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Implementation of Methods for Uncertainty Analysis of Nuclear Power Plant Probabilistic System Fault Tree Models

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A Comparison of Methods for Uncertainty Analysis of Nuclear Power Plant Safety System Fault Tree Models

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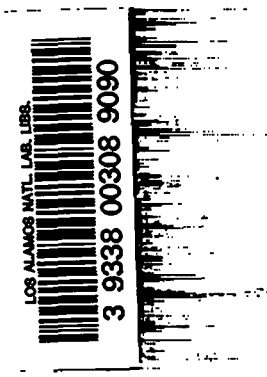

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CONTENTS

A COMPARISON OF METHODS FOR UNCERTAINTY ANALYSIS OF NUCLEAR POWER PLANT SAFETY SYSTEM FAULT TREE MODELS

by

Harry F. Martz, Richard J. Beckman, Katherine Campbell,
David E. Whiteman, and Jane M. Booker

ABSTRACT

A comparative evaluation is made of several methods for propagating uncertainties in actual coupled nuclear power plant safety system fault tree models. The methods considered are Monte Carlo simulation, the method of moments, a discrete distribution combination method, and a bootstrap method. The Monte Carlo method is found to be superior.

The sensitivity of the system unavailability distribution to the choice of basic event unavailability distribution is also investigated. The system distribution is especially sensitive to the choice of symmetric versus asymmetric basic event distributions. Gamma, log gamma, log normal, and log uniform distributions produce quite similar results, except that the system distribution corresponding to log normal basic event distributions has a heavier right-hand tail. Log Cauchy basic event distributions yield a system distribution with an extremely heavy right-hand tail. It is impossible to identify an unequivocal "best" universal family of basic event distributions to use in reactor probabilistic risk assessment fault tree uncertainty analyses.

A "quick-and-dirty" method for estimating percentiles of the system unavailability distribution is developed. The method identifies the appropriate basic event distribution percentiles that should be used in evaluating the Boolean system equivalent expression for a given fault tree model to arrive directly at the 5th, 10th, 50th, 90th, and 95th percentiles of the system unavailability distribution.

1. INTRODUCTION AND EXECUTIVE SUMMARY

An uncertainty analysis is performed either to estimate the uncertainty in the final risk results of a probabilistic risk assessment (PRA) or to estimate the uncertainty associated with intermediate quantities, such as core melt frequency.

For clarity of exposition in the report, the following definitions are given. The aim is to be simple and suggestive, not rigorous.

> Uncertainty denotes an imprecision in the PRA analyst's state-of-knowledge about physical processes, models of physical processes, parameters of those models, or the predictions from such models.
>
> An uncertainty analysis of a given task in a PRA consists of (1) estimation of the uncertainties in the inputs to the task, and (2) propagation of the input uncertainties through the task to obtain the corresponding uncertainty in the output of the task.

In the case of fault tree models, the input uncertainties associated with the basic fault event probabilities are propagated through the fault tree model to obtain the corresponding uncertainty associated with the probability of the top event.

The purpose of this report is (1) to comparatively evaluate the most common uncertainty analysis methods for propagating parameter uncertainties in actual front-line safety system fault tree models, and (2) to investigate the sensitivity to various distributions used to represent the uncertainty in the basic event probabilities.

Following the Introduction and Executive Summary in Section 1, Section 2 describes the fault tree models considered in this study. Section 3 surveys various methods for propagating uncertainties and considers the details in applying these methods to the fault tree models discussed in Section 2. Section 4 presents the detailed results and conclusions of the study, which are summarized in Section 1.2.

1.1 Scope

In this report we restrict our attention to parameter uncertainties associated with the basic fault events for a certain set of fault tree models developed for a recent plant-specific PRA. These models were used to quantify the

conditional unavailabilities of the nuclear power plant front-line safety systems considered in the accident sequence (event tree) models.

Because fault tree models are an integral part of PRAs, the propagation of input parameter uncertainties through such models to arrive at the corresponding uncertainty in the probability of the top event (that is, the system unavailability) is of fundamental importance.

Numerous methods for propagating uncertainties have been proposed or used in various nuclear reactor PRAs. Several surveys and comparative evaluations of such methods have also recently appeared in the PRA literature. Ahmed, Metcalf, and Pegram,[1] Cox and Baybutt,[2] and Jackson, Hockenbury, and Yeater[3] draw numerous conclusions regarding the range of applicability, advantages, and disadvantages of the methods. However, their conclusions may be of limited value in current reactor PRAs as these studies considered only relatively small fault trees, and the extrapolation of their conclusions to fault trees for front-line safety systems is questionable.

Current PRAs frequently incorporate different methods for propagating uncertainties. In evaluating such PRAs, it is often the case that it is unknown whether the methods used are satisfactory or not. Questions such as these often arise: Is it the best method to use? Are the results correct? Is it defensible? What are the shortcomings, if any? Why was this method used instead of some other method? Persons tasked with selecting, using, or critiquing uncertainty analysis methods and results must address questions such as these.

1.2 Conclusions

The following conclusions pertain to the accuracy in estimating the system unavailability distribution, particularly the percentiles, in fault tree models using basic event data. The conclusions also hold for accident sequence models consisting of these fault tree models plus an initiating event. In Section 4 of this report these conclusions are established:

- Monte Carlo simulation methods for propagating uncertainties are generally superior to other methods, particularly for large fault trees (Section 4.2).

- The method of moments, in conjunction with the use of Tchebyshev's inequality (a nonparametric approach to uncertainty propagation), yields results which are so conservative as to be of little practical value (Section 4.2).

- The performance of the discrete probability distribution method depends on the probability allocation scheme, as well as the arbitrary grouping scheme employed for large trees (Section 4.3).

- The Monte Carlo method outperforms the discrete probability distribution method (Section 4.3).

- The system unavailability distribution is especially sensitive to the choice of symmetric versus asymmetric (right skewed) basic event unavailability distributions (Section 4.1).

- Gamma, log gamma, log normal, and log uniform basic event unavailability distributions yield quite similar system unavailability distributions, except that the log normal yields a distribution with a heavier right-hand tail (Section 4.1).

- Log Cauchy basic event unavailability distributions yield a system unavailability distribution with an extremely heavy right-hand tail (Section 4.1).

- It is impossible to identify an unequivocal "best" family of basic event distributions, because such a choice depends on (1) the characteristics of the basic event distributions that are held fixed (such as the 5th and 95th percentiles, or median and 95th percentile), and (2) the characteristics of the system unavailability distribution of interest (such as the 99th percentile, mean, or median) (Sections 4.1 and 4.2).

- A "quick-and-dirty" method for estimating percentiles of the system unavailability distribution is developed in which appropriate percentiles of the basic event distributions are used in the system unavailability equation (for example, the 35th, 42nd, 63rd, 85th, and 90th percentiles of log normal basic event distributions, when propagated, estimate the 5th, 10th, 50th, 90th, and 95th percentiles, respectively, of the system unavailability distribution) (Section 4.4).

2. ANO-1 FAULT TREE MODELS

As part of the Interim Reliability Evaluation Program (IREP), Sandia National Laboratories (SNL) has recently completed a PRA of the Arkansas Nuclear One Unit 1 (ANO-1) nuclear power plant.[4] The ANO-1 nuclear power plant is an 886-MWe pressurized water reactor (PWR) located on Lake Dardanelle near Russelville, Arkansas. Arkansas Power and Light Company owns and operates the facility which began commercial operation on December 19, 1974.

Event trees were developed for the analyses of core melt accidents initiated by loss of coolant accidents (LOCAs) of six different pipe break size ranges and eight different types of transients.

Fault tree models were constructed for the front-line safety systems appearing in the event trees. The fault trees represented system failures in terms of component hardware faults, test and maintenance errors, and possible operator errors. Support system interfaces were also considered. In addition, both hardware and human common mode failures were identified and modeled in the fault trees. Several of the front-line systems have different success criteria, depending on the specific accident sequence description, and in such systems the top-level fault event incorporated this criterion. The ANO-1 accident sequence models consisted of the fault tree models considered here plus an initiating event.

The front-line systems for which fault trees were constructed included the high-pressure injection system (in three modes--one pump required, two pumps required, and feed-and-bleed); high-pressure recirculation system; the low-pressure systems of injection and recirculation (both the "usual" recirculation and that of containment heat removal); the core-flooding system for both one tank and two tanks; the reactor building spray injection and recirculation systems; the emergency feedwater system; the reactor building cooling system; the reactor protection system; and the power-conversion system.

2.1 Equivalent Boolean Expressions

The ANO-1 fault trees were analyzed using the SETS code.[5] SETS operates on the system fault tree models and performs the Boolean algebra necessary to logically represent the fault trees in an equivalent factored Boolean form that is given in terms of the minimal cut sets.

A lower bound cutoff was employed to insure that the Boolean expression would contain only those minimal cut sets that substantially contribute to the system unavailability. Table I gives the equivalent Boolean expression for the high-pressure injection system, using a 1-of-3 pump success criterion and a lower unavailability bound of 10^{-6}. Table II gives a summary of the ANO-1 front-line system fault trees considered in this report. The column headed "ID" contains a two-character system fault tree identifier that will be used in the remainder of this report. The column "No. of Terms" gives the number of unique basic events contained in the Boolean expression and is thus a measure of the size of the fault

tree. The Boolean equations range in size from small (ZW) to fairly large (Z5). The nomenclature for the basic events in the Boolean expression given in Table I is described in Reference 4. The remaining Boolean expressions are provided in Appendix A.

2.2 Fault Tree Quantification

The data for quantifying the fault trees were also developed and supplied by SNL and consisted of a mixture of generic and plant-specific data. Basic hardware failure rate data were obtained from a modified WASH-1400 data base.[6] For particular components, plant-specific data from plant logs were used. Plant-specific test and maintenance frequency data, taken from plant logs, were also used. Data for human error rates were obtained from human factors experts and such sources as Swain and Guttman.[7] Table III lists the basic fault event median unavailability values, including the corresponding error factors and coupling groups (see Section 3), which were used by SNL to quantify the fault tree given in Table I. The error factors are given in the column labeled "EF", and the coupling groups are displayed in the column labeled "CG". Similar data tables for the remaining fault trees may be found in Appendix A.

