
(M-MFW1 * (system(EFW_FTS) * system(/EFW_REC_A-FT)))) then
  GlobalPartition = "TH-21-N";
```

Table 4.3. LOP-3KI event tree sequence partitioning rules.

```
| Bin 33-N

elsif (init(LOP-3KI) * (M-B1 + M-B2)) * (system(/MFW_F-FT) + system(/EFW_F-FT) +
     system(/EFW_REC_B-FT))then
    GlobalPartition = "TH-33-N";

elsif ((init(LOP-3KI) * (M-B1 + M-B2)) * (M-EFW1 + system(EFW_REC_F-FT-T-B)))*
      system(/HPI_FTS) then
    GlobalPartition = "TH-33-N";

| Bin 43-N

elsif (init(LOP-3KI) * M-C) * (system(/MFW_F-FT) + (M-MFW1 * system(/EFW_F-FT)) +
(M-MFW1 * system(EFW_FTS) * system(/EFW_REC_B-FT))) then
   GlobalPartition = "TH-43-N";

|Bin 18-N

elsif (init(LOP-3KI) * M-C) * (M-EFW1 *system(/EFW_REC_F-FT-T-B)) *
      system(/HPI_FTS) then
   GlobalPartition = "TH-18-N";

elsif (init(LOP-3KI) * M-A) * (M-EFW1 *system(/EFW_REC_F-FT-T-A)) *
      system(/HPI_FTS) then
   GlobalPartition = "TH-18-N";

|Bin 19-N

elsif (init(LOP-3KI) * M-C) * (M-EFW1 * system(EFW_REC_F-FT-T-B) +
      system(EFW_FTS) * system(EFW_REC_F-FT-T-B)) *
      system(/HPI_FTS) then
   GlobalPartition = "TH-19-N";

elsif (init(LOP-3KI) * M-A) * (M-EFW1 * system(EFW_REC_F-FT-T-A) +
      system(EFW_FTS) * system(EFW_REC_F-FT-T-A)) *
      system(/HPI_FTS) then
   GlobalPartition = "TH-19-N";
```

Table 4.3. LOP-3KI event tree sequence partitioning rules.

```
| Bin 50

elsif init(LOP-3KI) * (M-A + (M-B1 + M-B2) + M-C) * system(/CBP_F-FT2) then
   GlobalPartition = "TH-50-Y";

elsif init(LOP-3KI) * (M-A + (M-B1 + M-B2) + M-C) * (system(CBP_OVRFD) *
      system(/HPI_FTS)) then
   GlobalPartition = "TH-50-Y";

elsif init(LOP-3KI) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
      system(TBV_ISO_F-FT7) * (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
      system(/HPI_FTS) then
    GlobalPartition = "TH-50-Y";

elsif init(LOP-3KI) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
      system(TBV_ISO_F-FT8) * (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
      system(/HPI_FTS)  then
    GlobalPartition = "TH-50-Y";

elsif init(LOP-3KI) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
      system(TBV_ISO_F-FT9) * (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
      system(/HPI_FTS) then
    GlobalPartition = "TH-50-Y";

elsif init(LOP-3KI) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT7) *
      (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
      system(/HPI_FTS) then
    GlobalPartition = "TH-50-Y";

elsif init(LOP-3KI) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT8) *
      (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
      system(/HPI_FTS) then
    GlobalPartition = "TH-50-Y";

elsif init(LOP-3KI) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT9) *
      (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
      system(/HPI_FTS) then
    GlobalPartition = "TH-50-Y";
```

Table 4.3. LOP-3KI event tree sequence partitioning rules.

```
elsif init(LOP-3KI) * (M-B2F1 + M-B2F) * (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
     system(/HPI_FTS) then
   GlobalPartition = "TH-50-Y";

| Bin 23

elsif init(LOP-3KI) * M-A * system(/MFW_REC_F-FT-A) * system(/HPI_FTS) then
   GlobalPartition = "TH-23-N";

elsif init(LOP-3KI) * (M-B1 + M-B2 + M-C) * system(/MFW_REC_F-FT-B) *
     system(/HPI_FTS) then
   GlobalPartition = "TH-23-N";

|elsif init(LOP-3KI) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
|     system(TBV_ISO_F-FT9) * system(/MFW_REC_F-FT-B) then
|   GlobalPartition = "TH-23-N";

elsif init(LOP-3KI) * (M-B2F1 + M-B2F) * system(/MFW_REC_F-FT-B) *
     system(/HPI_FTS) then
   GlobalPartition = "TH-23-N";

| Bin 44

elsif init(LOP-3KI) * (M-A + (M-B1 + M-B2) + M-C) *
     system(HPI_FTS) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LOP-3KI) * (M-B2F1 + M-B2F + system(/SRV_ISO_F) + system(SRV_ISO_F)) *
     system(HPI_FTS) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LOP-3KI) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_ISO_F-FT7) * (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
     system(HPI_FTS) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LOP-3KI) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_ISO_F-FT8) * (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
     system(HPI_FTS) * system(/HPI_REC_F) then
```

Table 4.3. LOP-3KI event tree sequence partitioning rules.

```
   GlobalPartition = "TH-44-Y";

elsif init(LOP-3KI) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_ISO_F-FT9) * (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
     system(HPI_FTS) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LOP-3KI) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT7) *
     (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
     system(HPI_FTS) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LOP-3KI) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT8) *
     (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
     system(HPI_FTS) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LOP-3KI) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT9) *
     (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
     system(HPI_FTS) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LOP-3KI) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_ISO_F-FT7) * system(HPI_FTS) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LOP-3KI) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_ISO_F-FT8) * (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B) +
     system(/MFW_REC_F-FT-B)) * system(HPI_FTS) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LOP-3KI) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_ISO_F-FT8) * (system(/EFW_F-FT4) + system(/EFW_REC_B-FT) +
     system(/MFW_REC_F-FT-B)) * system(HPI_FTS) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LOP-3KI) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_ISO_F-FT9) * (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B) +
     system(/MFW_REC_F-FT-B)) * system(HPI_FTS) * system(/HPI_REC_F) then
```

Table 4.3. LOP-3KI event tree sequence partitioning rules.

```
   GlobalPartition = "TH-44-Y";

elsif init(LOP-3KI) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_ISO_F-FT9) * (system(/EFW_F-FT4) + system(/EFW_REC_B-FT)) *
     system(HPI_FTS) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LOP-3KI) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT7) *
     system(HPI_FTS) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LOP-3KI) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT8) *
     system(HPI_FTS) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LOP-3KI) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT8) *
     system(HPI_FTS) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LOP-3KI) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT9) *
     system(HPI_FTS) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LOP-3KI) * system(/SRV_ISO_F) * system(CBP_F-FT1) *
     system(HPI_STARTS_F-FT1) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LOP-3KI) * system(/SRV_ISO_F) * system(HPI_FTS) *
     system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LOP-3KI) *system(SRV_ISO_F) * system(CBP_F-FT1) *
     system(HPI_STARTS_F-FT1) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LOP-3KI) *system(SRV_ISO_F) * system(HPI_FTS) *
     system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";
```

Table 4.3. LOP-3KI event tree sequence partitioning rules.

```
| Bin 15

elsif init(LOP-3KI) * (M-A + (M-B1 + M-B2) + M-C) *
    system(HPI_FTS) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(LOP-3KI) * (M-B2F1 + M-B2F + system(/SRV_ISO_F) + system(SRV_ISO_F)) *
    system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(LOP-3KI) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_ISO_F-FT7) * (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
    system(HPI_FTS) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(LOP-3KI) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_ISO_F-FT8) * (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
    system(HPI_FTS) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(LOP-3KI) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_ISO_F-FT9) * (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
    system(HPI_FTS) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(LOP-3KI) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT7) *
    (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
    system(HPI_FTS) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(LOP-3KI) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT8) *
    (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
    system(HPI_FTS) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(LOP-3KI) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT9) *
    (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
    system(HPI_FTS) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";
```

Table 4.3. LOP-3KI event tree sequence partitioning rules.

```
elsif init(LOP-3KI) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_ISO_F-FT7) * system(HPI_FTS) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(LOP-3KI) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_ISO_F-FT8) * (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B) +
    system(/MFW_REC_F-FT-B)) * system(HPI_FTS) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(LOP-3KI) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_ISO_F-FT8) * (system(/EFW_F-FT4) + system(/EFW_REC_B-FT) +
    system(/MFW_REC_F-FT-B)) * system(HPI_FTS) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(LOP-3KI) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_ISO_F-FT9) * (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B) +
    system(/MFW_REC_F-FT-B)) * system(HPI_FTS) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(LOP-3KI) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_ISO_F-FT9) * (system(/EFW_F-FT4) + system(/EFW_REC_B-FT)) *
    system(HPI_FTS) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(LOP-3KI) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT7) *
    system(HPI_FTS) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(LOP-3KI) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT8) *
    system(HPI_FTS) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(LOP-3KI) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT8) *
    system(HPI_FTS) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(LOP-3KI) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT9) *
    system(HPI_FTS) * system(HPI_REC_F) then
```

Table 4.3. LOP-3KI event tree sequence partitioning rules.

```
   GlobalPartition = "TH-15-Y";

elsif init(LOP-3KI) * system(/SRV_ISO_F) * system(CBP_F-FT1) *
      system(HPI_STARTS_F-FT1) * system(HPI_REC_F) then
   GlobalPartition = "TH-15-Y";

elsif init(LOP-3KI) * system(/SRV_ISO_F) * system(HPI_FTS) *
      system(HPI_REC_F) then
   GlobalPartition = "TH-15-Y";

elsif init(LOP-3KI) *system(SRV_ISO_F) * system(CBP_F-FT1) *
      system(HPI_STARTS_F-FT1) * system(HPI_REC_F)then
   GlobalPartition = "TH-15-Y";

elsif init(LOP-3KI) *system(SRV_ISO_F) * system(HPI_FTS) *
      system(HPI_REC_F) then
   GlobalPartition = "TH-15-Y";

| Bin 22

elsif init(LOP-3KI) * (M-A + (M-B1 + M-B2) + M-C) * system(CBP_F-FT1) *
      system(/HPI_STARTS_F-FT1) * system(SEC_COOLREC-ALL) then
   GlobalPartition = "TH-22-N";

elsif init(LOP-3KI) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
      system(TBV_ISO_F-FT7) * system(CBP_F-FT1) *
      system(/HPI_STARTS_F-FT1) * system(SEC_COOLREC-ALL) then
   GlobalPartition = "TH-22-N";

elsif init(LOP-3KI) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
      system(TBV_ISO_F-FT8) * system(CBP_F-FT1) *
      system(/HPI_STARTS_F-FT1) * system(SEC_COOLREC-ALL) then
   GlobalPartition = "TH-22-N";

elsif init(LOP-3KI) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
      system(TBV_ISO_F-FT9) * system(CBP_F-FT1) *
      system(/HPI_STARTS_F-FT1) * system(SEC_COOLREC-ALL) then
   GlobalPartition = "TH-22-N";
```

Table 4.3. LOP-3KI event tree sequence partitioning rules.

```
elsif init(LOP-3KI) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT7) *
      system(CBP_F-FT1) *
     system(/HPI_STARTS_F-FT1) * system(SEC_COOLREC-ALL) then
   GlobalPartition = "TH-22-N";

elsif init(LOP-3KI) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT8) *
      system(CBP_F-FT1) *
     system(/HPI_STARTS_F-FT1) * system(SEC_COOLREC-ALL) then
   GlobalPartition = "TH-22-N";

elsif init(LOP-3KI) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT9) *
      system(CBP_F-FT1) *
     system(/HPI_STARTS_F-FT1) * system(SEC_COOLREC-ALL) then
   GlobalPartition = "TH-22-N";

elsif init(LOP-3KI) * (M-B2F1 + M-B2F) * (system(/MFW_F-FT) + system(/EFW_F-FT) +
     M-EFW1 + system(/EFW_REC_B-FT) + system(EFW_REC_F-FT-T-B)) *
     system(/HPI_FTS) then
   GlobalPartition = "TH-22-N";

elsif init(LOP-3KI) * (M-B2F1 + M-B2F) * system(CBP_F-FT1) *
     system(SEC_COOLREC-ALL) then
   GlobalPartition = "TH-22-N";

| Bin 48

elsif init(LOP-3KI) * (M-A + (M-B1 + M-B2) + M-C) * system(CBP_F-FT1) *
     system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
     system(/HPI_TF_FT-E) then
   GlobalPartition = "TH-48-N";

elsif init(LOP-3KI) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_ISO_F-FT7) * system(CBP_F-FT1) *
     system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
     system(/HPI_TF_FT-E) then
   GlobalPartition = "TH-48-N";

elsif init(LOP-3KI) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_ISO_F-FT8) * system(CBP_F-FT1) *
```

Table 4.3. LOP-3KI event tree sequence partitioning rules.

```
    system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
    system(/HPI_TF_FT-E) then
  GlobalPartition = "TH-48-N";

elsif init(LOP-3KI) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_ISO_F-FT9) * system(CBP_F-FT1) *
    system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
    system(/HPI_TF_FT-E) then
  GlobalPartition = "TH-48-N";

elsif init(LOP-3KI) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT7) *
     system(CBP_F-FT1) *
    system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
    system(/HPI_TF_FT-E) then
  GlobalPartition = "TH-48-N";

elsif init(LOP-3KI) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT8) *
     system(CBP_F-FT1) *
    system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
    system(/HPI_TF_FT-E) then
  GlobalPartition = "TH-48-N";

elsif init(LOP-3KI) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT9) *
     system(CBP_F-FT1) *
    system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
    system(/HPI_TF_FT-E) then
  GlobalPartition = "TH-48-N";

elsif init(LOP-3KI) * (M-B2F1 + M-B2F) * system(CBP_F-FT1) *
    (system(/HPI_TF_FT-AB) + system(/HPI_TF_FT-C) + system(/HPI_TF_FT-D2) +
     system(/HPI_TF_FT-D1) + system(/HPI_TF_FT-E)) then
  GlobalPartition = "TH-48-N";

| Bin 47

elsif init(LOP-3KI) * (M-A + (M-B1 + M-B2) + M-C) * system(CBP_F-FT1) *
    system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
    system(HPI_TF_FT-E) then
  GlobalPartition = "TH-47-N";
```

Table 4.3. LOP-3KI event tree sequence partitioning rules.

```
elsif init(LOP-3KI) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
      system(TBV_ISO_F-FT7) * system(CBP_F-FT1) *
      system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
      system(HPI_TF_FT-E) then
    GlobalPartition = "TH-47-N";

elsif init(LOP-3KI) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
      system(TBV_ISO_F-FT8) * system(CBP_F-FT1) *
      system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
      system(HPI_TF_FT-E) then
    GlobalPartition = "TH-47-N";

elsif init(LOP-3KI) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
      system(TBV_ISO_F-FT9) * system(CBP_F-FT1) *
      system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
      system(HPI_TF_FT-E) then
    GlobalPartition = "TH-47-N";

elsif init(LOP-3KI) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT7) *
       system(CBP_F-FT1) *
      system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
      system(HPI_TF_FT-E) then
    GlobalPartition = "TH-47-N";

elsif init(LOP-3KI) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT8) *
       system(CBP_F-FT1) *
      system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
      system(HPI_TF_FT-E) then
    GlobalPartition = "TH-47-N";

elsif init(LOP-3KI) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT9) *
       system(CBP_F-FT1) *
      system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
      system(HPI_TF_FT-E) then
    GlobalPartition = "TH-47-N";

elsif init(LOP-3KI) * (M-B2F1 + M-B2F) * system(CBP_F-FT1) *
      (system(HPI_TF_FT-AB) + system(HPI_TF_FT-C) + system(HPI_TF_FT-D2) +
```

Table 4.3. LOP-3KI event tree sequence partitioning rules.

```
      system(HPI_TF_FT-D1) + system(HPI_TF_FT-E)) then
   GlobalPartition = "TH-47-N";

| Bin CD

elsif init(LOP-3KI) * (M-A + (M-B1 + M-B2) + M-C) * system(CBP_F-FT1) *
     system(HPI_STARTS_F-FT1) then
   GlobalPartition = "CD";

elsif init(LOP-3KI) * system(/SRV_ISO_F) * system(CBP_F-FT1) *
     system(HPI_STARTS_F-FT1) then
   GlobalPartition = "CD";

elsif init(LOP-3KI) *system(SRV_ISO_F) * system(CBP_F-FT1) *
     system(HPI_STARTS_F-FT1) then
   GlobalPartition = "CD";

elsif init(LOP-3KI) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_ISO_F-FT7) * system(CBP_F-FT1) * system(HPI_STARTS_F-FT1) then
   GlobalPartition = "CD";

elsif init(LOP-3KI) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_ISO_F-FT8) * system(CBP_F-FT1) * system(HPI_STARTS_F-FT1) then
   GlobalPartition = "CD";

elsif init(LOP-3KI) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_ISO_F-FT9) * system(CBP_F-FT1) * system(HPI_STARTS_F-FT1) then
   GlobalPartition = "CD";

elsif init(LOP-3KI) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT7) *
      system(CBP_F-FT1) * system(HPI_STARTS_F-FT1) then
   GlobalPartition = "CD";

elsif init(LOP-3KI) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT8) *
      system(CBP_F-FT1) * system(HPI_STARTS_F-FT1) then
   GlobalPartition = "CD";

elsif init(LOP-3KI) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT9) *
      system(CBP_F-FT1) * system(HPI_STARTS_F-FT1) then
```

Table 4.3. LOP-3KI event tree sequence partitioning rules.

```
   GlobalPartition = "CD";

elsif init(LOP-3KI) * ((M-B2F1 + M-B2F) * system(CBP_F-FT1) + system(/SRV_ISO_F) +
     system(SRV_ISO_F)) * system(HPI_STARTS_F-FT1) then
   GlobalPartition = "CD";

| Bin 28

elsif init(LOP-3KI) * (system(/PORV_SRV_SO-FT) * system(TBV_ISO_F-FT7) *
     system(/HPI_FTS) * system(HPI_TF_FT-AB)) + (system(/PORV_ISO_F-10) *
     system(TBV_ISO_F-FT7) * system(HPI_TF_FT-D2)) then
   GlobalPartition = "TH-28-Y";

| Bin 35

elsif init(LOP-3KI) * (system(/PORV_SRV_SO-FT) * system(TBV_ISO_F-FT7) *
     system(/HPI_FTS) * system(/HPI_TF_FT-AB)) + (system(/PORV_ISO_F-10) *
     system(TBV_ISO_F-FT7) * system(/HPI_TF_FT-D2)) then
   GlobalPartition = "TH-35-N";

| Bin 29

elsif init(LOP-3KI) * (system(/PORV_SRV_SO-FT) *
     system(TBV_ISO_F-FT8) * (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B) +
     system(/MFW_REC_F-FT-B)) * system(/HPI_FTS) * system(HPI_TF_FT-AB)) +
     (system(/PORV_ISO_F-10) * system(TBV_ISO_F-FT8) * (system(EFW_F-FT3) +
     system(EFW_REC_F-FT-T-B) + system(/MFW_REC_F-FT-B)) * system(/HPI_FTS) *
     system(HPI_TF_FT-D2))  then
   GlobalPartition = "TH-29-Y";

| Bin 36

elsif init(LOP-3KI) * (system(/PORV_SRV_SO-FT) *
     system(TBV_ISO_F-FT8) * (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B) +
     system(/MFW_REC_F-FT-B)) * system(/HPI_FTS) * system(/HPI_TF_FT-AB)) +
     (system(/PORV_ISO_F-10) * system(TBV_ISO_F-FT8) * (system(EFW_F-FT3) +
     system(EFW_REC_F-FT-T-B) + system(/MFW_REC_F-FT-B)) * system(/HPI_FTS) *
     system(/HPI_TF_FT-D2)) then
   GlobalPartition = "TH-36-Y";
```

Table 4.3. LOP-3KI event tree sequence partitioning rules.

```
|Bin 57

elsif init(LOP-3KI) * (system(/PORV_SRV_SO-FT) *
     system(TBV_ISO_F-FT8) * (system(/EFW_F-FT4) + system(/EFW_REC_B-FT) +
     system(/MFW_REC_F-FT-B)) * system(/HPI_FTS) * system(HPI_TF_FT-AB)) +
     (system(/PORV_ISO_F-10) * system(TBV_ISO_F-FT8) * (system(/EFW_F-FT4) +
     system(/EFW_REC_B-FT) + system(/MFW_REC_F-FT-B)) * system(/HPI_FTS) *
     system(HPI_TF_FT-D2))  then
    GlobalPartition = "TH-57-Y";

|Bin 59

elsif init(LOP-3KI) * (system(/PORV_SRV_SO-FT) *
     system(TBV_ISO_F-FT8) * (system(/EFW_F-FT4) + system(/EFW_REC_B-FT) +
     system(/MFW_REC_F-FT-B)) * system(/HPI_FTS) * system(/HPI_TF_FT-AB)) +
     (system(/PORV_ISO_F-10) * system(TBV_ISO_F-FT8) * (system(/EFW_F-FT4) +
     system(/EFW_REC_B-FT) + system(/MFW_REC_F-FT-B)) * system(/HPI_FTS) *
     system(/HPI_TF_FT-D2))  then
    GlobalPartition = "TH-59-Y";

| Bin 25

elsif init(LOP-3KI) * (system(/PORV_SRV_SO-FT) *
     system(TBV_ISO_F-FT9) * (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B) +
     system(/MFW_REC_F-FT-B)) * system(/HPI_FTS) * system(HPI_TF_FT-AB) *
     system(/RCP_INADV_TRIP)) + (system(/PORV_ISO_F-10) * system(TBV_ISO_F-FT9) *
    (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B) +
     system(/MFW_REC_F-FT-B)) * system(/HPI_FTS) * system(HPI_TF_FT-D2) *
     system(/RCP_INADV_TRIP))  then
    GlobalPartition = "TH-25-Y";

| Bin 27

elsif init(LOP-3KI) * (system(/PORV_SRV_SO-FT) *
     system(TBV_ISO_F-FT9) * (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B) +
     system(/MFW_REC_F-FT-B)) * system(/HPI_FTS) * system(/HPI_TF_FT-AB) *
     system(/RCP_INADV_TRIP)) + (system(/PORV_ISO_F-10) * system(TBV_ISO_F-FT9) *
    (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B) +
     system(/MFW_REC_F-FT-B)) * system(/HPI_FTS) * system(/HPI_TF_FT-D2) *
```

Table 4.3. LOP-3KI event tree sequence partitioning rules.

```
    system(/RCP_INADV_TRIP))  then
  GlobalPartition = "TH-27-Y";

| Bin 62

elsif init(LOP-3KI) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_ISO_F-FT9) * (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B) +
    system(/MFW_REC_F-FT-B)) * system(/HPI_FTS) * system(RCP_INADV_TRIP) then
  GlobalPartition = "TH-62-Y";

| Bin 61

elsif init(LOP-3KI) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_ISO_F-FT9) * (system(/EFW_F-FT4) + system(/EFW_REC_B-FT)) *
    system(/HPI_FTS) then
  GlobalPartition = "TH-61-N";

| Bin 8

elsif init(LOP-3KI) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT7) *
    system(/HPI_FTS) * system(HPI_TF_FT-AB) then
  GlobalPartition = "TH-08-Y";

| Bin 12

elsif init(LOP-3KI) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT7) *
    system(/HPI_FTS) * system(/HPI_TF_FT-AB) then
  GlobalPartition = "TH-12-Y";

| Bin 9

elsif init(LOP-3KI) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT8) *
    system(/HPI_FTS) * system(HPI_TF_FT-AB) then
  GlobalPartition = "TH-09-Y";

| Bin 13

elsif init(LOP-3KI) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT8) *
    system(/HPI_FTS) * system(/HPI_TF_FT-AB) then
```

Table 4.3. LOP-3KI event tree sequence partitioning rules.

```
   GlobalPartition = "TH-13-Y";

elsif init(LOP-3KI) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT9) *
     system(/HPI_FTS) * system(/HPI_TF_FT-AB) then
   GlobalPartition = "TH-13-Y";

| Bin 10

elsif init(LOP-3KI) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT9) *
     system(/HPI_FTS) * system(HPI_TF_FT-AB) then
   GlobalPartition = "TH-10-Y";

| Bin 41

elsif init(LOP-3KI) * system(/SRV_ISO_F) * system(CBP_F-FT1) *
     system(/HPI_STARTS_F-FT1) then
   GlobalPartition = "TH-41-Y";

elsif init(LOP-3KI) * system(/SRV_ISO_F) * system(/HPI_FTS) then
   GlobalPartition = "TH-41-Y";

elsif init(LOP-3KI) * system(/SRV_ISO_F) * system(/HPI_STARTS_F-FT1) then
   GlobalPartition = "TH-41-Y";

| Bin 34

elsif init(LOP-3KI) *system(SRV_ISO_F) * system(CBP_F-FT1) *
     system(/HPI_STARTS_F-FT1) then
   GlobalPartition = "TH-34-Y";

elsif init(LOP-3KI) *system(SRV_ISO_F) * system(/HPI_FTS) then
   GlobalPartition = "TH-34-Y";

elsif init(LOP-3KI) *system(SRV_ISO_F) * system(/HPI_STARTS_F-FT1) then
   GlobalPartition = "TH-34-Y";

else
   GlobalPartition = "TH-DUMMY";
endif
```

Table 4.4. LOP-3TC event tree sequence partitioning rules.

```
| Mapping sequences into T/H bins
| Map LOP-3TC sequences into TH bins
| Last Modified September 14, 2001
|
|Macros
|
M-A = system(/PORV_SRV_SO-FT) * system(/TBV_SO-FT);

M-MFW1 = system(MFW_TRIP0) + system(MFW_OVRFD_A) + system(MFW_OVRFD_AB);

M-TBV1 = system(TBV_1SO) + system(TBV_2SO) + system(TBV_4SO);

M-TBV2 = system(/TBV_ISO_F-FT7);

M-TBV-S = system(/TBV_ISO_F-FT7) + system(/TBV_ISO_F-FT8) + system(/TBV_ISO_F-FT9);

M-B1 = system(/PORV_SRV_SO-FT) * M-TBV-S;

M-EFW1 = system(EFW_OVRFD_A) + system(EFW_OVRFD_AB);

M-TBV-S1 = system(TBV_1SO) * system(/TBV_ISO_F-FT7);

M-TBV-S2 = system(TBV_2SO) * system(/TBV_ISO_F-FT8);

M-TBV-S4 = system(TBV_4SO) * system(/TBV_ISO_F-FT9);

M-B2 = (system(PORV_SO) * system(/PORV_ISO_F-10)) * M-TBV-S;

M-B2F1 = system(PORV_SO) * system(PORV_ISO_F-10) * system(/TBV_SO-FT);

M-B2F = (system(PORV_SO) * system(PORV_ISO_F-10)) * M-TBV-S;

M-C = system(PORV_SO) * system(/PORV_ISO_F-10) * system(/TBV_SO-FT);

| Bin 21

if (init(LOP-3TC) * M-A) * (system(/MFW_F-FT) + (M-MFW1 * system(/EFW_F-FT)) +
(M-MFW1 * (system(EFW_FTS) * system(/EFW_REC_A-FT)))) then
  GlobalPartition = "TH-21-N";
```

Table 4.4. LOP-3TC event tree sequence partitioning rules.

```
| Bin 33-N

elsif (init(LOP-3TC) * (M-B1 + M-B2)) * (system(/MFW_F-FT) + system(/EFW_F-FT) +
     system(/EFW_REC_B-FT))then
    GlobalPartition = "TH-33-N";

elsif ((init(LOP-3TC) * (M-B1 + M-B2)) * (M-EFW1 + system(EFW_REC_F-FT-T-B)))*
      system(/HPI_FTS) then
    GlobalPartition = "TH-33-N";

| Bin 43-N

elsif (init(LOP-3TC) * M-C) * (system(/MFW_F-FT) + (M-MFW1 * system(/EFW_F-FT)) +
(M-MFW1 * system(EFW_FTS) * system(/EFW_REC_B-FT))) then
   GlobalPartition = "TH-43-N";

|Bin 18-N

elsif (init(LOP-3TC) * M-C) * (M-EFW1 *system(/EFW_REC_F-FT-T-B)) *
      system(/HPI_FTS) then
   GlobalPartition = "TH-18-N";

elsif (init(LOP-3TC) * M-A) * (M-EFW1 *system(/EFW_REC_F-FT-T-A)) *
      system(/HPI_FTS) then
   GlobalPartition = "TH-18-N";

|Bin 19-N

elsif (init(LOP-3TC) * M-C) * (M-EFW1 * system(EFW_REC_F-FT-T-B) +
      system(EFW_FTS) * system(EFW_REC_F-FT-T-B)) *
      system(/HPI_FTS) then
   GlobalPartition = "TH-19-N";

elsif (init(LOP-3TC) * M-A) * (M-EFW1 * system(EFW_REC_F-FT-T-A) +
      system(EFW_FTS) * system(EFW_REC_F-FT-T-A)) *
      system(/HPI_FTS) then
   GlobalPartition = "TH-19-N";
```

Table 4.4. LOP-3TC event tree sequence partitioning rules.

```
| Bin 50

elsif init(LOP-3TC) * (M-A + (M-B1 + M-B2) + M-C) * system(/CBP_F-FT2) then
   GlobalPartition = "TH-50-Y";

elsif init(LOP-3TC) * (M-A + (M-B1 + M-B2) + M-C) * (system(CBP_OVRFD) *
      system(/HPI_FTS)) then
   GlobalPartition = "TH-50-Y";

elsif init(LOP-3TC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
      system(TBV_ISO_F-FT7) * (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
      system(/HPI_FTS) then
    GlobalPartition = "TH-50-Y";

elsif init(LOP-3TC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
      system(TBV_ISO_F-FT8) * (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
      system(/HPI_FTS)  then
    GlobalPartition = "TH-50-Y";

elsif init(LOP-3TC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
      system(TBV_ISO_F-FT9) * (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
      system(/HPI_FTS) then
    GlobalPartition = "TH-50-Y";

elsif init(LOP-3TC) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT7) *
      (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
      system(/HPI_FTS) then
    GlobalPartition = "TH-50-Y";

elsif init(LOP-3TC) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT8) *
      (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
      system(/HPI_FTS) then
    GlobalPartition = "TH-50-Y";

elsif init(LOP-3TC) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT9) *
      (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
      system(/HPI_FTS) then
    GlobalPartition = "TH-50-Y";
```

Table 4.4. LOP-3TC event tree sequence partitioning rules.

```
elsif init(LOP-3TC) * (M-B2F1 + M-B2F) * (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
     system(/HPI_FTS) then
   GlobalPartition = "TH-50-Y";

| Bin 23

elsif init(LOP-3TC) * M-A * system(/MFW_REC_F-FT-A) * system(/HPI_FTS) then
   GlobalPartition = "TH-23-N";

elsif init(LOP-3TC) * (M-B1 + M-B2 + M-C) * system(/MFW_REC_F-FT-B) *
     system(/HPI_FTS) then
   GlobalPartition = "TH-23-N";

|elsif init(LOP-3TC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
|     system(TBV_ISO_F-FT9) * system(/MFW_REC_F-FT-B) then
|   GlobalPartition = "TH-23-N";

elsif init(LOP-3TC) * (M-B2F1 + M-B2F) * system(/MFW_REC_F-FT-B) *
     system(/HPI_FTS) then
   GlobalPartition = "TH-23-N";

| Bin 44

elsif init(LOP-3TC) * (M-A + (M-B1 + M-B2) + M-C) *
     system(HPI_FTS) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LOP-3TC) * (M-B2F1 + M-B2F + system(/SRV_ISO_F) + system(SRV_ISO_F)) *
     system(HPI_FTS) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LOP-3TC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_ISO_F-FT7) * (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
     system(HPI_FTS) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LOP-3TC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_ISO_F-FT8) * (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
     system(HPI_FTS) * system(/HPI_REC_F) then
```

Table 4.4. LOP-3TC event tree sequence partitioning rules.

```
  GlobalPartition = "TH-44-Y";

elsif init(LOP-3TC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_ISO_F-FT9) * (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
    system(HPI_FTS) * system(/HPI_REC_F) then
  GlobalPartition = "TH-44-Y";

elsif init(LOP-3TC) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT7) *
    (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
    system(HPI_FTS) * system(/HPI_REC_F) then
  GlobalPartition = "TH-44-Y";

elsif init(LOP-3TC) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT8) *
    (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
    system(HPI_FTS) * system(/HPI_REC_F) then
  GlobalPartition = "TH-44-Y";

elsif init(LOP-3TC) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT9) *
    (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
    system(HPI_FTS) * system(/HPI_REC_F) then
  GlobalPartition = "TH-44-Y";

elsif init(LOP-3TC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_ISO_F-FT7) * system(HPI_FTS) * system(/HPI_REC_F) then
  GlobalPartition = "TH-44-Y";

elsif init(LOP-3TC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_ISO_F-FT8) * (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B) +
    system(/MFW_REC_F-FT-B)) * system(HPI_FTS) * system(/HPI_REC_F) then
  GlobalPartition = "TH-44-Y";

elsif init(LOP-3TC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_ISO_F-FT8) * (system(/EFW_F-FT4) + system(/EFW_REC_B-FT) +
    system(/MFW_REC_F-FT-B)) * system(HPI_FTS) * system(/HPI_REC_F) then
  GlobalPartition = "TH-44-Y";

elsif init(LOP-3TC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_ISO_F-FT9) * (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B) +
    system(/MFW_REC_F-FT-B)) * system(HPI_FTS) * system(/HPI_REC_F) then
```

Table 4.4. LOP-3TC event tree sequence partitioning rules.

```
   GlobalPartition = "TH-44-Y";

elsif init(LOP-3TC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
      system(TBV_ISO_F-FT9) * (system(/EFW_F-FT4) + system(/EFW_REC_B-FT)) *
      system(HPI_FTS) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LOP-3TC) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT7) *
      system(HPI_FTS) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LOP-3TC) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT8) *
      system(HPI_FTS) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LOP-3TC) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT8) *
      system(HPI_FTS) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LOP-3TC) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT9) *
      system(HPI_FTS) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LOP-3TC) * system(/SRV_ISO_F) * system(CBP_F-FT1) *
      system(HPI_STARTS_F-FT1) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LOP-3TC) * system(/SRV_ISO_F) * system(HPI_FTS) *
      system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LOP-3TC) *system(SRV_ISO_F) * system(CBP_F-FT1) *
      system(HPI_STARTS_F-FT1) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LOP-3TC) *system(SRV_ISO_F) * system(HPI_FTS) *
      system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";
```

Table 4.4. LOP-3TC event tree sequence partitioning rules.

```
| Bin 15

elsif init(LOP-3TC) * (M-A + (M-B1 + M-B2) + M-C) *
    system(HPI_FTS) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(LOP-3TC) * (M-B2F1 + M-B2F + system(/SRV_ISO_F) + system(SRV_ISO_F)) *
    system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(LOP-3TC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_ISO_F-FT7) * (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
    system(HPI_FTS) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(LOP-3TC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_ISO_F-FT8) * (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
    system(HPI_FTS) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(LOP-3TC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_ISO_F-FT9) * (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
    system(HPI_FTS) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(LOP-3TC) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT7) *
    (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
    system(HPI_FTS) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(LOP-3TC) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT8) *
    (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
    system(HPI_FTS) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(LOP-3TC) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT9) *
    (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
    system(HPI_FTS) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";
```

Table 4.4. LOP-3TC event tree sequence partitioning rules.

```
elsif init(LOP-3TC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_ISO_F-FT7) * system(HPI_FTS) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(LOP-3TC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_ISO_F-FT8) * (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B) +
    system(/MFW_REC_F-FT-B)) * system(HPI_FTS) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(LOP-3TC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_ISO_F-FT8) * (system(/EFW_F-FT4) + system(/EFW_REC_B-FT) +
    system(/MFW_REC_F-FT-B)) * system(HPI_FTS) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(LOP-3TC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_ISO_F-FT9) * (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B) +
    system(/MFW_REC_F-FT-B)) * system(HPI_FTS) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(LOP-3TC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_ISO_F-FT9) * (system(/EFW_F-FT4) + system(/EFW_REC_B-FT)) *
    system(HPI_FTS) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(LOP-3TC) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT7) *
    system(HPI_FTS) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(LOP-3TC) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT8) *
    system(HPI_FTS) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(LOP-3TC) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT8) *
    system(HPI_FTS) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(LOP-3TC) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT9) *
    system(HPI_FTS) * system(HPI_REC_F) then
```

Table 4.4. LOP-3TC event tree sequence partitioning rules.

```
   GlobalPartition = "TH-15-Y";

elsif init(LOP-3TC) * system(/SRV_ISO_F) * system(CBP_F-FT1) *
     system(HPI_STARTS_F-FT1) * system(HPI_REC_F) then
   GlobalPartition = "TH-15-Y";

elsif init(LOP-3TC) * system(/SRV_ISO_F) * system(HPI_FTS) *
     system(HPI_REC_F) then
   GlobalPartition = "TH-15-Y";

elsif init(LOP-3TC) *system(SRV_ISO_F) * system(CBP_F-FT1) *
     system(HPI_STARTS_F-FT1) * system(HPI_REC_F)then
   GlobalPartition = "TH-15-Y";

elsif init(LOP-3TC) *system(SRV_ISO_F) * system(HPI_FTS) *
     system(HPI_REC_F) then
   GlobalPartition = "TH-15-Y";

| Bin 22

elsif init(LOP-3TC) * (M-A + (M-B1 + M-B2) + M-C) * system(CBP_F-FT1) *
     system(/HPI_STARTS_F-FT1) * system(SEC_COOLREC-ALL) then
   GlobalPartition = "TH-22-N";

elsif init(LOP-3TC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_ISO_F-FT7) * system(CBP_F-FT1) *
     system(/HPI_STARTS_F-FT1) * system(SEC_COOLREC-ALL) then
   GlobalPartition = "TH-22-N";

elsif init(LOP-3TC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_ISO_F-FT8) * system(CBP_F-FT1) *
     system(/HPI_STARTS_F-FT1) * system(SEC_COOLREC-ALL) then
   GlobalPartition = "TH-22-N";

elsif init(LOP-3TC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_ISO_F-FT9) * system(CBP_F-FT1) *
     system(/HPI_STARTS_F-FT1) * system(SEC_COOLREC-ALL) then
   GlobalPartition = "TH-22-N";
```

Table 4.4. LOP-3TC event tree sequence partitioning rules.

```
elsif init(LOP-3TC) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT7) *
     system(CBP_F-FT1) *
    system(/HPI_STARTS_F-FT1) * system(SEC_COOLREC-ALL) then
  GlobalPartition = "TH-22-N";

elsif init(LOP-3TC) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT8) *
     system(CBP_F-FT1) *
    system(/HPI_STARTS_F-FT1) * system(SEC_COOLREC-ALL) then
  GlobalPartition = "TH-22-N";

elsif init(LOP-3TC) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT9) *
     system(CBP_F-FT1) *
    system(/HPI_STARTS_F-FT1) * system(SEC_COOLREC-ALL) then
  GlobalPartition = "TH-22-N";

elsif init(LOP-3TC) * (M-B2F1 + M-B2F) * (system(/MFW_F-FT) + system(/EFW_F-FT) +
    M-EFW1 + system(/EFW_REC_B-FT) + system(EFW_REC_F-FT-T-B)) *
    system(/HPI_FTS) then
  GlobalPartition = "TH-22-N";

elsif init(LOP-3TC) * (M-B2F1 + M-B2F) * system(CBP_F-FT1) *
    system(SEC_COOLREC-ALL) then
  GlobalPartition = "TH-22-N";

| Bin 48

elsif init(LOP-3TC) * (M-A + (M-B1 + M-B2) + M-C) * system(CBP_F-FT1) *
    system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
    system(/HPI_TF_FT-E) then
  GlobalPartition = "TH-48-N";

elsif init(LOP-3TC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_ISO_F-FT7) * system(CBP_F-FT1) *
    system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
    system(/HPI_TF_FT-E) then
  GlobalPartition = "TH-48-N";

elsif init(LOP-3TC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_ISO_F-FT8) * system(CBP_F-FT1) *
```

Table 4.4. LOP-3TC event tree sequence partitioning rules.

```
    system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
    system(/HPI_TF_FT-E) then
  GlobalPartition = "TH-48-N";

elsif init(LOP-3TC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_ISO_F-FT9) * system(CBP_F-FT1) *
    system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
    system(/HPI_TF_FT-E) then
  GlobalPartition = "TH-48-N";

elsif init(LOP-3TC) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT7) *
     system(CBP_F-FT1) *
    system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
    system(/HPI_TF_FT-E) then
  GlobalPartition = "TH-48-N";

elsif init(LOP-3TC) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT8) *
     system(CBP_F-FT1) *
    system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
    system(/HPI_TF_FT-E) then
  GlobalPartition = "TH-48-N";

elsif init(LOP-3TC) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT9) *
     system(CBP_F-FT1) *
    system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
    system(/HPI_TF_FT-E) then
  GlobalPartition = "TH-48-N";

elsif init(LOP-3TC) * (M-B2F1 + M-B2F) * system(CBP_F-FT1) *
    (system(/HPI_TF_FT-AB) + system(/HPI_TF_FT-C) + system(/HPI_TF_FT-D2) +
     system(/HPI_TF_FT-D1) + system(/HPI_TF_FT-E)) then
  GlobalPartition = "TH-48-N";

| Bin 47

elsif init(LOP-3TC) * (M-A + (M-B1 + M-B2) + M-C) * system(CBP_F-FT1) *
    system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
    system(HPI_TF_FT-E) then
  GlobalPartition = "TH-47-N";
```

Table 4.4. LOP-3TC event tree sequence partitioning rules.

```
elsif init(LOP-3TC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_ISO_F-FT7) * system(CBP_F-FT1) *
     system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
     system(HPI_TF_FT-E) then
   GlobalPartition = "TH-47-N";

elsif init(LOP-3TC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_ISO_F-FT8) * system(CBP_F-FT1) *
     system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
     system(HPI_TF_FT-E) then
   GlobalPartition = "TH-47-N";

elsif init(LOP-3TC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_ISO_F-FT9) * system(CBP_F-FT1) *
     system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
     system(HPI_TF_FT-E) then
   GlobalPartition = "TH-47-N";

elsif init(LOP-3TC) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT7) *
      system(CBP_F-FT1) *
     system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
     system(HPI_TF_FT-E) then
   GlobalPartition = "TH-47-N";

elsif init(LOP-3TC) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT8) *
      system(CBP_F-FT1) *
     system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
     system(HPI_TF_FT-E) then
   GlobalPartition = "TH-47-N";

elsif init(LOP-3TC) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT9) *
      system(CBP_F-FT1) *
     system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
     system(HPI_TF_FT-E) then
   GlobalPartition = "TH-47-N";

elsif init(LOP-3TC) * (M-B2F1 + M-B2F) * system(CBP_F-FT1) *
     (system(HPI_TF_FT-AB) + system(HPI_TF_FT-C) + system(HPI_TF_FT-D2) +
```

Table 4.4. LOP-3TC event tree sequence partitioning rules.

```
      system(HPI_TF_FT-D1) + system(HPI_TF_FT-E)) then
    GlobalPartition = "TH-47-N";

| Bin CD

elsif init(LOP-3TC) * (M-A + (M-B1 + M-B2) + M-C) * system(CBP_F-FT1) *
      system(HPI_STARTS_F-FT1) then
    GlobalPartition = "CD";

elsif init(LOP-3TC) * system(/SRV_ISO_F) * system(CBP_F-FT1) *
      system(HPI_STARTS_F-FT1) then
    GlobalPartition = "CD";

elsif init(LOP-3TC) *system(SRV_ISO_F) * system(CBP_F-FT1) *
      system(HPI_STARTS_F-FT1) then
    GlobalPartition = "CD";

elsif init(LOP-3TC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
      system(TBV_ISO_F-FT7) * system(CBP_F-FT1) * system(HPI_STARTS_F-FT1) then
    GlobalPartition = "CD";

elsif init(LOP-3TC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
      system(TBV_ISO_F-FT8) * system(CBP_F-FT1) * system(HPI_STARTS_F-FT1) then
    GlobalPartition = "CD";

elsif init(LOP-3TC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
      system(TBV_ISO_F-FT9) * system(CBP_F-FT1) * system(HPI_STARTS_F-FT1) then
    GlobalPartition = "CD";

elsif init(LOP-3TC) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT7) *
      system(CBP_F-FT1) * system(HPI_STARTS_F-FT1) then
    GlobalPartition = "CD";

elsif init(LOP-3TC) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT8) *
      system(CBP_F-FT1) * system(HPI_STARTS_F-FT1) then
    GlobalPartition = "CD";

elsif init(LOP-3TC) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT9) *
      system(CBP_F-FT1) * system(HPI_STARTS_F-FT1) then
```

Table 4.4. LOP-3TC event tree sequence partitioning rules.

```
   GlobalPartition = "CD";

elsif init(LOP-3TC) * ((M-B2F1 + M-B2F) * system(CBP_F-FT1) + system(/SRV_ISO_F) +
     system(SRV_ISO_F)) * system(HPI_STARTS_F-FT1) then
   GlobalPartition = "CD";

| Bin 28

elsif init(LOP-3TC) * (system(/PORV_SRV_SO-FT) * system(TBV_ISO_F-FT7) *
     system(/HPI_FTS) * system(HPI_TF_FT-AB)) + (system(/PORV_ISO_F-10) *
     system(TBV_ISO_F-FT7) * system(HPI_TF_FT-D2)) then
   GlobalPartition = "TH-28-Y";

| Bin 35

elsif init(LOP-3TC) * (system(/PORV_SRV_SO-FT) * system(TBV_ISO_F-FT7) *
     system(/HPI_FTS) * system(/HPI_TF_FT-AB)) + (system(/PORV_ISO_F-10) *
     system(TBV_ISO_F-FT7) * system(/HPI_TF_FT-D2)) then
   GlobalPartition = "TH-35-N";

| Bin 29

elsif init(LOP-3TC) * (system(/PORV_SRV_SO-FT) *
     system(TBV_ISO_F-FT8) * (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B) +
     system(/MFW_REC_F-FT-B)) * system(/HPI_FTS) * system(HPI_TF_FT-AB)) +
     (system(/PORV_ISO_F-10) * system(TBV_ISO_F-FT8) * (system(EFW_F-FT3) +
     system(EFW_REC_F-FT-T-B) + system(/MFW_REC_F-FT-B)) * system(/HPI_FTS) *
     system(HPI_TF_FT-D2))  then
   GlobalPartition = "TH-29-Y";

| Bin 36

elsif init(LOP-3TC) * (system(/PORV_SRV_SO-FT) *
     system(TBV_ISO_F-FT8) * (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B) +
     system(/MFW_REC_F-FT-B)) * system(/HPI_FTS) * system(/HPI_TF_FT-AB)) +
     (system(/PORV_ISO_F-10) * system(TBV_ISO_F-FT8) * (system(EFW_F-FT3) +
     system(EFW_REC_F-FT-T-B) + system(/MFW_REC_F-FT-B)) * system(/HPI_FTS) *
     system(/HPI_TF_FT-D2)) then
   GlobalPartition = "TH-36-Y";
```

Table 4.4. LOP-3TC event tree sequence partitioning rules.

```
|Bin 57

elsif init(LOP-3TC) * (system(/PORV_SRV_SO-FT) *
     system(TBV_ISO_F-FT8) * (system(/EFW_F-FT4) + system(/EFW_REC_B-FT) +
     system(/MFW_REC_F-FT-B)) * system(/HPI_FTS) * system(HPI_TF_FT-AB)) +
     (system(/PORV_ISO_F-10) * system(TBV_ISO_F-FT8) * (system(/EFW_F-FT4) +
     system(/EFW_REC_B-FT) + system(/MFW_REC_F-FT-B)) * system(/HPI_FTS) *
     system(HPI_TF_FT-D2))  then
   GlobalPartition = "TH-57-Y";

|Bin 59

elsif init(LOP-3TC) * (system(/PORV_SRV_SO-FT) *
     system(TBV_ISO_F-FT8) * (system(/EFW_F-FT4) + system(/EFW_REC_B-FT) +
     system(/MFW_REC_F-FT-B)) * system(/HPI_FTS) * system(/HPI_TF_FT-AB)) +
     (system(/PORV_ISO_F-10) * system(TBV_ISO_F-FT8) * (system(/EFW_F-FT4) +
     system(/EFW_REC_B-FT) + system(/MFW_REC_F-FT-B)) * system(/HPI_FTS) *
     system(/HPI_TF_FT-D2))  then
   GlobalPartition = "TH-59-Y";

| Bin 25

elsif init(LOP-3TC) * (system(/PORV_SRV_SO-FT) *
     system(TBV_ISO_F-FT9) * (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B) +
     system(/MFW_REC_F-FT-B)) * system(/HPI_FTS) * system(HPI_TF_FT-AB) *
     system(/RCP_INADV_TRIP)) + (system(/PORV_ISO_F-10) * system(TBV_ISO_F-FT9) *
    (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B) +
     system(/MFW_REC_F-FT-B)) * system(/HPI_FTS) * system(HPI_TF_FT-D2) *
     system(/RCP_INADV_TRIP))  then
   GlobalPartition = "TH-25-Y";

| Bin 27

elsif init(LOP-3TC) * (system(/PORV_SRV_SO-FT) *
     system(TBV_ISO_F-FT9) * (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B) +
     system(/MFW_REC_F-FT-B)) * system(/HPI_FTS) * system(/HPI_TF_FT-AB) *
     system(/RCP_INADV_TRIP)) + (system(/PORV_ISO_F-10) * system(TBV_ISO_F-FT9) *
    (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B) +
     system(/MFW_REC_F-FT-B)) * system(/HPI_FTS) * system(/HPI_TF_FT-D2) *
```

Table 4.4. LOP-3TC event tree sequence partitioning rules.

```
     system(/RCP_INADV_TRIP))  then
   GlobalPartition = "TH-27-Y";

| Bin 62

elsif init(LOP-3TC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_ISO_F-FT9) * (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B) +
     system(/MFW_REC_F-FT-B)) * system(/HPI_FTS) * system(RCP_INADV_TRIP) then
   GlobalPartition = "TH-62-Y";

| Bin 61

elsif init(LOP-3TC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_ISO_F-FT9) * (system(/EFW_F-FT4) + system(/EFW_REC_B-FT)) *
     system(/HPI_FTS) then
   GlobalPartition = "TH-61-N";

| Bin 8

elsif init(LOP-3TC) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT7) *
     system(/HPI_FTS) * system(HPI_TF_FT-AB) then
   GlobalPartition = "TH-08-Y";

| Bin 12

elsif init(LOP-3TC) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT7) *
     system(/HPI_FTS) * system(/HPI_TF_FT-AB) then
   GlobalPartition = "TH-12-Y";

| Bin 9

elsif init(LOP-3TC) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT8) *
     system(/HPI_FTS) * system(HPI_TF_FT-AB) then
   GlobalPartition = "TH-09-Y";

| Bin 13

elsif init(LOP-3TC) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT8) *
     system(/HPI_FTS) * system(/HPI_TF_FT-AB) then
```

Table 4.4. LOP-3TC event tree sequence partitioning rules.

```
   GlobalPartition = "TH-13-Y";

elsif init(LOP-3TC) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT9) *
     system(/HPI_FTS) * system(/HPI_TF_FT-AB) then
   GlobalPartition = "TH-13-Y";

| Bin 10

elsif init(LOP-3TC) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT9) *
     system(/HPI_FTS) * system(HPI_TF_FT-AB) then
   GlobalPartition = "TH-10-Y";

| Bin 41

elsif init(LOP-3TC) * system(/SRV_ISO_F) * system(CBP_F-FT1) *
     system(/HPI_STARTS_F-FT1) then
   GlobalPartition = "TH-41-Y";

elsif init(LOP-3TC) * system(/SRV_ISO_F) * system(/HPI_FTS) then
   GlobalPartition = "TH-41-Y";

elsif init(LOP-3TC) * system(/SRV_ISO_F) * system(/HPI_STARTS_F-FT1) then
   GlobalPartition = "TH-41-Y";

| Bin 34

elsif init(LOP-3TC) *system(SRV_ISO_F) * system(CBP_F-FT1) *
     system(/HPI_STARTS_F-FT1) then
   GlobalPartition = "TH-34-Y";

elsif init(LOP-3TC) *system(SRV_ISO_F) * system(/HPI_FTS) then
   GlobalPartition = "TH-34-Y";

elsif init(LOP-3TC) *system(SRV_ISO_F) * system(/HPI_STARTS_F-FT1) then
   GlobalPartition = "TH-34-Y";

else
   GlobalPartition = "TH-DUMMY";
endif
```

Table 4.5. LIA event tree sequence partitioning rules.

```
| Mapping sequences into T/H bins
| Map LIA sequences into TH bins
| Last Modified September 24, 2001
|
|Macros
|
M-A = system(/PORV_SRV_SO-FT) * system(/TBV_SO-FT);

M-MFW1 = system(MFW_TRIP0) + system(MFW_OVRFD_A) + system(MFW_OVRFD_AB);

M-TBV1 = system(TBV_1SO) + system(TBV_2SO) + system(TBV_4SO);

M-TBV2 = system(/TBV_SO_FI-TRUE);

M-TBV-S = system(/TBV_SO_FI-TRUE) + system(/TBV_SO_FI-TRUE) + system(/TBV_SO_FI-TRUE);

M-B1 = system(/PORV_SRV_SO-FT) * M-TBV-S;

M-EFW1 = system(EFW_OVRFD_A) + system(EFW_OVRFD_AB);

M-TBV-S1 = system(TBV_1SO) * system(/TBV_SO_FI-TRUE);

M-TBV-S2 = system(TBV_2SO) * system(/TBV_SO_FI-TRUE);

M-TBV-S4 = system(TBV_4SO) * system(/TBV_SO_FI-TRUE);

M-B2 = (system(PORV_SO) * system(/PORV_ISO_F-10)) * M-TBV-S;

M-B2F1 = system(PORV_SO) * system(PORV_ISO_F-10) * system(/TBV_SO-FT);

M-B2F = (system(PORV_SO) * system(PORV_ISO_F-10)) * M-TBV-S;

M-C = system(PORV_SO) * system(/PORV_ISO_F-10) * system(/TBV_SO-FT);

| Bin 21

if init(LIA) * M-A * system(/MFW_F-FT) then
   GlobalPartition = "TH-21-N";
```

Table 4.5. LIA event tree sequence partitioning rules.

```
elsif init(LIA) * M-A * M-MFW1 * system(/EFW_F-FT) then
  GlobalPartition = "TH-21-N";

elsif init(LIA) * M-A * M-MFW1 * system(EFW_FTS) * system(/EFW_REC_E-FT) then
  GlobalPartition = "TH-21-N";

| Bin 33-N

elsif (init(LIA) * (M-B1 + M-B2)) * (system(/MFW_F-FT) + system(/EFW_F-FT) +
     system(/EFW_REC_B-FT))then
   GlobalPartition = "TH-33-N";

elsif (init(LIA) * (M-B1 + M-B2)) * (M-EFW1 + system(EFW_REC_F-FT-T-B)) *
      system(/HPI_FTS) then
   GlobalPartition = "TH-33-N";

| Bin 43-N

elsif (init(LIA) * M-C) * (system(/MFW_F-FT) + (M-MFW1 * system(/EFW_F-FT)) +
(M-MFW1 * system(EFW_FTS) * system(/EFW_REC_B-FT))) then
  GlobalPartition = "TH-43-N";

|Bin 18-N

elsif (init(LIA) * M-C) * (M-EFW1 *system(/EFW_REC_F-FT-T-B)) *
      system(/HPI_FTS) then
  GlobalPartition = "TH-18-N";

elsif (init(LIA) * M-A) * (M-EFW1 *system(/EFW_REC_F-FT-T-E)) *
      system(/HPI_FTS) then
  GlobalPartition = "TH-18-N";

|Bin 19-N

elsif (init(LIA) * M-C) * (M-EFW1 * system(EFW_REC_F-FT-T-B) +
      system(EFW_FTS) * system(EFW_REC_F-FT-T-B)) *
      system(/HPI_FTS) then
  GlobalPartition = "TH-19-N";
```

Table 4.5. LIA event tree sequence partitioning rules.

```
elsif (init(LIA) * M-A) * (M-EFW1 * system(EFW_REC_F-FT-T-E) +
      system(EFW_FTS) * system(EFW_REC_F-FT-T-E)) *
      system(/HPI_FTS) then
   GlobalPartition = "TH-19-N";

| Bin 50

elsif init(LIA) * (M-A + (M-B1 + M-B2) + M-C) * system(/CBP_F-FT2) then
   GlobalPartition = "TH-50-Y";

elsif init(LIA) * (M-A + (M-B1 + M-B2) + M-C) * (system(CBP_OVRFD) *
     system(/HPI_FTS)) then
   GlobalPartition = "TH-50-Y";

elsif init(LIA) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_SO_FI-TRUE) * (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
     system(/HPI_FTS) then
    GlobalPartition = "TH-50-Y";

elsif init(LIA) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_SO_FI-TRUE) * (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
     system(/HPI_FTS)  then
    GlobalPartition = "TH-50-Y";

elsif init(LIA) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_SO_FI-TRUE) * (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
     system(/HPI_FTS) then
    GlobalPartition = "TH-50-Y";

elsif init(LIA) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
     (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
     system(/HPI_FTS) then
    GlobalPartition = "TH-50-Y";

elsif init(LIA) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
     (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
     system(/HPI_FTS) then
    GlobalPartition = "TH-50-Y";
```

Table 4.5. LIA event tree sequence partitioning rules.

```
elsif init(LIA) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
     (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
     system(/HPI_FTS) then
   GlobalPartition = "TH-50-Y";

elsif init(LIA) * (M-B2F1 + M-B2F) * (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
     system(/HPI_FTS) then
   GlobalPartition = "TH-50-Y";

| Bin 23

elsif init(LIA) * M-A * system(/MFW_REC_F-FT-C) * system(/HPI_FTS) then
   GlobalPartition = "TH-23-N";

elsif init(LIA) * (M-B1 + M-B2 + M-C) * system(/MFW_REC_F-FT-C) *
     system(/HPI_FTS) then
   GlobalPartition = "TH-23-N";

|elsif init(LIA) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
|      system(TBV_SO_FI-TRUE) * system(/MFW_REC_F-FT-C) then
|    GlobalPartition = "TH-23-N";

elsif init(LIA) * (M-B2F1 + M-B2F) * system(/MFW_REC_F-FT-C) *
     system(/HPI_FTS) then
   GlobalPartition = "TH-23-N";

| Bin 44

elsif init(LIA) * (M-A + (M-B1 + M-B2) + M-C) *
     system(HPI_FTS) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LIA) * (M-B2F1 + M-B2F + system(/SRV_ISO_F) + system(SRV_ISO_F)) *
     system(HPI_FTS) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LIA) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_SO_FI-TRUE) * (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
     system(HPI_FTS) * system(/HPI_REC_F) then
```

Table 4.5. LIA event tree sequence partitioning rules.

```
   GlobalPartition = "TH-44-Y";

elsif init(LIA) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_SO_FI-TRUE) * (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
     system(HPI_FTS) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LIA) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_SO_FI-TRUE) * (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
     system(HPI_FTS) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LIA) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
     (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
     system(HPI_FTS) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LIA) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
     (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
     system(HPI_FTS) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LIA) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
     (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
     system(HPI_FTS) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LIA) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_SO_FI-TRUE) * system(HPI_FTS) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LIA) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_SO_FI-TRUE) * (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-E) +
     system(/MFW_REC_F-FT-C)) * system(HPI_FTS) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LIA) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_SO_FI-TRUE) * (system(/EFW_F-FT4) + system(/EFW_REC_E-FT) +
     system(/MFW_REC_F-FT-C)) * system(HPI_FTS) * system(/HPI_REC_F) then
```

Table 4.5. LIA event tree sequence partitioning rules.

```
   GlobalPartition = "TH-44-Y";

elsif init(LIA) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_SO_FI-TRUE) * (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-E) +
     system(/MFW_REC_F-FT-C)) * system(HPI_FTS) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LIA) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_SO_FI-TRUE) * (system(/EFW_F-FT4) + system(/EFW_REC_E-FT)) *
     system(HPI_FTS) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LIA) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
     system(HPI_FTS) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LIA) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
     system(HPI_FTS) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LIA) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
     system(HPI_FTS) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LIA) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
     system(HPI_FTS) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LIA) * system(/SRV_ISO_F) * system(CBP_F-FT1) *
     system(HPI_STARTS_F-FT1) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LIA) * system(/SRV_ISO_F) * system(HPI_FTS) *
     system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LIA) *system(SRV_ISO_F) * system(CBP_F-FT1) *
     system(HPI_STARTS_F-FT1) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";
```

Table 4.5. LIA event tree sequence partitioning rules.

```
elsif init(LIA) *system(SRV_ISO_F) * system(HPI_FTS) *
      system(/HPI_REC_F) then
    GlobalPartition = "TH-44-Y";

| Bin 15

elsif init(LIA) * (M-A + (M-B1 + M-B2) + M-C) *
      system(HPI_FTS) * system(HPI_REC_F) then
    GlobalPartition = "TH-15-Y";

elsif init(LIA) * (M-B2F1 + M-B2F + system(/SRV_ISO_F) + system(SRV_ISO_F)) *
      system(HPI_REC_F) then
    GlobalPartition = "TH-15-Y";

elsif init(LIA) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
      system(TBV_SO_FI-TRUE) * (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
      system(HPI_FTS) * system(HPI_REC_F) then
    GlobalPartition = "TH-15-Y";

elsif init(LIA) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
      system(TBV_SO_FI-TRUE) * (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
      system(HPI_FTS) * system(HPI_REC_F) then
    GlobalPartition = "TH-15-Y";

elsif init(LIA) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
      system(TBV_SO_FI-TRUE) * (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
      system(HPI_FTS) * system(HPI_REC_F) then
    GlobalPartition = "TH-15-Y";

elsif init(LIA) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
      (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
      system(HPI_FTS) * system(HPI_REC_F) then
    GlobalPartition = "TH-15-Y";

elsif init(LIA) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
      (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
      system(HPI_FTS) * system(HPI_REC_F) then
```

Table 4.5. LIA event tree sequence partitioning rules.

```
   GlobalPartition = "TH-15-Y";

elsif init(LIA) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
     (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
     system(HPI_FTS) * system(HPI_REC_F) then
   GlobalPartition = "TH-15-Y";

elsif init(LIA) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_SO_FI-TRUE) * system(HPI_FTS) * system(HPI_REC_F) then
   GlobalPartition = "TH-15-Y";

elsif init(LIA) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_SO_FI-TRUE) * (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-E) +
     system(/MFW_REC_F-FT-C)) * system(HPI_FTS) * system(HPI_REC_F) then
   GlobalPartition = "TH-15-Y";

elsif init(LIA) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_SO_FI-TRUE) * (system(/EFW_F-FT4) + system(/EFW_REC_E-FT) +
     system(/MFW_REC_F-FT-C)) * system(HPI_FTS) * system(HPI_REC_F) then
   GlobalPartition = "TH-15-Y";

elsif init(LIA) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_SO_FI-TRUE) * (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-E) +
     system(/MFW_REC_F-FT-C)) * system(HPI_FTS) * system(HPI_REC_F) then
   GlobalPartition = "TH-15-Y";

elsif init(LIA) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_SO_FI-TRUE) * (system(/EFW_F-FT4) + system(/EFW_REC_E-FT)) *
     system(HPI_FTS) * system(HPI_REC_F) then
   GlobalPartition = "TH-15-Y";

elsif init(LIA) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
     system(HPI_FTS) * system(HPI_REC_F) then
   GlobalPartition = "TH-15-Y";

elsif init(LIA) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
     system(HPI_FTS) * system(HPI_REC_F) then
   GlobalPartition = "TH-15-Y";
```

Table 4.5. LIA event tree sequence partitioning rules.

```
elsif init(LIA) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
     system(HPI_FTS) * system(HPI_REC_F) then
   GlobalPartition = "TH-15-Y";

elsif init(LIA) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
     system(HPI_FTS) * system(HPI_REC_F) then
   GlobalPartition = "TH-15-Y";

elsif init(LIA) * system(/SRV_ISO_F) * system(CBP_F-FT1) *
     system(HPI_STARTS_F-FT1) * system(HPI_REC_F) then
   GlobalPartition = "TH-15-Y";

elsif init(LIA) * system(/SRV_ISO_F) * system(HPI_FTS) *
     system(HPI_REC_F) then
   GlobalPartition = "TH-15-Y";

elsif init(LIA) *system(SRV_ISO_F) * system(CBP_F-FT1) *
     system(HPI_STARTS_F-FT1) * system(HPI_REC_F)then
   GlobalPartition = "TH-15-Y";

elsif init(LIA) *system(SRV_ISO_F) * system(HPI_FTS) *
     system(HPI_REC_F) then
   GlobalPartition = "TH-15-Y";

| Bin 22

elsif init(LIA) * (M-A + (M-B1 + M-B2) + M-C) * system(CBP_F-FT1) *
     system(/HPI_STARTS_F-FT1) * system(SEC_COOLREC-ALL) then
   GlobalPartition = "TH-22-N";

elsif init(LIA) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_SO_FI-TRUE) * system(CBP_F-FT1) *
     system(/HPI_STARTS_F-FT1) * system(SEC_COOLREC-ALL) then
   GlobalPartition = "TH-22-N";

elsif init(LIA) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
      system(CBP_F-FT1) *
     system(/HPI_STARTS_F-FT1) * system(SEC_COOLREC-ALL) then
   GlobalPartition = "TH-22-N";
```

Table 4.5. LIA event tree sequence partitioning rules.

```
elsif init(LIA) * (M-B2F1 + M-B2F) * (system(/MFW_F-FT) + system(/EFW_F-FT) +
     M-EFW1 + system(/EFW_REC_B-FT) + system(EFW_REC_F-FT-T-B)) *
     system(/HPI_FTS) then
   GlobalPartition = "TH-22-N";

elsif init(LIA) * (M-B2F1 + M-B2F) * system(CBP_F-FT1) *
     system(SEC_COOLREC-ALL) then
   GlobalPartition = "TH-22-N";

| Bin 48

elsif init(LIA) * (M-A + (M-B1 + M-B2) + M-C) * system(CBP_F-FT1) *
     system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
     system(/HPI_TF_FT-E) then
   GlobalPartition = "TH-48-N";

elsif init(LIA) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_SO_FI-TRUE) * system(CBP_F-FT1) *
     system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
     system(/HPI_TF_FT-E) then
   GlobalPartition = "TH-48-N";

elsif init(LIA) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_SO_FI-TRUE) * system(CBP_F-FT1) *
     system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
     system(/HPI_TF_FT-E) then
   GlobalPartition = "TH-48-N";

elsif init(LIA) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_SO_FI-TRUE) * system(CBP_F-FT1) *
     system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
     system(/HPI_TF_FT-E) then
   GlobalPartition = "TH-48-N";

elsif init(LIA) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
      system(CBP_F-FT1) *
     system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
     system(/HPI_TF_FT-E) then
   GlobalPartition = "TH-48-N";
```

Table 4.5. LIA event tree sequence partitioning rules.

```
elsif init(LIA) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
      system(CBP_F-FT1) *
     system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
     system(/HPI_TF_FT-E) then
   GlobalPartition = "TH-48-N";

elsif init(LIA) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
      system(CBP_F-FT1) *
     system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
     system(/HPI_TF_FT-E) then
   GlobalPartition = "TH-48-N";

elsif init(LIA) * (M-B2F1 + M-B2F) * system(CBP_F-FT1) *
     (system(/HPI_TF_FT-AB) + system(/HPI_TF_FT-C) + system(/HPI_TF_FT-D2) +
      system(/HPI_TF_FT-D1) + system(/HPI_TF_FT-E)) then
   GlobalPartition = "TH-48-N";

| Bin 47

elsif init(LIA) * (M-A + (M-B1 + M-B2) + M-C) * system(CBP_F-FT1) *
     system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
     system(HPI_TF_FT-E) then
   GlobalPartition = "TH-47-N";

elsif init(LIA) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_SO_FI-TRUE) * system(CBP_F-FT1) *
     system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
     system(HPI_TF_FT-E) then
   GlobalPartition = "TH-47-N";

elsif init(LIA) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_SO_FI-TRUE) * system(CBP_F-FT1) *
     system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
     system(HPI_TF_FT-E) then
   GlobalPartition = "TH-47-N";

elsif init(LIA) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_SO_FI-TRUE) * system(CBP_F-FT1) *
```

Table 4.5. LIA event tree sequence partitioning rules.

```
    system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
    system(HPI_TF_FT-E) then
  GlobalPartition = "TH-47-N";

elsif init(LIA) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
     system(CBP_F-FT1) *
    system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
    system(HPI_TF_FT-E) then
  GlobalPartition = "TH-47-N";

elsif init(LIA) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
     system(CBP_F-FT1) *
    system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
    system(HPI_TF_FT-E) then
  GlobalPartition = "TH-47-N";

elsif init(LIA) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
     system(CBP_F-FT1) *
    system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
    system(HPI_TF_FT-E) then
  GlobalPartition = "TH-47-N";

elsif init(LIA) * (M-B2F1 + M-B2F) * system(CBP_F-FT1) *
    (system(HPI_TF_FT-AB) + system(HPI_TF_FT-C) + system(HPI_TF_FT-D2) +
     system(HPI_TF_FT-D1) + system(HPI_TF_FT-E)) then
  GlobalPartition = "TH-47-N";

| Bin CD

elsif init(LIA) * (M-A + (M-B1 + M-B2) + M-C) * system(CBP_F-FT1) *
    system(HPI_STARTS_F-FT1) then
  GlobalPartition = "CD";

elsif init(LIA) * system(/SRV_ISO_F) * system(CBP_F-FT1) *
    system(HPI_STARTS_F-FT1) then
  GlobalPartition = "CD";

elsif init(LIA) *system(SRV_ISO_F) * system(CBP_F-FT1) *
    system(HPI_STARTS_F-FT1) then
```

Table 4.5. LIA event tree sequence partitioning rules.

```
   GlobalPartition = "CD";



elsif init(LIA) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_SO_FI-TRUE) * system(CBP_F-FT1) * system(HPI_STARTS_F-FT1) then
   GlobalPartition = "CD";

elsif init(LIA) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_SO_FI-TRUE) * system(CBP_F-FT1) * system(HPI_STARTS_F-FT1) then
   GlobalPartition = "CD";

elsif init(LIA) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_SO_FI-TRUE) * system(CBP_F-FT1) * system(HPI_STARTS_F-FT1) then
   GlobalPartition = "CD";

elsif init(LIA) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
      system(CBP_F-FT1) * system(HPI_STARTS_F-FT1) then
   GlobalPartition = "CD";

elsif init(LIA) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
      system(CBP_F-FT1) * system(HPI_STARTS_F-FT1) then
   GlobalPartition = "CD";

elsif init(LIA) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
      system(CBP_F-FT1) * system(HPI_STARTS_F-FT1) then
   GlobalPartition = "CD";

elsif init(LIA) * ((M-B2F1 + M-B2F) * system(CBP_F-FT1) + system(/SRV_ISO_F) +
     system(SRV_ISO_F)) * system(HPI_STARTS_F-FT1) then
   GlobalPartition = "CD";

| Bin 28

elsif init(LIA) * system(/PORV_SRV_SO-FT) * system(TBV_1SO) * system(TBV_SO_FI-TRUE) *
     (system(/EFW_F-FT4) + system(EFW_F-FT3) + system(/EFW_REC_B-FT) +
     system(EFW_REC_F-FT-T-B) + system(/MFW_REC_F-FT-C)) *
     system(/HPI_FTS) * system(HPI_TF_FT-AB) then
   GlobalPartition = "TH-28-Y";
```

Table 4.5. LIA event tree sequence partitioning rules.

```
elsif init(LIA) * system(PORV_SO)* system(/PORV_ISO_F-10) * system(TBV_1SO) *
     system(TBV_SO_FI-TRUE) *
    (system(/EFW_F-FT4) + system(EFW_F-FT3) + system(/EFW_REC_B-FT) +
     system(EFW_REC_F-FT-T-B) + system(/MFW_REC_F-FT-C)) *
     system(/HPI_FTS) * system(HPI_TF_FT-D2) then
   GlobalPartition = "TH-28-Y";

| Bin 25

elsif init(LIA) * system(/PORV_SRV_SO-FT) * system(TBV_4SO) *
     system(TBV_SO_FI-TRUE) * (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B) +
     system(/MFW_REC_F-FT-C)) * system(/HPI_FTS) * system(/RCP_INADV_TRIP) *
     system(HPI_TF_FT-AB) then
   GlobalPartition = "TH-25-Y";

elsif init(LIA) * system(PORV_SO)* system(/PORV_ISO_F-10) * system(TBV_4SO) *
     system(TBV_SO_FI-TRUE) * (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B) +
     system(/MFW_REC_F-FT-C)) * system(/HPI_FTS) * system(/RCP_INADV_TRIP) *
     system(HPI_TF_FT-D2) then
   GlobalPartition = "TH-25-Y";

| Bin 27

elsif init(LIA) * system(/PORV_SRV_SO-FT) * system(TBV_4SO) *
     system(TBV_SO_FI-TRUE) * (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B) +
     system(/MFW_REC_F-FT-C)) * system(/HPI_FTS) * system(/RCP_INADV_TRIP) *
     system(/HPI_TF_FT-AB) then
   GlobalPartition = "TH-27-Y";

elsif init(LIA) * system(PORV_SO)* system(/PORV_ISO_F-10) * system(TBV_4SO) *
     system(TBV_SO_FI-TRUE) * (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B) +
     system(/MFW_REC_F-FT-C)) * system(/HPI_FTS) * system(/RCP_INADV_TRIP) *
     system(/HPI_TF_FT-D2) then
   GlobalPartition = "TH-27-Y";

| Bin 29

elsif init(LIA) * (system(/PORV_SRV_SO-FT)
                  + (system(PORV_SO)* system(/PORV_ISO_F-10)))
```

Table 4.5. LIA event tree sequence partitioning rules.

```
              *system(TBV_2SO) * system(TBV_SO_FI-TRUE)
               *(system(/MFW_REC_F-FT-C) + system(EFW_F-FT3)
                        + system(EFW_REC_F-FT-T-B))
                 *system(/HPI_FTS)
                   * (system(HPI_TF_FT-AB) + system(HPI_TF_FT-D2))then
   GlobalPartition = "TH-29-Y";

| Bin 35

elsif init(LIA) * system(/PORV_SRV_SO-FT) * system(TBV_1SO) * system(TBV_SO_FI-TRUE) *
     (system(/EFW_F-FT4) + system(EFW_F-FT3) + system(/EFW_REC_B-FT) +
     system(EFW_REC_F-FT-T-B) + system(/MFW_REC_F-FT-C)) *
     system(/HPI_FTS) * system(/HPI_TF_FT-AB) then
   GlobalPartition = "TH-35-N";

elsif init(LIA) * system(PORV_SO)* system(/PORV_ISO_F-10) * system(TBV_1SO) *
     system(TBV_SO_FI-TRUE) *
    (system(/EFW_F-FT4) + system(EFW_F-FT3) + system(/EFW_REC_B-FT) +
     system(EFW_REC_F-FT-T-B) + system(/MFW_REC_F-FT-C)) *
     system(/HPI_FTS) * system(/HPI_TF_FT-D2) then
   GlobalPartition = "TH-35-N";

| Bin 36

 elsif init(LIA) * (system(/PORV_SRV_SO-FT) +
      (system(PORV_SO)* system(/PORV_ISO_F-10))) * system(TBV_2SO) *
      system(TBV_SO_FI-TRUE) * (system(/MFW_REC_F-FT-C) +
      system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B)) *
      system(/HPI_FTS) * (system(/HPI_TF_FT-AB) + system(/HPI_TF_FT-D2))then
   GlobalPartition = "TH-36-Y";

|Bin 57

elsif init(LIA) * system(/PORV_SRV_SO-FT) * system(TBV_2SO) * system(TBV_SO_FI-TRUE) *
     (system(/EFW_F-FT4) + system(/EFW_REC_B-FT) + system(/MFW_REC_F-FT-C)) *
     system(/HPI_FTS) * system(HPI_TF_FT-AB)  then
   GlobalPartition = "TH-57-Y";

elsif init(LIA) * system(/PORV_ISO_F-10) * system(TBV_2SO) * system(TBV_SO_FI-TRUE) *
```

Table 4.5. LIA event tree sequence partitioning rules.

```
    (system(/EFW_F-FT4) + system(/EFW_REC_B-FT) + system(/MFW_REC_F-FT-C)) *
    system(/HPI_FTS) * system(HPI_TF_FT-D2)  then
  GlobalPartition = "TH-57-Y";

|Bin 59

elsif init(LIA) * system(/PORV_SRV_SO-FT) * system(TBV_2SO) * system(TBV_SO_FI-TRUE) *
    (system(/EFW_F-FT4) + system(/EFW_REC_B-FT) + system(/MFW_REC_F-FT-C)) *
    system(/HPI_FTS) * system(/HPI_TF_FT-AB)  then
  GlobalPartition = "TH-59-Y";

elsif init(LIA) * system(/PORV_ISO_F-10) * system(TBV_2SO) * system(TBV_SO_FI-TRUE) *
    (system(/EFW_F-FT4) + system(/EFW_REC_B-FT) + system(/MFW_REC_F-FT-C)) *
    system(/HPI_FTS) * system(/HPI_TF_FT-D2)  then
  GlobalPartition = "TH-59-Y";

| Bin 62

elsif init(LIA) * system(/PORV_SRV_SO-FT) * system(TBV_4SO) * system(TBV_SO_FI-TRUE) *
    (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B) + system(/MFW_REC_F-FT-C)) *
    system(/HPI_FTS) * system(RCP_INADV_TRIP) then
  GlobalPartition = "TH-62-Y";

elsif init(LIA) * system(/PORV_ISO_F-10) * system(TBV_4SO) * system(TBV_SO_FI-TRUE) *
    (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B) + system(/MFW_REC_F-FT-C)) *
    system(/HPI_FTS) * system(RCP_INADV_TRIP) then
  GlobalPartition = "TH-62-Y";

| Bin 61

elsif init(LIA) * system(/PORV_SRV_SO-FT) * system(TBV_4SO) * system(TBV_SO_FI-TRUE) *
    (system(/EFW_F-FT4) + system(/EFW_REC_B-FT)) *
    system(/HPI_FTS) then
  GlobalPartition = "TH-61-N";

elsif init(LIA) * system(/PORV_ISO_F-10) * system(TBV_4SO) * system(TBV_SO_FI-TRUE) *
    (system(/EFW_F-FT4) + system(/EFW_REC_B-FT)) *
    system(/HPI_FTS) then
  GlobalPartition = "TH-61-N";
```

Table 4.5. LIA event tree sequence partitioning rules.

```
| Bin 8

elsif init(LIA) * system(PORV_ISO_F-10) * system(TBV_1SO) * system(TBV_SO_FI-TRUE)
              * (system(/EFW_F-FT4) + system(EFW_F-FT3) + (system(EFW_SLB_FTS)
                   * (system(/EFW_REC_B-FT) + system(EFW_REC_F-FT-T-B))))
                * system(/HPI_FTS) * system(HPI_TF_FT-AB) then
   GlobalPartition = "TH-08-Y";

elsif init(LIA) * system(PORV_ISO_F-10) * system(TBV_1SO) * system(TBV_SO_FI-TRUE)
             * system(/MFW_REC_F-FT-C)
              * system(/HPI_FTS) * system(HPI_TF_FT-AB) then
   GlobalPartition = "TH-08-Y";

| Bin 12

elsif init(LIA) * system(PORV_ISO_F-10) * system(TBV_1SO) * system(TBV_SO_FI-TRUE)
              * (system(/EFW_F-FT4) + system(EFW_F-FT3) + (system(EFW_SLB_FTS)
                   * (system(/EFW_REC_B-FT) + system(EFW_REC_F-FT-T-B))))
                * system(/HPI_FTS) * system(/HPI_TF_FT-AB) then
   GlobalPartition = "TH-12-Y";

elsif init(LIA) * system(PORV_ISO_F-10) * system(TBV_1SO) * system(TBV_SO_FI-TRUE)
             * system(/MFW_REC_F-FT-C)
                * system(/HPI_FTS) * system(/HPI_TF_FT-AB) then
   GlobalPartition = "TH-12-Y";

| Bin 9

elsif init(LIA) * system(PORV_ISO_F-10) * system(TBV_2SO)* system(TBV_SO_FI-TRUE)
              * (system(/EFW_F-FT4) + system(EFW_F-FT3) + (system(EFW_SLB_FTS)
                  * (system(/EFW_REC_B-FT) + system(EFW_REC_F-FT-T-B))))
                * system(/HPI_FTS) * system(HPI_TF_FT-AB) then
   GlobalPartition = "TH-09-Y";

elsif init(LIA) * system(PORV_ISO_F-10) * system(TBV_2SO)* system(TBV_SO_FI-TRUE)
             * system(/MFW_REC_F-FT-C)
                * system(/HPI_FTS) * system(HPI_TF_FT-AB) then
   GlobalPartition = "TH-09-Y";
```

Table 4.5. LIA event tree sequence partitioning rules.

```
| Bin 13

elsif init(LIA) * system(PORV_ISO_F-10) * system(TBV_2SO) * system(TBV_SO_FI-TRUE)
              * (system(/EFW_F-FT4) + system(EFW_F-FT3) + (system(EFW_SLB_FTS)
                   * (system(/EFW_REC_B-FT) + system(EFW_REC_F-FT-T-B))))
                  * system(/HPI_FTS) * system(/HPI_TF_FT-AB) then
   GlobalPartition = "TH-13-Y";

elsif init(LIA) * system(PORV_ISO_F-10) * system(TBV_2SO) * system(TBV_SO_FI-TRUE)
             * system(/MFW_REC_F-FT-C)
              * system(/HPI_FTS) * system(/HPI_TF_FT-AB) then
   GlobalPartition = "TH-13-Y";

elsif init(LIA) * system(PORV_ISO_F-10) * system(TBV_4SO) * system(TBV_SO_FI-TRUE)
                 * (system(/EFW_F-FT4) + system(EFW_F-FT3) + (system(EFW_SLB_FTS)
                      * (system(/EFW_REC_B-FT) + system(EFW_REC_F-FT-T-B))))
                   * system(/HPI_FTS) * system(/HPI_TF_FT-AB) then
   GlobalPartition = "TH-13-Y";

elsif init(LIA) * system(PORV_ISO_F-10) * system(TBV_4SO) * system(TBV_SO_FI-TRUE)
              * system(/MFW_REC_F-FT-C)
                 * system(/HPI_FTS) * system(/HPI_TF_FT-AB) then
   GlobalPartition = "TH-13-Y";

| Bin 10

elsif init(LIA) * system(PORV_ISO_F-10) * system(TBV_4SO) * system(TBV_SO_FI-TRUE)
               * (system(/EFW_F-FT4) + system(EFW_F-FT3) + (system(EFW_SLB_FTS)
                    * (system(/EFW_REC_B-FT) + system(EFW_REC_F-FT-T-B))))
                 * system(/HPI_FTS) * system(HPI_TF_FT-AB) then
   GlobalPartition = "TH-10-Y";

elsif init(LIA) * system(PORV_ISO_F-10) * system(TBV_4SO) * system(TBV_SO_FI-TRUE)
              * system(/MFW_REC_F-FT-C)
                 * system(/HPI_FTS) * system(HPI_TF_FT-AB) then
   GlobalPartition = "TH-10-Y";

| Bin 41
```

Table 4.5. LIA event tree sequence partitioning rules.

```
elsif init(LIA) * system(/SRV_ISO_F) * system(CBP_F-FT1) *
     system(/HPI_STARTS_F-FT1) then
   GlobalPartition = "TH-41-Y";

elsif init(LIA) * system(/SRV_ISO_F) * system(/HPI_FTS) then
   GlobalPartition = "TH-41-Y";

elsif init(LIA) * system(/SRV_ISO_F) * system(/HPI_STARTS_F-FT1) then
   GlobalPartition = "TH-41-Y";

| Bin 34

elsif init(LIA) *system(SRV_ISO_F) * system(CBP_F-FT1) *
     system(/HPI_STARTS_F-FT1) then
   GlobalPartition = "TH-34-Y";

elsif init(LIA) *system(SRV_ISO_F) * system(/HPI_FTS) then
   GlobalPartition = "TH-34-Y";

elsif init(LIA) *system(SRV_ISO_F) * system(/HPI_STARTS_F-FT1) then
   GlobalPartition = "TH-34-Y";

else
   GlobalPartition = "TH-DUMMY";
endif
```

Table 4.6. LLOCA event tree sequence partitioning rules.

```
| Mapping sequences into T/H bins
| Map LLOCA sequences into TH bins
| Last Modified January 28, 2002

| Bin LLOCA

if init(LLOCA) then
  GlobalPartition = "TH-LLOCA-Y";
endif
```

Table 4.7. LMC event tree sequence partitioning rules.