3. METHODS FOR PROPAGATING UNCERTAINTIES

Many methods exist for the propagation of uncertainties in fault tree models. The purpose of this section is to describe some of the more common methods for uncertainty propagation and their implementation for the work presented here. We illustrate these methods with the following simple fault tree given by Henley and Kumamoto.[8]

Henley and Kumamoto gave as an example a two-out-of-three voting system in which three monitors check the state of a reactor system and shut it down when any two of the three monitors detect an abnormal condition. A schematic diagram of such a system is given in Fig. 1. A fault tree depicting an unnecessary shutdown of the system is given in Fig. 2. The events B_i in Fig. 2 represent a false shutdown signal from monitor i. The "top event" is an unnecessary (false) shutdown of the system. The minimal cut sets for this system are $\{B_1,B_2\}$, $\{B_2,B_3\}$, and $\{B_1,B_3\}$.

TABLE I

EQUIVALENT BOOLEAN EXPRESSION FOR
HIGH-PRESSURE INJECTION SYSTEM,
1-OF-3 PUMP CRITERION
(TRUNCATED AT 1.0E-6)

X = (IEDD114A-B00 + D114A-CBL-LF + LPI1407A-VCC-LF + 5164A-CBL-LF +
LPI5164A-B00-CC + LPI5164A-B00-LF + A-ECS-2 + ECS6036A-DPC-LF +
ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF +
5254A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + ECS5246A-B00-LF +
5246A-CBL-LF + ECSUC2BA-FAN-LF + SWS3643A-V00-LF + SWS3820A-V00-LF +
SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF +
SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF +
SWS0P4BA-PMD-LF) * (LPI1408B-VCC-LF + SWS3810B-VCC-LF) + (
IEDD114A-B00 + D114A-CBL-LF + LPI1407A-VCC-LF + 5164A-CBL-LF +
LPI5164A-B00-CC + LPI5164A-B00-LF + A-ECS-2 + ECS6036A-DPC-LF +
ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF +
ECS5136A-B00-CC + ECS5136A-B00-LF + 5254A-CBL-LF + 5136A-CBL-LF +
ECSCH4BA-CWU-LF + ECSC14DA-FAN-LF + ECS5246A-B00-CC + ECS5246A-B00-LF +
5246A-CBL-LF + ECSUC2BA-FAN-LF + SWS3643A-V00-LF + SWS3820A-V00-LF +
SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF +
SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF +
SWS0P4BA-PMD-LF) * (ECS6034B-DPC-LF + ECS6034B-BPC-LF +
LPI5164A-B00-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF +
ECS5254A-B00-CC + ECS5254A-B00-LF + ECS5136A-B00-CC + ECS5136A-B00-LF +
5254A-CBL-LF + 5136A-CBL-LF + ECSCH4BA-CWU-LF + ECSC14DA-FAN-LF +
ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + ECSUC2BA-FAN-LF +

TABLE I (Cont)

SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF) * (ECS6254B-B00-CC + ECS6246B-B00-CC + SWS0402B-B00-CC) + (IEDD114A-B00 + D114A-CBL-LF + LPI1407A-VCC-LF + 5164A-CBL-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + ECS5136A-B00-CC + ECS5136A-B00-LF + 5254A-CBL-LF + 5136A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF) * (6254B-CBL-LF + 6246B-CBL-LF + SWS0P4CB-PMD-LF) + (IEDD114A-B00 + D114A-CBL-LF + LPI1407A-VCC-LF + 5164A-CBL-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + 5254A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + ECSUC2BA-FAN-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF) * (LPI6164B-B00-CC + HPIA406B-B00-CC + SWS6214B-B00-CC) + (D114A-CBL-LF + LPI1407A-VCC-LF + 5164A-CBL-LF + LPI5164A-B00-CC + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5136A-B00-CC + 5254A-CBL-LF + 5136A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + 5246A-CBL-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS5653A-B00-CC + SWS5181A-B00-CC + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF) * (

TABLE I (Cont)

ECS6254B-B00-LF + ECS6246B-B00-LF + SWS0402B-B00-LF) + (IEDD114A-B00 + D114A-CBL-LF + LPI1407A-VCC-LF + 5164A-CBL-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + 5254A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF) * (A406B-CBL-LF + D214B-CBL-LF + 6164B-CBL-LF + 6214B-CBL-LF) + (D114A-CBL-LF + LPI1407A-VCC-LF + 5164A-CBL-LF + LPI5164A-B00-CC + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + 5254A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + 5246A-CBL-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-GC + SWS5653A-B00-CC + SWS5181A-B00-CC + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF) * (HPIP36CB-PMD-LF + IEDD214B-B00 + LPI6164B-B00-LF + HPIA406B-B00-LF + SWS6214B-B00-LF) + ECS5254A-B-AASF * (A-HPI-4 + A-SWS-1) + A-ECS-3 * (LPI1407A-VCC-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECSCH4BA-CWU-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + 5653A-CBL-LF + 5181A-CBL-LF) + ECSC2DB-FAN-LF * (LPI1407A-VCC-LF + LPI5164A-B00-CC + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5136A-B00-CC + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS5653A-B00-CC + SWS5181A-B00-CC + 5653A-CBL-LF + 5181A-CBL-LF) + ECS6254B-B-AASF * (IEDD114A-B00 + D114A-CBL-LF + LPI1407A-VCC-LF + 5164A-CBL-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + A-ECS-2 + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC +

TABLE I (Cont)

ECS5254A-B00-LF + ECS5136A-B00-CC + ECS5136A-B00-LF + 5254A-CBL-LF + 5136A-CBL-LF + ECSCH4BA-CWU-LF + ECSC14DA-FAN-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + ECSUC2BA-FAN-LF + A-SWS-3 + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF) + LPI0BW1X-X0C-LF + HPI-PUMP-CM + IEA0DG1A-GEN-LF * IEA0DG2B-GEN-LF * L0SS-0SP

TABLE II

A LISTING OF ANO-1 FRONT-LINE SYSTEM FAULT TREES

System	ID	Boolean Expression	No. of Terms	Data
High-Pressure Injection System, 1-of-3 Pumps Criterion	Z2	Table I	69	Table III
High-Pressure Injection System, 2-of-3 Pumps Criterion	Z3	Table A-I	69	Table A-II
High-Pressure Recirculation System	Z5	Table A-III	259	Table A-IV
Low-Pressure Injection System	Z7	Table A-V	106	Table A-VI
Low-Pressure Recirculation System	Z9	Table A-VII	135	Table A-VIII
Low-Pressure Recirculation System, Containment Heat-Removal Mode	Z8	Table A-IX	151	Table A-X
Reactor Building Spray Injection System	ZZ	Table A-XI	114	Table A-XII
Reactor Building Spray Recirculation System	ZX	Table A-XIII	143	Table A-XIV
Emergency Feedwater System, Engineered Safeguards Condition	Z0	Table A-XV	81	Table A-XVI
Emergency Feedwater System, Non-Engineered Safeguards Condition	Z1	Table A-XVII	33	Table A-XVIII
Reactor Building Cooling System	YZ	Table A-XIX	87	Table A-XX
Power-Conversion System	ZW	Table A-XXI	13	Table A-XXII

TABLE III

DATA FOR QUANTIFICATION OF FAULT TREE Z2

Basic Event	Median Unavailability	EF	CG
IEDD114A-BOO	0.10000000E-02	3	11
D114A-CBL-LF	0.11000000E-02	3	1
LPI1407A-VCC-LF	0.41000000E-02	3	8
5164A-CBL-LF	0.11000000E-02	3	1
LPI5164A-BOO-CC	0.20000001E-02	3	2
LPI5164A-BOO-LF	0.10000000E-02	3	11
A-ECS-2	0.42999999E-03	3	26
ECS6036A-DPC-LF	0.41000000E-02	3	8
ECS6036A-BPC-LF	0.41000000E-02	3	8
ECS5254A-B-AASF	0.54000001E-02	10	4
ECS5254A-BOO-CC	0.20000001E-02	3	2
ECS5254A-BOO-LF	0.10000000E-02	3	11
5254A-CBL-LF	0.11000000E-02	3	1
ECSCH4BA-CWU-LF	0.37000000E-02	3	13
ECS5246A-BOO-CC	0.20000001E-02	3	2
ECS5246A-BOO-LF	0.10000000E-02	3	11
5246A-CBL-LF	0.11000000E-02	3	1
ECSUC2BA-FAN-LF	0.53999998E-03	3	12
SWS3643A-VOO-LF	0.40000002E-02	3	8
SWS3820A-VOO-LF	0.40000002E-02	3	8
SWS0303A-BOO-CC	0.20000001E-02	3	2
SWS0303A-BOO-LF	0.10000000E-02	3	11
SWS5653A-BOO-CC	0.20000001E-02	3	2
SWS5653A-BOO-LF	0.10000000E-02	3	11
SWS5181A-BOO-CC	0.20000001E-02	3	2
SWS5181A-BOO-LF	0.10000000E-02	3	11
5653A-CBL-LF	0.33000000E-02	3	1
5181A-CBL-LF	0.33000000E-02	3	1
SWSOP4BA-PMD-LF	0.17000000E-02	3	13
LPI1408B-VCC-LF	0.41000000E-02	3	8
SWS3810B-VCC-LF	0.41000000E-02	3	8
ECS5136A-BOO-CC	0.20000001E-02	3	2
ECS5136A-BOO-LF	0.10000000E-02	3	11
5136A-CBL-LF	0.11000000E-02	3	1
ECSC14DA-FAN-LF	0.53999998E-03	3	12
ECS6034B-DPC-LF	0.41000000E-02	3	8
ECS6034B-BPC-LF	0.41000000E-02	3	8
ECS6254B-BOO-CC	0.20000001E-02	3	2
ECS6246B-BOO-CC	0.20000001E-02	3	2
SWS0402B-BOO-CC	0.20000001E-02	3	2
6254B-CBL-LF	0.11000000E-02	3	1
6246B-CBL-LF	0.11000000E-02	3	1
SWSOP4CB-PMD-LF	0.17000000E-02	3	13
LPI6164B-BOO-CC	0.20000001E-02	3	2
HPIA406B-BOO-CC	0.20000001E-02	3	2
SWS6214B-BOO-CC	0.20000001E-02	3	2

TABLE III (Cont)