```
| Mapping sequences into T/H bins
| Map LMC sequences into TH bins
| Last Modified September 21, 2001
|
|Macros
|
M-A = system(/PORV_SRV_SO-FT) * system(/TBV_SO-FT);

M-MFW1 = system(MFW_TRIP0) + system(MFW_OVRFD_A) + system(MFW_OVRFD_AB);

M-TBV1 = system(TBV_1SO) + system(TBV_2SO) + system(TBV_4SO);

M-TBV2 = system(/TBV_SO_FI-TRUE);

M-TBV-S = system(/TBV_SO_FI-TRUE) + system(/TBV_SO_FI-TRUE) + system(/TBV_SO_FI-TRUE);

M-B1 = system(/PORV_SRV_SO-FT) * M-TBV-S;

M-EFW1 = system(EFW_OVRFD_A) + system(EFW_OVRFD_AB);

M-TBV-S1 = system(TBV_1SO) * system(/TBV_SO_FI-TRUE);

M-TBV-S2 = system(TBV_2SO) * system(/TBV_SO_FI-TRUE);

M-TBV-S4 = system(TBV_4SO) * system(/TBV_SO_FI-TRUE);

M-B2 = (system(PORV_SO) * system(/PORV_ISO_F-10)) * M-TBV-S;

M-B2F1 = system(PORV_SO) * system(PORV_ISO_F-10) * system(/TBV_SO-FT);

M-B2F = (system(PORV_SO) * system(PORV_ISO_F-10)) * M-TBV-S;

M-C = system(PORV_SO) * system(/PORV_ISO_F-10) * system(/TBV_SO-FT);

| Bin 21-N

if (init(LMC) * M-A) * (system(/MFW_F-FT) + system(/MFW_TRIP0-TRUE) + (M-MFW1 *
  system(/EFW_F-FT)) + (M-MFW1 * (system(EFW_FTS) * system(/EFW_REC_A-FT)))) then
  GlobalPartition = "TH-21-N";
```

Table 4.7. LMC event tree sequence partitioning rules.

```
| Bin 33-N

elsif (init(LMC) * (M-B1 + M-B2)) * (system(/MFW_TRIP0-TRUE) + system(/EFW_F-FT) +
      system(/EFW_REC_B-FT))then
    GlobalPartition = "TH-33-N";

elsif ((init(LMC) * (M-B1 + M-B2)) * (M-EFW1 + system(EFW_REC_F-FT-T-B)))*
       system(/HPI_FTS) then
    GlobalPartition = "TH-33-N";

| Bin 43-N

elsif (init(LMC) * M-C) * (system(/MFW_F-FT) + system(/MFW_TRIP0-TRUE) +
      (M-MFW1 * system(/EFW_F-FT)) + (M-MFW1 * system(EFW_FTS) *
      system(/EFW_REC_B-FT))) then
   GlobalPartition = "TH-43-N";

|Bin 18-N

elsif (init(LMC) * M-C) * (M-EFW1 *system(/EFW_REC_F-FT-T-B)) *
       system(/HPI_FTS) then
   GlobalPartition = "TH-18-N";

elsif (init(LMC) * M-A) * (M-EFW1 *system(/EFW_REC_F-FT-T-A)) *
       system(/HPI_FTS) then
   GlobalPartition = "TH-18-N";

|Bin 19-N

elsif (init(LMC) * M-C) * (M-EFW1 * system(EFW_REC_F-FT-T-B) +
       system(EFW_FTS) * system(EFW_REC_F-FT-T-B)) *
       system(/HPI_FTS) then
   GlobalPartition = "TH-19-N";

elsif (init(LMC) * M-A) * (M-EFW1 * system(EFW_REC_F-FT-T-A) +
       system(EFW_FTS) * system(EFW_REC_F-FT-T-A)) *
       system(/HPI_FTS) then
   GlobalPartition = "TH-19-N";
```

Table 4.7. LMC event tree sequence partitioning rules.

```
| Bin 50-Y

elsif init(LMC) * (M-A + (M-B1 + M-B2) + M-C) * system(/CBP_F-TRUE) then
  GlobalPartition = "TH-50-Y";

elsif init(LMC) * (M-A + (M-B1 + M-B2) + M-C) * (system(CBP_OVRFD-FALSE) *
    system(/HPI_FTS)) then
  GlobalPartition = "TH-50-Y";

elsif init(LMC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_SO_FI-TRUE) * (system(/CBP_F-TRUE) + system(CBP_OVRFD-FALSE)) *
    system(/HPI_FTS) then
   GlobalPartition = "TH-50-Y";

elsif init(LMC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_SO_FI-TRUE) * (system(/CBP_F-TRUE) + system(CBP_OVRFD-FALSE)) *
    system(/HPI_FTS)  then
   GlobalPartition = "TH-50-Y";

elsif init(LMC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_SO_FI-TRUE) * (system(/CBP_F-TRUE) + system(CBP_OVRFD-FALSE)) *
    system(/HPI_FTS) then
   GlobalPartition = "TH-50-Y";

elsif init(LMC) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
    (system(/CBP_F-TRUE) + system(CBP_OVRFD-FALSE)) *
    system(/HPI_FTS) then
   GlobalPartition = "TH-50-Y";

elsif init(LMC) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
    (system(/CBP_F-TRUE) + system(CBP_OVRFD-FALSE)) *
    system(/HPI_FTS) then
   GlobalPartition = "TH-50-Y";

elsif init(LMC) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
    (system(/CBP_F-TRUE) + system(CBP_OVRFD-FALSE)) *
    system(/HPI_FTS) then
   GlobalPartition = "TH-50-Y";
```

Table 4.7. LMC event tree sequence partitioning rules.

```
elsif init(LMC) * (M-B2F1 + M-B2F) * (system(/CBP_F-TRUE) + system(CBP_OVRFD-FALSE)) *
     system(/HPI_FTS) then
   GlobalPartition = "TH-50-Y";

| Bin 23-N

elsif init(LMC) * M-A * system(/MFW_REC_F-FT-A) * system(/HPI_FTS) then
   GlobalPartition = "TH-23-N";

elsif init(LMC) * (M-B1 + M-B2 + M-C) * system(/MFW_REC_F-FT-B) *
     system(/HPI_FTS) then
   GlobalPartition = "TH-23-N";

|elsif init(LMC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
|     system(TBV_SO_FI-TRUE) * system(/MFW_REC_F-FT-B) then
|   GlobalPartition = "TH-23-N";

elsif init(LMC) * (M-B2F1 + M-B2F) * system(/MFW_REC_F-FT-B) *
     system(/HPI_FTS) then
   GlobalPartition = "TH-23-N";

| Bin 44-Y

elsif init(LMC) * (M-A + (M-B1 + M-B2) + M-C) *
     system(HPI_FTS) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LMC) * (M-B2F1 + M-B2F + system(/SRV_ISO_F) + system(SRV_ISO_F)) *
     system(HPI_FTS) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LMC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_SO_FI-TRUE) * (system(/CBP_F-TRUE) + system(CBP_OVRFD-FALSE)) *
     system(HPI_FTS) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(LMC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_SO_FI-TRUE) * (system(/CBP_F-TRUE) + system(CBP_OVRFD-FALSE)) *
```

Table 4.7. LMC event tree sequence partitioning rules.

```
   system(HPI_FTS) * system(/HPI_REC_F) then
  GlobalPartition = "TH-44-Y";

elsif init(LMC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
   system(TBV_SO_FI-TRUE) * (system(/CBP_F-TRUE) + system(CBP_OVRFD-FALSE)) *
   system(HPI_FTS) * system(/HPI_REC_F) then
  GlobalPartition = "TH-44-Y";

elsif init(LMC) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
   (system(/CBP_F-TRUE) + system(CBP_OVRFD-FALSE)) *
   system(HPI_FTS) * system(/HPI_REC_F) then
  GlobalPartition = "TH-44-Y";

elsif init(LMC) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
   (system(/CBP_F-TRUE) + system(CBP_OVRFD-FALSE)) *
   system(HPI_FTS) * system(/HPI_REC_F) then
  GlobalPartition = "TH-44-Y";

elsif init(LMC) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
   (system(/CBP_F-TRUE) + system(CBP_OVRFD-FALSE)) *
   system(HPI_FTS) * system(/HPI_REC_F) then
  GlobalPartition = "TH-44-Y";

elsif init(LMC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
   system(TBV_SO_FI-TRUE) * system(HPI_FTS) * system(/HPI_REC_F) then
  GlobalPartition = "TH-44-Y";

elsif init(LMC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
   system(TBV_SO_FI-TRUE) * (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B) +
   system(/MFW_REC_F-FT-B)) * system(HPI_FTS) * system(/HPI_REC_F) then
  GlobalPartition = "TH-44-Y";

elsif init(LMC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
   system(TBV_SO_FI-TRUE) * (system(/EFW_F-FT4) + system(/EFW_REC_B-FT) +
   system(/MFW_REC_F-FT-B)) * system(HPI_FTS) * system(/HPI_REC_F) then
  GlobalPartition = "TH-44-Y";

elsif init(LMC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
   system(TBV_SO_FI-TRUE) * (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B) +
```

Table 4.7. LMC event tree sequence partitioning rules.

```
    system(/MFW_REC_F-FT-B)) * system(HPI_FTS) * system(/HPI_REC_F) then
  GlobalPartition = "TH-44-Y";

elsif init(LMC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_SO_FI-TRUE) * (system(/EFW_F-FT4) + system(/EFW_REC_B-FT)) *
    system(HPI_FTS) * system(/HPI_REC_F) then
  GlobalPartition = "TH-44-Y";

elsif init(LMC) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
    system(HPI_FTS) * system(/HPI_REC_F) then
  GlobalPartition = "TH-44-Y";

elsif init(LMC) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
    system(HPI_FTS) * system(/HPI_REC_F) then
  GlobalPartition = "TH-44-Y";

elsif init(LMC) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
    system(HPI_FTS) * system(/HPI_REC_F) then
  GlobalPartition = "TH-44-Y";

elsif init(LMC) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
    system(HPI_FTS) * system(/HPI_REC_F) then
  GlobalPartition = "TH-44-Y";

elsif init(LMC) * system(/SRV_ISO_F) * system(CBP_F-TRUE) *
    system(HPI_STARTS_F-FT1) * system(/HPI_REC_F) then
  GlobalPartition = "TH-44-Y";

elsif init(LMC) * system(/SRV_ISO_F) * system(HPI_FTS) *
    system(/HPI_REC_F) then
  GlobalPartition = "TH-44-Y";

elsif init(LMC) *system(SRV_ISO_F) * system(CBP_F-TRUE) *
    system(HPI_STARTS_F-FT1) * system(/HPI_REC_F) then
  GlobalPartition = "TH-44-Y";

elsif init(LMC) *system(SRV_ISO_F) * system(HPI_FTS) *
    system(/HPI_REC_F) then
  GlobalPartition = "TH-44-Y";
```

Table 4.7. LMC event tree sequence partitioning rules.

```
| Bin 15-Y

elsif init(LMC) * (M-A + (M-B1 + M-B2) + M-C) *
     system(HPI_FTS) * system(HPI_REC_F) then
   GlobalPartition = "TH-15-Y";

elsif init(LMC) * (M-B2F1 + M-B2F + system(/SRV_ISO_F) + system(SRV_ISO_F)) *
     system(HPI_REC_F) then
   GlobalPartition = "TH-15-Y";

elsif init(LMC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_SO_FI-TRUE) * (system(/CBP_F-TRUE) + system(CBP_OVRFD-FALSE)) *
     system(HPI_FTS) * system(HPI_REC_F) then
   GlobalPartition = "TH-15-Y";

elsif init(LMC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_SO_FI-TRUE) * (system(/CBP_F-TRUE) + system(CBP_OVRFD-FALSE)) *
     system(HPI_FTS) * system(HPI_REC_F) then
   GlobalPartition = "TH-15-Y";

elsif init(LMC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_SO_FI-TRUE) * (system(/CBP_F-TRUE) + system(CBP_OVRFD-FALSE)) *
     system(HPI_FTS) * system(HPI_REC_F) then
   GlobalPartition = "TH-15-Y";

elsif init(LMC) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
     (system(/CBP_F-TRUE) + system(CBP_OVRFD-FALSE)) *
     system(HPI_FTS) * system(HPI_REC_F) then
   GlobalPartition = "TH-15-Y";

elsif init(LMC) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
     (system(/CBP_F-TRUE) + system(CBP_OVRFD-FALSE)) *
     system(HPI_FTS) * system(HPI_REC_F) then
   GlobalPartition = "TH-15-Y";

elsif init(LMC) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
     (system(/CBP_F-TRUE) + system(CBP_OVRFD-FALSE)) *
     system(HPI_FTS) * system(HPI_REC_F) then
```

Table 4.7. LMC event tree sequence partitioning rules.

```
   GlobalPartition = "TH-15-Y";

elsif init(LMC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_SO_FI-TRUE) * system(HPI_FTS) * system(HPI_REC_F) then
   GlobalPartition = "TH-15-Y";

elsif init(LMC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_SO_FI-TRUE) * (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B) +
     system(/MFW_REC_F-FT-B)) * system(HPI_FTS) * system(HPI_REC_F) then
   GlobalPartition = "TH-15-Y";

elsif init(LMC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_SO_FI-TRUE) * (system(/EFW_F-FT4) + system(/EFW_REC_B-FT) +
     system(/MFW_REC_F-FT-B)) * system(HPI_FTS) * system(HPI_REC_F) then
   GlobalPartition = "TH-15-Y";

elsif init(LMC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_SO_FI-TRUE) * (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B) +
     system(/MFW_REC_F-FT-B)) * system(HPI_FTS) * system(HPI_REC_F) then
   GlobalPartition = "TH-15-Y";

elsif init(LMC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_SO_FI-TRUE) * (system(/EFW_F-FT4) + system(/EFW_REC_B-FT)) *
     system(HPI_FTS) * system(HPI_REC_F) then
   GlobalPartition = "TH-15-Y";

elsif init(LMC) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
     system(HPI_FTS) * system(HPI_REC_F) then
   GlobalPartition = "TH-15-Y";

elsif init(LMC) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
     system(HPI_FTS) * system(HPI_REC_F) then
   GlobalPartition = "TH-15-Y";

elsif init(LMC) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
     system(HPI_FTS) * system(HPI_REC_F) then
   GlobalPartition = "TH-15-Y";

elsif init(LMC) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
```

Table 4.7. LMC event tree sequence partitioning rules.

```
    system(HPI_FTS) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(LMC) * system(/SRV_ISO_F) * system(CBP_F-TRUE) *
    system(HPI_STARTS_F-FT1) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(LMC) * system(/SRV_ISO_F) * system(HPI_FTS) *
    system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(LMC) *system(SRV_ISO_F) * system(CBP_F-TRUE) *
    system(HPI_STARTS_F-FT1) * system(HPI_REC_F)then
  GlobalPartition = "TH-15-Y";

elsif init(LMC) *system(SRV_ISO_F) * system(HPI_FTS) *
    system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

| Bin 22-N

elsif init(LMC) * (M-A + (M-B1 + M-B2) + M-C) * system(CBP_F-TRUE) *
    system(/HPI_STARTS_F-FT1) * system(SEC_COOLREC-ALL) then
  GlobalPartition = "TH-22-N";

elsif init(LMC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_SO_FI-TRUE) * system(CBP_F-TRUE) *
    system(/HPI_STARTS_F-FT1) * system(SEC_COOLREC-ALL) then
  GlobalPartition = "TH-22-N";

elsif init(LMC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_SO_FI-TRUE) * system(CBP_F-TRUE) *
    system(/HPI_STARTS_F-FT1) * system(SEC_COOLREC-ALL) then
  GlobalPartition = "TH-22-N";

elsif init(LMC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_SO_FI-TRUE) * system(CBP_F-TRUE) *
    system(/HPI_STARTS_F-FT1) * system(SEC_COOLREC-ALL) then
  GlobalPartition = "TH-22-N";
```

Table 4.7. LMC event tree sequence partitioning rules.

```
elsif init(LMC) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
      system(CBP_F-TRUE) *
     system(/HPI_STARTS_F-FT1) * system(SEC_COOLREC-ALL) then
   GlobalPartition = "TH-22-N";

elsif init(LMC) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
      system(CBP_F-TRUE) *
     system(/HPI_STARTS_F-FT1) * system(SEC_COOLREC-ALL) then
   GlobalPartition = "TH-22-N";

elsif init(LMC) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
      system(CBP_F-TRUE) *
     system(/HPI_STARTS_F-FT1) * system(SEC_COOLREC-ALL) then
   GlobalPartition = "TH-22-N";

elsif init(LMC) * system(PORV_SO) * system(PORV_ISO_F-10) * system(/TBV_SO-FT) *
     system(/MFW_F-FT) * system(/HPI_FTS) then
   GlobalPartition = "TH-22-N";

elsif init(LMC) * (M-B2F1 + M-B2F) * (system(/MFW_TRIP0-TRUE) + system(/EFW_F-FT) +
     M-EFW1 + system(/EFW_REC_B-FT) + system(EFW_REC_F-FT-T-B)) *
     system(/HPI_FTS) then
   GlobalPartition = "TH-22-N";

elsif init(LMC) * (M-B2F1 + M-B2F) * system(CBP_F-TRUE) *
     system(SEC_COOLREC-ALL) then
   GlobalPartition = "TH-22-N";

| Bin 48-N

elsif init(LMC) * (M-A + (M-B1 + M-B2) + M-C) * system(CBP_F-TRUE) *
     system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
     system(/HPI_TF_FT-E) then
   GlobalPartition = "TH-48-N";


elsif init(LMC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_SO_FI-TRUE) * system(CBP_F-TRUE) *
```

Table 4.7. LMC event tree sequence partitioning rules.

```
    system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
    system(/HPI_TF_FT-E) then
  GlobalPartition = "TH-48-N";

elsif init(LMC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_SO_FI-TRUE) * system(CBP_F-TRUE) *
    system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
    system(/HPI_TF_FT-E) then
  GlobalPartition = "TH-48-N";

elsif init(LMC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_SO_FI-TRUE) * system(CBP_F-TRUE) *
    system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
    system(/HPI_TF_FT-E) then
  GlobalPartition = "TH-48-N";

elsif init(LMC) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
     system(CBP_F-TRUE) *
    system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
    system(/HPI_TF_FT-E) then
  GlobalPartition = "TH-48-N";

elsif init(LMC) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
     system(CBP_F-TRUE) *
    system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
    system(/HPI_TF_FT-E) then
  GlobalPartition = "TH-48-N";

elsif init(LMC) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
     system(CBP_F-TRUE) *
    system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
    system(/HPI_TF_FT-E) then
  GlobalPartition = "TH-48-N";

elsif init(LMC) * (M-B2F1 + M-B2F) * system(CBP_F-TRUE) *
    (system(/HPI_TF_FT-AB) + system(/HPI_TF_FT-C) + system(/HPI_TF_FT-D2) +
     system(/HPI_TF_FT-D1) + system(/HPI_TF_FT-E)) then
  GlobalPartition = "TH-48-N";
```

Table 4.7. LMC event tree sequence partitioning rules.

```
| Bin 47-N

elsif init(LMC) * (M-A + (M-B1 + M-B2) + M-C) * system(CBP_F-TRUE) *
     system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
     system(HPI_TF_FT-E) then
   GlobalPartition = "TH-47-N";

elsif init(LMC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_SO_FI-TRUE) * system(CBP_F-TRUE) *
     system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
     system(HPI_TF_FT-E) then
   GlobalPartition = "TH-47-N";

elsif init(LMC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_SO_FI-TRUE) * system(CBP_F-TRUE) *
     system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
     system(HPI_TF_FT-E) then
   GlobalPartition = "TH-47-N";

elsif init(LMC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_SO_FI-TRUE) * system(CBP_F-TRUE) *
     system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
     system(HPI_TF_FT-E) then
   GlobalPartition = "TH-47-N";

elsif init(LMC) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
      system(CBP_F-TRUE) *
     system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
     system(HPI_TF_FT-E) then
   GlobalPartition = "TH-47-N";

elsif init(LMC) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
      system(CBP_F-TRUE) *
     system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
     system(HPI_TF_FT-E) then
   GlobalPartition = "TH-47-N";

elsif init(LMC) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
      system(CBP_F-TRUE) *
```

Table 4.7. LMC event tree sequence partitioning rules.

```
    system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
    system(HPI_TF_FT-E) then
  GlobalPartition = "TH-47-N";

elsif init(LMC) * (M-B2F1 + M-B2F) * system(CBP_F-TRUE) *
    (system(HPI_TF_FT-AB) + system(HPI_TF_FT-C) + system(HPI_TF_FT-D2) +
     system(HPI_TF_FT-D1) + system(HPI_TF_FT-E)) then
  GlobalPartition = "TH-47-N";

| Bin CD

elsif init(LMC) * (M-A + (M-B1 + M-B2) + M-C) * system(CBP_F-TRUE) *
    system(HPI_STARTS_F-FT1) then
  GlobalPartition = "CD";

elsif init(LMC) * system(/SRV_ISO_F) * system(CBP_F-TRUE) *
    system(HPI_STARTS_F-FT1) then
  GlobalPartition = "CD";

elsif init(LMC) *system(SRV_ISO_F) * system(CBP_F-TRUE) *
    system(HPI_STARTS_F-FT1) then
  GlobalPartition = "CD";

elsif init(LMC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_SO_FI-TRUE) * system(CBP_F-TRUE) * system(HPI_STARTS_F-FT1) then
  GlobalPartition = "CD";

elsif init(LMC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_SO_FI-TRUE) * system(CBP_F-TRUE) * system(HPI_STARTS_F-FT1) then
  GlobalPartition = "CD";

elsif init(LMC) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_SO_FI-TRUE) * system(CBP_F-TRUE) * system(HPI_STARTS_F-FT1) then
  GlobalPartition = "CD";

elsif init(LMC) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
     system(CBP_F-TRUE) * system(HPI_STARTS_F-FT1) then
  GlobalPartition = "CD";
```

Table 4.7. LMC event tree sequence partitioning rules.

```
elsif init(LMC) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
      system(CBP_F-TRUE) * system(HPI_STARTS_F-FT1) then
   GlobalPartition = "CD";

elsif init(LMC) * system(PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) *
      system(CBP_F-TRUE) * system(HPI_STARTS_F-FT1) then
   GlobalPartition = "CD";

elsif init(LMC) * ((M-B2F1 + M-B2F) * system(CBP_F-TRUE) + system(/SRV_ISO_F) +
     system(SRV_ISO_F)) * system(HPI_STARTS_F-FT1) then
   GlobalPartition = "CD";

|Bin 57-Y

elsif init(LMC) * system(/PORV_SRV_SO-FT) * system(TBV_2SO) *
     system(TBV_SO_FI-TRUE) * ((system(/MFW_TRIP0-FALSE) * (system(/EFW_F-FT4) +
     system(/EFW_REC_B-FT)) + (system(MFW_REC_F-FT-B) * (system(/EFW_F-FT4) +
     system(/EFW_REC_B-FT)))) * system(/HPI_FTS) * system(HPI_TF_FT-AB))  then
   GlobalPartition = "TH-57-Y";

elsif init(LMC) * system(/PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) * system(TBV_2SO) *
     system(TBV_SO_FI-TRUE) * ((system(/MFW_TRIP0-FALSE) * (system(/EFW_F-FT4) +
     system(/EFW_REC_B-FT)) + (system(MFW_REC_F-FT-B) * (system(/EFW_F-FT4) +
     system(/EFW_REC_B-FT)))) * system(/HPI_FTS) * system(HPI_TF_FT-D2))  then
   GlobalPartition = "TH-57-Y";

|Bin 59-Y

elsif init(LMC) * system(/PORV_SRV_SO-FT) * system(TBV_2SO) *
     system(TBV_SO_FI-TRUE) * ((system(/MFW_TRIP0-FALSE) * (system(/EFW_F-FT4) +
     system(/EFW_REC_B-FT)) + (system(MFW_REC_F-FT-B) * (system(/EFW_F-FT4) +
     system(/EFW_REC_B-FT)))) * system(/HPI_FTS) * system(/HPI_TF_FT-AB))  then
   GlobalPartition = "TH-59-Y";

elsif init(LMC) * system(/PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) * system(TBV_2SO) *
     system(TBV_SO_FI-TRUE) * ((system(/MFW_TRIP0-FALSE) * (system(/EFW_F-FT4) +
     system(/EFW_REC_B-FT)) + (system(MFW_REC_F-FT-B) * (system(/EFW_F-FT4) +
     system(/EFW_REC_B-FT)))) * system(/HPI_FTS) * system(/HPI_TF_FT-D2))  then
   GlobalPartition = "TH-59-Y";
```

Table 4.7. LMC event tree sequence partitioning rules.

```
| Bin 61-N

elsif init(LMC) * system(/PORV_SRV_SO-FT) * system(TBV_4SO) *
     system(TBV_SO_FI-TRUE) * ((system(/MFW_TRIP0-FALSE) * (system(/EFW_F-FT4) +
     system(/EFW_REC_B-FT)) + (system(MFW_REC_F-FT-B) * (system(/EFW_F-FT4) +
     system(/EFW_REC_B-FT)))) * system(/HPI_FTS))  then
   GlobalPartition = "TH-61-N";

elsif init(LMC) * system(/PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) * system(TBV_4SO) *
     system(TBV_SO_FI-TRUE) * ((system(/MFW_TRIP0-FALSE) * (system(/EFW_F-FT4) +
     system(/EFW_REC_B-FT)) + (system(MFW_REC_F-FT-B) * (system(/EFW_F-FT4) +
     system(/EFW_REC_B-FT)))) * system(/HPI_FTS))  then
   GlobalPartition = "TH-61-N";

| Bin 62

elsif init(LMC) * system(/PORV_SRV_SO-FT) * system(TBV_4SO) *
     system(TBV_SO_FI-TRUE) * ((system(/MFW_TRIP0-FALSE) * (system(EFW_F-FT3) +
     system(EFW_REC_F-FT-T-B))) + (system(MFW_TRIP0-FALSE) *
    (system(/MFW_REC_F-FT-B) + (system(MFW_REC_F-FT-B) * (system(EFW_F-FT3) +
     system(EFW_REC_F-FT-T-B)))))) * system(/HPI_FTS) * system(RCP_INADV_TRIP)  then
   GlobalPartition = "TH-62-Y";

elsif init(LMC) * system(/PORV_ISO_F-10) * system(TBV_SO_FI-TRUE) * system(TBV_4SO) *
     system(TBV_SO_FI-TRUE) * ((system(/MFW_TRIP0-FALSE) * (system(EFW_F-FT3) +
     system(EFW_REC_F-FT-T-B))) + (system(MFW_TRIP0-FALSE) *
    (system(/MFW_REC_F-FT-B) + (system(MFW_REC_F-FT-B) * (system(EFW_F-FT3) +
     system(EFW_REC_F-FT-T-B)))))) * system(/HPI_FTS) * system(RCP_INADV_TRIP)  then
   GlobalPartition = "TH-62-Y";

| Bin 25-Y

elsif init(LMC) * system(/PORV_SRV_SO-FT) * system(TBV_4SO) *
     system(TBV_SO_FI-TRUE) * system(/MFW_TRIP0-FALSE) * (system(EFW_F-FT3) +
     system(EFW_REC_F-FT-T-B)) * system(/HPI_FTS) * system(/RCP_INADV_TRIP) *
     system(HPI_TF_FT-AB)  then
   GlobalPartition = "TH-25-Y";
```

Table 4.7. LMC event tree sequence partitioning rules.

```
elsif init(LMC) * system(/PORV_SRV_SO-FT) * system(TBV_4SO) *
    system(TBV_SO_FI-TRUE) * system(MFW_TRIP0-FALSE) *
    (system(/MFW_REC_F-FT-B) + system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B)) *
    system(/HPI_FTS) * system(/RCP_INADV_TRIP) * system(HPI_TF_FT-AB) then
  GlobalPartition = "TH-25-Y";

elsif init(LMC) * system(/PORV_ISO_F-10) * system(TBV_4SO) *
    system(TBV_SO_FI-TRUE) * system(/MFW_TRIP0-FALSE) * (system(EFW_F-FT3) +
    system(EFW_REC_F-FT-T-B)) * system(/HPI_FTS) *
    system(/RCP_INADV_TRIP) * system(HPI_TF_FT-D2) then
  GlobalPartition = "TH-25-Y";

elsif init(LMC) * system(/PORV_ISO_F-10) * system(TBV_4SO) *
    system(TBV_SO_FI-TRUE) * system(MFW_TRIP0-FALSE) *
    (system(/MFW_REC_F-FT-B) + system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B)) *
    system(/HPI_FTS) * system(/RCP_INADV_TRIP) * system(HPI_TF_FT-D2) then
  GlobalPartition = "TH-25-Y";

| Bin 27-Y

elsif init(LMC) * system(/PORV_SRV_SO-FT) * system(TBV_4SO) *
    system(TBV_SO_FI-TRUE) * system(/MFW_TRIP0-FALSE) * (system(EFW_F-FT3) +
    system(EFW_REC_F-FT-T-B)) * system(/HPI_FTS) * system(/RCP_INADV_TRIP) *
    system(/HPI_TF_FT-AB)  then
  GlobalPartition = "TH-27-Y";

elsif init(LMC) * system(/PORV_SRV_SO-FT) * system(TBV_4SO) *
    system(TBV_SO_FI-TRUE) * system(MFW_TRIP0-FALSE) *
    (system(/MFW_REC_F-FT-B) + system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B)) *
    system(/HPI_FTS) * system(/RCP_INADV_TRIP) * system(/HPI_TF_FT-AB) then
  GlobalPartition = "TH-27-Y";

elsif init(LMC) * system(/PORV_ISO_F-10) * system(TBV_4SO) *
    system(TBV_SO_FI-TRUE) * system(/MFW_TRIP0-FALSE) * (system(EFW_F-FT3) +
    system(EFW_REC_F-FT-T-B)) * system(/HPI_FTS) *
    system(/RCP_INADV_TRIP) * system(/HPI_TF_FT-D2) then
  GlobalPartition = "TH-27-Y";

elsif init(LMC) * system(/PORV_ISO_F-10) * system(TBV_4SO) *
```

Table 4.7. LMC event tree sequence partitioning rules.

```
     system(TBV_SO_FI-TRUE) * system(MFW_TRIP0-FALSE) *
     (system(/MFW_REC_F-FT-B) + system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B)) *
     system(/HPI_FTS) * system(/RCP_INADV_TRIP) * system(/HPI_TF_FT-D2) then
   GlobalPartition = "TH-27-Y";

| Bin 28-Y

elsif init(LMC) * system(/PORV_SRV_SO-FT) * system(TBV_1SO) *
     system(TBV_SO_FI-TRUE) * system(/MFW_TRIP0-FALSE) * (system(/EFW_F-FT4)  +
     system(EFW_F-FT3) + system(/EFW_REC_B-FT) + system(EFW_REC_F-FT-T-B)) *
     system(/HPI_FTS) * system(HPI_TF_FT-AB)  then
   GlobalPartition = "TH-28-Y";

elsif init(LMC) * system(/PORV_SRV_SO-FT) * system(TBV_1SO) *
     system(TBV_SO_FI-TRUE) * system(MFW_TRIP0-FALSE) *
     (system(/MFW_REC_F-FT-B) + system(/EFW_F-FT4)  + system(EFW_F-FT3) +
     system(/EFW_REC_B-FT) +  system(EFW_REC_F-FT-T-B)) *
     system(/HPI_FTS) * system(HPI_TF_FT-AB) then
   GlobalPartition = "TH-28-Y";

elsif init(LMC) * system(/PORV_ISO_F-10) * system(TBV_1SO) *
     system(TBV_SO_FI-TRUE) * system(/MFW_TRIP0-FALSE) * (system(/EFW_F-FT4) +
     system(EFW_F-FT3) + system(/EFW_REC_B-FT) + system(EFW_REC_F-FT-T-B)) *
     system(/HPI_FTS) * system(HPI_TF_FT-D2) then
   GlobalPartition = "TH-28-Y";

elsif init(LMC) * system(/PORV_ISO_F-10) * system(TBV_1SO) *
     system(TBV_SO_FI-TRUE) * system(MFW_TRIP0-FALSE) *
     (system(/MFW_REC_F-FT-B) + system(/EFW_F-FT4)  + system(EFW_F-FT3) +
     system(/EFW_REC_B-FT) + system(EFW_REC_F-FT-T-B)) *
     system(/HPI_FTS) * system(HPI_TF_FT-D2) then
   GlobalPartition = "TH-28-Y";

| Bin 29-Y

elsif init(LMC) * system(/PORV_SRV_SO-FT) * system(TBV_2SO) *
     system(TBV_SO_FI-TRUE) * system(/MFW_TRIP0-FALSE) * (system(EFW_F-FT3) +
     system(EFW_REC_F-FT-T-B)) * system(/HPI_FTS) * system(HPI_TF_FT-AB)  then
   GlobalPartition = "TH-29-Y";
```

Table 4.7. LMC event tree sequence partitioning rules.

```
elsif init(LMC) * system(/PORV_SRV_SO-FT) * system(TBV_2SO) *
     system(TBV_SO_FI-TRUE) * system(MFW_TRIP0-FALSE) *
     (system(/MFW_REC_F-FT-B) + system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B)) *
     system(/HPI_FTS) * system(HPI_TF_FT-AB) then
   GlobalPartition = "TH-29-Y";

elsif init(LMC) * system(/PORV_ISO_F-10) * system(TBV_2SO) *
     system(TBV_SO_FI-TRUE) * system(/MFW_TRIP0-FALSE) * (system(EFW_F-FT3) +
     system(EFW_REC_F-FT-T-B)) * system(/HPI_FTS) * system(HPI_TF_FT-D2) then
   GlobalPartition = "TH-29-Y";

elsif init(LMC) * system(/PORV_ISO_F-10) * system(TBV_2SO) *
     system(TBV_SO_FI-TRUE) * system(MFW_TRIP0-FALSE) *
     (system(/MFW_REC_F-FT-B) + system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B)) *
     system(/HPI_FTS) * system(HPI_TF_FT-D2) then
   GlobalPartition = "TH-29-Y";

| Bin 35-Y

elsif init(LMC) * system(/PORV_SRV_SO-FT) * system(TBV_1SO) *
     system(TBV_SO_FI-TRUE) * system(/MFW_TRIP0-FALSE) * (system(/EFW_F-FT4)  +
     system(EFW_F-FT3) + system(/EFW_REC_B-FT) + system(EFW_REC_F-FT-T-B)) *
     system(/HPI_FTS) * system(/HPI_TF_FT-AB)  then
   GlobalPartition = "TH-35-N";

elsif init(LMC) * system(/PORV_SRV_SO-FT) * system(TBV_1SO) *
     system(TBV_SO_FI-TRUE) * system(MFW_TRIP0-FALSE) *
     (system(/MFW_REC_F-FT-B) + system(/EFW_F-FT4)  + system(EFW_F-FT3) +
     system(/EFW_REC_B-FT) +  system(EFW_REC_F-FT-T-B)) *
     system(/HPI_FTS) * system(/HPI_TF_FT-AB) then
   GlobalPartition = "TH-35-N";

elsif init(LMC) * system(/PORV_ISO_F-10) * system(TBV_1SO) *
     system(TBV_SO_FI-TRUE) * system(/MFW_TRIP0-FALSE) * (system(/EFW_F-FT4) +
     system(EFW_F-FT3) + system(/EFW_REC_B-FT) + system(EFW_REC_F-FT-T-B)) *
     system(/HPI_FTS) * system(/HPI_TF_FT-D2) then
   GlobalPartition = "TH-35-N";
```

Table 4.7. LMC event tree sequence partitioning rules.

```
elsif init(LMC) * system(/PORV_ISO_F-10) * system(TBV_1SO) *
     system(TBV_SO_FI-TRUE) * system(MFW_TRIP0-FALSE) *
     (system(/MFW_REC_F-FT-B) + system(/EFW_F-FT4)  + system(EFW_F-FT3) +
     system(/EFW_REC_B-FT) + system(EFW_REC_F-FT-T-B)) *
     system(/HPI_FTS) * system(/HPI_TF_FT-D2) then
   GlobalPartition = "TH-35-N";

| Bin 36-Y

elsif init(LMC) * system(/PORV_SRV_SO-FT) * system(TBV_2SO) *
     system(TBV_SO_FI-TRUE) * system(/MFW_TRIP0-FALSE) * (system(EFW_F-FT3) +
     system(EFW_REC_F-FT-T-B)) * system(/HPI_FTS) * system(/HPI_TF_FT-AB)  then
   GlobalPartition = "TH-36-Y";

elsif init(LMC) * system(/PORV_SRV_SO-FT) * system(TBV_2SO) *
     system(TBV_SO_FI-TRUE) * system(MFW_TRIP0-FALSE) *
     (system(/MFW_REC_F-FT-B) + system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B)) *
     system(/HPI_FTS) * system(/HPI_TF_FT-AB) then
   GlobalPartition = "TH-36-Y";

elsif init(LMC) * system(/PORV_ISO_F-10) * system(TBV_2SO) *
     system(TBV_SO_FI-TRUE) * system(/MFW_TRIP0-FALSE) * (system(EFW_F-FT3) +
     system(EFW_REC_F-FT-T-B)) * system(/HPI_FTS) * system(/HPI_TF_FT-D2) then
   GlobalPartition = "TH-36-Y";

elsif init(LMC) * system(/PORV_ISO_F-10) * system(TBV_2SO) *
     system(TBV_SO_FI-TRUE) * system(MFW_TRIP0-FALSE) *
     (system(/MFW_REC_F-FT-B) + system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B)) *
     system(/HPI_FTS) * system(/HPI_TF_FT-D2) then
   GlobalPartition = "TH-36-Y";

| Bin 8-Y

elsif init(LMC) * system(PORV_ISO_F-10) * system(TBV_1SO) * system(TBV_SO_FI-TRUE) *
     system(/HPI_FTS) * system(HPI_TF_FT-AB) then
   GlobalPartition = "TH-08-Y";

| Bin 12-Y
```

Table 4.7. LMC event tree sequence partitioning rules.

```
elsif init(LMC) * system(PORV_ISO_F-10) * system(TBV_1SO) * system(TBV_SO_FI-TRUE) *
    system(/HPI_FTS) * system(/HPI_TF_FT-AB) then
  GlobalPartition = "TH-12-Y";

| Bin 9-Y

elsif init(LMC) * system(PORV_ISO_F-10) * system(TBV_2SO) * system(TBV_SO_FI-TRUE) *
    system(/HPI_FTS) * system(HPI_TF_FT-AB) then
  GlobalPartition = "TH-09-Y";

| Bin 13-Y

elsif init(LMC) * system(PORV_ISO_F-10) * system(TBV_2SO) * system(TBV_SO_FI-TRUE) *
    system(/HPI_FTS) * system(/HPI_TF_FT-AB) then
  GlobalPartition = "TH-13-Y";

elsif init(LMC) * system(PORV_ISO_F-10) * system(TBV_4SO) * system(TBV_SO_FI-TRUE) *
    system(/HPI_FTS) * system(/HPI_TF_FT-AB) then
  GlobalPartition = "TH-13-Y";

| Bin 10-Y

elsif init(LMC) * system(PORV_ISO_F-10) * system(TBV_4SO) * system(TBV_SO_FI-TRUE) *
    system(/HPI_FTS) * system(HPI_TF_FT-AB) then
  GlobalPartition = "TH-10-Y";

| Bin 41-Y

elsif init(LMC) * system(/SRV_ISO_F) * system(CBP_F-TRUE) *
    system(/HPI_STARTS_F-FT1) then
  GlobalPartition = "TH-41-Y";

elsif init(LMC) * system(/SRV_ISO_F) * system(/HPI_FTS) then
  GlobalPartition = "TH-41-Y";

elsif init(LMC) * system(/SRV_ISO_F) * system(/HPI_STARTS_F-FT1) then
  GlobalPartition = "TH-41-Y";

| Bin 34-Y
```

Table 4.7. LMC event tree sequence partitioning rules.

```
elsif init(LMC) *system(SRV_ISO_F) * system(CBP_F-TRUE) *
      system(/HPI_STARTS_F-FT1) then
    GlobalPartition = "TH-34-Y";

elsif init(LMC) *system(SRV_ISO_F) * system(/HPI_FTS) then
    GlobalPartition = "TH-34-Y";

elsif init(LMC) *system(SRV_ISO_F) * system(/HPI_STARTS_F-FT1) then
    GlobalPartition = "TH-34-Y";

else
    GlobalPartition = "TH-DUMMY";
endif
```

Table 4.8. LOCA event tree sequence partitioning rules.

```
| Map all LOCA sequences (LOCA1, LOCA2, and LOCA3) into TH bins

| Bin 03

if init(LOCA) * (system(/TBV_SO-FT) * (system(/HPI_FTS) + system(/HPI_STARTS_F-FT1))) then
   GlobalPartition = "TH-03-Y";

| Bin 04

elsif init(LOCA) * ((system(TBV_1SO) + system(TBV_2SO) + system(TBV_4SO)) *
(system(/HPI_FTS) + system(/HPI_STARTS_F-FT1))) then
   GlobalPartition = "TH-04-Y";

| Bin 44

elsif init(LOCA) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

| Bin 15

elsif init(LOCA) * system(HPI_REC_F) then
   GlobalPartition = "TH-15-Y";
```

Table 4.8. LOCA event tree sequence partitioning rules.

```
| Bin CD

elsif init(LOCA) * system(HPI_STARTS_F-FT1) then
   GlobalPartition = "CD";

else
    GlobalPartition = "TH-DUMMY";

endif
```

Table 4.9. LOSP event trees sequence partitioning rules.

```
| Map LOSP1 sequences into TH bins
| Last modified 14 September 2001

| Bin 21

if init(LOSP) * (system(/EFW_F-FT) + system(/EFW_REC_E-FT)) then
    GlobalPartition = "TH-21-N";

|Bin 18

elsif init(LOSP) * (system(EFW_OVRFD_A) + system(EFW_OVRFD_AB))
                 * system(/EFW_REC_F-FT-T-E) * system(/HPI_FTS) then
    GlobalPartition = "TH-18-N";

|Bin 19

elsif init(LOSP) * (system(EFW_OVRFD_A) + system(EFW_OVRFD_AB)) *
       system(EFW_REC_F-FT-T-E) *
       system(/HPI_FTS) then
    GlobalPartition = "TH-19-N";

elsif init(LOSP) * system(EFW_FTS) * system(EFW_REC_F-FT-T-E) *
      system(/HPI_FTS) then
    GlobalPartition = "TH-19-N";
```

Table 4.9. LOSP event trees sequence partitioning rules.

```
|Bin 22

elsif init(LOSP) * system(EFW_REC_NONE) * system(SEC_COOLREC-LOSP) then
   GlobalPartition = "TH-22-N";

|Bin 47

elsif init(LOSP) * system(EFW_REC_NONE) * system(/SEC_COOLREC-LOSP)
                *system(HPI_TF_FT-E) then
GlobalPartition = "TH-47-N";

|Bin 48

elsif init(LOSP) * system(EFW_REC_NONE) * system(/SEC_COOLREC-LOSP)
                * system(/HPI_TF_FT-E) then
GlobalPartition = "TH-48-N";

|Bin 61

elsif init(LOSP) * system(TBV_4SO) *
    (system(/EFW_F-FT4) + system(/EFW_REC_B-FT)) * system(/HPI_FTS) then
   GlobalPartition = "TH-61-N";

|Bin 28

elsif init(LOSP) * system(TBV_1SO) * system(HPI_TF_FT-AB) then
   GlobalPartition = "TH-28-Y";

|Bin 35

elsif init(LOSP) * system(TBV_1SO) * system(/HPI_TF_FT-AB) then
   GlobalPartition = "TH-35-N";

| Bin 57

elsif init(LOSP) * system(TBV_2SO)
                 * (system(/EFW_F-FT4) + system(/EFW_REC_B-FT))
                  *system(HPI_TF_FT-AB) then
   GlobalPartition = "TH-57-Y";
```

Table 4.9. LOSP event trees sequence partitioning rules.

```
|Bin 59

elsif init(LOSP) * system(TBV_2SO)
        * (system(/EFW_F-FT4) + system(/EFW_REC_B-FT))
          *system(/HPI_TF_FT-AB) then
   GlobalPartition = "TH-59-Y";

|Bin 29

elsif init(LOSP) * system(TBV_2SO)
        * (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B))
         *system(HPI_TF_FT-AB) then
   GlobalPartition = "TH-29-Y";

|Bin 36

elsif init(LOSP) * system(TBV_2SO)
        * (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B))
         *system(/HPI_TF_FT-AB) then
   GlobalPartition = "TH-36-Y";

|Bin 62

elsif init(LOSP) * system(TBV_4SO) *
    (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B)) *
    system(/HPI_FTS) then
   GlobalPartition = "TH-62-Y";

|Bin 44

elsif init(LOSP) * (system(/EFW_F-FT4) + system(EFW_F-FT3)
        + system(/EFW_REC_F-FT-T-E) + system(EFW_REC_F-FT-T-E)
          + system(/EFW_REC_B-FT) + system(EFW_REC_F-FT-T-B))
            * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

|Bin 15
```

Table 4.9. LOSP event trees sequence partitioning rules.

```
elsif init(LOSP) * (system(/EFW_F-FT4) + system(EFW_F-FT3)
                + system(/EFW_REC_F-FT-T-E) + system(EFW_REC_F-FT-T-E)
                 + system(/EFW_REC_B-FT) + system(EFW_REC_F-FT-T-B))
                   * system(HPI_REC_F) then
    GlobalPartition = "TH-15-Y";

|Bin CD

elsif init(LOSP) * system(EFW_REC_NONE) * system(HPI_FTS) then
    GlobalPartition = "CD";

else
   GlobalPartition = "TH-DUMMY";

endif
```

```
| Map LOSP2 sequences into TH bins
| Last modified 18 September 2001

|Bin 08

if init(LOSP) * system(PORV_SO) * system(PORV_SELF_CLOSE) * system(TBV_1SO)
            *(system(/EFW_F-FT4) + system(/EFW_REC_B-FT) +
              system(EFW_REC_F-FT-T-B) + system(EFW_F-FT3))
             * system(/HPI_FTS) * system(HPI_TF_FT-AB) then
   GlobalPartition = "TH-08-Y";

|Bin 09

elsif init(LOSP) * system(PORV_SO) * system(PORV_SELF_CLOSE) * system(TBV_2SO)
            *(system(/EFW_F-FT4) + system(/EFW_REC_B-FT) +
              system(EFW_REC_F-FT-T-B) + system(EFW_F-FT3)
                + (system(EFW_SLB_FTS) * system(EFW_REC_NONE)))
                 * system(/HPI_FTS)
                  * (system(HPI_TF_FT-AB) + system(HPI_TF_FT-E))then
   GlobalPartition = "TH-09-Y";

|Bin 10
```

Table 4.9. LOSP event trees sequence partitioning rules.

```
elsif init(LOSP) * system(PORV_SO) * system(PORV_SELF_CLOSE) * system(TBV_4SO)
            *(system(/EFW_F-FT4) + system(/EFW_REC_B-FT) +
             system(EFW_REC_F-FT-T-B) + system(EFW_F-FT3)
               + (system(EFW_SLB_FTS) * system(EFW_REC_NONE)))
             * system(/HPI_FTS) * (system(HPI_TF_FT-AB) + system(HPI_TF_FT-E))then
   GlobalPartition = "TH-10-Y";

| Bin 21

elsif init(LOSP) * system(PORV_SO) * system(/PORV_SELF_CLOSE)
               * system(/TBV_SO-FT)
                *(system(/EFW_F-FT) + (system(EFW_FTS) * system(/EFW_REC_B-FT)))
                 * system(/HPI_FTS) then
   GlobalPartition = "TH-21-N";

|Bin 12

elsif init(LOSP) * system(PORV_SO) * system(PORV_SELF_CLOSE) * system(TBV_1SO)
            *(system(/EFW_F-FT4) + system(/EFW_REC_B-FT) +
              system(EFW_REC_F-FT-T-B) + system(EFW_F-FT3))
             * system(/HPI_FTS) * system(/HPI_TF_FT-AB) then
   GlobalPartition = "TH-12-Y";

|Bin 13

elsif init(LOSP) * system(PORV_SO) * system(PORV_SELF_CLOSE)
            * (system(TBV_2SO) + system(TBV_4SO))
            *((system(/EFW_F-FT4) + system(EFW_F-FT3))
              + (system(EFW_SLB_FTS) * (system(/EFW_REC_B-FT)
                                 + system(EFW_REC_F-FT-T-B))))
               * system(/HPI_FTS) * system(/HPI_TF_FT-AB) then
   GlobalPartition = "TH-13-Y";

elsif init(LOSP) * system(PORV_SO) * system(PORV_SELF_CLOSE)
               * (system(TBV_2SO) + system(TBV_4SO))
                * system(EFW_SLB_FTS) * system(EFW_REC_NONE) * system(/HPI_FTS)
                 * (system(SEC_COOLREC-LOSP) + system(/SEC_COOLREC-LOSP))
                  * (system(/HPI_TF_FT-E) + system(/HPI_TF_FT-AB)) then
   GlobalPartition = "TH-13-Y";
```

Table 4.9. LOSP event trees sequence partitioning rules.

```
|Bin 18

elsif init(LOSP) * system(PORV_SO) * system(/PORV_SELF_CLOSE)
            * (system(EFW_OVRFD_A) + system(EFW_OVRFD_AB))
             * system(/EFW_REC_F-FT-T-B) * system(/HPI_FTS) then
   GlobalPartition = "TH-18-N";

|Bin 19

elsif init(LOSP) * system(PORV_SO) * system(/PORV_SELF_CLOSE) * system(/TBV_SO-FT)
            * (system(EFW_OVRFD_A) + system(EFW_OVRFD_AB))
             * system(EFW_REC_F-FT-T-B) * system(/HPI_FTS) then
   GlobalPartition = "TH-19-N";

elsif init(LOSP) * system(PORV_SO) * system(/PORV_SELF_CLOSE) * system(/TBV_SO-FT)
            * system(EFW_FTS) * system(EFW_REC_F-FT-T-B)
             * system(/HPI_FTS) then
   GlobalPartition = "TH-19-N";

|Bin 22

elsif init(LOSP) * system(PORV_SO) * system(/PORV_SELF_CLOSE)
            * system(EFW_REC_NONE) * system(SEC_COOLREC-LOSP) then
   GlobalPartition = "TH-22-N";

elsif init(LOSP) * system(PORV_SO) * system(PORV_SELF_CLOSE) * system(/TBV_SO-FT)
            *(system(/EFW_F-FT) + system(EFW_OVRFD_A) + system(EFW_OVRFD_AB)
                + system(EFW_FTS)) * system(/HPI_FTS) then
   GlobalPartition = "TH-22-N";

elsif init(LOSP) * system(PORV_SO) * system(PORV_SELF_CLOSE)
            * system(TBV_1SO)
             * system(EFW_SLB_FTS) * system(EFW_REC_NONE)
             * system(/HPI_FTS) then
   GlobalPartition = "TH-22-N";

|Bin 47
```

Table 4.9. LOSP event trees sequence partitioning rules.

```
elsif init(LOSP) * system(PORV_SO) * system(/PORV_SELF_CLOSE)
               * system(EFW_REC_NONE) * system(/SEC_COOLREC-LOSP)
               *system(HPI_TF_FT-E) then
GlobalPartition = "TH-47-N";

|Bin 48

elsif init(LOSP) * system(PORV_SO) * system(/PORV_SELF_CLOSE)
               * system(EFW_REC_NONE) * system(/SEC_COOLREC-LOSP)
                 * system(/HPI_TF_FT-E) then
GlobalPartition = "TH-48-N";

|Bin 61

elsif init(LOSP) * system(PORV_SO) * system(/PORV_SELF_CLOSE) * system(TBV_4SO)
               * (system(/EFW_F-FT4) + system(/EFW_REC_B-FT))
                 * system(/HPI_FTS) then
   GlobalPartition = "TH-61-N";

|Bin 28

elsif init(LOSP) * system(PORV_SO) * system(/PORV_SELF_CLOSE)
               * system(TBV_1SO) * system(/HPI_FTS)* system(HPI_TF_FT-D1) then
   GlobalPartition = "TH-28-Y";

|Bin 35

elsif init(LOSP) * system(PORV_SO) * system(/PORV_SELF_CLOSE) * system(/HPI_FTS)
               * system(TBV_1SO) * system(/HPI_TF_FT-D1) then
   GlobalPartition = "TH-35-N";

| Bin 57

elsif init(LOSP) * system(PORV_SO) * system(/PORV_SELF_CLOSE) * system(TBV_2SO)
                * (system(/EFW_F-FT4) + system(/EFW_REC_B-FT))
                  * system(/HPI_FTS) * system(HPI_TF_FT-D1) then
   GlobalPartition = "TH-57-Y";

|Bin 59
```

Table 4.9. LOSP event trees sequence partitioning rules.

```
elsif init(LOSP) * system(PORV_SO) * system(/PORV_SELF_CLOSE) * system(TBV_2SO)
                 * (system(/EFW_F-FT4) + system(/EFW_REC_B-FT))
                  * system(/HPI_FTS) * system(/HPI_TF_FT-D1) then
    GlobalPartition = "TH-59-Y";

|Bin 29

elsif init(LOSP) * system(PORV_SO) * system(/PORV_SELF_CLOSE) * system(TBV_2SO)
                  * (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B))
                   * system(/HPI_FTS) * system(HPI_TF_FT-D1) then
    GlobalPartition = "TH-29-Y";

|Bin 36

elsif init(LOSP) * system(PORV_SO) * system(/PORV_SELF_CLOSE) * system(TBV_2SO)
                  * (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B))
                   * system(/HPI_FTS) * system(/HPI_TF_FT-D1) then
    GlobalPartition = "TH-36-Y";

|Bin 62

elsif init(LOSP) * system(PORV_SO) * system(/PORV_SELF_CLOSE) * system(TBV_4SO)
                 * (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B))
                  * system(/HPI_FTS) then
    GlobalPartition = "TH-62-Y";

|Bin 41

elsif init(LOSP) * system(SRV_SO) * system(/SRV_ISO_F) * system(/HPI_FTS) then
     GlobalPartition = "TH-41-Y";

|Bin 34

elsif init(LOSP) * system(SRV_SO) * system(SRV_ISO_F) * system(/HPI_FTS) then
     GlobalPartition = "TH-34-Y";

|Bin 44
```

Table 4.9. LOSP event trees sequence partitioning rules.

```
elsif init(LOSP) * system(PORV_SO) * system(/PORV_SELF_CLOSE)
                 * (system(/EFW_F-FT4) + system(EFW_F-FT3)
                  + system(/EFW_REC_F-FT-T-E) + system(EFW_REC_F-FT-T-E)
                    + system(/EFW_REC_B-FT) + system(EFW_REC_F-FT-T-B))
                        * system(/HPI_REC_F) then
    GlobalPartition = "TH-44-Y";

elsif init(LOSP) * system(HPI_FTS) * system(/HPI_REC_F) then
    GlobalPartition = "TH-44-Y";

|Bin 15

elsif init(LOSP) * system(PORV_SO) * system(/PORV_SELF_CLOSE)
                * (system(/EFW_F-FT4) + system(EFW_F-FT3)
                  + system(/EFW_REC_F-FT-T-E) + system(EFW_REC_F-FT-T-E)
                   + system(/EFW_REC_B-FT) + system(EFW_REC_F-FT-T-B))
                      * system(HPI_REC_F) then
    GlobalPartition = "TH-15-Y";

elsif init(LOSP) * system(HPI_FTS) * system(HPI_REC_F) then
    GlobalPartition = "TH-15-Y";

|Bin CD

elsif init(LOSP) * system(PORV_SO) * system(/PORV_SELF_CLOSE)
                 * system(EFW_REC_NONE) * system(HPI_FTS) then
    GlobalPartition = "CD";

elsif init(LOSP) * (system(PORV_SO) + system(SRV_SO)) * system(HPI_FTS) then
    GlobalPartition = "CD";

else
   GlobalPartition = "TH-DUMMY";

endif

| Mapping sequences into T/H bins
| Map SBO1 sequences into TH bins
```

Table 4.9. LOSP event trees sequence partitioning rules.

```
if init(LOSP) * system(EAC_F) * system(/PORV_SRV_SO-FT) * system(/TBV_SO-FT) *
   system(/EFWTDP_F-FT) then
  GlobalPartition = "TH-21-N";

elsif init(LOSP) * system(EAC_F) * system(/PORV_SRV_SO-FT) * system(/TBV_SO-FT) *
   system(EFWTDP_FTS) * system(/EFW_REC_E-FT) then
  GlobalPartition = "TH-21-N";

elsif init(LOSP) * system(EAC_F) * system(/PORV_SRV_SO-FT) * system(/TBV_SO-FT) *
   system(EFWTDP_FTS) * system(EFW_REC_NONE) then
  GlobalPartition = "CD";

else
    GlobalPartition = "TH-15-Y";
endif
```

Table 4.10. MLOCA event tree sequence partitioning rules.

```
| Mapping sequences into T/H bins
| Map MLOCA sequences into TH bins
| Last Modified January 28, 2002
|

| Bin MLOCA

if init(MLOCA) then
   GlobalPartition = "TH-MLOCA-Y";
endif
```

Table 4.11. RT1 event tree sequence partitioning rules.

```
| Mapping sequences into T/H bins
| Map RTTT sequences into TH bins
| Last Modified September 14, 2001
|
|Macros
|
M-A = system(/PORV_SRV_SO-FT) * system(/TBV_SO-FT);
```

Table 4.11. RT1 event tree sequence partitioning rules.

```
M-MFW1 = system(MFW_TRIP0) + system(MFW_OVRFD_A) + system(MFW_OVRFD_AB);

M-TBV1 = system(TBV_1SO) + system(TBV_2SO) + system(TBV_4SO);

M-TBV2 = system(/TBV_ISO_F-FT7);

M-TBV-S = system(/TBV_ISO_F-FT7) + system(/TBV_ISO_F-FT8) + system(/TBV_ISO_F-FT9);

M-B1 = system(/PORV_SRV_SO-FT) * M-TBV-S;

M-EFW1 = system(EFW_OVRFD_A) + system(EFW_OVRFD_AB);

M-TBV-S1 = system(TBV_1SO) * system(/TBV_ISO_F-FT7);

M-TBV-S2 = system(TBV_2SO) * system(/TBV_ISO_F-FT8);

M-TBV-S4 = system(TBV_4SO) * system(/TBV_ISO_F-FT9);

M-B2 = (system(PORV_SO) * system(/PORV_ISO_F-10)) * M-TBV-S;

M-B2F1 = system(PORV_SO) * system(PORV_ISO_F-10) * system(/TBV_SO-FT);

M-B2F = (system(PORV_SO) * system(PORV_ISO_F-10)) * M-TBV-S;

M-C = system(PORV_SO) * system(/PORV_ISO_F-10) * system(/TBV_SO-FT);

| Bin 21

if (init(RTTT) * M-A) * (system(/MFW_F-FT) + (M-MFW1 * system(/EFW_F-FT)) +
(M-MFW1 * (system(EFW_FTS) * system(/EFW_REC_A-FT)))) then
   GlobalPartition = "TH-21-N";

| Bin 33-N

elsif (init(RTTT) * (M-B1 + M-B2)) * (system(/MFW_F-FT) + system(/EFW_F-FT) +
      system(/EFW_REC_B-FT))then
    GlobalPartition = "TH-33-N";
```

Table 4.11. RT1 event tree sequence partitioning rules.

```
elsif ((init(RTTT) * (M-B1 + M-B2)) * (M-EFW1 + system(EFW_REC_F-FT-T-B)))*
      system(/HPI_FTS) then
    GlobalPartition = "TH-33-N";

| Bin 43-N

elsif (init(RTTT) * M-C) * (system(/MFW_F-FT) + (M-MFW1 * system(/EFW_F-FT)) +
(M-MFW1 * system(EFW_FTS) * system(/EFW_REC_B-FT))) then
   GlobalPartition = "TH-43-N";

|Bin 18-N

elsif (init(RTTT) * M-C) * (M-EFW1 *system(/EFW_REC_F-FT-T-B)) *
      system(/HPI_FTS) then
   GlobalPartition = "TH-18-N";

elsif (init(RTTT) * M-A) * (M-EFW1 *system(/EFW_REC_F-FT-T-A)) *
      system(/HPI_FTS) then
   GlobalPartition = "TH-18-N";

|Bin 19-N

elsif (init(RTTT) * M-C) * (M-EFW1 * system(EFW_REC_F-FT-T-B) +
      system(EFW_FTS) * system(EFW_REC_F-FT-T-B)) *
      system(/HPI_FTS) then
   GlobalPartition = "TH-19-N";

elsif (init(RTTT) * M-A) * (M-EFW1 * system(EFW_REC_F-FT-T-A) +
      system(EFW_FTS) * system(EFW_REC_F-FT-T-A)) *
      system(/HPI_FTS) then
   GlobalPartition = "TH-19-N";

| Bin 50

elsif init(RTTT) * (M-A + (M-B1 + M-B2) + M-C) * system(/CBP_F-FT2) then
   GlobalPartition = "TH-50-Y";

elsif init(RTTT) * (M-A + (M-B1 + M-B2) + M-C) * (system(CBP_OVRFD) *
     system(/HPI_FTS)) then
```

Table 4.11. RT1 event tree sequence partitioning rules.

```
   GlobalPartition = "TH-50-Y";

elsif init(RTTT) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
      system(TBV_ISO_F-FT7) * (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
      system(/HPI_FTS) then
    GlobalPartition = "TH-50-Y";

elsif init(RTTT) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
      system(TBV_ISO_F-FT8) * (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
      system(/HPI_FTS)  then
    GlobalPartition = "TH-50-Y";

elsif init(RTTT) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
      system(TBV_ISO_F-FT9) * (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
      system(/HPI_FTS) then
    GlobalPartition = "TH-50-Y";

elsif init(RTTT) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT7) *
      (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
      system(/HPI_FTS) then
    GlobalPartition = "TH-50-Y";

elsif init(RTTT) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT8) *
      (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
      system(/HPI_FTS) then
    GlobalPartition = "TH-50-Y";

elsif init(RTTT) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT9) *
      (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
      system(/HPI_FTS) then
    GlobalPartition = "TH-50-Y";

elsif init(RTTT) * (M-B2F1 + M-B2F) * (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
      system(/HPI_FTS) then
    GlobalPartition = "TH-50-Y";

| Bin 23

elsif init(RTTT) * M-A * system(/MFW_REC_F-FT-A) * system(/HPI_FTS) then
```

Table 4.11. RT1 event tree sequence partitioning rules.

```
   GlobalPartition = "TH-23-N";

elsif init(RTTT) * (M-B1 + M-B2 + M-C) * system(/MFW_REC_F-FT-B) *
      system(/HPI_FTS) then
   GlobalPartition = "TH-23-N";

|elsif init(RTTT) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
|      system(TBV_ISO_F-FT9) * system(/MFW_REC_F-FT-B) then
|    GlobalPartition = "TH-23-N";

elsif init(RTTT) * (M-B2F1 + M-B2F) * system(/MFW_REC_F-FT-B) *
      system(/HPI_FTS) then
   GlobalPartition = "TH-23-N";

| Bin 44

elsif init(RTTT) * (M-A + (M-B1 + M-B2) + M-C) *
      system(HPI_FTS) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(RTTT) * (M-B2F1 + M-B2F + system(/SRV_ISO_F) + system(SRV_ISO_F)) *
      system(HPI_FTS) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(RTTT) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
      system(TBV_ISO_F-FT7) * (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
      system(HPI_FTS) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(RTTT) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
      system(TBV_ISO_F-FT8) * (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
      system(HPI_FTS) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

elsif init(RTTT) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
      system(TBV_ISO_F-FT9) * (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
      system(HPI_FTS) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";
```

Table 4.11. RT1 event tree sequence partitioning rules.

```
elsif init(RTTT) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT7) *
    (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
    system(HPI_FTS) * system(/HPI_REC_F) then
  GlobalPartition = "TH-44-Y";

elsif init(RTTT) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT8) *
    (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
    system(HPI_FTS) * system(/HPI_REC_F) then
  GlobalPartition = "TH-44-Y";

elsif init(RTTT) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT9) *
    (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
    system(HPI_FTS) * system(/HPI_REC_F) then
  GlobalPartition = "TH-44-Y";

elsif init(RTTT) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_ISO_F-FT7) * system(HPI_FTS) * system(/HPI_REC_F) then
  GlobalPartition = "TH-44-Y";

elsif init(RTTT) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_ISO_F-FT8) * (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B) +
    system(/MFW_REC_F-FT-B)) * system(HPI_FTS) * system(/HPI_REC_F) then
  GlobalPartition = "TH-44-Y";

elsif init(RTTT) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_ISO_F-FT8) * (system(/EFW_F-FT4) + system(/EFW_REC_B-FT) +
    system(/MFW_REC_F-FT-B)) * system(HPI_FTS) * system(/HPI_REC_F) then
  GlobalPartition = "TH-44-Y";

elsif init(RTTT) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_ISO_F-FT9) * (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B) +
    system(/MFW_REC_F-FT-B)) * system(HPI_FTS) * system(/HPI_REC_F) then
  GlobalPartition = "TH-44-Y";

elsif init(RTTT) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_ISO_F-FT9) * (system(/EFW_F-FT4) + system(/EFW_REC_B-FT)) *
    system(HPI_FTS) * system(/HPI_REC_F) then
  GlobalPartition = "TH-44-Y";
```

Table 4.11. RT1 event tree sequence partitioning rules.

```
elsif init(RTTT) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT7) *
    system(HPI_FTS) * system(/HPI_REC_F) then
  GlobalPartition = "TH-44-Y";

elsif init(RTTT) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT8) *
    system(HPI_FTS) * system(/HPI_REC_F) then
  GlobalPartition = "TH-44-Y";

elsif init(RTTT) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT8) *
    system(HPI_FTS) * system(/HPI_REC_F) then
  GlobalPartition = "TH-44-Y";

elsif init(RTTT) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT9) *
    system(HPI_FTS) * system(/HPI_REC_F) then
  GlobalPartition = "TH-44-Y";

elsif init(RTTT) * system(/SRV_ISO_F) * system(CBP_F-FT1) *
    system(HPI_STARTS_F-FT1) * system(/HPI_REC_F) then
  GlobalPartition = "TH-44-Y";

elsif init(RTTT) * system(/SRV_ISO_F) * system(HPI_FTS) *
    system(/HPI_REC_F) then
  GlobalPartition = "TH-44-Y";

elsif init(RTTT) *system(SRV_ISO_F) * system(CBP_F-FT1) *
    system(HPI_STARTS_F-FT1) * system(/HPI_REC_F) then
  GlobalPartition = "TH-44-Y";

elsif init(RTTT) *system(SRV_ISO_F) * system(HPI_FTS) *
    system(/HPI_REC_F) then
  GlobalPartition = "TH-44-Y";

| Bin 15

elsif init(RTTT) * (M-A + (M-B1 + M-B2) + M-C) *
    system(HPI_FTS) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(RTTT) * (M-B2F1 + M-B2F + system(/SRV_ISO_F) + system(SRV_ISO_F)) *
```

Table 4.11. RT1 event tree sequence partitioning rules.

```
    system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(RTTT) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_ISO_F-FT7) * (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
    system(HPI_FTS) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(RTTT) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_ISO_F-FT8) * (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
    system(HPI_FTS) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(RTTT) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_ISO_F-FT9) * (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
    system(HPI_FTS) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(RTTT) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT7) *
    (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
    system(HPI_FTS) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(RTTT) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT8) *
    (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
    system(HPI_FTS) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(RTTT) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT9) *
    (system(/CBP_F-FT2) + system(CBP_OVRFD)) *
    system(HPI_FTS) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(RTTT) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_ISO_F-FT7) * system(HPI_FTS) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(RTTT) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_ISO_F-FT8) * (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B) +
```

Table 4.11. RT1 event tree sequence partitioning rules.

```
    system(/MFW_REC_F-FT-B)) * system(HPI_FTS) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(RTTT) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_ISO_F-FT8) * (system(/EFW_F-FT4) + system(/EFW_REC_B-FT) +
    system(/MFW_REC_F-FT-B)) * system(HPI_FTS) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(RTTT) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_ISO_F-FT9) * (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B) +
    system(/MFW_REC_F-FT-B)) * system(HPI_FTS) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(RTTT) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_ISO_F-FT9) * (system(/EFW_F-FT4) + system(/EFW_REC_B-FT)) *
    system(HPI_FTS) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(RTTT) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT7) *
    system(HPI_FTS) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(RTTT) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT8) *
    system(HPI_FTS) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(RTTT) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT8) *
    system(HPI_FTS) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(RTTT) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT9) *
    system(HPI_FTS) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(RTTT) * system(/SRV_ISO_F) * system(CBP_F-FT1) *
    system(HPI_STARTS_F-FT1) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

elsif init(RTTT) * system(/SRV_ISO_F) * system(HPI_FTS) *
```

Table 4.11. RT1 event tree sequence partitioning rules.

```
    system(HPI_REC_F) then
   GlobalPartition = "TH-15-Y";

elsif init(RTTT) *system(SRV_ISO_F) * system(CBP_F-FT1) *
    system(HPI_STARTS_F-FT1) * system(HPI_REC_F)then
   GlobalPartition = "TH-15-Y";

elsif init(RTTT) *system(SRV_ISO_F) * system(HPI_FTS) *
    system(HPI_REC_F) then
   GlobalPartition = "TH-15-Y";

| Bin 22

elsif init(RTTT) * (M-A + (M-B1 + M-B2) + M-C) * system(CBP_F-FT1) *
    system(/HPI_STARTS_F-FT1) * system(SEC_COOLREC-ALL) then
   GlobalPartition = "TH-22-N";

elsif init(RTTT) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_ISO_F-FT7) * system(CBP_F-FT1) *
    system(/HPI_STARTS_F-FT1) * system(SEC_COOLREC-ALL) then
   GlobalPartition = "TH-22-N";

elsif init(RTTT) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_ISO_F-FT8) * system(CBP_F-FT1) *
    system(/HPI_STARTS_F-FT1) * system(SEC_COOLREC-ALL) then
   GlobalPartition = "TH-22-N";

elsif init(RTTT) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_ISO_F-FT9) * system(CBP_F-FT1) *
    system(/HPI_STARTS_F-FT1) * system(SEC_COOLREC-ALL) then
   GlobalPartition = "TH-22-N";

elsif init(RTTT) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT7) *
     system(CBP_F-FT1) *
    system(/HPI_STARTS_F-FT1) * system(SEC_COOLREC-ALL) then
   GlobalPartition = "TH-22-N";

elsif init(RTTT) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT8) *
     system(CBP_F-FT1) *
```

Table 4.11. RT1 event tree sequence partitioning rules.

```
    system(/HPI_STARTS_F-FT1) * system(SEC_COOLREC-ALL) then
  GlobalPartition = "TH-22-N";

elsif init(RTTT) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT9) *
     system(CBP_F-FT1) *
    system(/HPI_STARTS_F-FT1) * system(SEC_COOLREC-ALL) then
  GlobalPartition = "TH-22-N";

elsif init(RTTT) * (M-B2F1 + M-B2F) * (system(/MFW_F-FT) + system(/EFW_F-FT) +
    M-EFW1 + system(/EFW_REC_B-FT) + system(EFW_REC_F-FT-T-B)) *
    system(/HPI_FTS) then
  GlobalPartition = "TH-22-N";

elsif init(RTTT) * (M-B2F1 + M-B2F) * system(CBP_F-FT1) *
    system(SEC_COOLREC-ALL) then
  GlobalPartition = "TH-22-N";

| Bin 48

elsif init(RTTT) * (M-A + (M-B1 + M-B2) + M-C) * system(CBP_F-FT1) *
    system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
    system(/HPI_TF_FT-E) then
  GlobalPartition = "TH-48-N";

elsif init(RTTT) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_ISO_F-FT7) * system(CBP_F-FT1) *
    system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
    system(/HPI_TF_FT-E) then
  GlobalPartition = "TH-48-N";

elsif init(RTTT) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_ISO_F-FT8) * system(CBP_F-FT1) *
    system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
    system(/HPI_TF_FT-E) then
  GlobalPartition = "TH-48-N";

elsif init(RTTT) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
    system(TBV_ISO_F-FT9) * system(CBP_F-FT1) *
    system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
```

Table 4.11. RT1 event tree sequence partitioning rules.

```
     system(/HPI_TF_FT-E) then
   GlobalPartition = "TH-48-N";

elsif init(RTTT) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT7) *
      system(CBP_F-FT1) *
     system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
     system(/HPI_TF_FT-E) then
   GlobalPartition = "TH-48-N";

elsif init(RTTT) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT8) *
      system(CBP_F-FT1) *
     system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
     system(/HPI_TF_FT-E) then
   GlobalPartition = "TH-48-N";

elsif init(RTTT) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT9) *
      system(CBP_F-FT1) *
     system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
     system(/HPI_TF_FT-E) then
   GlobalPartition = "TH-48-N";

elsif init(RTTT) * (M-B2F1 + M-B2F) * system(CBP_F-FT1) *
     (system(/HPI_TF_FT-AB) + system(/HPI_TF_FT-C) + system(/HPI_TF_FT-D2) +
      system(/HPI_TF_FT-D1) + system(/HPI_TF_FT-E)) then
   GlobalPartition = "TH-48-N";

| Bin 47

elsif init(RTTT) * (M-A + (M-B1 + M-B2) + M-C) * system(CBP_F-FT1) *
     system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
     system(HPI_TF_FT-E) then
   GlobalPartition = "TH-47-N";

elsif init(RTTT) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_ISO_F-FT7) * system(CBP_F-FT1) *
     system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
     system(HPI_TF_FT-E) then
   GlobalPartition = "TH-47-N";
```

Table 4.11. RT1 event tree sequence partitioning rules.

```
elsif init(RTTT) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_ISO_F-FT8) * system(CBP_F-FT1) *
     system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
     system(HPI_TF_FT-E) then
   GlobalPartition = "TH-47-N";

elsif init(RTTT) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_ISO_F-FT9) * system(CBP_F-FT1) *
     system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
     system(HPI_TF_FT-E) then
   GlobalPartition = "TH-47-N";

elsif init(RTTT) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT7) *
      system(CBP_F-FT1) *
     system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
     system(HPI_TF_FT-E) then
   GlobalPartition = "TH-47-N";

elsif init(RTTT) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT8) *
      system(CBP_F-FT1) *
     system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
     system(HPI_TF_FT-E) then
   GlobalPartition = "TH-47-N";

elsif init(RTTT) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT9) *
      system(CBP_F-FT1) *
     system(/HPI_STARTS_F-FT1) * system(/SEC_COOLREC-ALL) *
     system(HPI_TF_FT-E) then
   GlobalPartition = "TH-47-N";

elsif init(RTTT) * (M-B2F1 + M-B2F) * system(CBP_F-FT1) *
     (system(HPI_TF_FT-AB) + system(HPI_TF_FT-C) + system(HPI_TF_FT-D2) +
      system(HPI_TF_FT-D1) + system(HPI_TF_FT-E)) then
   GlobalPartition = "TH-47-N";

| Bin CD

elsif init(RTTT) * (M-A + (M-B1 + M-B2) + M-C) * system(CBP_F-FT1) *
     system(HPI_STARTS_F-FT1) then
```

Table 4.11. RT1 event tree sequence partitioning rules.

```
   GlobalPartition = "CD";

elsif init(RTTT) * system(/SRV_ISO_F) * system(CBP_F-FT1) *
      system(HPI_STARTS_F-FT1) then
   GlobalPartition = "CD";

elsif init(RTTT) *system(SRV_ISO_F) * system(CBP_F-FT1) *
      system(HPI_STARTS_F-FT1) then
   GlobalPartition = "CD";

elsif init(RTTT) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
      system(TBV_ISO_F-FT7) * system(CBP_F-FT1) * system(HPI_STARTS_F-FT1) then
   GlobalPartition = "CD";

elsif init(RTTT) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
      system(TBV_ISO_F-FT8) * system(CBP_F-FT1) * system(HPI_STARTS_F-FT1) then
   GlobalPartition = "CD";

elsif init(RTTT) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
      system(TBV_ISO_F-FT9) * system(CBP_F-FT1) * system(HPI_STARTS_F-FT1) then
   GlobalPartition = "CD";

elsif init(RTTT) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT7) *
       system(CBP_F-FT1) * system(HPI_STARTS_F-FT1) then
   GlobalPartition = "CD";

elsif init(RTTT) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT8) *
       system(CBP_F-FT1) * system(HPI_STARTS_F-FT1) then
   GlobalPartition = "CD";

elsif init(RTTT) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT9) *
       system(CBP_F-FT1) * system(HPI_STARTS_F-FT1) then
   GlobalPartition = "CD";

elsif init(RTTT) * ((M-B2F1 + M-B2F) * system(CBP_F-FT1) + system(/SRV_ISO_F) +
      system(SRV_ISO_F)) * system(HPI_STARTS_F-FT1) then
   GlobalPartition = "CD";

| Bin 28
```

Table 4.11. RT1 event tree sequence partitioning rules.

```
elsif init(RTTT) * (system(/PORV_SRV_SO-FT) * system(TBV_ISO_F-FT7) *
    system(/HPI_FTS) * system(HPI_TF_FT-AB)) + (system(/PORV_ISO_F-10) *
    system(TBV_ISO_F-FT7) * system(HPI_TF_FT-D2)) then
  GlobalPartition = "TH-28-Y";

| Bin 35

elsif init(RTTT) * (system(/PORV_SRV_SO-FT) * system(TBV_ISO_F-FT7) *
    system(/HPI_FTS) * system(/HPI_TF_FT-AB)) + (system(/PORV_ISO_F-10) *
    system(TBV_ISO_F-FT7) * system(/HPI_TF_FT-D2)) then
  GlobalPartition = "TH-35-N";

| Bin 29

elsif init(RTTT) * (system(/PORV_SRV_SO-FT) *
    system(TBV_ISO_F-FT8) * (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B) +
    system(/MFW_REC_F-FT-B)) * system(/HPI_FTS) * system(HPI_TF_FT-AB)) +
    (system(/PORV_ISO_F-10) * system(TBV_ISO_F-FT8) * (system(EFW_F-FT3) +
    system(EFW_REC_F-FT-T-B) + system(/MFW_REC_F-FT-B)) * system(/HPI_FTS) *
    system(HPI_TF_FT-D2))  then
  GlobalPartition = "TH-29-Y";

| Bin 36

elsif init(RTTT) * (system(/PORV_SRV_SO-FT) *
    system(TBV_ISO_F-FT8) * (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B) +
    system(/MFW_REC_F-FT-B)) * system(/HPI_FTS) * system(/HPI_TF_FT-AB)) +
    (system(/PORV_ISO_F-10) * system(TBV_ISO_F-FT8) * (system(EFW_F-FT3) +
    system(EFW_REC_F-FT-T-B) + system(/MFW_REC_F-FT-B)) * system(/HPI_FTS) *
    system(/HPI_TF_FT-D2)) then
  GlobalPartition = "TH-36-Y";

|Bin 57

elsif init(RTTT) * (system(/PORV_SRV_SO-FT) *
    system(TBV_ISO_F-FT8) * (system(/EFW_F-FT4) + system(/EFW_REC_B-FT) +
    system(/MFW_REC_F-FT-B)) * system(/HPI_FTS) * system(HPI_TF_FT-AB)) +
    (system(/PORV_ISO_F-10) * system(TBV_ISO_F-FT8) * (system(/EFW_F-FT4) +
```

Table 4.11. RT1 event tree sequence partitioning rules.

```
    system(/EFW_REC_B-FT) + system(/MFW_REC_F-FT-B)) * system(/HPI_FTS) *
    system(HPI_TF_FT-D2))  then
  GlobalPartition = "TH-57-Y";

|Bin 59

elsif init(RTTT) * (system(/PORV_SRV_SO-FT) *
    system(TBV_ISO_F-FT8) * (system(/EFW_F-FT4) + system(/EFW_REC_B-FT) +
    system(/MFW_REC_F-FT-B)) * system(/HPI_FTS) * system(/HPI_TF_FT-AB)) +
    (system(/PORV_ISO_F-10) * system(TBV_ISO_F-FT8) * (system(/EFW_F-FT4) +
    system(/EFW_REC_B-FT) + system(/MFW_REC_F-FT-B)) * system(/HPI_FTS) *
    system(/HPI_TF_FT-D2))  then
  GlobalPartition = "TH-59-Y";

| Bin 25

elsif init(RTTT) * (system(/PORV_SRV_SO-FT) *
    system(TBV_ISO_F-FT9) * (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B) +
    system(/MFW_REC_F-FT-B)) * system(/HPI_FTS) * system(HPI_TF_FT-AB) *
    system(/RCP_INADV_TRIP)) + (system(/PORV_ISO_F-10) * system(TBV_ISO_F-FT9) *
   (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B) +
    system(/MFW_REC_F-FT-B)) * system(/HPI_FTS) * system(HPI_TF_FT-D2) *
    system(/RCP_INADV_TRIP))  then
  GlobalPartition = "TH-25-Y";

| Bin 27

elsif init(RTTT) * (system(/PORV_SRV_SO-FT) *
    system(TBV_ISO_F-FT9) * (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B) +
    system(/MFW_REC_F-FT-B)) * system(/HPI_FTS) * system(/HPI_TF_FT-AB) *
    system(/RCP_INADV_TRIP)) + (system(/PORV_ISO_F-10) * system(TBV_ISO_F-FT9) *
   (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B) +
    system(/MFW_REC_F-FT-B)) * system(/HPI_FTS) * system(/HPI_TF_FT-D2) *
    system(/RCP_INADV_TRIP))  then
  GlobalPartition = "TH-27-Y";

| Bin 62

elsif init(RTTT) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
```

Table 4.11. RT1 event tree sequence partitioning rules.

```
     system(TBV_ISO_F-FT9) * (system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B) +
     system(/MFW_REC_F-FT-B)) * system(/HPI_FTS) * system(RCP_INADV_TRIP) then
   GlobalPartition = "TH-62-Y";

| Bin 61

elsif init(RTTT) * (system(/PORV_SRV_SO-FT) + system(/PORV_ISO_F-10)) *
     system(TBV_ISO_F-FT9) * (system(/EFW_F-FT4) + system(/EFW_REC_B-FT)) *
     system(/HPI_FTS) then
   GlobalPartition = "TH-61-N";

| Bin 8

elsif init(RTTT) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT7) *
     system(/HPI_FTS) * system(HPI_TF_FT-AB) then
   GlobalPartition = "TH-08-Y";

| Bin 12

elsif init(RTTT) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT7) *
     system(/HPI_FTS) * system(/HPI_TF_FT-AB) then
   GlobalPartition = "TH-12-Y";

| Bin 9

elsif init(RTTT) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT8) *
     system(/HPI_FTS) * system(HPI_TF_FT-AB) then
   GlobalPartition = "TH-09-Y";

| Bin 13

elsif init(RTTT) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT8) *
     system(/HPI_FTS) * system(/HPI_TF_FT-AB) then
   GlobalPartition = "TH-13-Y";

elsif init(RTTT) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT9) *
     system(/HPI_FTS) * system(/HPI_TF_FT-AB) then
   GlobalPartition = "TH-13-Y";
```

Table 4.11. RT1 event tree sequence partitioning rules.

```
| Bin 10

elsif init(RTTT) * system(PORV_ISO_F-10) * system(TBV_ISO_F-FT9) *
      system(/HPI_FTS) * system(HPI_TF_FT-AB) then
    GlobalPartition = "TH-10-Y";

| Bin 41

elsif init(RTTT) * system(/SRV_ISO_F) * system(CBP_F-FT1) *
      system(/HPI_STARTS_F-FT1) then
    GlobalPartition = "TH-41-Y";

elsif init(RTTT) * system(/SRV_ISO_F) * system(/HPI_FTS) then
    GlobalPartition = "TH-41-Y";

elsif init(RTTT) * system(/SRV_ISO_F) * system(/HPI_STARTS_F-FT1) then
    GlobalPartition = "TH-41-Y";

| Bin 34

elsif init(RTTT) *system(SRV_ISO_F) * system(CBP_F-FT1) *
      system(/HPI_STARTS_F-FT1) then
    GlobalPartition = "TH-34-Y";

elsif init(RTTT) *system(SRV_ISO_F) * system(/HPI_FTS) then
    GlobalPartition = "TH-34-Y";

elsif init(RTTT) *system(SRV_ISO_F) * system(/HPI_STARTS_F-FT1) then
    GlobalPartition = "TH-34-Y";

else
    GlobalPartition = "TH-DUMMY";
endif
```

Table 4.12. SGTR event tree sequence partitioning rules.

```
| Mapping sequences into T/H bins
| Map SGTR sequences into TH bins
| Last Modified September 23, 2001
```

Table 4.12. SGTR event tree sequence partitioning rules.

```
|
|Macros
|
M-A = system(/TBV_SO_SGTR-FT);

M-MFW1 = system(MFW_TRIP0) + system(MFW_OVRFD_A) + system(MFW_OVRFD_AB);

M-TBV1 = system(TBV_1SO_SGTR) + system(TBV_2SO_SGTR) + system(TBV_4SO_SGTR);

M-TBV2 = system(/TBV_ISO_F-FT3);

M-TBV-S = system(/TBV_ISO_F-FT3) + system(/TBV_ISO_F-FT5) + system(/TBV_ISO_F-FT6);

M-EFW1 = system(EFW_OVRFD_A) + system(EFW_OVRFD_AB);

M-TBV-S1 = system(TBV_1SO_SGTR) * system(/TBV_ISO_F-FT3);

M-TBV-S2 = system(TBV_2SO_SGTR) * system(/TBV_ISO_F-FT5);

M-TBV-S4 = system(TBV_4SO_SGTR) * system(/TBV_ISO_F-FT6);

| Bin 44

if init(SGTR) * system(/HPI_REC_F) then
   GlobalPartition = "TH-44-Y";

| Bin 15

elsif init(SGTR) * system(HPI_REC_F) then
   GlobalPartition = "TH-15-Y";

| Bin 40

elsif init(SGTR) * system(/TBV_SO_SGTR-FT) * system(/TBV_EX) * system(/RCS_SCM_F) *
      (system(/MFW_F-FT) + system(/EFW_F-FT) + system(/EFW_REC_B-FT)) then
   GlobalPartition = "TH-40-N";

elsif init(SGTR) * system(/RCS_SCM_F) * M-TBV-S * system(/TBV_EX) *
      (system(/MFW_F-FT) + system(/EFW_F-FT) + system(/EFW_REC_B-FT))
```

Table 4.12. SGTR event tree sequence partitioning rules.