Basic Event	Median Unavailability	EF	CG
ECS6254B-B00-LF	0.10000000E-02	3	11
ECS6246B-B00-LF	0.10000000E-02	3	11
SWS0402B-B00-LF	0.10000000E-02	3	11
A406B-CBL-LF	0.11000000E-02	3	1
D214B-CBL-LF	0.11000000E-02	3	1
6164B-CBL-LF	0.11000000E-02	3	1
6214B-CBL-LF	0.11000000E-02	3	1
HPIP36CB-PMD-LF	0.10000000E-02	3	13
IEDD214B-B00	0.10000000E-02	3	11
LPI6164B-B00-LF	0.10000000E-02	3	11
HPIA406B-B00-LF	0.10000000E-02	3	11
SWS6214B-B00-LF	0.10000000E-02	3	11
A-HPI-4	0.22000000E-03	3	26
A-SWS-1	0.22000000E-03	3	26
A-ECS-3	0.42999999E-03	3	26
ECSC2DB-FAN-LF	0.53999998E-03	3	12
ECS6254B-B-AASF	0.54000001E-02	10	4
A-SWS-3	0.22000000E-03	3	26
LPI0BW1X-X0C-LF	0.99999997E-04	3	5
HPI-PUMP-CM	0.17000000E-02	10	50
IEA0DG1A-GEN-LF	0.33000000E-01	10	23
IEA0DG2B-GEN-LF	0.33000000E-01	10	23
LOSS-0SP	0.10000000E-02	10	48

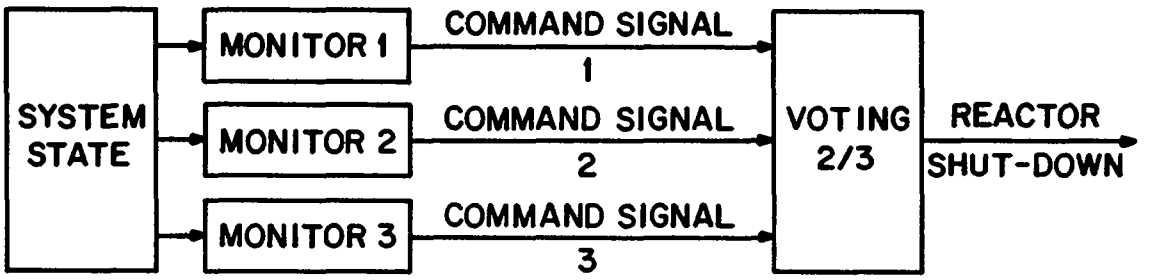

Fig. 1.
Two-out-of-three voting system (from Henley and Kumamoto[8]).

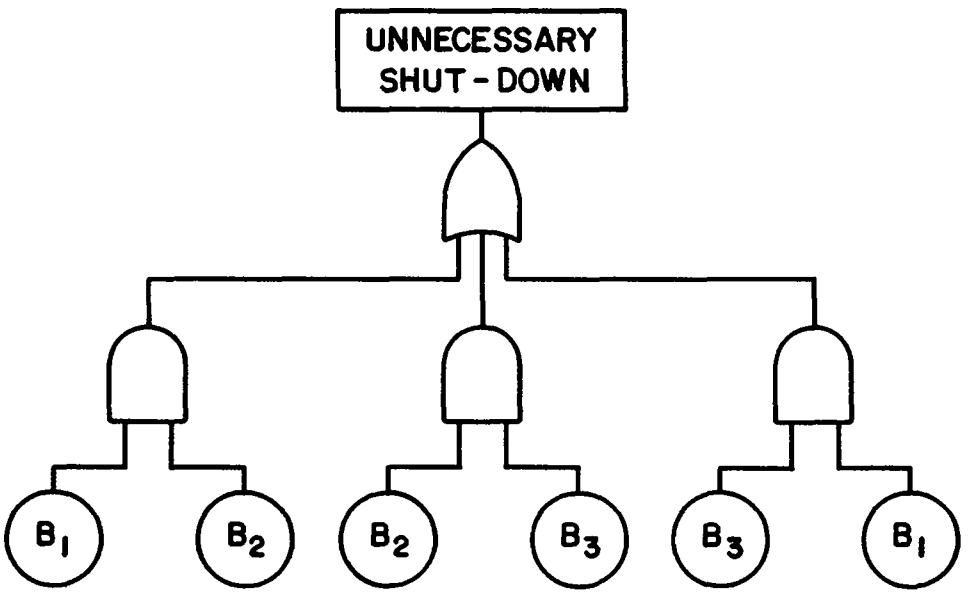

Fig. 2.
Fault tree for two-out-of-three voting system.

In this report we deal with only the equivalent Boolean expression (or structure function) generated from some or all of the minimal cut sets. For the simple example given here, the equivalent Boolean expression is

$$\Psi(\underset{\sim}{Y}) = Y_1Y_2 + Y_2Y_3 + Y_3Y_1 - 2Y_1Y_2Y_3 \quad (1)$$

where Y_i=1 if the ith event occurs and 0 otherwise. Also, $\Psi(\underset{\sim}{Y})$=1 if the top event occurs and 0 otherwise. For each variable Y_i (i = 1, 2, ..., n) in Boolean expressions, there is a probability p_i that the variable Y_i takes on the value 1. This is the same as saying that there is a probability p_i that the event B_i occurs. In the fault trees discussed in Section 2, the p_i values are the unavailabilities of the basic events. Therefore, assuming that all basic events are conditionally statistically independent given the p_i values, the probability of the occurrence of the top event, the expected value of $\Psi(\underset{\sim}{Y})$ or p, is given by the value of the Boolean expression evaluated at the expected value of Y_i or p_i. This evaluation is exact if the Boolean expression is based on all the minimal cut sets and, further, if all the p_i values in the Boolean expression are precisely known. However, some or all of the probabilities p_i are taken to be uncertain in a parameter uncertainty analysis.

To propagate parameter uncertainties through a fault tree for a PRA, some quantitative measures of uncertainty must be adopted. Usually, either probability distributions or attributes of probability distributions are used as measures to convey the uncertainty on the parameters of the PRA study. The attributes of probability distributions most commonly used are the moments of the distribution, such as the mean and variance, or selected percentiles such as the 5th, 95th, and median. The distributions chosen for the PRA study either represent a degree-of-belief in the unknown parameters or the frequency of occurrence of these parameters. For a complete discussion of these two notions of probability, the reader is referred to the PRA Procedures Guide[9] and to Parry and Winter.[10]

In the example given here, suppose each of the events B_i is taken to have a nominal probability of occurrence of 0.001 with a range factor of 3. We define range factor as the ratio of the 95th percentile of the distibution to the median. Distributions may then be generated that satisfy these requirements.

Because each of the probabilities p_i are taken to be uncertain, p (the probability of the occurrence of the top event) is also uncertain. This uncertainty in the top event probability may be obtained by deriving the distribution of the probability of the top event. However, for all but the simplest of trees, this distribution is either difficult or impossible to obtain analytically, especially for continuous basic event distributions that are not first discretized (see Section 3.4). This is true even for the simple tree given in the example. Therefore, approximate techniques are used to obtain selected percentiles of the distribution of the probability of the top event.

In many cases, the variables p_i used in evaluating the Boolean expression are not independent. This lack of independence or coupling between the p_i values is the result of the same data base value, such as a certain component unavailability, being assigned to more than one different basic event in the fault tree. In the example, if we were to assume that monitor 1 and 2 were virtually indistinguishable in manufacture and use, then the probability of events B_1 and B_2 would be identical and thus coupled. Hence, if B_1 has a probability p_1 of occurrence, then the probability of occurrence of B_2 is also p_1. In this report, dependence or coupling between such probabilities is taken to mean that values representing the same percentiles of the corresponding coupled distributions of the two variables are used together.

The distributions of the basic events studied in this report are the normal, log normal, gamma, log gamma, uniform, log uniform, and log Cauchy. A special binomial-based "bootstrap" distribution is also considered. For each fault tree studied, the parameters of the above distributions were determined by requiring that the distributions have the same 5th and 95th percentiles. Methods used to obtain these parameters may be found in Appendix B.

By knowing the distribution of the top event, one is able to make statements about the uncertainty in the probability of the top event. Therefore, the percentiles of the distribution of the top event probability are of most interest, rather than other attributes such as its moments, although these are also computed. So, to judge the effectiveness of the techniques we compared selected "true" percentiles of the distribution of the top event probability with those obtained by the various propagation methods.

The approximate methods used to estimate the percentiles of the distribution of the top event are described in the remainder of this section. The methods are Monte Carlo, method of moments, method of moments using Tchebyshev's inequality,

bootstrap, and discrete probability distributions. These methods encompass the most frequently used methods for propagating uncertainties in fault tree models, although a few other less appropriate and less widely used methods have also been suggested.[9] In addition, a large scale Monte Carlo study is described. The results of this large scale study were sufficiently accurate for use as the true (exact) percentiles of the top event and thus became the standard of comparison for the other methods.

Various computer codes have been written for using the above methods which are listed in Appendix C. We now present a brief summary of each of the methods.

3.1 Monte Carlo and the Truth

Ever since the Reactor Safety Study[11] was published in 1975, Monte Carlo methods have been popular for propagating uncertainties in fault tree and accident sequence models. This popularity is largely due to their straightforward ease of understanding and application.

In this technique, pseudorandom probabilities are drawn to be used as the probabilities of the basic events. The probability of the top event is then computed using Boolean equations similar to Eq. (1) of the example. This procedure is repeated numerous times, and percentiles of the distribution of the top event are estimated by sorting these realizations to obtain empirical percentiles.

In general, the more pseudoprobabilities generated for the top event probability, the more precise the estimates of the percentiles of the probability of the top event. For the samples generated here, 10 000 pseudorandom probabilities were generated for the top event which resulted in at least three-significant-digit accuracy of the estimated percentiles. These estimates were then used as the "standard" of comparison (that is, the "truth") for the other methods. In addition, various other numbers of Monte Carlo trials were generated. This is called the "Monte Carlo method". For the most part, 1 000 trials were used for this method, although several other sample sizes were also considered to examine the rate of convergence.

For each Monte Carlo trial, the coupled probabilities of the primary events were simulated. Uniform, log uniform, and log Cauchy random variates were generated by the inverse transform method. Normal and log normal variates were generated by the modified polar method. Gamma and log gamma variates are more difficult because the family of gamma distributions is not a location-scale

family. If a coupling class contains only one distribution class, then a relatively efficient method can be used to generate the variate;[12] but if there are several distribution classes, the inverse transform method must be used, which is very time-consuming. Any time a probability outside (0,1) is generated, it is rejected along with all coupled probabilities, and a new random number is generated. As a result of this procedure, not only are distributions that go outside (0,1) truncated at 0 and 1, but coupled distributions may be truncated even more severely. For example, if a log normal distribution whose 99.99th percentile is one is coupled with another whose 97th percentile is one, we will never get any probability above the 97th percentile of the first distribution, which is less than one.