```
then
   GlobalPartition = "TH-40-N";

| Bin 39

elsif init(SGTR) * (system(/TBV_SO_SGTR-FT) + M-TBV-S) * system(TBV_EX) * (system(/EFW_F-FT4) +
     system(EFW_F-FT3) + system(/EFW_REC_B-FT) +
     system(EFW_REC_F-FT-T-B) + system(/MFW_REC_F-FT-B)) *
     system(/HPI_FTS-FALSE) * system(/HPI_FTS) * system(/HPI_TF_FT-AB) then
   GlobalPartition = "TH-39-Y";
elsif init(SGTR) * (system(/TBV_SO_SGTR-FT) + M-TBV-S) * system(TBV_EX) * (system(/EFW_F-FT4) +
     system(EFW_F-FT3) + system(/EFW_REC_B-FT) +
     system(EFW_REC_F-FT-T-B) + system(/MFW_REC_F-FT-B)) *
     system(/HPI_FTS-FALSE) * system(/HPI_FTS) * system(HPI_TF_FT-AB) then
   GlobalPartition = "TH-39-Y";

elsif init(SGTR) * (system(/TBV_SO_SGTR-FT) + M-TBV-S) * system(TBV_EX) * (system(/EFW_F-FT4) +
     system(EFW_F-FT3) + system(/EFW_REC_B-FT) +
     system(EFW_REC_F-FT-T-B) + system(/MFW_REC_F-FT-B)) *
     system(/HPI_FTS-TRUE) * system(HPI_FTS) then
   GlobalPartition = "TH-39-Y";

elsif init(SGTR) * (system(TBV_1SO_SGTR) *
     system(TBV_ISO_F-FT3)) * (system(/EFW_F-FT4) + system(EFW_F-FT3) +
     system(/EFW_REC_B-FT) + system(EFW_REC_F-FT-T-B) +
     system(/MFW_REC_F-FT-B)) * system(/HPI_FTS) * system(/HPI_TF_FT-AB) then
   GlobalPartition = "TH-39-Y";

elsif init(SGTR) * (system(TBV_1SO_SGTR) *
     system(TBV_ISO_F-FT3)) * (system(/EFW_F-FT4) + system(EFW_F-FT3) +
     system(/EFW_REC_B-FT) + system(EFW_REC_F-FT-T-B) +
     system(/MFW_REC_F-FT-B)) * system(/HPI_FTS) * system(HPI_TF_FT-AB) then
   GlobalPartition = "TH-39-Y";

| Bin 9

elsif init(SGTR) * system(TBV_2SO_SGTR) * system(TBV_ISO_F-FT5) *
    (system(/EFW_F-FT4) +
     system(EFW_F-FT3) + system(/EFW_REC_B-FT) +
```

Table 4.12. SGTR event tree sequence partitioning rules.

```
    system(EFW_REC_F-FT-T-B) + system(/MFW_REC_F-FT-B)) *
    system(/HPI_FTS) *
    system(HPI_TF_FT-AB) then
  GlobalPartition = "TH-09-Y";

| Bin 13

elsif init(SGTR) * system(TBV_2SO_SGTR) * system(TBV_ISO_F-FT5) *
   (system(/EFW_F-FT4) +
    system(EFW_F-FT3) + system(/EFW_REC_B-FT) +
    system(EFW_REC_F-FT-T-B) + system(/MFW_REC_F-FT-B)) *
    system(/HPI_FTS) *
    system(/HPI_TF_FT-AB) then
  GlobalPartition = "TH-13-Y";

elsif init(SGTR) * system(TBV_4SO_SGTR) * system(TBV_ISO_F-FT6) *
   (system(/EFW_F-FT4) +
    system(EFW_F-FT3) + system(/EFW_REC_B-FT) +
    system(EFW_REC_F-FT-T-B) + system(/MFW_REC_F-FT-B)) *
    system(/HPI_FTS) *
    system(/HPI_TF_FT-AB) then
  GlobalPartition = "TH-13-Y";

| Bin 10

elsif init(SGTR) * system(TBV_4SO_SGTR) * system(TBV_ISO_F-FT6) *
   (system(/EFW_F-FT4) +
    system(EFW_F-FT3) + system(/EFW_REC_B-FT) +
    system(EFW_REC_F-FT-T-B) + system(/MFW_REC_F-FT-B)) *
    system(/HPI_FTS) *
    system(HPI_TF_FT-AB) then
  GlobalPartition = "TH-10-Y";

|Bin 18-N

elsif init(SGTR) * system(/RCS_SCM_F) *
     (M-EFW1 * system(/EFW_REC_F-FT-T-B)) *
     (system(/HPI_FTS-FALSE) + system(/HPI_FTS-TRUE)) then
  GlobalPartition = "TH-18-N";
```

Table 4.12. SGTR event tree sequence partitioning rules.

```
|Bin 19-N

elsif init(SGTR) * system(/RCS_SCM_F) * (M-EFW1 * system(EFW_REC_F-FT-T-B)) *
      (system(/HPI_FTS-FALSE) + system(/HPI_FTS-TRUE)) then
   GlobalPartition = "TH-19-N";

elsif init(SGTR) * system(/RCS_SCM_F) *
      system(EFW_FTS) * system(EFW_REC_F-FT-T-B) *
      (system(/HPI_FTS-FALSE) + system(/HPI_FTS-TRUE)) then
   GlobalPartition = "TH-19-N";

| Bin 50-Y

elsif init(SGTR) * system(/RCS_SCM_F) * system(/CBP_F-FT2) then
   GlobalPartition = "TH-50-Y";

elsif init(SGTR) * system(/RCS_SCM_F) * system(CBP_OVRFD) *
     (system(/HPI_FTS-FALSE) + system(/HPI_FTS-TRUE)) then
   GlobalPartition = "TH-50-Y";

elsif init(SGTR) * system(TBV_EX) * (system(/CBP_F-FT2) +
     system(CBP_OVRFD)) * (system(/HPI_FTS-FALSE) +
     system(/HPI_FTS-TRUE)) then
    GlobalPartition = "TH-50-Y";

elsif init(SGTR) * (system(TBV_1SO_SGTR) *
     system(TBV_ISO_F-FT3) + system(TBV_2SO_SGTR) *
     system(TBV_ISO_F-FT5) + system(TBV_4SO_SGTR) *
     system(TBV_ISO_F-FT6)) *
     (system(/CBP_F-FT2) + system(CBP_OVRFD)) * system(/HPI_FTS) then
    GlobalPartition = "TH-50-Y";

elsif init(SGTR) * system(PORV_SO_SGTR) * (system(/CBP_F-FT2) +
     system(CBP_OVRFD)) * (system(/HPI_FTS-FALSE) +
     system(/HPI_FTS-TRUE)) then
    GlobalPartition = "TH-50-Y";

| Bin 23
```

Table 4.12. SGTR event tree sequence partitioning rules.

```
elsif init(SGTR) * (system(/RCS_SCM_F) + system(PORV_SO_SGTR)) *
     system(/MFW_REC_F-FT-B) * (system(/HPI_FTS-FALSE) +
     system(/HPI_FTS-TRUE)) then
   GlobalPartition = "TH-23-N";

| Bin 22

elsif init(SGTR) * system(CBP_F-FT1) *
     system(SEC_COOLREC-ALL) then
   GlobalPartition = "TH-22-N";

elsif init(SGTR) * system(PORV_SO_SGTR) * (system(/MFW_F-FT) +
     system(/EFW_F-FT) + system(EFW_OVRFD_A) + system(EFW_OVRFD_AB) +
     (system(EFW_FTS) * (system(/EFW_REC_B-FT) + system(EFW_REC_F-FT-T-B))))
     * (system(/HPI_FTS-TRUE) + system(/HPI_FTS-FALSE)) then
   GlobalPartition = "TH-22-N";

| Bin 48

elsif init(SGTR) * system(CBP_F-FT1) *
     system(/SEC_COOLREC-ALL) *
     system(/HPI_TF_FT-E)  then
   GlobalPartition = "TH-48-N";

| Bin 47

elsif init(SGTR) * system(CBP_F-FT1) *
     system(/SEC_COOLREC-ALL) *
     system(HPI_TF_FT-E)  then
   GlobalPartition = "TH-47-N";

| Bin CD

elsif init(SGTR) * system(CBP_F-FT1) * system(HPI_STARTS_F-FT1) then
   GlobalPartition = "CD";

else
   GlobalPartition = "TH-DUMMY";
endif
```

Table 4.13. SLB1 event tree sequence partitioning rules.

```
| Mapping sequences into T/H bins
| Map SLB1 sequences into TH bins
| The following Macros are used

SLB-M1 = system(/EFW_F-FT4) + system(/EFW_REC_B-FT);
SLB-M2 = system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B) + system(/MFW_REC_F-FT-B);
SLB-M3 = system(/CBP_F-FT2) + system(CBP_OVRFD);
SLB-M4 = system(CBP_F-FT1);

| Bin 59

if init(SLB1) * SLB-M1 * system(/HPI_TF_FT-AB) then
  GlobalPartition = "TH-59-Y";

| Bin 57

elsif init(SLB1) * SLB-M1 * system(HPI_TF_FT-AB) then
  GlobalPartition = "TH-57-Y";

| Bin 36

elsif init(SLB1) * SLB-M2 * system(/HPI_TF_FT-AB) then
  GlobalPartition = "TH-36-Y";

| Bin 29

elsif init(SLB1) * SLB-M2 * system(HPI_TF_FT-AB) then
  GlobalPartition = "TH-29-Y";

| Bin 50

elsif init(SLB1) * SLB-M3 * (system(/HPI_TF_FT-AB) + system(HPI_TF_FT-AB)) then
  GlobalPartition = "TH-50-Y";

| Bin 44

elsif init(SLB1) * (SLB-M1 + SLB-M2 + SLB-M3) * system(/HPI_REC_F) then
  GlobalPartition = "TH-44-Y";
```

Table 4.13. SLB1 event tree sequence partitioning rules.

```
| Bin 15

elsif init(SLB1) * (SLB-M1 + SLB-M2 + SLB-M3) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";

| Bin 45

elsif init(SLB1) * SLB-M4 * system(/SEC_COOLREC-ALL) * system(/HPI_TF_FT-E) then
  GlobalPartition = "TH-45-N";

| Bin 47

elsif init(SLB1) * SLB-M4 * system(/SEC_COOLREC-ALL) * system(HPI_TF_FT-E) then
  GlobalPartition = "TH-47-N";

| Bin 22

elsif init(SLB1) * SLB-M4 * system(SEC_COOLREC-ALL) then
  GlobalPartition = "TH-22-N";

| Bin CD

elsif init(SLB1) * system(HPI_STARTS_F-FT1) then
  GlobalPartition = "CD";

else
   GlobalPartition = "TH-DUMMY";

endif
```

Table 4.14. SLB2 event tree sequence partitioning rules.

```
| Mapping sequences into T/H bins
| Map SLB2 sequences into TH bins
| The following Macros, defined for SLB1, are used here

SLB-M1 = system(/EFW_F-FT4) + system(/EFW_REC_B-FT);
SLB-M2 = system(EFW_F-FT3) + system(EFW_REC_F-FT-T-B) + system(/MFW_REC_F-FT-B);
SLB-M3 = system(/CBP_F-FT2) + system(CBP_OVRFD);
```

Table 4.14. SLB2 event tree sequence partitioning rules.

```
SLB-M4 = system(CBP_F-FT1);

| Bin 61

if init(SLB2) * SLB-M1 * (system(/HPI_TF_FT-AB) + system(HPI_TF_FT-AB)) then
  GlobalPartition = "TH-61-N";

| Bin 27

elsif init(SLB2) * SLB-M2 * system(/HPI_FTS) * system(/RCP_INADV_TRIP) *
system(/HPI_TF_FT-AB) then
  GlobalPartition = "TH-27-Y";

| Bin 25

elsif init(SLB2) * SLB-M2 * system(/HPI_FTS) * system(/RCP_INADV_TRIP) *
system(HPI_TF_FT-AB) then
  GlobalPartition = "TH-25-Y";

| Bin 62

elsif init(SLB2) * SLB-M2 * system(/HPI_FTS) * system(RCP_INADV_TRIP) then
  GlobalPartition = "TH-62-Y";

| Bin 50

elsif init(SLB2) * SLB-M3 * (system(/HPI_TF_FT-AB) + system(HPI_TF_FT-AB)) then
  GlobalPartition = "TH-50-Y";

| Bin 44

elsif init(SLB2) * (SLB-M1 + SLB-M2 + SLB-M3) * system(/HPI_REC_F) then
  GlobalPartition = "TH-44-Y";

| Bin 15

elsif init(SLB2) * (SLB-M1 + SLB-M2 + SLB-M3) * system(HPI_REC_F) then
  GlobalPartition = "TH-15-Y";
```

Table 4.14. SLB2 event tree sequence partitioning rules.

```
| Bin 45

elsif init(SLB2) * SLB-M4 * system(/SEC_COOLREC-ALL) * system(/HPI_TF_FT-E) then
   GlobalPartition = "TH-45-N";

| Bin 47

elsif init(SLB2) * SLB-M4 * system(/SEC_COOLREC-ALL) * system(HPI_TF_FT-E) then
   GlobalPartition = "TH-47-N";

| Bin 22

elsif init(SLB2) * SLB-M4 * system(SEC_COOLREC-ALL) then
   GlobalPartition = "TH-22-N";

| Bin CD

elsif init(SLB2) * system(HPI_STARTS_F-FT1) then
   GlobalPartition = "CD";

else
    GlobalPartition = "TH-DUMMY";

endif
```

Table 4.15. Initial set of TH bins created by application of binning rules.

Power		HZP	
Bin Identifier (Endstate Name)	**PTS Significant**	**Bin Identifier (Endstate Name)**	**PTS Significant**
TH-03-Y	Yes	TH-03-Y	Yes
TH-04-Y	Yes	TH-04-Y	Yes
TH-08-Y	Yes	TH-08-Y	Yes
TH-09-Y	Yes	TH-09-Y	Yes
TH-10-Y	Yes	TH-10-Y	Yes
TH-12-Y	Yes	TH-12-Y	Yes

Table 4.15. Initial set of TH bins created by application of binning rules.

Power		HZP	
Bin Identifier (Endstate Name)	**PTS Significant**	**Bin Identifier (Endstate Name)**	**PTS Significant**
TH-13-Y	Yes	TH-13-Y	Yes
TH-15-Y	Yes	TH-15-Y	Yes
TH-18-N	No	TH-18-N	No
TH-19-N	No	TH-19-N	No
TH-21-N	No	TH-21-N	No
TH-22-N	No	TH-22-N	No
TH-23-N	No	TH-23-N	No
TH-25-Y	Yes	TH-25-Y	Yes
TH-27-Y	Yes	TH-27-Y	Yes
TH-28-Y	Yes	TH-28-Y	Yes
TH-29-Y	Yes	TH-29-Y	Yes
TH-33-N	No	TH-33-N	No
TH-34-Y	Yes	TH-34-Y	Yes
TH-35-N	No	TH-35-Y	Yes
TH-36-Y	Yes	TH-36-Y	Yes
TH-39-Y	Yes	TH-39-Y	Yes
TH-40-N	No	TH-40-N	No
TH-41-Y	Yes	TH-41-Y	Yes
TH-43-N	No	TH-43-N	No
TH-44-Y	Yes	TH-44-Y	Yes
TH-45-N	No	TH-45-N	No
TH-47-N	No	TH-47-N	No
TH-48-N	No	TH-48-N	No
TH-50-Y	Yes	TH-50-Y	Yes
TH-57-Y	Yes	TH-57-Y	Yes
TH-59-Y	Yes	TH-59-Y	Yes
TH-61-N	No	TH-61-N	No
TH-62-Y	Yes	TH-62-Y	Yes
TH-LLOCA-Y	Yes	TH-LLOCA-Y	Yes
TH-MLOCA-Y	Yes	TH-MLOCA-Y	Yes

Table 4.16. Rules for slicing original power TH bin cut sets into new TH bins.

Original TH Bin	Action	New TH Bin
3	Slice cut sets with LOCA into	3-loca
4	Slice cut sets with LOCA and /HPI_TF_FT-AB into	12-loca
4	Slice cut sets with LOCA and HPI_TF-10AB into	8-loca-1
4	Slice cut sets with LOCA and HPI_TF-20AB into	8-loca-2
8	Slice cut sets with RTTT into	8-rttt
8	Slice cut sets with LOP-3KI into	8-3ki
8	Slice cut sets with LOP-3TC into	8-3tc
8	Slice cut sets with LOSP into	8-losp
9	No slice for SGTR cut sets	
12	Slice cut sets with RTTT into	12-rttt
12	Slice cut sets with LOP-3KI into	12-3ki
12	Slice cut sets with LOP-3TC into	12-3tc
12	Slice cut sets with LMC into	12-lmc
12	Slice cut sets with LOSP into	12-losp
13	No slice for RTTT, LOP-3KI, and LOP-3TC cut sets	
13	No slice for SGTR cut sets	
15	Slice cut sets with LOCA, HPI_FTS, and HPI_REC_F into	81-loca
15	Slice cut sets with RTTT and SRV_SO into	81-rttt
15	Slice cut sets with LOP-3KI and SRV_SO into	81-3ki
15	Slice cut sets with LOP-3TC and SRV_SO into	81-3tc
15	Slice cut sets with LIA and SRV_SO into	81-lia
15	Slice cut sets with LMC and SRV_SO into	81-lmc
15	Slice cut sets with LOSP and SRV_SO into	81-losp
15	Slice cut sets with RTTT and PORV_SO into	15-rttt
15	Slice cut sets with LOP-3KI and PORV_SO into	15-3ki
15	Slice cut sets with LOP-3TC and PORV_SO into	15-3tc
15	Slice cut sets with LIA and PORV_SO into	15-lia
15	Slice cut sets with LMC and PORV_SO into	15-lmc
15	Slice cut sets with LOSP and PORV_SO into	15-losp
15	No slice for SLB1 cut sets	
15	No slice for SLB2 cut sets	

Table 4.16. Rules for slicing original power TH bin cut sets into new TH bins.

Original TH Bin	Action	New TH Bin
15	Slice SGTR and PORV_SO_SGTR cut sets into	81-sgtr
25	Slice cut sets with SLB2 into	99-slb2
27	Slice cut sets with SLB2 into	27-slb2
28	Slice cut sets with RTTT and EFW_SLB_FI-10A into	28-rttt-1
28	Slice cut sets with LOP-3KI and EFW_SLB_FI-10A into	28-3ki-1
28	Slice cut sets with LOP-3TC and EFW_SLB_FI-10A into	28-3tc-1
28	Slice cut sets with LIA and EFW_SLB_FI-10A into	28-lia-1
28	Slice cut sets with LMC and EFW_SLB_FI-10A into	28-lmc-1
28	Slice cut sets with RTTT and EFW_REC_FL-30B into	28-rttt-2
28	Slice cut sets with LOP-3KI and EFW_REC_FL-30B into	28-3ki-2
28	Slice cut sets with LOP-3TC and EFW_REC_FL-30B into	28-3tc-2
28	Slice cut sets with LIA and EFW_REC_FL-30B into	28-lia-2
28	Slice cut sets with LMC and EFW_REC_FL-30B into	28-lmc-2
28	Slice cut sets with LOSP and EFW_SLB_FI-10A into	28-losp-1
28	Slice cut sets with LOSP and EFW_REC_FL-30B into	28-losp-2
29	Slice cut sets with RTTT into	29-rttt
29	Slice cut sets with LOP-3KI into	29-3ki
29	Slice cut sets with LOP-3TC into	29-3tc
29	Slice cut sets with LMC into	29-lmc
29	Slice cut sets with LOSP into	29-losp
	Create new basic events HPI_TF-10AB-SEC and HPI_TF-20AB-SEC	
29	Slice cut sets with SLB1 and HPI_TF-10AB into Edit cut sets, changing HPI_TF-10AB into HPI_TF-10AB-SEC	90-slb1
29	Slice cut sets with SLB1 and HPI_TF-20AB into Edit cut sets, changing HPI_TF-20AB into HPI_TF-20AB-SEC	29-slb1
34	Slice cut sets with RTTT into	34-rttt
34	Slice cut sets with LOP-3KI into	34-3ki
34	Slice cut sets with LOP-3TC into	34-3tc
34	Slice cut sets with LIA into	34-lia
34	Slice cut sets with LMC into	34-lmc
34	Slice cut sets with LOSP into	34-losp

Table 4.16. Rules for slicing original power TH bin cut sets into new TH bins.

Original TH Bin	Action	New TH Bin
36	Slice cut sets with RTTT into	36-rttt
36	Slice cut sets with LOP-3KI into	36-3ki
36	Slice cut sets with LOP-3TC into	36-3tc
36	Slice cut sets with LIA into	36-lia
36	Slice cut sets with LMC into	36-lmc
36	Slice cut sets with LOSP into	36-losp
	Create new fault tree HPI_TF_FT-AB-SEC from HPI_TF-10AB-SEC and HPI_TF-20AB-SEC	
36	Slice cut sets with SLB1 and /HPI_TF_FT-AB into Edit cut sets, changing /HPI_TF_FT-AB into /HPI_TF_FT-AB-SEC	36-slb1
39	Slice SGTR and RCP_TRIP into Edit cut sets, changing HPI_TF-10AB into HPI_TF-10AB-SEC Edit cut sets, changing HPI_TF-20AB into HPI_TF-20AB-SEC Edit cut sets, changing /HPI_TF_FT-AB into /HPI_TF_FT-AB-SEC	91-sgtr
	Create new basic event HPI_FT-1D1. Create new fault tree HPI_TF_FT-D1-N from HPI_FT-1D1, HPI_FT-10D1, and HPI_FT-20D1.	
41	Slice cut sets with RTTT and /HPI_TF_FT-D1 into Edit cut sets, changing /HPI_TF_FT-D1 into /HPI_TF_FT-D1-N	83-rttt-1 85-rttt-1
41	Slice cut sets with RTTT and /HPI_TF_FT-E into	83-rttt-2 85-rttt-2
41	Slice cut sets with RTTT and HPI_FT-10D1 into Edit cut sets, changing HPI_FT-10D1 to HPI_FT-1D1	84-rttt-1 86-rttt-1
41	Slice cut sets with RTTT and HPI_FT-10D1 into	41-rttt-1
41	Slice cut sets with RTTT and HPI_FT-02E into	41-rttt-2
41	Slice cut sets with RTTT and HPI_FT-03E into	41-rttt-3
41	Slice cut sets with LOP-3KI and /HPI_TF_FT-D1 into Edit cut sets, changing /HPI_TF_FT-D1 into /HPI_TF_FT-D1-N	83-3ki-1 85-3ki-1
41	Slice cut sets with LOP-3KI and /HPI_TF_FT-E into	83-3ki-2 85-3ki-2
41	Slice cut sets with LOP-3KI and HPI_FT-10D1 into Edit cut sets, changing HPI_FT-10D1 to HPI_FT-1D1	84-3ki-1 86-3ki-1
41	Slice cut sets with LOP-3KI and HPI_FT-10D1 into	41-3ki-1
41	Slice cut sets with LOP-3KI and HPI_FT-02E into	41-3ki-2
41	Slice cut sets with LOP-3KI and HPI_FT-03E into	41-3ki-3

Table 4.16. Rules for slicing original power TH bin cut sets into new TH bins.

Original TH Bin	Action	New TH Bin
41	Slice cut sets with LOP-3TC and /HPI_TF_FT-D1 into Edit cut sets, changing /HPI_TF_FT-D1 into /HPI_TF_FT-D1-N	83-3tc-1 85-3tc-1
41	Slice cut sets with LOP-3TC and /HPI_TF_FT-E into	83-3tc-2 85-3tc-2
41	Slice cut sets with LOP-3TC and HPI_FT-10D1 into Edit cut sets, changing HPI_FT-10D1 to HPI_FT-1D1	84-3tc-1 86-3tc-1
41	Slice cut sets with LOP-3TC and HPI_FT-10D1 into	41-3tc-1
41	Slice cut sets with LOP-3TC and HPI_FT-02E into	41-3tc-2
41	Slice cut sets with LOP-3TC and HPI_FT-03E into	41-3tc-3
41	Slice cut sets with LIA and /HPI_TF_FT-D1 into Edit cut sets, changing /HPI_TF_FT-D1 into /HPI_TF_FT-D1-N	83-lia-1 85-lia-1
41	Slice cut sets with LIA and /HPI_TF_FT-E into	83-lia-2 85-lia-2
41	Slice cut sets with LIA and HPI_FT-10D1 into Edit cut sets, changing HPI_FT-10D1 to HPI_FT-1D1	84-lia-1 86-lia-1
41	Slice cut sets with LIA and HPI_FT-10D1 into	41-lia-1
41	Slice cut sets with LIA and HPI_FT-02E into	41-lia-2
41	Slice cut sets with LIA and HPI_FT-03E into	41-lia-3
41	Slice cut sets with LMC and /HPI_TF_FT-D1 into Edit cut sets, changing /HPI_TF_FT-D1 into /HPI_TF_FT-D1-N	83-lmc-1 85-lmc-1
41	Slice cut sets with LMC and /HPI_TF_FT-E into	83-lmc-2 85-lmc-2
41	Slice cut sets with LMC and HPI_FT-10D1 into Edit cut sets, changing HPI_FT-10D1 to HPI_FT-1D1	84-lmc-1 86-lmc-1
41	Slice cut sets with LMC and HPI_FT-10D1 into	41-lmc-1
41	Slice cut sets with LMC and HPI_FT-02E into	41-lmc-2
41	Slice cut sets with LMC and HPI_FT-03E into	41-lmc-3
41	Slice cut sets with LOSP and /HPI_TF_FT-D1 into Edit cut sets, changing /HPI_TF_FT-D1 into /HPI_TF_FT-D1-N	83-losp-1 85-losp-1
41	Slice cut sets with LOSP and /HPI_TF_FT-E into	83-losp-2 85-losp-2
41	Slice cut sets with LOSP and HPI_FT-10D1 into Edit cut sets, changing HPI_FT-10D1 to HPI_FT-1D1	84-losp-1 86-losp-1
41	Slice cut sets with LOSP and HPI_FT-10D1 into	41-losp-1
41	Slice cut sets with LOSP and HPI_FT-02E into	41-losp-2
41	Slice cut sets with LOSP and HPI_FT-03E into	41-losp-3
44	Slice cut sets with LOCA and /HPI_REC_F into	82-loca

Table 4.16. Rules for slicing original power TH bin cut sets into new TH bins.

Original TH Bin	Action	New TH Bin
44	Slice cut sets with RTTT and SRV_ISO_F into	87-rttt
44	Slice cut sets with RTTT, /SRV_ISO_F, and /HPI_TF_FT-D1 into Edit cut sets, changing /HPI_TF_FT-D1 into /HPI_TF_FT-D1-N	88-rttt
44	Slice cut sets with RTTT, /SRV_ISO_F, and HPI_TF-10D1 into Edit cut sets, changing HPI_TF-10D1 into HPI_TF-1D1	44-rttt-1
44	Slice cut sets with RTTT, /SRV_ISO_F, and HPI_TF-10D1 into	44-rttt-2
44	Slice cut sets with LOP-3KI and SRV_ISO_F into	87-3ki
44	Slice cut sets with LOP-3KI, /SRV_ISO_F, and /HPI_TF_FT-D1 into Edit cut sets, changing /HPI_TF_FT-D1 into /HPI_TF_FT-D1-N	88-3ki
44	Slice cut sets with LOP-3KI, /SRV_ISO_F, and HPI_TF-10D1 into Edit cut sets, changing HPI_TF-10D1 into HPI_TF-1D1	44-3ki-1
44	Slice cut sets with LOP-3KI, /SRV_ISO_F, and HPI_TF-10D1 into	44-3ki-2
44	Slice cut sets with LOP-3TC and SRV_ISO_F into	87-3tc
44	Slice cut sets with LOP-3TC, /SRV_ISO_F, and /HPI_TF_FT-D1 into Edit cut sets, changing /HPI_TF_FT-D1 into /HPI_TF_FT-D1-N	88-3tc
44	Slice cut sets with LOP-3TC, /SRV_ISO_F, and HPI_TF-10D1 into Edit cut sets, changing HPI_TF-10D1 into HPI_TF-1D1	44-3tc-1
44	Slice cut sets with LOP-3TC, /SRV_ISO_F, and HPI_TF-10D1 into	44-3tc-2
44	Slice cut sets with LIA and SRV_ISO_F into	87-lia
44	Slice cut sets with LIA, /SRV_ISO_F, and /HPI_TF_FT-D1 into Edit cut sets, changing /HPI_TF_FT-D1 into /HPI_TF_FT-D1-N	88-lia
44	Slice cut sets with LIA, /SRV_ISO_F, and HPI_TF-10D1 into Edit cut sets, changing HPI_TF-10D1 into HPI_TF-1D1	44-lia-1
44	Slice cut sets with LIA, /SRV_ISO_F, and HPI_TF-10D1 into	44-lia-2
44	Slice cut sets with LMC and SRV_ISO_F into	87-lmc
44	Slice cut sets with LMC, /SRV_ISO_F, and /HPI_TF_FT-D1 into Edit cut sets, changing /HPI_TF_FT-D1 into /HPI_TF_FT-D1-N	88-lmc
44	Slice cut sets with LMC, /SRV_ISO_F, and HPI_TF-10D1 into Edit cut sets, changing HPI_TF-10D1 into HPI_TF-1D1	44-lmc-1
44	Slice cut sets with LMC, /SRV_ISO_F, and HPI_TF-10D1 into	44-lmc-2
44	Slice cut sets with LOSP and SRV_ISO_F into	87-losp
44	Slice cut sets with LOSP, /SRV_ISO_F, and /HPI_TF_FT-D1 into Edit cut sets, changing /HPI_TF_FT-D1 into /HPI_TF_FT-D1-N	88-losp
44	Slice cut sets with LOSP, /SRV_ISO_F, and HPI_TF-10D1 into Edit cut sets, changing HPI_TF-10D1 into HPI_TF-1D1	44-losp-1
44	Slice cut sets with LOSP, /SRV_ISO_F, and HPI_TF-10D1 into	44-losp-2
44	No slice for SLB1 and SLB2 cut sets	
44	Slice cut sets with SGTR and PORV_SO_SGTR into	82-sgtr

Table 4.16. Rules for slicing original power TH bin cut sets into new TH bins.

Original TH Bin	Action	New TH Bin
50	Slice cut sets with RTTT and CBP_OVRFD into	89-rttt
50	Slice cut sets with LOP-3KI and CBP_OVRFD into	89-3ki
50	Slice cut sets with LOP-3TC and CBP_OVRFD into	89-3tc
50	Slice cut sets with LIA and CBP_OVRFD into	89-lia
50	No slice for LMC cut sets	
50	Slice cut sets with SLB1 and CBP_OVRFD into	89-slb1
50	Slice cut sets with SLB2 and CBP_OVRFD into	89-slb2
50	No slice for SGTR cut sets	
57	No slice for RTTT, LOP-3KI, LOP-3TC, LOSP, SLB1, SLB2, LIA, and LMC cut sets	
59	No slice for RTTT, LOP-3KI, LOP-3TC, LOSP, SLB1, SLB2, LIA, and LMC cut sets	
62	No slice for SLB2 cut sets	

Table 4.17. Rules for slicing original HZP TH bin cut sets into new TH bins.

Original TH Bin	Action	New TH Bin
3	Slice cut sets with LOCA into	70-loca
4	Slice cut sets with LOCA into	106-loca
15	Slice cut sets with LIA and SRV_SO into	74-lia-1
15	Slice cut sets with LMC and SRV_SO into	74-lmc-1
15	Slice cut sets with LOP-3KI and SRV_SO into	74-3ki-1
15	Slice cut sets with LOP-3TC and SRV_SO into	74-3tc-1
15	Slice cut sets with LOSP and SRV_SO into	74-losp-1
15	Slice cut sets with RTTT and SRV_SO into	74-rttt-1
15	Slice cut sets with LIA and PORV_SO into	74-lia-2
15	Slice cut sets with LMC and PORV_SO into	74-lmc-2
15	Slice cut sets with LOP-3KI and PORV_SO into	74-3ki-2
15	Slice cut sets with LOP-3TC and PORV_SO into	74-3tc-2

Table 4.17. Rules for slicing original HZP TH bin cut sets into new TH bins.

Original TH Bin	Action	New TH Bin
15	Slice cut sets with LOSP and PORV_SO into	74-losp-2
15	Slice cut sets with RTTT and PORV_SO into	74-rttt-2
15	Slice cut sets with LOCA, HPI_FTS, and HPI_REC_F into	74-loca
25	Slice cut sets with SLB2 into	100-slb2
27	Slice cut sets with SLB2 into	101-slb2
28	Slice cut sets with LIA and EFW_SLB_FI-10A into	30-lia-1
28	Slice cut sets with LMC and EFW_SLB_FI-10A into	30-lmc-1
28	Slice cut sets with LOP-3KI and EFW_SLB_FI-10A into	30-3ki-1
28	Slice cut sets with LOP-3TC and EFW_SLB_FI-10A into	30-3tc-1
28	Slice cut sets with RTTT and EFW_SLB_FI-10A into	30-rttt-1
28	Slice cut sets with LIA and EFW_REC_FL-30B into	30-lia-2
28	Slice cut sets with LMC and EFW_REC_FL-30B into	30-lmc-2
28	Slice cut sets with LOP-3KI and EFW_REC_FL-30B into	30-3ki-2
28	Slice cut sets with LOP-3TC and EFW_REC_FL-30B into	30-3tc-2
28	Slice cut sets with RTTT and EFW_REC_FL-30B into	30-rttt-2
29	Slice cut sets with LMC into	31-lmc
29	Slice cut sets with LOP-3KI into	31-3ki
29	Slice cut sets with LOP-3TC into	31-3tc
29	Slice cut sets with SLB1 and HPI_TF-10AB into Edit cut sets, changing HPI_TF-10AB into HPI_TF-10AB-SEC	102-slb1-1
29	Slice cut sets with SLB1 and HPI_TF-20AB into Edit cut sets, changing HPI_TF-20AB into HPI_TF-20AB-SEC	102-slb1-2
29	Slice cut sets with RTTT into	31-rttt
34	Slice cut sets with LIA into	106-lia
34	Slice cut sets with LMC into	106-lmc
34	Slice cut sets with LOP-3KI into	106-3ki
34	Slice cut sets with LOP-3TC into	106-3tc
34	Slice cut sets with LOSP into	106-losp
34	Slice cut sets with RTTT into	106-rttt
35	Slice cut sets with LIA and EFW_SLB_FI-10A into	37-lia-1

Table 4.17. Rules for slicing original HZP TH bin cut sets into new TH bins.

Original TH Bin	Action	New TH Bin
35	Slice cut sets with LMC and EFW_SLB_FI-10A into	37-lmc-1
35	Slice cut sets with LOP-3KI and EFW_SLB_FI-10A into	37-3ki-1
35	Slice cut sets with LOP-3TC and EFW_SLB_FI-10A into	37-3tc-1
35	Slice cut sets with LOSP and EFW_SLB_FI-10A into	37-losp-1
35	Slice cut sets with RTTT and EFW_SLB_FI-10A into	37-rttt-1
35	Slice cut sets with LIA and EFW_REC_FL-30B into	37-lia-2
35	Slice cut sets with LMC and EFW_REC_FL-30B into	37-lmc-2
35	Slice cut sets with LOP-3KI and EFW_REC_FL-30B into	37-3ki-2
35	Slice cut sets with LOP-3TC and EFW_REC_FL-30B into	37-3tc-2
35	Slice cut sets with LOSP and EFW_REC_FL-30B into	37-losp-2
35	Slice cut sets with RTTT and EFW_REC_FL-30B into	37-rttt-2
36	Slice cut sets with LIA into	38-lia
36	Slice cut sets with LMC into	38-lmc
36	Slice cut sets with LOP-3KI into	38-3ki
36	Slice cut sets with LOP-3TC into	38-3tc
36	Slice cut sets with LOSP into	38-losp
36	Slice cut sets with RTTT into	38-rttt
36	Slice cut sets with SLB1 and /HPI_TF_FT-AB into Edit cut sets, changing /HPI_TF_FT-AB into /HPI_TF_FT-AB-SEC	38-slb1
39	Slice cut sets with SGTR and RCP_TRIP into Edit cut sets, changing HPI_TF-10AB into HPI_TF-10AB-SEC Edit cut sets, changing HPI_TF-20AB into HPI_TF-20AB-SEC Edit cut sets, changing /HPI_TF_FT-AB into /HPI_TF_FT-AB-SEC	103-sgtr
41	Slice cut sets with LIA and /HPI_TF_FT-D1 into Edit cut sets, changing /HPI_TF_FT-D1 into /HPI_TF_FT-D1-N	92-lia-1 94-lia-1
41	Slice cut sets with LIA and /HPI_TF_FT-E into	92-lia-2 94-lia-2
41	Slice cut sets with LIA and HPI_FT-10D1 into Edit cut sets, changing HPI_FT-10D1 to HPI_FT-1D1	93-lia-1 95-lia-1
41	Slice cut sets with LIA and HPI_FT-10D1 into	42-lia-1
41	Slice cut sets with LIA and HPI_FT-02E into	42-lia-2
41	Slice cut sets with LIA and HPI_FT-03E into	42-lia-3
41	Slice cut sets with LMC and /HPI_TF_FT-D1 into Edit cut sets, changing /HPI_TF_FT-D1 into /HPI_TF_FT-D1-N	92-lmc-1 94-lmc-1

Table 4.17. Rules for slicing original HZP TH bin cut sets into new TH bins.

Original TH Bin	Action	New TH Bin
41	Slice cut sets with LMC and /HPI_TF_FT-E into	92-lmc-2 94-lmc-2
41	Slice cut sets with LMC and HPI_FT-10D1 into Edit cut sets, changing HPI_FT-10D1 to HPI_FT-1D1	93-lmc-1 95-lmc-1
41	Slice cut sets with LMC and HPI_FT-10D1 into	42-lmc-1
41	Slice cut sets with LMC and HPI_FT-02E into	42-lmc-2
41	Slice cut sets with LMC and HPI_FT-03E into	42-lmc-3
41	Slice cut sets with LOP-3KI and /HPI_TF_FT-D1 into Edit cut sets, changing /HPI_TF_FT-D1 into /HPI_TF_FT-D1-N	92-3ki-1 94-3ki-1
41	Slice cut sets with LOP-3KI and /HPI_TF_FT-E into	92-3ki-2 94-3ki-2
41	Slice cut sets with LOP-3KI and HPI_FT-10D1 into Edit cut sets, changing HPI_FT-10D1 to HPI_FT-1D1	93-3ki-1 95-3ki-1
41	Slice cut sets with LOP-3KI and HPI_FT-10D1 into	42-3ki-1
41	Slice cut sets with LOP-3KI and HPI_FT-02E into	42-3ki-2
41	Slice cut sets with LOP-3KI and HPI_FT-03E into	42-3ki-3
41	Slice cut sets with LOP-3TC and /HPI_TF_FT-D1 into Edit cut sets, changing /HPI_TF_FT-D1 into /HPI_TF_FT-D1-N	92-3tc-1 94-3tc-1
41	Slice cut sets with LOP-3TC and /HPI_TF_FT-E into	92-3tc-2 94-3tc-2
41	Slice cut sets with LOP-3TC and HPI_FT-10D1 into Edit cut sets, changing HPI_FT-10D1 to HPI_FT-1D1	93-3tc-1 95-3tc-1
41	Slice cut sets with LOP-3TC and HPI_FT-10D1 into	42-3tc-1
41	Slice cut sets with LOP-3TC and HPI_FT-02E into	42-3tc-2
41	Slice cut sets with LOP-3TC and HPI_FT-03E into	42-3tc-3
41	Slice cut sets with LOSP and /HPI_TF_FT-D1 into Edit cut sets, changing /HPI_TF_FT-D1 into /HPI_TF_FT-D1-N	92-losp-1 94-losp-1
41	Slice cut sets with LOSP and /HPI_TF_FT-E into	92-losp-2 94-losp-2
41	Slice cut sets with LOSP and HPI_FT-10D1 into Edit cut sets, changing HPI_FT-10D1 to HPI_FT-1D1	93-losp-1 95-losp-1
41	Slice cut sets with LOSP and HPI_FT-10D1 into	42-losp-1
41	Slice cut sets with LOSP and HPI_FT-02E into	42-losp-2
41	Slice cut sets with LOSP and HPI_FT-03E into	42-losp-3
41	Slice cut sets with RTTT and /HPI_TF_FT-D1 into Edit cut sets, changing /HPI_TF_FT-D1 into /HPI_TF_FT-D1-N	92-rttt-1 94-rttt-1
41	Slice cut sets with RTTT and /HPI_TF_FT-E into	92-rttt-2 94-rttt-2

Table 4.17. Rules for slicing original HZP TH bin cut sets into new TH bins.

Original TH Bin	Action	New TH Bin
41	Slice cut sets with RTTT and HPI_FT-10D1 into Edit cut sets, changing HPI_FT-10D1 to HPI_FT-1D1	93-rttt-1 95-rttt-1
41	Slice cut sets with RTTT and HPI_FT-10D1 into	42-rttt-1
41	Slice cut sets with RTTT and HPI_FT-02E into	42-rttt-2
41	Slice cut sets with RTTT and HPI_FT-03E into	42-rttt-3
44	Slice cut sets with LIA and SRV_ISO_F into	96-lia
44	Slice cut sets with LIA, /SRV_ISO_F, and /HPI_TF_FT-D1 into Edit cut sets, changing /HPI_TF_FT-D1 into /HPI_TF_FT-D1-N	97-lia
44	Slice cut sets with LIA, /SRV_ISO_F, and HPI_TF-10D1 into Edit cut sets, changing HPI_TF-10D1 into HPI_TF-1D1	75-lia-1
44	Slice cut sets with LIA, /SRV_ISO_F, and HPI_TF-10D1 into	75-lia-2
44	Slice cut sets with LMC and SRV_ISO_F into	96-lmc
44	Slice cut sets with LMC, /SRV_ISO_F, and /HPI_TF_FT-D1 into Edit cut sets, changing /HPI_TF_FT-D1 into /HPI_TF_FT-D1-N	97-lmc
44	Slice cut sets with LMC, /SRV_ISO_F, and HPI_TF-10D1 into Edit cut sets, changing HPI_TF-10D1 into HPI_TF-1D1	75-lmc-1
44	Slice cut sets with LMC, /SRV_ISO_F, and HPI_TF-10D1 into	75-lmc-2
44	Slice cut sets with LOP-3KI and SRV_ISO_F into	96-3ki
44	Slice cut sets with LOP-3KI, /SRV_ISO_F, and /HPI_TF_FT-D1 into Edit cut sets, changing /HPI_TF_FT-D1 into /HPI_TF_FT-D1-N	97-3ki
44	Slice cut sets with LOP-3KI, /SRV_ISO_F, and HPI_TF-10D1 into Edit cut sets, changing HPI_TF-10D1 into HPI_TF-1D1	75-3ki-1
44	Slice cut sets with LOP-3KI, /SRV_ISO_F, and HPI_TF-10D1 into	75-3ki-2
44	Slice cut sets with LOP-3TC and SRV_ISO_F into	96-3tc
44	Slice cut sets with LOP-3TC, /SRV_ISO_F, and /HPI_TF_FT-D1 into Edit cut sets, changing /HPI_TF_FT-D1 into /HPI_TF_FT-D1-N	97-3tc
44	Slice cut sets with LOP-3TC, /SRV_ISO_F, and HPI_TF-10D1 into Edit cut sets, changing HPI_TF-10D1 into HPI_TF-1D1	75-3tc-1
44	Slice cut sets with LOP-3TC, /SRV_ISO_F, and HPI_TF-10D1 into	75-3tc-2
44	Slice cut sets with LOCA and /HPI_REC_F into	75-loca
44	Slice cut sets with LOSP and SRV_ISO_F into	96-losp
44	Slice cut sets with LOSP, /SRV_ISO_F, and /HPI_TF_FT-D1 into Edit cut sets, changing /HPI_TF_FT-D1 into /HPI_TF_FT-D1-N	97-losp
44	Slice cut sets with LOSP, /SRV_ISO_F, and HPI_TF-10D1 into Edit cut sets, changing HPI_TF-10D1 into HPI_TF-1D1	75-losp-1
44	Slice cut sets with LOSP, /SRV_ISO_F, and HPI_TF-10D1 into	75-losp-2
44	Slice cut sets with RTTT and SRV_ISO_F into	96-rttt

Table 4.17. Rules for slicing original HZP TH bin cut sets into new TH bins.

Original TH Bin	Action	New TH Bin
44	Slice cut sets with RTTT, /SRV_ISO_F, and /HPI_TF_FT-D1 into Edit cut sets, changing /HPI_TF_FT-D1 into /HPI_TF_FT-D1-N	97-rttt
44	Slice cut sets with RTTT, /SRV_ISO_F, and HPI_TF-10D1 into Edit cut sets, changing HPI_TF-10D1 into HPI_TF-1D1	75-rttt-1
44	Slice cut sets with RTTT, /SRV_ISO_F, and HPI_TF-10D1 into	75-rttt-2
50	Slice cut sets with LIA and CBP_OVRFD into	98-lia
50	Slice cut sets with LOP-3KI and CBP_OVRFD into	98-3kit
50	Slice cut sets with LOP-3TC and CBP_OVRFD into	98-3tc
50	Slice cut sets with RTTT and CBP_OVRFD into	98-rttt
50	Slice cut sets with SLB1 and CBP_OVRFD into	98-slb1
50	Slice cut sets with SLB2 and CBP_OVRFD into	98-slb2

Table 4.18. Power TH bins resulting from application of slicing rules in Table 4.16.

03-LOCA
08-3KI
08-3TC
08-LOCA-1
08-LOCA-2
08-LOSP
08-RTTT
12-3KI
12-3TC
12-LMC
12-LOCA
12-LOSP
12-RTTT
15-3KI
15-3TC
15-LIA
15-LMC
15-LOSP

Table 4.18. Power TH bins resulting from application of slicing rules in Table 4.16.

15-RTTT
27-SLB2
28-3KI-1
28-3KI-2
28-3TC-1
28-3TC-2
28-LIA-1
28-LIA-2
28-LMC-1
28-LMC-2
28-LOSP-1
28-LOSP-2
28-RTTT-1
28-RTTT-2
29-3KI
29-3TC
29-LMC
29-LOSP
29-RTTT
29-SLB1
34-3KI
34-3TC
34-LIA
34-LMC
34-LOSP
34-RTTT
36-3KI
36-3TC
36-LIA
36-LMC
36-LOSP
36-RTTT
36-SLB1

Table 4.18. Power TH bins resulting from application of slicing rules in Table 4.16.

41-3KI-1
41-3KI-2
41-3KI-3
41-3TC-1
41-3TC-2
41-3TC-3
41-LIA-1
41-LIA-2
41-LIA-3
41-LMC-1
41-LMC-2
41-LMC-3
41-LOSP-1
41-LOSP-2
41-LOSP-3
41-RTTT-1
41-RTTT-2
41-RTTT-3
44-3KI-1
44-3KI-2
44-3TC-1
44-3TC-2
44-LIA-1
44-LIA-2
44-LMC-1
44-LMC-2
44-LOSP-1
44-LOSP-2
44-RTTT-1
44-RTTT-2
81-3KI
81-3TC
81-LIA

Table 4.18. Power TH bins resulting from application of slicing rules in Table 4.16.

81-LMC
81-LOCA
81-LOSP
81-RTTT
81-SGTR
82-LOCA
82-SGTR
83-3KI-1
83-3KI-2
83-3TC-1
83-3TC-2
83-LIA-1
83-LIA-2
83-LMC-1
83-LMC-2
83-LOSP-1
83-LOSP-2
83-RTTT-1
83-RTTT-2
84-3KI-1
84-3TC-1
84-LIA-1
84-LMC-1
84-LOSP-1
84-RTTT-1
85-3KI-1
85-3KI-2
85-3TC-1
85-3TC-2
85-LIA-1
85-LIA-2
85-LMC-1
85-LMC-2

Table 4.18. Power TH bins resulting from application of slicing rules in Table 4.16.

85-LOSP-1
85-LOSP-2
85-RTTT-1
85-RTTT-2
86-3KI-1
86-3TC-1
86-LIA-1
86-LMC-1
86-LOSP-1
86-RTTT-1
87-3KI
87-3TC
87-LIA
87-LMC
87-LOSP
87-RTTT
88-3KI
88-3TC
88-LIA
88-LMC
88-LOSP
88-RTTT
89-3KI
89-3TC
89-LIA
89-RTTT
89-SLB1
89-SLB2
90-SLB1
91-SGTR
99-SLB2

Table 4.19. HZP TH bins resulting from application of slicing rules in Table 4.17.

30-3KI-1
30-3KI-2
30-3TC-1
30-3TC-2
30-LIA-1
30-LIA-2
30-LMC-1
30-LMC-2
30-RTTT-1
30-RTTT-2
31-3KI
31-3TC
31-LMC
31-RTTT
37-3KI-1
37-3KI-2
37-3TC-1
37-3TC-2
37-LIA-1
37-LIA-2
37-LMC-1
37-LMC-2
37-LOSP-1
37-LOSP-2
37-RTTT-1
37-RTTT-2
38-3KI
38-3TC
38-LIA
38-LMC
38-LOSP
38-RTTT

Table 4.19. HZP TH bins resulting from application of slicing rules in Table 4.17.

38-SLB1
42-3KI-1
42-3KI-2
42-3KI-3
42-3TC-1
42-3TC-2
42-3TC-3
42-LIA-1
42-LIA-2
42-LIA-3
42-LMC-1
42-LMC-2
42-LMC-3
42-LOSP-1
42-LOSP-2
42-LOSP-3
42-RTTT-1
42-RTTT-2
42-RTTT-3
70-LOCA
74-3KI-1
74-3KI-2
74-3TC-1
74-3TC-2
74-LIA-1
74-LIA-2
74-LMC-1
74-LMC-2
74-LOCA
74-LOSP-1
74-LOSP-2
74-RTTT-1

Table 4.19. HZP TH bins resulting from application of slicing rules in Table 4.17.

74-RTTT-2
75-3KI-1
75-3KI-2
75-3TC-1
75-3TC-2
75-LIA-1
75-LIA-2
75-LMC-1
75-LMC-2
75-LOCA
75-LOSP-1
75-LOSP-2
75-RTTT-1
75-RTTT-2
92-3KI-1
92-3KI-2
92-3TC-1
92-3TC-2
92-LIA-1
92-LIA-2
92-LMC-1
92-LMC-2
92-LOSP-1
92-LOSP-2
92-RTTT-1
92-RTTT-2
93-3KI-1
93-3TC-1
93-LIA-1
93-LMC-1
93-LOSP-1
93-RTTT-1

Table 4.19. HZP TH bins resulting from application of slicing rules in Table 4.17.

94-3KI-1
94-3KI-2
94-3TC-1
94-3TC-2
94-LIA-1
94-LIA-2
94-LMC-1
94-LMC-2
94-LOSP-1
94-LOSP-2
94-RTTT-1
94-RTTT-2
95-3KI-1
95-3TC-1
95-LIA-1
95-LMC-1
95-LOSP-1
95-RTTT-1
96-3KI
96-3TC
96-LIA
96-LMC
96-LOSP
96-RTTT
97-3KI
97-3TC
97-LIA
97-LMC
97-LOSP
97-RTTT
98-3KI
98-3TC

Table 4.19. HZP TH bins resulting from application of slicing rules in Table 4.17.

98-LIA
98-RTTT
98-SLB1
98-SLB2
100-SLB2
101-SLB2
102-SLB1-1
102-SLB1-2
103-SGTR
106-3KI
106-3TC
106-LIA
106-LMC
106-LOCA
106-LOSP
106-RTTT

Table 4.20. Collapsed Power bins.

03-P-FINAL
08-P-FINAL
12-P-FINAL
15-P-FINAL
27-P-FINAL
28-P-FINAL
29-P-FINAL
34-P-FINAL
36-P-FINAL
41-P-FINAL
44-P-FINAL
81-P-FINAL
82-P-FINAL

Table 4.20. Collapsed Power bins.

83-P-FINAL
84-P-FINAL
85-P-FINAL
86-P-FINAL
87-P-FINAL
88-P-FINAL
89-P-FINAL
90-P-FINAL
91-P-FINAL
99-P-FINAL

Table 4.21. Collapsed HZP bins.

30-HZP-FINAL
31-HZP-FINAL
37-HZP-FINAL
38-HZP-FINAL
42-HZP-FINAL
70-HZP-FINAL
74-HZP-FINAL
75-HZP-FINAL
92-HZP-FINAL
93-HZP-FINAL
94-HZP-FINAL
95-HZP-FINAL
96-HZP-FINAL
97-HZP-FINAL
98-HZP-FINAL
100-HZP-FINAL
101-HZP-FINAL
102-HPZ-FINAL
103-HZP-FINAL
106-HZP-FINAL

As part of the overall PTS project, the University of Maryland (UMD) performed a series of uncertainty analyses on many of the inputs and parameters potentially affecting the PTS results to see which uncertainties would most affect those results [Chang]. That work concluded that a few modeling uncertainties were sufficiently important that they needed to be explicitly treated in the PRA model. The uncertainties identified as important included:

- size of the LOCA within a LOCA category plus other factors (e.g., initial injection water temperature),
- size of the opening associated with a single or multiple stuck open SRV(s) that remain open,
- size of the opening associated with a single or multiple stuck open SRV(s) that reclose, and
- time at which a stuck open SRV recloses.

These uncertainties and how they affected the TH bin creation process are discussed in the following paragraphs.

The actual break size of a LOCA for a specific LOCA class (i.e., small, medium, or large) can be any point on the spectrum of sizes defined by the two end points for that class. In addition, other factors (e.g., initial injection water temperature, break location, and injection flow rate) can contribute to the overall PTS model uncertainty since these factors along with the specific break size affect the rate of cooling and subsequent plant response. Results from the UMD uncertainty analysis [Chang] indicated that for the small LOCA category five distinct small LOCA cases (i.e., break size and other factors) were needed to adequately represent the uncertainty associated with the factors considered during the UMD analysis.

To incorporate this finding into the PRA, the cut sets for small LOCA from the Power and HZP models (i.e., 03-P-FINAL and 70-HZP-FINAL) were combined in SAPHIRE to produce a single set of small LOCA cut sets. SAPHIRE was then used to reproduce this set of cut sets to create five sets of identical cut sets. Each of the five sets of cut sets was then edited in SAPHIRE to insert a new event that represented a probabilities assigned by UMD of how much of the total spectrum of uncertainty the five distinct small LOCA cases represented. Each of these new sets of small LOCA cut sets was then assigned to a new T-H bin. Table 4.22 provides the five probabilities assigned by UMD, a short description of each of the new TH bins, and the new TH bin designators. For the medium LOCA a similar process was used; however, only three new bins were needed. Thus, the medium LOCA cut sets from the Power and HZP models (i.e., TH-MLOCA-Y for both Power and HZP) were combined to produce a single set of medium LOCA cut sets, reproduced to produce three sets, and edited to insert a new event representing the portion of the uncertainty spectrum associated with each of the three medium LOCA cases. Each new medium LOCA case was assigned to a new TH bin. Table 4.23 provides the medium LOCA information similar to that provided for the small LOCA in Table 4.22. For the large LOCA it was decided that a single TH bin was sufficient. Thus, the large LOCA cut sets from the Power and HZP models (i.e., TH-LLOCA-Y for both Power and HZP) were combined to produce a single set of large LOCA cut sets. This set was then assigned to a new TH bin (i.e., bin 156).

Table 4.22. Information on small LOCA bins.

Probability	TH Description	TH Bin Designator
0.23	4.34 cm (1.71 in) surge line break (Break flow area increased by 30% from 3.81 cm (1.5 in) break). Winter conditions assumed (HPI, LPI temp = 277 K (40˚ F) and CFT temp = 294 K (70˚ F)). High K.	145
0.18	8.19 cm (3.22 in) surge line break (Break flow area increased by 30% from 7.18 cm (2.828 in) break). High K.	141
0.18	6.01 cm (2.37 in) surge line break (Break flow area decreased by 30% from 7.18 cm (2.828 in) break). High K	142
0.18	8.53 cm (3.35 in) surge line break (Break flow area reduced by 30% from 10.16 cm (4 in) break). Vent valves do not function. High K.	172
0.23	8.53 cm (3.36 in) surge line break (Break flow area reduced by 30% from 10.16 cm (4 in) break). Vent valves do not function. ECC suction switch to the containment sump included in the analysis. High K	154

Table 4.23. Information on medium LOCA bins.

Probability	TH Description	TH Bin Designator
0.30	14.37 cm (5.656 in) surge line break. ECC suction switch to the containment sump included in the analysis.	160
0.35	20.32 cm (8 inch) surge line break. ECC suction switch to the containment sump included in the analysis.	164
0.35	8.53 cm (3.36 in) surge line break (Break flow area reduced by 30% from 10.16 cm (4 in) break). Vent valves do not function. ECC suction switch to the containment sump included in the analysis.	178

Just as with the LOCAs, the size of the opening associated with a stuck open SRV can vary from a size that is not PTS significant all the way to the valve being stuck fully open. To deal with this issue and other relevant issues examined in the UMD analysis, the cut sets from the stuck open SRV Power and HZP bins (i.e., 34-P-FINAL and 106-HZP-FINAL) were each reproduced three times using SAPHIRE. Each of these new bins were then edited using SAPHIRE to add two new events. The first event represented the fraction of valve openings that is PTS significant assuming that the SRV opening size is uniformly distributed (any specific opening is equally likely). The second event represented a probability assigned by UMD of how much of the total spectrum of uncertainty each of the three distinct stuck open SRV cases represented. As with the LOCAs, each set of the three new stuck open SRV cut sets was assigned to a new TH bin. Table 4.24 provides the values assigned to the new events added to the original cut sets, a short description of each of the new TH bins, and the new TH bin designators.

Table 4.24. Information on stuck open SRV(s) bins.

Model	Probability		TH Description	TH Bin Designator
	Valve Opening	Uncertainty Spectrum		
Power	0.31	0.35	Turbine trip/reactor trip (TT/RT) with stuck open pressurizer (PZR) SRV (valve flow area reduced by 30 percent). Summer conditions assumed (HPI, LPI temp = 302 K (85˚ F) and CFT temp = 310 K (100˚ F)). Vent valves do not function.	146
	0.31	0.30	TT/RT with stuck open PZR SRV. Summer conditions assumed (HPI, LPI temp = 302 K (85˚ F) and CFT temp = 310 K (100˚ F)).	147
	0.31	0.35	TT/RT with partially stuck open PZR SRV (flow area equivalent to 1.5 in diameter opening). HTC coefficients increased by 1.3.	148
HZP	0.31	0.35	TT/RT with stuck open PZR SRV (valve flow area reduced by 30 percent). Summer conditions assumed (HPI, LPI temp = 302 K (85˚ F) and CFT temp = 310 K (100˚ F)). Vent valves do not function.	169
	0.31	0.30	TT/RT with stuck open PZR SRV. Summer conditions assumed (HPI, LPI temp = 302 K (85˚ F) and CFT temp = 310 K (100˚ F)).	170
	0.31	0.35	TT/RT with partially stuck open PZR SRV (flow area equivalent to 1.5 in diameter opening). Heat transfer coefficients (HTCs) increased by 1.3.	171

The time at which a stuck open SRV recloses is unknown and can occur at any point after the valve sticks open. To approximate this, the cut sets associated with stuck open SRV sequences with subsequent closure of the SRV were modified using SAPHIRE to add a new event representing the probability of a specific SRV reclosure time (i.e., either 3000 sec and 6000 sec). These two time points were chosen after reviewing stuck open SRV thermal-hydraulic conditions. The 6000 sec point was chosen to coincide with the point where the change in downcomer wall temperature had essentially flattened out[10]. The 3000 sec point was chosen to coincide with the point where sufficient cooling has occurred to the downcomer wall such that PTS could become an issue. Each case (i.e., 6000 sec and 3000 sec) was assigned a 50% chance of occurring; i.e., of all the possible reclosure times, these two discrete times were considered sufficiently representative of all times with all the reclosure probability assigned equally to these two discrete times. In addition, each cut set was modified to add the event representing the fraction of valve openings that is PTS significant as described in the previous paragraph. Finally, new TH bins were assigned to replace the original TH bin (as given in Tables 4.20 and 4.21). Table 4.25 summarizes these changes.

[10] This was judged to be sufficient to represent a worst case reclosure time since downcomer cooling had achieved nearly its lowest level and subsequent repressurization at this point could still cause a PTS challenge. Subsequent sensitivity analyses showed that delaying the reclosure until 7000 sec or beyond could result in higher conditional probabilities of vessel failure about two times that predicted for 6000 seconds but (a) this is a small difference and within the uncertainties of the analysis and (b) beyond 1-2 hours, the operators are likely to transition the plant toward cold shutdown changing the TH response of the plant to a safer state (from a PTS perspective). Hence the 6000 sec case was kept as representative of a worst condition.

Table 4.25. Information on stuck open SRV(s) reclosure bins.

Original T-H Bin	New T-H Bin	Probability		TH Description
		Valve Opening	Closure Time	
41-P-FINAL	109	0.31	0.5	Stuck open pressurizer safety valve. Valve recloses at 6000 secs (RCS low pressure point).
41-P-FINAL	149	0.31	0.5	TT/RT with stuck open pzr SRV. SRV assumed to reclose at 3000 secs. Operator does not throttle HPI.
83-P-FINAL	112	0.31	0.5	Stuck open pressurizer safety valve. Valve recloses at 6000 secs After valve recloses, operator throttles HPI 1 minute after 2.7 K (5˚F) subcooling and 254 cm (100") pressurizer level is reached (throttling criteria is 27 K (50˚F) subcooling)
84-P-FINAL	113	0.31	0.5	Stuck open pressurizer safety valve. Valve recloses at 6000 secs. After valve recloses, operator throttles HPI 10 minutes after 2.7 K (5˚F) subcooling and 254 cm (100") pressurizer level is reached (throttling criteria is 27.8 K (50˚F) subcooling)
85-P-FINAL	114	0.31	0.5	Stuck open pressurizer safety valve. Valve recloses at 3000 secs. After valve recloses, operator throttles HPI 1 minute after 2.7 K (5˚F) subcooling and 254 cm (100") pressurizer level is reached (throttling criteria is 50˚F subcooling)
86-P-FINAL	115	0.31	0.5	Stuck open pressurizer Safety Valve. Valve recloses at 3000 secs. After valve recloses, operator throttles HPI 10 minutes after 2.7 K (5˚F) subcooling and 254 cm (100") pressurizer level is reached (throttling criteria is 50˚F subcooling)
42-HZP-FINAL	165	0.31	0.5	Stuck open pressurizer safety valve. Valve recloses at 6000 secs (RCS low pressure point).
42-HZP-FINAL	168	0.31	0.5	TT/RT with stuck open pzr SRV. SRV assumed to reclose at 3000 secs. Operator does not throttle HPI.

Table 4.25. Information on stuck open SRV(s) reclosure bins.

Original T-H Bin	New T-H Bin	Probability		TH Description
		Valve Opening	Closure Time	
92-HZP-FINAL	121	0.31	0.5	Stuck open pressurizer safety valve. Valve recloses at 6000 secs . Operator throttles HPI at 1 minute after 2.7 K (5˚F) subcooling and 254 cm (100") pressurizer level is reached (throttling criteria is 27.8 K (50˚F) subcooling).
93-HZP-FINAL	122	0.31	0.5	Stuck open pressurizer safety valve. Valve recloses at 6000 secs. Operator throttles HPI at 10 minutes after 2.7 K (5˚F) subcooling and 254 cm (100") pressurizer level is reached (throttling criteria is 27.8 K (50˚F) subcooling).
94-HZP-FINAL	123	0.31	0.5	Stuck open pressurizer safety valve. Valve recloses at 3000 secs. Operator throttles HPI at 1 minute after 2.7 K (5˚F) subcooling and 254 cm (100") pressurizer level is reached (throttling criteria is 27.8 K (50˚F) subcooling).
95-HZP-FINAL	124	0.31	0.5	Stuck open pressurizer safety valve. Valve recloses at 3000 secs. Operator throttles HPI at 10 minutes after 2.7 K (5˚F) subcooling and 254 cm (100") pressurizer level is reached (throttling criteria is 27.8 K (50˚F) subcooling).

The final step in the TH bin creation process was to assign final TH characteristics (and a new T-H descriptor) to the remainder of the collapsed TH bins contained in Tables 4.20 and 4.21. This was accomplished by reviewing available PTS-relevant information and determining whether existing T-H calculations were still appropriate or whether new T-H calculations should be performed. Table 4.26 provides a cross-reference between the remaining collapsed bins and the final bins used in the PTS analysis. Table 4.27 provides a complete listing of the final set of T-H bins used in the PTS analysis. (NOTE: In Table 4.27 there is a “High K” column. This refers to the fact that generally the LOCA analyses were performed using large reverse flow loss coefficients in the pump suction cold leg region of the RELAP5 model. These coefficients are used to preclude setting up non-physical flow recirculation between the two common cold legs on each coolant loop.)

Table 4.26. Cross-reference of remaining collapsed power bins to final T-H bins.

Collapsed Bin	Final T-H Bin
08-P-FINAL	8
12-P-FINAL	12
15-P-FINAL	15
27-P-FINAL	27
28-P-FINAL	28
29-P-FINAL	29
36-P-FINAL	36
44-P-FINAL	44
81-P-FINAL	110
82-P-FINAL	111
87-P-FINAL	116
88-P-FINAL	117
89-P-FINAL	89
90-P-FINAL	90
91-P-FINAL	91
99-P-FINAL	99
30-HZP-FINAL	30
31-HZP-FINAL	31
37-HZP-FINAL	37
38-HZP-FINAL	38
74-HZP-FINAL	119
75-HZP-FINAL	120
96-HZP-FINAL	125
97-HZP-FINAL	126
98-HZP-FINAL	98
100-HZP-FINAL	100
101-HZP-FINAL	101
102-HPZ-FINAL	102
103-HZP-FINAL	127

Table 4.27 Final set of TH bins used in PTS analysis.

TH Bin No.	IE	Primary Side Failure	Secondary Side Failure	Operator Action	HZP	Hi K
8	LOCA	2.54 cm (1 inch) surge line break	1 stuck open safety valve in SG-A	None	No	No
12	LOCA	2.54 cm (1 inch) surge line break	1 stuck open safety valve in SG-A	HPI throttled to maintain 27.8 K (50°˚ F) subcooling margin	No	No
15	LOCA	2.54 cm (1 in) surge line break with HPI Failure	None	At 15 minutes after transient initiation, operator opens all TBVs to lower primary system pressure and allow CFT and LPI injection.	No	No
27	MSLB	None	MSLB without trip of turbine driven emergency feedwater.	Operator throttles HPI to maintain 27.8 K (50°˚ F) subcooling margin.	No	No
28	TT/RT	None	1 stuck open safety valve in SG-A	None	No	No
29	TT/RT	None	1 stuck open safety valve in SG-A and a second stuck open safety valve in SG-B	None	No	No
30	TT/RT	None	1 stuck open safety valve in SG-A	None	Yes	No
31	TT/RT	None	1 stuck open safety valve in SG-A and a second stuck open safety valve in SG-B	None	Yes	No
36	TT/RT	None	1 stuck open safety valve in SG-A and a second stuck open safety valve in SG-B	Operator throttles HPI to maintain 27.8 K (50°˚ F) subcooling and 304.8 cm (120 in) pressurizer level.	No	No
37	TT/RT	None	1 stuck open safety valve in SG-A	Operator throttles HPI to maintain 27.8 K (50°˚ F)) subcooling and 304.8 cm (120 in) pressurizer level.	Yes	No

Table 4.27 Final set of TH bins used in PTS analysis.

TH Bin No.	IE	Primary Side Failure	Secondary Side Failure	Operator Action	HZP	Hi K
38	TT/RT	None	1 stuck open safety valve in SG-A and a second stuck open safety valve in SG-B	Operator throttles HPI to maintain 27.8 K (50°˚ F) subcooling and 304.8 cm (120 in) pressurizer level.	Yes	No
44	LOCA	2.54 cm (1 in) surge line break with HPI Failure	None.	At 15 minutes after initiation, operators open all TBVs to depressurize the system to the CFT setpoint. When the CFTs are 50 percent discharged, HPI is assumed to be recovered. The TBVs are assumed remain open for the duration of the transient.	No	No
89	TT/RT	None	Loss of MFW and EFW.	Operator opens all TBVs to depressurize the secondary side to below the condensate booster pump shutoff head so that these pumps feed the steam generators. Booster pumps are assumed to be initially uncontrolled so that the steam generators are overfilled (609 cm (240 in) startup level). Operator controls booster pump flow to maintain SG level at 76 cm (30 in) due to continued RCP operation. Operator also throttles HPI to maintain 55 K (100oF) subcooling and a pressurizer level of 254 cm (100 in). The TBVs are kept fully opened due to operator error.	No	No
90	TT/RT	None	2 stuck open safety valves in SG-A	Operator throttles HPI 20 minutes after 2.7 K (5°˚F) subcooling and 254 cm (100") pressurizer level is reached (throttling criteria is 27.8 K (50°˚F) subcooling).	No	No
91	SGTR	None	SGTR with a stuck open SRV in SG-B. A reactor trip is assumed to occur at the time of the tube rupture. Stuck safety relief valve is assumed to reclose 10 minutes after initiation.	Operator trips RCP's 1 minute after initiation. Operator also throttles HPI 10 minutes after 2.7 K (5°˚F) subcooling and 254 cm (100") pressurizer level is reached (assumed throttling criteria is 27.8 K (50°˚F) subcooling).	No	No

Table 4.27 Final set of TH bins used in PTS analysis.

TH Bin No.	IE	Primary Side Failure	Secondary Side Failure	Operator Action	HZP	Hi K
98	TT/RT	None	Loss of MFW and EFW.	Operator opens all TBVs to depressurize the secondary side to below the condensate booster pump shutoff head so that these pumps feed the steam generators. Booster pumps are assumed to be initially uncontrolled so that the steam generators are overfilled (610 cm (240 in) startup level). Operator controls booster pump flow to maintain SG level at 76 cm (30 in) due to continued RCP operation. Operator also throttles HPI to maintain 55 K (100oF) subcooling and a pressurizer level of 254 cm (100 in). The TBVs are kept fully opened due to operator error.	Yes	No
99	MSLB	None	MSLB with trip of turbine driven EFW by MSLB Circuitry.	HPI is throttled 20 minutes after 2.7 K (5°˚F) subcooling and 254 cm (100") pressurizer level is reached (throttling criteria is 27.8 K (50°˚F) subcooling).	No	No
100	MSLB	None	MSLB with trip of turbine driven EFW by MSLB Circuitry	Operator throttles HPI 20 minutes after 2.7 K (5°˚F) subcooling and 254 cm (100") pressurizer level is reached (throttling criteria is 27.8 K (50°˚F) subcooling).	Yes	No
101	MSLB	None	MSLB without trip of turbine driven EFW by MSLB Circuitry	Operator throttles HPI to maintain 27.8 K (50°˚ F) subcooling margin (throttling criteria is 27.8 K (50°˚F) subcooling).	Yes	No
102	TT/RT	None	2 stuck open safety valves in SG-A	Operator throttles HPI 20 minutes after 2.77 K (5°˚F) subcooling and 254 cm (100 in) pressurizer level is reached (throttling criteria is 27 K (50°˚F) subcooling).	Yes	No
109	TT/RT	Stuck open pressurizer safety valve. Valve recloses at 6000 secs (RCS low pressure point).	None	None	No	Yes
110	LOCA		None	At 15 minutes after transient initiation, operator opens both TBV to lower primary system pressure and allow CFT and LPI injection.	No	Yes

Table 4.27 Final set of TH bins used in PTS analysis.

TH Bin No.	IE	Primary Side Failure	Secondary Side Failure	Operator Action	HZP	Hi K
111	LOCA		None	At 15 minutes after initiation, operator opens all TBVs to lower primary pressure and allow CFT and LPI injection. When the CFTs are 50% discharged, HPI is recovered. At 3000 seconds after initiation, operator starts throttling HPI to 55 K (100°˚F) subcooling and 254 cm (100") pressurizer level.	No	Yes
112	TT/RT	Stuck open pressurizer safety valve. Valve recloses at 6000 secs.	None	After valve recloses, operator throttles HPI 1 minute after 2.7 K (5°˚F) subcooling and 254 cm (100") pressurizer level is reached (throttling criteria is 27 K (50°˚F) subcooling)	No	Yes
113	TT/RT	Stuck open pressurizer safety valve. Valve recloses at 6000 secs.	None	After valve recloses, operator throttles HPI 10 minutes after 2.7 K (5°˚F) subcooling and 254 cm (100") pressurizer level is reached (throttling criteria is 27.8 K (50°˚F) subcooling)	No	Yes
114	TT/RT	Stuck open pressurizer safety valve. Valve recloses at 3000 secs.	None	After valve recloses, operator throttles HPI 1 minute after 2.7 K (5°˚F) subcooling and 254 cm (100") pressurizer level is reached (throttling criteria is 50°˚F subcooling)	No	Yes
115	TT/RT		None	After valve recloses, operator throttles HPI 10 minutes after 2.7 K (5°˚F) subcooling and 254 cm (100") pressurizer level is reached (throttling criteria is 50°˚F subcooling)	No	Yes
116	TT/RT		None	At 15 minutes after initiation, operator opens all TBVs to lower primary pressure and allow CFT and LPI injection. When the CFTs are 50% discharged, HPI is recovered. The HPI is throttled 20 minutes after 2.7 K (5°˚F) subcooling and 254 cm (100") pressurizer level is reached (throttling criteria is 50°˚F subcooling).	No	Yes
117	TT/RT		None	At 15 minutes after initiation, operator opens all TBV to lower primary pressure and allow CFT and LPI injection. When the CFTs are 50% discharged, HPI is recovered. The SRV is closed 5 minutes after HPI recovered. HPI is throttled at 1 minute after 2.7 K (5°˚F) subcooling and 254 cm (100") pressurizer level is reached (throttling criteria is 27.8 K (50°˚F) subcooling).	No	Yes

Table 4.27 Final set of TH bins used in PTS analysis.

TH Bin No.	IE	Primary Side Failure	Secondary Side Failure	Operator Action	HZP	Hi K
119	LOCA	2.54 cm (1 in) surge line break with HPI Failure	None	At 15 minutes after transient initiation, the operator opens all turbine bypass valves to lower primary system pressure and allow core flood tank and LPI injection.	Yes	Yes
120	LOCA	2.54 cm (1 in) surge line break with HPI Failure	None	At 15 minutes after sequence initiation, operators open all TBVs to depressurize the system to the CFT setpoint. When the CFTs are 50 percent discharged, HPI is assumed to be recovered. The TBVs are assumed remain opened for the duration of the transient.	Yes	Yes
121	TT/RT	Stuck open pressurizer safety valve. Valve recloses at 6000 secs .	None	Operator throttles HPI at 1 minute after 2.7 K (5°˚F) subcooling and 254 cm (100") pressurizer level is reached (throttling criteria is 27.8 K (50°˚F) subcooling).	Yes	Yes
122	TT/RT	Stuck open pressurizer safety valve. Valve recloses at 6000 secs.	None	Operator throttles HPI at 10 minutes after 2.7 K (5°˚F) subcooling and 254 cm (100") pressurizer level is reached (throttling criteria is 27.8 K (50°˚F) subcooling).	Yes	Yes
123	TT/RT	Stuck open pressurizer safety valve. Valve recloses at 3000 secs.	None	Operator throttles HPI at 1 minute after 2.7 K (5°˚F) subcooling and 254 cm (100") pressurizer level is reached (throttling criteria is 27.8 K (50°˚F) subcooling).	Yes	Yes
124	TT/RT	Stuck open pressurizer safety valve. Valve recloses at 3000 secs.	None	Operator throttles HPI at 10 minutes after 2.7 K (5°˚F) subcooling and 254 cm (100") pressurizer level is reached (throttling criteria is 27.8 K (50°˚F) subcooling).	Yes	Yes
125	TT/RT	Stuck open pressurizer safety valve and HPI Failure	None	At 15 minutes after initiation, operator opens all TBVs to lower primary pressure and allow CFT and LPI injection. When the CFTs are 50% discharged, HPI is recovered. HPI is throttled 20 minutes after 2.7 K (5°˚F) subcooling and 254 cm (100") pressurizer level is reached (throttling criteria is 27.8 K (50°˚F) subcooling).	Yes	Yes
126	TT/RT	Stuck open pressurizer safety valve and HPI Failure	None	At 15 minutes after initiation, operator opens all TBVs to lower primary pressure and allow CFT and LPI injection. When the CFTs are 50% discharged, HPI is recovered. SRV is closed at 5 minutes after HPI is recovered. HPI is throttled at 1 minute after 2.7 K (5°˚F) subcooling and 254 cm (100") pressurizer level is reached (throttling criteria is 27.8 K (50°˚F) subcooling).	Yes	Yes

Table 4.27 Final set of TH bins used in PTS analysis.

TH Bin No.	IE	Primary Side Failure	Secondary Side Failure	Operator Action	HZP	Hi K
127	SGTR	None	SGTR with a stuck open SRV in SG-B. A reactor trip is assumed to occur at the time of the tube rupture. Stuck safety relief valve is assumed to reclose 10 minutes after initiation.	Operator trips RCP's 1 minute after initiation. Operator also throttles HPI 10 minutes after 2.77 K (5°˚ F) subcooling and 254 cm (100 in) pressurizer level is reached (assumed throttling criteria is 27 K (50°˚F) subcooling).	Yes	Yes
141	LOCA	8.19 cm (3.22 in) surge line break (Break flow area increased by 30% from 7.18 cm (2.828 in) break).	None	None	No	Yes
142	LOCA	6.01 cm (2.37 in) surge line break (Break flow area decreased by 30% from 7.18 cm (2.828 in) break).	None	None	No	Yes
145	LOCA	4.34 cm (1.71 in) surge line break (Break flow area increased by 30% from 3.81 cm (1.5 in) break). Winter conditions assumed (HPI, LPI temp = 277 K (40°˚ F) and CFT temp = 294 K (70°˚ F)).	None	None	No	Yes
146	TT/RT	TT/RT with stuck open pzr SRV (valve flow area reduced by 30 percent). Summer conditions assumed (HPI, LPI temp = 302 K (85°˚ F) and CFT temp = 310 K (100°˚ F)). Vent valves do not function.	None	None	No	Yes

Table 4.27 Final set of TH bins used in PTS analysis.

TH Bin No.	IE	Primary Side Failure	Secondary Side Failure	Operator Action	HZP	Hi K
147	TT/RT	TT/RT with stuck open pzr SRV. Summer conditions assumed (HPI, LPI temp = 302 K (85°° F) and CFT temp = 310 K (100°° F)).	None	None	No	Yes
148	TT/RT	TT/RT with partially stuck open pzr SRV (flow area equivalent to 1.5 in diameter opening). HTC coefficients increased by 1.3.	None	None	No	Yes
149	TT/RT	TT/RT with stuck open pzr SRV. SRV assumed to reclose at 3000 secs. Operator does not throttle HPI.	None	None	No	Yes
154	LOCA	8.53 cm (3.36 in) surge line break (Break flow area reduced by 30% from 10.16 cm (4 in) break). Vent valves do not function. ECC suction switch to the containment sump included in the analysis.	None	None	No	Yes
156	LOCA	40.64 cm (16 in) hot leg break. ECC suction switch to the containment sump included in the analysis.	None	None	No	Yes
160	LOCA	14.37 cm (5.656 in) surge line break. ECC suction switch to the containment sump included in the analysis.	None	None	No	Yes
164	LOCA	20.32 cm (8 inch) surge line break. ECC suction switch to the containment sump included in the analysis.	None	None	No	Yes
165	TT/RT	Stuck open pressurizer safety valve. Valve recloses at 6000 secs (RCS low pressure point).	None	None	Yes	Yes

Table 4.27 Final set of TH bins used in PTS analysis.

TH Bin No.	IE	Primary Side Failure	Secondary Side Failure	Operator Action	HZP	Hi K
168	TT/RT	TT/RT with stuck open pzr SRV. SRV assumed to reclose at 3000 secs. Operator does not throttle HPI.	None	None	Yes	Yes
169	LOCA	TT/RT with stuck open pzr SRV (valve flow area reduced by 30 percent). Summer conditions assumed (HPI, LPI temp = 302 K (85°˚ F) and CFT temp = 310 K (100°˚ F)). Vent valves do not function.	None	None	Yes	Yes
170	TT/RT	TT/RT with stuck open pzr SRV. Summer conditions assumed (HPI, LPI temp = 302 K (85°˚ F) and CFT temp = 310 K (100°˚ F)).	None	None	Yes	Yes
171	TT/RT	TT/RT with partially stuck open pzr SRV (flow area equivalent to 1.5 in diameter opening). HTC coefficients increased by 1.3.	None	None	Yes	Yes
172	LOCA	10.16 cm (4 in) cold leg break. ECC suction switch to the containment sump included in the analysis.	None	None	No	Yes
178	LOCA	8.53 cm (3.36 in) surge line break (Break flow area reduced by 30% from 10.16 cm (4 in) break). Vent valves do not function. ECC suction switch to the containment sump included in the analysis.	None	None	No	Yes

5. SUCCESS CRITERIA

In a typical full-power probabilistic risk assessment (PRA), success criteria are defined for systems, structures, components (SSCs), and human actions such that an operation of the SSCs and performance of the human actions will *prevent* an undesired condition (e.g., core damage). However, in this pressurized thermal shock (PTS) PRA, the objective is different. Here the objective is to determine the combinations of SSCs and human actions that if the SSCs work and the human actions are performed (or not performed) will *cause or exacerbate* an undesired condition (i.e., PTS). To this end, the basic assumption made in this analysis was that if an SSC was demanded it either worked or failed, i.e., there were no partial operations. Obviously, an exception was made for those cases where the initiating event prevented certain SSCs or portions of systems from operating (e.g., for the loss of main condenser initiating event, main feed water is lost initially). Similarly, for human errors, if the action was required to be performed within a certain time period (error of omission) or postulated (error of commission), the action was either performed or not. Table 5.1 identifies in general terms the "success criteria" examined in this analysis where "success criteria" are the combinations of SSCs and human actions that alter the reactor coolant system pressure and amount of overcooling and hence the PTS challenge.

Table 5.1. General "success criteria" versus function.

Primary Integrity	Secondary Pressure	Secondary Feed	Primary Flow/Pressure
Reactor coolant system (RCS) piping [different size breaks] • small • medium • large	Steam lines [different size breaks] • small • large	Status of main feedwater (MFW) • successfully operating • tripped • overfeeding one steam generator (SG) • overfeeding two SGs Status of MFW trip on high SG level • tripped • not tripped Status of recovery from MFW overfeed • overfeed controlled • overfeed not controlled	Status of reactor coolant pumps (RCPs) • tripped • not tripped • if tripped, restarted • if tripped, not restarted

5. Success Criteria

Table 5.1. General "success criteria" versus function.

Primary Integrity	Secondary Pressure	Secondary Feed	Primary Flow/Pressure
Power-operated relief valve (PORV) status • opens but recloses • opens and sticks open Status of PORV block valve • closed • not closed	Status of turbine bypass valves (TBVs) • 0 stuck open (SO) • 1 SO • 2 SO • 4 SO Status of turbine block valves • closed • not closed	Status of emergency feedwater (EFW) system Case 1 • successfully operating • overfeeding one steam generator (SG) • overfeeding two SGs • fails to start Case 2 • starts and feed to faulted SG isolated • starts and feed to faulted SG not isolated • fails to start Status of EFW recovery Case 1: EFW overfeed • overfeed controlled • overfeed not controlled Case 2: EFW fails to start • recovered and successfully operating • recovered but flow to SG not controlled • not recovered	Status of high pressure injection (HPI) pumps [1] and the core flood tanks (CFTs) [2] • system operates • system fails Status of HPI recovery • recovered • not recovered HPI injection throttled • throttled • not throttled
Pressurizer safety relief valves (SRVs) status • opens but recloses • opens and remains open	Status of secondary steam relief valves (SSRVs) [referred to as main steam safety relief valves (SRVs)] • 0 SO • 1 SO • 2 SO • 4 SO	Status of condensate (i.e., condensate booster pump [CBP]) • successful use of CBP (operator depressurize, CBP works, operator controls CBP injection) • CBP injection control failed • depressurization failed or CBP fails	low pressure injection (LPI) pumps • assumed to function if required (i.e., not explicitly incorporated into the model)

[1] Note that Oconee's pumps serve both normal makeup and safety injection functions and can pressurize the primary system to the pressurizer safety valve setpoints.
[2] Failure of CFTs not explicitly incorporated into the model. If required, they are assumed to function as designed.

6. SYSTEMS ANALYSIS

This section provides a description of the systems analysis effort performed to support the pressurized thermal shock (PTS) probabilistic risk assessment (PRA) of Unit 1 at Oconee. Given that the purpose of this analysis was to identify and quantify potential PTS scenarios, the development of detailed system models (consisting of the various component-related failure mechanisms) was deemed unnecessary. The major justification for this decision is that for many systems detailed knowledge of which set of component failure mechanisms occurred to cause system failure ultimately has minimal impact on PTS since for many systems *continued* operation (sometimes beyond the point where the system should have stopped) contributes to PTS conditions. In addition, the use of simple models allowed the analysts to concentrate on development of the expanded set of thermal-hydraulic bins used to characterize the plant's susceptibility to PTS (see section 4), one of the major enhancements of this PTS analysis.

6.1 Modeling Approach and Scope

Two different types of system models were used in the systems analysis:

1. Black box models, and
2. Simplified fault tree models.

The black box models use a single event to represent a system's unavailability, where the unavailability is determined from existing data sources or is derived from the quantification of more detailed system models (e.g., a system model from an Individual Plant Examination). The simplified fault tree models, as the description implies, consist of simple representations of system failure, including major equipment unavailabilities and/or human actions. Table 6.1 lists the events used to represent the systems included in this analysis. The system event names are grouped by major function, and the type of model constructed for each event is identified. In addition, Table 6.1 identifies the figure (Figures 6.1 through 6.41) that depicts the system logic for each model.

6.2 System Description

The following sections provide a brief description of the main function of the systems included in this analysis. In addition, a brief description of the PTS-related consequences of the system's successful operation or failure to operate is provided.

6.2.1 Power-Operated Relief Valve and Its Block Valve

The single power-operated relief valve (PORV) provides both automatic and manual control of reactor coolant system (RCS) pressure by releaving pressure from the pressurizer. The block valve can be used to terminate flow from the PORV in the event it becomes stuck open.

If a PORV opens and then sticks open, the loss of inventory will require injection by some system (e.g., high pressure injection). This injection of relatively cold water enhances the potential for PTS. If a stuck open PORV subsequently recloses, the relatively sudden increase in reactor pressure enhances the potential for PTS. Early closure of the PORV block valve can minimize the PTS consequences associated with a stuck open PORV.

Table 6.1. Events model types by system/function.

Function	System	Event Name	Model Type	Fault Tree Figure
Primary integrity	Stuck open PORV/SRV	PORV_SRV_SO-FT	simplified fault tree	6.1
		PORV_SO	black box	
		PORV_SO_SGTR	black box	
		SRV_SO	black box	
	PORV/SRV isolation	PORV_ISO_F-10	black box	
		PORV_SELF_CLOSE	black box	
		SRV_ISO_F	black box	
Secondary pressure	Stuck open TBVs/MS-SRVs	TBV_1SO	black box	
		TBV_1SO_SGTR	black box	
		TBV_2SO	black box	
		TBV_2SO_SGTR	black box	
		TBV_4SO	black box	
		TBV_4SO_SGTR	black box	
		TBV_SO-FT	simplified fault tree	6.2
		TBV_SO_SGTR-FT	simplified fault tree	6.3
		TBV_SO_FI-TRUE	black box	
		TBV_EX	black box	
	TBV isolation	TBV_ISO_F-FT3	simplified fault tree	6.4
		TBV_ISO_F-FT5	simplified fault tree	6.5
		TBV_ISO_F-FT6	simplified fault tree	6.6
		TBV_ISO_F-FT7	simplified fault tree	6.7
		TBV_ISO_F-FT8	simplified fault tree	6.8
		TBV_ISO_F-FT9	simplified fault tree	6.9
	Isolation of steam line break	SLB1_ISO_F	black box	
		SLB2_ISO_F	black box	
Secondary feed	Main feed	MFW_F-FT	simplified fault tree	6.10
		MFW_TRIP_F	black box	
		MFW_OVRFD_A	black box	
		MFW_OVRFD_AB	black box	
		MFW_TRIP0	black box	
		MFW_TRIP0-FALSE	black box	
		MFW_TRIP0-TRUE	black box	
		MFW_OVRFD-FALSE	black box	
		MFW_ESD_OF	black box	
	Recovery of main feed	MFW_REC_F-FT-A	simplified fault tree	6.11
		MFW_REC_F-FT-B	simplified fault tree	6.12
		MFW_REC_F-FT-C	simplified fault tree	6.13
	Emergency feed	EFW_F-FT	simplified fault tree	6.14
		EFW_F-FT1	simplified fault tree	6.15
		EFW_F-FT2	simplified fault tree	6.16
		EFW_F-FT3	simplified fault tree	6.17
		EFW_F-FT4	simplified fault tree	6.18
		EFW_FTS	black box	
		EFW_OVRFD_A	black box	
		EFW_OVRFD_AB	black box	
		EFWTDP_F-FT	simplified fault tree	6.19

Table 6.1. Events model types by system/function.

Function	System	Event Name	Model Type	Fault Tree Figure
		EFWTDP_FTS	black box	
		EFWTDP_OVRFD_A	black box	
		EFWTDP_OVRFD_AB	black box	
		EFW_SLB_FTS	black box	
		EFW_SLBSBO_FTS	black box	
	Recovery of emergency feed	EFW_REC_A-FT	simplified fault tree	6.20
		EFW_REC_B-FT	simplified fault tree	6.21
		EFW_REC_E-FT	simplified fault tree	6.22
		EFW_REC_F-FT-T-A	simplified fault tree	6.23
		EFW_REC_F-FT-T-B	simplified fault tree	6.24
		EFW_REC_F-FT-T-E	simplified fault tree	6.25
		EFW_REC_NONE	black box	
	Condensate	CBP_F-FT1	simplified fault tree	6.26
		CBP_F-FT2	simplified fault tree	6.27
		CBP_F-TRUE	black box	
		CBP_OVRFD	black box	
		CBP_OVRFD-FALSE	black box	
	Secondary cooling recovery late	SEC_COOLREC-ALL	simplified fault tree	6.28
		SEC_COOLREC-LOSP	simplified fault tree	6.29
Primary flow/ pressure	High pressure injection	HPI_FTS	black box	
		HPI_STARTS_F-FT1	simplified fault tree	6.30
		HPI_FTS-FALSE	black box	
		HPI_FTS-TRUE	black box	
	Recovery of high pressure injection	HPI_REC_F	black box	
	Throttling high pressure injection	HPI_TF_FT-AB	simplified fault tree	6.31
		HPI_TF_FT-AB-SEC	simplified fault tree	6.32
		HPI_TF-10AB	black box	
		HPI_TF-10AB-SEC	black box	
		HPI_TF_FT-C	simplified fault tree	6.33
		HPI_TF_FT-D1	simplified fault tree	6.34
		HPI_TF_FT-D1-N	simplified fault tree	6.35
		HPI_TF_FT-D2	simplified fault tree	6.36
		HPI_TF_FT-E	simplified fault tree	6.37
	Reactor coolant pump trip	RCP_TRIP	black box	
		RCP_TRIP-TRUE	black box	
		RCP_TRIP_PORV	black box	
		RCP_TRIP_SRV	black box	
		RCP_RF-TRUE	black box	
Miscellaneous		EAC_F	black box	
		RX_TRIP	black box	
		EFW-NOT-ISO-T-A	simplified transfer fault tree	6.38
		EFW-NOT-ISO-T-C	simplified transfer fault tree	6.39
		TBV-NOT-ISO-T-A	simplified transfer fault tree	6.40
		TBV-NOT-ISO-T-B	simplified transfer fault tree	6.41

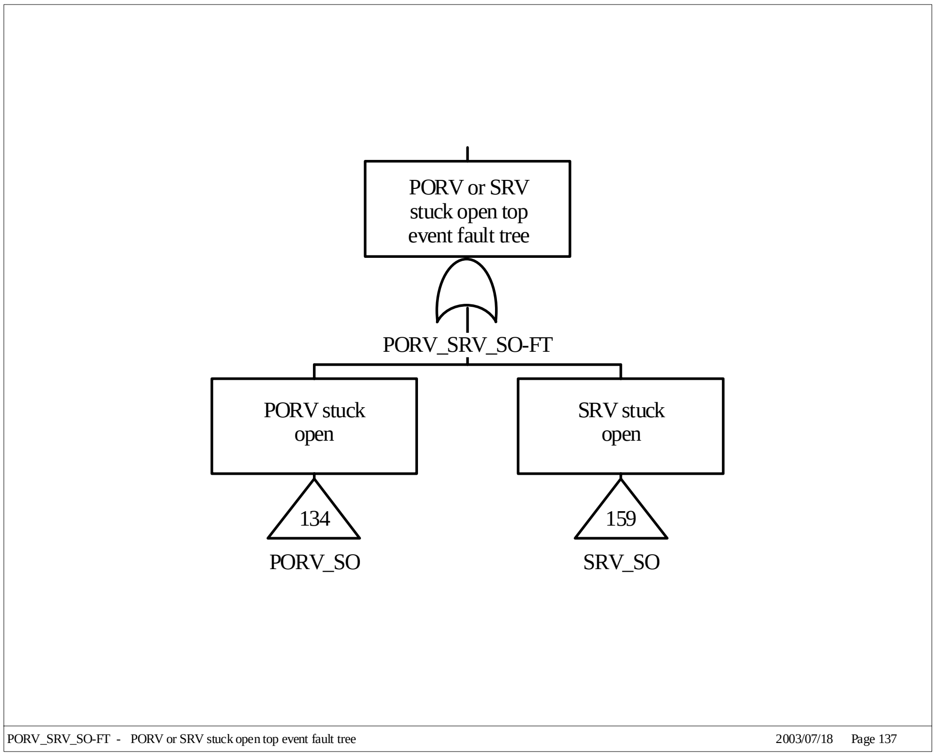

Figure 6.1. Fault tree for PORV_SRV_SO-FT.

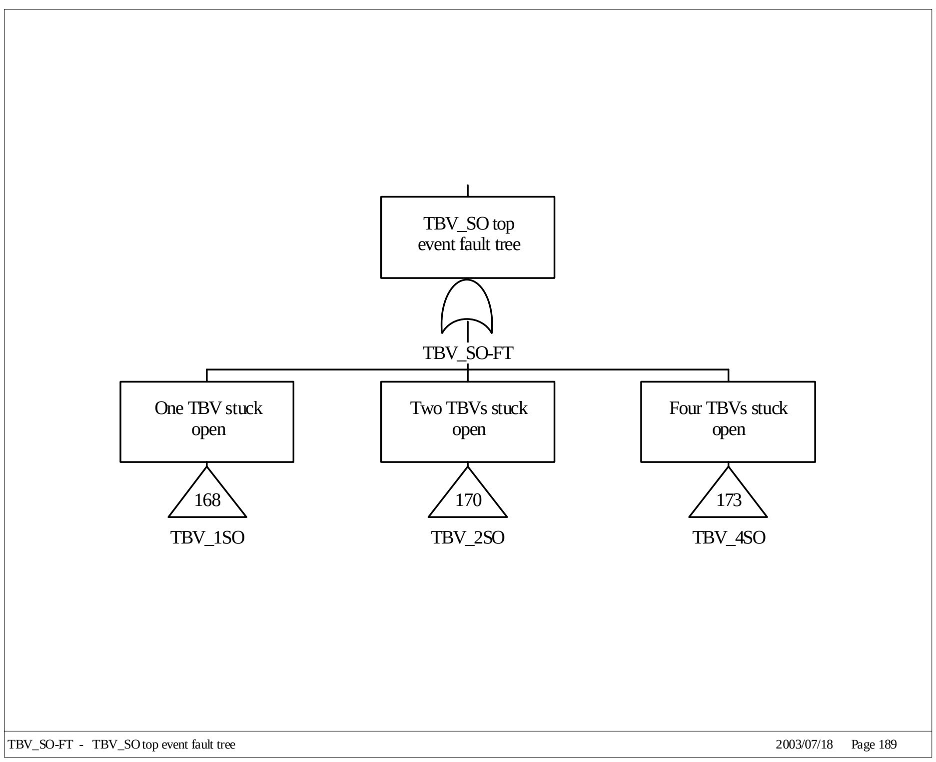

Figure 6.2. Fault tree for TBV_SO-FT.

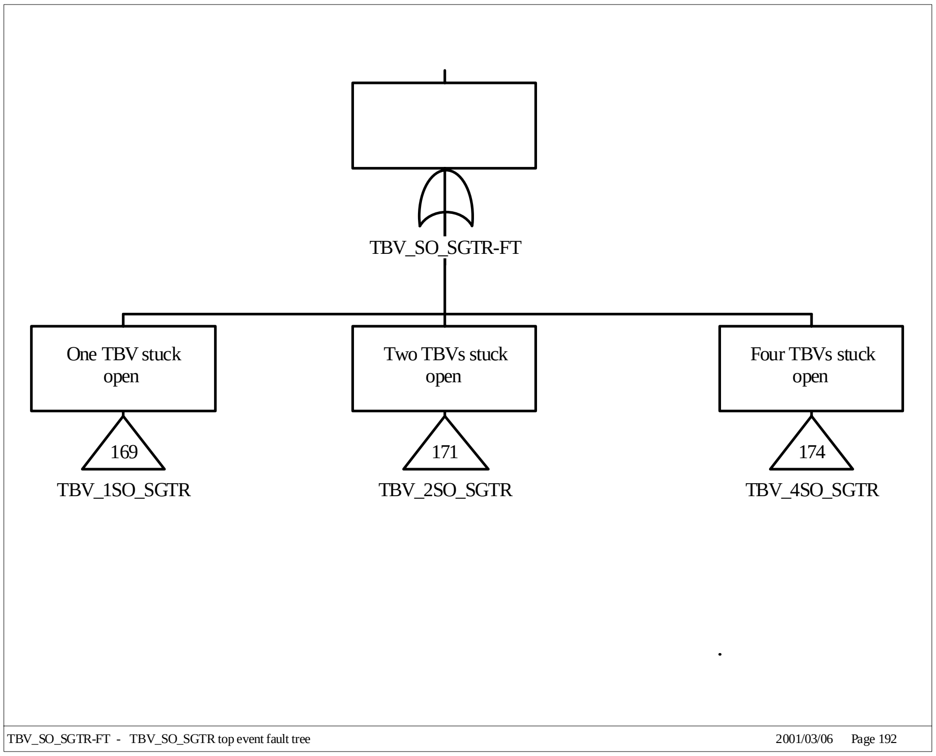

Figure 6.3. Fault tree for TBV_SO_SGTR-FT.

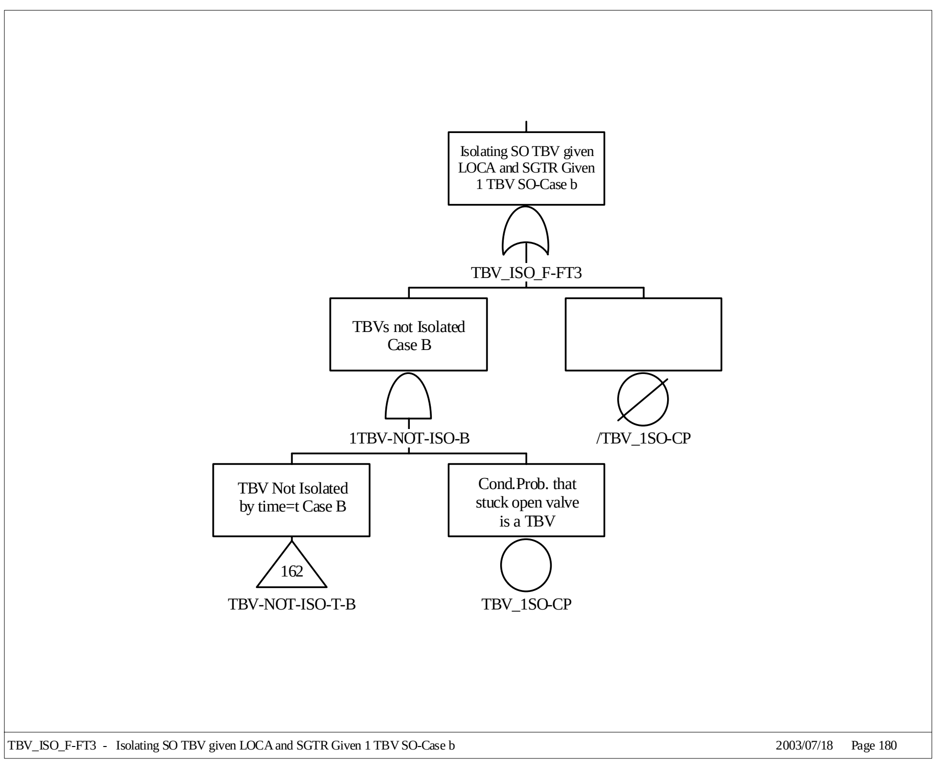

Figure 6.4. Fault tree for TBV_ISO_F-FT3.

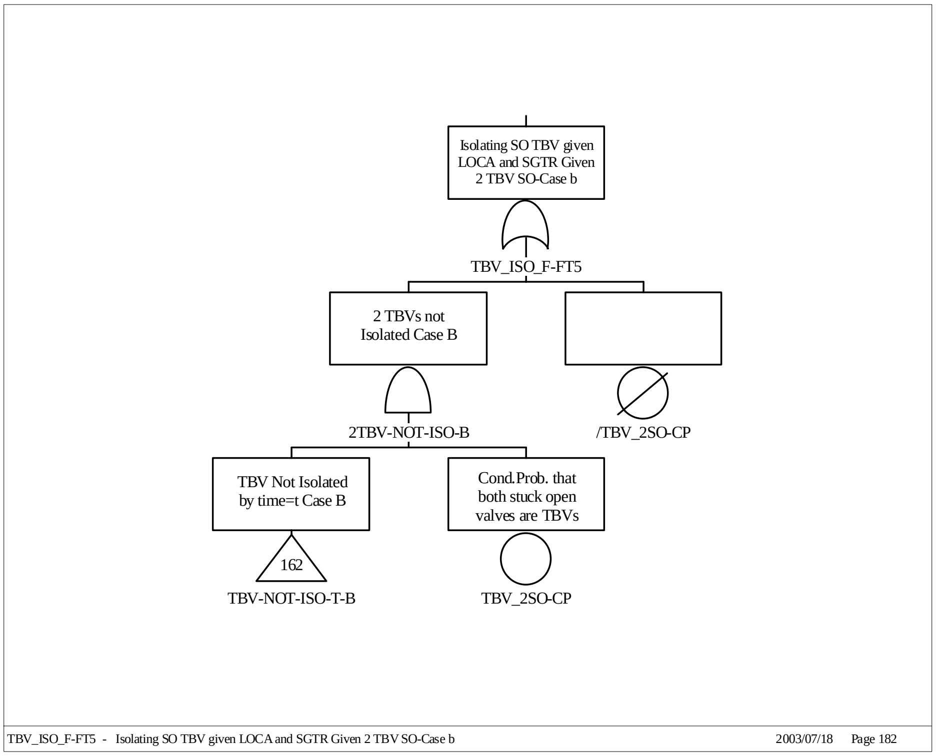

Figure 6.5. Fault tree for TBV_ISO_F-FT5.

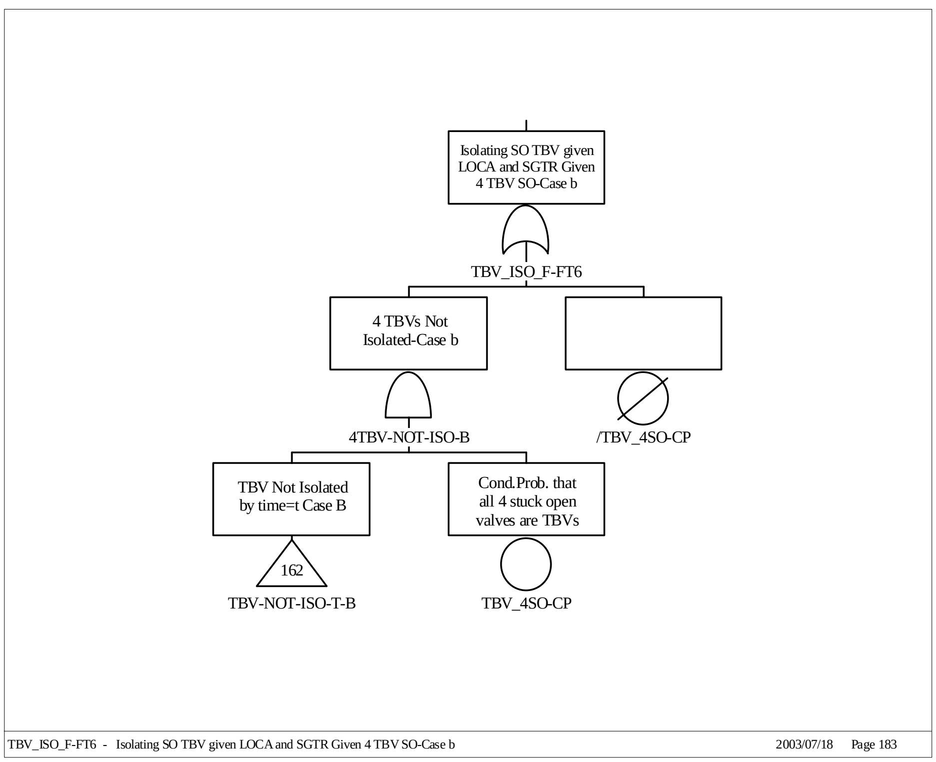

Figure 6.6. Fault tree for TBV_ISO_F-FT6.

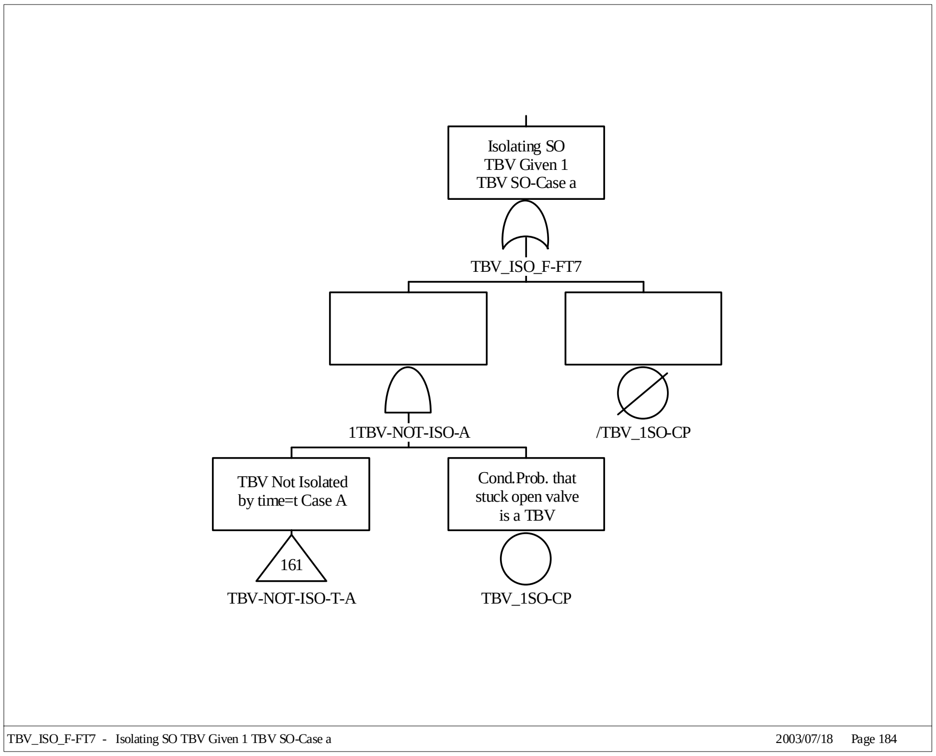

Figure 6.7. Fault tree for TBV_ISO_F-FT7.

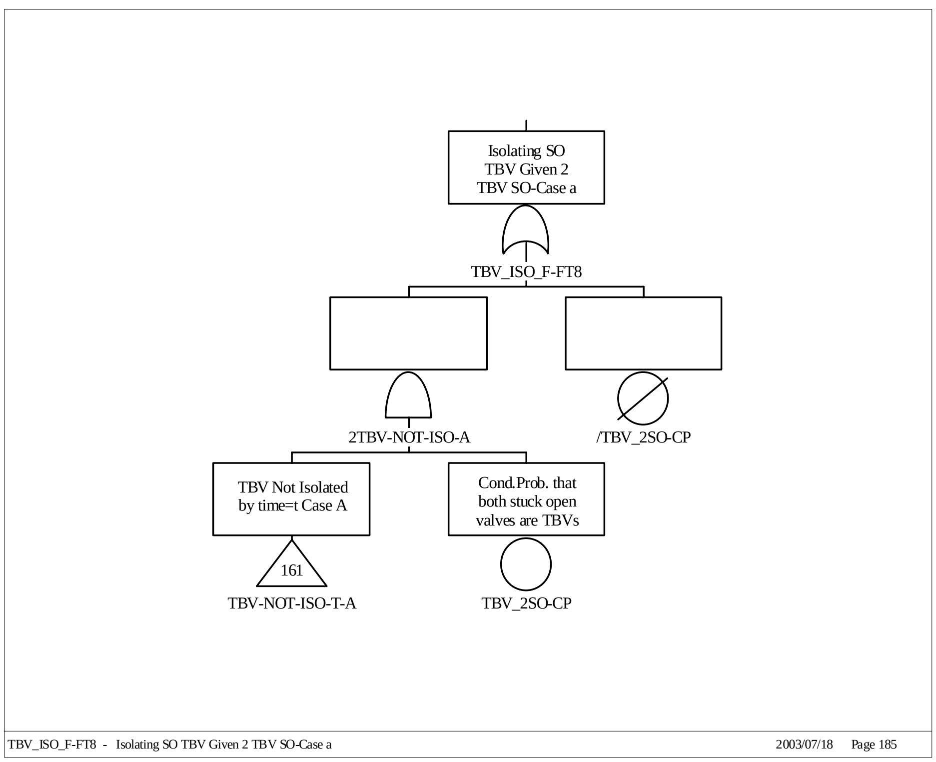

Figure 6.8. Fault tree for TBV_ISO_F-FT8.

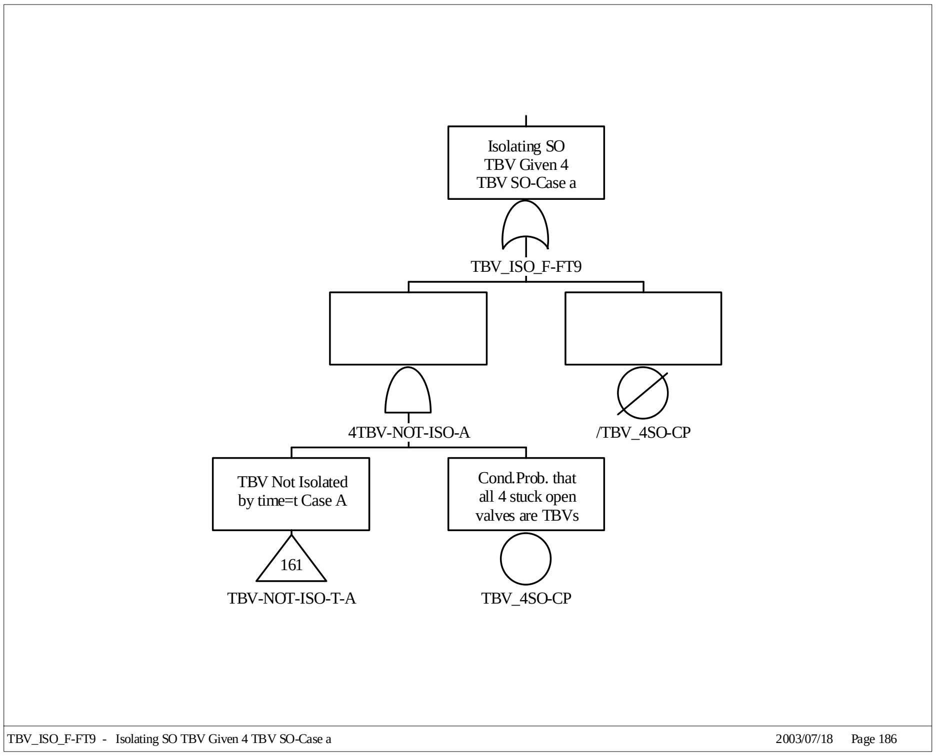

Figure 6.9. Fault tree for TBV_ISO_F-FT9.

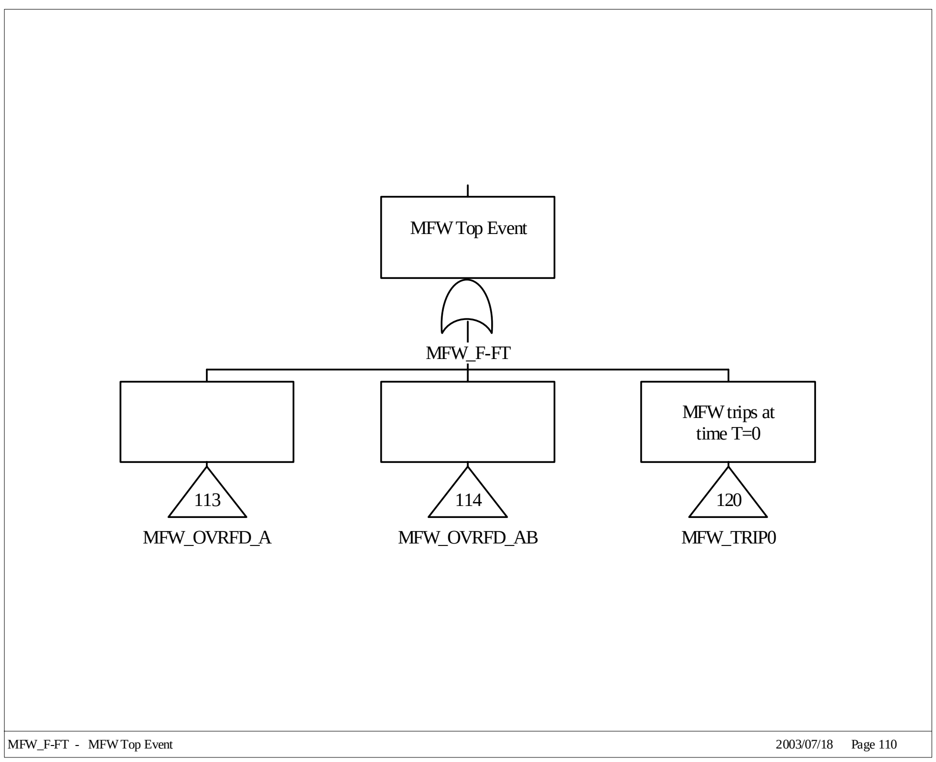

Figure 6.10. Fault tree for MFW_F-FT.

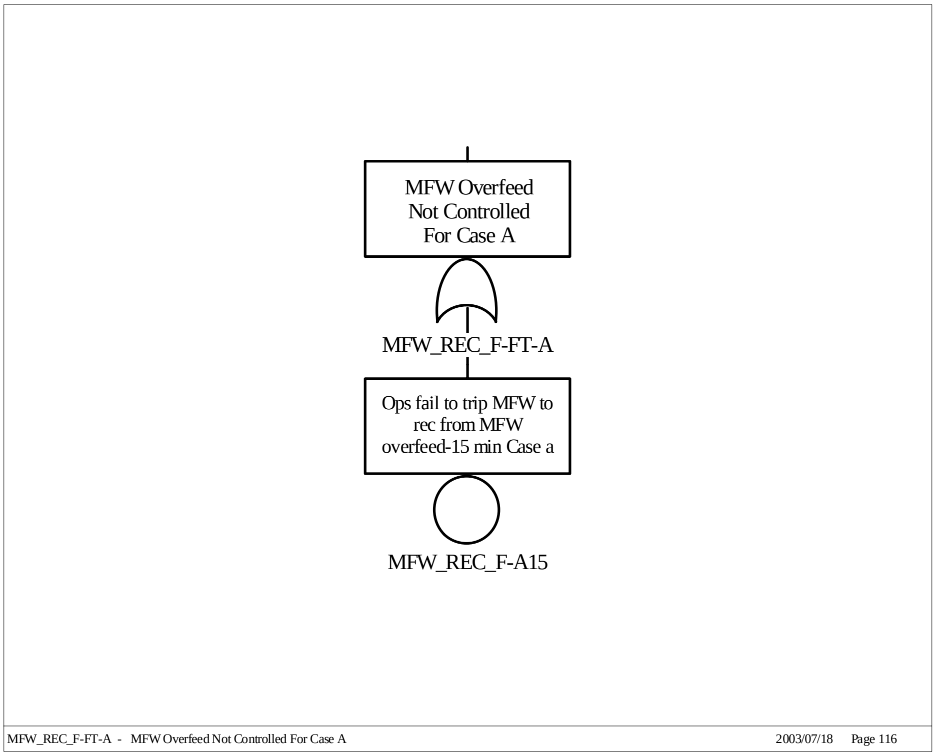

Figure 6.11. Fault tree for MFW_REC_F-FT-A.

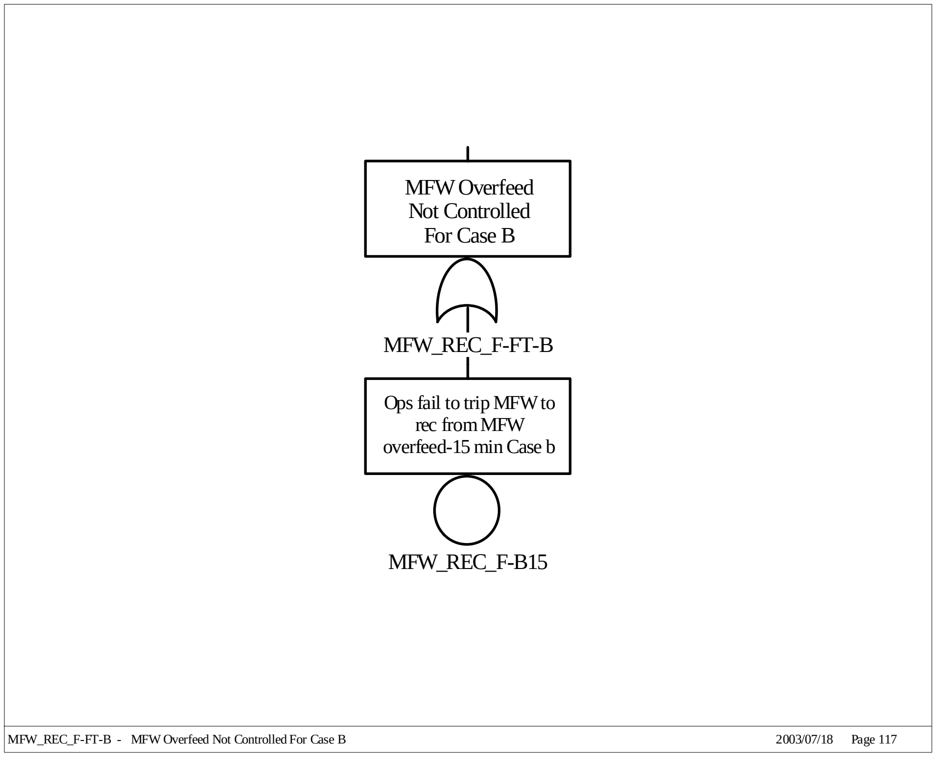

Figure 6.12. Fault tree for MFW_REC_F-FT-B.

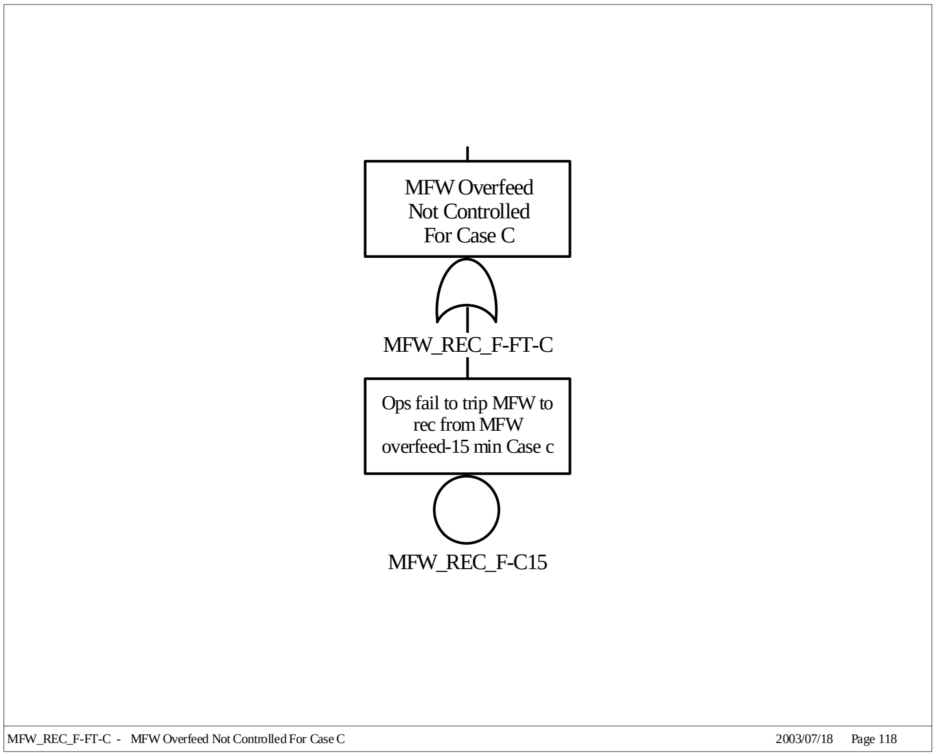

Figure 6.13. Fault tree for MFW_REC_F-FT-C.

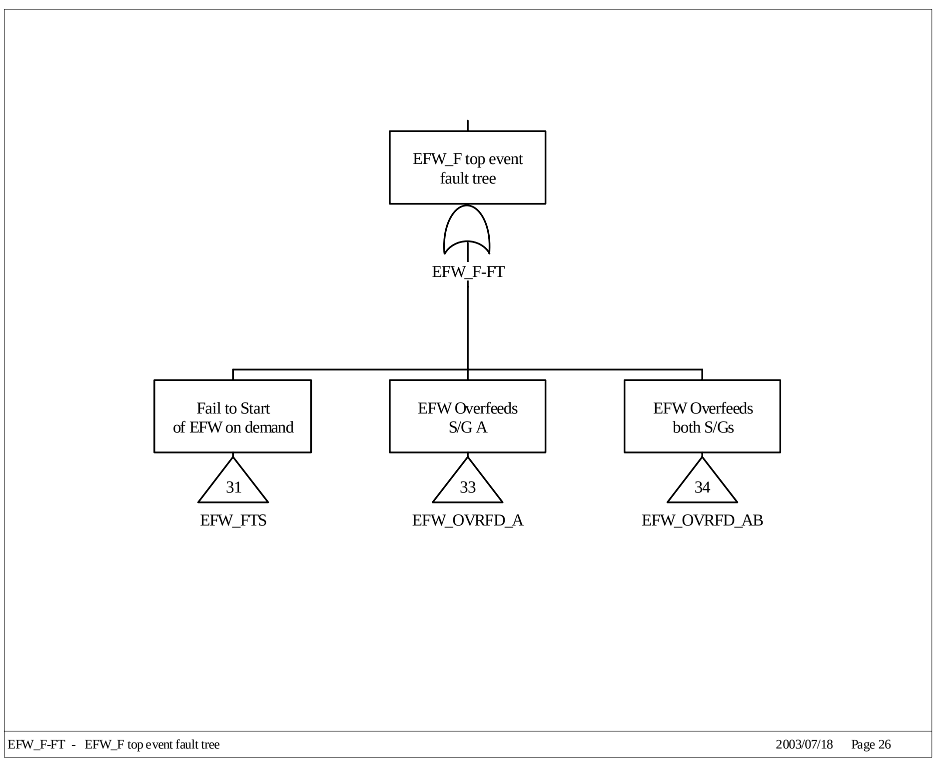

Figure 6.14. Fault tree for EFW_F-FT.

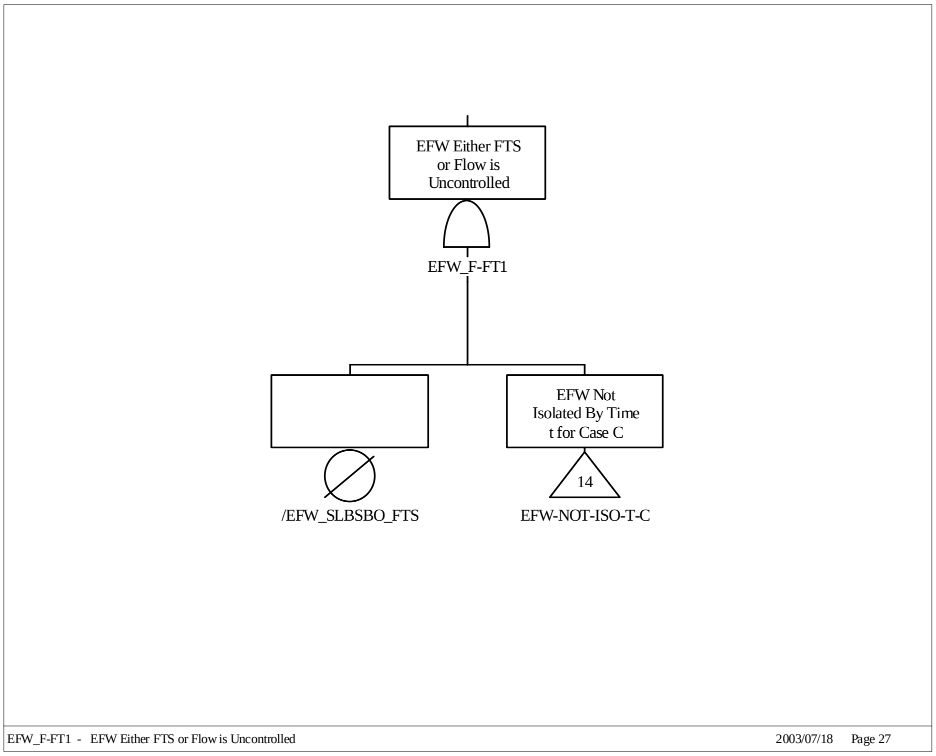

Figure 6.15. Fault tree for EFW_F-FT1.

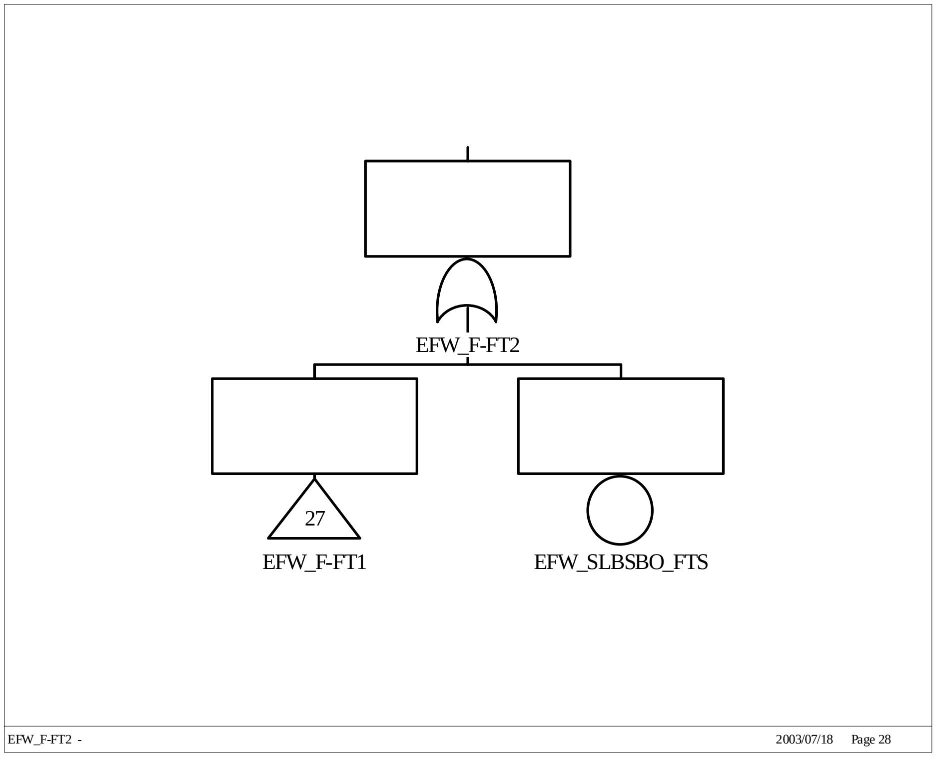

Figure 6.16. Fault tree for EFW_F-FT2.

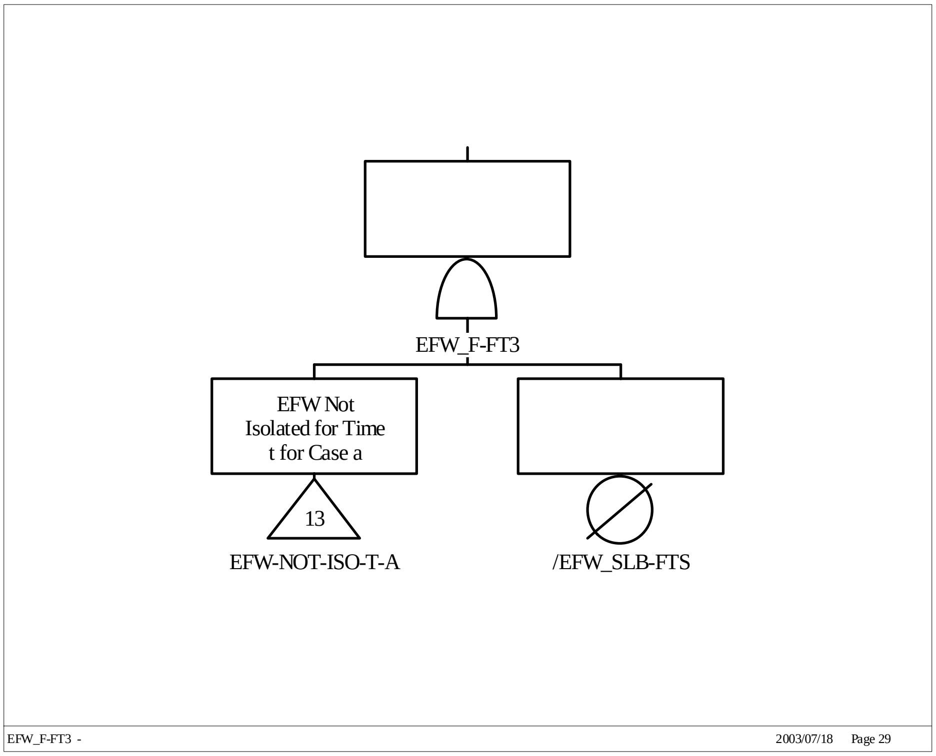

Figure 6.17. Fault tree for EFW_F_FT3.

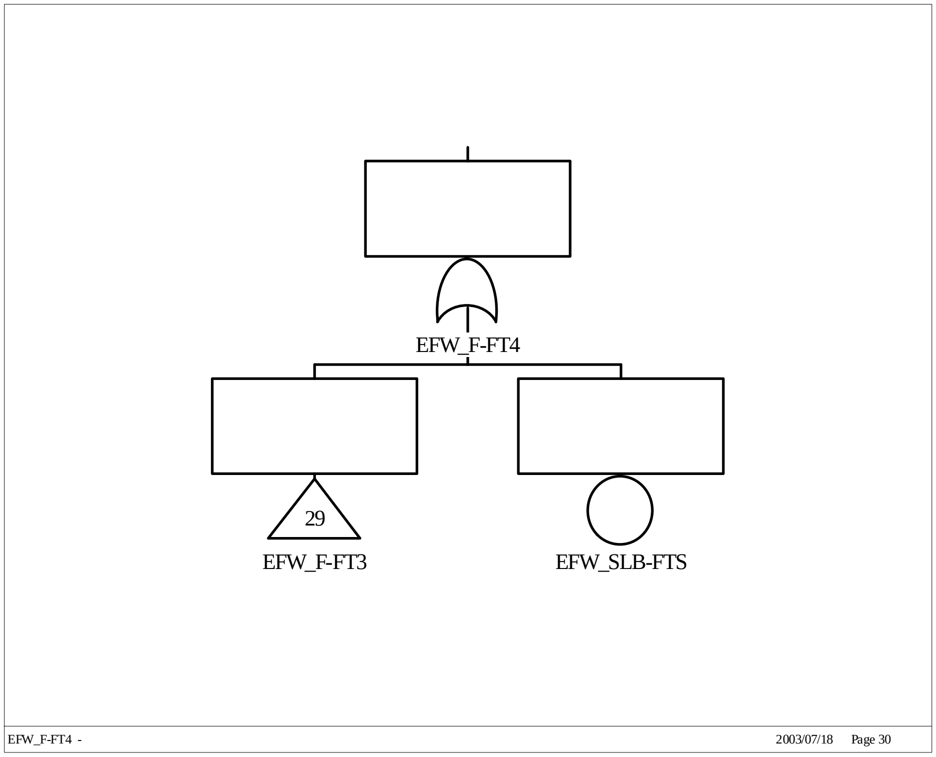

Figure 6.18. Fault tree for EFW_F-FT4.

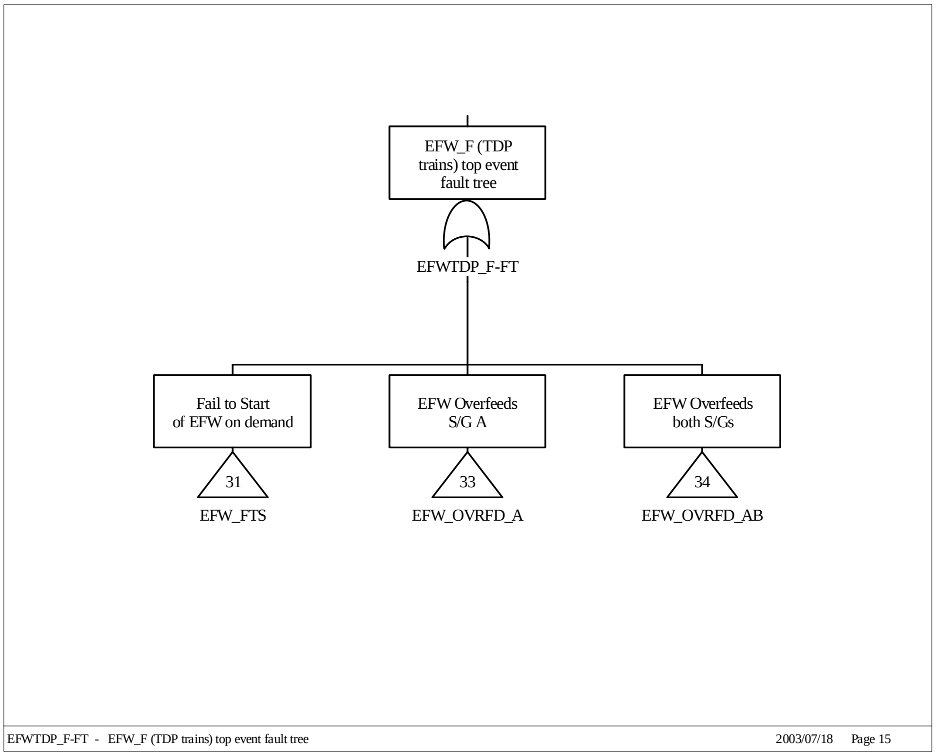

Figure 6.19. Fault tree for EFWTDP_F-FT.

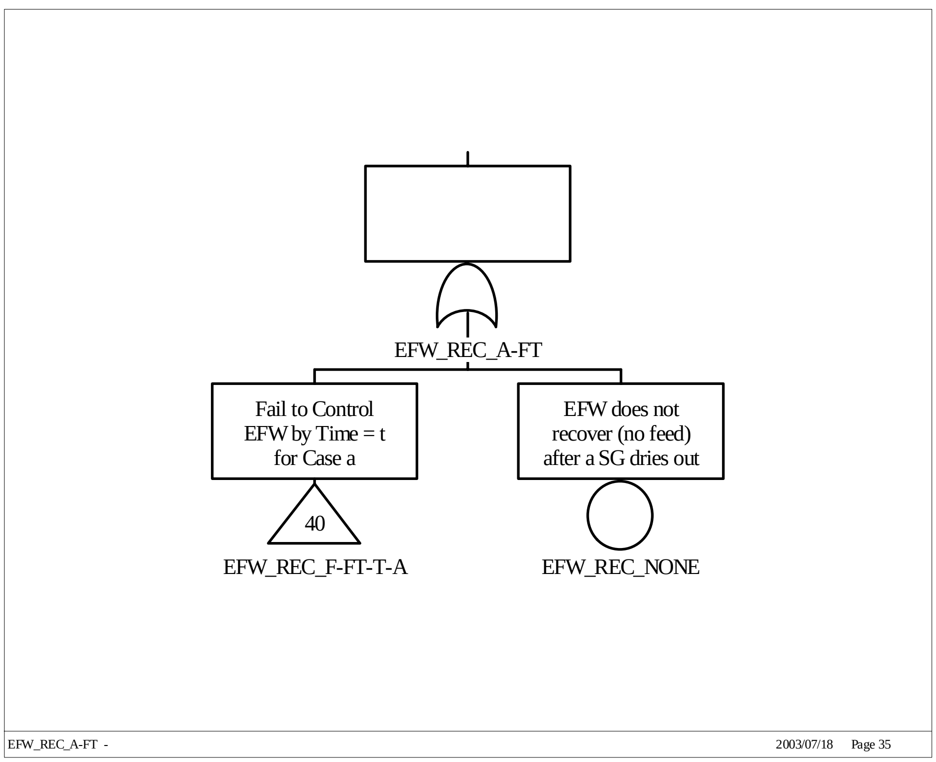

Figure 6.20. Fault tree for EFW_REC_A-FT.

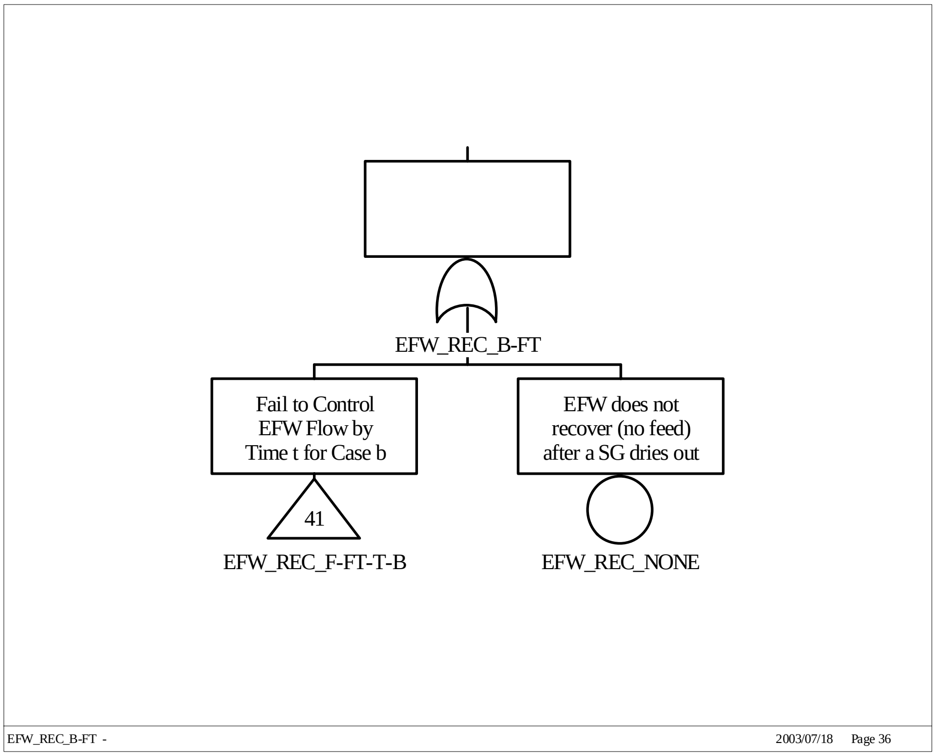

Figure 6.21. Fault tree for EFW_REC_B-FT.

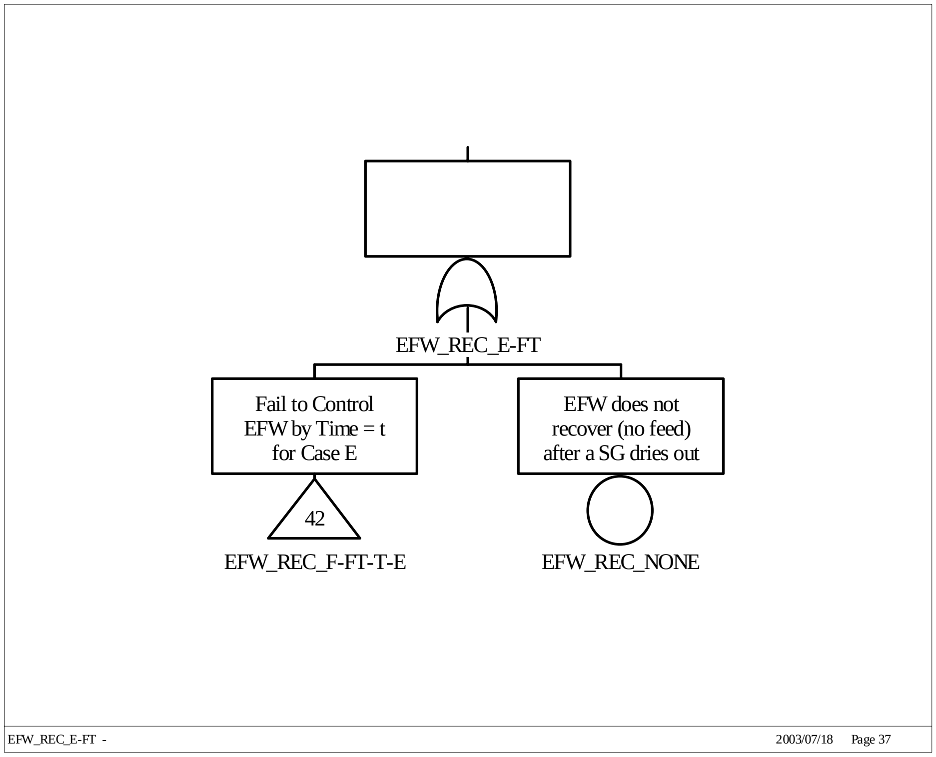

Figure 6.22. Fault tree for EFW_REC_E-FT.

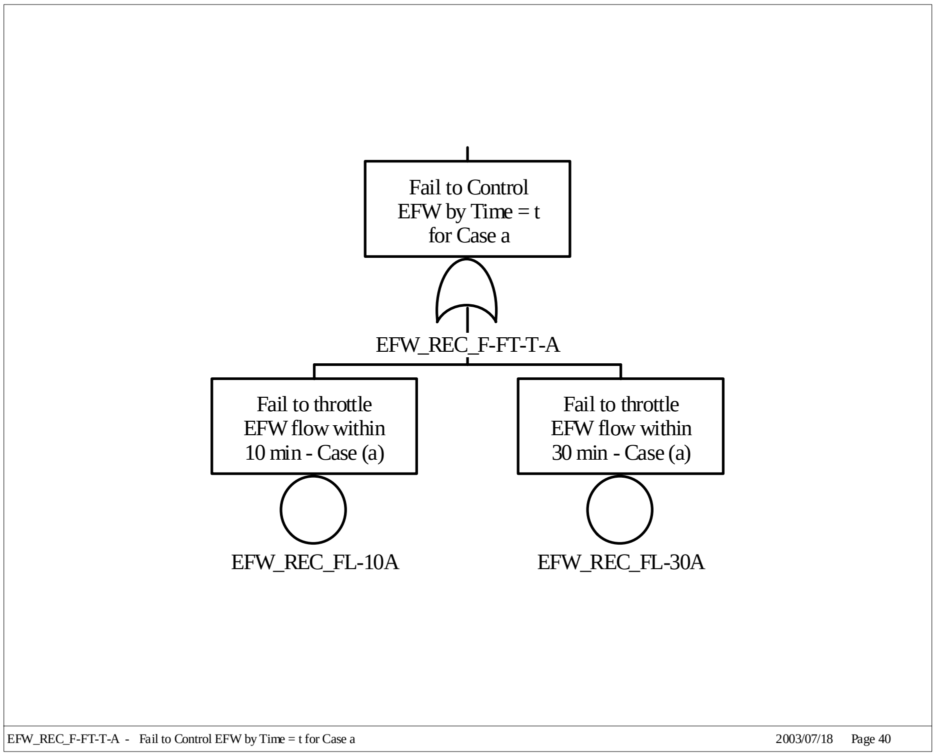

Figure 6.23. Fault tree for EFW_REC_F-FT-T-A.

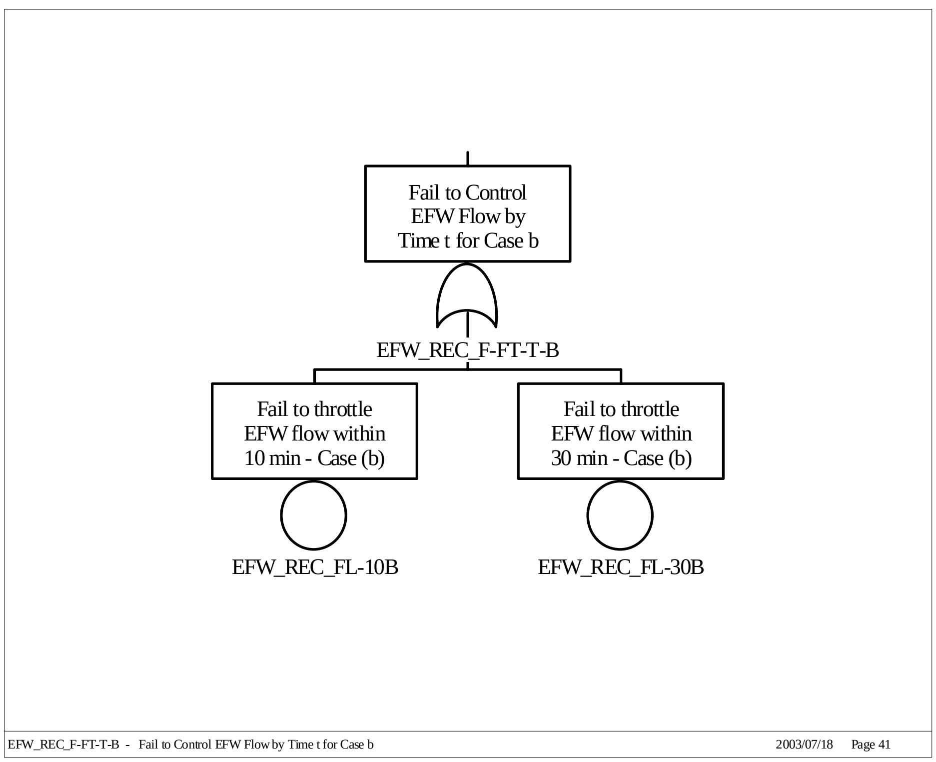

Figure 6.24. Fault tree for EFW_REC_F-FT-T-B.

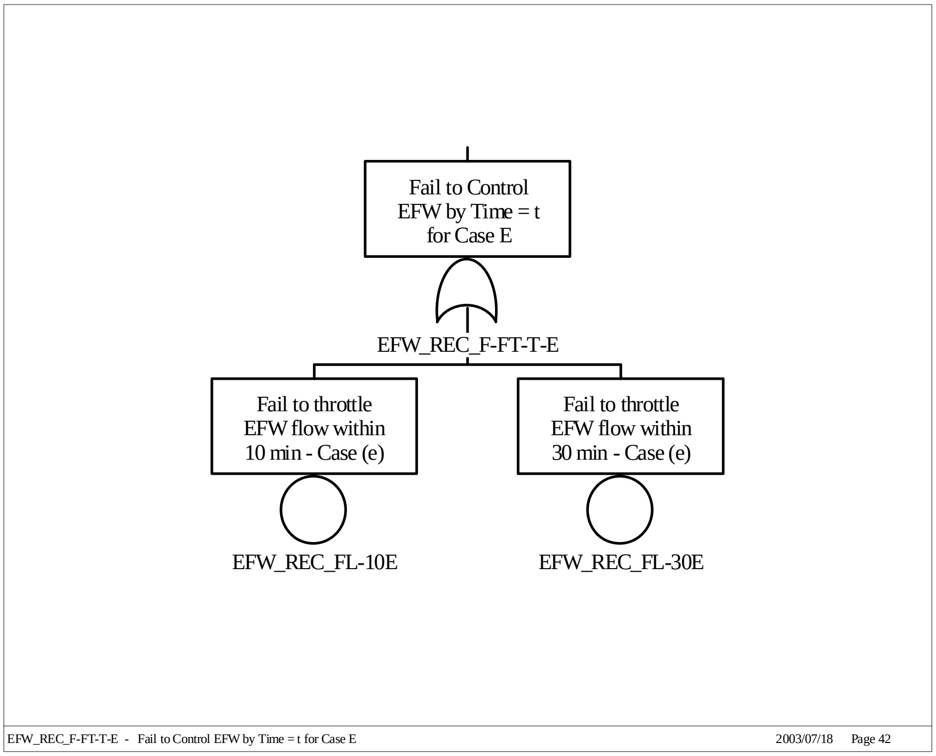

Figure 6.25. Fault tree for EFW_REC_F-FT-T-E.

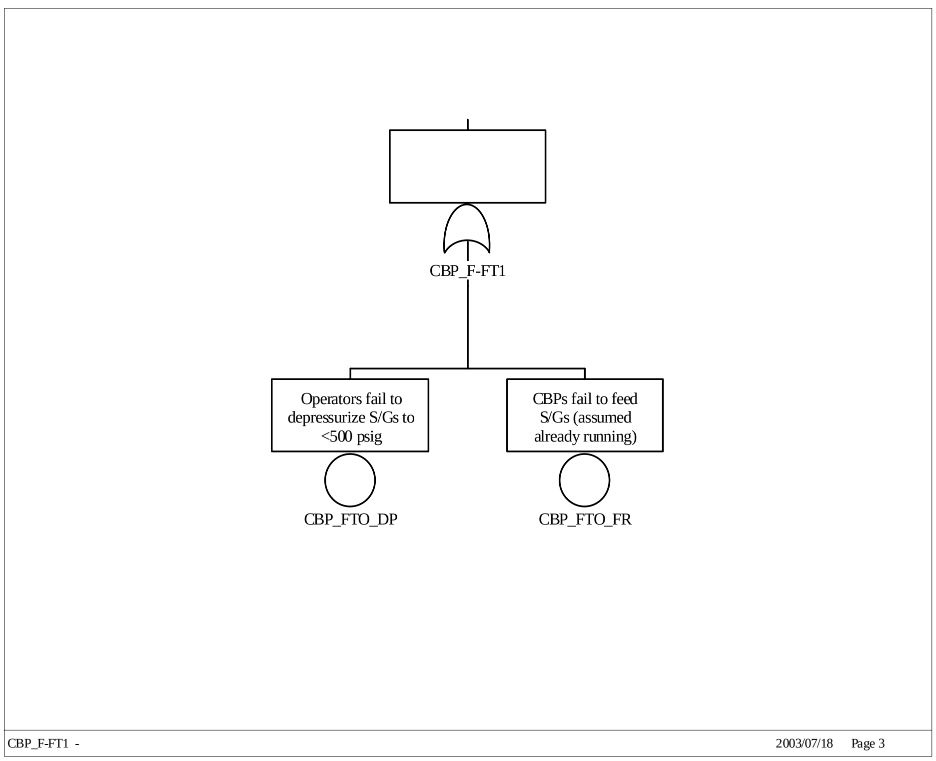

Figure 6.26. Fault tree for CBP_F-FT1.

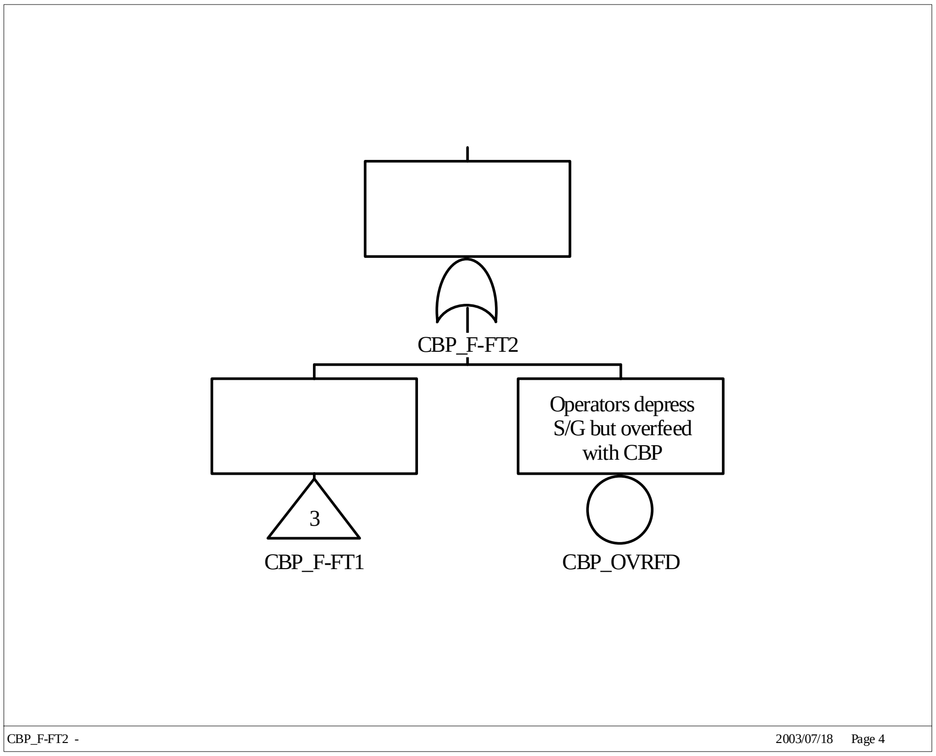

Figure 6.27. Fault tree for CBP_F-FT2.

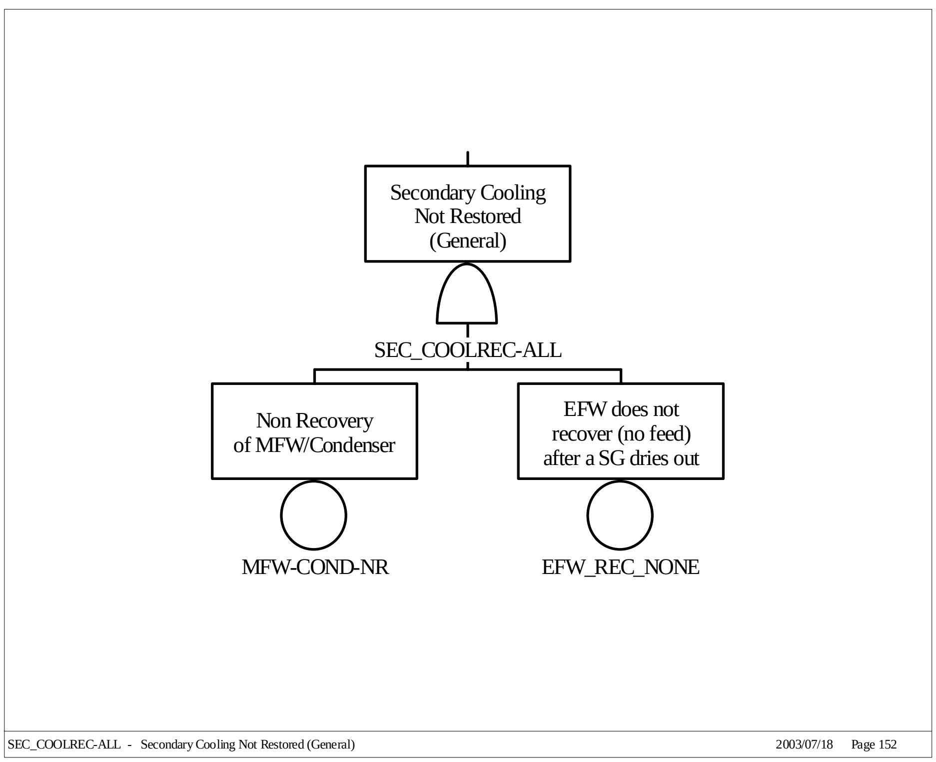

Figure 6.28. Fault tree for SEC_COOLREC-ALL.

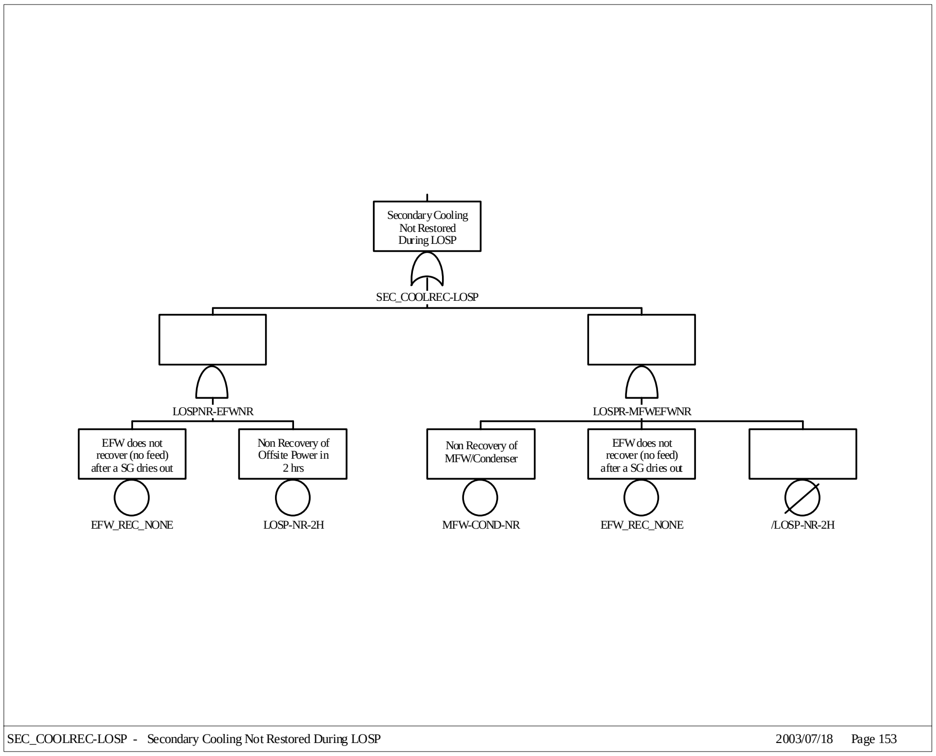

Figure 6.29. Fault tree for SEC_COOLREC-LOSP.

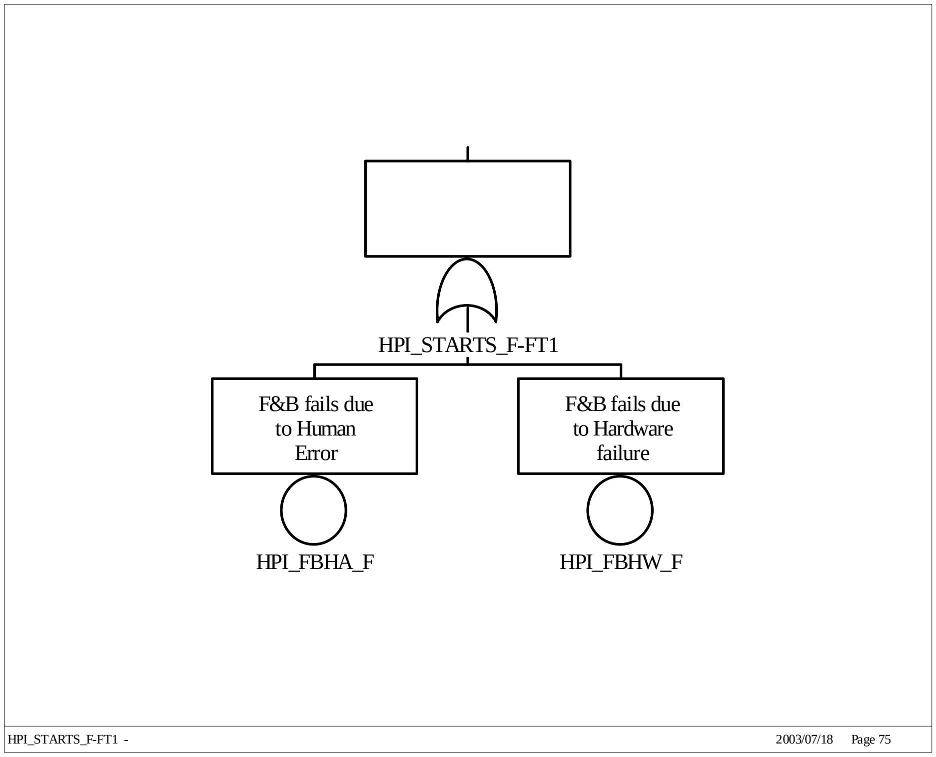

Figure 6.30. Fault tree for HPI_STARTS_F-FT1.

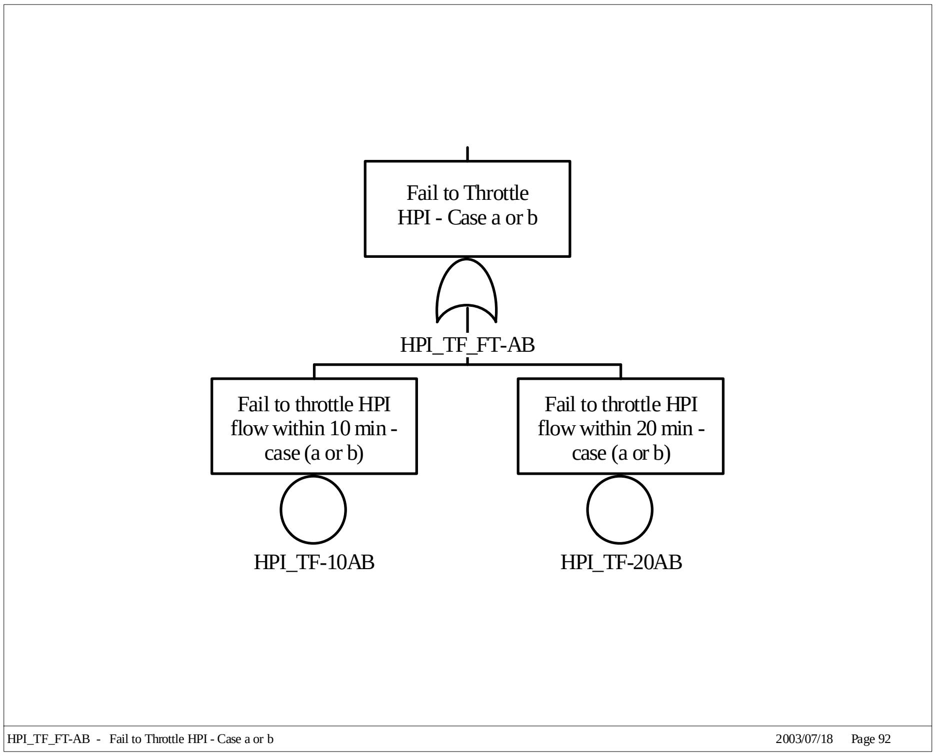

Figure 6.31. Fault tree for HPI_TF_FT-AB.

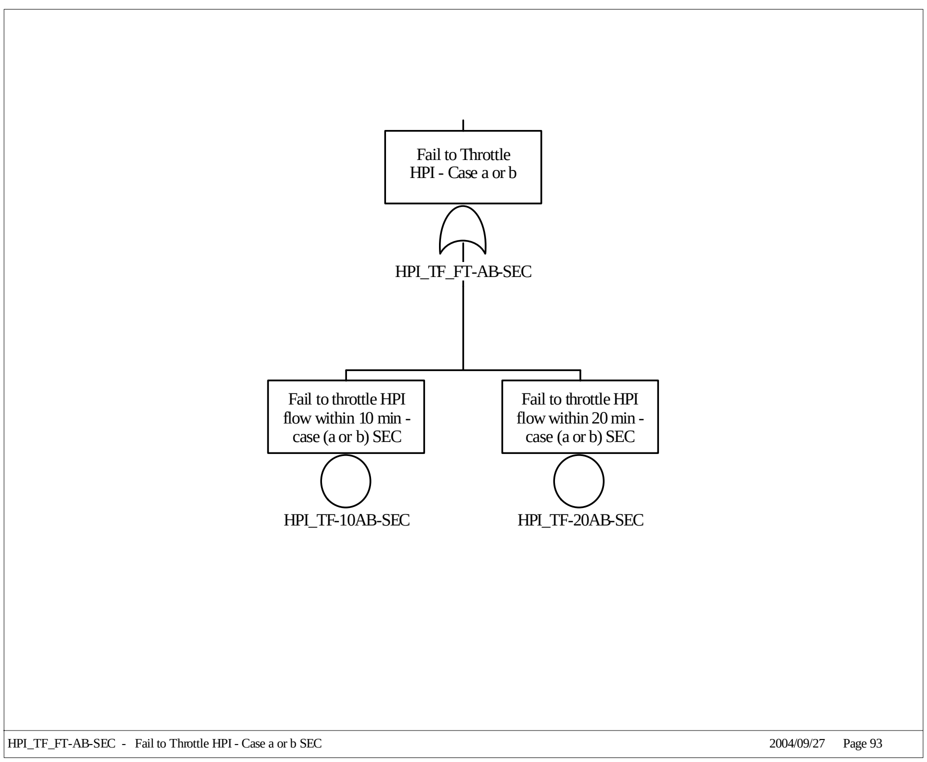

Figure 6.31. Fault tree for HPI_TF_FT-AB-SEC.

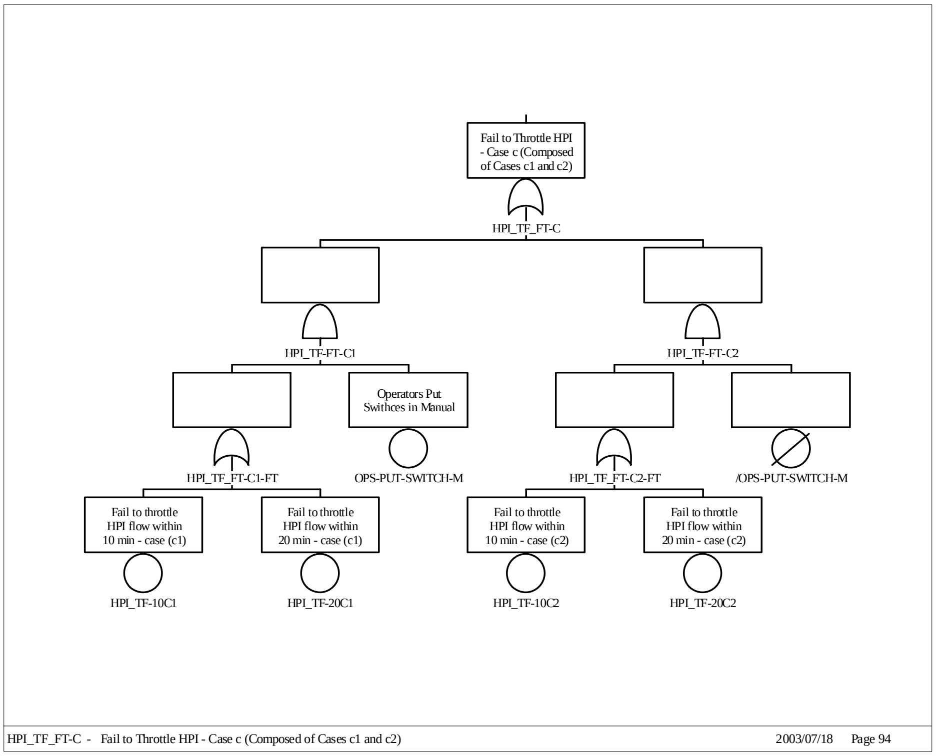

Figure 6.33. Fault tree for HPI_TF_FT-C.

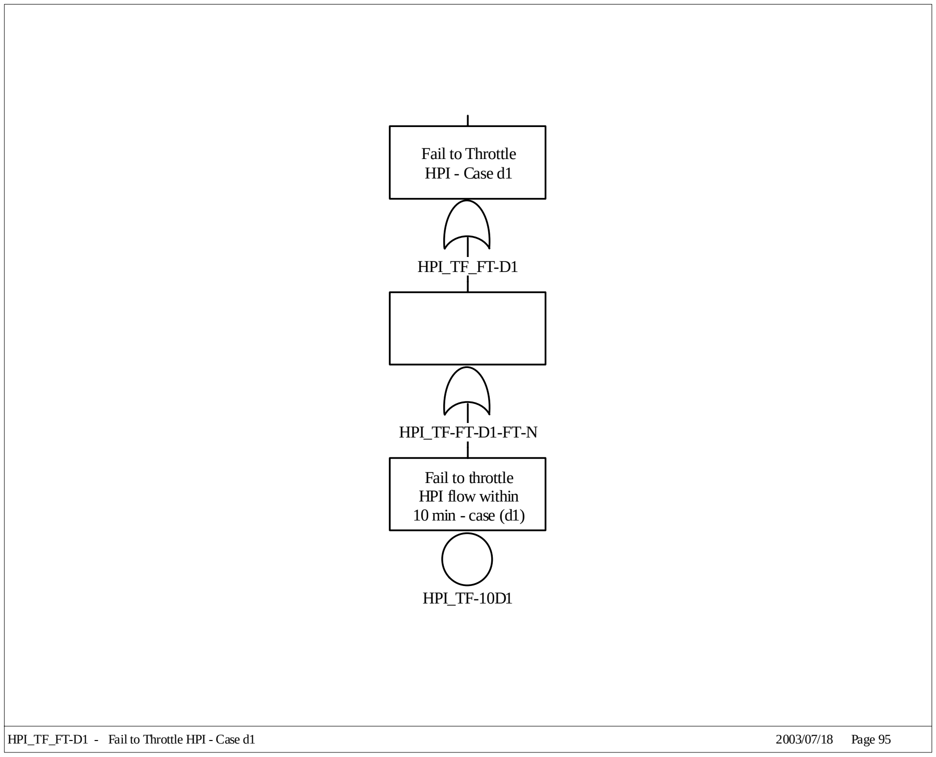

Figure 6.34. Fault tree for HPI_TF_FT-D1.

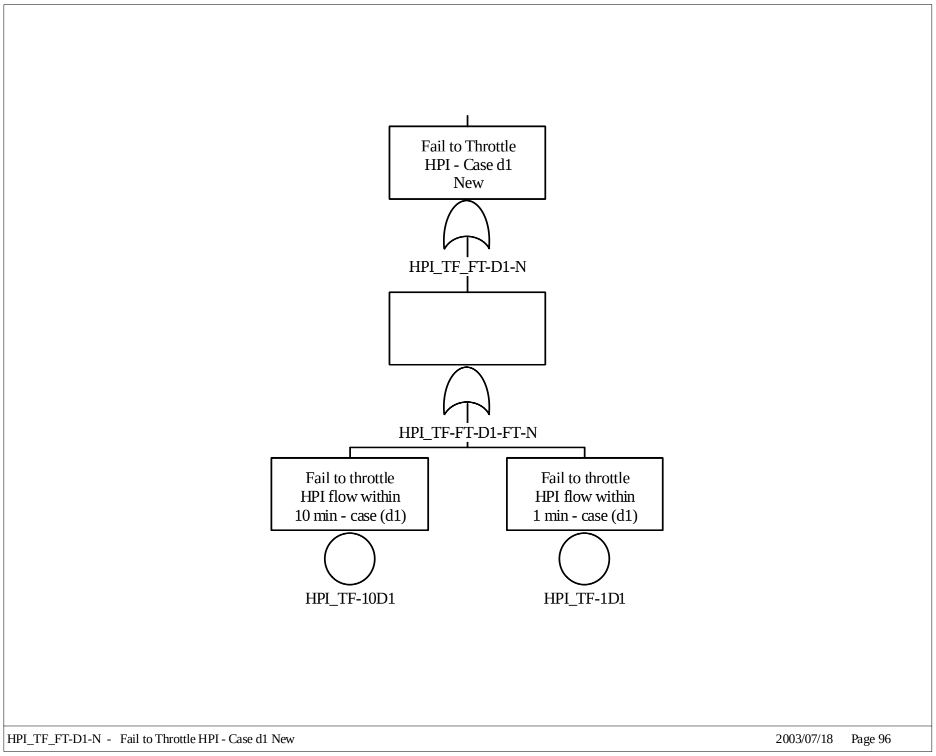

Figure 6.35. Fault tree for HPI_TF_FT-D1-N.

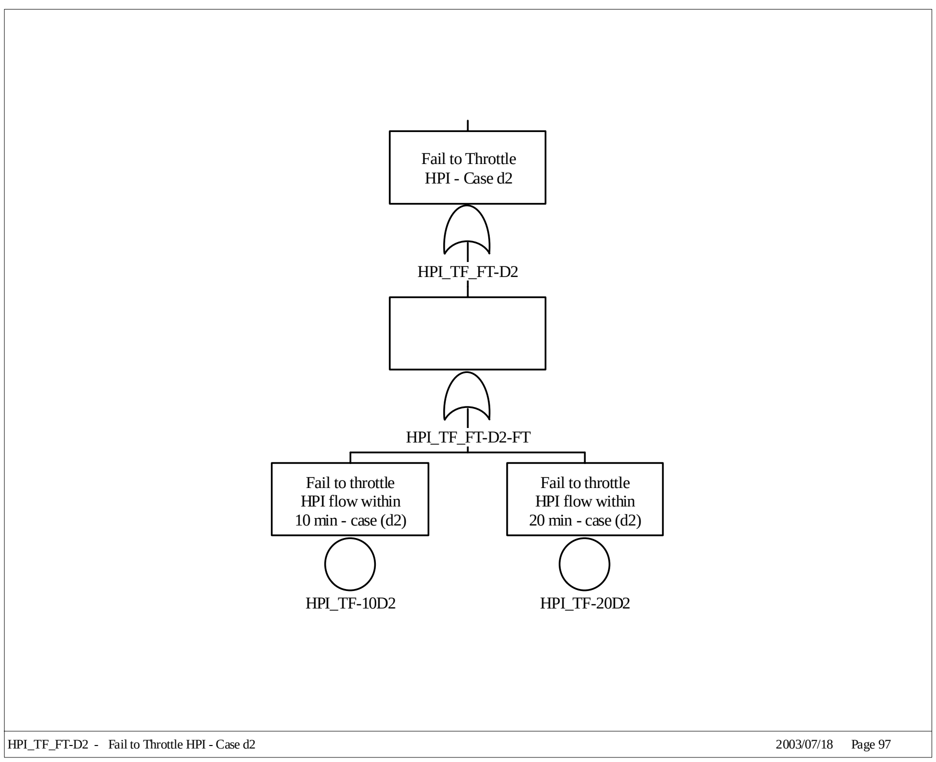

Figure 6.36. Fault tree for HPI_FT_FT-D2.

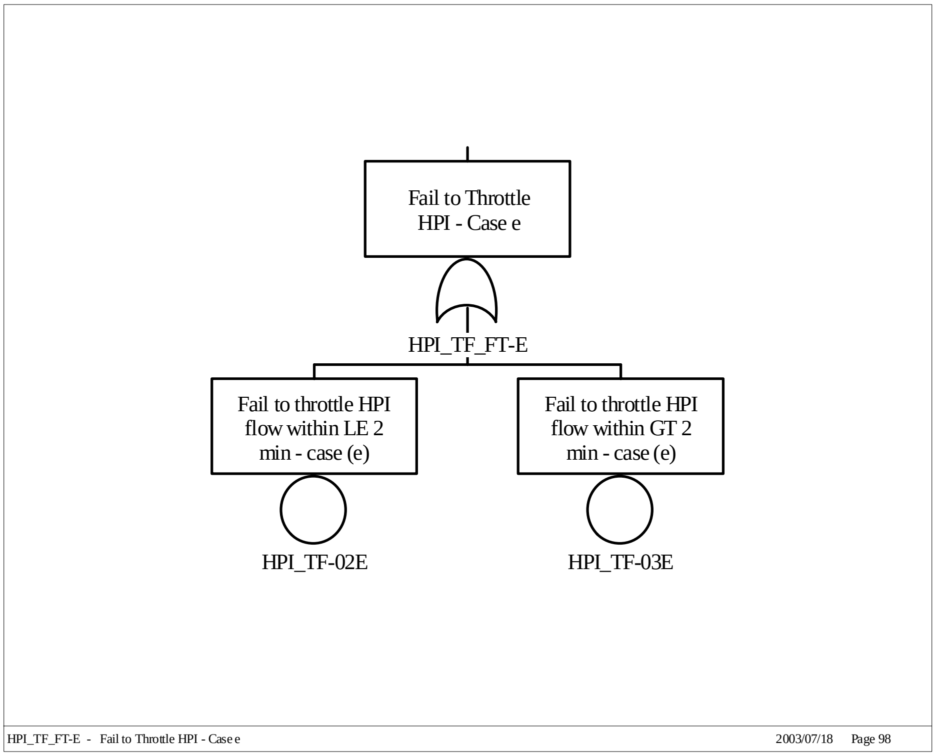

Figure 6.37. Fault tree for HPI_FT_FT-E.

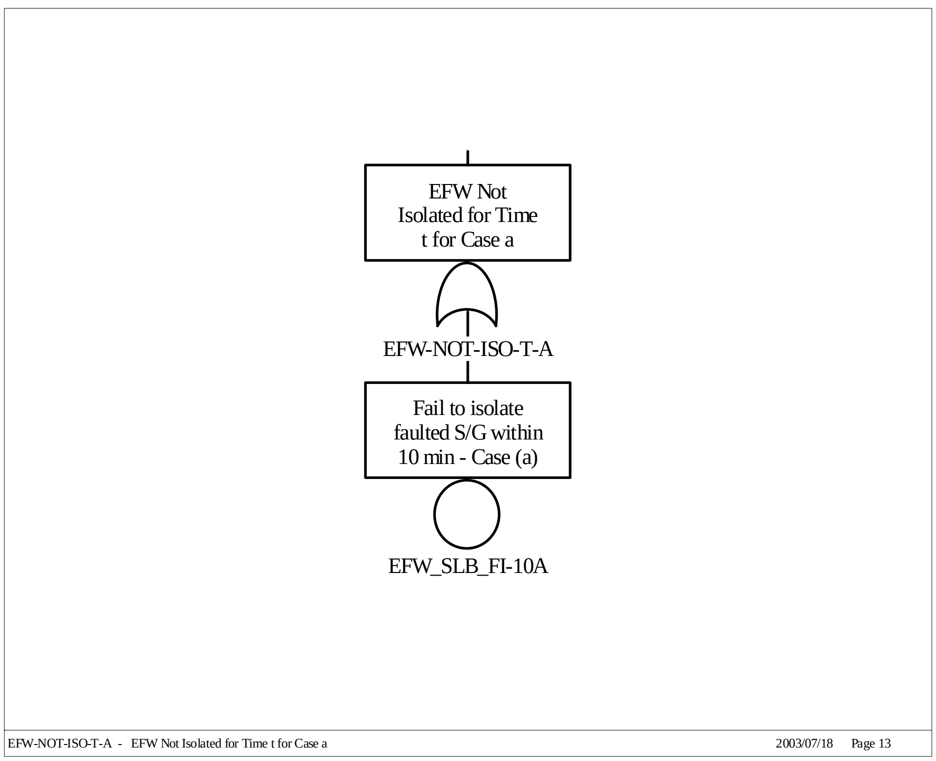

Figure 6.38. Fault tree for EFW-NOT-ISO-T-A.

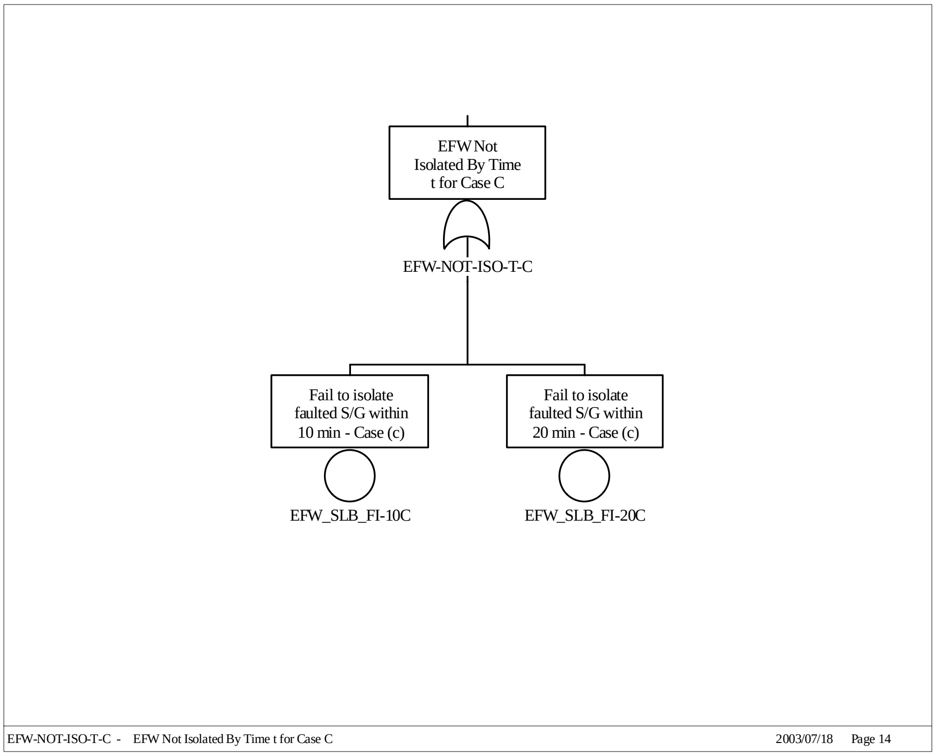

Figure 6.39. Fault tree for EFW-NOT-ISO-T-C.

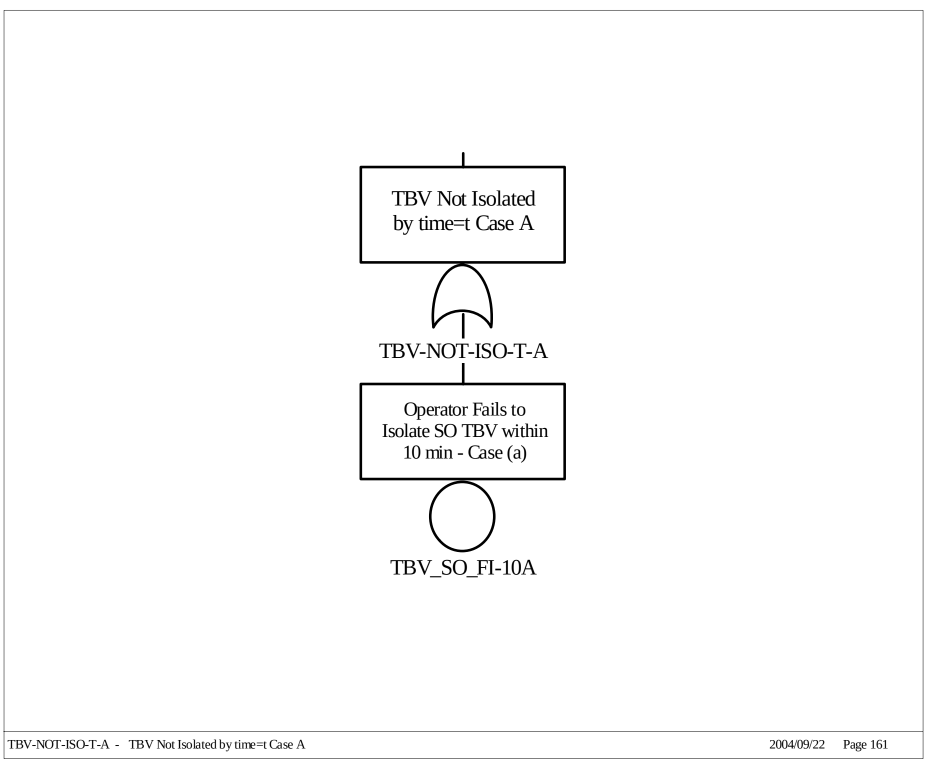

Figure 6.40. Fault tree for TBV-NOT-ISO-T-A.

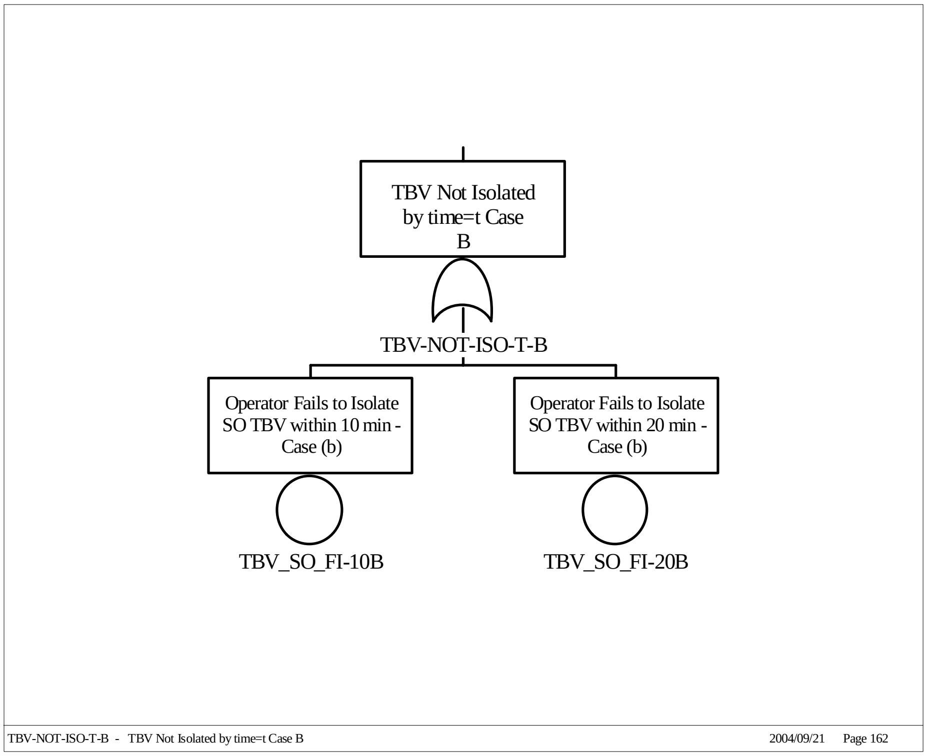

Figure 6.41. Fault tree for TBV-NOT-ISO-T-B.

6.2.2 Pressurizer Safety Relief Valves

The two pressurizer safety relief valves (SRVs) provide code safety relief of pressure if the PORV fails or if pressure continues to increase with an open PORV.

If a SRV sticks open, the effect on PTS is similar to that described for the PORV.

6.2.3 Turbine Bypass Valves and Their Block Valves

The four turbine bypass valves (TBVs) provide steam bypass capability to the condenser, thereby minimizing the consequences of a sudden loss of generator load. The block valve associated with a TBV can be used to terminate flow from the TBV in the event it becomes stuck open.

If a TBV opens and then sticks open, heat is removed from the primary system as long as the primary and secondary systems remain thermally “connected.” Removal of sufficient heat will cause the primary system pressure to decrease and the inventory to shrink, necessitating injection of relatively cold water. This injection of relatively cold water enhances the potential for PTS. Early closure of the TBV block valve can minimize the PTS consequences associated with a stuck open TBV.

6.2.4 Secondary Steam Relief Valves

The 16 secondary steam relief valves (or main steam safety relief valves [MSSRVs]) provide code safety relief of pressure in the main steam system.

If a MSSRV sticks open, the effect on PTS is similar to that described for the TBVs.

6.2.5 Main Feedwater

The main feedwater (MFW) system provides feedwater to the two once-through steam generators by means of two steam-driven MFW pumps. Feedwater flow to the steam generators is controlled by the integrated control system.

If MFW flow is not controlled to intact steam generators or flow is not terminated to a faulted steam generator, then excessive heat can be removed from the primary system as long as the primary and secondary systems remain thermally "connected." Removal of sufficient heat will cause the primary system pressure to decrease and the inventory to shrink, necessitating injection of relatively cold water. This injection of relatively cold water enhances the potential for PTS.

6.2.6 Emergency Feedwater

The emergency feedwater (EFW) system provides feedwater to the two once-through steam generators by means of two motor-driven pumps and one steam-driven pump after loss of MFW. Once started, EFW flow to the steam generators is automatically controlled.

If EFW flow is not controlled to intact steam generators or flow is not terminated to a faulted steam generator, the effect on PTS is similar to that described for MFW.

6.2.7 Condensate Booster Pumps

Any one of the three condensate booster pumps (CBPs) can be used to provide alternate feedwater to the steam generators if EFW fails to provide feedwater flow. Use of a CBP requires the depressurization of the secondary side of the steam generators.

The process required to establish alternate feedwater flow by a CBP to the steam generators enhances the potential for PTS by removing heat from the primary system. This removal of heat causes the primary system pressure to decrease and the inventory to shrink, necessitating injection of relatively cold water. Failure to control alternate feedwater flow by a CBP to the steam generators increases the potential for PTS.

6.2.8 High Pressure Injection

The high pressure injection (HPI) system is a three-pump, two-injection-train system that normally provides makeup to the RCS and RCP seal injection flow. It also supplies high-pressure emergency cooling and can be used to provide an alternate means of core heat removal if cooling via the steam generators is lost. Discharge pressure for the HPI system is sufficient to lift the pressurizer SRVs.

The injection of relatively cold water by the HPI system enhances the potential for PTS. Continued, uncontrolled injection by the HPI system that results in an increase in reactor pressure enhances the potential for PTS both by injection of relatively cold water and the increase in reactor pressure. The control or throttling of HPI minimizes the potential for PTS.

6.2.9 Core Flood Tanks

The core flood tanks (CFTs), i.e., the core flood system, inject borated water from two tanks into the reactor vessel whenever reactor coolant system pressure falls below 600 psig.

The injection of relatively cold water by the CFTs enhances the potential for PTS.

6.2.10 Low Pressure Injection

The low pressure injection (LPI) system is a two-train, high-capacity, low pressure system designed to protect the reactor core from overheating due to loss of coolant resulting from RCS breaks up to and including a double-ended break of a 36-inch pipe. (NOTE: This system was not explicitly modeled in the PTS probabilistic risk assessment (PRA). Its description is provided here because the thermal-hydraulic [TH] calculations that were performed as part of the overall PTS project did include operation of the LPI system if RCS conditions were such that the LPI system would be demanded. The non inclusion of LPI in the PRA is slightly conservative given that failure of the LPI system would tend to minimize PTS by preventing the injection of relatively cold water into the reactor vessel.)

6.2.11 Reactor Coolant Pumps

The reactor coolant pumps (RCPs) provide mixing of the water within the RCS to prevent thermal stratification. In addition, operation of an RCP minimizes the cooling effect on the reactor vessel internal wall during injection of water to the reactor vessel.

The loss of the RCPs would tend to enhance the potential for PTS.

6.2.12 Internal Vent Valves

The eight reactor vessel internal vent valves allow injection water to be mixed. This mixing lessens the cooling effect on the reactor vessel internal wall. This decreased cooling of the internal wall tends to reduce the potential for PTS. (NOTE: The success or failure of these valves was not explicitly modeled in the PTS PRA. Its description is provided here because the TH calculations that were performed as part of the overall PTS project did include operation, or non operation, of the internal vent valves in the TH calculations.)

6.2.13 Emergency AC Power

The emergency AC (EAC) power system provide AC power to equipment. Loss of the EAC power system results in the loss of 1E equipment dependent upon AC power.

Typically, loss of EAC power dependent equipment will tend to reduce the potential for PTS because the equipment cannot inject relatively cold water into the reactor vessel.

6.2.14 Reactor Protection System

The reactor protection system (RPS) monitors various parameters related to safe operation and trips the reactor whenever sufficient parameters deviate from allowed ranges.

7. HUMAN RELIABILITY ANALYSIS

This section summarizes the human reliability analysis (HRA) performed to support the Oconee PTS PRA. As for the overall PRA study, both nominal/full power and low power cases were analyzed. The HRA performed for this study addressed post-initiator human failure events (HFEs) only. Pre-initiator HFEs were not modeled explicitly in the Oconee PTS PRA. Rather, such human events were assumed to be included in the industry-wide data used to model system unavailabilities as this was sufficient to meet the needs of the PTS study.

Plant records of overcooling events that have actually occurred [INEEL LER Review] as well as the earlier and other PTS analyses [NUREG/CR-3770, NUREG/CR-4183, NUREG/CR-4022, WCAP-15156] demonstrate that operator actions and inactions can significantly influence the degree of overcooling and the RCS pressure for many types of overcooling events. Consequently, operator action directly influences, in both beneficial and detrimental ways, the potential for many types of sequences of events to become a serious PTS challenge. For example, early operator action to isolate the feed to a faulted (depressurizing or already depressurized) steam generator, directly affects the amount of overcooling that occurs and how long such cooling is sustained. Hence, any "realistic" PTS analysis needs to consider operator actions and inactions that influence overcooling sequences. Therefore, consistent with the guiding principals of this project to adopt best-estimate models and treat uncertainties explicitly whenever practicable, we have included a rigorous treatment of human actions in the Oconee PTS PRA model.

Improvements in the current work as compared to that performed in the earlier PTS analyses include:

- a more realistic treatment of operator actions based on detailed consideration of sequence specific contextual factors, multiple simulator observations, latest procedures and training, and numerous discussions with licensee operating and training staffs, as compared to a lack of significant credit in the early Oconee PTS analysis