The probabilities of the primary events determine the probability of the top event. Probabilities outside (0,1) cause the whole trial to be rejected. (For log normal and especially log Cauchy distributions on the primary events substantial numbers of probabilities greater than one were generated.)

The first 1 000 probabilities for the top event were simply saved. After 1 000 runs, a binning system was set up. Upper and lower bounds for a histogram were determined as a function of the range of the first 1 000 observations. This interval is then subdivided linearly or geometrically into K-2 = 1 000 bins for the histogram, and the first 1 000 observations are sorted to begin the histogram. (By a linear subdivision, we mean that the cell boundary $y_{k+1} = y_k + \Delta$ for all k, $1 \leq k \leq K-2$, while for a geometric subdivision, $\log(y_{k+1}) = \log(y_k) + \Delta$. Linear histograms were used when the distribution of the primary events was uniform or normal, and geometric histograms in all other cases.) The remaining runs are recorded only as entries in the histogram.

After all Monte Carlo runs were made, an empirical distribution function was computed from the histogram. Letting I_k be the interval $[y_{k-1}, y_k)$, estimates $\hat{g}_k$ of $\Pr[Y \in I_k]$ are formed by N_k/N, the ratio of the number of observations in the kth bin to the total number. Note that $\hat{g}_1 = \hat{g}_K = 0$. The empirical distribution function is the step function

$$\hat{G}(y) = \begin{cases} 0 & y < y_1 \\ \sum_{i=0}^{k-1} \hat{g}_i & y_k \leq y < y_{k+1} \quad , \quad k = 1, \ldots, K-1 \quad . \end{cases} \tag{2}$$

In particular, $\hat{G}(y_k)$ is an unbiased binomial estimate of $Pr[Y < y_k]$. The inverse of the step function $\hat{G}$ is

$$\hat{G}^{-1}(x) = y_k, \qquad \sum_{i=0}^{k=2} \hat{g}_i < x \leq \sum_{i=0}^{k=1} \hat{g}_i \quad . \tag{3}$$

We interpolated linearly between y_k and y_{k+1} to obtain the qth quantile when $\hat{G}(y_k) = \hat{G}_k \leq q < \hat{G}(y_{k+1}) = \hat{G}_{k+1}$, specifically,

$$\hat{y}_q = y_i + \frac{q - \hat{G}_k}{G_{k+1} - G_k} (y_{k+1} - y_k) \quad . \tag{4}$$

The values for the percentiles for the "truth" were then generated using Eq. (4). For the Monte Carlo method, the values for the qth percentile of the distribution of the probability of the top event was estimated by the q*Nth ordered observation in the sample of size N.

3.2 Method of Moments

Another method for uncertainty progagation in fault trees is the generation of lower order moments, such as the mean and variance, of the distribution of system unavailability from the moments of the unavailability distribution of the basic events. Once the moments of the system unavailability distribution have been calculated, the moments can be matched to the moments of a chosen distribution from which the desired percentiles can be calculated. This procedure is known as the method of moments for propagating uncertainties. Although we consider only the first two moments of the distribution of system availability, moments exist for estimating as many as four system unavailability moments based on eight basic event unavailability moments.[3]

One important advantage of this method over Monte Carlo simulation methods is that only the first few moments of the basic event unavailability distributions, and not the entire form of the distributions, need to be identified. Thus, fewer assumptions are required to implement the method. However, a system unavailability distribution must be selected to estimate the percentiles and hence the uncertainty in the system unavailability. The method is now described.

In general, it is difficult to find the exact mean and variance of a function of n variables. These two moments may be approximated in the following way: Let f denote the system unavailability function of n variables, $p_1, \ldots, p_n$, where p_i represents the unavailability corresponding to the ith basic fault event, each with known mean μ_i and variance σ_i^2. Then the mean of f may be approximated by

$$\mu \equiv E[f(p_1,\ldots,p_n)] \simeq f(\mu_1,\mu_2,\ldots,\mu_n) \quad . \tag{5}$$

An approximation to the variance of f is

$$\sigma^2 \equiv \mathrm{Var}[f(p_1,p_2,\ldots,p_n)] \simeq \sum_i \left(\frac{\partial f}{\partial p_i}\right)^2 \sigma_i^2 + \sum_{i\neq j} \left(\frac{\partial f}{\partial p_i}\right)\left(\frac{\partial f}{\partial p_j}\right) \mathrm{Cov}(p_i,p_j) \quad , \tag{6}$$

where $\mathrm{Cov}(p_i,p_j)$ is the covariance between p_i and p_j. For coupled events, $\mathrm{Cov}(p_i,p_j) = \sigma_i\sigma_j$; otherwise, $\mathrm{Cov}(p_i,p_j) = 0$. In actual practice the derivatives $\partial f/\partial p_i$ and $\partial^2 f/\partial p_i^2$ are evaluated at the mean vector $(\mu_1, \mu_2, \ldots, \mu_n)$.

Other methods, which require the knowledge of higher moments, exist for the approximation of the mean and variance of a function.[3] This is the result of including second-order terms in the Taylor expansions used to represent the mean and variance of f. We believe that the means and variances given here would be changed little by the inclusion of higher order terms, as higher moments typically decrease by orders of magnitude for typical unavailability distributions of rare basic events.[3]

For the Boolean expression in Eq. (1), the approximated mean and variance [assuming $\mathrm{Cov}(p_i,p_j) = 0$ for all i and j] are

$$\mu \simeq \mu_1\mu_2 + \mu_2\mu_3 + \mu_1\mu_3 - 2\mu_1\mu_2\mu_3 \quad , \tag{7}$$

and

$$\sigma^2 \simeq \sigma_1^2(\mu_2 + \mu_3 - 2\mu_2\mu_3)^2 + \sigma_2^2(\mu_1 + \mu_3 - 2\mu_1\mu_3)^2 + \sigma_3^2(\mu_1 + \mu_2 - 2\mu_1\mu_2)^2 \quad . \tag{8}$$

As discussed earlier, to estimate the percentiles of the system unavailability distribution given only the moments, one must make an assumption about the form of its distribution. In the work presented here, we assume the system availability distribution to be normal, log normal, or the same as that used for the basic fault event unavailabilities. The mean and variance are used to estimate the parameters of the distribution by equating moments, and the resulting distribution is then integrated to obtain the percentile estimates. For example, for the mean and variance given in Eq. (7) and Eq. (8), the 95th percentile of a normal distribution is $\mu + 1.64\sigma$. The relationships between the mean and variance and the parameters used in this study are given in Appendix B.

The derivatives in Eq. (5) and Eq. (6) can be obtained in many ways. In this report, all derivatives were found numerically using Richardson's algorithm,[13] which works well on polynomial functions such as Boolean fault tree expressions.

3.3 Method of Moments Using Tchebyshev's Inequality

In Section 3.2, we pointed out that a distributional form must be assumed for the system unavailability to use the method of moments for estimating percentiles. Whereas this is generally true, approximate percentiles of a distribution may be found by the use of Tchebyshev's inequality. These percentile estimates are necessarily conservative, as Tchebyshev's inequality is true for all distributions.

The basic form for Tchebyshev's inequality when two moments are known is $\Pr[|P-\mu|/\sigma<t] \geq 1 - 1/t^2$, where P denotes a random variable with mean μ and variance σ^2. Therefore, for $\alpha>0.5$, the αth percentile of a distribution may be estimated by $\mu + t_\alpha\sigma$, where $t_\alpha = 1/\sqrt{1-\alpha}$. For $\alpha<0.5$, the αth percentile may be estimated as $\mu - t_{1-\alpha}\sigma$.

In this report, the estimated percentiles, using Tchebyshev's inequality, are generated as above. However, Tchebyshev's inequalities may be formed using more than two moments.[14] This results in improved percentile estimates.

3.4 Discrete Probability Distributions

Discrete probability distributions (DPD) is a technique used to obtain a discrete analog of the distribution of the probability of the top event. It is generated in the following way. Let the two independent variables x and y have probability distributions f(x) and g(y) respectively. Let $\{x_i,f_i\}$ and $\{y_i,g_i\}$ represent the probability that the variables x and y take on the values x_i and y_i.

These probabilities are formed by $f_i = \int_{a_i}^{a_{i+1}} f(x)dx$ where $a_i < x_i < a_{i+1}$ for $i = 1, 2, \ldots, n$, and $a_1 = -\infty$, $a_{n+1} = \infty$. The distribution of any function $H(x,y)$ may then be obtained by computing all values $h_{ij} = H(x_i,y_j)$, each of which occurs with probability $f_i g_j$. The values h_{ij} and their probabilities $f_i g_j$ are then sorted, and a discrete distribution function is formed. More information on this technique may be found in Kaplan.[15] Various codes also exist for implementing this method, and these are discussed in Appendix C.

There are some difficulties in the implementation of the DPD method. Although it is true in theory that the method could be used for a function of many variables, in practice the technique quickly becomes unmanageable. For each new variable considered, n times more computer storage locations are required, where n is the number of discrete probabilities for a single variable. Thus, for n as small as five, nine variables require more than one million words of computer storage. Therefore, in most applications of this method, variables are combined a few at a time, and the resulting distribution collapsed to just a small number of entries. However, even this approach to the method has its problems, for if two variables are coupled then they must be treated simultaneously. For large fault trees, this requirement can lead to many man hours of labor to partition the function into small independent parts. In some cases it is impossible. For these reasons, we studied the performance of this technique for only the smallest of the ANO-1 fault trees, ZW.

For this study, the DPD method was used in the following way: For each variable in the study, the support of its density function f(x) was partitioned into five intervals $(a_i,a_{i+1}]$ for $i = 1, 2, \ldots, 5$. Two schemes were used for the partitioning. The first involved finding the values of a_i such that the probabilities $\int_{a_i}^{a_{i+1}} f(x)dx$ are equal at 0.2. In the second scheme, the probabilities for the five intervals were 0.15, 0.2, 0.3, 0.2, 0.15, and the corresponding a_i values were found. This second scheme was suggested by Ahmed, Clark, and Metcalf.[16]

The central values x_i and y_i were taken as the mean values of their respective intervals; that is, $x_i = \int_{a_i}^{a_{i+1}} xf(x)dx$.

3.5 Bootstrap Methods

Bootstrap is a term used by Efron[17] to describe a procedure to determine the sampling distribution of a random variable. This distribution is found by

evaluating the random variable from repeated samplings from the empirical distribution function.

This is in contrast to the so-called "bootstrap" method described in Chapter 12 of the PRA guide.[9] It is the technique given in the PRA quide that is investigated here and which is briefly described.

Basic hardware component fault event data is usually in one of the following forms: f failures in n trials or demands, f failures in total fault exposure or operating time T, or mean or median failure rates with error factors.

For the demand failure data of f failures in n demands, a binomial model can be used to describe the demand failure rate as f/n. The bootstrap method provides a sample distribution of the unknown binomial parameter, the demand failure rate, p, in this case. The unknown distribution could be constructed (bootstrapped) by using a binomial distribution with parameters n and f/n. Each bootstrap sample is then formed by sampling a value of x^* from a binomial (n,f/n). The bootstrap estimate of p is then given by $p^* = x^*/n$. By repeated sampling from the binomial and formulation of p^*'s, a bootstrap distribution of p is compiled. This distribution then becomes the input parameter distribution for use in the uncertainty propagation.

Time failure data can likewise be bootstrapped to obtain a distribution for the failure rate λ (failures per unit time). The distribution of λ is estimated by repeated samplings of x^* from a Poisson distribution with parameter f/T.

With log normally distributed failure data, bootstrap distributions for the mean and variance can be found. The recommended procedure given in Chapter 12 of the "PRA Procedures Guide"[9] relies on the central limit theorem. That is, μ^* is formed by sampling from a normal distribution with a mean μ equal to the sample mean and a variance σ^2 equal to the sample variance s^2 divided by n. A bootstrap distribution for the variance σ^2 is constructed by sampling x^* from a chi-square distribution with (n-1) degrees of freedom. The bootstrap estimate of the variance is then given by:

$$\sigma^{2*} = \frac{s^2 x^*}{n-1} \quad . \tag{9}$$

Because very skewed log normal distributions produce sample means that only slowly converge to normality, it would be more prudent to bootstrap log normal data in the traditional framework. That is, let F^* be a log normal with the mean equal to the sample mean and variance that of the sample variance. The bootstrap mean and variance and corresponding distributions are then formed by repeatedly taking samples of size n from this F^*.

Once the bootstrap distributions for the unknown p's, λ's, and means are formulated, the distributions can be used as any other assumed probability distribution in the propagation of uncertainty. For example, in a fault tree, each basic event would have its own probability distribution formed from the bootstrap technique. Using these distributions, the top event probability distribution is calculated using the Monte Carlo simulation.

As discussed in Section 2.2, the data for the basic events in the ANO-1 system fault trees studied here consisted of median failure rates and corresponding error factors. These data do not readily match that described above for the bootstrap method. However, these data can easily be translated to a normal mean and standard deviation by the following:

$$\mu_n = \log_e(\text{median})$$

$$\sigma_n = \frac{\log_e(\text{error factor})}{1.645} \quad . \tag{10}$$

However, bootstrapping for the mean or variance requires knowledge of the sample size n. To decide what values to use for n constitutes an entire study on its own. Because this information is not available, the use of a data-based technique like the bootstrap is not advisable. In view of the absence of information relating to exposure time, no Poisson-based analysis can be performed either.

However, binomial-type information can be fashioned from the component data. This is done by translating the normal mean and variance in Eq. (10) to that of the log normal mean and variance. Solving for the binomial p and n is then accomplished by equating the log normal mean and variance to the binomial mean and variance as follows:

$$\mu_{ln} = \exp(\mu_n + 0.5\sigma_n^2)$$

$$\sigma_{1\hat{n}}^2 = \exp(2\mu_n + \sigma_n^2)\cdot[\exp(\sigma_n^2 - 1)]$$

$$\hat{p} = \mu_{1n}$$

$$\hat{n} = \frac{\mu_{1n}(1 - \mu_{1n})}{\sigma_{1\hat{n}}^2} \quad . \tag{11}$$

Thus, a new data set for each ANO-1 fault tree was constructed by converting medians and error factors to $\hat{p}$'s and $\hat{n}$'s for use in the binomial bootstrap.

For each basic fault event, a bootstrap distribution for the unknown parameter p was constructed by taking 10 000 samples from the appropriate binomial (based on the $\hat{p}$ and $\hat{n}$ values) and formulating 10 000 values of $p^* = x^*/\hat{n}$. The resulting table of values of p^* is the sampling distribution for that fault event.

To propagate uncertainty through a fault tree, the bootstrap distributions are sampled obtaining a value of p_i^* for the ith basic event. The set of p_i^*'s is substituted into the Boolean expression that calculates the top event probability of the tree. Using the Monte Carlo simulation code, this process is repeated forming a distribution of values for the system unavailability. In this sense, the bootstrap distributions are used in the Monte Carlo simulation in the same way as other specified distributions for basic events.

4. RESULTS AND CONCLUSIONS

The results of the study are primarily of two types: the first considers the sensitivity of the distribution of the top event probability, that is the ANO-1 front-line system unavailability distribution, to the choice of basic event unavailability distributions. These are given in Section 4.1. The second, contained in Sections 4.2 and 4.3, concerns the comparative assessment of the performance of the uncertainty propagation methods discussed in Section 3. Finally, Section 4.4 discusses the situation in which system unavailability distribution percentiles are estimated based on the propagation of certain percentiles of the basic event unavailability distributions. The figures for this section (Figs. 3-81) can be found at the end of Section 4.

4.1 Sensitivity to Basic Event Distributions

Recall from Section 3 that to uniformly compare the seven basic event unavailability distributions it was decided to match the 5th and 95th percentiles of all the distributions. This decision was based on the notion that, in an uncertainty analysis, an uncertainty interval (as opposed to a central or best value) is of primary interest and frequently a 90 percent interval is chosen. This decision thus affords uniform control over both five percent tail areas of all seven distributions. The results presented below heavily depend on this decision. If other pairs of distributional characteristics are held fixed for all seven distributions, such as the median and 95th percentile or the mean and variance, many of the results would be different. This fact will be subsequently demonstrated. Therefore, the results to be presented are conditional on the decision to compare the top event unavailability distributions for basic event distributions having matching 5th and 95th percentiles.

Box-and-whisker plots[18] are used to summarize the distribution of the system unavailability, using the notation defined in Fig. 3. Figures 4-15 give the results for eight different basic event distributions, including the binomial-based bootstrap distribution discussed in Section 3.5, for all 12 ANO-1 fault tree models discussed in Section 2. The distributional code used in these figures, and throughout the remainder of this section, is as follows:

BS--Bootstrap
G--Gamma
LC--Log Cauchy
LG--Log Gamma
LN--Log Normal
LU--Log Uniform
N--Normal
U--Uniform

In Figs. 4-15 the vertical axis represents the system unavailability on a log scale.

Similarly, Figs. 16-27 compare the distributions on a linear vertical scale rather than a log scale. However, the results for both the bootstrap and log Cauchy distributions are not shown in Figs. 16-27 to keep from completely distorting the other results.

The results in all of these figures are based on Monte Carlo simulation using 10 000 replications. The accuracy of the results is shown in Table IV for the case of the log normal distribution and ANO-1 fault tree Z2. The 95 percent confidence intervals on each of the estimates were derived using nonparametric methods as described by Conover[19] and measure the accuracy of the corresponding estimate. As more and more replications are considered, the confidence intervals become narrower, ultimately collapsing onto the estimate in the limit.

In Table V the typical accuracy of Monte Carlo simulation results is shown as a function of the Monte Carlo sample size (the number of replications) for fault tree Z5 and log normal basic event unavailability distributions. Both the point estimate and 95 percent confidence intervals are given. Except for the 99th percentile estimate, the accuracy is fairly good for as few as 1 000 replications; however, 10 000 replications are used in Figs. 4-27.

Table VI gives the approximate central processing unit (CPU) time in seconds (within a factor of about 2) for obtaining the Monte Carlo results reported in Figs. 4-27, using 10 000 replications, for each of the basic event distributions (excluding bootstrap) and for each of the fault tree models. In general, the CPU time is proportional to the number of distinct distributions required in quantifying a fault tree having coupled basic events. The fastest execution times are reported for N, U, LU, LN, and LC distributions, whereas the slowest times are reported for the G and LG distributions. The slow times for the G and LG distributions are the result of coupling.

TABLE IV

ACCURACY OF MONTE CARLO RESULTS FOR THE LOG NORMAL DISTRIBUTION AND FAULT TREE Z2[a]

	1st Percentile	5th Percentile	Median	Mean	95th Percentile	99th Percentile
Estimate	0.0154	0.0227	0.0668	0.1076	0.2972	0.7332
95 Percent Confidence Interval	(0.0146, 0.0159)	(0.0223, 0.0233)	(0.0657, 0.0679)	(0.1041, 0.1112)	(0.2790, 0.3137)	(0.6638, 0.8251)

[a]All numbers to be multiplied by 10^{-1}.

TABLE V

ACCURACY OF MONTE CARLO RESULTS FOR THE LOG NORMAL DISTRIBUTION AND FAULT TREE Z5 AS A FUNCTION OF THE SAMPLE SIZE N

Percentile	N=100	N=500	N=1 000	N=10 000
1st	0.0567 (0.0000,0.0705)	0.0660 (0.0537,0.0703)	0.0686 (0.0608,0.0712)	0.0666 (0.0652,0.0678)
5th	0.0802 (0.0543,0.0933)	0.0783 (0.0741,0.0820)	0.0804 (0.0770,0.0834)	0.0801 (0.0792,0.0809)
Median	0.1485 (0.1325,0.1666)	0.1327 (0.1270,0.1387)	0.1347 (0.1313,0.1383)	0.1366 (0.1354,0.1378)
95th	0.2830 (0.2311,0.4076)	0.3013 (0.2649,0.3389)	0.2867 (0.2730,0.3206)	0.2933 (0.2868,0.3027)
99th	0.3962 (0.3227,1.0000)	0.4774 (0.3784,0.9153)	0.4321 (0.4004,0.7193)	0.5123 (0.4852,0.5868)

By examining Figs. 4-27 the following conclusions are made:

- The system unavailability distribution, which represents the uncertainty in quantifying the system unavailability, is generally somewhat sensitive to the form of the distribution chosen to represent the uncertainty in quantifying the basic event unavailabilities.

- The system unavailability distribution is particularly sensitive to the choice of symmetric versus asymmetric basic event distributions. That is, symmetric N and U basic event distributions tend to yield fundamentally different system unavailability distributions than those produced by the use of BS, G, LC, LG, LN, and LU distributions in that they are shifted towards higher unavailability values (that is, more conservative), were less diffuse (that is, less uncertainty in the system unavailability), and had greater symmetry.