- a greater number of discrete operator action times (where important to the degree of PTS challenge) is considered as compared to fewer and more conservative time periods treated in the early Oconee work (for instance, the current Oconee analysis may examine operator action/inaction in 1, 10 and 30 minutes for a specific human event compared with (in some cases) a corresponding early analysis of only the 30 minute time period thereby leading to conservative results since overcooling is allowed to continue for 30 minutes before human action is potentially credited in the model)

- modeling of detrimental acts of commission, especially where procedural steps call for actions that could exacerbate overcooling conditions.

The HRA for this study was performed by NRC contractors. However, significant plant support was provided by Oconee staff. In particular the plant staff supported the HRA by:

- supplying relevant, up-to-date plant information such as procedures, training materials, drawings, systems design information, and documentation of the previously performed PTS analysis

- hosting a plant site visit, including discussions with operator trainers, thermal hydraulic engineers, PRA specialists, and observations of operator simulator training on relevant scenarios

- answering questions, formally and informally, throughout the analysis

- hosting a second plant visit for reviewing preliminary results, including providing feedback and clarifying information associated with all elements of the PTS analysis including the HRA.

The ATHEANA process [NUREG-1624] was the basic approach used to perform this HRA analysis. The ATHEANA quantification approach evolved over the course of the Oconee PTS HRA and this evolution is reflected in the results. A recent paper [OECD/NEA] describes the up-to-date, detailed ATHEANA quantification approach, called "quantification-including-uncertainty." Only those human failure events found to be most important to the analysis such that they required detailed HRA quantification (after an initial PRA/HRA quantification) were analyzed with the "quantification-including-uncertainty" approach.

Also, because the HRA was begun before other PTS program tasks (e.g., PRA, thermal-hydraulic calculations, fracture mechanics results) could provide required HRA inputs, the Oconee PTS HRA analysis was performed, by necessity, in an iterative fashion. The positive effects of the HRA analysis "leading" other aspects of the study were:

- greater integration between the HRA and the overall PRA tasks than is oftentimes achieved
- greater input from the HRA into the development of the PRA models
- greater input from the HRA into the selection of thermal-hydraulic calculations to perform.

For the HRA, the principal negative effect of "leading" other aspects of the study was the need to, at first, make more assumptions or rely on previous, rather than current, study inputs. To the extent possible, the early PTS analysis for Oconee [NUREG/CR-3770] was used, including the HRA portions of that study. The information from this previous PTS study was augmented by additional, up-to-date information provided by Oconee staff through written questions and answers and the HRA team's analysis of current plant aspects (e.g., relevant procedures, training practices, observations of Oconee simulator exercises for PTS-relevant scenarios).

7.1 Summary of the HRA Process

As noted above, the ATHEANA HRA process [NUREG-1624] was used to perform the Oconee PTS HRA. This section summarizes the major tasks and milestones achieved in the HRA process as it was applied to the Oconee PTS study more or less sequentially.[11]

The following is the general sequence of milestones in the Oconee PTS HRA:

- information collection (continuous throughout the process)

- HRA qualitative analysis (continuous throughout the process)

- first site visit to Oconee

[11] As noted above, some aspects of the Oconee PTS HRA process steps were performed iteratively or even continuously.

- initial HRA quantification
- initial PRA quantification
- second site visit to Oconee and receipt of comments and feedback from Oconee staff on the initial results, including the HRA
- response to Oconee comments and concerns including, when judged appropriate, re-quantification of some HFEs
- based on the initial PRA results, detailed HRA quantification (using the "quantification-including-uncertainty" approach) for a few particularly important HFEs that appeared in the most dominant PTS challenging scenarios.

While all steps in the ATHEANA process were performed, the specific tasks that supported the achievement of these milestones were:

- information collection
- review of previous PTS studies
- identification of potential HFEs (at first generally, and later on a sequence and action-specific basis)
- identification of potential vulnerabilities
- deviation analysis
- Oconee plant visits
- quantification (preliminary and final)

Each of these tasks are summarized in the sections below.

7.1.1 Information Collection

Information collection was performed throughout the Oconee PTS HRA as dictated by the information needs of the analysis. The following information comprised the initial information request to the Oconee staff:

- The Emergency Operating Procedures and their accompanying "Bases" documentation

- Listing of the Abnormal Procedures[12]

- Thermal hydraulic (and if any, fracture mechanic) calculations/summaries relevant to PTS (in order to determine timing of key events and actions, assumed equipment automatic and manual operation, etc.)
- System P&IDs and related FSAR sections and other system/plant descriptive information[13]

- PTS Training information, including:
  - a description of the frequency of training
  - how such training is provided (e.g., does specific PTS training exist? Are PTS concerns discussed/simulated as part of other operator training?)
  - a copy of any relevant classroom training material
  - a description of typical scenarios trained
  - key results of any recent simulator debriefings
  - plant drill information related to the PTS issue
  - control room layout information and crew characteristics (e.g., size, key responsibilities, and communication protocols)

This initial information was augmented by the Oconee plant staff who provided answers to HRA-related questions throughout the analysis (e.g., information related to hot zero power plant conditions and control as opposed to full power operation).

7.1.2 Review of Previous PTS Studies

Information in the previous PTS study for Oconee [NUREG/CR-3770] in particular, and from other PTS studies [NUREG/CR-4183, NUREG/CR-4022, WCAP-15156] was reviewed in parallel with the collection and review of current Oconee plant information. This review allowed the HRA team to quickly define general scenarios of interest and important related thermal-hydraulic plant responses (which dictate many of the cues for action) and relevant human actions for the Oconee PTS study.

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12 This list was reviewed to determine whether any of these procedures would be useful to determine likely human actions for some PTS-relevant initiators. Procedures were later requested and received as needed.

13 Oconee's IPE [Oconee IPE] was also reviewed to get as much of this information as possible. So, the focus of this information was on those systems/equipment particularly expected to influence PTS scenarios (e.g., auxiliary/emergency feedwater, integrated control system, turbine control/stop valves, pressurizer SRV and PORV/block valve arrangement and supporting electric power, high pressure injection system, and MSSV-ADV-turbine bypass valves and any associated isolation valves arrangement).

It should be noted that the information in NUREG/CR-3370 was vitally important to the performance of this updated PTS HRA for Oconee because, at the time of initial HRA quantification, updated thermal-hydraulic (TH) and fracture mechanics results were not yet available for Oconee. Fortunately, the updated TH and fracture mechanics calculations resulted in minor changes to the initial HRA (e.g., fewer PTS-relevant scenarios and some minor adjustments to the important times for human action). Consequently, the principal impact on the HRA was some loss in efficiency (i.e., some scenarios and associated actions were analyzed that, ultimately, did not require analysis).

7.1.2.1 General Scenarios of Interest

In addition to providing basic background information and knowledge on PTS potentially important for Oconee, review of the early Oconee PTS analysis [NUREG/CR-3770] allowed the HRA team to specifically perform Step 3 (i.e., define the base case scenarios) and part of Step 6 (i.e., identify deviation scenarios) of the ATHEANA process [NUREG-1624]. NUREG/CR-3770 examined primarily what the ATHEANA process would call "base case *and* deviations from the base case" scenarios. Base case scenarios are defined as scenarios in which everything functions as planned, including operator actions. An example would be a main steam line break where all equipment and operator actions are performed successfully yielding a relatively minor over-cooling event. Most of the scenarios analyzed in NUREG/CR-3770 also included many equipment and operator failures (what ATHEANA would consider as "deviations" from the base case scenarios) that lead to many "deviation scenarios."

The current HRA took advantage of this prior work which included organization of possible scenarios and associated operator actions as they relate to four types of functional failures of interest to PTS (i.e., primary integrity, secondary pressure, secondary feed, and primary flow/pressure) as has already been discussed in prior sections of this document. Using this knowledge and particularly the same broad classification of scenarios by the functions affected, the possible human actions of interest were identified considering both (a) broad definitions of possible ways operators could affect or influence the four functions of interest as well as (b) the specific actions already analyzed in the earlier PTS studies. This is discussed more in section 7.1.3.

7.1.2.2 Thermal-Hydraulic Considerations

In performing a detailed and realistic HRA, it is important to understand the plant's expected thermal-hydraulic (TH) behavior in both base case and deviation scenarios. This is because the plant response, and associated equipment and instrument indications, form the basis and the timing for many of the cues that the crew will use in implementing their symptom-based procedures to know when and what actions to take in response to plant conditions. While updated TH calculations for Oconee were in progress, few results were available at the time of initial HRA quantification. Consequently, initial HRA quantification relied considerably upon the TH calculations done in support of the original Oconee PTS PRA [NUREG/CR-3770]. As updated Oconee TH calculation results became available, the HRA was modified, as necessary, to reflect such results. Fortunately, as noted above, the updated TH and fracture mechanics calculations resulted in only minor changes to the initial HRA.

Based on this knowledge of plant thermal-hydraulic response in potential PTS-challenge scenarios, the following was observed to be particularly relevant to the HRA and the inclusion of these types of human actions in the Oconee PTS study:

- timely action by the operators to control secondary feed and primary system injection could be important to the effects of overcooling events including overfeed events
- timely recognition and isolation of a depressurizing steam generator(s) (SG)(s) and control of primary system injection are very important to secondary depressurization events
- timely isolation (if possible) of primary integrity breaches (in which rather low downcomer temperatures may be unavoidable, depending on the break size) and control of primary pressure (if it is possible to subsequently increase the pressure via primary injection) are key operator actions.

The HRA focused on these actions in subsequent steps, although other actions such as appropriate or improper reactor coolant pump (RCP) tripping were also addressed. More complete definition of the human failure events (HFEs) of concern is presented in the next section.

Another consequence of the unavailability of updated TH and fracture mechanics results for Oconee at the time of initial HRA quantification was that this analysis lacked (at first) a definitive temperature limit above which PTS is not a concern. Based upon this information gap and the potential downcomer temperatures and rates of change from the thermal-hydraulic information, it was not possible to screen out certain types of functional scenarios and related human actions that might be expected to be unimportant to the PTS risk. Hence, in the initial HRA analysis for Oconee, all of the functional scenarios of potential concern and the associated possible HFEs needed to be considered. In other words, no sequences (e.g., scenarios involving steam-generator overfeed only) could be eliminated from analysis on the basis of the potential downcomer temperature being too high or the rate of temperature drop being too small to be of concern.

7.1.3 Identification of Human Actions to be Modeled

In the earlier Oconee PTS analysis, NUREG/CR-3770 examined the human failure events shown in Table 7.1, including consideration of responses to some equipment failures.

Besides examining the associated contexts and resulting probabilities for these HFEs for various initiating events, the current HRA considered other possible HFEs including any contexts in which errors of commission (EOCs) may be possible. The EOCs of interest are any operator actions that are detrimental to PTS and might be performed when they should not be, although the operators believe the action(s) to be the correct thing to do. Consideration of the four functions of interest to PTS and how the operator could affect these functions proved a valuable way to define the HFEs, at a general level, that were of interest to the Oconee PTS study.

Using the earlier information about modeled HFEs, following the ATHEANA guidance to explore other possible HFEs, and considering the general types of scenarios of interest and the corresponding TH impacts, possible human interventions were identified. Table 7.2 presents a summary of the HFEs of potential concern (defined at a general level) in the Oconee HRA. Note that these potential HFEs cover operator interaction with all the functions of concern, and represent both errors of omission (EOOs) and possible errors of commission (EOCs). The remainder of the HRA process focused on gathering and analyzing information (e.g., procedures) potentially relevant to the HFEs of concern as well as identifying possible contexts (i.e., plant conditions, training biases, etc.) that might make such HFEs more likely.

Table 7.1. Human Failure Events (HFEs) considered in NUREG/CR-3770

Function/System Status	General HFEs
Decreasing secondary pressure (multiple reasons)	• Failure to isolate isolable sources • Failure to isolate/restore SGs appropriately
Erratic SG feed (over or under-feeding)	• Failure to actuate (recover)/throttle (control) SG feed as necessary
Primary system injection begun/attempted and flow controlled	• Failure to trip/restart reactor coolant pumps (RCPs) • Failure to throttle or even start injection • Failure to control feed & bleed
Primary system "LOCA"	• Failure to isolate isolable sources

Table 7.2. General classes of human failures considered in the PTS analysis.

Primary Integrity Control	Secondary Pressure Control	Secondary Feed Control	Primary Pressure/Flow Control
• Operator fails to isolate an isolable LOCA in a timely manner (e.g., close a block valve to a stuck-open PORV) • Operator induces a LOCA (e.g., opens a PORV) that induces or enhances a cooldown	• Operator fails to isolate a depressurization condition in a timely manner • Operator isolates when not needed (this may create a new depressurization challenge, lose heat sink, etc.) • Operator isolates wrong path/SG (depressurization continues) • Operator creates an excess steam demand such as opening turbine bypass or atmospheric dump valves	• Operator fails to stop/throttle or properly align feed in a timely manner (overcooling enhanced or continues) • Operator feeds wrong (affected) SG (overcooling continues) • Operator stops/throttles feed when inappropriate (causes underfeed, may have to go to feed and bleed & possible overcooling)	• Operator does not properly control cooling and throttle or terminate injection to control RCS pressure • Operator trips reactor coolant pumps when not suppose to and/or fails to restore them when desirable • Operator does not provide sufficient injection or fails to trip RCPs appropriately (modeled as leading to core damage rather than a PTS concern)

For specific modeled sequences in the PRA, these "general" HFEs were defined at a greater level of detail (i.e., specific act in a specific time period as appropriate) and quantified accordingly. More on the detailed HFEs is found in section 7.2.

7.1.4 Identification of Potential Vulnerabilities

This portion of the HRA process focuses on identifying reasons why operators might make the errors of interest. Hence, per the ATHEANA guidance [NUREG-1624], this is a search for so-called "vulnerabilities" (or lack thereof) in procedures, training, informal and formal operator rules for taking actions, etc., that might be relevant to ultimately quantifying the likelihood of the errors being made under various plant conditions. This section summarizes the key findings of the "vulnerability" analysis.

For the Oconee PTS HRA, potential vulnerabilities were identified through the following:

- evaluation of formal rules as primarily dictated by the emergency operating procedures and other procedures expected to be used in response to various overcooling scenarios
- development of a crew characterization
- the investigation of potential vulnerabilities in operator expectations for various overcooling scenarios
- understanding of possible plant response timelines and any inherent difficulties associated with the required response
- identification of operation action tendencies and informal rules

The key findings for each search for potential vulnerabilities are summarized in the subsections below.

7.1.4.1 Evaluation of Emergency Operating Procedures and Other Procedures

With the help of Oconee staff, the numerous emergency operating procedures (EOPs) and abnormal operating procedures (AOPs) of potential relevance to PTS were identified. In turn, the PTS relevant portions of these procedures and associated training were studied and summarized. For example, procedure maps, such as that shown in Figure 7.1, were developed for important procedures.

Based upon the evaluation of Oconee procedures and training, summary observations with regard to PTS were developed. For example, it was observed that, on the positive side, the Oconee procedure set quickly directs operator attention to plant conditions that may be PTS significant, then calls for transition to other procedures that have relevant mitigating actions (even before the reactor trip entry procedure EP-1 is finished). In addition, the Oconee procedure set has frequent notes and cautions that alert operators to potential PTS concerns, especially with regard to throttling high pressure injection (HPI) which will avoid excessive pressurization of the reactor coolant system (RCS) and limit the reactor vessel wall cooling as a result of the injection.

The HRA team further observed that the Oconee procedures and associated guidance generally caution operators to maintain a balance between recovering steam generator (SG) and pressurizer (PZR) levels to acceptable ranges, and throttling to avoid thermal shocks while doing so. Once conditions become reasonably stabilized, specific throttling of turbine bypass valves (TBVs), feed control valves, injection,

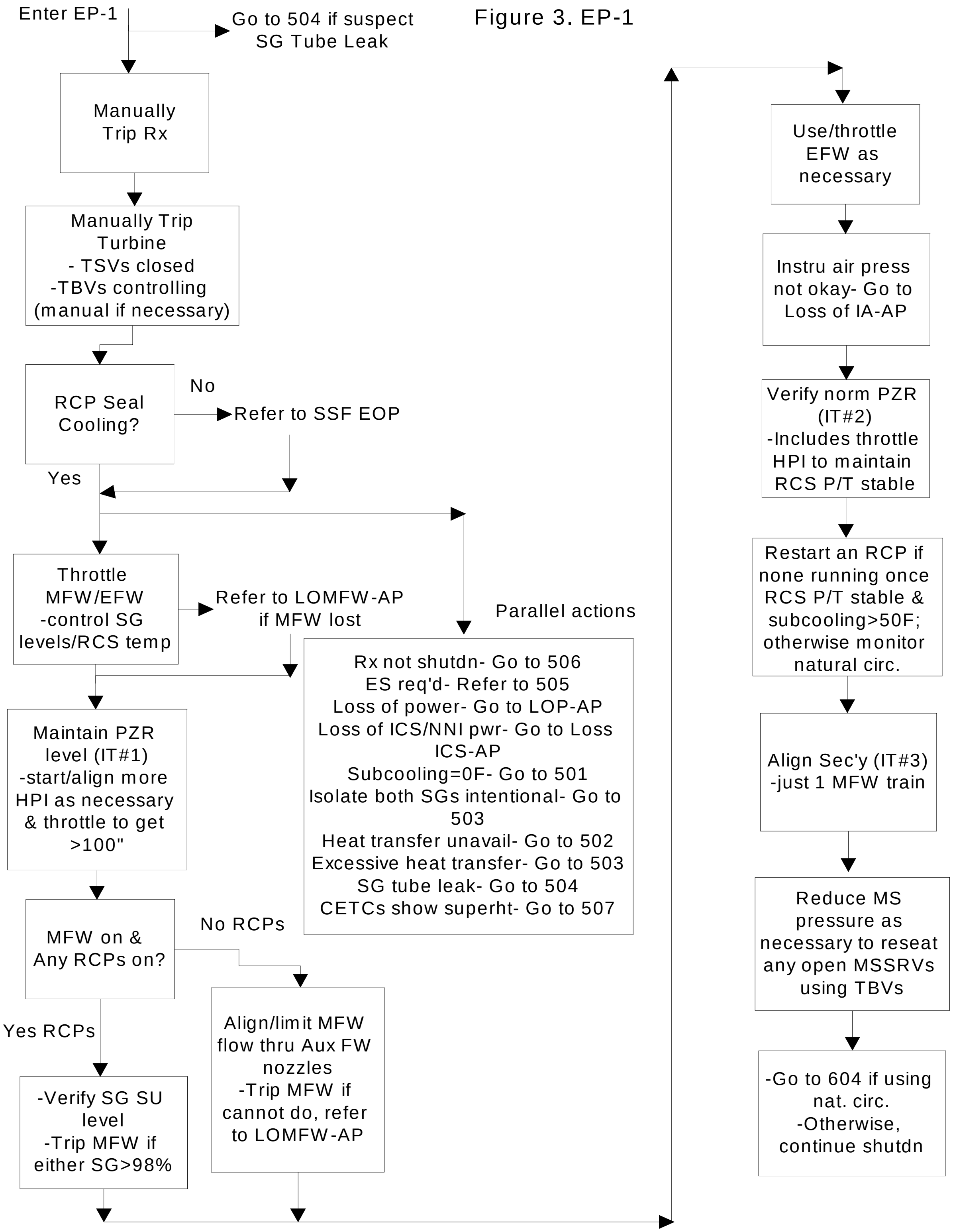

Figure 7.1. Example procedure flowchart.

etc. are more specifically directed to maintain stable core exit thermocouples (CETCs), and RCS pressure and temperature. Hence, deviation scenarios (i.e., scenarios with other complications from the nominal or "expected" scenarios) that create additional complexities and diversions (e.g., concurrent failures in the support systems), or that otherwise create high work loads or induce different and unexpected timing of events, would seem more apt to test the operators' ability to be successful at these maintaining balances. Delays or inaction could then result in higher primary or secondary flows than ideal for the conditions at the time, therefore potentially prolonging or exacerbating an overcooling event.

Several other observations regarding the procedures and training were recognized as key issues to remember in ascertaining what operators might do under various plant conditions and the hierarchal practices carried out by the operators in responding to events. Namely,

1. The hierarchy of safety functions that require entry in other EOPs is:

    - Reactor not shutdown Such symptoms are associated with anticipated transient without scram (ATWS) types of events.

    - Inadequate core cooling (based on CETC indications) More of a potential core damage concern although mitigating actions (e.g., open a PORV) could lead to a subsequent overcooling event.

    - Loss of subcooling Subcooling will be lost in all loss of coolant accidents (LOCAs) and in any main steamline break (MSLB) or similar events that are not isolated immediately. Subcooling might be lost in other kinds of events if enough failures or other causes of depressurization or cooling occur. Loss of subcooling and the subsequent tripping of reactor coolant pumps (RCPs) causes loss of forced primary flow possibly worsening cooling of the reactor pressure vessel wall.

    - Overcooling When these conditions occur, concerns with respect to PTS are particularly relevant.

    - Undercooling When these conditions occur, lack of cooling is more of concern although some mitigating actions (e.g., feed and bleed) could cause subsequent overcooling.

    - Steam Generator (SG) tube leak Specific to this type of event. The called-for depressurization and cooldown could be PTS relevant if not properly controlled.

    - Engineered Safeguards Actuation Lack of control of HPI and/or other coolant injection could be relevant to PTS.

2. Operators are to address these safety functions in order. Note that the most directly relevant procedure for PTS concerns is not at the top of the list, although all the procedures have some PTS-relevancy.

3. Operators are generally aware of the fact that they will need to throttle secondary and primary feed (e.g., emergency feedwater (EFW) and high pressure injection (HPI)). However, procedural guidance is (probably purposefully) somewhat vague in order to balance needs of cooling and recovering level(s) versus overcooling.

4. There is no specific chart-guided "diagnosis" step in Oconee's initial reactor trip response EOP (EP-1). However, this EOP directs operators to monitor plant conditions for "symptoms" that would require transition to one of the other procedural paths associated with the hierarchy of safety functions and to transfer to these other EOPs even before completion of EP-1. This makes for timely transitions to mitigating problems with the safety functions if the symptoms are quickly identified.

7.1.4.2 Crew Characterization

Understanding the makeup of the crew and the individual responsibilities of crew members along with communication protocols and other characteristics of the operating crew is important and needs to be accounted for in any detailed and realistic HRA. Such things as the degree of independence allowed among crew members, the frequency and content of plant status discussions, the amount of review and oversight that takes place to correct inappropriate actions, among other characteristics can be important to ascertaining the likelihood of human errors occurring and going uncorrected.

Regarding the Oconee control room, Units 1 and 2 actually share the same room and are mirror images of each other (but individual controls are still left-to-right, etc.). Unit 3 is a room dedicated to just that unit. As a minimum, there are 3 operators in the control room. First, there is the control room senior reactor operator (SRO) who directs and reads from the EOPs/AOPs and verifies that immediate trip actions have been performed. The Operator at the Controls (OATC) ensures or carries out if necessary, the immediate actions (Rx trip, turbine trip, proper operation of TBVs) and may note if an entry condition exists for entering another EOP/rule. The Balance of Plant (BOP) Operator does an initial symptoms check to see if it is necessary to enter another EOP/rule.

Regarding procedure use, if either operator enters another EOP/rule based on observed symptoms, that operator begins the initial rule steps (written out on placards near where the controls to carry out the rule are located) and announces that entry into the associated EOP is required. This means that initially, the operators may be performing independent actions without much interaction until the initial rule steps are complete and the entire crew is able to get back into synch with each other. At that time, entry into the hierarchically most important EOP is first performed, then others if/as necessary. Should a higher hierarchically important EOP need to be entered, it is entered immediately even though other EOPs were not completed. After the initial responses, the crew acts in a more interactive way, guided by the SRO, although some actions may still be performed independent of much interaction (such as following a specific enclosure (e.g., Enclosure 7.1) or the detailed lining up of residual heat removal (RHR), etc.). Communication among the operators when the crew acts interactively is direct and formal, calling out the operator's name, and requiring the operator to repeat the directive.

Various additional observations of Oconee operating crew characteristics were developed during a plant site visit and observing relevant overcooling scenarios on the Oconee simulator. These observations include some comparisons between Oconee operating crews and those observed at the Westinghouse plant used for the ATHEANA documented examples [NUREG-1624].

The following observations were made:

- At Oconee, independent actions are expected and planned for (i.e., proceduralized) at the beginning. This allows for rapid response but could generate unchecked actions until subsequent verification occurs.

- Oconee operating crews periodically stop and perform plant status discussions. These tend to be simplistic and focused on specific acts (i.e., “did you do check 3, check 4?”) and seem to be less focused on the bigger picture of the plant status (which may assumed to be understood). Nevertheless, these provide for crew interaction and a consensus regarding what is happening.

- Oconee operating crews are trained to closely follow their procedures and thus seem less likely to question the procedures. As long as the procedures can “deal” with the scenario, this makes for an expected and uniform response among the crews. Should plant conditions threaten the procedural adequacy, difficulties could arise.

- Oconee operating crews did not appear to look ahead as much as those at the Westinghouse plant. By itself, this does not seem necessarily an advantage or disadvantage.

- Oconee operating crews seem better/faster at things that are predictable, especially because of the way the procedures are written and trained on that allow quick transitions. (The operating crews at the Westinghouse plant were slower and more methodical.)

- Within Duke Power, each plant is recognized to have a different character. For a given site, the character of the crews tends to be the same. However, different plant sites can be quite different.

7.1.4.3 Operator Expectations

Actual industry-wide events and particularly Oconee-specific operator experience and training can provide a level of expectation by operators as to the types of overcooling events that may occur and the appropriate actions to take. Section 3.1 of this document has already summarized many of the observations made with regard to types of overcooling events that might occur, as well as the degree and types of challenges to the operators in responding to these events. In general, it could be concluded from the observations in section 3.1 that the more failures and/or cascading effects occur concurrent with the event, the more complicated the response may need to be and perhaps, the more error-prone the situation since the procedural guidance and training becomes more challenged and potentially less adequate.

It can also be observed that in the past twenty years, actual overcooling events have been minor and required only relatively simple responses. Actual events have not generally involved multiple or cascading failure effects making the events more complicated and less certain as to the necessary response. Oconee did have an overcooling event occur during a fire approximately fifteen years ago and thus there is a very limited and old experience base as a result of that event. Overall, this experience suggests, again, familiarity with relatively simple overcooling situations, but not with more severe and complicated situations.

While training at Oconee does not have significant elements aimed at PTS per se, reviewing operators’ control of plant cooldowns in real and simulated events is part of the overall training. So, Oconee operators have a limited familiarity of potential overcooling events through training and simulations. However, while some degree of complexity is included in the Oconee training, it is not clear that multiple failures are generally included in simulated overcooling events (e.g., a stuck-open PORV or pressurizer spray valve *and* a secondary feed or pressure equipment fault such as failure of runback or a stuck-open

MSSRV). Hence, particularly challenging overcooling events involving unexpected or multiple equipment failures, indication failures, or support system failures are probably not within Oconee operator experience and expectations. While in principle, Oconee procedural guidance should be sufficient for such events, operator familiarity with such events is probably limited.

All this suggests that, not surprisingly, the more complicated overcooling events would seemingly test the operators' knowledge and experience the most since they are generally outside operators' training and expectations. Hence, the HRA included a focus on identifying possible complicated situations (deviations) that might cause more error-prone situations for the operators (discussed further in Section 7.1.5). It is also observed that while the human error rate may be somewhat higher than when responding to uncomplicated overcooling situations, the frequency of complicated events should also be smaller in most cases than that of uncomplicated events thus balancing out concerns as to the overall PTS risk.

7.1.4.4 Scenario Timelines

Potential Oconee PTS scenario timing concerns were investigated as related to the four PTS-relevant plant functions to examine possible TH plant response considerations that may make certain errors more likely. Generally, the sooner the appropriate intervention is enacted, the less severe the overcooling event; so, quick action in some instances is preferred. Summaries of the key concerns with respect to timing for each of the PTS-relevant major functions were developed. From these summaries, the HRA team concluded that quick and appropriate actions are required to:

- initially control or isolate secondary depressurization and feed problems, if they have occurred

- isolate a primary LOCA (if isolable) and trip the reactor coolant pumps (RCPs), if a primary breach has occurred

Otherwise, most actions can be generally done in a somewhat less time-sensitive manner unless the operator must again quickly respond to a new or delayed malfunction. However, desirable actions still should be performed on the order of tens of minutes to avoid serious PTS challenges in most situations.

7.1.4.5 Operator Action Tendencies and Informal Rules

This aspect of the HRA focused on identifying operator action tendencies and informal rules that if applied might cause or exacerbate an overcooling situation. These tendencies and rules were considered in the evaluations to assign probabilities for the HFEs of interest.

The following operator action tendencies were identified as having the potential to be particularly troublesome if operators incorrectly perceive the noted condition exists:

- Loss of support systems (power, cooling, air, etc): The operator tendency is to expend some attention and resources to recovering the lost system. This could be a diversion to other, more pressing needs to control any potential overcooling.

• Low pressurizer level or pressure:	The operator tendency is to increase injection and lessen letdown potentially overpressurizing the RCS relative to ideal control of PTS conditions.
• Low core heat removal or subcooling insufficient:	The operator tendency is to provide more injection and increase cooldown capability.
• Low SG level:	The operator tendency is to increase feed or go to feed and bleed if necessary.
• High SG pressure:	The operator tendency is to increase steam dump or provide additional steam relief.

In addition, a tendency by the Oconee operators (shared at other plants) is some reluctance to restart RCPs (based on discussion with training personnel) due to the sensitivity to possible reactivity insertion caused by RCP startup. Not restarting RCPs prevents forced-flow mixing of the RCS coolant thereby exacerbating the effects of injection water on the RPV downcomer wall.

Regarding informal rules, little was discovered in this area for the Oconee PTS analysis, specifically. One observation fitting this category is that the Oconee operators are not necessarily encouraged to "beat" auto equipment functions. While this is not a good or bad bias in and of itself, this approach was considered for where it might cause untimely or incorrect response by the operator in unique situations. Additionally, operators at Oconee are trained to closely follow the procedures and deviations from them should be the rare exception.

7.1.5 Deviation Analysis

The purpose of the deviation analysis step is to identify scenarios and associated conditions that might deviate from the more simple, nominal (expected) sequence of events and be particularly troublesome (i.e., have potentially higher probabilities of operator failure) because the scenarios and conditions enable or otherwise take advantage of any vulnerabilities found in the procedures, training, timeline issues, crew characterization, crew expectations, or operator tendencies and uses of formal and informal rules or practices. Depending on the potential likelihood of such deviation scenarios, they should be (and were made) part of the PTS PRA modeled sequences as part of the closely coordinated PRA and HRA efforts. Further, the associated human failure probabilities should generally be higher than the human failure probabilities for the simple (nominal or expected) types of overcooling scenarios also in the PTS PRA model.

NUREG-1624 describes this step as a brainstorming step that involves four different types of searches:

1. Searches for initiator and scenario progression deviations from the base case (nominal) scenarios,

2. Searches regarding the use of relevant rules that could be troublesome,

3. Searches for support system dependencies and their failures and effects that could make the scenarios more complex, add to the workload, become further distractions, etc., and

4. Searches regarding operator tendencies and error types that could be troublesome.

The reader is referred to the ATHEANA methodology [NUREG-1624] for more details regarding the search process and the use of "guide words" to conduct the search.

While each of these searches were explicitly addressed for the Oconee PTS HRA, it was found that the performance of the first type of search, as it was performed for the Oconee PTS HRA, also inherently addressed the other types of searches adequately. Consequently, only the first search is discussed here.

The deviation searches were performed by the entire HRA team. An important part of this activity was a preliminary re-cap of previously collected information. Discussion of the deviation analysis is divided into two sections below. The first section addresses the preliminary re-cap while the second section addresses the specific searches performed as part of the overall search for initiator and scenario progression deviations, and their results.

7.1.5.1 Preliminary Re-Cap

The first step performed for conducting the deviation search brainstorming was for the HRA team to integrate previously collected information, such as:

- the possible types of initiators and other failures being considered for the analysis (see Section 3.1 & Table 3.3 of this document)

- the PTS-relevant functions, individually, as well as in combinations (see Section 2 of this document)

- the potential HFEs applicable to the failed functions (see Table 7.2)

- the previously identified potential vulnerabilities summarized in Section 7.1.4 above.

Four topics, in particular, were discussed by the team as preparation for the deviation searches:

- HFE definitions
- Oconee-specific procedures
- Oconee crew characterization
- Other initiator/scenario-specific vulnerabilities

Regarding HFE definitions, it was noted that there is no obvious endpoint for the success of the action for overcooling scenarios. As long as overcooling occurs, the RCS temperature will continue to fall. At some point and if quick enough, the temperature will get low enough that depending on the RCS pressure, a crack could develop in the vessel. The probability of a crack increases as the overcooling situation worsens. This situation has implications for modeling and quantifying human errors and their probabilities, requiring the HRA task to provide several human failure probabilities for a single HFE associated with human actions of interest at different times (e.g., failure to perform the action by 3 minutes, by 10 minutes, by 30 minutes). At the time of the deviation analysis, updated thermal-hydraulic (TH) and fracture mechanics information were not available[14] to determine these critical times. As a result, the HRA task needed to define times likely to be PTS-relevant for consideration during HRA quantification. Such times were estimated based on the earlier PTS analyses and refined as updated TH and fracture mechanics information became available. It turned out that few adjustments had to be made to these human action times.

Regarding Oconee-specific procedures and crew characterization, the material in Sections 7.1.4.1 and 7.1.4.2 were considered. As for consideration of other potential vulnerabilities, the HRA team found it helpful to review the previously collected information, especially potential vulnerabilities as discussed in Section 7.1.4, but in an initiator-specific format. Elements of this review have already been provided in Section 3.1 of this document and summarized in Tables 3.2 and 3.3. Highlights of potential vulnerabilities of most concern are provided in Table 7.3.

On the basis of all of the above considerations, the HRA team concluded that the deviation analysis needed to focus on scenario complicating factors that involved multiple failures of equipment associated with one or more of the PTS-relevant functions, support system faults (e.g., instrument air or power) and their sometimes unexpected cascading effects, as well as potential differences in the timing sequence of events. These types of complications would seem to increase the gap between operator familiarity and expectations, and the actual event. Such deviation scenarios might increase the human failure probabilities for the actions of interest and hence be particularly worthy of modeling and quantitative evaluation.

Table 7.3. Highlights of potential vulnerabilities by sequence type.

Sequence Type	Potential Vulnerabilities
Reactor trip	• There is limited industry-generic “recent” experience with main feedwater overfeeds and secondary pressure control losses. • Oconee does not train on PTS per se, but does treat as part of other training. • Oconee operating crews have simulator experience of “minor” complexities. However, scenarios involving multiple failures, “sneaky” cascading or common cause failures, unexpected timing of failures, etc. are not generally trained.

[14] Probability of crack is function of time history of temperature profile across the vessel wall (from inner to outer wall), & vessel pressure. Preliminary estimates were that it takes at least about 1000 seconds or about 15 minutes at a “cold” temperature to make enough of a difference between inner & outer wall temperature to obtain the stress needed to make a crack.

Table 7.3. Highlights of potential vulnerabilities by sequence type.

Sequence Type	Potential Vulnerabilities

Loss of instrument air (example of a concurrent support system failure)	Such events are not generally expected. In particular, there is lots of redundancy at Oconee with regard to this system.
	
	• If such a failure would occur, it could pose a distraction for operators who are directed to ensure air supply or to restore it
	
	• Upon loss of air, the following occur at Oconee making the scenario more complex:
	
	  • Normal letdown closes down (i.e., RCS pressure goes up) and operators must align an alternate letdown path.
	
	  • RCP seal injection increases (and pressurizer level rises at about 2" per min.
	
	  • MFW startup and control valves fail “as is.” If MFW is uncontrolled, then operators must trip MFW pumps and the reactor if not already tripped. (MFW will eventually trip on low suction pressure due to other secondary plant effects.)
	
	  • TBVs fail closed, placing more demand on the MSSRVs.
	
	  • The return line in CCW closes. There is not much time before CCW is lost. Once CCW is lost, the temperature goes up on the major loads (e.g., RCPs). Eventually, this results in trip. Also, the operators will eventually have to trip the RCPs.
	
	  • Should there also be a loss of nitrogen from the nitrogen bottles to EFW valves (not caused by a loss of air), these valves will fail open which could exacerbate an overcooling event.
	
	  • Some indications are lost, but none of them are critical.

ICS failures	• The complexity of this system and its reliance on auto-switching make its failures/effects difficult to predict. • When transferring from manual to auto control, there can be feedwater swings. • On loss of “hand” power and any controller in “hand,” the demand signal goes to 50% which could be unanticipated. • On loss of all power (auto and hand), TBVs close (placing more demand on MSSRVs), all demand signals go to 50%, and all ICS/nuclear instrument indications (e.g., control rods) fail.
Main steamline breaks or similar	• These are unexpected events. • Oconee does some periodic training.
Small LOCAs	• These events are unexpected or, at least, are infrequent (e.g., a PORV sticking open). • Oconee does some training on SLOCAs, but isolable LOCAs and very small LOCAs are not trained on much.

Table 7.3. Highlights of potential vulnerabilities by sequence type.

Sequence Type	Potential Vulnerabilities
Low power	• Low power operations involve many transitions including transfer to auto control. • Operators do not spend lots of time (i.e., are less experienced) in this mode. • Certain auto-protections are not in place or not as redundant. • During low power, there is the potential for much more heat removal then heat generation (i.e., the situation is worse than at full-power from a TH standpoint).

7.1.5.2 Deviation Searches and Results

Using the first type of deviation search approach, eight separate deviation searches were conducted in all:

1. An unconstrained search for initiator/sequence progression deviations for the reactor trip initiator.
2. The reactor trip initiator, with a focus on possible PTS-relevant failures of secondary feed such as caused by integrated control system (ICS) anomalies as well as other faults.
3. An overcooling event involving the loss of cooling water.
4. An overcooling event involving the loss of electric power to a bus(es).
5. An overcooling event involving the loss of offsite power.
6. An overcooling event involving the loss of instrument air.
7. An overcooling event involving a main steam line break or similar secondary depressurization.
8. An overcooling event involving a small LOCA.

Tables were created summarizing each search. Table 7.4 provides an example of these tables by showing a portion of the deviation analysis summary table for the unconstrained reactor trip search.

The following were the team's conclusions from the deviation analysis:

1. From the unconstrained search for the reactor trip initiator, the most potentially interesting scenario that was identified involves an inadvertent SI, especially at low power. Such an scenario could be worthy of pursuit from a HRA perspective because, with scram, the event starts with already too much HPI that must be throttled or even shutdown. (Failures or delays in HPI throttling were addressed later in the small LOCA (SLOCA) deviation search.) If other faults occur, such as secondary side failures, operator attention initially may be on those faults, delaying HPI throttling.

Table 7.4. Summary table (only a portion is shown) for the unconstrained reactor trip search.

Guide Word	Possible/Example Deviation	Significance/ Comments	Comments/ Observations
No/not	No Rx trip -> ATWS (one or more rods don't insert)	1 rod - distraction Many - distraction + real problem	Tends to keep you hot; more of a CD problem than an overcooling. If RX didn't trip & turbine didn't trip, everything should be OK re: PTS. If RX didn't trip but turbine does, temperature goes up, pressure goes up, something breaks (LOCA), then pressure drops, boiling, RX shuts down. (No worse PTS than SLOCA & much less likely.) If ICS works - tries to hold T_{av} constant. If late scram, rods go in, T_{av} goes down, MF flow goes down, EFW holds SG level = feed OK. (ICS would need to fail.) Have a reason to inject & feed; if, get a late scram or rod insertion, could then get overcooling, but probability of late scram & ICS problem seems much less than just transient & ICS problem (by 5 orders of magnitude). Doesn't seem worth pursuing.
More	More boration. Pure water in borated water storage tank (BWST) - prompt critical when inserted. Spurious SI or auto-SI signal at 25%		More boration - not significant problem. Pure water in BWST - seems very improbable and then must still have ICS, etc. failures for overcooling and challenge to operator. SI- just another scram reason but with cold HPI already entering - maybe need to consider especially at low power.
Less	Partial rod insertion - see above		

Such an event is similar to events starting with a secondary side problem that causes HPI initiation, except that in this case, HPI flow is "too much" right from the start. However, as later discovered by the updated TH analyses, inadvertent SI represents a relatively small overcooling situation as compared with many other types of events. Primarily for this reason, this specific type of scenario was not analyzed but other events involving a secondary side problem with the subsequent need to throttle HPI were analyzed in the PRA and HRA.

2. For the deviation search focused on secondary feed anomalies along with a reactor trip, the team first concluded that such anomalies at Oconee could occur if:
   a. ICS (and/or associated components) fail,

   b. ICS is put in manual and not properly controlled,

   c. multiple failures in MFW and EFW auto-control occur, or

   d. the initiator is a MSLB or similar secondary depressurization event (i.e., continued feeding at "normal" SG level can still result in overcooling).

   Based on the results of the deviation search for this type of event, the HRA team concluded that the most challenging scenarios with regard to controlling feed (with no other function anomalies such as involving a loss of primary integrity) seem to be:

   - Loss of MFW or loss of offsite power (LOSP) as either an initiator or as a subsequent failure such as a failure of MFW runback or the ICS, with failure of EFW control system/control valves leading to high flow or with the EFW in manual and pre-set at a high flowrate. However, in order to create the most severe PTS conditions, operators must also fail to throttle HPI and otherwise control RCS pressure within allowable pressure-temperature (P-T) limits.

   - Loss of MFW/LOSP as either an initiator or as a subsequent failure such as a failure of MFW runback or the ICS, with all EFW initially unavailable. Operators are procedurally directed to get some other feed established, especially to depressurize the steam generators (SGs) with TBVs (which causes cooling) and to use condensate booster pumps, controlling flow through the feed valves. The possibility exists of doing this in a less than desirable controlled fashion. The scenario is likely to cause HPI to start and could cause loss of subcooling so that RCP trip is called for (i.e., likely to be performed since it is the first step in EP-501). As in the previous scenario, not throttling HPI is still needed to create the most severe conditions.[15]

   - Scenarios in which there is a potential delay of MFW tripping/throttling, especially for cases where there is no runback and the SG high level trip fails. However, this context does not seem strong to prevent operators from eventually tripping/throttling MFW. In addition, not throttling HPI is still needed to create the most severe conditions.

   - Low power scenarios involving an excess of MFW with failure of high SG level trip (similar to the scenario involving delay in MFW tripping/throttling above). However, it seems likely that operators will see and control such problems before there is too much cooling.

   - For all the cases above, anomalies affecting both SGs rather than one SG could be a more error-prone condition.

[15] The operators tendency will be to re-gain SG level as soon as possible. The loss of EFW (and pursuing its recovery) could be sufficient added workload/distraction in of itself to delay HPI throttling. Also, controllability of condensate booster pumps is not as fine (especially at first) than EFW pumps. The condensate booster pumps are high flow pumps (after SG depressurized enough). Also, ICS is no longer a factor because ICS doesn't control condensate booster pumps and FW control valves will have been put in manual. Finally, the SG high level trip doesn't apply to condensate booster pumps.

3. From the deviation search for scenarios involving loss of cooling water, the HRA team concluded (for both full and partial losses) that:

    - This case is very similar to the previous deviation analysis cases in which loss of MFW has occurred. However, the operators will experience other diversion/concerns (e.g., load heatup issues). For example, if the loss of cooling water (either closed cooling water system or "ultimate heat sink") is complete and prolonged, then condensate booster pumps and HPI may also be affected by heatup. This adds other complexities and "attention-getters" that could affect the timeliness of operator responses to any overcooling.

    - The results from the constrained search of the reactor trip initiator that addressed the cases of loss of MFW and loss of EFW appear to apply to the loss of cooling water initiator deviation analysis. However, the loss of cooling water analysis must address additional factors related to more distractions, workload, etc.

    - This sequence type does differ from a non-complicated reactor trip in that it is an example of those cases where RCPs are tripped early in the scenario (which might be due to actual/perceived imminent damage, seal failure, etc.) and the RCPs may not be restarted (until the threat of pump damage is eliminated). Shutdown of the RCPs translates to worse overcooling conditions because of loss of forced flow mixing.

    - In this case, MFW (and eventually condensate) pumps also may have to be tripped to avoid damage.

    - TBVs will close due to loss of condenser vacuum caused by loss of service water. This could increase demand on MSSRVs with a greater than normal potential of MSSRV(s) sticking open, causing an overcooling event that requires operator responses while dealing with an unisolable secondary fault.

    - The above added complexities of such a scenario could make this more challenging with regard to successful and timely operator response to the overcooling situation. Since, however, instrument air loss can cause all these effects and more, it was eventually decided that this type of sequence and the resulting human error probabilities could be bounded/covered considering a loss of air type of event.

4. From the deviation search involving loss of bus(es) electric power, the team concluded that:

    - This type of support failure needs to be considered due to its potential added workload, and loss of equipment redundancy effects which could affect operator response and timing to the overcooling with added workload to restore the problems.

5. From the deviation search for scenarios involving loss of offsite power, the team concluded that:

    - The additional potential complications of this type of scenario could delay, somewhat, necessary responses to the overcooling. Ensuring or troubleshooting the alternate ac supply, and potentially dealing with station blackout conditions could add other distractions and workload for the operators. Further, it is likely that condenser vacuum will be lost at Oconee adding further complexity since steam control cannot be through the normal path (TBVs).

6. From the deviation search for scenarios involving loss of instrument air, the team concluded that:

   - This type of scenario will involve additional diversion and workload issues due to some complexities resulting from the effects of loss of air. If operators do not know that the plant is experiencing a loss of air (i.e., the reactor trips, for some reason, and there are no "first out" lights), the operators may be puzzled by the scenario, as seemingly multiple and unconnected failures develop. If loss of air is due to contamination, the air compressor still may seem to be working normally, which also may be a puzzle to operators.

   - This is another scenario in which, because of its effect on CCW (i.e., likely loss of the closed cooling water system) at Oconee, MFW and RCPs will need to be shutdown at or near the start of the scenario. (Initially, MFW is controlled to 50% flow by ICS. With respect to the RCPs, operators need to trip them to avoid overheating because of the loss of CCW.)

   - Since EFW control valves rely on nitrogen bottles for air, one of the effects of this scenario may be to change the reliability of EFW control.

   - Consideration of this type of scenario must include thinking about what the effect of a fast or total loss of air are on operator performance versus that for a slow/contamination/partial loss of air.

   - Based upon the above, this initiator seemed to be worthy of treatment as a unique initiator by the HRA analysis and PRA study.

7. From the deviation search for scenarios involving a main steam line break or similar significant uncontrolled secondary depressurization, the team concluded that:

   - Three representative cases that deviate from the base case ought to be considered since the operator challenges may be more significant:

     A case in which the principal deviation is that the MSLB circuitry fails (resulting in continuing MFW feed, then MFW pump trips on high SG level and EFW auto-starts) and one SG is faulted. In this case, operator actions include: identifying the affected SG(s), tripping the motor-driven EFW pump(s) to the affected SG(s), isolating the affected SG(s) to stop overcooling, and throttling HPI.

     A case in which the principal deviation is that the TBVs do not close and the turbine does not automatically trip. For this case, the immediate action is taken by the OATC who must manually close the turbine valves.

     A case in which the principal deviation is that two TBVs stick open, one on each SG. For this case, the operators must isolate both SGs. Then, they must pick the SG that is least affected and feed it. Otherwise, the operators will be required to perform feed and bleed.

- It seems improbable that operators will misdiagnose the affected SG (i.e., the deviation analysis did not come up with any compelling circumstances at a high enough probability). Oconee has an excellent display of SG pressures to easily tell the affected SG.

- Isolation of the affected SG (including isolation of EFW) is a very critical action since overcooling starts immediately with the break. The degree of cooling is a function of the “time-to-isolate,” so it is likely that human error probabilities (HEPs) for several different times will be needed during quantification.

- If operators correctly identify the affected SG, then only slips seem to apply in the isolation steps, due to the fast feedback of error. However, slips seem easily identifiable and recoverable (i.e., the bad SG continues to depressurize) but they will delay “time-to-isolate.”

- There is a strong tendency for operators to use and recover at least one SG, even if both affected, so that there is a heat sink available.

- This event could be a diversion or attention-getter, thereby delaying or preventing HPI throttling. However, in procedure EP-503, there are reminders to throttle HPI.

- A “small break” in the steam line could be a bit more of a problem. In such a scenario, the overcooling starts but not as rapidly in other cases. Will, or when will, the operator isolate the affected SG could be sensitive to the degree and rate of depressurization.

- If the MSLB is a delayed “break” (e.g., TBV stuck-open later), operator identification and isolation of affected steam path/SG also may delayed especially if already handling other symptoms.

- It is not clear if one versus two steam lines affected makes a big difference in operator response(s) other than the need to restore the “better” SG.

8. From the deviation search for scenarios involving a small LOCA, the team concluded that:
   - It seems highly probable that operators will trip RCPs when subcooling = 0F and ensure full HPI, at first.

   - It seems quite probable that operators will check for and isolate isolable LOCA paths, but they are not trained on this action much. Slips associated with this action might be possible with little re-checking.

   - If all the above are done, and there is excessive heat transfer, operator attention to the secondary-side problems seems quite likely. (Operators are directed by procedure EP-501 to go to procedure EP-503 very early in the EP-501 procedure.) However, a potential complicating issue (deviation from the norm) is: What if a RCS-primary side problem is persistent such as HPI sufficient flow not achieved? This should be an “attention-getter” and since the RCS subcooling is a very high hierarchal function, it seems that attention to subcooling could delay actions needed on the secondary side of the plant if there are anomalies there with feed control or depressurization. Such a situation involves serious multiple function problems beyond operator expectations with increasing anxiety, complexity, etc. (Oconee operators are used to training on scenarios with one or two functions failed at the same time. However, notes from discussions with the Oconee training staff during the plant site visit say that if the scenario is a LOCA and a depressurization event, then the operators could get locked (i.e., focused) on the primary side.

- Even without other secondary problems, insufficient HPI alone calls for further depressurization (see procedure EP-507) to get to CFTs/LPI (low head systems) which further adds to the cooling effects. Then, what if HPI re-starts while depressurizing? Operators could potentially overreact and repressurize with HPI (i.e., not throttle as they should) while and after trying to achieve >80" PZR level and 5F subcooling. (This type of deviation of the nominal LOCA scenario is a possible setup of overcooling and then repressurization.)

- Just a primary LOCA, by itself and with no HPI problems, may be sufficient to at least delay attentiveness/response to any secondary problems with feed control or a secondary depressurization (e.g., stuck open MSSRV), causing a delay in the “time-to-isolate” any secondary breaks.

- The need for operators to do calculations for proper PZR/SG levels could be a further distraction later in the scenario.

- A later LOCA (e.g., subsequent PORV sticking-open or RCP seal failure) may call attention from current activities and somewhat delay other response actions, such as any secondary problems.

- Oconee operators seem somewhat reluctant to restart RCPs due to reactivity insertion concerns.

- If there is a subsequent/concurrent support system failure with the LOCA, complexities and attention diversions further increase. This could add a little more delay in any needed responses.

To summarize the above insights, it was the opinion of the HRA team that in general, the human error probabilities for the actions of interest should be higher for scenarios with one or more of the following characteristics (than for actions in scenarios that are simple, nominal types of scenarios):

- concurrent support system (e.g., instrument air or loss of power) faults exist
- numerous equipment faults (e.g., more than two) exist
- more than one of the PTS relevant functions are affected by the faults in the scenario.

These summary observations helped guide the construction of the PTS PRA model and the types of scenarios that ought to be captured by the model. That is, besides the simple or nominal types of scenarios (e.g., one TBV stuck-open), these HRA insights supported the need to also model more complex scenarios with the above characteristics. This would ensure the PTS evaluation also captured somewhat less likely scenarios, but ones that led to greater chances of human error during the response. Additionally, these same observations formed the basis for the relative values of the human error probabilities assessed for the HFEs in the PTS-PRA model.

One other observation should be made with regard to the results of the deviation analysis in particular, and the insights gained from the other aspects of the HRA process. It became clear that in many complicating situations that would be modeled in the PTS PRA, the procedures would direct the operators to take actions that tended to cooldown or even overcool the plant. These typically occur when the existing scenario (including the various faults) is leading toward undercooling the core and more drastic actions have to be taken by the operators to restore adequate core cooling. Such actions include depressurizing the SGs to establish feed with condensate, going to feed and bleed, opening a PORV in response to inadequate core cooling, etc. Given a number of these procedure-directed acts of commission of potentially overcooling the core, it was felt that more complex searches to find other errors of commission were unnecessary. While investigation into such possibilities did occur, the procedures and training were judged to make such possibilities a low likelihood, even with some instrument failures that might provide erroneous information. Thus, for the most part, the commission errors in the model are those procedure-directed acts as mentioned above. Consequently, only a few "errors" of commission were also modeled (e.g., inappropriate trip of the RCPs).

7.1.6 Plant Visits

Early in the Oconee PTS study but after an initial review of the Oconee procedures, training documents, and other pertinent information, a plant visit was made to the Oconee site by members of the NRC and the NRC contractors working on the PTS study. During this first visit, members of the PTS study team including the PRA, HRA, and TH disciplines collected additional information. More importantly, numerous discussions occurred which clarified aspects of the Oconee design, operating practices, etc. On the basis of the analyses described in the previous sections, the HRA team identified questions for operators and trainers and with Oconee staff cooperation, observed simulator exercises the team wanted to see (e.g., simulated main steamline break event). On the basis of information collected during this plant visit, the HRA team was able to, for example, develop a crew characterization and understand the Oconee procedure implementation strategy and crew communication and interaction protocols. The HRA team came to understand the typical timing to take various actions and they learned the ease, or potential difficulties that might exist with some actions in certain situations. In addition, the visiting HRA team members strove to examine the potential for various human errors and tried to enlist operators and trainers to validate the potential impact of deviation scenarios. Also, team members were able to screen out some hypothesized EOCs as being very unlikely.

Besides ongoing communications and e-mailed questions and answers during the entire study, a second visit to the plant site also occurred following an initial quantification of the entire PRA-PTS model including some preliminary conditional probabilities of vessel failure. These preliminary results were provided to the Oconee staff and discussions took place with regard to the significance of the results, and comments were solicited. As for the HRA part of the analysis, both specific and general comments were received from the Oconee staff following a one-to-two week review period. These comments generally comprised of three types: the providing of additional factors affecting a specific human error that we had apparently not accounted for and might affect the human error probability, criticism with regard to the appropriateness of the size or shape of the preliminary uncertainty bounds that had been placed on the human error probabilities, or suggestions regarding clarification of the meaning or intent of certain HFEs. In response to these comments, the HRA team did agree with about half of the Oconee provided suggestions and made changes to the HRA accordingly. In other cases, the HRA team either disagreed with the comment or it was judged that the significance of the change was too small to worry about (i.e., it would not matter to the PTS PRA results) and the change would not be trivial.

Hence, while much of the PRA process was carried out by the NRC contractors including the quantification of the human error probabilities (discussed in the next section), it was all done with considerable and frequent Oconee staff input and review. It is felt by the HRA team that in the end, there was a reasonable consensus reached among the NRC contractors and the licensee staff with regard to the human errors included in the model and the associated human error probabilities.

7.1.7 Quantification of the Human Error Probabilities

As noted earlier, HRA quantification for the Oconee PTS PRA involved both initial and detailed quantification. Both used an expert elicitation process for the Oconee PTS HRA.

At a high-level, this two-step quantification process is similar to the standard HRA practice of, first, performing HRA screening analysis and then performing detailed quantification, especially for those human events particularly important to the results. However, while the initial quantification results performed for the Oconee PTS PRA are more conservative than those produced in a detailed analysis, they are different from the screening HRA values typically assigned in initial HRA quantification. In fact, the Oconee PTS initial HRA quantification results are based on scenario context descriptions and analysis that are quite substantial and hence the initial human error probabilities are better characterized as "realistic (not screening values) but conservative". Hence the Oconee PTS PRA contains human error values from both the initial quantification effort and from the detailed re-analysis of a few human events that are particularly important to the results.

The two subsections below describe the initial and detailed HRA quantification approaches used in the Oconee PTS PRA that was devised specifically for the PTS study but based on principles in the ATHEANA approach [NUREG-1624].

7.1.7.1 Initial Quantification Approach

This section describes the initial HRA quantification approach used for the Oconee PTS PRA. Aspects of the initial HRA quantification that are specific to the Oconee PTS PRA are discussed. Then the approach for developing uncertainty distributions for the assigned human failure probabilities in the Oconee PTS PRA's initial HRA quantification is described.

7.1.7.1.1 Oconee-Specific Initial Quantification

The process for the initial Oconee PTS HRA quantification is described in six steps below.

Step 1: Describe the HFE and plant-specific associated context

The purpose of Step 1 is to:

a. Collect any supplemental information that is not already collected and that is needed to describe and define the HFEs (and associated contexts),

b. Review all information for clarity, completeness, etc., and

c. Interpret and prioritize all information with respect to relevance, credibility, and significance.

Table 7.5 provides examples of information that serve as inputs to the quantification process, whether collected during the search process or as part of Step 1 of quantification.

Table 7.5. Examples of information useful to HFE quantification.

Information Type	Examples
Plant conditions & behavior for base case scenarios	Thermal-hydraulic conditions as a function of time, expected plant indications as a function of time, system/equipment operations, expected operator actions.
Plant conditions & behavior for deviations of the scenarios	Expansion of the above including reasonably possible unusual plant behavior and failures of systems, equipment, and indications, especially those that may be unexpected or difficult to diagnose by operators.
Critical plant functions for accident mitigation	Specific equipment operation, requirements for operator action, possible operator recovery actions for failed systems/equipment.
Operating crew characteristics (i.e., crew characterization)	Crew structure, communication style, emphasis on crew discussion of "big picture", behaviors observed in simulator exercises and/or identified by training staff.
Features of procedures	Structure, how implemented by operating crews, opportunities for "big picture" assessment and monitoring of critical safety functions, emphasis on relevant issue (e.g., PTS), priorities, any potential mismatches with deviation scenarios.
Relevant informal rules	Experience, training, practice, ways of doing things - especially those that may conflict with informal rules or otherwise lead operators to take inappropriate actions.
Timing	Plant behavior and requirements for operator intervention versus expected timing of operator response in performing procedure steps, etc.; input from training staff and results of simulator exercises; based upon perceived needs of the PRA, multiple times or time frames may need to be considered for each HFE.
Relevant vulnerabilities	Any potential mismatches between deviation scenarios and expected operator response with respect to timing, formal and informal rules, biases from operator experience and training, etc.
Error mechanisms	Any that may be particularly relevant by plant context or implied by vulnerabilities; applicable mechanisms depend upon whether HFE is a slip or mistake. Examples include: failures of attention, possible tunnel vision, conflicts in priorities, biases, missing or misleading indications, complex situations, lack of technical knowledge, timing mismatches and delays, workload and human-machine interface concerns.
Performance shaping factors	Those deemed associated with or triggered by the relevant plant conditions and error mechanisms.

The third item from the above list is especially important if:

- some information is applicable only to certain scenarios, HFEs, or contexts
- there are conflicts between information sources
- information is ambiguous, confusing, or incomplete
- information must be extrapolated, interpolated, etc.

All of the above three items, and especially the third item, were performed as part of an open discussion among the experts (in this case, the HRA team for the study made up of NRC contractors) in the elicitation process. The goal of this discussion was not to achieve a consensus but, rather, to advance the understanding of all the experts through the sharing of distributed knowledge and expertise. In each case, the scenario (or group of similar scenarios) and the HFE in question are described and the vulnerabilities and strong points associated with taking the right action are discussed openly among the team.

It is important that a "crew characterization" be developed as part of or prior to performing Step 1. In addition, the significance or relevance of this crew characterization with respect to expected operator performance should be discussed by the experts.

Step 2: Identify the key or driving factors of the plant-specific context

The purpose of Step 2 is to identify the key or driving factors on operator behavior/performance for each HFE and associated context. Each expert participating in the elicitation process individually identifies these factors based on the expert's own judgment. Usually, these factors are not formally documented until Step 4.

Typically, there will be multiple factors deemed most important to assessing the probability for the HFE in question. This is due to the focus of the ATHEANA search process on combinations of factors that are more likely to result in an integrated context. When there is only a single driving factor, it is usually one that is so overwhelming that it alone can easily drive the estimated probability. For example, if the time available is shorter than the time required to perform the actions associated with the HFE, quantification becomes much simplified and does not need to consider other factors.

Step 3: Generalize the plant-specific context by matching it with generic, contextually-anchored rankings or ratings

In Step 3, each expert participating in the elicitation process must answer the following question for each HFE:

- Based upon the factors identified in Step 2, how difficult or challenging is this context?

Answering this question involves independent assessments by each expert. In order to perform this assessment, the specifics of the context defined for a HFE must be generalized or characterized. These characterizations or generalizations then must be matched to general categories of failures and associated failure probabilities.

In the initial HRA quantification for the Oconee PTS PRA, quantification of the HFEs was constrained to four values and associated categories of failure:

Category	HEP (human error probability)
"Likely" to make the error	0.5
"Infrequent" errors expected	1E-1
"Unlikely" to make the error	1E-2
"Extremely unlikely" to make the error	1E-3

For exceptional cases, the quantification approach also allowed a HEP of 1.0 to be used when failure was deemed essentially certain.

The above categories of failures and associated failure probabilities can be (and were) further interpreted in the following way to aid the experts in arriving at their HEP judgments:

- 0.5 Given an understanding of the HFE and the context, including the range of possible plant conditions represented by deviations of the nominal context, general crew characteristics, and variability among crews, one can imagine 5 of 10 crews failing the action associated with this HFE.

- 0.1 Given an understanding of the HFE and the context, including the range of possible plant conditions represented by deviations of the nominal context, general crew characteristics, and variability among crews, one can imagine 1 of 10 crews failing the action associated with this HFE.

- 1E-2 Given an understanding of the HFE and the context, including the range of possible plant conditions represented by deviations of the nominal context, general crew characteristics, and variability among crews, one can realistically foresee a crew failing the action associated with this HFE, but at a rate considerably less than 1 in 10 crews.

- 1E-3 Given an understanding of the HFE and the context, including the range of possible plant conditions represented by deviations of the nominal context, general crew characteristics, and variability among crews, it is difficult to foresee how, realistically, a crew could fail the action associated with this HFE, but must acknowledge that it could happen.

Step 4: Discuss and justify the matches made in Step 3

In Step 4, each expert was asked to independently provide his/her estimate for each HFE. As noted in Step 3, the assignment of failure probabilities was generally constrained to four values. However, if any expert needed to express uncertainty in making a failure probability assignment, the analyst was allowed to report that his/her best estimate lies somewhere between two of the above values.

Once all the expert estimates were recorded, each expert was asked to describe the reasons why he/she chose a particular failure probability. In describing his/her reasons, each expert should identify what factors (positive and negative) were thought to be key to characterizing the context and how this characterization fit the failure category description.

After the original elicited estimates were provided, a discussion was then held that addressed not only the individual expert estimates but also differences and similarities among the context characterizations, key factors, and failure probability assignments made by all of the experts. This discussion allowed the identification of any differences in the technical understanding or interpretation of the HFE versus differences in judgment regarding the assignment of failure probabilities. Examples of factors important to HFE quantification that might be revealed in the discussion include:

- differences in key factors and their significance, relevance, etc. based upon expert-specific expertise and perspective
- differences in interpretations of context descriptions
- simplifications made in defining the context
- ambiguities and uncertainties in context definitions

A consensus opinion was not required following the discussion.

Step 5: Refinement of HFEs, associated contexts, and assigned HEPs (if needed)

Based upon the discussion in Step 4, the experts formed a consensus on whether or not the HFE definition must be refined or modified, based upon its associated context. If the HFE must be refined or re-defined, this is done in Step 5. If such modifications were necessary, the experts "re-estimated" based upon the newly defined context for the HFE (or new HFEs, each with an associated context).

The experts participating in the elicitation process also were allowed to change their estimate after the discussion in Step 4, whether or not the HFE definition and context were changed. Once again, a consensus was not required.

Step 6: Determine final HEP for HFE and associated context

The final probability estimate (from the initial quantification process) that will be incorporated into the PRA for each HFE is determined in Step 6.[16]

The failure probabilities assigned in the initial HRA quantification are similar to traditional HRA screening values in that these values are expected to be conservative. For the initial HRA quantification approach used here, the principal source of conservatism is that the failure probability that was assigned to each HFE for the Oconee PTS PRA was determined by choosing the highest assigned probability among the final estimates of the experts participating in the expert elicitation process.

Nevertheless, as illustrated by the above process, more supporting detail was used to make the initial

[16] It is important that HRA and other PRA analysts communicate throughout the HRA/PRA modeling process in order to have a common understanding of what the HFE represents in the PRA model. This interface is especially important if HFE contexts (e.g., timing of operator actions) are not explicitly modeled by the PRA (i.e., simplifications, interpolations, or extrapolations must be made because of limited resources, etc.).

quantification estimates than is typical for HRA screening. Even with a more detailed context, there may be some gaps in understanding or information, or some simplifications in representing context (e.g., wide varieties of plant scenarios or ranges of plant conditions, all represented by a single context description). Such gaps can be tolerated in the initial HRA quantification process. However, if the HFE was later determined to be important to the overall results, such gaps or simplifications were re-investigated in detailed HRA quantification.

Dependencies among multiple HFEs in a scenario

It is important to note, here, how dependencies among multiple HFEs appearing in the same scenario were handled. Given the detail provided in the contextual development for each HFE, the HRA team was careful to identify cases where the HFE being considered was one of multiple HFEs that were part of the overall scenario of concern. For example, if it was known that one scenario involved multiple PTS-relevant functional failures that would require multiple human actions in the same sequence of events vs. another scenario where this was not the case for the HFE of interest, then human error values were estimated both for cases where the HFE of interest would appear among other multiple HFEs and where it would not. This was possible since (1) the PRA model, being largely an event tree model, easily displayed where multiple HFEs would appear in a given scenario and (2) given the close integration of the PRA and HRA efforts, the HRA team was well aware of where these multiple HFEs applied. In this way, the HRA team was able to know, in large part, where there might be multiple and dependent HFEs needing to be quantified within the same scenario context and the resulting elicited estimates already accounted for such possible dependencies.

The need to handle these dependencies was minimized to some degree on the basis of the observed simulations at Oconee and talking with Oconee staff about the crew member roles and protocols used at Oconee. It was observed that the actions of the board operators (one primarily handling primary system functions and the other secondary system functions) were largely independent of each other. Further, with the independent checking of plant parameters and conditions by the control room SRO and the technical advisor, possible common errors tended to be minimized or caught and rectified, further minimizing the dependencies among actions. This tended to result in low dependency effects among the actions in the minds of the experts, which was factored into their judgments.

Nevertheless, after the PRA sequences were quantified, an additional check was made where multiple HFEs appeared in a scenario to ensure that dependencies among the events (and hence the effect on quantification) had been properly taken into account. In a few cases, minor adjustments were made, using approximately 1E-5 (because of the strong independence and checking observed among operator actions at Oconee) as a lower combined probability threshold for the HFEs in a sequence.

7.1.7.1.2 Oconee-Specific Initial Assignment of Uncertainties

In initial HRA quantification, uncertainty estimates were based on the following three considerations:

1. the typical ranges of individual expert estimates for point values,

2. suggested ranges of error factors based on Swain's HRA guidance [NUREG/CR-1278], and

3. any other qualitative considerations considered relevant (e.g., time is very short so upper bound should be purposefully high).

Generally, the following “rules” were applied considering the above. In applying these rules, the chosen HEP from Step 6 was assumed to be a mean value (rather than upper end value based on the elicited estimates) further providing some “built-in” conservatism during initial quantification.

- If the mean is 0.5, then set the 95% percentile at 0.9 and the 5% percentile at 1E-2.
- If the mean is 1E-1, then set the 95% percentile at 0.5 and the 5% percentile at 1E-2.
- If the mean is 1E-2, then set the 95% percentile and 5% percentile at +/- factor of approximately 10 from the mean.
- If the mean is 1E-3, then set the 95% percentile and the 5% percentile at +/- factor of approximately 10 from the mean.

However, exceptions to the above cases were allowed, with justification. The recommended distribution shape was assumed to be lognormal or some other similar skewed distribution.

7.1.7.2 Detailed HRA Quantification

As the final Oconee PTS PRA results were becoming apparent, considering not only the PRA sequence frequencies but also the conditional probabilities of vessel failure for the sequences based on the fracture mechanics results, it was observed that a few human actions were particularly important to the overall Oconee PTS results. Given the purposely conservative bias performed during the initial HRA quantification, it was decided that these few actions should be revisited and quantified even more realistically with a deeper and simultaneous consideration of the specific context and factors that would affect both the mean and uncertainty estimates for the actions of interest. This process was referred to earlier as the “quantification-including-uncertainty” approach.

The process essentially parallels the six step process outlined for the initial quantification, but with two major differences. First, the context associated with the human action of interest is even more specifically defined since at this stage, the specific sequence and related failures are known based on the interim PRA results from “running” the PRA model. Second, when the experts provide their estimates, they do not provide just a point estimate to which an uncertainty distribution is separately applied. Instead, considering reasonable deviations such as the possibility of different crew experiences, time of day, possible instrument or other equipment failures, nuisance alarms, etc. (i.e., possible variations not explicitly described by the PRA sequence model), the experts provide their estimate of the entire probability distribution (at whatever shape) for the human error being quantified (hence the “quantification-including-uncertainty” label for the approach). This distribution accounts both for the variability in conditions (e.g., different crews) for the scenario beyond that described by the level of the PRA model, as well as a reasonable range of different conditions (e.g., existence of other failures or nuisances) about the PRA described context. In this way, the uncertainty expressed for the HFE being evaluated captures not only the uncertainty in the human response for the PRA given context, but also, to some degree, the uncertainty in the context itself (e.g., a TBV stuck open event with no nuisance alarms vs. the same event but with the random possibility of nuisance failures and alarms also occurring). Because of this approach, it has been observed that the uncertainties described here generally are much wider than typical uncertainties evaluated using other HRA methods and tools.

In examining the context more fully, a worksheet was developed as an aid for the experts to consider nearly fifty factors that might influence either or both the mean and uncertainty estimates. That worksheet is provided as Table 7.6 and is still undergoing improvement in other ATHEANA-applied applications. For the HFE of interest, the expert elicitation included an evaluation and discussion of the relevancy of these factors and the specifics regarding those factors (e.g., a specific instrument that could be particularly influential for the action being analyzed) in assessing the likelihood of the human error being considered. During these discussions, it was noted whether a factor was largely aleatory or epistemic in nature, whether it might affect primarily the mean or the uncertainty (or both) in the human error estimate, the likelihood of variations in the factor occurring, and ultimately, which few factors seemed to be most critical to deriving the human error probability distribution estimate. Based on these discussions, the experts then provided their individual probability distributions and refined those distributions using the same steps 4 through 6 described for the initial HRA quantification. At the end of this process, a single distribution describing the human error probability was agreed upon by the experts and that distribution, described as a histogram, was provided to the PRA modelers for inclusion into the model.

In coming up with the distribution estimates, each expert was asked to provide the following information:

- Provide the distribution describing the probability of this human error by providing the following probability values for that distribution: the 1 percentile value (i.e., there is judged to be only a 1% chance that the true value, if it could be known, is less than the probability value provided), the 10 percentile value, the 25^{th}, the 50^{th} (median), the 75^{th}, the 90^{th}, and the 99^{th}.

In developing these distributions, the experts were asked to perform the following in the order given:

1. Based on the discussion about the factors, build a rationale for a high end bound for the probability of failure based on the worst set of reasonably conceivable conditions for the PRA modeled context under which this action might need to be performed. Estimate the likelihood of the error and consider this the 99^{th} percentile value of the distribution.

2. Based on the discussion about the factors, build a rationale for a low end bound for the probability of failure based on the most ideal set of reasonably conceivable conditions for the PRA modeled context under which this action might need to be performed. Estimate the likelihood of the error and consider this the 1^{st} percentile value of the distribution.

3. Based on the discussion about the factors, build a rationale for estimating the 50^{th} percentile value considered to be that probability for which if many crews were “tested” for this human action, half of them would fail at a probability less than the 50^{th} probability and half of them would fail at a probability higher than the 50^{th} probability.

Table 7.6. Worksheet for detailed evaluation of human failure events.

WORKSHEET Human Event ____________________ Date _________	
Factor	**Notes**
Plant Context Factors	
Operations/Maintenance factors	
Time available for action	
Instrumentation or controls unavailable due to maintenance	
Multi-train (or all-train) maintenance has been performed, contrary to Technical Specifications	
Technical Specification requirements (e.g., tank levels) may not be met at the time of the plant trip	
Impacts of support systems that affect control of other systems can cause very confusing plant response, e.g., IA, inst. AC, I&C	
Management decisions regarding plant configurations can result in defeated plant defenses and additional burdens on operators, e.g., • scheduling of maintenance and testing activities • on-line corrective maintenance and entering Limiting Condition for Operation (LCO) statements in technical specifications • special configurations or exceptions from Technical Specifications to address persistent hardware problems	
Time of day	
Systems Factors	
Instrumentation/controls fail	
Spurious actuations	
Plant scenario behavior with respect to variations in speed, timing, ordering, etc. that are not treated explicitly in the PRA scenario definition	
Systems do not always fail at t=0 in accident sequence	
Systems and components are not truly binary state (i.e., they can experience a range of degraded conditions between optimal performance and catastrophic failure)	
Detailed timing of events, the dynamic nature of the accident sequence, can affect the progress of the accident	

Table 7.6. Worksheet for detailed evaluation of human failure events.

WORKSHEET Human Event ____________________ Date _________	
Factor	**Notes**
Cross-system common cause failures can and do occur	
Electrical “sneak circuits” can occur	
Selective tripping (coordination) failures of electrical circuit breakers are possible	
Plant power at time of trip may be < 100%	
Operational/testing evolutions may be in progress	
Preexisting Conditions not Usually Modeled in PRA	
Instrumentation pre-accident failure (human and hard-ware-caused)	
History of false/spurious/ automatic actions	
Work-arounds	
Configuration anomalies	
Plant evolutions in progress	
Power level	
Specific, detailed causes of initiating events (especially those caused by humans)	
The recovery of "slips" may be complicated (e.g., unexpected difficulties in re-setting I&C)	
Crews/Operator Behavior Factors *(if plant context is fixed?)*	
Time at which action occurs	
Duration of action (Time to complete, given start)	
Crew characteristics, e.g., • team aspects (i.e., how does a crew perform regarding communication, problem-solving, use of procedures, other team skills w/r to general, site-specific crew characteristics) • understanding of plant-specific priorities, goals, deep technical knowledge, etc. • experience level • time together • (need help from psychologist-types to fill out the team aspects list)	
Procedure design, incorporation of technical knowledge into procedures	
“Informal” procedures, work practices, ...	

Table 7.6. Worksheet for detailed evaluation of human failure events.

WORKSHEET Human Event ____________________	**Date _________**
Factor	**Notes**
Instrumentation problems that cause operators to not use it	
The instrumentation used by operators is not necessarily all that is available to them or what designers expect them to use	
Operators often will believe valve position indicators in spite of contradictory indications	
Operators can misunderstand how instrumentation & control (I&C) systems work resulting in erroneous explanations for their operation and indication	
One plausible explanation can create a "group mindset" for an operating crew	
Operators will persist in the recovery of failed systems if, e.g., • the alternatives have negative consequences • recovery is imminent (in the operators' opinion) • they were the cause of the system failure (i.e., recoverable failure)	
A variety of environmental factors have been shown to affect operator performance such as:	
• time of day	
• day of shift	
• room color and lighting	
• quality and physical location of audible alarm sound sources	
• instrument panel layout	
Context-triggered PSFs	
Effect of support system failures (degrading conditions)	
Mismatches between plant conditions and procedures	
Mismatches between plant conditions and training	
Workload	
Reports of hazardous conditions in the plant	
Reports of serious injuries in the plant	

4. Fill-in the rest of the distribution while also testing your curve to see if you really believe that:

   - it is equally likely that the failure probability is above and below the 50th percentile

   - it is equally likely that the failure probability is (between 25th -75th) or (below 25th or above 75th)

   - it is equally likely that the failure probability is below the 10th or above the 90th.

5. In estimating these probabilities, the experts were encouraged to think about how many crews out of a total number of crews (e.g., 100) would fail, to help them convert their qualitative judgments into quantitative probabilities.

As already stated, when all the experts' distributions were provided and discussed, a consensus distribution was agreed upon and ultimately provided for incorporation into the PRA model.

The above detailed analysis process was applied to the final "most important" HFEs to the Oconee PTS results. These are:

- Failure to throttle HPI and otherwise control RCS pressure within allowable limits (e.g., within the thermal shock operating region (TSOR) or allowable pressure-temperature limits) within 1 minute after the allowable throttling criteria of 5F subcooling is reached in the scenario involving a sudden reclosure of a pressurizer safety relief valve (SRV) that has been opened for a long time (taken as a representative 6000 seconds in the PRA model) since the initial reactor trip and start of the overcooling event.

- Failure to throttle HPI and otherwise control RCS pressure within allowable limits (e.g., within the TSOR or allowable pressure-temperature limits) within 10 minutes after the allowable throttling criteria of 5F subcooling is reached in the scenario involving a sudden reclosure of a pressurizer safety relief valve (SRV) that has been opened for a long time (taken as a representative 6000 seconds in the PRA model) since the initial reactor trip and start of the overcooling event.
- Failure to throttle HPI and otherwise control RCS pressure within allowable limits (e.g., within the TSOR or normal allowable pressure-temperature limits) within 10 minutes after the allowable throttling criteria of 5F subcooling is reached in the scenario involving a significant steam generator depressurization event when the crew has previously failed to isolate the feed to the affected steam generator (hence consider the possible dependency of the previous failure on this human action).

- Failure to throttle HPI and otherwise control RCS pressure within allowable limits (e.g., within the TSOR or normal allowable pressure-temperature limits) within 20 minutes after the allowable throttling criteria of 5F subcooling is reached in the scenario involving a significant steam generator depressurization event when the crew has previously failed to isolate the feed to the affected steam generator (hence consider the possible dependency of the previous failure on this human action).

7.2 HRA Results

7.2.1 Results of Initial Quantification

The results of the Oconee PTS HRA analysis consist of:

- identified human failures
- failure probabilities and associated uncertainties for each human failure.

Oconee HRA results are provided for full-power and low power conditions. Tables 7.7 and 7.8 provide the list of identified HFEs, and the associated failure probabilities and uncertainty distributions for full-power and low power, respectively, based on the initial quantification effort. For reasons described later in Section 7.2.3, these human failure probabilities were modified somewhat for final inclusion into the Oconee PTS PRA. Additionally, some of the human failure estimates were not needed in the final model (much of the HRA effort preceded the finalization of the PRA and hence some human events were quantified based on an anticipated need in the model). Section 7.2.3 provides the list of human events actually modeled in the Oconee PTS PRA and explains how these PRA human events are related to the human failures shown in Tables 7.7 and 7.8. Also note that as indicated in Table 7.7, a few of the HFEs for full power conditions were re-analyzed during detailed quantification and it is those values that were used in the Oconee PTS PRA. No detailed quantification adjustments were required for any of the low power HFEs.

7.2.1.1 HFEs for Full Power Conditions

The results for the initial quantification of full-power HFEs are shown in Table 7.7. This table documents:

- the HFE description
- applicable scenarios and plant conditions
- the key factors influencing the failure probability for the HFE (e.g., error mechanisms, performance shaping factors), as identified by the HRA team

Table 7.7. HFE results and analysis for Oconee PTS PRA: Full-Power.

HFE #	HFE	Condition When Applied	Dominant Considerations Most Affecting the HFE Estimate	Error Factor from NUREG/CR-1278, Table 7-2 and (Range of Experts' Estimates)	HRA Mean[1] and Uncertainty Values
1	Operators fail to trip RCPs quickly (~1 min) when suppose to (i.e., after subcooling is lost (O^0F))	Applies for all events under all circumstances	Training strongly oriented toward follow procedures. Is essentially an "auto rule" and first thing operator does in entering EP-501. Use of rule placards lessens chance of not doing. Multiple indications of subcooling exist lessening likelihood of instrumentation failure. Operators also sometimes train on loss of instrumentation. Because of rule, seems relatively independent of event/scenario once enter EP-501. No identified strong error mechanisms (EMs) to not perform this action. Discussions/observations show strong tendency to protect pumps if thought to be in jeopardy (e.g., loss of cooling) Desirable response is "quick" so there is little time.	Either item 5 or item 8 EF= 5 or 10 (Consensus: 1E-2)	**1E-2 = mean** (95%, 5%) = 1E-1, 1E-3 (Duke Comment: 1E-1 too high on the skew. Response: Until deemed important to results, will leave skew. Seems if subcooling is dropping slowly, crew might miss 'momentarily' while doing other things).

Table 7.7. HFE results and analysis for Oconee PTS PRA: Full-Power.

HFE #	HFE	Condition When Applied	Dominant Considerations Most Affecting the HFE Estimate	Error Factor from NUREG/CR-1278, Table 7-2 and (Range of Experts' Estimates)	HRA Mean[1] and Uncertainty Values
2	Operators trip RCPs when not required	Applies for all events under all circumstances except when there is an instrument problem (failure, bus problem) and one instrument reads 0F incorrectly	General tendency is to keep RCPs running based on discussions and observation of simulator runs. Seems only "likely" if operators perceive potential damage/problem with pump operation, because of tendency to protect these pumps (like fire in 1989 event) [Note, ops will likely trip RCPs (assume 1.0) on loss of air/loss of CCW due to heatup of pump seals/bearings.] Maybe try to beat the 0F if see subcooling drop, but probably need to make ~5F mistake, or more, to make a difference.	Items 4,5, 6, or 7 EF= 5 or 10 (Consensus: 1E-3)	Case 2(a): **1E-3 =mean**; (95%, 5%) = 1E-2, 1E-4
		With an instrument problem	See above. Would be particularly troublesome if other readings also going down but not far different from incorrect 0F reading. Can crew notice instrument reading 0F is incorrect? Crew tends to act conservatively on any one 0F reading.	As above (1E-1 to 1E-2)	Case 2(b) Given instrument problem: **1E-1 = mean** (95%, 5%) = 0.5, 1E-2

Table 7.7. HFE results and analysis for Oconee PTS PRA: Full-Power.

HFE #	HFE	Condition When Applied	Dominant Considerations Most Affecting the HFE Estimate	Error Factor from NUREG/CR-1278, Table 7-2 and (Range of Experts' Estimates)	HRA Mean[1] and Uncertainty Values
3	Operators fail to restart RCPs when suppose to (primarily 50F subcooling but other criteria, too) will assume, for context purposes, fail to do by ~1 to 1-1/2 hrs into event while it still may make a difference on crack propagation.	Applies for all events under all circumstances	Training strongly oriented toward follow procedures. Multiple indications of subcooling exist lessening likelihood of instrumentation failure. Operators also sometimes train on loss of instrumentation. Seems relatively independent of event/scenario as this is a "late" recovery step in all the procedures. Discussions indicate a strong reluctance factor because of positive reactivity concerns when pumps restart; especially if pumps are "off" for quite awhile. Input from Duke Training: No pressing need to accomplish - probably will get TSC input.	Item 5 EF = 5 (Consensus: 0.5)	**0.5 = mean**; (95%, 5%) = 0.9, 0.1 (Duke recommended 1.0. Response: Not guaranteed to not do so; this gives some chance will do it)

Table 7.7. HFE results and analysis for Oconee PTS PRA: Full-Power.

HFE #	HFE	Condition When Applied	Dominant Considerations Most Affecting the HFE Estimate	Error Factor from NUREG/CR-1278, Table 7-2 and (Range of Experts' Estimates)	HRA Mean[1] and Uncertainty Values
4	Operators <u>successfully</u> go to F&B when supposed to (key is 2300 psig in RCS) or successfully depress/cool to use Condensate or to get to CFTs/LPI if necessary	Applies to all events under all conditions when these actions become necessary.	This is among the known/called out/trained options for when heat sink is lost and EP-502 is entered or if must recover from insufficient HPI. There is a desire (based on discussions/observations of simulator events) to not use F&B cooling unless have to; will tend to use/recover SGs if can. EP-502 step and training make operators attuned to need to not let pressure go above this point and let system go solid (discussions indicate operators are to F&B without hesitation if this RCS pressure is reached). Using 1.0 is conservative (but not overly so) for PTS since if successful, get potential overcooling.	- - - (Consensus: 1.0)	**1.0 (success)** (Note: Failure of this action heads toward core damage, not PTS).
5	Operators fail to trip turbine manually if auto trip fails (in 15-30 seconds)	Applies to all events under all circumstances.	One of the "immediate actions" to verify/do per EP-1 regardless of event/scenario. Hence, an "auto rule" and observed as such in simulator observations. Training strongly oriented toward follow procedures. No identified strong EMs to not perform this action.	Either item 4 or item 5 EF= 5 - 10 (Consensus: 1E-3)	**1E-3 = mean** (95%, 5%) = 1E-2, 1E-4

Table 7.7. HFE results and analysis for Oconee PTS PRA: Full-Power.

HFE #	HFE	Condition When Applied	Dominant Considerations Most Affecting the HFE Estimate	Error Factor from NUREG/CR-1278, Table 7-2 and (Range of Experts' Estimates)	HRA Mean[1] and Uncertainty Values
6	Operators fail to throttle/trip MFW given it is overfeeding 1 or both SGs, before overfilling SG(s)	Case (a): Applies to all initiators where MFW can be overfeeding, but with no other serious anomalies with the other functions (no concurrent depressurization, SLOCA, etc.)	So little time. "Expected" response is MFW will auto trip on high SG level if not already dealt with manually per procedure. Must have ICS/control failure and failure of high SG level trip. Will assume no alarms given these failures (could likely fail alarm, too). So operator must notice rising SG levels, lowering Tavg, too much feed flow, etc. Early step in all procedures to check status of SG(s)/feed, etc.	Either item 5,7 or item 8 EF = 5-10 (Within 1 min, consensus: 1E-1; within 5 min, 1E-2 to 1E-3; within 15 min, consensus: 1E-3)	Case 6(a): Within ~1min: **0.1 = mean**; (95%, 5%) =0.5,1E-2 Within 5min: **1E-2 = mean**; (95%, 5%) = 1E-1, 1E-3 Within 15min: **1E-3 = mean**; (95%, 5%) = 1E-2, 1E-4
		Case (b): Like above except there is a concurrent functional problem (depressurization in another SG, SLOCA, etc.)	Same as above.	As above. (Within 1 min, consensus: 0.5; within 5 min, consensus: 1E-2; within 15 min, consensus: 1E-3)	Case 6(b): Within 1 min: **0.5= mean**; (95%, 5%) = 0.9, 0.1 Within 5 min: **1E-2 = mean**; (95%, 5%) = 1E-1, 1E-3 Within 15 min: **1E-3= mean**; (95%, 5%) = 1E-2, 1E-4

Table 7.7. HFE results and analysis for Oconee PTS PRA: Full-Power.

HFE #	HFE	Condition When Applied	Dominant Considerations Most Affecting the HFE Estimate	Error Factor from NUREG/CR-1278, Table 7-2 and (Range of Experts' Estimates)	HRA Mean[1] and Uncertainty Values
		Case (c): Initiator is a more complex support system failure like loss of air regardless of status of other functions	Same as above. Thought about a concurring instrument/bus problem but seemed would only affect 5min value (perhaps change to 0.1) and considering need to account for probability of problem, seems already captured in existing values.	As above. (Same as above)	Case 6(c): Same as above.
7	Operators fail to throttle EFW within the time frames noted after the start of overfeed, given MFW is gone and EFW is overfeeding 1 or both SG(s)	Applies to all initiators except the more complicating support system failure cases like loss of air, loss of cooling water, loss of offsite power- no other functional anomalies: Case (a): System will successfully respond if/when operator puts into manual and attempts to regain control of the feed	Proper feed control is an early, proceduralized verification to look for in EP-1 as observed in simulator events, with corresponding steps to throttle. Training strongly oriented toward follow procedures. Seems should notice rising SG level, continuing RCS temp drop, and multiple indicators of these parameters lessens likelihood of incorrect indications or missing indications of a potential secondary problem and signs of overcooling. Use of "BAGS" could catch error in later times, if not done yet. EFW verification/control is a well-practiced event. Per NRC TH, ~1000 sec (17min) or more is critical time; 10 and 30 min time frames bound this nicely.	Either item 5 or item 8 EF = 5-10 (Within 10 min, 1E-2 to 1E-3; within 30 min, consensus: 1E-3)	Case 7(a): Within 10 minutes: **1E-2 = mean** (95%, 5%) = 1E-1, 1E-3 (Duke Comment: Skew too high. Response: Until deemed important to results, will leave skew). Within 30 minutes: **1E-3 = mean** (95%, 5%) = 1E-2, 1E-4

Table 7.7. HFE results and analysis for Oconee PTS PRA: Full-Power.

HFE #	HFE	Condition When Applied	Dominant Considerations Most Affecting the HFE Estimate	Error Factor from NUREG/CR-1278, Table 7-2 and (Range of Experts' Estimates)	HRA Mean[1] and Uncertainty Values
		Case (b): Same as case (a) except manual control will not respond (e.g., control valve stuck-open) so eventually must choose to stop pump then restart; or perhaps isolate that SG.	Same as above. May spend a little more time than in case (a) trying to get a response from the system. Use of pump as an alternative, is directed by procedure, trained on, the controls are easily accessible, and the action is uncomplicated. This seems to make case (b) essentially the same as case (a) per consensus opinion.	As above. (Same as above)	Case 7(b): Within 10 minutes**:** **1E-2 = mean** (95%, 5%) = 1E-1, 1E-3 Within 30 minutes: **1E-3 = mean** (95%, 5%) = 1E-2, 1E-4 (Duke Comment: Should not be different from case (a)).
		Case (c): Same as case (a) except there is a concurrent other serious functional problem (e.g., SLOCA or depressurization in another SG)	Same as above. Workload/distraction issues would seem to make this less likely to be successful in the same time period. For example, discussions indicated "possible" focus on primary (RCS) concerns if there is a concurrent primary-secondary problem.	As above. (Within 10 min, consensus: 1E-1; within 30 min, consensus: 1E-3)	Case 7(c): Within 10 minutes: **1E-1 = mean**; (95%, 5%) = 0.5, 1E-2 Within 30 minutes: **1E-3= mean**; (95%, 5%) = 1E-2, 1E-4 (Duke Comment: Suggest 1E-2 (10min) and 1E-3 (30 min). Response: more comfortable with values shown).

Table 7.7. HFE results and analysis for Oconee PTS PRA: Full-Power.

HFE #	HFE	Condition When Applied	Dominant Considerations Most Affecting the HFE Estimate	Error Factor from NUREG/CR-1278, Table 7-2 and (Range of Experts' Estimates)	HRA Mean[1] and Uncertainty Values
		Case (d): Same as case (b) except there is a concurrent other serious functional problem (SLOCA, depressurization)	While there is some additional problems of non-response, for these timeframes, a significant difference in probabilities were not deemed appropriate from those in case (c). Seems case(d) should be similar to case (c) like (b) is to (a) - per consensus opinion.	As above. (Same as above)	Case 7(d): Within 10 minutes: **1E-1 = mean;** (95%, 5%) = 0.5, 1E-2 Within 30 minutes: **1E-3= mean**; (95%, 5%) = 1E-2, 1E-4
		Case (e): Involves a concurrent support system problem like loss of air, loss of CCW, LOSP, etc. regardless of actual status of other functions.	Additional complexities/distraction/ workload associated with support system initiators. However for timeframes of interest, seemed values should not be much different than latter cases above.	As above. (Same as above)	Case 7(e): Within 10 minutes: **1E-1 = mean** (95%, 5%) = 0.5, 1E-2 Within 30 minutes: **1E-3= mean** (95%, 5%) = 1E-2, 1E-4

Table 7.7. HFE results and analysis for Oconee PTS PRA: Full-Power.

HFE #	HFE	Condition When Applied	Dominant Considerations Most Affecting the HFE Estimate	Error Factor from NUREG/CR-1278, Table 7-2 and (Range of Experts' Estimates)	HRA Mean[1] and Uncertainty Values
8	Operators fail to trickle/throttle condensate into SG(s) (including proper control of SG pressures) when depressurized to use condensate into SGs (so it overfeeds and quickly refills SG(s))	All initiators/ conditions where use of condensate is possible, including support system problems.	Serious situation - lots of attention as this is a top priority remedy if enter EP-502. Procedure warnings call for worry about thermal shock to SG tubes as well, so talks about throttling. Per discussions, ICS doesn't control cond pumps, FW control valves probably in manual, and SG high level trip does not affect condensate pumps - so much a manual control action. Remember, also attending to HPI/throttling due to depressurization so a competing workload issue. No concern for water hammer unless no feed for >30min. Training shows tendency to err on side of under-feeding. Procedure/training: Not trying to restore SG level - bring feed in slowly - operators know about both overcooling and SG tube shock concerns.	Either item 5 or item 8 EF = 5-10 (Consensus: 1E-2)	**1E-2= mean**; (95%, 5%) = 1E-1, 1E-3 (Initial results modified based upon Duke's suggestion of 1E-2 to 1E-3 and new information from Duke.)

Table 7.7. HFE results and analysis for Oconee PTS PRA: Full-Power.

HFE #	HFE	Condition When Applied	Dominant Considerations Most Affecting the HFE Estimate	Error Factor from NUREG/CR-1278, Table 7-2 and (Range of Experts' Estimates)	HRA Mean[1] and Uncertainty Values
9	Operators fail to isolate a secondary depressurization event (regardless of whether it is a stuck-open TBVand they just close the TBV block valve, or some other fault like a steam line break and therefore isolate the whole SG including feed). The HRA participants saw little reason to distinguish between the two.	Applies to all initiators except the more complex support system initiators like loss of air, loss of CCW, LOSP, etc. Case (a): There is no other serious functional anomaly such as a SLOCA, overfeed in another SG, etc.	Number, location, and readability of SG pressure indications make depressurization easily discernable, as seen in simulator events. Isolation is in early procedure guidance in EP-503. Per discussions, if pressure drop is slow/partial, operators taught to err on side of isolation. Training strongly oriented toward follow procedures. Use of "BAGS" could catch error in later times, if not done yet. Takes only one action to isolate (close EFW control valve) unless verification checks show that an auto action failure requires multiple actions to completely isolate, as observed in simulator events. Simulated event - isolation occurred in ~1-2 min w/verification complete by 5 min. NRC TH runs show that time periods out to typically 4000-6000 sec (66-100min) are of interest with regard to final temps. (where rate of drop slows down considerably). TH runs also show that <~1000 sec typically still at/above 400F in RCS (even at low decay heat), so shortest time period of interest ~10 min.	Either item 5 or item 8 EF = 5-10 (Within 10 min, consensus: 1E-3)	Case 9(a): 10 minutes: **1E-3 = mean**; (95%, 5%) = 1E-2, 1E-4 (Initial results changed based upon Duke's suggestion of 1E-2 - 1E-3 with skew upper end at 1E-2 and new information.)

Table 7.7. HFE results and analysis for Oconee PTS PRA: Full-Power.

HFE #	HFE	Condition When Applied	Dominant Considerations Most Affecting the HFE Estimate	Error Factor from NUREG/CR-1278, Table 7-2 and (Range of Experts' Estimates)	HRA Mean[1] and Uncertainty Values
		Case (b): Same as case (a) except concurrent anomaly in other function (e.g., SLOCA or overfeed in another SG).	Same as above. Now more workload/distraction - could get focused on other anomaly especially if primary-RCS problem. Depressurization/cooling a focus for the crew. Unclear if anomaly/distractions will be significant or even recognized.	As above. (Within 10 min, consensus: 1E-2; within 20 min, consensus: 1E-3).	Case 9(b): 10 minutes: **1E-2= mean**; (95%, 5%) = 1E-1, 1E-3 20 minutes: **1E-3= mean;** (95%, 5%) = 1E-2, 1E-4 (Duke Comment: Should be same values as Case (a). Response: More comfortable with values shown).
		Case (c): Involves a concurrent support system problem like loss of air, loss of CCW, LOSP, etc. regardless of actual status of other functions.	Same as above. Additional complexities/distraction/ workload associated with support system initiators. Values based on 5 min - 10 min cases we considered and values already assigned in cases above. Depressurization/cooling a focus for the crew. Unclear anomaly/distractions will be significant or even recognized.	As above (Same as above)	Case 9(c): As case (b) above. (Duke Comment: Should be same values as Case (a). Response: More comfortable with values shown).
10	Operators isolate wrong SG	All initiators/situations	As discussed, operators would continue to see a depressurization in "bad" SG. Discussions with training- cannot remember ever seeing this occur in simulations. Could not find compelling reason this would happen; seems slip from THERP most appropriate.	Either items 4,5 or 8 EF = 5-10 (Consensus: 1E-3)	**1E-3 = mean**; (95%, 5%) = 1E-2, 1E-4

Table 7.7. HFE results and analysis for Oconee PTS PRA: Full-Power.

HFE #	HFE	Condition When Applied	Dominant Considerations Most Affecting the HFE Estimate	Error Factor from NUREG/CR-1278, Table 7-2 and (Range of Experts' Estimates)	HRA Mean[1] and Uncertainty Values
11	Operators fail to restore good SG and isolate bad SG if isolated wrong SG initially.	All initiators/situations	As discussed, would be a continued drop in secondary pressure and RCS temperatures; potential continued mismatch in SG pressures. As discussed, operators want to have a heat sink. Seems some time may go by before seeing they have not properly dealt with SG isolation needs. Nevertheless, 10 min (shortest time of interest) considered considerable time to rectify error.	Either items 5 or 8 EF = 5-10 (Consensus: 1E-2)	**1E-2 = mean**; (95%, 5%) = 1E-1, 1E-3 (Initial results changed based upon Duke's suggestion of 1E-2 and new information from Duke).

Table 7.7. HFE results and analysis for Oconee PTS PRA: Full-Power.

HFE #	HFE	Condition When Applied	Dominant Considerations Most Affecting the HFE Estimate	Error Factor from NUREG/CR-1278, Table 7-2 and (Range of Experts' Estimates)	HRA Mean[1] and Uncertainty Values
12	Operators fail to close PORV/its block valve upon stuck-open PORV	Applies to all initiators/ situations.	As discussed, operators will show awareness of situation and probably be looking for reason HPI started. May need to "find" acoustical/quench tank etc. alarms among many alarms; but not too hard to find. May be harder if valve had been cycling. Subcooling not necessarily lost so may not enter EP-501, so for example, could decide there has just been an overcooling event. If enter EP-501, one of 1st steps is to isolate PORV path. Trained toward tendency to follow procedures. Isolable LOCAs and very small LOCAs not trained on much. TH runs show that time periods <10min not critical to cooling	Either item 5 or item 8 EF = 5-10 (1E-2 to 1E-3)	Case 12(a): 10 minutes: **1E-2 = mean**; (95%, 5%) = 1E-1, 1E-3 (Initial results changed based upon Duke's suggestion of 1E-2 and new information).
		Agreed Case (b) (same as above except HPI not yet throttled) could be dropped (not important in $\geq$10 min).			

Table 7.7. HFE results and analysis for Oconee PTS PRA: Full-Power.

HFE #	HFE	Condition When Applied	Dominant Considerations Most Affecting the HFE Estimate	Error Factor from NUREG/CR-1278, Table 7-2 and (Range of Experts' Estimates)	HRA Mean[1] and Uncertainty Values
13	Operators fail to successfully align/use alternate EFW from other unit (assumed will use with success = 1.0 if plenty of time); this is for case where time is of the essence such as condensate feed and F&B have both failed.	All initiators/situations	Probabilities more reflect potential for difficulties that may arise, etc. as discussed with staff. Procedures/training call for want/need of some feed and yet rather not use aux SW (lake water). Takes about 10 - 15 min to line up/initiate under "ideal" conditions per discussions. Other staff will likely be working on other options. There are regular, timed exercises.	Most likely item 8 EF = 10 (Within 15 min, consensus: 1E-1; within 30 min, consensus: 1E-3)	15 minutes**:** **1E-1 = mean;** (95%, 5%) = 0.9, 1E-2 (time may be minimal) (Duke: Suggested 1E-2 and provided additional information but more comfortable with shown estimate). 30 minutes: **1E-3 = mean**; (95%, 5%) = 1E-2, 1E-4

Table 7.7. HFE results and analysis for Oconee PTS PRA: Full-Power.

HFE #	HFE	Condition When Applied	Dominant Considerations Most Affecting the HFE Estimate	Error Factor from NUREG/CR-1278, Table 7-2 and (Range of Experts' Estimates)	HRA Mean[1] and Uncertainty Values
14	Operators fail to control cooldown during SGTR and thus, lose subcooling	SGTR type event	One of the most practiced events at Oconee. Crew usually less aggressive than stated 100F/hr cooldown rate (i.e., usually go slower); and, as temp's lower, cooldown rate harder to maintain. Usually use TBVs with less cooldown capability than ADVs. Need to account for low margin between desired subcooling (5-15F) and 0F subcooling. Consider possible slips in manual control of pressurizer spray, TBVs; in reading displays; and possible instrument errors, etc.	Either item 5 or item 8 EF = 5-10 (Agreed upon estimate and range as shown)	**0.1=mean**; (95%, 5%) = 0.5, 1E-2 (Duke Comment: Should value be different? Response: stayed with this value).

Table 7.7. HFE results and analysis for Oconee PTS PRA: Full-Power.

HFE #	HFE	Condition When Applied	Dominant Considerations Most Affecting the HFE Estimate	Error Factor from NUREG/CR-1278, Table 7-2 and (Range of Experts' Estimates)	HRA Mean[1] and Uncertainty Values
15	Operators fail to throttle HPI to maintain pressure in TSOR/ allowable P-T range when it is required to do so (essentially between 5F-100F subcooling when temp<500F)	(a) Regardless of initiator, HPI injection has occurred (such as in SLOCA) or loss of subcooling is only anomaly (no other significant problems with SG feed, depressurization)	Proceduralized -can follow P/T curves when $\geq$ 5F. Warnings/cautions-throttle HPI in procedures. Training strong toward follow procedures. But also want to first reach >80" PZR to at least cover heaters, and more likely want to get to 100" or higher based on discussions with & observations of operators in simulator events. May need to do some calculations to ensure proper level readings if adverse containment environment - takes time. Need to reset logic first to be able to throttle system - takes a little time as observed in simulator events (~2-3min minimum). Short time response (few minutes, especially if wait for PZR level recovery, etc. besides 5F subcooling), as this can make potentially big difference in final pressure. Any other distractions/nuisances could seemingly delay response somewhat. Use of "BAGS" could catch error in later times, if not done yet. NRC TH: 1st 500-750sec after HPI start typically most important time.	Either item 5 or item 8 EF = 5-10 (Within 10 min, 1E-1 to 1E-2; within 20 min, consensus: 1E-3 because of new cues like pressure higher than desirable or PORV lifting)	Case 15(a) Within 10min after start of HPI: **1E-1= mean** (95%,5%)= 0.5,1E-2 Within 20 min after start of HPI: **1E-3= mean** (95%,5%)= 1E-2, 1E-4

Table 7.7. HFE results and analysis for Oconee PTS PRA: Full-Power.

HFE #	HFE	Condition When Applied	Dominant Considerations Most Affecting the HFE Estimate	Error Factor from NUREG/CR-1278, Table 7-2 and (Range of Experts' Estimates)	HRA Mean[1] and Uncertainty Values
		(b) Like (a) above except there is also a concurrent secondary anomaly such as a problem with SG feed in one or both SGs (over or under feed) or a problem with secondary pressure (like a depressurization)	Same as above. Discussions indicated "possible" focus on primary (RCS) concerns if there is a concurrent secondary problem as well as "possibility" of confusion as to whether there is only a secondary problem - so focus could be on secondary. Seems need to consider concurrent secondary problem as a distraction/additional concern which may make attentiveness to HPI throttling slightly delayed.	As above. (Same as above for these timeperiods).	Case 15(b) like case 15(a): Within 10min after start of HPI: **1E-1= mean** (95%,5%)= 0.5,1E-2 Within 20 min after start of HPI: **1E-3= mean** (95%,5%)= 1E-2, 1E-4 **NOTE: values changed later during detailed quantification for specific cases when feed to SG(s) has not been successfully isolated- see those results.**

Table 7.7. HFE results and analysis for Oconee PTS PRA: Full-Power.

HFE #	HFE	Condition When Applied	Dominant Considerations Most Affecting the HFE Estimate	Error Factor from NUREG/CR-1278, Table 7-2 and (Range of Experts' Estimates)	HRA Mean[1] and Uncertainty Values
		(c) Special case where HPI is needed (LOCA, PORV open, shrinkage, etc.) and there is insufficient flow. Operator then tries to depressurize using the TBVs (PORV and head vents only if necessary) to get to CFT/LPI and on the way down, sufficient HPI recovered; then fails to throttle once ≥5F subcooling. * The .9-.1 split of whether operator puts switches in manual: see THERP pg 16-6 estimate of 0.01 of failure to follow a common policy but raised by a factor of 10 to account for application of such an error in a very dynamic/high stress situation.	Same as above. CP-602 or if necessary, EP-507, if entered, clearly call for depressurization as described. Discussions indicated that operators may likely put HPI into manual to avoid an unexpected and sudden restart. Case (c)(1): Switches in manual: With required manual restart of HPI, seems operators will be more focused on its use and its effects as level/pressure get restored. Case (c)(2): Switches in auto: With potential auto restart and additional workload/stress situation, seems somewhat similar to, but maybe more likely to make error than case (a) above. Assumed "surprise" restart for evaluation.	Either item 5 or item 8 EF = 5 - 10 (Case (c)(1): within 10 min, consensus: 1E-2; within 20 min, consensus: 1E-3; Case (c)(2): within 10 min, consensus: 1E-1; within 20 min, consensus: 1E-3)	Case 15(c)(1): Within 10min after start of HPI: **1E-2= mean**; (95%,5%) = 1E-1, 1E-3 Within 20 min after start of HPI: **1E-3= mean**; (95%,5%)= 1E-2, 1E-4 Case 15(c)(2): Within 10min after start of HPI: **1E-1=mean**; (95%,5%) =0.5,1E-2 Within 20 min after start of HPI: **1E-3= mean**;(95%,5%) =1E-2, 1E-4

Table 7.7. HFE results and analysis for Oconee PTS PRA: Full-Power.

HFE #	HFE	Condition When Applied	Dominant Considerations Most Affecting the HFE Estimate	Error Factor from NUREG/CR-1278, Table 7-2 and (Range of Experts' Estimates)	HRA Mean[1] and Uncertainty Values
		(d) Case where throttling not controlled after a LOCA re-isolates (i.e., re-pressurization event)	See 15(a) above. Depending on whether repressurization is expected or unexpected, and based on the very short time to catch a subsequent pressure rise (such as reclosure of a SRV), this could be difficult to avoid at least some level of repressurization especially if surprised. Case (d)(1): an unexpected reclosure (surprise). Case (d)(2): expected reclosure (e.g., purposeful closure of PORV block valve)	Either item 5 or item 8 EF = 5 - 10 (For Case 15d(1), same as case 15(c)(2); For Case 15d(2), same as case 15(c)(1))	For case15 (d)(1): Within 10min after start of HPI: **1E-1=mean**; (95%,5%) =0.5,1E-2 Within 20 min after start of HPI: **1E-3= mean**;(95%,5%) =1E-2, 1E-4 **NOTE: values changed later during detailed quantification - used a 1 min and 10 min case - see those results** For case 15(d)(2): Within 10min after start of HPI: **1E-2= mean**; (95%,5%) = 1E-1, 1E-3 Within 20 min after start of HPI: **1E-3= mean**; (95%,5%)= 1E-2, 1E-4

Table 7.7. HFE results and analysis for Oconee PTS PRA: Full-Power.

HFE #	HFE	Condition When Applied	Dominant Considerations Most Affecting the HFE Estimate	Error Factor from NUREG/CR-1278, Table 7-2 and (Range of Experts' Estimates)	HRA Mean[1] and Uncertainty Values
		(e) Case where HPI throttling and/or feed to SG(s) not controlled transferring from F&B back to SG cooling (potential late re-pressurization and/or late cooling)	A planned event. Should calculate ahead of time ~amount of feed needed to match heat removal needs. Operators train on this recovery and aware of re-pressurization as well as under/over-cooling concerns. Will hold a discussion before crew does it, to go over expectations. Crew should be very focused. Close PORV, throttling HPI, feed SG(s) virtually simultaneously. May be hard to match conditions at first as transfer from F&B cooling to SG cooling begins. Momentary mismatch/problems seem possible. Recovery seems likely. Assumed, for our evaluation, that throttling must begin just before closing PORV to get to desired PZR level range as close PORV	Either item 5 or item 8 EF = 5 - 10. (For first ~2min, consensus: as high as 1E-1; for beyond ~2min, consensus: 1E-3)	Case 15(e): For first ~2min from start of transfer from F&B to SG cooling: **1E-1= mean**; (95%,5%)=0.5,1E-2 Beyond ~2min: **1E-3= mean**; (95%,5%)=1E-2, 1E-4

[1] When mean values and associated 95th and 5th percentiles are provided, these values are intended to represent a skewed (e.g., lognormal) distribution.

Table 7.8. HFE results and analysis for Oconee PTS PRA: Low Power.

HFE #	HFE	Condition When Applied	HRA Mean[1] and Uncertainty for Full Power	HRA Mean[1] and Uncertainty for Low Power	Notes/Basis for Low Power Estimates
1	Operators fail to trip RCPs quickly (~1 min) when suppose to (i.e., after subcooling is lost (O^0F))	Applies for all events under all circumstances	**1E-2 = mean** (95%, 5%) = 1E-1, 1E-3	**1E-1 = mean** (95%,5%) = 0.5, 1E-2	Since a plant condition might be more likely present at low power that could hinder correct diagnosis, we will simply assume an order of magnitude higher.
2	Operators trip RCPs when not required	Applies for all events under all circumstances except when there is an instrument problem and one instrument reads 0F incorrectly	**1E-3 = mean** (95%, 5%) = 1E-2, 1E-4	**1E-2 = mean** (95%,5%)= 0.1, 1E-3	Since a plant condition might be more likely present at low power that could hinder correct diagnosis, we will simply assume an order of magnitude higher.
		With an instrument problem	Conditional on instrument problem: **1E-1 = mean** (95%, 5%) = 0.5, 1E-2	Conditional on instrument problem : **1E-1 = mean** (95%,5%) = 0.5, 1E-2	Value seems already high enough.
3	Operators fail to restart RCPs when supposed to (primarily 50F subcooling but other criteria, too)	Applies for all events under all circumstances	**0.5 = mean** (95%, 5%) = 0.9, 0.1	**0.5 = mean** (95%,5%) = 0.9, 0.1	For high power, it was argued this event was relatively independent of event/scenario (because it occurs so late in the scenario when things are being cleaned up). That notion would still seem to apply, so don't see a strong reason to change estimate. Besides, value already quite high.

Table 7.8. HFE results and analysis for Oconee PTS PRA: Low Power.

HFE #	HFE	Condition When Applied	HRA Mean[1] and Uncertainty for Full Power	HRA Mean[1] and Uncertainty for Low Power	Notes/Basis for Low Power Estimates
4	Operators successfully go to F&B when supposed to (key is 2300 psig in RCS) or successfully depress/cool to use condensate or to get to CFTs/LPI if necessary	Applies to all events under all conditions when these actions become necessary.	**1.0 (success)**	**1.0 (success)**	1.0 is the most conservative case from a PTS perspective and as this is a success, should be near 1.0 anyway - so use same value.
5	Operators fail to trip turbine manually if auto trip fails (in 15-30 seconds)	Applies to all events under all circumstances.	**1E-3 = mean** (95%,5%) = 1E-2, 1E-4	**1E-3 = mean** (95%,5%) = 1E-2, 1E-4	For high power, it was argued this is an “immediate” action to be verified/do regardless of event (almost automatic). Difficult to see why response would differ for any reason, following a trip signal. Need for turbine trip is paramount when signs of a reactor trip occur, regardless of power level.
6	Operators fail to throttle/trip MFW given it is overfeeding 1 or both SGs, before overfilling SG(s)	Case (a): Applies to all initiators where MFW can be overfeeding, but with no other serious anomalies with the other functions (e.g., no concurrent depressurization, SLOCA)	Within ~1min: **0.1 = mean** (95%, 5%) =0.5, 1E-2 Within 5min: **1E-2 = mean** (95%,5%) = 1E-1, 1E-3 Within 15min: **1E-3 = mean** (95%, 5%) = 1E-2, 1E-4	Within ~1min: **0.1 = mean** (95%, 5%) =0.5, 1E-2 Within 5min: **1E-2 = mean** (95%,5%) = 1E-1, 1E-3 Within 15min: **1E-3 = mean** (95%, 5%) = 1E-2, 1E-4	Values already seem high enough for time periods - go with same estimates.

Table 7.8. HFE results and analysis for Oconee PTS PRA: Low Power.

HFE #	HFE	Condition When Applied	HRA Mean[1] and Uncertainty for Full Power	HRA Mean[1] and Uncertainty for Low Power	Notes/Basis for Low Power Estimates
		Case (b): Like above except there is a concurrent functional problem (e.g., depressurization in another SG, SLOCA)	Within 1 min: **0.5= mean** (95%,5%) = 0.9, 0.1 Within 5 min: **1E-2 = mean** (95%, 5%) = 1E-1, 1E-3 Within 15 min: **1E-3= mean** (95%,5%)= 1E-2, 1E-4	Within 1 min: **0.5= mean** (95%,5%) = 0.9, 0.1 Within 5 min: **1E-2 = mean** (95%, 5%) = 1E-1, 1E-3 Within 15 min: **1E-3= mean** (95%,5%)= 1E-2, 1E-4	Values already seem high enough for time periods - go with same estimates.
		Case (c): Initiator is a more complex support system failure (e.g., loss of air) regardless of status of other functions	Same as above.	As above.	As above.

Table 7.8. HFE results and analysis for Oconee PTS PRA: Low Power.

HFE #	HFE	Condition When Applied	HRA Mean[1] and Uncertainty for Full Power	HRA Mean[1] and Uncertainty for Low Power	Notes/Basis for Low Power Estimates
7	Operators fail to throttle EFW within the time frames noted, given MFW is gone and EFW is overfeeding 1 or both SG(s)	Applies to all initiators except the more complicating support system failure cases (e.g., loss of air, loss of cooling water, loss of offsite power) - no other functional anomalies. Case (a): System will successfully respond if/when operator puts into manual and attempts to regain control of the feed	Within 10 min: **1E-2 = mean** (95%,5%) = 1E-1, 1E-3 Within 30 min: **1E-3 = mean** (95%,5%) = 1E-2, 1E-4	Within 10 min: **5E-2 = mean** (95%,5%)=0.5, 5E-3 Within 30 min: **1E-2 = mean** (95%,5%)= 0.1, 1E-3	If EFW starts due to some disruption at low power, procedure guidance and warnings in procedures to throttle still apply. Concern is could there be more likely instrumentation conditions that could add confusion as to the feed flowrate and/or SG levels, or could there be something going on in the plant at low power that can be used by the crew as an incorrect explanation why throttling is not yet necessary? Even if assumed the error rate should go up to 0.5 for 10 min and 1E-1 for 30 min, we need to multiply by the likelihood of the low power condition or instrumentation problem (let's assume 10% chance for such a plant condition). Therefore, end up with 5E-2 for 10 min and 1E-2 for 30 min. Probably conservative.
		Case (b): Same as case (a) except manual control will not respond (e.g., control valve stuck-open) so eventually must choose to stop pump/ then restart; or perhaps isolate that SG.	10 min: **1E-2 = mean** (95%, 5%) = 1E-1, 1E-3 30 min: **1E-3 = mean** (95%, 5%) = 1E-2, 1E-4	Same as above	Same as above

Table 7.8. HFE results and analysis for Oconee PTS PRA: Low Power.

HFE #	HFE	Condition When Applied	HRA Mean[1] and Uncertainty for Full Power	HRA Mean[1] and Uncertainty for Low Power	Notes/Basis for Low Power Estimates
		Case (c): Same as case (a) except there is a concurrent other serious functional problem (e.g., SLOCA, depressurization in another SG)	10 min: **1E-1 = mean** (95%,5%) = 0.5, 1E-2 30 min: **1E-3= mean** (95%,5%) = 1E-2, 1E-4	Within 10 min: **1E-1 = mean** (95%,5%) = 0.5, 1E-2 Within 30 min: **1E-2 = mean** (95%,5%) = 0.1, 1E-3	Based on the thought process above, even assuming a 10% chance of such a condition and even a 1.0 error rate, value cannot be higher than 0.1. 30 min seems long enough to overcome any short-term confusion or misdiagnosis.
		Case (d): Same as case (b) except there is a concurrent other serious functional problem (SLOCA, depressurization)	10 min: **1E-1 = mean** (95%,5%) = 0.5, 1E-2 30 min: **1E-3= mean** (95%,5%) = 1E-2, 1E-4	As above for case (c).	As above.
		Case (e): Involves a concurrent support system problem (e.g., loss of air, loss of CCW, LOSP) regardless of actual status of other functions.	10 min: **1E-1 = mean** (95%,5%) = 0.5, 1E-2 30 min **1E-3= mean** (95%,5%) = 1E-2, 1E-4	As above for case (c).	As above.

Table 7.8. HFE results and analysis for Oconee PTS PRA: Low Power.

HFE #	HFE	Condition When Applied	HRA Mean[1] and Uncertainty for Full Power	HRA Mean[1] and Uncertainty for Low Power	Notes/Basis for Low Power Estimates
8	Operators fail to trickle/throttle condensate into SG(s) when depressurized to use condensate into SGs (so it overfeeds and quickly refills SG(s))	All initiators/conditions where use of condensate is possible, including support system problems.	**1E-2= mean** (95%,5%)= 1E-1, 1E-3	**1E-2= mean** (95%,5%)=1E-1,1E-3	This action would only occur in a dire loss of heat sink situation and it seems if crew has decided to do this, their subsequent response in controlling condensate feed should be about the same. Even if a shutdown condition could alter the response, its probability has to be accounted for and the point estimate is already 1E-2 for high power. Recommend same values.
9	Operators fail to isolate a secondary depressurization event	Applies to all initiators except the more complex support system initiators (e.g., loss of air, loss of CCW, LOSP) Case (a): There is no other serious functional anomaly (e.g., SLOCA, overfeed in another SG)	10 min: **1E-3 = mean** (95%,5%)= 1E-2,1E-4	10 min: **1E-2 = mean** (95%,5%)=1E-1,1E-3 20 min: **1E-3 = mean** (95%,5%)=1E-2,1E-4	Assuming a 10% chance of a shutdown plant condition or work-around that could explain why a secondary depressurization appears to be happening; and an assumed 1E-1 failure probability at 10 min and a 1E-2 at 20 min due to the possibility of sticking with a wrong diagnosis or explanation for the apparent conditions; multiplying these values together provides the values show.
		Case (b): Same as case (a) except concurrent anomaly in other function (e.g., SLOCA, overfeed in another SG)	10 min: **1E-2= mean** (95%,5%)= 1E-1,1E-3 20 min: **1E-3= mean** (95%,5%)= 1E-2,1E-4	10 min: **5E-2 = mean** (95%,5%)=1E-1,5E-3 20 min: **5E-3 = mean** (95%,5%)=1E-2,5E-4	Will simply go with a factor of 5 higher to capture any potential effects of a more complex scenario while at low power.

Table 7.8. HFE results and analysis for Oconee PTS PRA: Low Power.

HFE #	HFE	Condition When Applied	HRA Mean[1] and Uncertainty for Full Power	HRA Mean[1] and Uncertainty for Low Power	Notes/Basis for Low Power Estimates
		Case (c): Involves a concurrent support system problem (e.g., loss of air, loss of CCW, LOSP) regardless of actual status of other functions.	As case (b) above	As above: 10 min: **5E-2 = mean** (95%,5%)=1E-1,5E-3 20 min: **5E-3 = mean** (95%,5%)=1E-2,5E-4	As above.
10	Operators isolate wrong SG	All initiators/situations	**1E-3 = mean** (95%,5%)= 1E-2,1E-4	**1E-2 = mean** (95%,5%)=1E-1,1E-3	Since a plant condition might be more likely present at low power that could hinder correct diagnosis, will simply assume an order of magnitude higher.
11	Operators fail to restore good SG and isolate bad SG if isolated wrong SG initially.	All initiators/situations	**1E-2 = mean** (95%,5%)= 1E-1,1E-3	Use values to left. **1E-2 = mean** (95%,5%)= 1E-1,1E-3	Like above, but values already somewhat high, so just go with same values.
12	Operators fail to close PORV/its block valve upon stuck-open PORV	Applies to all initiators/ situations.	10 min: **1E-2 = mean** (95%,5%)= 1E-1,1E-3	Use values to left. 10 min: **1E-2 = mean** (95%,5%)= 1E-1,1E-3	Assuming a 10% chance of a plant condition at low power that might incorrectly explain what the crew is seeing such that the 10 min case error rate is assumed as 1E-1, get same values for 10 min case anyway.
		Agreed this case could be dropped (not important in ≥10 min.	Eliminated	Eliminated	

Table 7.8. HFE results and analysis for Oconee PTS PRA: Low Power.

HFE #	HFE	Condition When Applied	HRA Mean[1] and Uncertainty for Full Power	HRA Mean[1] and Uncertainty for Low Power	Notes/Basis for Low Power Estimates
13	Operators fail to successfully align/use alternate EFW from other unit	All initiators/situations	15 min: **1E-1 = mean** (95%,5%)= 0.9,1E-2 (time may be minimal) 30 min: **1E-3 = mean** (95%,5%)= 1E-2,1E-4	Use values to left. 15 min: **1E-1 = mean** (95%,5%)= 0.9,1E-2 30 min: **1E-3 = mean** (95%,5%)=1E-2,1E-4	This is only done if crew thinks (even at low power) all SG feed is lost and F&B is also failed. Values are more representative of HRA analysts' belief about whether alignment can physically be completed in the time periods shown - this is not a situation assessment issue. So even at low power, seems same values should apply.
14	Operators fail to control cooldown during SGTR and thus, lose subcooling	SGTR type event	**0.1=mean** (95%,5%)= 0.5,1E-2	Use values to left. **0.1=mean** (95%,5%)= 0.5,1E-2	Value for high power already relatively high, and thus simply use same value and uncertainties for low power.
15	Operators fail to throttle HPI to maintain pressure in TSOR/ allowable P-T range when it is required to do so (essentially between 5F-100F subcooling when temp<500F)	(a) Regardless of initiator, HPI injection has occurred (e.g., SLOCA) or loss of subcooling is only anomaly (e.g., no other significant problems with SG feed or depressurization)	Within 10min after start of HPI: **1E-1= mean** (95%,5%)= 0.5,1E-2 Within 20 min after start of HPI: **1E-3= mean** (95%,5%)= 1E-2, 1E-4	1min case eliminated. Within 10min after start of HPI: Use values to left **1E-1= mean** (95%,5%)= 0.5, 1E-2 Within 20 min after start of HPI: **5E-3= mean** (95%,5%)=5E-2,5E-4	If HPI starts due to some disruption at low power, procedure guidance and warnings to throttle still apply. Concern is could there be more likely instrumentation condition or other activities during shutdown that might inaccurately explain why the crew believes subcooling is not >5F. Even if assumed error should go to 0.5 for 10 min case, we need to multiply by the likelihood of the low power condition or instrument. problem. Therefore, just stay with same value for 10 min but will increase by factor of 5 for 20 min evaluation to account for any persistence in wrong diagnosis or confusion.

Table 7.8. HFE results and analysis for Oconee PTS PRA: Low Power.

HFE #	HFE	Condition When Applied	HRA Mean[1] and Uncertainty for Full Power	HRA Mean[1] and Uncertainty for Low Power	Notes/Basis for Low Power Estimates
		(b) Like (a) above except there is also a concurrent secondary anomaly such as a problem with SG feed in one or both SGs (over or under feed) or a problem with secondary pressure (e.g., depressurization.)	Within 10min after HPI start: **1E-1= mean** (95%,5%)= 0.5, 1E-2 Within 20min after HPI start: **1E-3= mean** (95%,5%)= 1E-2,1E-4	Same as above values. Within 10min after HPI start: **1E-1= mean** (95%,5%)= 0.5, 1E-2 Within 20min after HPI start: **5E-3= mean** (95%,5%)=5E-2,5E-4	Same as above.

Table 7.8. HFE results and analysis for Oconee PTS PRA: Low Power.

HFE #	HFE	Condition When Applied	HRA Mean[1] and Uncertainty for Full Power	HRA Mean[1] and Uncertainty for Low Power	Notes/Basis for Low Power Estimates
		(c) Special case where HPI is needed (LOCA, PORV open, shrinkage, etc.) and there is insufficient flow. Operator then tries to depressurize using the TBVs (PORV and head vents only if necessary) to get to CFT/LPI and on the way down, sufficient HPI recovered; then fails to throttle once ≥5F subcooling. * The .9-.1 split of whether operator puts switches in manual: see THERP pg 16-6 estimate of 0.01 of failure to follow a common policy but raised by a factor of 10 to account for application of such an error in a very dynamic/high stress situation.	Case (c)(1): Within 10min after start of HPI: **1E-2= mean** (95%,5%)= 1E-1,1E-3 Within 20 min after start of HPI: **1E-3= mean** (95%,5%)= 1E-2, 1E-4 Case (c)(2): Within 10min after start of HPI,: **1E-1= mean** (95%,5%)= 0.5,1E-2 Within 20 min after start of HPI: **1E-3= mean** (95%,5%)= 1E-2,1E-4	Case (c)(1): Within 10min after start of HPI: **5E-2= mean** (95%,5%)=1E-1,5E-3 Within 20 min after start of HPI: **5E-3= mean** (95%,5%)=5E-2,5E-4 Case (c)(2): Within 10min after start of HPI: **1E-1= mean** (95%,5%)= 0.5, 1E-2 Within 20 min after start of HPI: **5E-3= mean** (95%,5%)=5E-2,5E-4	As above; but will use 5 multiplier on mean for both times except (c)(2) 10 min case seems already high enough, considering uncertainty band.

Table 7.8. HFE results and analysis for Oconee PTS PRA: Low Power.

HFE #	HFE	Condition When Applied	HRA Mean[1] and Uncertainty for Full Power	HRA Mean[1] and Uncertainty for Low Power	Notes/Basis for Low Power Estimates
		(d) Case where throttling not controlled after a LOCA re-isolates (i.e., re-pressurization event)	For case (d)(1): an unexpected (surprise) closure - - Within 10min after start of HPI: **1E-1=mean**; (95%,5%) =0.5,1E-2 Within 20 min after start of HPI: **1E-3= mean**;(95%,5%) =1E-2, 1E-4 For case (d)(2): an expected closure - - Within 10min after start of HPI: **1E-2= mean**; (95%,5%) = 1E-1, 1E-3 Within 20 min after start of HPI: **1E-3= mean**; (95%,5%)= 1E-2, 1E-4	Case (d)(1): Within 10min after start of HPI: **1E-1= mean** (95%,5%)= 0.5, 1E-2 Within 20 min after start of HPI: **5E-3= mean** (95%,5%)=5E-2,5E-4 Case (d)(2): Within 10min after start of HPI: **5E-2= mean** (95%,5%)=1E-1,5E-3 Within 20 min after start of HPI: **5E-3= mean** (95%,5%)=5E-2,5E-4	As above.

Table 7.8. HFE results and analysis for Oconee PTS PRA: Low Power.

HFE #	HFE	Condition When Applied	HRA Mean[1] and Uncertainty for Full Power	HRA Mean[1] and Uncertainty for Low Power	Notes/Basis for Low Power Estimates
		(e) Case where HPI throttling and/or feed to SG(s) not controlled transferring from F&B back to SG cooling (potential late re-pressurization and/or late cooling)	For first ~2min from start of transfer from F&B to SG cooling: **1E-1= mean** (95%,5%)= 0.5, 1E-2 Beyond ~2min: **1E-3= mean** (95%,5%)= 1E-2, 1E-4	Same as at left. For first ~2min from start of transfer from F&B to SG cooling: **1E-1= mean** (95%,5%)= 0.5, 1E-2 Beyond ~2min: **1E-3= mean** (95%,5%)= 1E-2, 1E-4	Regardless of initial power conditions, operators will be performing same actions with same focus during such a transfer. No unique conditions identified. Use same values.

[1] When mean values and associated 95th and 5th percentiles are provided, these values are intended to represent a skewed (e.g., lognormal) distribution.

- the recommended error factor from NUREG/CR-1278, Table 7-2, as well as the range of the expert elicitation estimates for the HFE

- the mean human failure probability passed on for inclusion in the PTS PRA model

- estimated 95th and 5th percentiles of a skewed (lognormal) distribution passed on for inclusion in the PTS PRA model

- comments from Duke Power and responses from the HRA team.

In some cases, HRA results are given for multiple times. These results were developed in anticipation of the needs of the overall PTS PRA study and while most times were based on earlier work and selected before much of the updated TH and fracture mechanics calculations were available, few adjustments had to be made in finalizing the HRA effort.

It should be noted that the point estimate values given in Table 7.7 are considered to "tend" toward conservative estimates. Also, the uncertainty estimates are "rough" estimates about the point estimates (used as means) and are thought to reasonably approximate the degree of uncertainty (although they are biased toward the conservative end). Particularly, where different values have been estimated for different times, the analysis has considered "recovery" by the operators due to prolonged conditions and/or cues of the need to take the action as well as new cues that the action still needs to be taken. So "recovery" has already been accounted for in the HRA. Finally, and as explained earlier, it should be noted that the analysts tried to account for dependencies among functions and/or human errors and the effect on multiple human error probabilities in the same scenario in their estimates (e.g., if more than one function has anomalies, generally higher values are used, but crediting the actions of at least 2 or more operators).

7.2.1.2 HFEs for Low Power (i.e., Hot Zero Power) Conditions