TABLE VI

APPROXIMATE CPU TIME FOR 10 000 MONTE CARLO REPLICATIONS

ANO-1 Fault Tree	No. of Basic Events	No. of CGs	No. of Distinct Distn's	Basic Event Distribution						
				U	N	G	LU	LN	LC	LG
Z0	81	15	29	293	1068	3291	689	400	499	3420
Z1	33	10	17	64	162	1425	57	36	55	2937
Z2	69	12	17	94	139	1155	157	65	59	2541
Z3	221	27	39	235	304	2539	334	114	472	2627
Z5	259	38	57	300	403	3864	411	156	601	4453
Z7	106	19	26	131	240	1697	219	87	264	1720
Z8	151	21	32	186	268	2308	283	103	340	2289
Z9	135	21	31	167	246	2145	285	99	371	2198
ZW	13	7	7	31	65	65	54	21	78	35
ZX	143	21	32	173	246	5129	281	100	325	2292
ZZ	114	19	27	29	260	4604	227	125	365	1740
YZ	87	13	23	97	341	1953	166	64	193	2013

- LN basic event distributions yield a system unavailability distribution that has a heavy right-hand tail, in the sense that the 99th percentile is generally significantly greater than that for the G, LG, LU, N, or U distributions; however, many other characteristics, such as the 5th and 95th percentiles, are virtually the same for the G, LG, LN, and LU distributions.

- LC basic event distributions yield quite heavy right-hand tailed system unavailability distributions.

- Bootstrap basic event distributions yield quite diffuse system unavailability distributions that generally tend to be less conservatively located (that is, shifted toward smaller unavailability values) than the LC results.

- For the case in which the 5th and 95th percentiles of all the basic event distributions are the same, the LN distribution yields a system unavailability distribution whose median is generally less conservative than the median values corresponding to the G, LG, LU, N, or U distributions (because of the heavy right-hand tail of the LN distribution).

- Symmetric basic event distributions, such as the N and U distributions, tend to yield fairly symmetric system unavailability distributions, whereas right-skewed basic event distributions, such as the G, LG, LN, and LU distributions, tend to yield right-skewed system unavailability distributions.

- G and LG basic event distributions yield almost identical system unavailability distributions.

Figures 28 and 29 consider the case in which the median and 95th percentiles are matched across all basic event distributions for fault tree Z2. These figures may be directly compared to Figs. 4 and 16, respectively. The comparative system unavailability distributions depend on the characteristics of the basic event unavailability distributions that are held fixed and may yield different results depending on the characteristics chosen. In the case of matching 5th and 95th percentiles (Fig. 16), LN basic event distributions yield a top event distribution that is shifted toward lower unavailability values; in the case of matching median and 95th percentiles (Fig. 29), G and LG distributions shift the top event distribution toward lower values. In this single example, the G and LG distributions are the most sensitive to the characteristics that are selected to be held fixed, a result which may or may not be true in general. In Fig. 29, the G and LG results are much more highly skewed than those in Fig. 16. The N results are also somewhat different in Figs. 16 and 29.

4.2 Comparison of Uncertainty Propagation Methods

In this section, we will compare the uncertainty propagation results for the Monte Carlo method based on 1 000 replications, Monte Carlo simulation using the bootstrap basic event distributions, the method of moments based on the assumption of LN, N, and several other system unavailability distributions, and the method of moments using Tchebyshev's inequality. As discussed earlier, all of these results will be compared to Monte Carlo results based on 10 000 replications, which will be taken as the standard of comparison or "truth". Section 4.3 separately considers the case of the DPD approach.

Figures 30-41 show the results obtained for each of the ANO-1 fault trees considered here and a G basic event unavailability distribution (except for the MC-BS method). The method code used in these and all subsequent figures of this type is as follows:

TRUTH--Monte Carlo simulation using 10 000 replications

MC--Monte Carlo simulation using 1 000 replications

MM-LN--Method of moments using an assumed LN system unavailability distribution

MM-N--Method of moments using an assumed N system unavailability distribution

MM-U--Method of moments using an assumed U system unavailability distribution

MM-G--Method of moments using an assumed G system unavailability distribution

MM-TI--Method of moments using Tchebyshev's inequality

MC-BS--Monte Carlo simulation using 10 000 replications and bootstrap basic event distributions

Log gamma basic event unavailability distributions give the same results as in Figs. 30-40; Fig. 41 is slightly different.

Similarly, Figs. 42-53 give the comparative results for an LN; Figs. 54-65 for an N; and Figs. 66-77 for a U basic event distribution. The LC distribution was not considered, as the moments of the LN distribution do not exist. The LU distribution also was not considered.

The following conclusions are made based on Figs. 30-77:

- MC compares favorably with the TRUTH and, for a randomly selected fault tree, is likely to perform better than any of the other methods.

- MM-LN and MM-G both perform well compared to the TRUTH and, in many cases, the MM-LN method outperforms the MM-G method in estimating the 99th percentile because of its heavier right-hand tail; however, both methods produce nearly the same results for all other percentiles studied as well as the mean (average).

- MM-N and MM-U do not perform as well as MM-LN and MM-G, especially for estimating extreme tail area percentiles such as the 1st and 99th, even in the case of N or U basic event distributions.

- MM-TI provides upper(lower) percentile estimates of the system unavailability distribution which greatly overestimate(underestimate) the TRUTH.

- MC-BS does not produce good results compared to the TRUTH.

4.3 Propagating Discrete Probability Distributions

In this section, we will compare the DPD method with the MC method and the TRUTH. As mentioned in Section 3.4, this comparison is only performed on ANO-1 fault tree ZW, because all of the remaining trees are too large for efficiently applying the DPD method. Even the comparison on tree ZW would not have been possible without condensing if the coupled variables did not have the same distribution. This fact reduced the number of basic events from 13 to 7.

For this comparison, the LN, N, U, and G basic event distributions were used. Figs. 78-81 present the results. It is clear that the DPD method with unequal probability intervals (DPD-UP) and the DPD method with equal probability intervals (DPD-EP) yield 99th percentiles that are less than the true 99th percentile and 1st percentiles that are greater than the true 1st percentile. Further conclusions regarding the remaining percentiles cannot be made since the unavailability distribution is dominated by a single basic event, the first basic event in the expression in Table A-XXI.

Two serious drawbacks of the DPD method are:

- Trees with more than about 9 or 10 basic events cannot be analyzed by the DPD method in a straightforward single application of the method without first arbitrarily partitioning the tree into smaller trees.

- In partitioning a large fault tree into smaller independent trees, coupled basic events must be placed in the same group; thus, some of these groups may still be too large for implementing the method.

Also, the performance of the DPD method depends on the probability allocation scheme arbitrarily chosen for each basic event as well as the arbitrary grouping scheme employed for large trees. As observed in Figs. 78-81, the MC method outperforms the DPD method. Because the MC method is less arbitrary, applicable

to larger trees (either coupled or uncoupled), and performs better, the MC method is deemed to be superior to the DPD method.

4.4 "Quick-and-Dirty" Estimates of the Percentiles of the System Unavailability Distribution

Often it is desired to estimate certain percentiles of the distribution of system unavailability in a fault tree model. There are two common ways to accomplish this. The first is to assume some distribution for this probability, which is fitted by a technique such as the method of moments, and to estimate the percentiles from this fitted distribution. The second is to estimate the percentiles from those of the empirical distribution obtained by means of Monte Carlo simulation. Both of these methods have been considered here.

An alternative method is to propagate appropriate percentiles of the basic event unavailability distributions directly through the Boolean equation to estimate the percentiles. This procedure will be referred to here as the "quick-and-dirty" method as each system-level percentile estimate is the result of a single easy and inexpensive computational evaluation of the Boolean equation. If this approach yields reasonably accurate estimates (as will be shown to be the case), it can be used for preliminary uncertainty analyses (for screening purposes) before using better methods such as Monte Carlo techniques.

The relevant question thus becomes: Which basic event percentiles do I propagate through the equation to estimate, say, the median of the system unavailability distribution? Or the 5th percentile? Or the 95th percentile?

To estimate the median top event probability in fault tree models, basic event percentiles other than the median must often be used, particularly for skewed distributions. Our results indicate that the basic event percentiles to be used depend on the fault tree model as well as the distribution assumed for the basic events. Table VII gives the basic event percentiles (when multiplied by 100) that must be propagated through each of the 12 fault tree Boolean equations considered here to obtain the 5th, 10th, 50th, 90th, and 95th percentiles of the system unavailability distribution in the case of LN basic event distributions. Table VII, and subsequent tables, were obtained from the Monte Carlo results based on 10 000 replications. For example, for fault tree Z2, if the 63rd percentile of each basic event distribution is propagated through the Boolean equation, the median system unavailability is obtained. Similarly, if the 5th percentile is

desired, then the 33rd percentile of each LN basic event distribution should be used. Small fault tree ZW is an outlier compared to the remaining larger trees.

The range and interquartile range (IQR) of the basic event distribution percentiles (Table VII) in the column headed 0.50 are (0.54,0.65) and (0.61,0.64), respectively, which are reasonably tight spreads, particularly the IQR. The median percentile value in this column is 0.63, which says that for 50 percent of the fault trees, this value will produce an estimate above the desired median, whereas for the remaining 50 percent, the use of the 63rd percentile will yield an estimate below the median.

Table VIII gives the actual system distribution percentile (when multiplied by 100) that will be obtained if the median is used of the 12 percentiles reported in Table VII for each of the 5th, 10th, 50th, 90th, and 95th percentile cases. For example, if the 63rd percentile of each basic event distribution is propagated through fault tree Z0, then the 56th percentile of the system unavailability distribution is obtained. Of course if the 60th percentiles are propagated, the median is exactly obtained (Table VII). From Table VIII we see that if the 63rd basic event distribution percentile is propagated, the median system percentile obtained is the 50th as expected; however, the actual system percentile obtained

TABLE VII

LOG NORMAL BASIC EVENT DISTRIBUTION PERCENTILES REQUIRED FOR ESTIMATING SYSTEM UNAVAILABILITY DISTRIBUTION PERCENTILES

Fault Tree	Percentile 0.05	0.10	0.50	0.90	0.95
Z0	0.24	0.31	0.60	0.85	0.89
Z1	0.27	0.33	0.60	0.87	0.93
Z2	0.33	0.40	0.63	0.86	0.90
Z3	0.34	0.41	0.62	0.83	0.88
Z5	0.40	0.44	0.65	0.84	0.89
Z7	0.39	0.43	0.64	0.83	0.88
Z8	0.38	0.43	0.64	0.84	0.89
Z9	0.37	0.43	0.64	0.83	0.88
ZW	0.07	0.13	0.54	0.90	0.95
ZX	0.38	0.43	0.65	0.86	0.90
ZZ	0.37	0.42	0.64	0.86	0.91
YZ	0.34	0.40	0.62	0.86	0.92
Median	0.35	0.42	0.63	0.85	0.90
I.Q.R.	0.30 0.38	0.37 0.43	0.61 0.64	0.84 0.86	0.88 0.91
Range	0.07 0.40	0.13 0.44	0.54 0.65	0.83 0.90	0.88 0.95

may be as small as the 47th (for fault tree Z5) or as large as the 61st (for fault tree ZW).

It is observed from Table VII that, on the average, the 35th percentile of the basic event distributions must be propagated to obtain roughly the 5th percentile of the top event distribution; the 42nd for roughly estimating the 10th; the 63rd for the 50th; the 85th for the 90th; and the 90th for the 95th. Thus, when estimating the 5th and 10th percentiles of the system unavailability distribution, percentiles approximately 30 percentage points more than that desired must be used, whereas for the 90th and 95th percentiles approximately 5 percentage points less than that desired must be used.

Similarly, Tables IX and X, corresponding to Tables VII and VIII, consider the case of G basic event distributions. The G results are similar to the LN results; however, the median values in the row labeled Median in Table IX are all shifted to the left of the corresponding values in Table VII.

Finally, Table XI gives the median values (for all 12 fault trees) for use in estimating the 5th, 10th, 50th, 90th, and 95th system unavailability distribution percentiles for the LU, LC, U, and N basic event distributions. For example, to estimate the 5th percentile of the system unavailability distribution, on the average the 29th percentile of either N or U basic event distributions should be propagated to produce the desired estimate.

TABLE VIII

SYSTEM UNAVAILABILITY DISTRIBUTION PERCENTILES OBTAINED USING THE MEDIAN BASIC EVENT DISTRIBUTION VALUES FROM TABLE VII

	Median Value				
Fault Tree	0.35	0.42	0.63	0.85	0.90
Z0	0.14	0.21	0.56	0.91	0.96
Z1	0.12	0.20	0.57	0.88	0.93
Z2	0.07	0.12	0.51	0.89	0.95
Z3	0.06	0.11	0.53	0.92	0.97
Z5	0.03	0.07	0.47	0.92	0.96
Z7	0.03	0.08	0.49	0.93	0.97
Z8	0.04	0.08	0.49	0.92	0.96
Z9	0.04	0.08	0.49	0.93	0.97
ZW	0.31	0.37	0.61	0.85	0.90
ZX	0.04	0.08	0.47	0.89	0.95
ZZ	0.04	0.09	0.48	0.89	0.94
YZ	0.06	0.12	0.53	0.89	0.94
Median	0.05	0.10	0.50	0.90	0.95
I.Q.R.	0.04 0.09	0.08 0.16	0.49 0.54	0.89 0.92	0.94 0.97
Range	0.03 0.31	0.07 0.37	0.47 0.61	0.85 0.93	0.90 0.97

TABLE IX

GAMMA BASIC EVENT DISTRIBUTION PERCENTILES REQUIRED FOR ESTIMATING SYSTEM UNAVAILABILITY DISTRIBUTION PERCENTILES

Fault Tree	Percentile 0.05	0.10	0.50	0.90	0.95
Z0	0.23	0.30	0.57	0.79	0.85
Z1	0.24	0.30	0.56	0.84	0.89
Z2	0.26	0.32	0.57	0.79	0.85
Z3	0.32	0.36	0.58	0.77	0.82
Z5	0.35	0.41	0.60	0.78	0.83
Z7	0.33	0.39	0.58	0.77	0.81
Z8	0.32	0.37	0.59	0.78	0.83
Z9	0.32	0.38	0.59	0.77	0.80
ZW	0.06	0.12	0.50	0.88	0.94
ZX	0.32	0.38	0.60	0.80	0.86
ZZ	0.32	0.37	0.60	0.81	0.87
YZ	0.29	0.34	0.57	0.84	0.89
Median	0.32	0.37	0.58	0.79	0.85
I.Q.R.	0.25	0.31	0.57	0.78	0.82
	0.32	0.38	0.59	0.82	0.88
Range	0.06	0.12	0.50	0.77	0.80
	0.35	0.41	0.60	0.88	0.94

TABLE X

SYSTEM UNAVAILABILITY DISTRIBUTION PERCENTILES OBTAINED USING THE MEDIAN BASIC EVENT DISTRIBUTION VALUES FROM TABLE IX

Fault Tree	Median Value 0.32	0.37	0.58	0.79	0.85
Z0	0.12	0.17	0.52	0.90	0.95
Z1	0.12	0.19	0.54	0.85	0.91
Z2	0.10	0.17	0.51	0.90	0.95
Z3	0.05	0.10	0.51	0.92	0.97
Z5	0.03	0.06	0.44	0.92	0.96
Z7	0.04	0.08	0.49	0.93	0.97
Z8	0.04	0.09	0.48	0.92	0.96
Z9	0.04	0.09	0.48	0.94	0.97
ZW	0.31	0.36	0.59	0.81	0.86
ZX	0.04	0.09	0.46	0.89	0.94
ZZ	0.05	0.10	0.46	0.87	0.93
YZ	0.08	0.14	0.52	0.86	0.91
Median	0.05	0.10	0.50	0.90	0.95
I.Q.R.	0.04	0.09	0.47	0.87	0.92
	0.11	0.17	0.52	0.92	0.96
Range	0.03	0.06	0.44	0.81	0.86
	0.31	0.36	0.59	0.94	0.97

TABLE XI

MEDIAN BASIC EVENT UNAVAILABILITY DISTRIBUTION PERCENTILES[a] REQUIRED FOR ESTIMATING THE 5th, 10th, 50th, 90th, AND 95th PERCENTILES OF THE SYSTEM UNAVAILABILITY DISTRIBUTION

Basic Event Distribution	Percentile				
	0.05	0.10	0.50	0.90	0.95
Log Uniform	0.39	0.44	0.62	0.78	0.82
Log Cauchy	0.21	0.27	0.65	0.93	0.95
Uniform	0.29	0.33	0.50	0.68	0.71
Normal	0.29	0.33	0.53	0.74	0.79

[a]When multiplied by 100.

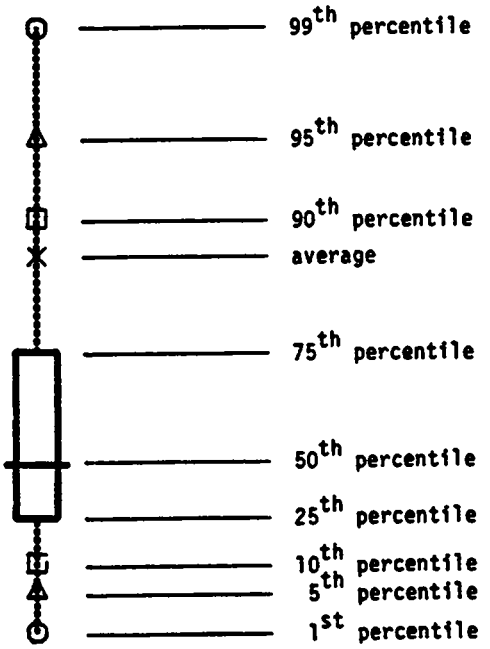

Fig. 3.
Notation for the box-and-whisker plots.

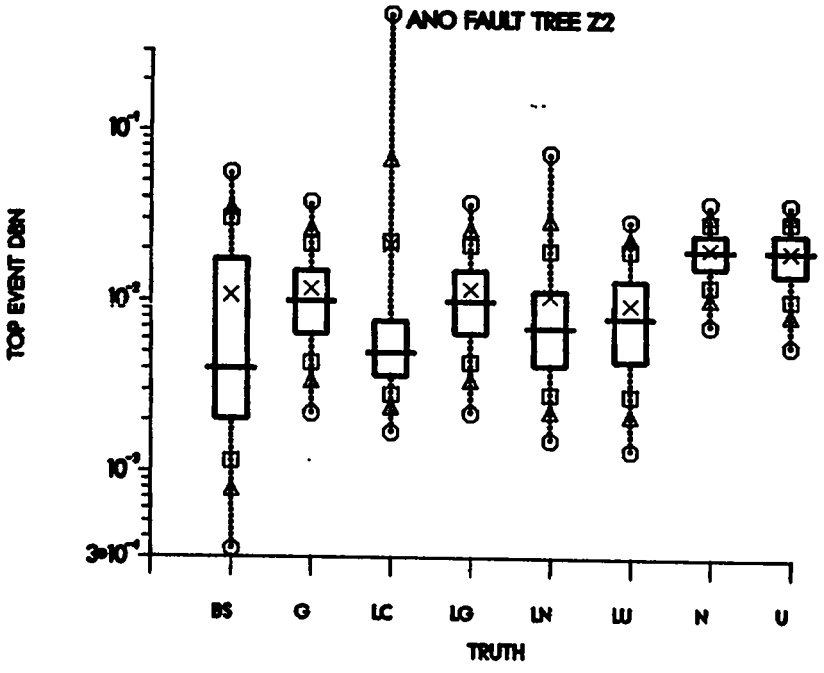

Fig. 4.

Sensitivity to basic event distributions for fault tree Z2 (log scale).

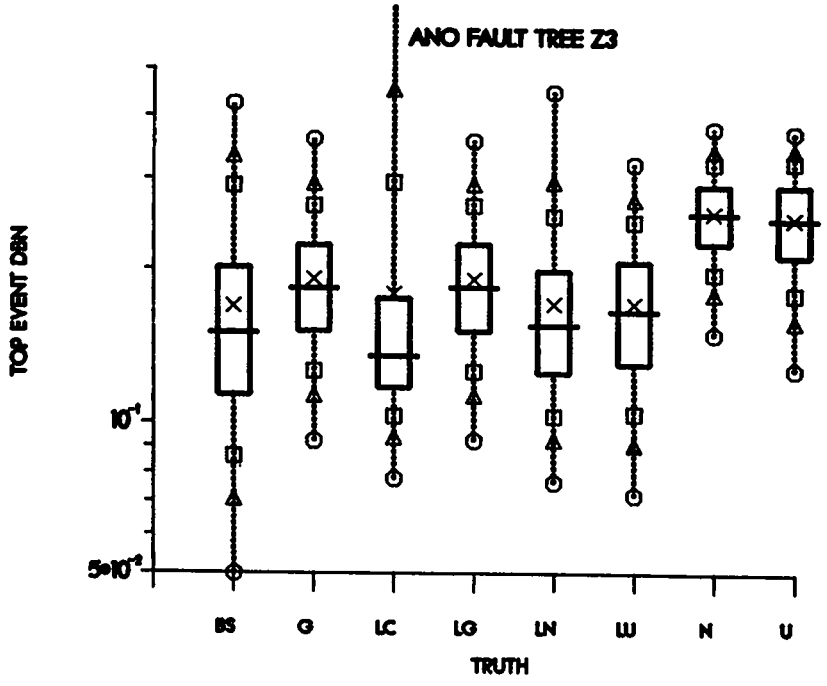

Fig. 5.