To perform the HRA for low power conditions, information was collected to understand possible differences between Oconee full-power and low power operations. Then, the HRA results for the full power conditions were modified to reflect PTS-relevant differences between full- and low-power conditions. Consequently, the HRA analysis for low power conditions can be considered a "deviation analysis" from the full power results provided above.

Table 7.8 summarizes the HRA input to the Oconee PTS PRA with regard to relevant HFEs during low power operation (i.e., turbine is not yet on line and the reactor is either subcritical or at very low power).

The resulting HFEs and their quantification are based largely on questions and answers exchanged between the NRC contractors and the Oconee staff. From those questions and answers, primarily what was learned was:

1. crew response to adverse plant conditions (e.g., overcooling) should be generally the same at low power as at high power since the same procedures and training are used;

2. Oconee's new Integrated Control System (ICS) allows for automatic operation at very low power level (~2%), which further lessens the differences between full and low power conditions including the potential for inappropriate human actions that may otherwise induce or exacerbate overcooling during low power operation;

3. it is possible that plant circumstances (conditions) could exist while at low power (e.g., continue low power operation with instrument deficiencies or other workarounds not normally experienced at high power) that could explain (incorrectly) what the crew is seeing, and so some higher likelihood of error was judged to be possible (e.g., explaining rising sump level incorrectly on washing actions taking place in the containment during a shutdown Oconee event).

Based on these summary observations and the specific bases noted in Table 7.8, the HFEs and their quantification for low power operation were estimated. The uncertainty estimates are based on similar values used for the high power uncertainty analysis.

7.2.2 Results of Detailed Quantification of Important HFEs

As the PTS PRA model was solved and quantified, it became apparent that certain HFEs were particularly important to the Oconee results since they appeared among the most dominant PTS-risk scenarios. The analysis of these HFEs was re-visited to lessen the conservative bias of the initial quantification and to provide the most realistic estimate for the failure probabilities associated with these HFEs. The process followed to perform the detailed quantification has been described in Section 7.1.7.2 above. The HFEs requiring detailed analysis have also been delineated in Section 7.1.7.2. The following text documents the revised, detailed quantification of these most important HFEs and the primary bases for the estimated failure probabilities and uncertainties (expressed as histograms described by the following percentiles of the probability distribution: 1st, 10th, 25th, 50th (median), 75th, 90th, and 99th).

HFE

Failure to throttle HPI and otherwise control RCS pressure within allowable limits (e.g., within the TSOR or allowable pressure-temperature limits) within 10 minutes after the allowable throttling criteria of 5F subcooling is reached in the scenario involving a sudden reclosure of a pressurizer safety relief valve (SRV) that has been opened for a long time (taken as a representative 6000 seconds in the PRA model) since the initial reactor trip and start of the overcooling event.

General Context

In the scenarios of interest, a primary safety relief valve (SRV) has stuck open (it's been open for a significant period of time), resulting in a small LOCA (SLOCA, ~2.5 in. break). The crew has stabilized the SLOCA. HPI is working and is "on full." Given the assumed TH characteristics of the scenario so far, significant cooling has occurred in the downcomer region which could be in the 250F range. The issue of concern is what happens if the SRV suddenly closes. When the SRV closes under these conditions, primary pressure will go from ~ 300 psi, back up to the PORV setpoint in about 10 minutes. The operating crew must eventually throttle HPI and take other measures (e.g., use pressurizer sprays) to control RCS pressure to avoid a full repressurization, once the throttling criteria are met.

Procedures instruct that the crew can throttle HPI when 5F subcooling is reached. The crew would have approximately 10 minutes before 5F subcooling would be reached following the SRV reclosure, and during this time they would have the opportunity to observe that RCS pressure has risen and that pressurizer level had reached or gone over 100 inches (preferred level in the pressurizer). The latter indications would support the need to throttle HPI and otherwise regain control of RCS pressure. Around the point at which 5F subcooling is reached (approximately 10 minutes would have elapsed since the SRV closed), RCS pressure and subcooling would then increase very rapidly. The estimate of interest is the probability that the crew would fail to throttle HPI and control RCS pressure within 10 minutes of when subcooling of 5F is reached. Approximately 1 - 2 minutes after 5F subcooling is reached, in addition to the very rapid increase in RCS pressure, high pressure alarms would sound. Thus, multiple cues would indicate the rising pressure in the RCS. It should also be noted that there is significant redundancy in sensors and indications available. Numerous subcooling, pressure, and pressurizer level indications would probably have to fail in order to confuse (or fool) the crew.

Nevertheless, in spite of numerous procedure steps and cautions regarding the throttling of HPI at Oconee and maintaining control within allowable pressure-temperature limits, the main concern is whether the crew would fail to notice the indications of a rapid repressurization and respond appropriately within the specified time frame. The closing of the SRV would be an unexpected event and the crew would not receive any alarms indicating that it had closed other than the possible ending of an acoustic signal which could go unnoticed. In addition, there is at least some possibility that the crew would be somewhat complacent and would not be monitoring their instruments carefully, thinking that the “LOCA” situation is now well-in-hand. Thus, it is likely that the crew could have a LOCA “mindset” and that they would have the sense that the “event is over.” Moreover, they may not be anxious to throttle HPI unless they were sure that the SRV had closed. They could be thinking that such an action might cause them to lose control of the LOCA and verifying closure of the SRV might take a little time. However, there would be supporting indications that the SRV closure had occurred (e.g., lowering temperature indications for the SRV quench tank).

Other important “fixed” factors include the following:

- The crews would have been in the subcooling procedure (EP-501) and there are cautions regarding PTS concerns. Moreover, in all EOPs, once they are stabilized at greater than 5 degrees F subcooling, they can transfer to Enclosure 7.1 (TSOR curve) which guides them to maintain RCS temperature and pressure within acceptable limits.
- Discussions with operators and trainers, along with simulator observations, indicated that the crews are sensitized to maintain pressuruizer level at approximately 100 inches and are very aware of PTS concerns (which leads them to attend to subcooling and control of HPI).

Aleatory Factors

There were several factors identified that were judged to have likely aleatory effects on the probability of failure to throttle HPI and otherwise control RCS pressure. That is, to the extent the factors vary randomly, variations in the probability of failure would be expected; thereby contributing to the uncertainty associated with estimates of the probability. Some aspects of the factors would be expected to improve the probability of success and others would exacerbate the probability of failure. Some relevant factors identified included:

- instrumentation or controls unavailable due to maintenance or failure
- impacts of support systems that affect control of other systems (could cause confusing plant response)
- time of day
- crew “having a bad day” (for any number of possible reasons).

Epistemic Factors

Of course, the analysts must also consider the fact that they cannot be exactly sure how all of the various factors will influence performance. Thus, they must also take into account the impact of epistemic uncertainty (such as how these factors influence performance) in developing their distributions for the probability of failure.

All of the different types of uncertainty were considered together in deriving each individual’s uncertainty distribution. The initial distributions for the three analysts, along with the consensus distribution, are presented below.

Basis for the Consensus Distribution

In reaching a consensus, two basic arguments seemed prominent, along with the impact of the set of aleatory factors. First, the crew has successfully stabilized the SLOCA, but they remain in a SLOCA condition until the SRV closes. Water has been entering containment and a serious event has occurred. The crew would have been in EP-501 (Loss of Subcooling) and there are many cautions bearing on PTS within this procedure and other relevant procedures. Thus, it is reasonable to expect that the crew would be carefully monitoring critical plant parameters. In addition, observation of the Oconee crews in the simulator supports the belief that the procedures would be attended to and that the crew would be carefully monitoring critical parameters, particularly over a 10 minute period. Moreover, as noted above, after another one to two minutes, high pressure alarms (along with a drastic change in pressure) would further indicate the need for the crew to throttle HPI. It was also thought that the crew would be put on alert for changing conditions from the slow rise in pressure just before the quick rise in both pressure and subcooling. This plant behavior, along with “possible” recognition that the SRV has reclosed due to lowering temperature indications for the SRV quench tank readings, further supported the idea that the crew would be able to appropriately recognize and respond to the situation.

The general counter argument was based on the idea that the event is a “surprise.” The crew would be in a LOCA “mindset” and would be thinking that they had the event under control (it’s over). Thus, they might be complacent and might not recognize and adjust quickly to the changing conditions. They would have to switch from a “saturated” condition mind set to a “solid” condition mind set quickly and would probably need to change to another procedure to turn on pressurizer sprays (to decrease pressure), severely throttle back HPI, and take other actions as deemed appropriate to bring the pressure back down into the TSOR range. The emergency safeguards logic must be reset before HPI can be throttled and it is usually the case that different crew members perform the reset and throttling of HPI. Thus, there is at least some reason to believe that successfully turning the pressure around within the time available could be fairly challenging. There was also the concern that the crew may take the time to do some investigation before throttling HPI. They might be concerned about taking such an action because it might lead them to lose control of the LOCA that they currently have under control (they may not yet know that the stuck open SRV has closed).

The consensus distribution (Table 7.9) was based on the analysts weighing the relative strengths of the above arguments and their consideration of the impact of the different types of uncertainty on the distribution.

Table 7.9. Uncertainty distributions for HFE involving operators fail to throttle high pressure injection and control RCS pressure within 10 minutes after 5F subcooling.

Analyst	Percentiles						
	1st	10th	25th	50th	75th	90th	99th
#1	.0001	.0002	.001	.003	.01	.10	.50
#2	.001	.005	.01	.04	.08	.20	.50
#3	.001	.005	.015	.05	.08	.10	.50
Consensus	.0001	.0007	.002	.01	.05	.10	.50

HFE

Failure to throttle HPI and otherwise control RCS pressure within allowable limits (e.g., within the TSOR or allowable pressure-temperature limits) within 1 minute after the allowable throttling criteria of 5F subcooling is reached in the scenario involving a sudden reclosure of a pressurizer safety relief valve (SRV) that has been opened for a long time (taken as a representative 6000 seconds in the PRA model) since the initial reactor trip and start of the overcooling event.

General Context

The general context for this event is identical to that for the HFE above. However, in this scenario, the estimate of interest is the probability that the crew would fail to throttle HPI within 1 minute (rather than 10 minutes) of when subcooling of 5F is reached. As before, once the stuck open SRV which caused the SLOCA closes, approximately 10 minutes will elapse before 5F subcooling is reached and throttling of HPI is indicated.

Aleatory and Epistemic Factors

The factors identified as most likely to have effects on the probability of failure to throttle HPI within 1 minute were the same as for 10 minutes. Clearly, the one major difference is the very short response time for this HFE.

Basis for the Consensus Distribution

Although confidence in the crew response to throttle HPI in the 1 minute case is less than in the 10 minute case, it is still expected that given that the operators had stabilized the SLOCA, they would remain vigilant about what was occurring in the plant. That is, even though the SLOCA is under control, until they determine the SRV has closed, they believe that they are still in a SLOCA and that water is entering the containment. Moreover, a serious event has occurred but it is under control. Once the SRV closes, they will have the opportunity to see pressure increasing gradually over the next 10 minutes. As discussed above, given the crews usual vigilance, "board coverage," and the procedural cautions regarding PTS, there is a reasonable expectation that the crew will recognize that pressure is increasing. If so, they may be prepared to immediately (within 1 minute, if not before) throttle HPI (per procedure) when subcooling reaches 5F and RCS pressure begins to increase very rapidly. In fact, if they do notice the changing conditions, they could anticipate that pressure will shoot up as solid conditions are approached. In that case, they could be waiting to cut back HPI as soon as possible once 5 degrees F subcooling is reached.

Of course, there is some likelihood that the crew would not respond strongly to the gradual rise in pressure and cessation of the drop in temperature that begins when the SRV recloses (about 9 minutes before 5F subcooling is reached). Again, the potential LOCA "mindset" and sense that the event is under control (it's over) could contribute to complacency. Moreover, the possibility that the crew may take some time to do some investigation before preparing to throttle HPI may prevent them from being able to respond within the 1 minute time frame for this HFE. The surprise factor would be more important in the 1 minute case than the 10 minute case and unless the crew was prepared to respond as soon as 5F subcooling was reached, successfully turning the pressure around within the time available could be fairly challenging.

The consensus distribution (Table 7.10) was based on the analysts weighing the relative strengths of the above arguments and their consideration of the impact of the different types of uncertainty on the distribution.

Table 7.10. Uncertainty distributions for HFE involving operators fail to throttle high pressure injection and control RCS pressure within 1 minute after 5F subcooling.

Analyst	Percentiles						
	1st	10th	25th	50th	75th	90th	99th
#1	.015	.03	.06	.1	.3	.8	.95
#2	.01	.05	.08	.2	.5	.8	1
#3	.001	.01	.05	.3	.4	.5	1
Consensus	.001	.03	.06	.2	.4	.8	.99

HFE

Failure to throttle HPI and otherwise control RCS pressure within allowable limits (e.g., within the TSOR or allowable pressure-temperature limits) within 10 minutes after the allowable throttling criteria of 5F subcooling is reached in the scenario involving a significant steam generator depressurization event when the crew has previously failed to isolate the feed to the affected steam generator (hence consider the possible dependency of the previous failure on this human action).

General Context

In the scenarios of interest, a MSLB or other significant secondary side breach has occurred and the crew has not yet isolated the break. In this excessive steam demand event (ESDE), the question is what is the probability that the crew would fail to depressurize in order to keep temperature and pressure in the thermal shock operating region (TSOR) within 10 minutes of when the depressurizing/throttling criteria are met.

With the faulted SG, subcooling will be increasing and pressurizer level and pressure will be dropping. The pressure will decrease rapidly and at 1600 psia (about 1 minute or less into the scenario), HPI will auto-start and begin to refill the pressurizer within seconds. The cooldown rate will exceed the criterion of 50F in ½ hour and a 100F change in temperature will occur within about 15 minutes or less of the initiating event (i.e., RCS temperature will be below 500F). At this point, with the reactor coolant pumps (RCPs) likely on, the criteria for maintaining the RCS within the TSOR will have been met. In addition, subcooling is greater than 5F and pressurizer level be within 100 to 150 inches (the desirable pressurizer level). Thus the criteria for depressurizing and throttling HPI will have been met per Enclosure 7.1, including the TSOR curve.

In the given scenarios, all relevant procedures will direct the crew to Enclosure 7.1. There are consistent reminders for the crew to attend to PTS concerns. In addition to the normal indications for pressure and temperature, the TSOR is often displayed on a screen in the control room. A bright dot indicates where they are in the TSOR (i.e., pressure plotted against temperature) and a light "trail" shows the trend.

The easiest way for the crew to depressurize is to open the pressurizer spray valve. If that works, all will be fine. If not, they can choose to throttle HPI or even open the PORV in an emergency.

The only unusual aspect of this scenario is that the crew has not yet completed isolation of the faulted steam generator in the context associated with this particular HFE. There are many reasons why this might be the case, some of which could be related to the demands on the crew. However, observations of simulator exercises at Oconee and discussions with operating crews revealed that board operators at Oconee are given significant independence to carry-out standard actions in their areas of responsibility. While they will inform the shift supervisor of the actions and other crew members at an appropriate time, they are free to respond quickly as indicated by procedures and the "rule cards" available at the control room consoles. Thus, the operator addressing the primary side could depressurize independently of the secondary board operator isolating the SG. However, in most instances, in addition to the monitoring by the board operators, the Shift Supervisor will also be monitoring the TSOR The excessive steam demand event will be clear, the crew will almost certainly be following the correct procedure, the indications for the need to depressurize should be clear, and the basic actions are simple (even if keeping pressure and temperature in the TSOR requires attention).

Thus, the only concerns with this event are the following rather unlikely situations:

- potential delays caused by the crew waiting to depressurize in order to make sure pressurizer level is where it should be (i.e., above the heaters to facilitate pressure control),
- potential difficulties in achieving the desired pressure control (i.e., sometimes appropriate pressure control can require steady attention and response), and
- because the crews have not yet isolated the faulted SG, they may not completely understand the event, which may distract and delay the primary board operator's actions.

Aleatory Factors

There were several factors identified that were judged to have likely aleatory effects on the probability of failure to depressurize. That is, to the extent the factors vary randomly, variations in the probability of failure would be expected; thereby contributing to the uncertainty associated with estimates of the probability. Some aspects of the factors would be expected to improve the probability of success and others would exacerbate the probability of failure. The factors identified included:

- instrumentation or controls unavailable due to maintenance or failure
- impacts of support systems that affect control of other systems
- time of day/day of shift
- too much of a focus on restoring level
- potential steam hazards associated with the still unisolated SG causing distractions for the operating crew
- crew "having a bad day" (for any number of possible reasons).

Epistemic Factors

Of course, the analysts must also consider the fact that they cannot be exactly sure how all of the various factors will influence performance. Thus, they must also take into account the impact of epistemic uncertainty in developing their distributions for the probability of failure.

All of the different types of uncertainty were considered together in deriving each individual's uncertainty distribution. The initial distributions for the three analysts, along with the consensus distribution, are presented below.

Basis for the Consensus Distribution

Although all initial estimates of the "middle" probabilities were close (see Table 7.11 below), after discussions the judges agreed with the assertions regarding the difficulty with controlling pressure and the strength of the potential effects of aleatory factors on the high end values. The potential for the aleatory effects, coupled with the somewhat limited time frame for recognizing the need to depressurize, impacted the probability of failure on the high end. Furthermore, while it was thought there may be some small probability that the crew could get overly focused on pressurizer level and delay depressurizing or that they would delay depressurizing because they were confused about the events, it was not thought that such situations would be very likely. Thus, the main drivers for the likelihood of success were the independence of the board operators and their knowledge of the need to maintain conditions within the TSOR if overcooling, the strength of the procedures given the context, the obviousness of the cues for the action, the Oconee crews' general approach (team interactions) for responding to such accident scenarios, and their overall concern with the potential for PTS.

The consensus distribution (Table 7.11) was based on the analysts weighing the relative strengths of the above arguments and their consideration of the impact of the different types of uncertainty on the distribution.

Table 7.11. Uncertainty distributions for HFE involving operators failing to depressurize the RCS/throttle high pressure injection within 10 minutes in the context of a secondary side breach that has not been isolated.

Analyst	Percentiles						
	1st	10th	25th	50th	75th	90th	99th
#1	.0001	.0003	.001	.005	.01	.08	.4
#2	.0001	.0004	.0009	.007	.02	.08	.2
#3	.0002	.0006	.0015	.005	.02	.1	.8
Consensus	.0002	.0006	.001	.006	.02	.09	.7

HFE

Failure to throttle HPI and otherwise control RCS pressure within allowable limits (e.g., within the TSOR or allowable pressure-temperature limits) within 20 minutes after the allowable throttling criteria of 5F subcooling is reached in the scenario involving a significant steam generator depressurization event when the crew has previously failed to isolate the feed to the affected steam generator (hence consider the possible dependency of the previous failure on this human action).

General Context

The general context for this event is identical to that for the HFE above. However, in this scenario, the estimate of interest is the probability that the crew would fail to depressurize in order to keep temperature and pressure in the thermal shock operating region (TSOR) within 20 minutes (rather than 10) of when the depressurizing/throttling criteria are met.

Aleatory and Epistemic Factors

The factors identified as being likely to have effects on the probability of failure to depressurize in order to keep temperature and pressure in the TSOR within 20 minutes were the same as for 10 minutes. However, there is more time to respond.

Basis for the Consensus Distribution

The basis for the consensus distribution is in general the same as for the 10 minute case above, with the understanding that the extra time would reduce the potential effects of various kinds of delays or distractions on the likelihood of success within the time period. Only a significant misunderstanding of the event (e.g., caused by instrument problems) should prevent the crew from successfully depressurizing the RCS within 20 minutes. Otherwise, it would seem difficult for the crew not to be alerted to the fact that they are outside the TSOR and that correction is needed to re-enter the TSOR or allowable pressure-temperature range. The extra time would allow the crew to deal with events such as personnel being injured from the steam in the turbine building or problems in attempting to isolate the faulted SG. Thus, the HRA analysts agreed that at least some additional credit beyond that given for the 10 minute case would be appropriate. However, even with 20 minutes available, it needed to be kept in mind that the crew could be relatively busy in this scenario, particularly if isolating the faulted SG is causing problems. Thus, the analysts agreed that the low end of the consensus distribution should not be too low.

The consensus distribution (Table 7.12) was based on the analysts weighing the relative strengths of the above arguments and their consideration of the impact of the different types of uncertainty on the distribution.

Table 7.12. Uncertainty distributions for HFE involving operators failing to depressurize the RCS/throttle high pressure injection within 20 minutes in the context of a secondary side breach that has not been isolated.

Analyst	Percentiles						
	1st	10th	25th	50th	75th	90th	99th
#1	.00001	.00005	.0006	.002	.006	.05	.1
#2	.0001	.0003	.0005	.002	.008	.03	.1
#3	.0002	.0006	.0015	.005	.015	.06	.2
Consensus	.0002	.0004	.001	.004	.01	.05	.15

7.2.3 Incorporation Into the PTS PRA Model

The failure probabilities reported in Tables 7.7 through 7.12 were modified before final incorporation into the PTS PRA model. Depending on the specific input, there are four reasons why this final modification took place.

1. Incorporation of the uncertainty bounds provided in the HRA initial quantification was an approximation process, in order to arrive at a smooth but skewed probability distribution. The process attempted to duplicate the provided mean, 5th, and 95th percentile values for each HFE, as closely as possible. During this process, the final mean value used for each HFE in the PTS PRA was forced to be as close to the estimated mean as possible, and while attempting to fit the 95th and 5th values, priority was given to coming as close to the 95th while letting the 5th percentile value be the loosest fit of all three values. Hence the final PTS HRA values are slightly different from that provided by the initial quantification.

2. Incorporation of the histograms provided by the detailed quantification of the most important HFEs required a slight expansion of the distribution to create values for the end points (0th and 100th). This was accomplished by adding 10% to the last value to produce the 100th percentile and subtracting 10% from the first value to produce the 0th percentile.
3. For the HFE probabilities with different time periods associated with the action (e.g., by 10 minutes, by 20 minutes, etc.), adjustments were necessary to translate the HRA provided values and uncertainties into the PTS PRA model. This process, is summarized below.

4. A combination of the above.

With regard to item 3 above, while the PRA end states are related to time durations, the HRA task necessarily focused on the logical time sequencing of accident progression that is the operator's perspective. In other words, the HRA analysts determined what action cues and plant conditions would be expected to occur over time. These cues and conditions suggested logical time points for HRA evaluation. For example, human failure probabilities were generated on the basis of what cues and conditions would have accumulated by certain times (e.g., 10 and 20 minutes) and assigned probabilities that the operators would have failed to perform the necessary mitigative action (e.g., throttle HPI) on the basis of these contexts. Using these example times and actions, the Oconee PTS PRA model required, for instance, three human events:

1. The successful throttling of HPI by 10 minutes (assumed to occur right at 10 minutes in the model).

2. The failure to throttle by 10 minutes, but successful throttling by 20 minutes (i.e., throttling is assumed to occur at 20 minutes in the model, resulting in 10 more minutes of exposure to overcooling conditions).

3. The failure to throttle HPI by 20 minutes (assumed, therefor, to never occur for modeling purposes).

The first event is not a failure at all. This probability of success is the complement of the failure probability assigned for the 10-minute HRA case. Hence, for the PTS PRA, the complement of the mean and uncertainty distribution was used to express this success probability. The third event is equivalent to the 20-minute HRA case and is a direct translation of that probability distribution. The second event is the most complicated of all, involving failure by 10 minutes but success by 20 minutes. Simplistically, this failure probability is calculated by subtracting the failure probability of the 20-minute case from that for the 10-minute case.[17] This was performed by using LHS software [SAND98-0210] to create a new distribution for the second case where this new distribution is defined as the results of subtracting the 20-minute-case distribution from the 10-minute-case distribution using a sample size of 1000. The resulting distribution was then incorporated into SAPHIRE [SAPHIRE] by way of a 20-point uncertainty histogram.

Accounting for the above modifications, Table 7.13 shows the HFEs and their respective probabilities as they were actually included in the full-power and low power Oconee PTS PRA models.

[17] In practice, this subtraction involved not simply the mean values but the failure probability distributions for each case.

Table 7.13. Modeled HFE values for Oconee PTS PRA: Full and Low Power.

HFE #	HFE	Condition When Applied	HRA Mean and Uncertainty for Full Power (original estimate)	HRA Mean and Uncertainty for Low Power (original estimate)	PTS PRA Modeled HFE Name	PTS PRA Model Mean Value (Full Power / Low Power)	PTS PRA Model Uncertainty Factor (Full Power / Low Power)
1	Operators fail to trip RCPs quickly (~1 min) when suppose to (i.e., after subcooling is lost (O^0F))	Applies for all events under all circumstances	**1E-2 = mean** (95%, 5%) = 1E-1, 1E-3	**1E-1 = mean** (95%,5%) = 0.5, 1E-2	Not used in final model[1]	Not used in final model	Not used in final model
2	Operators trip RCPs when not required	Applies for all events under all circumstances except when there is an instrument problem and one instrument reads 0F incorrectly	**1E-3 = mean** (95%, 5%) = 1E-2, 1E-4	**1E-2 = mean** (95%,5%)= 0.1, 1E-3	RCP_INADV_TRIP	1.0E-3 / 1.0E-2	10 lognormal / 10 lognormal
		With an instrument problem	Conditional on instrument problem: **1E-1 = mean** (95%, 5%) = 0.5, 1E-2	Conditional on instrument problem : **1E-1 = mean** (95%,5%) = 0.5, 1E-2	Not used in final model	Not used in final model	Not used in final model
3	Operators fail to restart RCPs when supposed to (primarily 50F subcooling but other criteria, too)	Applies for all events under all circumstances	**0.5 = mean** (95%, 5%) = 0.9, 0.1	**0.5 = mean** (95%,5%) = 0.9, 0.1	RCP_RESTART_F	5.0E-1 / 5.0E-1	9.0E-2 to 1.0 max entropy / 9.0E-2 to 1.0 max entropy

[1] Events typically not used because likelihood of plant state and original conservative HFE estimate showed this situation had too low a frequency.

Table 7.13. Modeled HFE values for Oconee PTS PRA: Full and Low Power.

HFE #	HFE	Condition When Applied	HRA Mean and Uncertainty for Full Power (original estimate)	HRA Mean and Uncertainty for Low Power (original estimate)	PTS PRA Modeled HFE Name	PTS PRA Model Mean Value (Full Power / Low Power)	PTS PRA Model Uncertainty Factor (Full Power / Low Power)
4	Operators successfully go to F&B when supposed to (key is 2300 psig in RCS) or successfully depress/cool to use condensate or to get to CFTs/LPI if necessary	Applies to all events under all conditions when these actions become necessary.	**1.0 (success)**	**1.0 (success)**	HPI_FBHA_F **(failure)**	0.0 / 0.0	point value / point value
5	Operators fail to trip turbine manually if auto trip fails (in 15-30 seconds)	Applies to all events under all circumstances.	**1E-3 = mean** (95%,5%) = 1E-2, 1E-4	**1E-3 = mean** (95%,5%) = 1E-2, 1E-4	Not used in final model	Not used in final model	Not used in final model
6	Operators fail to throttle/trip MFW given it is overfeeding 1 or both SGs, before overfilling SG(s)	Case (a): Applies to all initiators where MFW can be overfeeding, but with no other serious anomalies with the other functions (e.g., no concurrent depressurization, SLOCA)	Within ~1min: **0.1 = mean** (95%, 5%) =0.5, 1E-2 Within 5min: **1E-2 = mean** (95%,5%) = 1E-1, 1E-3 Within 15min: **1E-3 = mean** (95%, 5%) = 1E-2, 1E-4	Within ~1min: **0.1 = mean** (95%, 5%) =0.5, 1E-2 Within 5min: **1E-2 = mean** (95%,5%) = 1E-1, 1E-3 Within 15min: **1E-3 = mean** (95%, 5%) = 1E-2, 1E-4	Only 15 min event used: MFW_REC_F-A15 **(success of event)**	9.99E-1 / 9.99E-1	point value / use of a histogram

Table 7.13. Modeled HFE values for Oconee PTS PRA: Full and Low Power.

HFE #	HFE	Condition When Applied	HRA Mean and Uncertainty for Full Power (original estimate)	HRA Mean and Uncertainty for Low Power (original estimate)	PTS PRA Modeled HFE Name	PTS PRA Model Mean Value (Full Power / Low Power)	PTS PRA Model Uncertainty Factor (Full Power / Low Power)
		Case (b): Like above except there is a concurrent functional problem (e.g., depressurization in another SG, SLOCA)	Within 1 min: **0.5= mean** (95%,5%) = 0.9, 0.1 Within 5 min: **1E-2 = mean** (95%, 5%) = 1E-1, 1E-3 Within 15 min: **1E-3= mean** (95%,5%)= 1E-2, 1E-4	Within 1 min: **0.5= mean** (95%,5%) = 0.9, 0.1 Within 5 min: **1E-2 = mean** (95%, 5%) = 1E-1, 1E-3 Within 15 min: **1E-3= mean** (95%,5%)= 1E-2, 1E-4	Only 15 min event used: MFW_REC_F-B15 **(success of event)**	9.99E-1 / 9.99E-1	use of a histogram / use of a histogram
		Case (c): Initiator is a more complex support system failure (e.g., loss of air) regardless of status of other functions	Same as above.	As above.	Only 15 min event used: MFW_REC_F-C15 **(success of event)**	9.99E-1 / 9.99E-1	use of a histogram / point value

Table 7.13. Modeled HFE values for Oconee PTS PRA: Full and Low Power.

HFE #	HFE	Condition When Applied	HRA Mean and Uncertainty for Full Power (original estimate)	HRA Mean and Uncertainty for Low Power (original estimate)	PTS PRA Modeled HFE Name	PTS PRA Model Mean Value (Full Power / Low Power)	PTS PRA Model Uncertainty Factor (Full Power / Low Power)
7	Operators fail to throttle EFW within the time frames noted, given MFW is gone and EFW is overfeeding 1 or both SG(s)	Applies to all initiators except the more complicating support system failure cases (e.g., loss of air, loss of cooling water, loss of offsite power) - no other functional anomalies. Case (a): System will successfully respond if/when operator puts into manual and attempts to regain control of the feed	Within 10 min: **1E-2 = mean** (95%,5%) = 1E-1, 1E-3	Within 10 min: **5E-2 = mean** (95%,5%)=0.5, 5E-3	EFW_REC_FL-10A	5.0E-1 (conservative) / 4.0E-2	1.005 beta / 5 lognormal
			Within 30 min: **1E-3 = mean** (95%,5%) = 1E-2, 1E-4	Within 30 min: **1E-2 = mean** (95%,5%)= 0.1, 1E-3	EFW_REC_FL-30A	1.0E-3 / 1.0E-2	5 lognormal / 5 lognormal
		Case (b): Same as case (a) except manual control will not respond (e.g., control valve stuck-open) so eventually must choose to stop pump/ then restart; or perhaps isolate that SG.	10 min: **1E-2 = mean** (95%, 5%) = 1E-1, 1E-3	Same as above	EFW_REC_FL-10B	1.1E-2 / 1.1E-2	use of a histogram/ use of a histogram
			30 min: **1E-3 = mean** (95%, 5%) = 1E-2, 1E-4		EFW_REC_FL-30B	1.0E-3 / 1.0E-2	10 lognormal / 10 lognormal

Table 7.13. Modeled HFE values for Oconee PTS PRA: Full and Low Power.

HFE #	HFE	Condition When Applied	HRA Mean and Uncertainty for Full Power (original estimate)	HRA Mean and Uncertainty for Low Power (original estimate)	PTS PRA Modeled HFE Name	PTS PRA Model Mean Value (Full Power / Low Power)	PTS PRA Model Uncertainty Factor (Full Power / Low Power)
		Case (c): Same as case (a) except there is a concurrent other serious functional problem (e.g., SLOCA, depressurization in another SG)	10 min: **1E-1 = mean** (95%,5%) = 0.5, 1E-2 30 min: **1E-3= mean** (95%,5%) = 1E-2, 1E-4	Within 10 min: **1E-1 = mean** (95%,5%) = 0.5, 1E-2 Within 30 min: **1E-2 = mean** (95%,5%) = 0.1, 1E-3	Not used in final model	Not used in final model	Not used in final model
		Case (d): Same as case (b) except there is a concurrent other serious functional problem (SLOCA, depressurization)	10 min: **1E-1 = mean** (95%,5%) = 0.5, 1E-2 30 min: **1E-3= mean** (95%,5%) = 1E-2, 1E-4	As above for case (c).	Not used in final model	Not used in final model	Not used in final model
		Case (e): Involves a concurrent support system problem (e.g., loss of air, loss of CCW, LOSP) regardless of actual status of other functions.	10 min: **1E-1 = mean** (95%,5%) = 0.5, 1E-2 ____ 30 min **1E-3= mean** (95%,5%) = 1E-2, 1E-4	As above for case (c).	EFW_REC_FL-10E ____ EFW_REC_FL-30E	9.9E-2 / 9.4E-2 ____ 1.0E-3 / 1.0E-2	3 lognormal / use of a histogram ____ 5 lognormal / 5 lognormal

Table 7.13. Modeled HFE values for Oconee PTS PRA: Full and Low Power.

HFE #	HFE	Condition When Applied	HRA Mean and Uncertainty for Full Power (original estimate)	HRA Mean and Uncertainty for Low Power (original estimate)	PTS PRA Modeled HFE Name	PTS PRA Model Mean Value (Full Power / Low Power)	PTS PRA Model Uncertainty Factor (Full Power / Low Power)
8	Operators fail to trickle/throttle condensate into SG(s) when depressurized to use condensate into SGs (so it overfeeds and quickly refills SG(s))	All initiators/conditions where use of condensate is possible, including support system problems.	**1E-2= mean** (95%,5%)= 1E-1, 1E-3	**1E-2= mean** (95%,5%)=1E-1, 1E-3	CBP_FTO_DP (fail to depressurize) CBP_OVRFD (fail to throttle condensate and so overfeed)	1.0E-3 / 1.0E-3 1.0E-2 / 1.0E-2	3 lognormal / 3 lognormal 10 lognormal / 10 lognormal
9	Operators fail to isolate a secondary depressurization event	Applies to all initiators except the more complex support system initiators (e.g., loss of air, loss of CCW, LOSP) Case (a): There is no other serious functional anomaly (e.g., SLOCA, overfeed in another SG)	10 min: **1E-3 = mean** (95%,5%)= 1E-2, 1E-4	10 min: **1E-2 = mean** (95%,5%)=1E-1, 1E-3 20 min: **1E-3 = mean** (95%,5%)=1E-2, 1E-4	Only 10 min event used: EFW_SLB_FI-10A and TBV_SO_FI-10A	1.0E-3 (both events)/ 9.7E-3 (1.2E-2 for TBV event)	10 lognormal (both events) / use of a histogram (both events)

Table 7.13. Modeled HFE values for Oconee PTS PRA: Full and Low Power.

HFE #	HFE	Condition When Applied	HRA Mean and Uncertainty for Full Power (original estimate)	HRA Mean and Uncertainty for Low Power (original estimate)	PTS PRA Modeled HFE Name	PTS PRA Model Mean Value (Full Power / Low Power)	PTS PRA Model Uncertainty Factor (Full Power / Low Power)
		Case (b): Same as case (a) except concurrent anomaly in other function (e.g., SLOCA, overfeed in another SG)	10 min: **1E-2= mean** (95%,5%)= 1E-1, 1E-3	10 min: **5E-2 = mean** (95%,5%)=1E-1, 5E-3	TBV_SO_FI-10B	1.2E-2 / 4.5E-2	use of a histogram / 3 lognormal
			20 min: **1E-3= mean** (95%,5%)= 1E-2, 1E-4	20 min: **5E-3 = mean** (95%,5%)=1E-2, 5E-4	TBV_SO_FI-20B	1.0E-3 / 5.0E-3	10 lognormal / 3 lognormal
		Case (c): Involves a concurrent support system problem (e.g., loss of air, loss of CCW, LOSP) regardless of actual status of other functions.	As case (b) above	As above: 10 min: **5E-2 = mean** (95%,5%)=1E-1, 5E-3	EFW_SLB_FI-10C	9.0E-3 / 4.5E-2	3 lognormal / 3 lognormal
				20 min: **5E-3 = mean** (95%,5%)=1E-2, 5E-4	EFW_SLB_FI-20C	1.0E-3 / 5.0E-3	3 lognormal / 3 lognormal
10	Operators isolate wrong SG	All initiators/situations	**1E-3 = mean** (95%,5%)= 1E-2, 1E-4	**1E-2 = mean** (95%,5%)=1E-1, 1E-3	Not used in final model	Not used in final model	Not used in final model

Table 7.13. Modeled HFE values for Oconee PTS PRA: Full and Low Power.

HFE #	HFE	Condition When Applied	HRA Mean and Uncertainty for Full Power (original estimate)	HRA Mean and Uncertainty for Low Power (original estimate)	PTS PRA Modeled HFE Name	PTS PRA Model Mean Value (Full Power / Low Power)	PTS PRA Model Uncertainty Factor (Full Power / Low Power)
11	Operators fail to restore good SG and isolate bad SG if isolated wrong SG initially.	All initiators/situations	**1E-2 = mean** (95%,5%)= 1E-1, 1E-3	Use values to left. **1E-2 = mean** (95%,5%)= 1E-1, 1E-3	Not used in final model	Not used in final model	Not used in final model
12	Operators fail to close PORV/its block valve upon stuck-open PORV	Applies to all initiators/ situations.	10 min: **1E-2 = mean** (95%,5%)= 1E-1, 1E-3	Use values to left. 10 min: **1E-2 = mean** (95%,5%)= 1E-1, 1E-3	PORV_ISO_F-10	1.0E-2 / 1.0E-2	10 lognormal / 10 lognormal
		Agreed this case could be dropped (not important in ≥10 min.	Eliminated	Eliminated	Not used in final model	Not used in final model	Not used in final model
13	Operators fail to successfully align/use alternate EFW from other unit	All initiators/situations	15 min: **1E-1 = mean** (95%,5%)= 0.9,1E-2 (time may be minimal) 30 min: **1E-3 = mean** (95%,5%)= 1E-2, 1E-4	Use values to left. 15 min: **1E-1 = mean** (95%,5%)= 0.9, 1E-2 30 min: **1E-3 = mean** (95%,5%)=1E-2, 1E-4	Not used in final model	Not used in final model	Not used in final model

Table 7.13. Modeled HFE values for Oconee PTS PRA: Full and Low Power.

HFE #	HFE	Condition When Applied	HRA Mean and Uncertainty for Full Power (original estimate)	HRA Mean and Uncertainty for Low Power (original estimate)	PTS PRA Modeled HFE Name	PTS PRA Model Mean Value (Full Power / Low Power)	PTS PRA Model Uncertainty Factor (Full Power / Low Power)
14	Operators fail to control cooldown during SGTR and thus, lose subcooling	SGTR type event	**0.1=mean** (95%,5%)= 0.5, 1E-2	Use values to left. **0.1=mean** (95%,5%)= 0.5, 1E-2	RCS_SCM_F	1.0E-1 / 1.0E-1	use of constrained non-informative prior
15	Operators fail to throttle HPI to maintain pressure in TSOR/ allowable P-T range when it is required to do so (essentially between 5F-100F subcooling when temp<500F)	(a) Regardless of initiator, HPI injection has occurred (e.g., SLOCA) or loss of subcooling is only anomaly (e.g., no other significant problems with SG feed or depressurization)	Within 10min after start of HPI: **1E-1= mean** (95%,5%)= 0.5, 1E-2	1min case eliminated. Within 10min after start of HPI: Use values to left **1E-1= mean** (95%,5%)= 0.5, 1E-2	HPI_TF-10AB and HPI_TF-10AB-SEC	1.0E-1 (4.5E-2 for SEC event) / 9.8E-2 (4.5E-2 for SEC event)	use of a histogram / use of a histogram
			Within 20 min after start of HPI: **1E-3= mean** (95%,5%)= 1E-2, 1E-4	Within 20 min after start of HPI: **5E-3= mean** (95%,5%)=5E-2, 5E-4	HPI_TF-20AB and HPI_TF-20AB-SEC	1.0E-3 (1.8E-2 for SEC event) / 5.0E-3 (1.8E-2 for SEC event)	10 lognormal (histogram for SEC event) / 10 lognormal (histogram for SEC event)

Table 7.13. Modeled HFE values for Oconee PTS PRA: Full and Low Power.

HFE #	HFE	Condition When Applied	HRA Mean and Uncertainty for Full Power (original estimate)	HRA Mean and Uncertainty for Low Power (original estimate)	PTS PRA Modeled HFE Name	PTS PRA Model Mean Value (Full Power / Low Power)	PTS PRA Model Uncertainty Factor (Full Power / Low Power)
		(b) Like (a) above except there is also a concurrent secondary anomaly such as a problem with SG feed in one or both SGs (over or under feed) or a problem with secondary pressure (e.g., depressurization.)	Within 10min after HPI start: **1E-1= mean** (95%,5%)= 0.5, 1E-2 Within 20min after HPI start: **1E-3= mean** (95%,5%)= 1E-2, 1E-4	Same as above values. Within 10min after HPI start: **1E-1= mean** (95%,5%)= 0.5, 1E-2 Within 20min after HPI start: **5E-3= mean** (95%,5%)=5E-2, 5E-4	See above.	See above.	See above.

Table 7.13. Modeled HFE values for Oconee PTS PRA: Full and Low Power.

HFE #	HFE	Condition When Applied	HRA Mean and Uncertainty for Full Power (original estimate)	HRA Mean and Uncertainty for Low Power (original estimate)	PTS PRA Modeled HFE Name	PTS PRA Model Mean Value (Full Power / Low Power)	PTS PRA Model Uncertainty Factor (Full Power / Low Power)
		(c) Special case where HPI is needed (LOCA, PORV open, shrinkage, etc.) and there is insufficient flow. Operator then tries to depressurize using the TBVs (PORV and head vents only if necessary) to get to CFT/LPI and on the way down, sufficient HPI recovered; then fails to throttle once ≥5F subcooling. * The .9-.1 split of whether operator puts switches in manual: see THERP pg 16-6 estimate of 0.01 of failure to follow a common policy but raised by a factor of 10 to account for application of such an error in a very dynamic/high stress situation.	Case (c)(1): Within 10min after start of HPI: **1E-2= mean** (95%,5%)= 1E-1, 1E-3 Within 20 min after start of HPI: **1E-3= mean** (95%,5%)= 1E-2, 1E-4 Case (c)(2): Within 10min after start of HPI,: **1E-1= mean** (95%,5%)= 0.5, 1E-2 Within 20 min after start of HPI: **1E-3= mean** (95%,5%)= 1E-2, 1E-4	Case (c)(1): Within 10min after start of HPI: **5E-2= mean** (95%,5%)=1E-1, 5E-3 Within 20 min after start of HPI: **5E-3= mean** (95%,5%)=5E-2, 5E-4 Case (c)(2): Within 10min after start of HPI: **1E-1= mean** (95%,5%)= 0.5, 1E-2 Within 20 min after start of HPI: **5E-3= mean** (95%,5%)=5E-2, 5E-4	HPI_TF-10C1 _ _ _ _ _ _ HPI_TF-10C2 _ _ _ _ _ _ HPI_TF-20C1 _ _ _ _ _ _ HPI_TF-20C2 _ _ _ _ _ _ OPS-PUT-SWITCH-M (operators put switches in manual)	1.1E-2 / 4.8E-2 _ _ _ _ 1.0E-1 / 5.3E-2 _ _ _ _ 1.0E-3 / 5.0E-3 _ _ _ _ 1.0E-3 / 5.0E-3 _ _ _ _ 9.0E-1 / 9.0E-1	use of a histogram / use of a histogram _ _ _ _ use of a histogram / use of a histogram _ _ _ _ 10 lognormal / 10 lognormal _ _ _ _ 3 lognormal / 3 lognormal _ _ _ _ use of constrained non-informative prior

Table 7.13. Modeled HFE values for Oconee PTS PRA: Full and Low Power.

HFE #	HFE	Condition When Applied	HRA Mean and Uncertainty for Full Power (original estimate)	HRA Mean and Uncertainty for Low Power (original estimate)	PTS PRA Modeled HFE Name	PTS PRA Model Mean Value (Full Power / Low Power)	PTS PRA Model Uncertainty Factor (Full Power / Low Power)
		(d) Case where throttling not controlled after a LOCA re-isolates (i.e., re-pressurization event)	For case (d)(1): an unexpected (surprise) closure - - Within 10min after start of HPI: **1E-1=mean**; (95%,5%) =0.5, 1E-2 Within 20 min after start of HPI: **1E-3= mean**;(95%,5%) =1E-2, 1E-4 For case (d)(2): an expected closure - - Within 10min after start of HPI: **1E-2= mean**; (95%,5%) = 1E-1, 1E-3 Within 20 min after start of HPI: **1E-3= mean**; (95%,5%)= 1E-2, 1E-4	Case (d)(1): Within 10min after start of HPI: **1E-1= mean** (95%,5%)= 0.5, 1E-2 Within 20 min after start of HPI: **5E-3= mean** (95%,5%)=5E-2, 5E-4 Case (d)(2): Within 10min after start of HPI: **5E-2= mean** (95%,5%)=1E-1, 5E-3 Within 20 min after start of HPI: **5E-3= mean** (95%,5%)=5E-2, 5E-4	HPI_TF-1D1 (1 min) _ _ _ _ _ _ HPI_TF-10D1 (10min) _ _ _ _ _ _ HPI_TF-10D2 (10min) _ _ _ _ _ _ HPI_TF-20D2 (20min) (other cases not used)	3.0E-1 / 2.4E-1 _ _ _ _ 5.3E-2 / 5.3E-2 _ _ _ _ 9.0E-3 / 4.5E-2 _ _ _ _ 1.0E-3 / 5.0E-3	use of a histogram/ use of a histogram _ _ _ _ use of a histogram/ use of a histogram _ _ _ _ 3 lognormal / 3 lognormal _ _ _ _ 3 lognormal / 3 lognormal

Table 7.13. Modeled HFE values for Oconee PTS PRA: Full and Low Power.

HFE #	HFE	Condition When Applied	HRA Mean and Uncertainty for Full Power (original estimate)	HRA Mean and Uncertainty for Low Power (original estimate)	PTS PRA Modeled HFE Name	PTS PRA Model Mean Value (Full Power / Low Power)	PTS PRA Model Uncertainty Factor (Full Power / Low Power)
		(e) Case where HPI throttling and/or feed to SG(s) not controlled transferring from F&B back to SG cooling (potential late re-pressurization and/or late cooling)	For first ~2min from start of transfer from F&B to SG cooling: **1E-1= mean** (95%,5%)= 0.5, 1E-2	Same as at left. For first ~2min from start of transfer from F&B to SG cooling: **1E-1= mean** (95%,5%)= 0.5, 1E-2	HPI_TF-02E	1.0E-1 / 9.9E-2	use of a histogram / 3 lognormal
			Beyond ~2min: **1E-3= mean** (95%,5%)= 1E-2, 1E-4	Beyond ~2min: **1E-3= mean** (95%,5%)= 1E-2, 1E-4	HPI_TF-03E	1.0E-3 / 1.0E-3	use of a histogram / 3 lognormal

8. DATA ANALYSIS

This section discusses the probabilities assigned to each of the basic events in the Oconee pressurized thermal shock (PTS) models with the exceptions of the initiating events (see section 3) and the human action events (see section 7). The information provided includes the event's:

- name (i.e., identifier),
- description,
- probability,
- uncertainty distribution, if applicable, and
- the source used to estimate the probability and uncertainty distribution.

Table 8.1 provides the above information.

Table 8.1. Basic events: value and uncertainty information.

Name	Description	Calc. Probability	Unc Type Unc Value 1 Unc Value 2	Corr. Class	Source Discussion
AREA-FRACTION-1	Area Fraction #1	3.10E-01	Point Value		UMD uncertainty report [Chang] Used to represent uncertainty associated with stuck open SRV area important to PTS.
C-PROB-1	Conditional Probability #1	3.50E-01	Point Value		UMD uncertainty report [Chang] Used to represent uncertainty associated with stuck open SRV or medium LOCA.
C-PROB-2	Conditional Probability #2	3.00E-01	Point Value		UMD uncertainty report [Chang] Used to represent uncertainty associated with stuck open SRV or medium LOCA.
C-PROB-3	Conditional Probability #3	2.30E-01	Point Value		UMD uncertainty report [Chang] Used to represent uncertainty associated with small LOCA.
C-PROB-4	Conditional Probability #4	1.80E-01	Point Value		UMD uncertainty report [Chang] Used to represent uncertainty associated with small LOCA.
CBP_F-TRUE	CBPs unavailable	1.00E+00	Point Value		Prior conditions result in CBP unavailability.
CBP_FTO_FR	CBPs fail to feed S/Gs (assumed already running)	1.00E-01	Lognormal EF = 3		Assumption Engineering judgment used to set value to determine whether operation of CBPs important.
CBP_OVRFD-FALSE	CBPs don't overfeed (unavailable)	0.00E+00	Point Value		Prior conditions imply CBPs cannot overfeed.

Table 8.1. Basic events: value and uncertainty information.

Name	Description	Calc. Probability	Unc Type Unc Value 1 Unc Value 2	Corr. Class	Source Discussion
DUMMY	ET-top Developed Event	1.00E+00	Point Value		Dummy event used to create large and medium LOCA sequences.
EAC_F	ET-top Failure of Emergency AC Power	1.00E-03	Lognormal EF =10		Assumption (in the range of typical EAC reliabilities)
EFW_FTS	Fail to Start of EFW on demand	4.90E-03	Beta 1.11E+03	3	NUREG/CR-5500, Vol. 1 [NUREG/CR-5500-V1] Page 22 indicates 0 failures in 1117 demands. Section 3.5 states that there were five instances where a MDP train failed to auto start on demand, but that all 5 were recovered by the operators manually starting the pumps. Therefore, the probability of an initial "failure" (in this context, failure refers to the occurrence of one or more trains failing to start automatically) is determined by performing a Bayes update using non-informative prior Beta (0.5, 0.5) with 5 failures in 1117 demands to yield posterior Beta (5.5, 1112.5).
EFW_OVRFD_A	EFW Overfeeds S/G A	1.60E-03	Beta 3.13E+02	4	Assumed to be same as MFW_OVERF_A.
EFW_OVRFD_AB	EFW Overfeeds both S/Gs	4.50E-03	Beta 1.05E+02	2	Assumption Performed Bayes update using non-informative prior Beta (0.5, 0.5) with 0 failures in 100 demands to yield posterior Beta (0.5, 100.5).

Table 8.1. Basic events: value and uncertainty information.

Name	Description	Calc. Probability	Unc Type Unc Value 1 Unc Value 2	Corr. Class	Source Discussion
EFW_REC_NONE	EFW does not recover (no feed) after a SG dries out	8.30E-02	Beta 5.50E+00		NUREG/CR-5500, Vol. 1 [NUREG/CR-5500-V1] Section 3.5 states that there were five instances where a MDP train failed to auto start on demand, but that all 5 were recovered by the operators manually starting the pumps. Therefore, the probability of recovery from an initial "failure" (in this context, failure refers to the occurrence of one or more trains failing to start automatically) is determined by performing a Bayes update using non-informative prior Beta (0.5, 0.5) with 0 failures in 5 demands to yield posterior Beta (0.5, 5.5).
EFW_SLB-FTS		4.90E-03	Beta 1.11E+03	3	Assumed to be same as EFW_FTS.
EFW_SLB_FTS	EFW Fails To Start (Excessive Steam Demand)	4.90E-03	Beta 1.11E+03	3	Assumed to be same as EFW_FTS.
EFW_SLBSBO_FTS	EFW FTS (SBO plus ESD)	1.00E+00	Point Value		Assumes EFW cannot function because motor-driven pumps unavailable due to SBO, and turbine-driven pump unavailable due to excessive steam demand.
EFWTDP_FTS	Fail to Start of EFW TDP trains on demand	1.40E-02	Beta 1.71E+02		NUREG/CR-5500, Vol. 1, [NUREG/CR-5500-V1] Table 4, Unrecovered FTS-T failure mode.
EFWTDP_OVRFD_A	EFW TDP train Overfeeds S/G A	1.60E-03	Beta 3.13E+02		Assumed to be same as MFW_OVERF_A.
EFWTDP_OVRFD_AB	EFW TDP trains Overfeed both S/Gs	4.50E-03	Beta 1.05E+02	2	Assumed to be same as EFW_OVERF_AB.

Table 8.1. Basic events: value and uncertainty information.

Name	Description	Calc. Probability	Unc Type Unc Value 1 Unc Value 2	Corr. Class	Source Discussion
H-EFW_REC_B-FT		1.02E-01	Point Value		Min cut upper bound value from fault tree solution.
H-EFW_REC_F-FT-T-B		2.08E-02	Point Value		Min cut upper bound value from fault tree solution.
HPI_FBHW_F	F&B fails due to Hardware failure	2.20E-03	Beta 2.25E+02		Same as for HPI_FTS.
HPI_FTS		2.20E-03	Beta 2.25E+02		NUREG/CR-5500, Vol. 9 [NUREG/CR-5500-V9], page xi. Performed Bayes update using non-informative prior Beta (0.5, 0.5) with 0 failures in 224 demands to yield posterior Beta (0.5, 224.5).
HPI_FTS-FALSE	HPI Available due to previous success	0.00E+00	Point Value		Previous success of HPI in sequence logic implies HPI available.
HPI_FTS-TRUE	HPI Unavailable Due to Previous Failure	1.00E+00	Point Value		Previous failure of HPI in sequence logic implies HPI unavailable.
HPI_REC_F	ET-top HPI Recovered	7.00E-01	Beta 4.00E-01		Table 4 of NUREG/CR-5500, Volume 9 [NUREG/CR-5500-V9] provides several non recovery probabilities. Using the range of values provided, we estimated the non recovery of HPI to be 0.7 with a Beta of 0.4.
HZP-FRACTION	Fraction of time at HZP	2.00E-02	Max Entropy 5.00E-03 4.00E-02		Oconee experience Review of recent experience indicated Oconee in hot zero power approximately 1 – 2 percent of year.

Table 8.1. Basic events: value and uncertainty information.

Name	Description	Calc. Probability	Unc Type Unc Value 1 Unc Value 2	Corr. Class	Source Discussion
HZP-MULTIPLIER	HZP Multiplier for RTTT	2.00E-01	Max Entropy 1.00E-01 3.00E-01		Engineering judgment Factor of 10 increase to HZP-FRACTION to account for increased likelihood of reactor/turbine trips due to transient conditions that arise as a result of changing feedwater and steam conditions along with changing power and other parameters in the plant.
LOSP-NR-2H	Non Recovery of Offsite Power in 2 hrs	6.40E-02	Point Value		Oconee SPAR Model, Version 3i, Basic event OP-2H (failure to recover offsite power in 2 hours)
MFW-COND-NR	Non Recovery of MFW/Condenser	6.00E-02	Max Entropy 6.00E-03 6.00E-01		NUREG/CR-4550, Vol. 1, Rev. 1 [NUREG/CR-4550, V1R1] Table 8.2-10 (70-120)
MFW_ESD_OF		2.40E-02	Beta 2.05E+01		Assumption – 0 failures in 20 demands Performed Bayes update using non-informative prior Beta (0.5, 0.5) with 0 failures in 20 demands to yield posterior Beta (0.5, 20.5).
MFW_OVRFD-FALSE	MFW does not overfeed (unavailable)	0.00E+00	Point Value		Prior conditions imply MFW cannot overfeed.
MFW_OVRFD_A		1.60E-03	Beta 3.13E+02	4	Oconee experience. Performed Bayes update using non-informative prior Beta (0.5, 0.5) with 0 failures in 312 demands to yield posterior Beta (0.5, 312.5).

Table 8.1. Basic events: value and uncertainty information.

Name	Description	Calc. Probability	Unc Type Unc Value 1 Unc Value 2	Corr. Class	Source Discussion
MFW_OVRFD_AB		4.50E-02	Beta 1.05E+01		Assumption Performed Bayes update using non-informative prior Beta (0.5, 0.5) with 0 failures in 10 demands to yield posterior Beta (0.5, 10.5).
MFW_TRIP_F	ET-top MFW fails to trip on high S/G level	7.00E-03	Beta 7.05E+01		Based on LER data. Performed Bayes update using non-informative prior Beta (0.5, 0.5) with 0 failures in 70 demands to yield posterior Beta (0.5, 70.5).
MFW_TRIP0	MFW trips at time T=0	8.40E-02	Beta 1.41E+03		NUREG/CR-5750-Addendum, Table D.4, P1–Total loss of feedwater flow Performed Bayes update using non-informative prior Beta (0.5, 0.5) with 128 failures in 1535 demands to yield posterior Beta (128.5, 1407.5).
MFW_TRIP0-FALSE	MFW Does not Trip at T=0	0.00E+00	Point Value		Prior conditions define whether MFW trips or does not trip at Time = 0. Event occurs in LMC event tree where loss of main condenser is assumed to cause trip of MFW at Time = 0.

Table 8.1. Basic events: value and uncertainty information.

Name	Description	Calc. Probability	Unc Type Unc Value 1 Unc Value 2	Corr. Class	Source Discussion
MFW_TRIP0-TRUE	MFW trips at Time=0 give loss of main condenser IE	1.00E+00	Point Value		Prior conditions imply MFW tripped at Time = 0. Event occurs in LMC event tree where loss of main condenser is assumed to cause trip of MFW at Time = 0.
PORV_SELF_CLOSE	ET-top PORV self closes	2.50E-01	Lognormal EF = 1.5	6	Assumed to be the same as SRV_ISO_F.
PORV_SO	PORV stuck open	3.30E-04	Beta 1.54E+03		NUREG/CR-5750-Addendum, Table D-4 Performed Bayes update using non-informative prior Beta (0.5, 0.5) with 0 failures in 1535 demands to yield posterior Beta (0.5, 1535.5).
PORV_SO_SGTR	ET-top PORV sticks open when used to depress RCS during SGTR	1.00E-01	Lognormal EF = 3		Assumption Engineering judgment used to set value to determine whether stuck open PORV during SGTR important.
RCP_RF-TRUE	RCP Not Restarted	1.00E+00	Point Value		Prior conditions imply RCPs cannot be restarted (e.g., LOSP).
RCP_TRIP	ET-top RCP Trip (loss of RCS subcooling)	1.00E-01	Lognormal EF = 3		Assumed to be same as RCP_TRIP_PORV. Used only for SGTR. Size of primary break could be comparable to stuck open PORV.
RCP_TRIP-TRUE	RCPs are tripped - true	1.00E+00	Point Value		Prior conditions imply RCPs are tripped (i.e., unavailable).

Table 8.1. Basic events: value and uncertainty information.

Name	Description	Calc. Probability	Unc Type Unc Value 1 Unc Value 2	Corr. Class	Source Discussion
RCP_TRIP_PORV	RCP Trip (loss of RCS subcooling) given stuck open PORV	1.00E-01	Lognormal EF = 3		Engineering judgment Assume 10% chance that subcooling lost implying operators trip pumps.
RCP_TRIP_SRV	RCP Trip (loss of RCS subcooling) given stuck open SRV	1.00E+00	Point Value		Prior condition implies RCPs are tripped by the operators.
RX_TRIP	ET-top Probability of an auto Rx-Trip given a SGTR	5.00E-01	Constrained Non-inform.		Assumption Engineering judgment used to set value to determine whether reactor trip important.
SLB1_ISO_F	ET-top Steam side of SLB fails to be isolated (No MSIVs)	1.00E+00	Point Value		Assumption Steam line break assumed to occur in section of piping that cannot be isolated. Thus, failure to isolate is 1.0.
SLB2_ISO_F	ET-top Steam side of SLB fails to be isolated (No MSIVs)	1.00E+00	Point Value		Assumption Steam line break assumed to occur in section of piping that cannot be isolated. Thus, failure to isolate is 1.0.
SRV_ISO_F	ET-top Stuck open SRV closes	2.50E-01	Lognormal EF = 1.5	6	Appendix I Section 1 of NUREG/CR-5750 indicates three (3) of four (4) stuck open PWR SRVs closed or "nearly closed." Thus, probability of stuck open SRV failing to close is 0.25.

Table 8.1. Basic events: value and uncertainty information.

Name	Description	Calc. Probability	Unc Type Unc Value 1 Unc Value 2	Corr. Class	Source Discussion
SRV_SO	SRV stuck open	1.60E-03	Beta 1.53E+03		NUREG/CR-5750-Addendum, Table D-4 Performed Bayes update using non-informative prior Beta (0.5, 0.5) with 2 failures in 1535 demands to yield posterior Beta (2.5, 1535.5).
TBV_1SO	One TBV stuck open	1.60E-03	Beta 3.13E+02		Oconee experience Oconee reactor-trips/shutdowns as of 3/15/2000 Unit 1 – 128 Unit 2 – 99 Unit 3 – 85 Total – 312 Information from Oconee states: TBVs open every Reactor-trip, but they have never had one stick open. (Note: TBVs were replaced a few years ago because of leakage problems.) Probability of stuck open TBV per reactor-trip obtained by performing Bayes update using non-informative prior Beta (0.5, 0.5) with 0 failures in 312 demands (0.5, 312.5).
TBV_1SO-CP	Conditional probabiolity that stuck open valve is a TBV	5.00E-01	Point Value		Assumption Engineering judgment of 50 percent likelihood that stuck open valve is TBV rather than MSSRV.

Table 8.1. Basic events: value and uncertainty information.

Name	Description	Calc. Probability	Unc Type Unc Value 1 Unc Value 2	Corr. Class	Source Discussion
TBV_1SO_SGTR	One TBV stuck open during SGTR	1.60E-02	Beta 3.13E+01		Assumption Value is assumed to be a facto of 10 greater than value for TBV_1SO.
TBV_2SO	Two TBVs stuck open	6.90E-05	Beta 3.13E+02		alpha factor method and CCF database [NUREG/CR-6268]
TBV_2SO-CP	Conditional probability that both stuck open valves are TBVs	2.50E-01	Point Value		Based on value for TBV_1SO-CP. (0.5)*(0.5) = 0.25
TBV_2SO_SGTR	Two TBVs stuck open during SGTR	6.90E-04	Beta 3.13E+01		Assumption Value is assumed to be a facto of 10 greater than value for TBV_2SO.
TBV_4SO	Four TBVs stuck open	6.40E-09	Beta 3.13E+02		alpha factor method and CCF database [NUREG/CR-6268]
TBV_4SO-CP	Conditional probability that all 4 stuck open valves are TBVs	6.30E-02	Point Value		Based on value for TBV_1SO-CP. (0.5)*(.5)*(0.5)*(0.5) = 0.063
TBV_4SO_SGTR	Four TBVs stuck open during SGTR	6.40E-08	Beta 3.13E+01		Assumption Value is assumed to be a factor of 10 greater than value for TBV_4SO.
TBV_EX	ET-top Prob TBV sticks open during SGTR motivated depress.	1.60E-02	Beta 3.15E+01		Assumption Value is assumed to be a factor of 10 greater than value for TBV_1SO.
TBV_SO_FI-TRUE	Stuck open valve is MS-SRV not isolatable	1.00E+00	Point Value		Prior conditions imply that stuck open valve is main steam safety relief valve. This valve cannot be isolated.

Table 8.1. Basic events: value and uncertainty information.

Name	Description	Calc. Probability	Unc Type Unc Value 1 Unc Value 2	Corr. Class	Source Discussion
TIME-SPLIT-1	Split Fraction for 100 vs 50 minute SO SRV Reclosure	5.00E-01	Point Value		UMD uncertainty report [Chang] Used to represent uncertainty associated with when stuck open SRV recloses.

9. QUANTIFICATION

This section describes how the frequencies for the final thermal-hydraulic (TH) bins were estimated and provides frequency distribution information for each bin. This TH bin frequency distribution information was then transmitted to the Nuclear Regulatory Commission's contractor at Oak Ridge National Laboratory who had responsibility for the probabilistic fracture mechanics (PFM) calculations. It was used as one of the inputs in producing an estimate of the through-wall-crack frequency (TWCF) for each TH bin. This TWCF estimate was produced by combining the TH bin frequency with the conditional probability of failure (CPF) of the reactor vessel given the specific TH conditions represented by the bin. Details of how the CPFs and TWCFs were calculated are provided in a separate report [TWCF].

9.1 Process for Estimating TH Bin Frequencies

The process for estimating the frequency of each of the final TH bins was relatively simple and straightforward. SAPHIRE [SAPHIRE] was used to perform an uncertainty analysis, using Latin Hypercube sampling, on the set of cut sets in each of the final TH bins. A sample size of 1000 was chosen to help ensure the robustness of the uncertainty calculation.

9.2 TH Bin Frequency Distributions

Distribution information for each of the 56 final TH bins was produced using the process described in section 9.1. Table 9.1 presents selected information (e.g., mean, maximum and minimum sampled values) from the uncertainty analysis for each TH bin. Table 9.2 presents the detailed quantile information for each TH bin.

Table 9.1. Selected information from uncertainty analysis for final Oconee TH bins.

End State (TH Bin)	Minimum Cut Upper Bound	Mean	5th	Median	95th	Minimum	Maximum	Standard Deviation	Skewness	Kurtosis	Samples	Seed
8	1.04E-07	9.68E-08	2.18E-10	2.21E-08	4.47E-07	2.73E-13	4.24E-06	2.44E-07	7.87E+00	1.01E+02	1000	12345
12	9.04E-07	9.24E-07	4.29E-09	3.33E-07	3.84E-06	2.79E-12	3.07E-05	1.87E-06	7.30E+00	9.13E+01	1000	12345
15	3.66E-08	3.39E-08	5.24E-11	7.18E-09	1.52E-07	6.32E-15	7.16E-07	7.64E-08	4.84E+00	3.23E+01	1000	12345
27	2.13E-06	2.13E-06	1.46E-07	9.03E-07	7.72E-06	2.51E-08	9.24E-05	4.63E-06	1.03E+01	1.67E+02	1000	12345
28	8.89E-08	7.53E-08	3.44E-11	7.80E-09	3.12E-07	1.61E-14	6.44E-06	3.15E-07	1.27E+01	2.17E+02	1000	12345
29	2.72E-07	3.09E-07	1.17E-09	2.65E-08	1.19E-06	1.11E-10	4.21E-05	1.79E-06	1.81E+01	3.83E+02	1000	12345
30	1.39E-07	1.46E-07	7.29E-11	1.22E-08	4.49E-07	1.90E-13	4.45E-05	1.44E-06	2.91E+01	8.93E+02	1000	12345
31	8.57E-09	8.36E-09	0.00E+00	0.00E+00	7.19E-09	0.00E+00	1.07E-06	6.93E-08	1.17E+01	1.54E+02	1000	12345
36	1.42E-05	1.40E-05	8.85E-07	6.05E-06	5.03E-05	1.54E-07	3.81E-04	2.72E-05	6.65E+00	6.66E+01	1000	12345
37	1.22E-06	1.41E-06	1.04E-09	1.67E-07	5.39E-06	4.19E-13	8.56E-05	5.73E-06	9.51E+00	1.12E+02	1000	12345
38	2.65E-06	2.65E-06	8.46E-08	8.32E-07	1.07E-05	1.45E-08	7.71E-05	5.75E-06	6.48E+00	6.31E+01	1000	12345
44	2.52E-07	2.69E-07	1.13E-11	1.77E-08	1.28E-06	1.81E-15	1.79E-05	1.02E-06	1.01E+01	1.36E+02	1000	12345
89	5.27E-07	5.38E-07	3.77E-10	7.80E-08	1.80E-06	2.25E-15	1.31E-04	4.27E-06	2.87E+01	8.75E+02	1000	12345
90	6.75E-07	6.29E-07	2.21E-10	1.98E-08	2.73E-06	7.56E-12	3.69E-05	2.62E-06	8.65E+00	9.68E+01	1000	12345
91	6.22E-06	6.12E-06	2.24E-08	2.07E-06	2.31E-05	8.95E-12	1.92E-04	1.28E-05	7.15E+00	7.96E+01	1000	12345
98	9.04E-08	9.96E-08	5.59E-11	1.11E-08	3.14E-07	1.14E-14	1.47E-05	5.62E-07	1.94E+01	4.69E+02	1000	12345
99	2.46E-07	2.44E-07	5.60E-09	6.96E-08	9.73E-07	1.01E-09	9.36E-06	6.74E-07	7.51E+00	7.43E+01	1000	12345
100	4.40E-08	5.11E-08	6.20E-10	9.71E-09	1.94E-07	6.60E-11	4.31E-06	2.19E-07	1.27E+01	2.05E+02	1000	12345
101	3.82E-07	3.86E-07	1.20E-08	1.32E-07	1.63E-06	3.05E-09	1.19E-05	8.57E-07	5.91E+00	5.32E+01	1000	12345
102	1.71E-07	2.03E-07	3.64E-10	1.58E-08	7.28E-07	4.21E-11	2.77E-05	1.19E-06	1.59E+01	3.21E+02	1000	12345
109	9.56E-06	9.58E-06	4.49E-08	1.74E-06	4.50E-05	4.17E-09	3.88E-04	2.59E-05	6.96E+00	7.25E+01	1000	12345
110	3.43E-06	3.42E-06	2.66E-08	1.07E-06	1.37E-05	9.54E-10	4.62E-05	6.18E-06	3.66E+00	1.94E+01	1000	12345
111	4.13E-07	4.16E-07	4.03E-11	4.92E-08	2.04E-06	1.63E-14	1.11E-05	1.04E-06	5.05E+00	3.70E+01	1000	12345
112	1.24E-04	1.25E-04	2.33E-05	1.02E-04	3.02E-04	4.60E-06	9.15E-04	9.35E-05	1.97E+00	1.06E+01	1000	12345
113	5.00E-05	5.07E-05	1.19E-06	2.44E-05	1.76E-04	3.93E-08	1.79E-03	9.79E-05	8.83E+00	1.24E+02	1000	12345
114	1.24E-04	1.25E-04	2.33E-05	1.02E-04	3.02E-04	4.60E-06	9.15E-04	9.35E-05	1.97E+00	1.06E+01	1000	12345
115	5.00E-05	5.07E-05	1.19E-06	2.44E-05	1.76E-04	3.93E-08	1.79E-03	9.79E-05	8.83E+00	1.24E+02	1000	12345
116	2.57E-07	2.60E-07	2.03E-11	2.98E-08	1.16E-06	4.55E-16	9.26E-06	7.52E-07	6.45E+00	5.68E+01	1000	12345
117	5.29E-07	5.38E-07	2.67E-11	6.08E-08	2.37E-06	1.58E-14	2.39E-05	1.59E-06	7.92E+00	9.01E+01	1000	12345

Table 9.1. Selected information from uncertainty analysis for final Oconee TH bins.

End State (TH Bin)	Minimum Cut Upper Bound	Mean	5th	Median	95th	Minimum	Maximum	Standard Deviation	Skewness	Kurtosis	Samples	Seed
119	4.42E-07	4.41E-07	1.23E-09	1.29E-07	1.96E-06	4.41E-11	1.20E-05	9.18E-07	5.33E+00	4.54E+01	1000	12345
120	4.73E-08	4.22E-08	5.17E-12	4.41E-09	2.19E-07	2.88E-17	1.17E-06	1.17E-07	5.50E+00	4.06E+01	1000	12345
121	2.28E-05	2.28E-05	3.74E-06	1.74E-05	5.99E-05	4.09E-07	1.87E-04	1.97E-05	2.76E+00	1.72E+01	1000	12345
122	7.69E-06	7.57E-06	1.88E-07	3.80E-06	2.76E-05	3.53E-09	8.33E-05	1.01E-05	2.80E+00	1.36E+01	1000	12345
123	2.28E-05	2.28E-05	3.74E-06	1.74E-05	5.99E-05	4.09E-07	1.87E-04	1.97E-05	2.76E+00	1.72E+01	1000	12345
124	7.69E-06	7.57E-06	1.88E-07	3.80E-06	2.76E-05	3.53E-09	8.33E-05	1.01E-05	2.80E+00	1.36E+01	1000	12345
125	4.47E-08	4.61E-08	3.52E-12	5.21E-09	2.25E-07	0.00E+00	1.09E-06	1.14E-07	4.54E+00	2.78E+01	1000	12345
126	9.69E-08	8.41E-08	9.58E-12	9.59E-09	3.82E-07	3.27E-15	2.75E-06	2.08E-07	5.74E+00	5.00E+01	1000	12345
127	1.25E-07	1.25E-07	3.65E-10	3.66E-08	5.59E-07	7.93E-14	6.18E-06	3.00E-07	1.01E+01	1.76E+02	1000	12345
141	1.06E-04	1.06E-04	2.79E-05	8.44E-05	2.52E-04	1.02E-05	6.71E-04	7.76E-05	2.19E+00	1.08E+01	1000	12345
142	1.06E-04	1.06E-04	2.79E-05	8.44E-05	2.52E-04	1.02E-05	6.71E-04	7.76E-05	2.19E+00	1.08E+01	1000	12345
145	1.34E-04	1.34E-04	3.52E-05	1.06E-04	3.18E-04	1.29E-05	8.45E-04	9.81E-05	2.20E+00	1.08E+01	1000	12345
146	4.23E-05	4.23E-05	7.21E-06	3.27E-05	1.10E-04	6.73E-07	2.43E-04	3.37E-05	1.82E+00	7.92E+00	1000	12345
147	3.63E-05	3.63E-05	6.18E-06	2.80E-05	9.44E-05	5.77E-07	2.09E-04	2.88E-05	1.82E+00	7.92E+00	1000	12345
148	4.23E-05	4.23E-05	7.21E-06	3.27E-05	1.10E-04	6.73E-07	2.43E-04	3.37E-05	1.82E+00	7.92E+00	1000	12345
149	9.56E-06	9.58E-06	4.49E-08	1.74E-06	4.50E-05	4.17E-09	3.88E-04	2.59E-05	6.96E+00	7.25E+01	1000	12345
154	1.34E-04	1.34E-04	3.52E-05	1.06E-04	3.18E-04	1.29E-05	8.45E-04	9.81E-05	2.20E+00	1.08E+01	1000	12345
156	7.00E-06	7.03E-06	2.64E-07	2.63E-06	2.61E-05	3.12E-08	3.39E-04	1.68E-05	1.05E+01	1.72E+02	1000	12345
160	1.84E-05	1.82E-05	6.87E-07	6.93E-06	6.84E-05	4.93E-08	6.57E-04	3.94E-05	7.79E+00	9.51E+01	1000	12345
164	2.14E-05	2.12E-05	8.02E-07	8.09E-06	7.98E-05	5.76E-08	7.66E-04	4.60E-05	7.79E+00	9.51E+01	1000	12345
165	1.68E-06	1.76E-06	5.40E-09	2.93E-07	8.24E-06	2.24E-10	4.64E-05	4.49E-06	4.99E+00	3.34E+01	1000	12345
168	1.68E-06	1.76E-06	5.40E-09	2.93E-07	8.24E-06	2.24E-10	4.64E-05	4.49E-06	4.99E+00	3.34E+01	1000	12345
169	7.43E-06	7.33E-06	1.05E-06	5.64E-06	1.86E-05	1.25E-07	7.93E-05	6.60E-06	3.31E+00	2.57E+01	1000	12345
170	6.36E-06	6.28E-06	9.02E-07	4.83E-06	1.59E-05	1.07E-07	6.79E-05	5.66E-06	3.31E+00	2.57E+01	1000	12345
171	7.43E-06	7.33E-06	1.05E-06	5.64E-06	1.86E-05	1.25E-07	7.93E-05	6.60E-06	3.31E+00	2.57E+01	1000	12345
172	1.06E-04	1.06E-04	2.79E-05	8.44E-05	2.52E-04	1.02E-05	6.71E-04	7.76E-05	2.19E+00	1.08E+01	1000	12345
178	2.14E-05	2.12E-05	8.02E-07	8.09E-06	7.98E-05	5.76E-08	7.66E-04	4.60E-05	7.79E+00	9.51E+01	1000	12345

Table 9.2. Detailed quantile information for final Oconee TH bins.

End State	Distribution Quantile (%)	95% Confidence Interval in %	Quantile Values	Lower Bound 95% Confidence Interval	Upper Bound 95% Confidence Interval
08	0.5	0.5	2.649E-012	2.728E-013	1.054E-011
	1.0	0.7	1.054E-011	1.353E-012	1.861E-011
	2.5	1.0	4.994E-011	1.839E-011	1.185E-010
	5.0	1.4	2.184E-010	1.199E-010	3.119E-010
	10.0	1.9	7.506E-010	4.884E-010	1.116E-009
	20.0	2.5	3.335E-009	2.559E-009	3.790E-009
	25.0	2.7	4.490E-009	3.775E-009	5.370E-009
	30.0	2.9	6.340E-009	5.285E-009	7.611E-009
	40.0	3.1	1.138E-008	9.148E-009	1.311E-008
	50.0	3.2	2.212E-008	1.791E-008	2.618E-008
	60.0	3.1	3.948E-008	3.405E-008	4.411E-008
	70.0	2.9	6.242E-008	5.209E-008	7.369E-008
	75.0	2.7	8.088E-008	7.170E-008	9.711E-008
	80.0	2.5	1.142E-007	9.549E-008	1.298E-007
	90.0	1.9	2.356E-007	2.030E-007	3.005E-007
	95.0	1.4	4.466E-007	3.966E-007	5.213E-007
	97.5	1.0	6.923E-007	5.404E-007	8.595E-007
	99.0	0.7	1.087E-006	8.215E-007	1.911E-006
	99.5	0.5	1.627E-006	1.087E-006	4.244E-006
12	0.5	0.5	3.287E-011	2.794E-012	1.227E-010
	1.0	0.7	1.227E-010	1.721E-011	4.966E-010
	2.5	1.0	1.013E-009	4.077E-010	2.006E-009
	5.0	1.4	4.291E-009	2.209E-009	7.367E-009
	10.0	1.9	1.290E-008	9.498E-009	1.642E-008
	20.0	2.5	4.279E-008	3.383E-008	6.087E-008
	25.0	2.7	8.019E-008	5.943E-008	1.034E-007
	30.0	2.9	1.174E-007	9.863E-008	1.361E-007
	40.0	3.1	2.077E-007	1.702E-007	2.400E-007
	50.0	3.2	3.330E-007	2.841E-007	3.700E-007
	60.0	3.1	5.002E-007	4.339E-007	5.754E-007
	70.0	2.9	7.734E-007	6.808E-007	8.969E-007
	75.0	2.7	9.839E-007	8.709E-007	1.116E-006
	80.0	2.5	1.248E-006	1.114E-006	1.458E-006
	90.0	1.9	2.371E-006	2.071E-006	2.661E-006
	95.0	1.4	3.843E-006	3.473E-006	4.394E-006
	97.5	1.0	5.693E-006	4.567E-006	6.904E-006
	99.0	0.7	7.759E-006	6.799E-006	1.060E-005
	99.5	0.5	1.058E-005	7.759E-006	3.070E-005

Table 9.2. Detailed quantile information for final Oconee TH bins.

End State	Distribution Quantile (%)	95% Confidence Interval in %	Quantile Values	Lower Bound 95% Confidence Interval	Upper Bound 95% Confidence Interval
15	0.5	0.5	7.554E-013	6.315E-015	2.790E-012
	1.0	0.7	2.790E-012	3.364E-013	5.132E-012
	2.5	1.0	1.467E-011	4.639E-012	2.847E-011
	5.0	1.4	5.236E-011	3.104E-011	8.073E-011
	10.0	1.9	1.934E-010	1.302E-010	2.669E-010
	20.0	2.5	9.166E-010	6.527E-010	1.126E-009
	25.0	2.7	1.424E-009	1.122E-009	1.857E-009
	30.0	2.9	2.330E-009	1.742E-009	2.867E-009
	40.0	3.1	4.221E-009	3.642E-009	4.990E-009
	50.0	3.2	7.177E-009	6.247E-009	8.356E-009
	60.0	3.1	1.297E-008	1.076E-008	1.466E-008
	70.0	2.9	2.309E-008	1.924E-008	2.728E-008
	75.0	2.7	3.073E-008	2.605E-008	3.611E-008
	80.0	2.5	4.172E-008	3.577E-008	5.089E-008
	90.0	1.9	8.628E-008	7.199E-008	1.096E-007
	95.0	1.4	1.521E-007	1.337E-007	1.879E-007
	97.5	1.0	2.491E-007	1.900E-007	3.285E-007
	99.0	0.7	4.450E-007	3.242E-007	5.977E-007
	99.5	0.5	5.959E-007	4.450E-007	7.157E-007
27	0.5	0.5	5.120E-008	2.513E-008	7.130E-008
	1.0	0.7	7.130E-008	4.935E-008	9.162E-008
	2.5	1.0	1.065E-007	8.950E-008	1.215E-007
	5.0	1.4	1.455E-007	1.233E-007	1.724E-007
	10.0	1.9	2.192E-007	1.893E-007	2.393E-007
	20.0	2.5	3.516E-007	3.091E-007	3.827E-007
	25.0	2.7	4.149E-007	3.817E-007	4.592E-007
	30.0	2.9	4.986E-007	4.487E-007	5.461E-007
	40.0	3.1	6.620E-007	6.036E-007	7.302E-007
	50.0	3.2	9.030E-007	8.346E-007	1.004E-006
	60.0	3.1	1.260E-006	1.131E-006	1.392E-006
	70.0	2.9	1.763E-006	1.591E-006	1.947E-006
	75.0	2.7	2.131E-006	1.929E-006	2.385E-006
	80.0	2.5	2.621E-006	2.375E-006	2.960E-006
	90.0	1.9	4.580E-006	4.192E-006	5.418E-006
	95.0	1.4	7.716E-006	6.356E-006	9.228E-006
	97.5	1.0	1.186E-005	9.434E-006	1.459E-005
	99.0	0.7	1.965E-005	1.428E-005	2.992E-005
	99.5	0.5	2.731E-005	1.965E-005	9.244E-005

Table 9.2. Detailed quantile information for final Oconee TH bins.

End State	Distribution Quantile (%)	95% Confidence Interval in %	Quantile Values	Lower Bound 95% Confidence Interval	Upper Bound 95% Confidence Interval
28	0.5	0.5	2.544E-013	1.609E-014	1.189E-012
	1.0	0.7	1.189E-012	1.629E-013	3.069E-012
	2.5	1.0	8.316E-012	1.935E-012	1.475E-011
	5.0	1.4	3.440E-011	2.179E-011	6.510E-011
	10.0	1.9	1.588E-010	9.571E-011	2.224E-010
	20.0	2.5	7.889E-010	6.016E-010	9.850E-010
	25.0	2.7	1.254E-009	9.805E-010	1.616E-009
	30.0	2.9	2.026E-009	1.532E-009	2.361E-009
	40.0	3.1	3.965E-009	3.115E-009	4.656E-009
	50.0	3.2	7.804E-009	6.403E-009	9.341E-009
	60.0	3.1	1.420E-008	1.202E-008	1.720E-008
	70.0	2.9	2.895E-008	2.290E-008	3.535E-008
	75.0	2.7	4.109E-008	3.457E-008	4.860E-008
	80.0	2.5	5.869E-008	4.748E-008	6.864E-008
	90.0	1.9	1.472E-007	1.251E-007	1.871E-007
	95.0	1.4	3.122E-007	2.460E-007	3.988E-007
	97.5	1.0	6.314E-007	4.109E-007	8.591E-007
	99.0	0.7	1.281E-006	8.500E-007	1.720E-006
	99.5	0.5	1.692E-006	1.281E-006	6.439E-006
29	0.5	0.5	1.818E-010	1.110E-010	3.703E-010
	1.0	0.7	3.703E-010	1.796E-010	4.623E-010
	2.5	1.0	6.307E-010	4.608E-010	7.620E-010
	5.0	1.4	1.166E-009	7.822E-010	1.342E-009
	10.0	1.9	2.340E-009	1.844E-009	2.866E-009
	20.0	2.5	5.348E-009	4.404E-009	6.304E-009
	25.0	2.7	7.446E-009	6.299E-009	8.814E-009
	30.0	2.9	9.890E-009	8.628E-009	1.147E-008
	40.0	3.1	1.620E-008	1.422E-008	1.886E-008
	50.0	3.2	2.653E-008	2.310E-008	3.003E-008
	60.0	3.1	4.806E-008	3.945E-008	5.754E-008
	70.0	2.9	8.681E-008	7.453E-008	1.126E-007
	75.0	2.7	1.309E-007	1.083E-007	1.631E-007
	80.0	2.5	1.936E-007	1.625E-007	2.397E-007
	90.0	1.9	5.275E-007	4.181E-007	6.437E-007
	95.0	1.4	1.186E-006	9.555E-007	1.506E-006
	97.5	1.0	2.454E-006	1.622E-006	3.473E-006
	99.0	0.7	4.206E-006	3.305E-006	5.991E-006
	99.5	0.5	5.876E-006	4.206E-006	4.214E-005

Table 9.2. Detailed quantile information for final Oconee TH bins.

End State	Distribution Quantile (%)	95% Confidence Interval in %	Quantile Values	Lower Bound 95% Confidence Interval	Upper Bound 95% Confidence Interval
30	0.5	0.5	6.517E-013	1.898E-013	1.969E-012
	1.0	0.7	1.969E-012	4.827E-013	5.314E-012
	2.5	1.0	2.132E-011	5.297E-012	4.331E-011
	5.0	1.4	7.286E-011	4.454E-011	1.185E-010
	10.0	1.9	2.077E-010	1.524E-010	2.697E-010
	20.0	2.5	9.543E-010	7.917E-010	1.269E-009
	25.0	2.7	1.616E-009	1.266E-009	2.258E-009
	30.0	2.9	2.890E-009	2.086E-009	3.677E-009
	40.0	3.1	6.317E-009	5.128E-009	7.473E-009
	50.0	3.2	1.223E-008	1.014E-008	1.505E-008
	60.0	3.1	2.279E-008	1.874E-008	2.709E-008
	70.0	2.9	4.328E-008	3.677E-008	5.117E-008
	75.0	2.7	5.873E-008	4.994E-008	6.810E-008
	80.0	2.5	8.309E-008	6.789E-008	9.581E-008
	90.0	1.9	2.070E-007	1.613E-007	2.605E-007
	95.0	1.4	4.493E-007	3.695E-007	6.487E-007
	97.5	1.0	9.939E-007	7.121E-007	1.386E-006
	99.0	0.7	2.093E-006	1.287E-006	3.538E-006
	99.5	0.5	3.108E-006	2.093E-006	4.445E-005
31	0.5	0.5	+0.000E+000	+0.000E+000	+0.000E+000
	1.0	0.7	+0.000E+000	+0.000E+000	+0.000E+000
	2.5	1.0	+0.000E+000	+0.000E+000	+0.000E+000
	5.0	1.4	+0.000E+000	+0.000E+000	+0.000E+000
	10.0	1.9	+0.000E+000	+0.000E+000	+0.000E+000
	20.0	2.5	+0.000E+000	+0.000E+000	+0.000E+000
	25.0	2.7	+0.000E+000	+0.000E+000	+0.000E+000
	30.0	2.9	+0.000E+000	+0.000E+000	+0.000E+000
	40.0	3.1	+0.000E+000	+0.000E+000	+0.000E+000
	50.0	3.2	+0.000E+000	+0.000E+000	+0.000E+000
	60.0	3.1	+0.000E+000	+0.000E+000	+0.000E+000
	70.0	2.9	2.764E-015	4.247E-016	1.447E-014
	75.0	2.7	8.688E-014	1.065E-014	5.127E-013
	80.0	2.5	2.196E-012	5.106E-013	7.089E-012
	90.0	1.9	2.387E-010	9.540E-011	9.226E-010
	95.0	1.4	7.185E-009	4.181E-009	2.025E-008
	97.5	1.0	4.180E-008	2.397E-008	9.484E-008
	99.0	0.7	2.789E-007	8.597E-008	7.877E-007
	99.5	0.5	5.959E-007	2.789E-007	1.073E-006

Table 9.2. Detailed quantile information for final Oconee TH bins.

End State	Distribution Quantile (%)	95% Confidence Interval in %	Quantile Values	Lower Bound 95% Confidence Interval	Upper Bound 95% Confidence Interval
36	0.5	0.5	2.707E-007	1.537E-007	5.046E-007
	1.0	0.7	5.046E-007	2.631E-007	6.038E-007
	2.5	1.0	7.167E-007	5.888E-007	7.697E-007
	5.0	1.4	8.849E-007	7.974E-007	1.013E-006
	10.0	1.9	1.408E-006	1.166E-006	1.571E-006
	20.0	2.5	2.322E-006	2.097E-006	2.601E-006
	25.0	2.7	2.844E-006	2.594E-006	3.070E-006
	30.0	2.9	3.334E-006	3.019E-006	3.677E-006
	40.0	3.1	4.634E-006	4.268E-006	5.060E-006
	50.0	3.2	6.052E-006	5.635E-006	6.599E-006
	60.0	3.1	8.346E-006	7.399E-006	8.929E-006
	70.0	2.9	1.146E-005	1.047E-005	1.293E-005
	75.0	2.7	1.390E-005	1.273E-005	1.528E-005
	80.0	2.5	1.769E-005	1.515E-005	1.988E-005
	90.0	1.9	3.099E-005	2.726E-005	3.718E-005
	95.0	1.4	5.032E-005	4.402E-005	6.131E-005
	97.5	1.0	7.742E-005	6.333E-005	9.886E-005
	99.0	0.7	1.396E-004	9.619E-005	1.994E-004
	99.5	0.5	1.914E-004	1.396E-004	3.814E-004
37	0.5	0.5	1.072E-011	4.188E-013	3.241E-011
	1.0	0.7	3.241E-011	8.898E-012	1.348E-010
	2.5	1.0	2.336E-010	8.808E-011	3.230E-010
	5.0	1.4	1.039E-009	3.957E-010	1.632E-009
	10.0	1.9	3.626E-009	2.776E-009	4.951E-009
	20.0	2.5	1.507E-008	1.154E-008	1.760E-008
	25.0	2.7	2.563E-008	1.752E-008	3.146E-008
	30.0	2.9	3.876E-008	2.971E-008	5.017E-008
	40.0	3.1	8.873E-008	6.696E-008	1.054E-007
	50.0	3.2	1.672E-007	1.451E-007	1.883E-007
	60.0	3.1	2.869E-007	2.426E-007	3.376E-007
	70.0	2.9	5.515E-007	4.071E-007	6.323E-007
	75.0	2.7	7.276E-007	6.259E-007	8.772E-007
	80.0	2.5	1.131E-006	8.749E-007	1.345E-006
	90.0	1.9	2.479E-006	2.029E-006	2.913E-006
	95.0	1.4	5.389E-006	3.756E-006	6.668E-006
	97.5	1.0	1.036E-005	7.375E-006	1.716E-005
	99.0	0.7	2.551E-005	1.563E-005	5.559E-005
	99.5	0.5	5.021E-005	2.551E-005	8.562E-005

Table 9.2. Detailed quantile information for final Oconee TH bins.

End State	Distribution Quantile (%)	95% Confidence Interval in %	Quantile Values	Lower Bound 95% Confidence Interval	Upper Bound 95% Confidence Interval
38	0.5	0.5	2.273E-008	1.445E-008	3.105E-008
	1.0	0.7	3.105E-008	1.908E-008	3.981E-008
	2.5	1.0	5.353E-008	3.804E-008	6.433E-008
	5.0	1.4	8.459E-008	6.761E-008	9.541E-008
	10.0	1.9	1.257E-007	1.101E-007	1.496E-007
	20.0	2.5	2.414E-007	2.132E-007	2.747E-007
	25.0	2.7	3.033E-007	2.742E-007	3.472E-007
	30.0	2.9	3.889E-007	3.438E-007	4.304E-007
	40.0	3.1	5.830E-007	4.938E-007	6.615E-007
	50.0	3.2	8.317E-007	7.494E-007	9.312E-007
	60.0	3.1	1.288E-006	1.133E-006	1.463E-006
	70.0	2.9	2.017E-006	1.730E-006	2.366E-006
	75.0	2.7	2.709E-006	2.293E-006	2.916E-006
	80.0	2.5	3.417E-006	2.913E-006	3.735E-006
	90.0	1.9	6.135E-006	5.341E-006	7.117E-006
	95.0	1.4	1.067E-005	8.977E-006	1.462E-005
	97.5	1.0	1.724E-005	1.475E-005	2.146E-005
	99.0	0.7	2.595E-005	2.109E-005	4.553E-005
	99.5	0.5	3.967E-005	2.595E-005	7.708E-005
44	0.5	0.5	7.499E-015	1.809E-015	1.031E-013
	1.0	0.7	1.031E-013	7.063E-015	4.737E-013
	2.5	1.0	1.808E-012	4.156E-013	3.809E-012
	5.0	1.4	1.129E-011	4.238E-012	1.802E-011
	10.0	1.9	7.060E-011	4.524E-011	1.176E-010
	20.0	2.5	6.831E-010	4.803E-010	9.357E-010
	25.0	2.7	1.369E-009	9.038E-010	1.903E-009
	30.0	2.9	2.545E-009	1.814E-009	3.302E-009
	40.0	3.1	6.635E-009	4.534E-009	9.698E-009
	50.0	3.2	1.774E-008	1.412E-008	2.220E-008
	60.0	3.1	3.704E-008	2.865E-008	4.667E-008
	70.0	2.9	8.793E-008	6.617E-008	1.115E-007
	75.0	2.7	1.361E-007	1.087E-007	1.704E-007
	80.0	2.5	1.966E-007	1.669E-007	2.312E-007
	90.0	1.9	6.125E-007	4.915E-007	8.164E-007
	95.0	1.4	1.280E-006	1.029E-006	1.618E-006
	97.5	1.0	2.117E-006	1.681E-006	2.880E-006
	99.0	0.7	4.098E-006	2.728E-006	9.068E-006
	99.5	0.5	7.319E-006	4.098E-006	1.789E-005

Table 9.2. Detailed quantile information for final Oconee TH bins.

End State	Distribution Quantile (%)	95% Confidence Interval in %	Quantile Values	Lower Bound 95% Confidence Interval	Upper Bound 95% Confidence Interval
89	0.5	0.5	5.041E-012	2.251E-015	1.509E-011
	1.0	0.7	1.509E-011	3.075E-013	3.995E-011
	2.5	1.0	7.255E-011	2.623E-011	1.388E-010
	5.0	1.4	3.770E-010	1.416E-010	5.461E-010
	10.0	1.9	1.756E-009	1.132E-009	2.449E-009
	20.0	2.5	6.960E-009	5.000E-009	8.527E-009
	25.0	2.7	1.074E-008	8.490E-009	1.371E-008
	30.0	2.9	1.753E-008	1.262E-008	2.146E-008
	40.0	3.1	3.871E-008	3.045E-008	4.871E-008
	50.0	3.2	7.796E-008	6.151E-008	8.780E-008
	60.0	3.1	1.400E-007	1.165E-007	1.649E-007
	70.0	2.9	2.225E-007	2.008E-007	2.535E-007
	75.0	2.7	2.981E-007	2.471E-007	3.646E-007
	80.0	2.5	4.473E-007	3.632E-007	5.265E-007
	90.0	1.9	9.514E-007	8.055E-007	1.190E-006
	95.0	1.4	1.799E-006	1.618E-006	2.419E-006
	97.5	1.0	3.446E-006	2.558E-006	4.521E-006
	99.0	0.7	6.050E-006	4.456E-006	1.038E-005
	99.5	0.5	7.957E-006	6.050E-006	1.311E-004
90	0.5	0.5	1.713E-011	7.557E-012	3.368E-011
	1.0	0.7	3.368E-011	1.571E-011	6.558E-011
	2.5	1.0	1.007E-010	6.359E-011	1.304E-010
	5.0	1.4	2.212E-010	1.385E-010	2.869E-010
	10.0	1.9	4.278E-010	3.772E-010	5.767E-010
	20.0	2.5	1.688E-009	1.117E-009	2.238E-009
	25.0	2.7	2.808E-009	2.211E-009	3.470E-009
	30.0	2.9	4.282E-009	3.381E-009	5.213E-009
	40.0	3.1	9.460E-009	7.239E-009	1.199E-008
	50.0	3.2	1.979E-008	1.632E-008	2.443E-008
	60.0	3.1	3.945E-008	3.270E-008	5.214E-008
	70.0	2.9	9.555E-008	7.371E-008	1.245E-007
	75.0	2.7	1.601E-007	1.154E-007	2.059E-007
	80.0	2.5	2.753E-007	2.055E-007	3.846E-007
	90.0	1.9	1.162E-006	9.144E-007	1.424E-006
	95.0	1.4	2.734E-006	2.092E-006	4.030E-006
	97.5	1.0	6.489E-006	4.723E-006	8.706E-006
	99.0	0.7	1.260E-005	8.411E-006	2.378E-005
	99.5	0.5	2.145E-005	1.260E-005	3.688E-005

Table 9.2. Detailed quantile information for final Oconee TH bins.

End State	Distribution Quantile (%)	95% Confidence Interval in %	Quantile Values	Lower Bound 95% Confidence Interval	Upper Bound 95% Confidence Interval
91	0.5	0.5	1.077E-010	8.950E-012	4.877E-010
	1.0	0.7	4.877E-010	5.088E-011	2.354E-009
	2.5	1.0	5.579E-009	1.807E-009	1.154E-008
	5.0	1.4	2.243E-008	1.350E-008	3.207E-008
	10.0	1.9	6.886E-008	4.575E-008	9.874E-008
	20.0	2.5	2.718E-007	2.192E-007	3.615E-007
	25.0	2.7	4.669E-007	3.613E-007	6.031E-007
	30.0	2.9	7.027E-007	5.758E-007	8.458E-007
	40.0	3.1	1.250E-006	1.045E-006	1.489E-006
	50.0	3.2	2.074E-006	1.762E-006	2.370E-006
	60.0	3.1	3.408E-006	2.936E-006	3.784E-006
	70.0	2.9	5.486E-006	4.761E-006	6.306E-006
	75.0	2.7	7.172E-006	6.228E-006	8.116E-006
	80.0	2.5	9.128E-006	8.081E-006	9.933E-006
	90.0	1.9	1.516E-005	1.366E-005	1.774E-005
	95.0	1.4	2.307E-005	1.950E-005	2.774E-005
	97.5	1.0	3.477E-005	2.883E-005	4.418E-005
	99.0	0.7	5.187E-005	4.341E-005	1.031E-004
	99.5	0.5	7.006E-005	5.187E-005	1.916E-004
98	0.5	0.5	8.123E-013	1.137E-014	2.348E-012
	1.0	0.7	2.348E-012	1.037E-013	7.853E-012
	2.5	1.0	1.531E-011	7.049E-012	2.441E-011
	5.0	1.4	5.591E-011	2.561E-011	8.343E-011
	10.0	1.9	2.701E-010	1.734E-010	3.401E-010
	20.0	2.5	1.014E-009	7.839E-010	1.314E-009
	25.0	2.7	1.704E-009	1.305E-009	2.230E-009
	30.0	2.9	2.908E-009	2.129E-009	3.659E-009
	40.0	3.1	6.105E-009	4.929E-009	7.162E-009
	50.0	3.2	1.112E-008	9.109E-009	1.342E-008
	60.0	3.1	1.960E-008	1.723E-008	2.345E-008
	70.0	2.9	3.434E-008	2.906E-008	4.069E-008
	75.0	2.7	4.678E-008	3.964E-008	5.685E-008
	80.0	2.5	7.045E-008	5.679E-008	8.605E-008
	90.0	1.9	1.660E-007	1.375E-007	2.131E-007
	95.0	1.4	3.143E-007	2.762E-007	4.645E-007
	97.5	1.0	6.823E-007	4.944E-007	1.026E-006
	99.0	0.7	1.526E-006	9.765E-007	2.945E-006
	99.5	0.5	2.399E-006	1.526E-006	1.466E-005

Table 9.2. Detailed quantile information for final Oconee TH bins.

End State	Distribution Quantile (%)	95% Confidence Interval in %	Quantile Values	Lower Bound 95% Confidence Interval	Upper Bound 95% Confidence Interval
99	0.5	0.5	1.812E-009	1.011E-009	2.435E-009
	1.0	0.7	2.435E-009	1.685E-009	3.090E-009
	2.5	1.0	3.631E-009	3.050E-009	4.150E-009
	5.0	1.4	5.603E-009	4.465E-009	7.297E-009
	10.0	1.9	1.040E-008	9.121E-009	1.172E-008
	20.0	2.5	1.940E-008	1.706E-008	2.228E-008
	25.0	2.7	2.489E-008	2.219E-008	2.799E-008
	30.0	2.9	3.053E-008	2.747E-008	3.446E-008
	40.0	3.1	4.656E-008	4.223E-008	5.117E-008
	50.0	3.2	6.956E-008	6.118E-008	7.971E-008
	60.0	3.1	1.054E-007	9.162E-008	1.146E-007
	70.0	2.9	1.528E-007	1.328E-007	1.697E-007
	75.0	2.7	1.930E-007	1.663E-007	2.163E-007
	80.0	2.5	2.477E-007	2.162E-007	2.911E-007
	90.0	1.9	4.903E-007	4.160E-007	5.977E-007
	95.0	1.4	9.728E-007	7.593E-007	1.129E-006
	97.5	1.0	1.558E-006	1.267E-006	2.186E-006
	99.0	0.7	4.010E-006	2.098E-006	6.573E-006
	99.5	0.5	6.374E-006	4.010E-006	9.359E-006
100	0.5	0.5	1.359E-010	6.597E-011	2.447E-010
	1.0	0.7	2.447E-010	1.242E-010	3.367E-010
	2.5	1.0	4.171E-010	3.285E-010	4.499E-010
	5.0	1.4	6.204E-010	4.520E-010	7.390E-010
	10.0	1.9	1.117E-009	9.572E-010	1.317E-009
	20.0	2.5	2.191E-009	1.892E-009	2.476E-009
	25.0	2.7	2.680E-009	2.472E-009	3.065E-009
	30.0	2.9	3.513E-009	2.981E-009	4.088E-009
	40.0	3.1	5.703E-009	4.936E-009	6.586E-009
	50.0	3.2	9.712E-009	8.076E-009	1.132E-008
	60.0	3.1	1.513E-008	1.330E-008	1.664E-008
	70.0	2.9	2.408E-008	2.090E-008	2.777E-008
	75.0	2.7	3.034E-008	2.733E-008	3.373E-008
	80.0	2.5	3.996E-008	3.347E-008	4.545E-008
	90.0	1.9	7.642E-008	6.931E-008	1.014E-007
	95.0	1.4	1.936E-007	1.449E-007	2.473E-007
	97.5	1.0	3.478E-007	2.548E-007	5.430E-007
	99.0	0.7	6.635E-007	5.210E-007	1.654E-006
	99.5	0.5	1.230E-006	6.635E-007	4.310E-006

Table 9.2. Detailed quantile information for final Oconee TH bins.

End State	Distribution Quantile (%)	95% Confidence Interval in %	Quantile Values	Lower Bound 95% Confidence Interval	Upper Bound 95% Confidence Interval
101	0.5	0.5	4.151E-009	3.051E-009	4.658E-009
	1.0	0.7	4.658E-009	3.852E-009	6.045E-009
	2.5	1.0	7.505E-009	5.751E-009	1.039E-008
	5.0	1.4	1.201E-008	1.049E-008	1.479E-008
	10.0	1.9	1.943E-008	1.742E-008	2.216E-008
	20.0	2.5	3.379E-008	2.989E-008	3.984E-008
	25.0	2.7	4.493E-008	3.968E-008	4.963E-008
	30.0	2.9	5.644E-008	4.903E-008	6.352E-008
	40.0	3.1	8.677E-008	7.763E-008	9.810E-008
	50.0	3.2	1.315E-007	1.133E-007	1.455E-007
	60.0	3.1	1.777E-007	1.622E-007	1.937E-007
	70.0	2.9	2.695E-007	2.357E-007	3.015E-007
	75.0	2.7	3.350E-007	2.950E-007	3.759E-007
	80.0	2.5	4.586E-007	3.724E-007	5.067E-007
	90.0	1.9	8.930E-007	7.536E-007	1.046E-006
	95.0	1.4	1.626E-006	1.304E-006	1.921E-006
	97.5	1.0	2.960E-006	2.188E-006	4.029E-006
	99.0	0.7	4.578E-006	3.918E-006	6.584E-006
	99.5	0.5	5.647E-006	4.578E-006	1.193E-005
102	0.5	0.5	8.496E-011	4.208E-011	1.120E-010
	1.0	0.7	1.120E-010	7.222E-011	1.630E-010
	2.5	1.0	2.035E-010	1.594E-010	2.295E-010
	5.0	1.4	3.637E-010	2.401E-010	4.765E-010
	10.0	1.9	8.202E-010	6.281E-010	9.697E-010
	20.0	2.5	2.130E-009	1.705E-009	2.703E-009
	25.0	2.7	3.217E-009	2.698E-009	3.846E-009
	30.0	2.9	4.356E-009	3.759E-009	5.046E-009
	40.0	3.1	8.238E-009	6.986E-009	1.013E-008
	50.0	3.2	1.584E-008	1.229E-008	1.796E-008
	60.0	3.1	2.748E-008	2.342E-008	3.416E-008
	70.0	2.9	4.992E-008	4.475E-008	5.962E-008
	75.0	2.7	7.071E-008	5.884E-008	8.255E-008
	80.0	2.5	1.044E-007	8.179E-008	1.252E-007
	90.0	1.9	2.762E-007	2.300E-007	4.117E-007
	95.0	1.4	7.282E-007	5.256E-007	9.929E-007
	97.5	1.0	1.415E-006	1.123E-006	2.204E-006
	99.0	0.7	3.344E-006	2.111E-006	1.170E-005
	99.5	0.5	7.396E-006	3.344E-006	2.769E-005

Table 9.2. Detailed quantile information for final Oconee TH bins.

End State	Distribution Quantile (%)	95% Confidence Interval in %	Quantile Values	Lower Bound 95% Confidence Interval	Upper Bound 95% Confidence Interval
109	0.5	0.5	6.418E-009	4.168E-009	9.612E-009
	1.0	0.7	9.612E-009	6.277E-009	1.654E-008
	2.5	1.0	2.500E-008	1.576E-008	3.082E-008
	5.0	1.4	4.492E-008	3.219E-008	5.604E-008
	10.0	1.9	8.949E-008	7.099E-008	1.095E-007
	20.0	2.5	2.163E-007	1.817E-007	2.609E-007
	25.0	2.7	3.050E-007	2.586E-007	3.665E-007
	30.0	2.9	4.408E-007	3.606E-007	5.318E-007
	40.0	3.1	8.572E-007	7.091E-007	1.036E-006
	50.0	3.2	1.742E-006	1.335E-006	2.149E-006
	60.0	3.1	3.228E-006	2.639E-006	3.806E-006
	70.0	2.9	5.771E-006	4.810E-006	6.618E-006
	75.0	2.7	7.436E-006	6.553E-006	8.902E-006
	80.0	2.5	1.054E-005	8.897E-006	1.206E-005
	90.0	1.9	2.200E-005	1.951E-005	2.527E-005
	95.0	1.4	4.502E-005	3.345E-005	5.815E-005
	97.5	1.0	7.655E-005	6.006E-005	1.028E-004
	99.0	0.7	1.407E-004	1.007E-004	2.028E-004
	99.5	0.5	1.559E-004	1.407E-004	3.879E-004
110	0.5	0.5	3.443E-009	9.543E-010	4.356E-009
	1.0	0.7	4.356E-009	2.795E-009	5.728E-009
	2.5	1.0	9.019E-009	5.451E-009	1.402E-008
	5.0	1.4	2.657E-008	1.718E-008	3.663E-008
	10.0	1.9	5.736E-008	4.661E-008	7.388E-008
	20.0	2.5	1.821E-007	1.383E-007	2.358E-007
	25.0	2.7	2.762E-007	2.336E-007	3.188E-007
	30.0	2.9	3.726E-007	3.023E-007	4.359E-007
	40.0	3.1	6.870E-007	5.469E-007	7.809E-007
	50.0	3.2	1.072E-006	9.154E-007	1.234E-006
	60.0	3.1	1.680E-006	1.442E-006	1.954E-006
	70.0	2.9	2.765E-006	2.479E-006	3.205E-006
	75.0	2.7	3.609E-006	3.168E-006	4.286E-006
	80.0	2.5	4.883E-006	4.276E-006	5.815E-006
	90.0	1.9	9.419E-006	8.133E-006	1.089E-005
	95.0	1.4	1.366E-005	1.254E-005	1.674E-005
	97.5	1.0	2.308E-005	1.707E-005	2.807E-005
	99.0	0.7	3.495E-005	2.754E-005	4.113E-005
	99.5	0.5	4.108E-005	3.495E-005	4.624E-005

Table 9.2. Detailed quantile information for final Oconee TH bins.

End State	Distribution Quantile (%)	95% Confidence Interval in %	Quantile Values	Lower Bound 95% Confidence Interval	Upper Bound 95% Confidence Interval
111	0.5	0.5	8.762E-014	1.626E-014	1.379E-012
	1.0	0.7	1.379E-012	7.881E-014	2.547E-012
	2.5	1.0	6.797E-012	1.784E-012	1.139E-011
	5.0	1.4	4.025E-011	1.849E-011	9.062E-011
	10.0	1.9	3.282E-010	2.055E-010	6.289E-010
	20.0	2.5	2.213E-009	1.755E-009	3.344E-009
	25.0	2.7	4.659E-009	3.287E-009	6.656E-009
	30.0	2.9	8.801E-009	6.491E-009	1.142E-008
	40.0	3.1	1.936E-008	1.546E-008	2.550E-008
	50.0	3.2	4.917E-008	3.515E-008	6.305E-008
	60.0	3.1	1.065E-007	8.607E-008	1.290E-007
	70.0	2.9	2.014E-007	1.695E-007	2.441E-007
	75.0	2.7	2.831E-007	2.365E-007	3.572E-007
	80.0	2.5	4.675E-007	3.562E-007	5.688E-007
	90.0	1.9	1.191E-006	9.535E-007	1.387E-006
	95.0	1.4	2.037E-006	1.686E-006	2.824E-006
	97.5	1.0	3.409E-006	2.837E-006	4.551E-006
	99.0	0.7	5.605E-006	4.444E-006	7.111E-006
	99.5	0.5	6.896E-006	5.605E-006	1.105E-005
112	0.5	0.5	8.603E-006	4.600E-006	1.065E-005
	1.0	0.7	1.065E-005	8.105E-006	1.326E-005
	2.5	1.0	1.672E-005	1.256E-005	1.937E-005
	5.0	1.4	2.325E-005	2.011E-005	2.735E-005
	10.0	1.9	3.424E-005	3.088E-005	3.617E-005
	20.0	2.5	5.035E-005	4.656E-005	5.319E-005
	25.0	2.7	5.833E-005	5.318E-005	6.378E-005
	30.0	2.9	6.764E-005	6.206E-005	7.213E-005
	40.0	3.1	8.402E-005	7.879E-005	8.884E-005
	50.0	3.2	1.023E-004	9.735E-005	1.069E-004
	60.0	3.1	1.234E-004	1.155E-004	1.296E-004
	70.0	2.9	1.476E-004	1.383E-004	1.548E-004
	75.0	2.7	1.620E-004	1.538E-004	1.727E-004
	80.0	2.5	1.867E-004	1.722E-004	1.966E-004
	90.0	1.9	2.526E-004	2.327E-004	2.694E-004
	95.0	1.4	3.016E-004	2.866E-004	3.123E-004
	97.5	1.0	3.471E-004	3.142E-004	3.984E-004
	99.0	0.7	4.562E-004	3.943E-004	5.704E-004
	99.5	0.5	5.555E-004	4.562E-004	9.153E-004

Table 9.2. Detailed quantile information for final Oconee TH bins.

End State	Distribution Quantile (%)	95% Confidence Interval in %	Quantile Values	Lower Bound 95% Confidence Interval	Upper Bound 95% Confidence Interval
113	0.5	0.5	7.527E-008	3.926E-008	1.568E-007
	1.0	0.7	1.568E-007	6.990E-008	2.620E-007
	2.5	1.0	5.663E-007	2.414E-007	9.108E-007
	5.0	1.4	1.194E-006	9.247E-007	1.541E-006
	10.0	1.9	2.785E-006	2.187E-006	3.058E-006
	20.0	2.5	6.282E-006	5.482E-006	7.181E-006
	25.0	2.7	8.184E-006	7.148E-006	9.269E-006
	30.0	2.9	9.923E-006	9.036E-006	1.158E-005
	40.0	3.1	1.594E-005	1.417E-005	1.836E-005
	50.0	3.2	2.444E-005	2.148E-005	2.667E-005
	60.0	3.1	3.404E-005	3.101E-005	3.833E-005
	70.0	2.9	4.981E-005	4.501E-005	5.477E-005
	75.0	2.7	5.960E-005	5.436E-005	6.813E-005
	80.0	2.5	7.249E-005	6.798E-005	8.056E-005
	90.0	1.9	1.144E-004	1.043E-004	1.310E-004
	95.0	1.4	1.755E-004	1.517E-004	1.892E-004
	97.5	1.0	2.165E-004	1.924E-004	3.177E-004
	99.0	0.7	4.245E-004	3.088E-004	7.929E-004
	99.5	0.5	6.315E-004	4.245E-004	1.787E-003
114	0.5	0.5	8.603E-006	4.600E-006	1.065E-005
	1.0	0.7	1.065E-005	8.105E-006	1.326E-005
	2.5	1.0	1.672E-005	1.256E-005	1.937E-005
	5.0	1.4	2.325E-005	2.011E-005	2.735E-005
	10.0	1.9	3.424E-005	3.088E-005	3.617E-005
	20.0	2.5	5.035E-005	4.656E-005	5.319E-005
	25.0	2.7	5.833E-005	5.318E-005	6.378E-005
	30.0	2.9	6.764E-005	6.206E-005	7.213E-005
	40.0	3.1	8.402E-005	7.879E-005	8.884E-005
	50.0	3.2	1.023E-004	9.735E-005	1.069E-004
	60.0	3.1	1.234E-004	1.155E-004	1.296E-004
	70.0	2.9	1.476E-004	1.383E-004	1.548E-004
	75.0	2.7	1.620E-004	1.538E-004	1.727E-004
	80.0	2.5	1.867E-004	1.722E-004	1.966E-004
	90.0	1.9	2.526E-004	2.327E-004	2.694E-004
	95.0	1.4	3.016E-004	2.866E-004	3.123E-004
	97.5	1.0	3.471E-004	3.142E-004	3.984E-004
	99.0	0.7	4.562E-004	3.943E-004	5.704E-004
	99.5	0.5	5.555E-004	4.562E-004	9.153E-004

Table 9.2. Detailed quantile information for final Oconee TH bins.

End State	Distribution Quantile (%)	95% Confidence Interval in %	Quantile Values	Lower Bound 95% Confidence Interval	Upper Bound 95% Confidence Interval
115	0.5	0.5	7.527E-008	3.926E-008	1.568E-007
	1.0	0.7	1.568E-007	6.990E-008	2.620E-007
	2.5	1.0	5.663E-007	2.414E-007	9.108E-007
	5.0	1.4	1.194E-006	9.247E-007	1.541E-006
	10.0	1.9	2.785E-006	2.187E-006	3.058E-006
	20.0	2.5	6.282E-006	5.482E-006	7.181E-006
	25.0	2.7	8.184E-006	7.148E-006	9.269E-006
	30.0	2.9	9.923E-006	9.036E-006	1.158E-005
	40.0	3.1	1.594E-005	1.417E-005	1.836E-005
	50.0	3.2	2.444E-005	2.148E-005	2.667E-005
	60.0	3.1	3.404E-005	3.101E-005	3.833E-005
	70.0	2.9	4.981E-005	4.501E-005	5.477E-005
	75.0	2.7	5.960E-005	5.436E-005	6.813E-005
	80.0	2.5	7.249E-005	6.798E-005	8.056E-005
	90.0	1.9	1.144E-004	1.043E-004	1.310E-004
	95.0	1.4	1.755E-004	1.517E-004	1.892E-004
	97.5	1.0	2.165E-004	1.924E-004	3.177E-004
	99.0	0.7	4.245E-004	3.088E-004	7.929E-004
	99.5	0.5	6.315E-004	4.245E-004	1.787E-003
116	0.5	0.5	6.828E-014	4.551E-016	4.147E-013
	1.0	0.7	4.147E-013	5.640E-014	1.171E-012
	2.5	1.0	5.115E-012	1.053E-012	7.445E-012
	5.0	1.4	2.030E-011	9.441E-012	4.455E-011
	10.0	1.9	1.537E-010	8.845E-011	2.400E-010
	20.0	2.5	1.367E-009	8.678E-010	1.847E-009
	25.0	2.7	2.378E-009	1.843E-009	3.492E-009
	30.0	2.9	4.873E-009	3.273E-009	7.045E-009
	40.0	3.1	1.405E-008	1.105E-008	1.766E-008
	50.0	3.2	2.982E-008	2.479E-008	3.735E-008
	60.0	3.1	6.128E-008	4.974E-008	7.385E-008
	70.0	2.9	1.244E-007	1.020E-007	1.501E-007
	75.0	2.7	1.840E-007	1.450E-007	2.296E-007
	80.0	2.5	2.606E-007	2.283E-007	3.000E-007
	90.0	1.9	6.416E-007	5.112E-007	7.846E-007
	95.0	1.4	1.159E-006	9.997E-007	1.728E-006
	97.5	1.0	2.181E-006	1.797E-006	2.971E-006
	99.0	0.7	3.454E-006	2.961E-006	7.116E-006
	99.5	0.5	6.131E-006	3.454E-006	9.260E-006

Table 9.2. Detailed quantile information for final Oconee TH bins.

End State	Distribution Quantile (%)	95% Confidence Interval in %	Quantile Values	Lower Bound 95% Confidence Interval	Upper Bound 95% Confidence Interval
117	0.5	0.5	8.786E-013	1.580E-014	1.136E-012
	1.0	0.7	1.136E-012	4.044E-013	2.755E-012
	2.5	1.0	6.931E-012	2.714E-012	1.364E-011
	5.0	1.4	2.670E-011	1.495E-011	7.906E-011
	10.0	1.9	3.986E-010	2.016E-010	7.283E-010
	20.0	2.5	3.042E-009	1.946E-009	3.955E-009
	25.0	2.7	5.254E-009	3.924E-009	7.400E-009
	30.0	2.9	9.684E-009	6.580E-009	1.387E-008
	40.0	3.1	2.824E-008	2.136E-008	3.625E-008
	50.0	3.2	6.080E-008	4.950E-008	7.386E-008
	60.0	3.1	1.303E-007	1.009E-007	1.561E-007
	70.0	2.9	2.512E-007	2.089E-007	3.362E-007
	75.0	2.7	3.939E-007	3.115E-007	4.775E-007
	80.0	2.5	5.469E-007	4.752E-007	6.823E-007
	90.0	1.9	1.426E-006	1.221E-006	1.749E-006
	95.0	1.4	2.372E-006	2.039E-006	3.017E-006
	97.5	1.0	4.573E-006	3.224E-006	5.551E-006
	99.0	0.7	6.596E-006	5.482E-006	1.363E-005
	99.5	0.5	1.157E-005	6.596E-006	2.387E-005
119	0.5	0.5	8.002E-011	4.409E-011	2.430E-010
	1.0	0.7	2.430E-010	7.611E-011	4.028E-010
	2.5	1.0	4.721E-010	3.677E-010	6.897E-010
	5.0	1.4	1.228E-009	7.640E-010	1.672E-009
	10.0	1.9	4.049E-009	2.949E-009	5.078E-009
	20.0	2.5	1.300E-008	1.111E-008	1.663E-008
	25.0	2.7	2.113E-008	1.644E-008	2.805E-008
	30.0	2.9	3.322E-008	2.657E-008	4.096E-008
	40.0	3.1	7.114E-008	5.349E-008	8.710E-008
	50.0	3.2	1.287E-007	1.119E-007	1.438E-007
	60.0	3.1	1.937E-007	1.673E-007	2.357E-007
	70.0	2.9	3.462E-007	3.114E-007	4.018E-007
	75.0	2.7	4.350E-007	3.876E-007	5.123E-007
	80.0	2.5	5.735E-007	5.115E-007	6.578E-007
	90.0	1.9	1.215E-006	9.980E-007	1.360E-006
	95.0	1.4	1.958E-006	1.625E-006	2.317E-006
	97.5	1.0	2.810E-006	2.435E-006	3.697E-006
	99.0	0.7	4.951E-006	3.419E-006	6.112E-006
	99.5	0.5	5.654E-006	4.951E-006	1.195E-005

Table 9.2. Detailed quantile information for final Oconee TH bins.

End State	Distribution Quantile (%)	95% Confidence Interval in %	Quantile Values	Lower Bound 95% Confidence Interval	Upper Bound 95% Confidence Interval
120	0.5	0.5	2.128E-014	2.880E-017	9.548E-014
	1.0	0.7	9.548E-014	7.570E-015	2.685E-013
	2.5	1.0	7.621E-013	2.226E-013	1.483E-012
	5.0	1.4	5.165E-012	1.852E-012	8.214E-012
	10.0	1.9	2.607E-011	1.342E-011	3.474E-011
	20.0	2.5	1.948E-010	1.257E-010	2.705E-010
	25.0	2.7	3.950E-010	2.649E-010	6.225E-010
	30.0	2.9	8.292E-010	6.025E-010	1.066E-009
	40.0	3.1	2.140E-009	1.674E-009	2.666E-009
	50.0	3.2	4.411E-009	3.481E-009	5.859E-009
	60.0	3.1	1.015E-008	8.055E-009	1.216E-008
	70.0	2.9	1.875E-008	1.546E-008	2.274E-008
	75.0	2.7	2.782E-008	2.225E-008	3.254E-008
	80.0	2.5	4.220E-008	3.250E-008	4.942E-008
	90.0	1.9	1.001E-007	8.046E-008	1.271E-007
	95.0	1.4	2.189E-007	1.633E-007	3.028E-007
	97.5	1.0	3.764E-007	3.078E-007	4.641E-007
	99.0	0.7	6.413E-007	4.399E-007	9.497E-007
	99.5	0.5	8.894E-007	6.413E-007	1.173E-006
121	0.5	0.5	1.018E-006	4.089E-007	1.396E-006
	1.0	0.7	1.396E-006	9.580E-007	1.821E-006
	2.5	1.0	2.780E-006	1.809E-006	3.228E-006
	5.0	1.4	3.739E-006	3.260E-006	4.155E-006
	10.0	1.9	5.591E-006	4.808E-006	6.142E-006
	20.0	2.5	8.400E-006	7.764E-006	8.985E-006
	25.0	2.7	9.693E-006	8.976E-006	1.063E-005
	30.0	2.9	1.120E-005	1.037E-005	1.204E-005
	40.0	3.1	1.442E-005	1.330E-005	1.553E-005
	50.0	3.2	1.736E-005	1.657E-005	1.875E-005
	60.0	3.1	2.175E-005	2.031E-005	2.296E-005
	70.0	2.9	2.602E-005	2.481E-005	2.837E-005
	75.0	2.7	2.952E-005	2.756E-005	3.156E-005
	80.0	2.5	3.344E-005	3.133E-005	3.608E-005
	90.0	1.9	4.599E-005	4.296E-005	5.101E-005
	95.0	1.4	5.985E-005	5.486E-005	6.350E-005
	97.5	1.0	7.261E-005	6.598E-005	8.260E-005
	99.0	0.7	9.053E-005	8.238E-005	1.358E-004
	99.5	0.5	1.148E-004	9.053E-005	1.867E-004

Table 9.2. Detailed quantile information for final Oconee TH bins.

End State	Distribution Quantile (%)	95% Confidence Interval in %	Quantile Values	Lower Bound 95% Confidence Interval	Upper Bound 95% Confidence Interval
122	0.5	0.5	1.679E-008	3.534E-009	2.489E-008
	1.0	0.7	2.489E-008	1.511E-008	4.710E-008
	2.5	1.0	9.141E-008	4.374E-008	1.219E-007
	5.0	1.4	1.877E-007	1.236E-007	2.552E-007
	10.0	1.9	4.500E-007	3.219E-007	5.230E-007
	20.0	2.5	1.033E-006	8.839E-007	1.154E-006
	25.0	2.7	1.320E-006	1.150E-006	1.492E-006
	30.0	2.9	1.645E-006	1.473E-006	1.970E-006
	40.0	3.1	2.562E-006	2.301E-006	2.831E-006
	50.0	3.2	3.803E-006	3.341E-006	4.294E-006
	60.0	3.1	5.656E-006	5.056E-006	6.307E-006
	70.0	2.9	8.105E-006	7.387E-006	9.110E-006
	75.0	2.7	1.010E-005	8.882E-006	1.139E-005
	80.0	2.5	1.212E-005	1.126E-005	1.336E-005
	90.0	1.9	1.894E-005	1.686E-005	2.096E-005
	95.0	1.4	2.762E-005	2.505E-005	3.112E-005
	97.5	1.0	3.618E-005	3.306E-005	4.366E-005
	99.0	0.7	5.089E-005	4.357E-005	6.458E-005
	99.5	0.5	5.943E-005	5.089E-005	8.328E-005
123	0.5	0.5	1.018E-006	4.089E-007	1.396E-006
	1.0	0.7	1.396E-006	9.580E-007	1.821E-006
	2.5	1.0	2.780E-006	1.809E-006	3.228E-006
	5.0	1.4	3.739E-006	3.260E-006	4.155E-006
	10.0	1.9	5.591E-006	4.808E-006	6.142E-006
	20.0	2.5	8.400E-006	7.764E-006	8.985E-006
	25.0	2.7	9.693E-006	8.976E-006	1.063E-005
	30.0	2.9	1.120E-005	1.037E-005	1.204E-005
	40.0	3.1	1.442E-005	1.330E-005	1.553E-005
	50.0	3.2	1.736E-005	1.657E-005	1.875E-005
	60.0	3.1	2.175E-005	2.031E-005	2.296E-005
	70.0	2.9	2.602E-005	2.481E-005	2.837E-005
	75.0	2.7	2.952E-005	2.756E-005	3.156E-005
	80.0	2.5	3.344E-005	3.133E-005	3.608E-005
	90.0	1.9	4.599E-005	4.296E-005	5.101E-005
	95.0	1.4	5.985E-005	5.486E-005	6.350E-005
	97.5	1.0	7.261E-005	6.598E-005	8.260E-005
	99.0	0.7	9.053E-005	8.238E-005	1.358E-004
	99.5	0.5	1.148E-004	9.053E-005	1.867E-004

Table 9.2. Detailed quantile information for final Oconee TH bins.

End State	Distribution Quantile (%)	95% Confidence Interval in %	Quantile Values	Lower Bound 95% Confidence Interval	Upper Bound 95% Confidence Interval
124	0.5	0.5	1.679E-008	3.534E-009	2.489E-008
	1.0	0.7	2.489E-008	1.511E-008	4.710E-008
	2.5	1.0	9.141E-008	4.374E-008	1.219E-007
	5.0	1.4	1.877E-007	1.236E-007	2.552E-007
	10.0	1.9	4.500E-007	3.219E-007	5.230E-007
	20.0	2.5	1.033E-006	8.839E-007	1.154E-006
	25.0	2.7	1.320E-006	1.150E-006	1.492E-006
	30.0	2.9	1.645E-006	1.473E-006	1.970E-006
	40.0	3.1	2.562E-006	2.301E-006	2.831E-006
	50.0	3.2	3.803E-006	3.341E-006	4.294E-006
	60.0	3.1	5.656E-006	5.056E-006	6.307E-006
	70.0	2.9	8.105E-006	7.387E-006	9.110E-006
	75.0	2.7	1.010E-005	8.882E-006	1.139E-005
	80.0	2.5	1.212E-005	1.126E-005	1.336E-005
	90.0	1.9	1.894E-005	1.686E-005	2.096E-005
	95.0	1.4	2.762E-005	2.505E-005	3.112E-005
	97.5	1.0	3.618E-005	3.306E-005	4.366E-005
	99.0	0.7	5.089E-005	4.357E-005	6.458E-005
	99.5	0.5	5.943E-005	5.089E-005	8.328E-005
125	0.5	0.5	5.200E-015	+0.000E+000	5.643E-014
	1.0	0.7	5.643E-014	4.688E-015	1.327E-013
	2.5	1.0	3.187E-013	1.276E-013	1.404E-012
	5.0	1.4	3.523E-012	1.881E-012	7.961E-012
	10.0	1.9	2.182E-011	1.396E-011	3.115E-011
	20.0	2.5	1.782E-010	1.136E-010	2.630E-010
	25.0	2.7	3.660E-010	2.564E-010	5.524E-010
	30.0	2.9	7.200E-010	5.022E-010	9.504E-010
	40.0	3.1	1.998E-009	1.528E-009	2.836E-009
	50.0	3.2	5.205E-009	4.133E-009	6.554E-009
	60.0	3.1	1.196E-008	9.504E-009	1.415E-008
	70.0	2.9	2.253E-008	1.875E-008	2.803E-008
	75.0	2.7	3.306E-008	2.763E-008	4.089E-008
	80.0	2.5	5.068E-008	4.061E-008	5.892E-008
	90.0	1.9	1.304E-007	1.078E-007	1.589E-007
	95.0	1.4	2.246E-007	1.851E-007	2.900E-007
	97.5	1.0	3.815E-007	3.232E-007	5.735E-007
	99.0	0.7	6.751E-007	5.703E-007	8.151E-007
	99.5	0.5	7.481E-007	6.751E-007	1.091E-006

Table 9.2. Detailed quantile information for final Oconee TH bins.

End State	Distribution Quantile (%)	95% Confidence Interval in %	Quantile Values	Lower Bound 95% Confidence Interval	Upper Bound 95% Confidence Interval
126	0.5	0.5	2.503E-014	3.269E-015	9.243E-014
	1.0	0.7	9.243E-014	1.624E-014	4.366E-013
	2.5	1.0	7.731E-013	4.027E-013	2.210E-012
	5.0	1.4	9.584E-012	2.999E-012	2.268E-011
	10.0	1.9	6.315E-011	3.591E-011	1.050E-010
	20.0	2.5	4.677E-010	3.433E-010	7.482E-010
	25.0	2.7	9.584E-010	7.201E-010	1.424E-009
	30.0	2.9	1.927E-009	1.291E-009	2.459E-009
	40.0	3.1	4.242E-009	3.145E-009	5.305E-009
	50.0	3.2	9.592E-009	7.441E-009	1.265E-008
	60.0	3.1	2.244E-008	1.697E-008	2.804E-008
	70.0	2.9	5.271E-008	4.017E-008	6.277E-008
	75.0	2.7	7.299E-008	6.109E-008	8.231E-008
	80.0	2.5	1.031E-007	8.218E-008	1.229E-007
	90.0	1.9	2.436E-007	1.979E-007	2.922E-007
	95.0	1.4	3.822E-007	3.414E-007	4.838E-007
	97.5	1.0	6.287E-007	5.062E-007	7.696E-007
	99.0	0.7	1.128E-006	7.523E-007	1.714E-006
	99.5	0.5	1.477E-006	1.128E-006	2.746E-006
127	0.5	0.5	7.539E-013	7.926E-014	1.325E-011
	1.0	0.7	1.325E-011	6.918E-013	4.368E-011
	2.5	1.0	1.103E-010	3.810E-011	1.965E-010
	5.0	1.4	3.648E-010	2.196E-010	5.018E-010
	10.0	1.9	1.087E-009	7.770E-010	1.473E-009
	20.0	2.5	4.602E-009	3.474E-009	5.475E-009
	25.0	2.7	7.288E-009	5.400E-009	9.281E-009
	30.0	2.9	1.185E-008	8.985E-009	1.431E-008
	40.0	3.1	2.178E-008	1.852E-008	2.510E-008
	50.0	3.2	3.664E-008	3.192E-008	4.226E-008
	60.0	3.1	5.977E-008	5.155E-008	6.965E-008
	70.0	2.9	9.315E-008	8.248E-008	1.067E-007
	75.0	2.7	1.191E-007	1.039E-007	1.404E-007
	80.0	2.5	1.655E-007	1.385E-007	1.827E-007
	90.0	1.9	3.151E-007	2.712E-007	3.812E-007
	95.0	1.4	5.591E-007	4.610E-007	6.642E-007
	97.5	1.0	7.549E-007	6.716E-007	1.080E-006
	99.0	0.7	1.361E-006	1.065E-006	1.711E-006
	99.5	0.5	1.655E-006	1.361E-006	6.180E-006

Table 9.2. Detailed quantile information for final Oconee TH bins.

End State	Distribution Quantile (%)	95% Confidence Interval in %	Quantile Values	Lower Bound 95% Confidence Interval	Upper Bound 95% Confidence Interval
141	0.5	0.5	1.648E-005	1.024E-005	1.874E-005
	1.0	0.7	1.874E-005	1.510E-005	1.993E-005
	2.5	1.0	2.279E-005	1.972E-005	2.582E-005
	5.0	1.4	2.786E-005	2.592E-005	3.012E-005
	10.0	1.9	3.564E-005	3.259E-005	3.858E-005
	20.0	2.5	4.843E-005	4.508E-005	5.078E-005
	25.0	2.7	5.404E-005	5.076E-005	5.580E-005
	30.0	2.9	5.907E-005	5.516E-005	6.213E-005
	40.0	3.1	7.075E-005	6.725E-005	7.494E-005
	50.0	3.2	8.436E-005	7.968E-005	8.957E-005
	60.0	3.1	1.018E-004	9.629E-005	1.081E-004
	70.0	2.9	1.208E-004	1.146E-004	1.287E-004
	75.0	2.7	1.325E-004	1.276E-004	1.411E-004
	80.0	2.5	1.505E-004	1.403E-004	1.600E-004
	90.0	1.9	2.005E-004	1.903E-004	2.151E-004
	95.0	1.4	2.524E-004	2.297E-004	2.827E-004
	97.5	1.0	3.161E-004	2.886E-004	3.449E-004
	99.0	0.7	3.887E-004	3.381E-004	5.180E-004
	99.5	0.5	4.782E-004	3.887E-004	6.706E-004
142	0.5	0.5	1.648E-005	1.024E-005	1.874E-005
	1.0	0.7	1.874E-005	1.510E-005	1.993E-005
	2.5	1.0	2.279E-005	1.972E-005	2.582E-005
	5.0	1.4	2.786E-005	2.592E-005	3.012E-005
	10.0	1.9	3.564E-005	3.259E-005	3.858E-005
	20.0	2.5	4.843E-005	4.508E-005	5.078E-005
	25.0	2.7	5.404E-005	5.076E-005	5.580E-005
	30.0	2.9	5.907E-005	5.516E-005	6.213E-005
	40.0	3.1	7.075E-005	6.725E-005	7.494E-005
	50.0	3.2	8.436E-005	7.968E-005	8.957E-005
	60.0	3.1	1.018E-004	9.629E-005	1.081E-004
	70.0	2.9	1.208E-004	1.146E-004	1.287E-004
	75.0	2.7	1.325E-004	1.276E-004	1.411E-004
	80.0	2.5	1.505E-004	1.403E-004	1.600E-004
	90.0	1.9	2.005E-004	1.903E-004	2.151E-004
	95.0	1.4	2.524E-004	2.297E-004	2.827E-004
	97.5	1.0	3.161E-004	2.886E-004	3.449E-004
	99.0	0.7	3.887E-004	3.381E-004	5.180E-004
	99.5	0.5	4.782E-004	3.887E-004	6.706E-004

Table 9.2. Detailed quantile information for final Oconee TH bins.

End State	Distribution Quantile (%)	95% Confidence Interval in %	Quantile Values	Lower Bound 95% Confidence Interval	Upper Bound 95% Confidence Interval
145	0.5	0.5	2.075E-005	1.293E-005	2.361E-005
	1.0	0.7	2.361E-005	1.904E-005	2.535E-005
	2.5	1.0	2.878E-005	2.497E-005	3.261E-005
	5.0	1.4	3.518E-005	3.290E-005	3.792E-005
	10.0	1.9	4.512E-005	4.132E-005	4.894E-005
	20.0	2.5	6.153E-005	5.700E-005	6.431E-005
	25.0	2.7	6.804E-005	6.427E-005	7.032E-005
	30.0	2.9	7.472E-005	6.995E-005	7.869E-005
	40.0	3.1	8.970E-005	8.529E-005	9.464E-005
	50.0	3.2	1.064E-004	1.008E-004	1.136E-004
	60.0	3.1	1.293E-004	1.218E-004	1.362E-004
	70.0	2.9	1.528E-004	1.443E-004	1.628E-004
	75.0	2.7	1.673E-004	1.617E-004	1.772E-004
	80.0	2.5	1.888E-004	1.765E-004	2.017E-004
	90.0	1.9	2.542E-004	2.408E-004	2.699E-004
	95.0	1.4	3.183E-004	2.906E-004	3.576E-004
	97.5	1.0	3.978E-004	3.659E-004	4.312E-004
	99.0	0.7	4.925E-004	4.274E-004	6.523E-004
	99.5	0.5	6.075E-004	4.925E-004	8.445E-004
146	0.5	0.5	2.320E-006	6.726E-007	3.539E-006
	1.0	0.7	3.539E-006	2.294E-006	4.047E-006
	2.5	1.0	5.839E-006	4.044E-006	6.595E-006
	5.0	1.4	7.206E-006	6.623E-006	8.375E-006
	10.0	1.9	1.064E-005	9.670E-006	1.118E-005
	20.0	2.5	1.585E-005	1.475E-005	1.733E-005
	25.0	2.7	1.893E-005	1.708E-005	2.030E-005
	30.0	2.9	2.174E-005	1.996E-005	2.318E-005
	40.0	3.1	2.693E-005	2.518E-005	2.827E-005
	50.0	3.2	3.267E-005	3.097E-005	3.514E-005
	60.0	3.1	4.014E-005	3.815E-005	4.301E-005
	70.0	2.9	4.977E-005	4.784E-005	5.324E-005
	75.0	2.7	5.615E-005	5.293E-005	6.109E-005
	80.0	2.5	6.480E-005	6.082E-005	6.784E-005
	90.0	1.9	8.703E-005	8.154E-005	9.320E-005
	95.0	1.4	1.101E-004	1.012E-004	1.165E-004
	97.5	1.0	1.248E-004	1.167E-004	1.464E-004
	99.0	0.7	1.657E-004	1.356E-004	2.052E-004
	99.5	0.5	2.023E-004	1.657E-004	2.432E-004

Table 9.2. Detailed quantile information for final Oconee TH bins.

End State	Distribution Quantile (%)	95% Confidence Interval in %	Quantile Values	Lower Bound 95% Confidence Interval	Upper Bound 95% Confidence Interval
147	0.5	0.5	1.989E-006	5.765E-007	3.033E-006
	1.0	0.7	3.033E-006	1.966E-006	3.469E-006
	2.5	1.0	5.005E-006	3.466E-006	5.653E-006
	5.0	1.4	6.176E-006	5.677E-006	7.178E-006
	10.0	1.9	9.117E-006	8.288E-006	9.582E-006
	20.0	2.5	1.359E-005	1.265E-005	1.486E-005
	25.0	2.7	1.622E-005	1.464E-005	1.740E-005
	30.0	2.9	1.864E-005	1.711E-005	1.987E-005
	40.0	3.1	2.308E-005	2.158E-005	2.424E-005
	50.0	3.2	2.800E-005	2.655E-005	3.012E-005
	60.0	3.1	3.441E-005	3.270E-005	3.687E-005
	70.0	2.9	4.266E-005	4.100E-005	4.563E-005
	75.0	2.7	4.813E-005	4.537E-005	5.236E-005
	80.0	2.5	5.554E-005	5.213E-005	5.815E-005
	90.0	1.9	7.460E-005	6.989E-005	7.989E-005
	95.0	1.4	9.440E-005	8.675E-005	9.982E-005
	97.5	1.0	1.070E-004	1.000E-004	1.254E-004
	99.0	0.7	1.420E-004	1.163E-004	1.759E-004
	99.5	0.5	1.734E-004	1.420E-004	2.085E-004
148	0.5	0.5	2.320E-006	6.726E-007	3.539E-006
	1.0	0.7	3.539E-006	2.294E-006	4.047E-006
	2.5	1.0	5.839E-006	4.044E-006	6.595E-006
	5.0	1.4	7.206E-006	6.623E-006	8.375E-006
	10.0	1.9	1.064E-005	9.670E-006	1.118E-005
	20.0	2.5	1.585E-005	1.475E-005	1.733E-005
	25.0	2.7	1.893E-005	1.708E-005	2.030E-005
	30.0	2.9	2.174E-005	1.996E-005	2.318E-005
	40.0	3.1	2.693E-005	2.518E-005	2.827E-005
	50.0	3.2	3.267E-005	3.097E-005	3.514E-005
	60.0	3.1	4.014E-005	3.815E-005	4.301E-005
	70.0	2.9	4.977E-005	4.784E-005	5.324E-005
	75.0	2.7	5.615E-005	5.293E-005	6.109E-005
	80.0	2.5	6.480E-005	6.082E-005	6.784E-005
	90.0	1.9	8.703E-005	8.154E-005	9.320E-005
	95.0	1.4	1.101E-004	1.012E-004	1.165E-004
	97.5	1.0	1.248E-004	1.167E-004	1.464E-004
	99.0	0.7	1.657E-004	1.356E-004	2.052E-004
	99.5	0.5	2.023E-004	1.657E-004	2.432E-004

Table 9.2. Detailed quantile information for final Oconee TH bins.

End State	Distribution Quantile (%)	95% Confidence Interval in %	Quantile Values	Lower Bound 95% Confidence Interval	Upper Bound 95% Confidence Interval
149	0.5	0.5	6.418E-009	4.168E-009	9.612E-009
	1.0	0.7	9.612E-009	6.277E-009	1.654E-008
	2.5	1.0	2.500E-008	1.576E-008	3.082E-008
	5.0	1.4	4.492E-008	3.219E-008	5.604E-008
	10.0	1.9	8.949E-008	7.099E-008	1.095E-007
	20.0	2.5	2.163E-007	1.817E-007	2.609E-007
	25.0	2.7	3.050E-007	2.586E-007	3.665E-007
	30.0	2.9	4.408E-007	3.606E-007	5.318E-007
	40.0	3.1	8.572E-007	7.091E-007	1.036E-006
	50.0	3.2	1.742E-006	1.335E-006	2.149E-006
	60.0	3.1	3.228E-006	2.639E-006	3.806E-006
	70.0	2.9	5.771E-006	4.810E-006	6.618E-006
	75.0	2.7	7.436E-006	6.553E-006	8.902E-006
	80.0	2.5	1.054E-005	8.897E-006	1.206E-005
	90.0	1.9	2.200E-005	1.951E-005	2.527E-005
	95.0	1.4	4.502E-005	3.345E-005	5.815E-005
	97.5	1.0	7.655E-005	6.006E-005	1.028E-004
	99.0	0.7	1.407E-004	1.007E-004	2.028E-004
	99.5	0.5	1.559E-004	1.407E-004	3.879E-004
154	0.5	0.5	2.075E-005	1.293E-005	2.361E-005
	1.0	0.7	2.361E-005	1.904E-005	2.535E-005
	2.5	1.0	2.878E-005	2.497E-005	3.261E-005
	5.0	1.4	3.518E-005	3.290E-005	3.792E-005
	10.0	1.9	4.512E-005	4.132E-005	4.894E-005
	20.0	2.5	6.153E-005	5.700E-005	6.431E-005
	25.0	2.7	6.804E-005	6.427E-005	7.032E-005
	30.0	2.9	7.472E-005	6.995E-005	7.869E-005
	40.0	3.1	8.970E-005	8.529E-005	9.464E-005
	50.0	3.2	1.064E-004	1.008E-004	1.136E-004
	60.0	3.1	1.293E-004	1.218E-004	1.362E-004
	70.0	2.9	1.528E-004	1.443E-004	1.628E-004
	75.0	2.7	1.673E-004	1.617E-004	1.772E-004
	80.0	2.5	1.888E-004	1.765E-004	2.017E-004
	90.0	1.9	2.542E-004	2.408E-004	2.699E-004
	95.0	1.4	3.183E-004	2.906E-004	3.576E-004
	97.5	1.0	3.978E-004	3.659E-004	4.312E-004
	99.0	0.7	4.925E-004	4.274E-004	6.523E-004
	99.5	0.5	6.075E-004	4.925E-004	8.445E-004

Table 9.2. Detailed quantile information for final Oconee TH bins.

End State	Distribution Quantile (%)	95% Confidence Interval in %	Quantile Values	Lower Bound 95% Confidence Interval	Upper Bound 95% Confidence Interval
156	0.5	0.5	7.023E-008	3.121E-008	1.003E-007
	1.0	0.7	1.003E-007	6.368E-008	1.339E-007
	2.5	1.0	1.730E-007	1.284E-007	2.075E-007
	5.0	1.4	2.641E-007	2.132E-007	3.108E-007
	10.0	1.9	4.388E-007	3.714E-007	5.038E-007
	20.0	2.5	8.094E-007	7.126E-007	9.098E-007
	25.0	2.7	1.026E-006	9.063E-007	1.146E-006
	30.0	2.9	1.262E-006	1.124E-006	1.410E-006
	40.0	3.1	1.849E-006	1.648E-006	2.054E-006
	50.0	3.2	2.632E-006	2.361E-006	2.921E-006
	60.0	3.1	3.748E-006	3.354E-006	4.196E-006
	70.0	2.9	5.474E-006	4.892E-006	6.158E-006
	75.0	2.7	6.769E-006	6.033E-006	7.613E-006
	80.0	2.5	8.567E-006	7.583E-006	9.688E-006
	90.0	1.9	1.580E-005	1.373E-005	1.853E-005
	95.0	1.4	2.608E-005	2.238E-005	3.230E-005
	97.5	1.0	4.141E-005	3.375E-005	5.434E-005
	99.0	0.7	7.075E-005	5.207E-005	1.171E-004
	99.5	0.5	1.029E-004	7.075E-005	3.388E-004
160	0.5	0.5	1.841E-007	4.934E-008	2.522E-007
	1.0	0.7	2.522E-007	1.640E-007	3.481E-007
	2.5	1.0	4.434E-007	3.383E-007	5.429E-007
	5.0	1.4	6.874E-007	5.694E-007	8.150E-007
	10.0	1.9	1.151E-006	9.690E-007	1.326E-006
	20.0	2.5	2.137E-006	1.868E-006	2.372E-006
	25.0	2.7	2.694E-006	2.369E-006	3.002E-006
	30.0	2.9	3.290E-006	2.938E-006	3.685E-006
	40.0	3.1	4.831E-006	4.308E-006	5.412E-006
	50.0	3.2	6.930E-006	6.188E-006	7.697E-006
	60.0	3.1	9.910E-006	8.741E-006	1.096E-005
	70.0	2.9	1.449E-005	1.279E-005	1.608E-005
	75.0	2.7	1.795E-005	1.569E-005	1.977E-005
	80.0	2.5	2.250E-005	1.976E-005	2.548E-005
	90.0	1.9	4.153E-005	3.637E-005	4.871E-005
	95.0	1.4	6.840E-005	5.885E-005	8.523E-005
	97.5	1.0	1.087E-004	8.907E-005	1.392E-004
	99.0	0.7	1.798E-004	1.356E-004	2.873E-004
	99.5	0.5	2.631E-004	1.798E-004	6.566E-004

Table 9.2. Detailed quantile information for final Oconee TH bins.

End State	Distribution Quantile (%)	95% Confidence Interval in %	Quantile Values	Lower Bound 95% Confidence Interval	Upper Bound 95% Confidence Interval
164	0.5	0.5	2.148E-007	5.756E-008	2.943E-007
	1.0	0.7	2.943E-007	1.913E-007	4.061E-007
	2.5	1.0	5.173E-007	3.947E-007	6.334E-007
	5.0	1.4	8.020E-007	6.642E-007	9.509E-007
	10.0	1.9	1.343E-006	1.131E-006	1.547E-006
	20.0	2.5	2.494E-006	2.179E-006	2.767E-006
	25.0	2.7	3.142E-006	2.764E-006	3.503E-006
	30.0	2.9	3.838E-006	3.428E-006	4.299E-006
	40.0	3.1	5.636E-006	5.026E-006	6.314E-006
	50.0	3.2	8.085E-006	7.220E-006	8.980E-006
	60.0	3.1	1.156E-005	1.020E-005	1.279E-005
	70.0	2.9	1.691E-005	1.493E-005	1.876E-005
	75.0	2.7	2.094E-005	1.831E-005	2.307E-005
	80.0	2.5	2.625E-005	2.305E-005	2.972E-005
	90.0	1.9	4.845E-005	4.244E-005	5.682E-005
	95.0	1.4	7.980E-005	6.866E-005	9.943E-005
	97.5	1.0	1.268E-004	1.039E-004	1.624E-004
	99.0	0.7	2.097E-004	1.582E-004	3.352E-004
	99.5	0.5	3.070E-004	2.097E-004	7.661E-004
165	0.5	0.5	1.286E-009	2.240E-010	1.864E-009
	1.0	0.7	1.864E-009	6.599E-010	2.256E-009
	2.5	1.0	2.821E-009	2.180E-009	3.142E-009
	5.0	1.4	5.400E-009	3.308E-009	7.400E-009
	10.0	1.9	1.154E-008	9.852E-009	1.548E-008
	20.0	2.5	3.368E-008	2.525E-008	4.003E-008
	25.0	2.7	4.642E-008	4.002E-008	6.510E-008
	30.0	2.9	7.704E-008	6.037E-008	9.232E-008
	40.0	3.1	1.598E-007	1.300E-007	1.865E-007
	50.0	3.2	2.933E-007	2.469E-007	3.270E-007
	60.0	3.1	4.985E-007	4.193E-007	5.915E-007
	70.0	2.9	8.529E-007	7.540E-007	1.099E-006
	75.0	2.7	1.276E-006	1.014E-006	1.553E-006
	80.0	2.5	1.830E-006	1.546E-006	2.277E-006
	90.0	1.9	4.288E-006	3.667E-006	5.218E-006
	95.0	1.4	8.237E-006	6.881E-006	1.146E-005
	97.5	1.0	1.636E-005	1.301E-005	2.059E-005
	99.0	0.7	2.648E-005	1.949E-005	3.151E-005
	99.5	0.5	3.054E-005	2.648E-005	4.641E-005

Table 9.2. Detailed quantile information for final Oconee TH bins.

End State	Distribution Quantile (%)	95% Confidence Interval in %	Quantile Values	Lower Bound 95% Confidence Interval	Upper Bound 95% Confidence Interval
168	0.5	0.5	1.286E-009	2.240E-010	1.864E-009
	1.0	0.7	1.864E-009	6.599E-010	2.256E-009
	2.5	1.0	2.821E-009	2.180E-009	3.142E-009
	5.0	1.4	5.400E-009	3.308E-009	7.400E-009
	10.0	1.9	1.154E-008	9.852E-009	1.548E-008
	20.0	2.5	3.368E-008	2.525E-008	4.003E-008
	25.0	2.7	4.642E-008	4.002E-008	6.510E-008
	30.0	2.9	7.704E-008	6.037E-008	9.232E-008
	40.0	3.1	1.598E-007	1.300E-007	1.865E-007
	50.0	3.2	2.933E-007	2.469E-007	3.270E-007
	60.0	3.1	4.985E-007	4.193E-007	5.915E-007
	70.0	2.9	8.529E-007	7.540E-007	1.099E-006
	75.0	2.7	1.276E-006	1.014E-006	1.553E-006
	80.0	2.5	1.830E-006	1.546E-006	2.277E-006
	90.0	1.9	4.288E-006	3.667E-006	5.218E-006
	95.0	1.4	8.237E-006	6.881E-006	1.146E-005
	97.5	1.0	1.636E-005	1.301E-005	2.059E-005
	99.0	0.7	2.648E-005	1.949E-005	3.151E-005
	99.5	0.5	3.054E-005	2.648E-005	4.641E-005
169	0.5	0.5	3.769E-007	1.251E-007	5.043E-007
	1.0	0.7	5.043E-007	3.704E-007	6.001E-007
	2.5	1.0	7.813E-007	5.962E-007	8.898E-007
	5.0	1.4	1.053E-006	9.056E-007	1.224E-006
	10.0	1.9	1.637E-006	1.427E-006	1.797E-006
	20.0	2.5	2.522E-006	2.313E-006	2.683E-006
	25.0	2.7	2.895E-006	2.675E-006	3.242E-006
	30.0	2.9	3.460E-006	3.148E-006	3.692E-006
	40.0	3.1	4.562E-006	4.188E-006	4.836E-006
	50.0	3.2	5.638E-006	5.324E-006	5.942E-006
	60.0	3.1	7.089E-006	6.453E-006	7.540E-006
	70.0	2.9	8.864E-006	8.119E-006	9.344E-006
	75.0	2.7	9.890E-006	9.302E-006	1.046E-005
	80.0	2.5	1.088E-005	1.042E-005	1.148E-005
	90.0	1.9	1.464E-005	1.359E-005	1.604E-005
	95.0	1.4	1.856E-005	1.763E-005	2.106E-005
	97.5	1.0	2.286E-005	2.140E-005	2.566E-005
	99.0	0.7	2.917E-005	2.532E-005	4.238E-005
	99.5	0.5	4.190E-005	2.917E-005	7.926E-005

Table 9.2. Detailed quantile information for final Oconee TH bins.

End State	Distribution Quantile (%)	95% Confidence Interval in %	Quantile Values	Lower Bound 95% Confidence Interval	Upper Bound 95% Confidence Interval
170	0.5	0.5	3.231E-007	1.073E-007	4.323E-007
	1.0	0.7	4.323E-007	3.175E-007	5.144E-007
	2.5	1.0	6.696E-007	5.111E-007	7.627E-007
	5.0	1.4	9.022E-007	7.763E-007	1.049E-006
	10.0	1.9	1.403E-006	1.223E-006	1.540E-006
	20.0	2.5	2.161E-006	1.983E-006	2.300E-006
	25.0	2.7	2.482E-006	2.293E-006	2.779E-006
	30.0	2.9	2.966E-006	2.698E-006	3.165E-006
	40.0	3.1	3.910E-006	3.590E-006	4.145E-006
	50.0	3.2	4.832E-006	4.564E-006	5.093E-006
	60.0	3.1	6.076E-006	5.531E-006	6.463E-006
	70.0	2.9	7.598E-006	6.959E-006	8.009E-006
	75.0	2.7	8.477E-006	7.974E-006	8.967E-006
	80.0	2.5	9.322E-006	8.927E-006	9.841E-006
	90.0	1.9	1.255E-005	1.165E-005	1.375E-005
	95.0	1.4	1.591E-005	1.511E-005	1.805E-005
	97.5	1.0	1.960E-005	1.835E-005	2.199E-005
	99.0	0.7	2.500E-005	2.171E-005	3.633E-005
	99.5	0.5	3.592E-005	2.500E-005	6.794E-005
171	0.5	0.5	3.769E-007	1.251E-007	5.043E-007
	1.0	0.7	5.043E-007	3.704E-007	6.001E-007
	2.5	1.0	7.813E-007	5.962E-007	8.898E-007
	5.0	1.4	1.053E-006	9.056E-007	1.224E-006
	10.0	1.9	1.637E-006	1.427E-006	1.797E-006
	20.0	2.5	2.522E-006	2.313E-006	2.683E-006
	25.0	2.7	2.895E-006	2.675E-006	3.242E-006
	30.0	2.9	3.460E-006	3.148E-006	3.692E-006
	40.0	3.1	4.562E-006	4.188E-006	4.836E-006
	50.0	3.2	5.638E-006	5.324E-006	5.942E-006
	60.0	3.1	7.089E-006	6.453E-006	7.540E-006
	70.0	2.9	8.864E-006	8.119E-006	9.344E-006
	75.0	2.7	9.890E-006	9.302E-006	1.046E-005
	80.0	2.5	1.088E-005	1.042E-005	1.148E-005
	90.0	1.9	1.464E-005	1.359E-005	1.604E-005
	95.0	1.4	1.856E-005	1.763E-005	2.106E-005
	97.5	1.0	2.286E-005	2.140E-005	2.566E-005
	99.0	0.7	2.917E-005	2.532E-005	4.238E-005
	99.5	0.5	4.190E-005	2.917E-005	7.926E-005

Table 9.2. Detailed quantile information for final Oconee TH bins.

End State	Distribution Quantile (%)	95% Confidence Interval in %	Quantile Values	Lower Bound 95% Confidence Interval	Upper Bound 95% Confidence Interval
172	0.5	0.5	1.648E-005	1.024E-005	1.874E-005
	1.0	0.7	1.874E-005	1.510E-005	1.993E-005
	2.5	1.0	2.279E-005	1.972E-005	2.582E-005
	5.0	1.4	2.786E-005	2.592E-005	3.012E-005
	10.0	1.9	3.564E-005	3.259E-005	3.858E-005
	20.0	2.5	4.843E-005	4.508E-005	5.078E-005
	25.0	2.7	5.404E-005	5.076E-005	5.580E-005
	30.0	2.9	5.907E-005	5.516E-005	6.213E-005
	40.0	3.1	7.075E-005	6.725E-005	7.494E-005
	50.0	3.2	8.436E-005	7.968E-005	8.957E-005
	60.0	3.1	1.018E-004	9.629E-005	1.081E-004
	70.0	2.9	1.208E-004	1.146E-004	1.287E-004
	75.0	2.7	1.325E-004	1.276E-004	1.411E-004
	80.0	2.5	1.505E-004	1.403E-004	1.600E-004
	90.0	1.9	2.005E-004	1.903E-004	2.151E-004
	95.0	1.4	2.524E-004	2.297E-004	2.827E-004
	97.5	1.0	3.161E-004	2.886E-004	3.449E-004
	99.0	0.7	3.887E-004	3.381E-004	5.180E-004
	99.5	0.5	4.782E-004	3.887E-004	6.706E-004
178	0.5	0.5	2.148E-007	5.756E-008	2.943E-007
	1.0	0.7	2.943E-007	1.913E-007	4.061E-007
	2.5	1.0	5.173E-007	3.947E-007	6.334E-007
	5.0	1.4	8.020E-007	6.642E-007	9.509E-007
	10.0	1.9	1.343E-006	1.131E-006	1.547E-006
	20.0	2.5	2.494E-006	2.179E-006	2.767E-006
	25.0	2.7	3.142E-006	2.764E-006	3.503E-006
	30.0	2.9	3.838E-006	3.428E-006	4.299E-006
	40.0	3.1	5.636E-006	5.026E-006	6.314E-006
	50.0	3.2	8.085E-006	7.220E-006	8.980E-006
	60.0	3.1	1.156E-005	1.020E-005	1.279E-005
	70.0	2.9	1.691E-005	1.493E-005	1.876E-005
	75.0	2.7	2.094E-005	1.831E-005	2.307E-005
	80.0	2.5	2.625E-005	2.305E-005	2.972E-005
	90.0	1.9	4.845E-005	4.244E-005	5.682E-005
	95.0	1.4	7.980E-005	6.866E-005	9.943E-005
	97.5	1.0	1.268E-004	1.039E-004	1.624E-004
	99.0	0.7	2.097E-004	1.582E-004	3.352E-004
	99.5	0.5	3.070E-004	2.097E-004	7.661E-004

9.3 Important T-H Bin Cut Set Information

To aid reader understanding, Tables 9.3 through 9.10 provide summaries of the most significant cut sets (i.e., initiators, equipment and operator failures, and modeled successes) and explanatory text for the most important T-H bins because these bins ended up contributing the most to the estimated through wall crack frequency (TWCF) for Oconee Unit 1.

Table 9.3. Contribution of cut sets to T-H bin (end state) 122.

T-H Description for End State 122
Initiating Event: Transient (various)
Primary Side Failure: Stuck-open pressurizer SRV that recloses at 6000 sec.
Secondary Side Failure: None
Operator Action: Operator throttles high pressure injection 10 min after throttling criteria met
Power Level: Hot Zero Power

Cut Set #	% Total	Cut Set %	Frequency	Inputs
1	42.8	42.8	3.3E-006	IE->RTTT, AREA-FRACTION-1, /HPI_FTS, HPI_TF-1D1, HZP-MULTIPLIER, /MFW_F-FT, RCP_RESTART_F, RCP_TRIP_SRV, /SRV_ISO_F, SRV_SO, /TBV_SO-FT, TIME-SPLIT-1
2	85.5	42.8	3.3E-006	IE->RTTT, AREA-FRACTION-1, /HPI_FTS, HPI_TF-1D1, HZP-MULTIPLIER, /MFW_F-FT, /RCP_RESTART_F, RCP_TRIP_SRV, /SRV_ISO_F, SRV_SO, /TBV_SO-FT, TIME-SPLIT-1
3	89.6	4.1	3.1E-007	IE->RTTT, AREA-FRACTION-1, /EFW_F-FT, /HPI_FTS, HPI_TF-1D1, HZP-MULTIPLIER, MFW_TRIP0, /RCP_RESTART_F, RCP_TRIP_SRV, /SRV_ISO_F, SRV_SO, /TBV_SO-FT, TIME-SPLIT-1
4	93.7	4.1	3.1E-007	IE->RTTT, AREA-FRACTION-1, /EFW_F-FT, /HPI_FTS, HPI_TF-1D1, HZP-MULTIPLIER, MFW_TRIP0, RCP_RESTART_F, RCP_TRIP_SRV, /SRV_ISO_F, SRV_SO, /TBV_SO-FT, TIME-SPLIT-1
5	95.8	2.2	1.7E-007	IE->RTTT, AREA-FRACTION-1, /EFW_F-FT, /HPI_FTS, HPI_TF-1D1, HZP-MULTIPLIER, MFW_OVRFD_AB, /MFW_TRIP_F, /RCP_RESTART_F, RCP_TRIP_SRV, /SRV_ISO_F, SRV_SO, /TBV_SO-FT, TIME-SPLIT-1
6	98.0	2.2	1.7E-007	IE->RTTT, AREA-FRACTION-1, /EFW_F-FT, /HPI_FTS, HPI_TF-1D1, HZP-MULTIPLIER, MFW_OVRFD_AB, /MFW_TRIP_F, RCP_RESTART_F, RCP_TRIP_SRV, /SRV_ISO_F, SRV_SO, /TBV_SO-FT, TIME-SPLIT-1
7	98.4	0.4	3.4E-008	IE->LOSP, AREA-FRACTION-1, /EAC_F, /EFW_F-FT, /HPI_FTS, HPI_TF-1D1, HZP-FRACTION, /SRV_ISO_F, SRV_SO, /TBV_SO-FT, TIME-SPLIT-1
8	98.8	0.4	2.6E-008	IE->LMC, AREA-FRACTION-1, /HPI_FTS, HPI_TF-1D1, HZP-FRACTION, /MFW_F-FT, /RCP_RESTART_F, RCP_TRIP_SRV, /SRV_ISO_F, SRV_SO, /TBV_SO-FT, TIME-SPLIT-1
9	99.1	0.4	2.6E-008	IE->LMC, AREA-FRACTION-1, /HPI_FTS, HPI_TF-1D1, HZP-FRACTION, /MFW_F-FT, RCP_RESTART_F, RCP_TRIP_SRV, /SRV_ISO_F, SRV_SO, /TBV_SO-FT, TIME-SPLIT-1

End state 122 involves a plant trip from hot zero power (HZP) initiated by a transient (various types) with a subsequent stuck-open pressurizer safety relief valve (SRV) that recloses 6000 seconds following the trip. Operator action is credited to throttle high pressure injection 10 minutes after the throttling criteria is met. A mixture of other system and operator successes and failures are included within this bin but these are variations that do not significantly alter the thermal-hydraulic response of the plant as far as the PTS challenge is concerned.

Approximately 85% of the T-H bin frequency involves cut sets 1and 2 that involve a reactor trip/turbine trip as the initiator while at hot zero power (HZP), success of injection (denoted by the /HPI_FTS event), failure of the operator to throttle injection by 1 minute after the throttling criteria are met but the operator successfully throttles by 10 minutes after the criteria are met (denoted by the HPI_TF-1D1 event), main feedwater properly runs back and operates as expected (denoted by the /MFW_F-FT event), the reactor coolant pumps are tripped appropriately (denoted by the RCP_TRIP_SRV event), a pressurizer safety relief valve (SRV) sticks open and subsequently recloses 6000 seconds after the trip (denoted by the SRV_SO and /SRV_ISO_F events respectively) and no other secondary breaches occur such as a stuck-open turbine bypass valve (denoted by the /TBV_SO-FT event). The HZP-MULTIPLIER event accounts for the likelihood of a reactor trip while at HZP and the AREA-FRACTION-1 event accounts for the fraction of the area that a SRV may be stuck-open (e.g., it could be barely open, full open, or somewhere in-between) that is sufficiently large to cause enough of a cooldown to be a PTS challenge. The TIME-SPLIT-1 event accounts for the 50-50 probability assigned to whether the SRV recloses at 6000 seconds or 3000 seconds; for this bin the SRV recloses at 6000 seconds. The only difference in the first two cut sets is whether the operator subsequently restarts the reactor coolant pumps late in the scenario (denoted by the RCP_RESTART (failure to restart) and /RCP_RESTART (successfully restarts) events). This difference occurs so late in the scenario, it has no effect on the through wall crack frequency results and so these two cut sets are binned together into this T-H bin.

The remaining cut sets are variations of the first two cut sets involving different initiators (e.g., loss of offsite power or loss of main condenser), as well as different conditions for main feedwater and emergency feedwater. In some cases, main feedwater trips (denoted by MFW_TRIP0) and emergency feedwater subsequently provides steam generator cooling in a controlled fashion (denoted by the /EFW_F-FT event). In other cases, main feedwater does not properly runback but initially overfeeds the steam generators (denoted by the MFW_OVRFD_AB event) but subsequently trips on high steam generator level (denoted by /MFW_TRIP_F) and then emergency feedwater responds as expected. These variations are unimportant since the stuck-open SRV causes the primary system to be somewhat decoupled thermal-hydraulically from the secondary side of the plant and hence these variations of main feedwater and emergency feedwater response do not significantly alter the degree of the PTS challenge which is predominantly driven by the break itself. For this reason, it is acceptable that these variable cut sets are binned together into this T-H bin. Collectively, the nine cut sets shown make up approximately 99.1% of the overall bin frequency.

Table 9.4. Contribution of cut sets to T-H bin (end state) 124.

T-H Description for End State 124 **Initiating Event: Transient (various)** **Primary Side Failure: Stuck-open pressurizer SRV that recloses at 3000 sec.** **Secondary Side Failure: None** **Operator Action: Operator throttles high pressure injection 10 min after throttling criteria met** **Power Level: Hot Zero Power**				
Cut Set #	**% Total**	**Cut Set %**	**Frequency**	**Inputs**
1	42.8	42.8	3.3E-006	IE->RTTT, AREA-FRACTION-1, /HPI_FTS, HPI_TF-1D1, HZP-MULTIPLIER, /MFW_F-FT, RCP_RESTART_F, RCP_TRIP_SRV, /SRV_ISO_F, SRV_SO, /TBV_SO-FT, TIME-SPLIT-1
2	85.5	42.8	3.3E-006	IE->RTTT, AREA-FRACTION-1, /HPI_FTS, HPI_TF-1D1, HZP-MULTIPLIER, /MFW_F-FT, /RCP_RESTART_F, RCP_TRIP_SRV, /SRV_ISO_F, SRV_SO, /TBV_SO-FT, TIME-SPLIT-1
3	89.6	4.1	3.1E-007	IE->RTTT, AREA-FRACTION-1, /EFW_F-FT, /HPI_FTS, HPI_TF-1D1, HZP-MULTIPLIER, MFW_TRIP0, /RCP_RESTART_F, RCP_TRIP_SRV, /SRV_ISO_F, SRV_SO, /TBV_SO-FT, TIME-SPLIT-1
4	93.7	4.1	3.1E-007	IE->RTTT, AREA-FRACTION-1, /EFW_F-FT, /HPI_FTS, HPI_TF-1D1, HZP-MULTIPLIER, MFW_TRIP0, RCP_RESTART_F, RCP_TRIP_SRV, /SRV_ISO_F, SRV_SO, /TBV_SO-FT, TIME-SPLIT-1
5	95.8	2.2	1.7E-007	IE->RTTT, AREA-FRACTION-1, /EFW_F-FT, /HPI_FTS, HPI_TF-1D1, HZP-MULTIPLIER, MFW_OVRFD_AB, /MFW_TRIP_F, /RCP_RESTART_F, RCP_TRIP_SRV, /SRV_ISO_F, SRV_SO, /TBV_SO-FT, TIME-SPLIT-1

T-H Description for End State 124 Initiating Event: Transient (various) Primary Side Failure: Stuck-open pressurizer SRV that recloses at 3000 sec. Secondary Side Failure: None Operator Action: Operator throttles high pressure injection 10 min after throttling criteria met Power Level: Hot Zero Power				
Cut Set #	**% Total**	**Cut Set %**	**Frequency**	**Inputs**
6	98.0	2.2	1.7E-007	IE->RTTT, AREA-FRACTION-1, /EFW_F-FT, /HPI_FTS, HPI_TF-1D1, HZP-MULTIPLIER, MFW_OVRFD_AB, /MFW_TRIP_F, RCP_RESTART_F, RCP_TRIP_SRV, /SRV_ISO_F, SRV_SO, /TBV_SO-FT, TIME-SPLIT-1
7	98.4	0.4	3.4E-008	IE->LOSP, AREA-FRACTION-1, /EAC_F, /EFW_F-FT, /HPI_FTS, HPI_TF-1D1, HZP-FRACTION, /SRV_ISO_F, SRV_SO, /TBV_SO-FT, TIME-SPLIT-1
8	98.8	0.4	2.6E-008	IE->LMC, AREA-FRACTION-1, /HPI_FTS, HPI_TF-1D1, HZP-FRACTION, /MFW_F-FT, /RCP_RESTART_F, RCP_TRIP_SRV, /SRV_ISO_F, SRV_SO, /TBV_SO-FT, TIME-SPLIT-1
9	99.1	0.4	2.6E-008	IE->LMC, AREA-FRACTION-1, /HPI_FTS, HPI_TF-1D1, HZP-FRACTION, /MFW_F-FT, RCP_RESTART_F, RCP_TRIP_SRV, /SRV_ISO_F, SRV_SO, /TBV_SO-FT, TIME-SPLIT-1

End state 124 involves a plant trip from hot zero power (HZP) initiated by a transient (various types) with a subsequent stuck-open pressurizer safety relief valve (SRV) that recloses 3000 seconds following the trip. Operator action is credited to throttle high pressure injection 10 minutes after the throttling criteria is met. A mixture of other system and operator successes and failures are included within this bin but these are variations that do not significantly alter the thermal-hydraulic response of the plant as far as the PTS challenge is concerned.

The cut sets and their contributions as well as the overall bin frequency are the same as for T-H bin 122 above. The only difference is that the bin is thermal-hydraulically modeled as the pressurizer safety relief valve reclosing at 3000 seconds after the plant trip rather than at 6000 seconds, yielding less of an overall cooldown and hence less of a PTS challenge.

Table 9.5. Contribution of cut sets to T-H bin (end state) 141.

T-H Description for End State 141 Initiating Event: LOCA Primary Side Failure: 8.19 cm. (3.22 inch) surge line break Secondary Side Failure: None Operator Action: None Power Level: Power				
Cut Set #	**% Total**	**Cut Set %**	**Frequency**	**Inputs**
1	79.3	79.3	8.4E-005	IE->LOCA, C-PROB-4, /HPI_FTS, /HPI_TF_FT-AB, /MFW_F-FT, RCP_RF-TRUE, RCP_TRIP-TRUE, /TBV_SO-FT
2	88.4	9.1	9.6E-006	IE->LOCA, C-PROB-4, /HPI_FTS, HPI_TF-10AB, /MFW_F-FT, RCP_RF-TRUE, RCP_TRIP-TRUE, /TBV_SO-FT
3	95.9	7.6	8.0E-006	IE->LOCA, C-PROB-4, /EFW_F-FT, /HPI_FTS, /HPI_TF_FT-AB, MFW_TRIP0, RCP_RF-TRUE, RCP_TRIP-TRUE, /TBV_SO-FT
4	99.9	4.0	4.3E-006	IE->LOCA, C-PROB-4, /EFW_F-FT, /HPI_FTS, /HPI_TF_FT-AB, MFW_OVRFD_AB, /MFW_TRIP_F, RCP_RF-TRUE, RCP_TRIP-TRUE, /TBV_SO-FT

End state 141 involves a reactor trip from full power initiated by a small size primary system LOCA, modeled as a 3.22 inch diameter surge line break. A mixture of other system and operator successes and failures are included within this bin but these are variations that do not significantly alter the thermal-hydraulic response of the plant as far as the PTS challenge is concerned.

Approximately 79% of the T-H bin frequency involves cut set 1which involves the small LOCA, and success of injection including throttling of the injection by the operator (denoted by the /HPI... events) when conditions are met (successful throttling conservatively puts this cut set into this bin, which is intended to be a bin involving failure of throttling, but this has little influence for this bin because the size of the break, the resulting rate of cooldown, and the expected timing of when vessel breach may occur make success or failure of throttling relatively inconsequential). Additionally, main feedwater properly runs back and operates as expected (denoted by the /MFW_F-FT event), the reactor coolant pumps are tripped appropriately (denoted by the RCP... events), and no other secondary breaches occur such as a stuck-open turbine bypass valve (denoted by the /TBV_SO-FT event). The C-PROB-4 event is an assigned probability (0.18) from the uncertainty analysis that accounts for this discrete bin being representative of that portion of the total range of small LOCA results (considering ranges of break sizes, flow rates, injection water temperatures, etc.) obtained for all the small LOCA analyses.

Another ~9% of the T-H bin frequency involves cut set 2 which is just like the first cut set except that the operator does not throttle injection (denoted by the HPI_TF-10AB event) which is exactly the intent of this bin, although throttling (or not) has little influence as mentioned above.

Cut set 3, representing slightly over 7% of the T-H bin frequency is also like cut set 1 except main feedwater trips as part of the plant initial response (denoted by the MFW_TRIP0 event) and hence emergency feedwater starts and operates as expected to provide controlled steam generator cooling (denoted by the /EFW_F-FT event).

Cut set 4, contributing another 4% of the T-H bin frequency, is like cut set 3 except main feedwater initially does not runback but instead overfeeds both steam generators (denoted by the MFW_OVRFD_AB event) until it trips on high steam generator level (denoted by the /MFW_TRIP_F event) at which time emergency feedwater responds as expected.

Note that given the size of this LOCA, the primary system is somewhat decoupled thermal-hydraulically from the secondary side of the plant and hence these variations of main feedwater and emergency feedwater response do not significantly alter the degree of the PTS challenge which is predominantly driven by the break itself. For this reason, it is acceptable that these variable cut sets are binned together into this T-H bin. Collectively, the four cut sets shown make up approximately 99.9% of the overall bin frequency.

Table 9.6. Contribution of cut sets to T-H bin (end state) 156.

T-H Description for End State 156 **Initiating Event: LOCA** **Primary Side Failure: 40.64 cm. (16 inch) hot leg break** **Secondary Side Failure: None** **Operator Action: None** **Power Level: Power**				
Cut Set #	**% Total**	**Cut Set %**	**Frequency**	**Inputs**
1	98.0	98.0	7.0E-006	IE->LLOCA, DUMMY
2	100.0	2.0	1.4E-007	IE->LLOCA, HZP-FRACTION

End state 156 involves a reactor trip from full power initiated by a large size primary system LOCA, modeled as a 16 inch diameter hot leg break. All other systems perform as intended including the operator response that is primarily only a monitoring function since full injection occurs and needs to be maintained during the time of interest in order to make up for the rapid and significant loss of RCS inventory.

Due to the very simple but adequate modeling of the large LOCA for PTS since all other systems and actions are assumed successful (this provides significant cold water injection into the reactor vessel downcomer region), there are only two cut sets in this bin. Approximately 98% of the T-H bin frequency involves cut set 1 which includes the large LOCA initiating event assigned a frequency when the plant is at full power and a "DUMMY" event set at a probability of 1.0 simply as a necessary modeling event in order for the computer code to recognize this as a cut set. Cut set 1 exactly matches the modeled end state, a large LOCA from full power conditions.

The remaining 2% of the T-H bin frequency involves cut set 2 that models the possibility of the large LOCA occurring while the plant is at hot zero power (HZP) conditions modeled to be 2% of the year (accounted for by the HZP-FRACTION event). This cut set is non-conservatively binned in this end state since a large LOCA initiated from HZP conditions will provide a slightly more severe cooldown than a large LOCA from full power because of the lower initial decay heat. However, T-H runs show this difference is not significant and given the much lower frequency of cut set 2 compared with cut set 1, any resulting through-wall crack frequency (TWCF) from this cut set will not be a large contributor to the overall TWCF and hence binning cut set 2 into this end-state is acceptable.

Table 9.7. Contribution of cut sets to T-H bin (end state) 160.

T-H Description for End State 160
Initiating Event: LOCA
Primary Side Failure: 14.37 cm. (5.656 inch) surge line break
Secondary Side Failure: None
Operator Action: None
Power Level: Power

Cut Set #	% Total	Cut Set %	Frequency	Inputs
1	98.0	98.0	1.8E-005	IE->DUMMY, C-PROB-2, MLOCA
2	100.0	2.0	3.6E-007	IE->MLOCA, C-PROB-2, HZP-FRACTION

End state 160 involves a reactor trip from full power initiated by a medium size primary system LOCA, modeled as a 5.656 inch diameter surge line break. All other systems perform as intended including the operator response that is primarily only a monitoring function since full injection occurs and needs to be maintained during the time of interest in order to make up for the rapid and significant loss of RCS inventory.

Due to the very simple but adequate modeling of the medium LOCA for PTS since all other systems and actions are assumed successful (this provides significant cold water injection into the reactor vessel downcomer region), there are only two cut sets in this bin. Approximately 98% of the T-H bin frequency involves cut set 1 which includes the medium LOCA initiating event assigned a frequency when the plant is at full power and a "DUMMY" event set at a value of 1.0 simply as a necessary modeling event in order for the computer code to recognize this as a cut set. The C-PROB-2 event is an assigned probability (0.30) from the uncertainty analysis that accounts for this discrete bin being representative of that portion of the total range of medium LOCA results (considering ranges of break sizes, flow rates, injection water temperatures, etc.) obtained for all the medium LOCA analyses. Cut set 1 exactly matches the modeled end state, a medium LOCA from full power conditions.

The remaining 2% of the T-H bin frequency involves cut set 2 that models the possibility of the medium LOCA occurring while the plant is at hot zero power (HZP) conditions modeled to be 2% of the year (accounted for by the HZP-FRACTION event). This cut set is non-conservatively binned in this end state since a medium LOCA initiated from HZP conditions will provide a slightly more severe cooldown than a medium LOCA from full power because of the lower initial decay heat. However, T-H runs show this difference is not significant and given the much lower frequency of cut set 2 compared with cut set 1, any resulting through-wall crack frequency (TWCF) from this cut set will not be a large contributor to the overall TWCF and hence binning cut set 2 into this end-state is acceptable.

Table 9.8. Contribution of cut sets to T-H bin (end state) 164.

T-H Description for End State 164
Initiating Event: **LOCA**
Primary Side Failure: **20.32 cm. (8 inch) surge line break**
Secondary Side Failure: **None**
Operator Action: **None**
Power Level: **Power**

Cut Set #	% Total	Cut Set %	Frequency	Inputs
1	98.0	98.0	2.1E-005	IE->DUMMY, C-PROB-1, MLOCA
2	100.0	2.0	4.2E-007	IE->MLOCA, C-PROB-1, HZP-FRACTION

End state 164 involves a reactor trip from full power initiated by a medium size primary system LOCA, modeled as a 8 inch diameter surge line break. All other systems perform as intended including the operator response that is primarily only a monitoring function since full injection occurs and needs to be maintained during the time of interest in order to make up for the rapid and significant loss of RCS inventory.

Due to the very simple but adequate modeling of the medium LOCA for PTS since all other systems and actions are assumed successful (this provides significant cold water injection into the reactor vessel downcomer region), there are only two cut sets in this bin. Approximately 98% of the T-H bin frequency involves cut set 1 which includes the medium LOCA initiating event assigned a frequency when the plant is at full power and a "DUMMY" event set at a value of 1.0 simply as a necessary modeling event in order for the computer code to recognize this as a cut set. The C-PROB-1 event is an assigned probability (0.35) from the uncertainty analysis that accounts for this discrete bin being representative of that portion of the total range of medium LOCA results (considering ranges of break sizes, flow rates, injection water temperatures, etc.) obtained for all the medium LOCA analyses. Cut set 1 exactly matches the modeled end state, a medium LOCA from full power conditions.

The remaining 2% of the T-H bin frequency involves cut set 2 that models the possibility of the medium LOCA occurring while the plant is at hot zero power (HZP) conditions modeled to be 2% of the year (accounted for by the HZP-FRACTION event). This cut set is non-conservatively binned in this end state since a medium LOCA initiated from HZP conditions will provide a slightly more severe cooldown than a medium LOCA from full power because of the lower initial decay heat. However, T-H runs show this difference is not significant and given the much lower frequency of cut set 2 compared with cut set 1, any resulting through-wall crack frequency (TWCF) from this cut set will not be a large contributor to the overall TWCF and hence binning cut set 2 into this end-state is acceptable.

Table 9.9. Contribution of cut sets to T-H bin (end state) 165.

T-H Description for End State 165
Initiating Event: Transient (various)
Primary Side Failure: Stuck-open pressurizer SRV that recloses at 6000 sec.
Secondary Side Failure: None
Operator Action: None
Power Level: Hot Zero Power

Cut Set #	% Total	Cut Set %	Frequency	Inputs
1	42.8	42.8	7.2E-007	IE->RTTT, AREA-FRACTION-1, /HPI_FTS, HPI_TF-10D1, HZP-MULTIPLIER, /MFW_F-FT, RCP_RESTART_F, RCP_TRIP_SRV, /SRV_ISO_F, SRV_SO, /TBV_SO-FT, TIME-SPLIT-1
2	85.5	42.8	7.2E-007	IE->RTTT, AREA-FRACTION-1, /HPI_FTS, HPI_TF-10D1, HZP-MULTIPLIER, /MFW_F-FT, /RCP_RESTART_F, RCP_TRIP_SRV, /SRV_ISO_F, SRV_SO, /TBV_SO-FT, TIME-SPLIT-1
3	89.6	4.1	6.8E-008	IE->RTTT, AREA-FRACTION-1, /EFW_F-FT, /HPI_FTS, HPI_TF-10D1, HZP-MULTIPLIER, MFW_TRIP0, /RCP_RESTART_F, RCP_TRIP_SRV, /SRV_ISO_F, SRV_SO, /TBV_SO-FT, TIME-SPLIT-1
4	93.7	4.1	6.8E-008	IE->RTTT, AREA-FRACTION-1, /EFW_F-FT, /HPI_FTS, HPI_TF-10D1, HZP-MULTIPLIER, MFW_TRIP0, RCP_RESTART_F, RCP_TRIP_SRV, /SRV_ISO_F, SRV_SO, /TBV_SO-FT, TIME-SPLIT-1
5	95.8	2.2	3.6E-008	IE->RTTT, AREA-FRACTION-1, /EFW_F-FT, /HPI_FTS, HPI_TF-10D1, HZP-MULTIPLIER, MFW_OVRFD_AB, /MFW_TRIP_F, /RCP_RESTART_F, RCP_TRIP_SRV, /SRV_ISO_F, SRV_SO, /TBV_SO-FT, TIME-SPLIT-1
6	98.0	2.2	3.6E-008	IE->RTTT, AREA-FRACTION-1, /EFW_F-FT, /HPI_FTS, HPI_TF-10D1, HZP-MULTIPLIER, MFW_OVRFD_AB, /MFW_TRIP_F, RCP_RESTART_F, RCP_TRIP_SRV, /SRV_ISO_F, SRV_SO, /TBV_SO-FT, TIME-SPLIT-1
7	98.4	0.4	7.3E-009	IE->LOSP, AREA-FRACTION-1, /EAC_F, /EFW_F-FT, /HPI_FTS, HPI_TF-10D1, HZP-FRACTION, /SRV_ISO_F, SRV_SO, /TBV_SO-FT, TIME-SPLIT-1
8	98.8	0.4	5.7E-009	IE->LMC, AREA-FRACTION-1, /HPI_FTS, HPI_TF-10D1, HZP-FRACTION, /MFW_F-FT, /RCP_RESTART_F, RCP_TRIP_SRV, /SRV_ISO_F, SRV_SO, /TBV_SO-FT, TIME-SPLIT-1
9	99.1	0.4	5.7E-009	IE->LMC, AREA-FRACTION-1, /HPI_FTS, HPI_TF-10D1, HZP-FRACTION, /MFW_F-FT, RCP_RESTART_F, RCP_TRIP_SRV, /SRV_ISO_F, SRV_SO, /TBV_SO-FT, TIME-SPLIT-1

End state 165 involves a plant trip from hot zero power (HZP) initiated by a transient (various types) with a subsequent stuck-open pressurizer safety relief valve (SRV) that recloses 6000 seconds following the trip. As opposed to bin 122, for this bin, the operator does not successfully throttle high pressure injection even though the throttling criteria may be met, thus causing a higher primary system pressure than is necessary and a more than needed flow rate of cold water to continue to be injected into the reactor vessel downcomer region. A mixture of other system and operator successes and failures are included within this bin but these are variations that do not significantly alter the thermal-hydraulic response of the plant as far as the PTS challenge is concerned.

The cut sets and their contributions are virtually the same as for T-H bin 122 above. The key difference in the cut sets is the use of the HPI_TF-10D1 term (instead of the HPI_TF-1D1 used in bin 122) that for this bin, denotes the operator fails to throttle injection at any time and thus the primary system pressure and injection flow rate are not properly controlled. Accounting for the failure probability of the operator failing to throttle, causes the cut set frequencies and the overall bin frequency to be different from that shown for bin 122, but otherwise, the cut sets look the same.

Table 9.10. Contribution of cut sets to T-H bin (end state) 168.

Cut Set #	% Total	Cut Set %	Frequency	Inputs
T-H Description for End State 168 **Initiating Event: Transient (various)** **Primary Side Failure: Stuck-open pressurizer SRV that recloses at 3000 sec.** **Secondary Side Failure: None** **Operator Action: None** **Power Level: Hot Zero Power**				
1	42.8	42.8	7.2E-007	IE->RTTT, AREA-FRACTION-1, /HPI_FTS, HPI_TF-10D1, HZP-MULTIPLIER, /MFW_F-FT, RCP_RESTART_F, RCP_TRIP_SRV, /SRV_ISO_F, SRV_SO, /TBV_SO-FT, TIME-SPLIT-1
2	85.5	42.8	7.2E-007	IE->RTTT, AREA-FRACTION-1, /HPI_FTS, HPI_TF-10D1, HZP-MULTIPLIER, /MFW_F-FT, /RCP_RESTART_F, RCP_TRIP_SRV, /SRV_ISO_F, SRV_SO, /TBV_SO-FT, TIME-SPLIT-1
3	89.6	4.1	6.8E-008	IE->RTTT, AREA-FRACTION-1, /EFW_F-FT, /HPI_FTS, HPI_TF-10D1, HZP-MULTIPLIER, MFW_TRIP0, /RCP_RESTART_F, RCP_TRIP_SRV, /SRV_ISO_F, SRV_SO, /TBV_SO-FT, TIME-SPLIT-1
4	93.7	4.1	6.8E-008	IE->RTTT, AREA-FRACTION-1, /EFW_F-FT, /HPI_FTS, HPI_TF-10D1, HZP-MULTIPLIER, MFW_TRIP0, RCP_RESTART_F, RCP_TRIP_SRV, /SRV_ISO_F, SRV_SO, /TBV_SO-FT, TIME-SPLIT-1
5	95.8	2.2	3.6E-008	IE->RTTT, AREA-FRACTION-1, /EFW_F-FT, /HPI_FTS, HPI_TF-10D1, HZP-MULTIPLIER, MFW_OVRFD_AB, /MFW_TRIP_F, /RCP_RESTART_F, RCP_TRIP_SRV, /SRV_ISO_F, SRV_SO, /TBV_SO-FT, TIME-SPLIT-1
6	98.0	2.2	3.6E-008	IE->RTTT, AREA-FRACTION-1, /EFW_F-FT, /HPI_FTS, HPI_TF-10D1, HZP-MULTIPLIER, MFW_OVRFD_AB, /MFW_TRIP_F, RCP_RESTART_F, RCP_TRIP_SRV, /SRV_ISO_F, SRV_SO, /TBV_SO-FT, TIME-SPLIT-1
7	98.4	0.4	7.3E-009	IE->LOSP, AREA-FRACTION-1, /EAC_F, /EFW_F-FT, /HPI_FTS, HPI_TF-10D1, HZP-FRACTION, /SRV_ISO_F, SRV_SO, /TBV_SO-FT, TIME-SPLIT-1
8	98.8	0.4	5.7E-009	IE->LMC, AREA-FRACTION-1, /HPI_FTS, HPI_TF-10D1, HZP-FRACTION, /MFW_F-FT, /RCP_RESTART_F, RCP_TRIP_SRV, /SRV_ISO_F, SRV_SO, /TBV_SO-FT, TIME-SPLIT-1
9	99.1	0.4	5.7E-009	IE->LMC, AREA-FRACTION-1, /HPI_FTS, HPI_TF-10D1, HZP-FRACTION, /MFW_F-FT, RCP_RESTART_F, RCP_TRIP_SRV, /SRV_ISO_F, SRV_SO, /TBV_SO-FT, TIME-SPLIT-1

End state 168 involves a plant trip from hot zero power (HZP) initiated by a transient (various types) with a subsequent stuck-open pressurizer safety relief valve (SRV) that recloses 3000 seconds following the trip. As opposed to bin 124, for this bin, the operator does not successfully throttle high pressure injection even though the throttling criteria may be met, thus causing a higher primary system pressure than is necessary and a more than needed flow rate of cold water to continue to be injected into the reactor vessel downcomer region. A mixture of other system and operator successes and failures are included within this bin but these are variations that do not significantly alter the thermal-hydraulic response of the plant as far as the PTS challenge is concerned.

The cut sets and their contributions are virtually the same as for T-H bin 124 above. The key difference in the cut sets is the use of the HPI_TF-10D1 term (instead of the HPI_TF-1D1 used in bin 124) that for this bin, denotes the operator fails to throttle injection at any time and thus the primary system pressure and injection flow rate are not properly controlled. Accounting for the failure probability of the operator failing to throttle, causes the cut set frequencies and the overall bin frequency to be different from that shown for bin 124, but otherwise, the cut sets look the same.

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