Sensitivity to basic event distributions for fault tree Z3 (log scale).

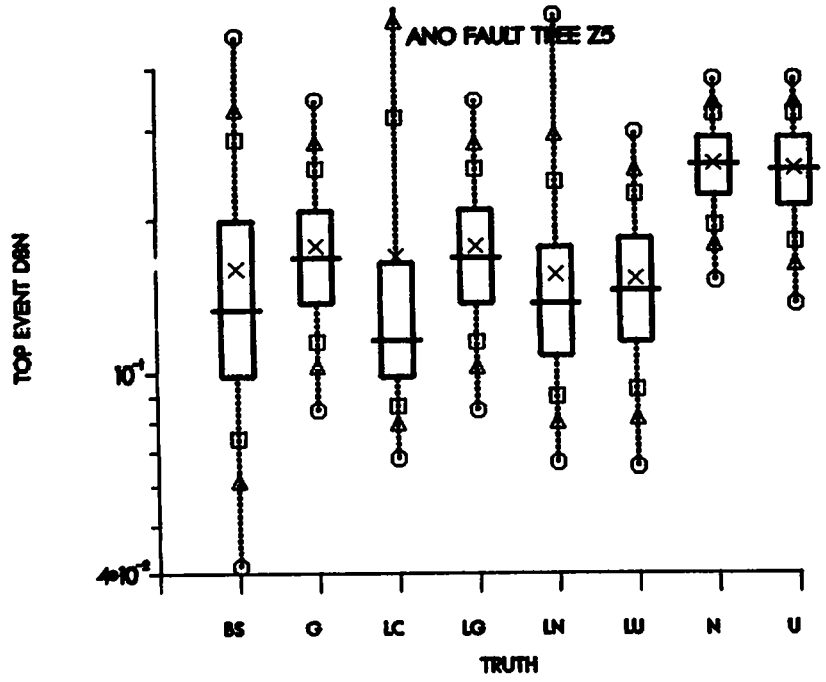

Fig. 6.

Sensitivity to basic event distributions for fault tree Z5 (log scale).

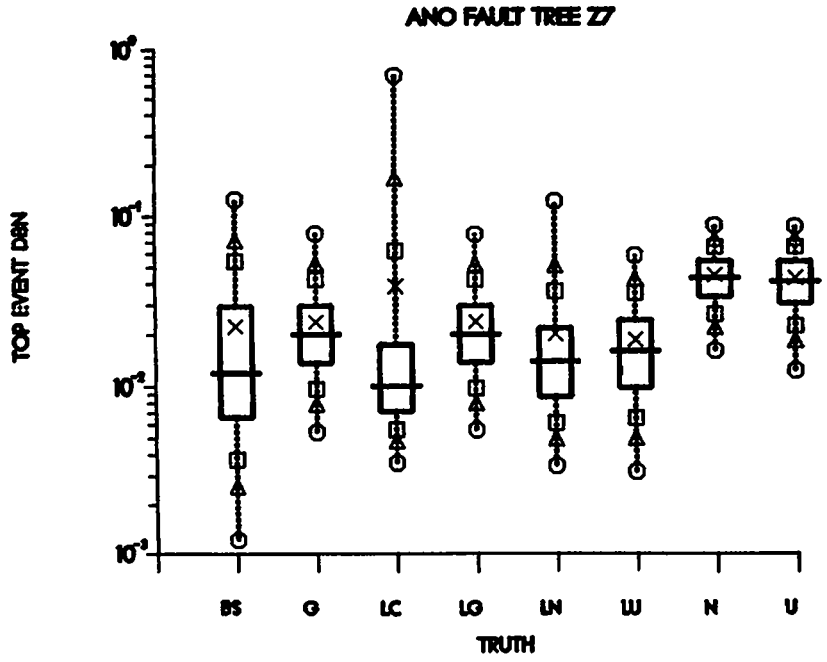

Fig. 7.

Sensitivity to basic event distributions for fault tree Z7 (log scale).

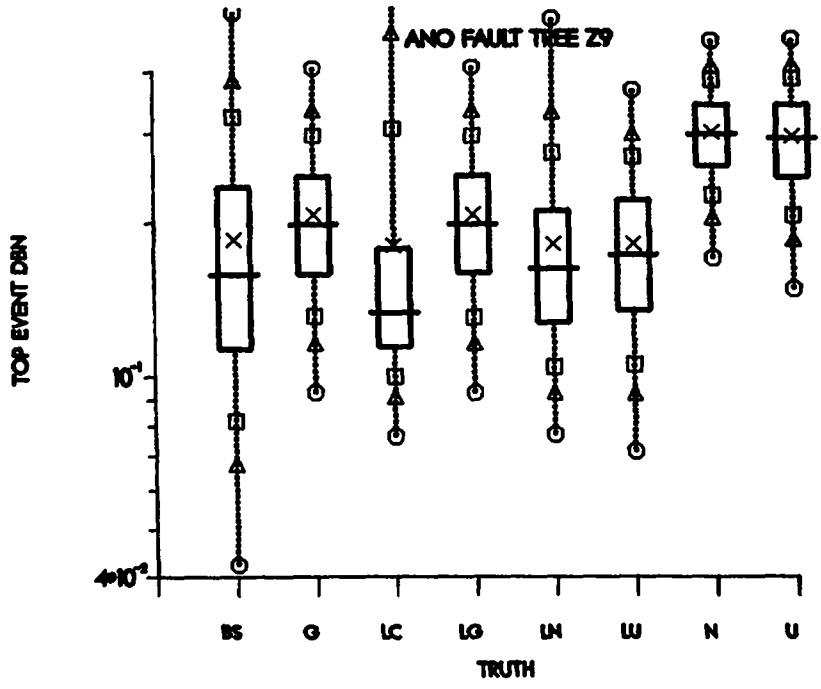

Fig. 8.

Sensitivity to basic event distributions for fault tree Z9 (log scale).

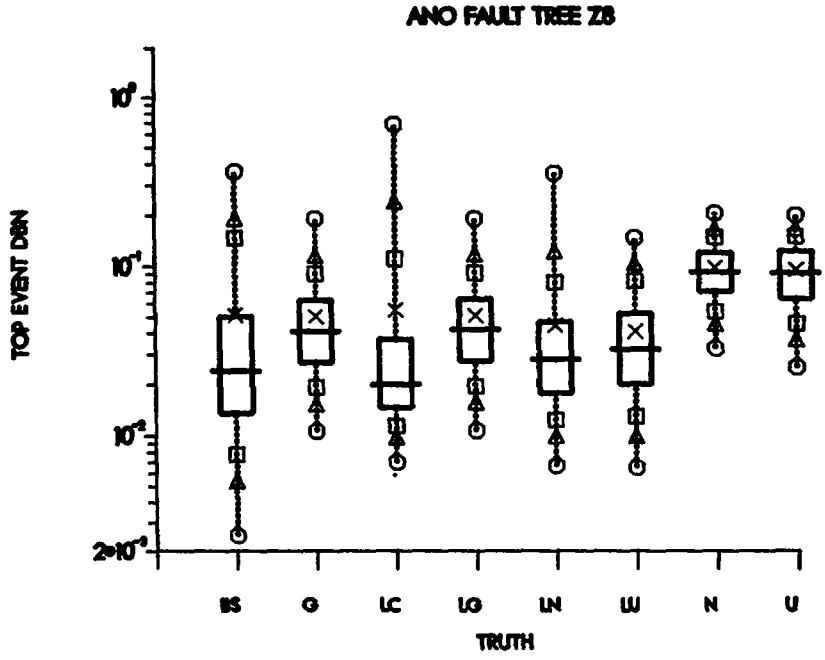

Fig. 9.

Sensitivity to basic event distributions for fault tree Z8 (log scale).

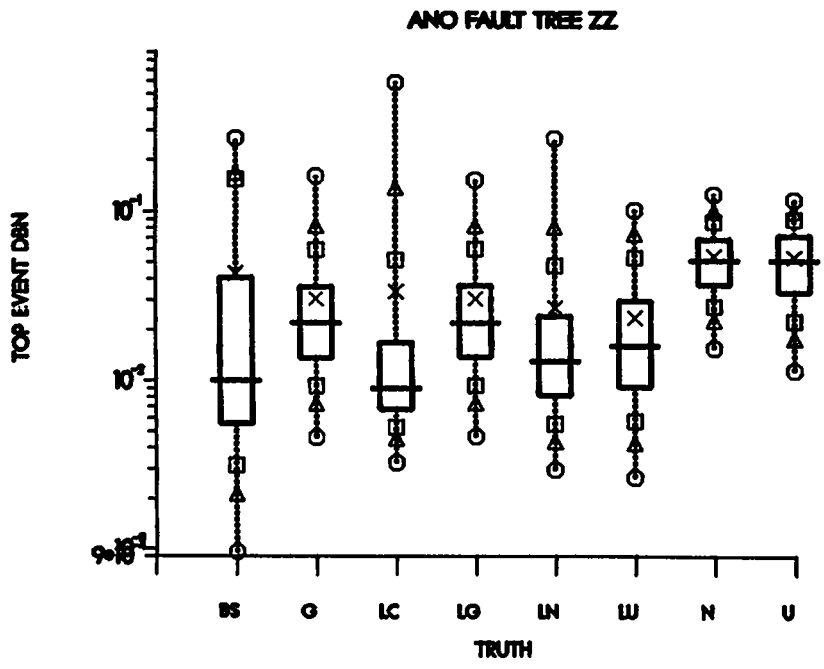

Fig. 10.

Sensitivity to basic event distributions for fault tree ZZ (log scale).

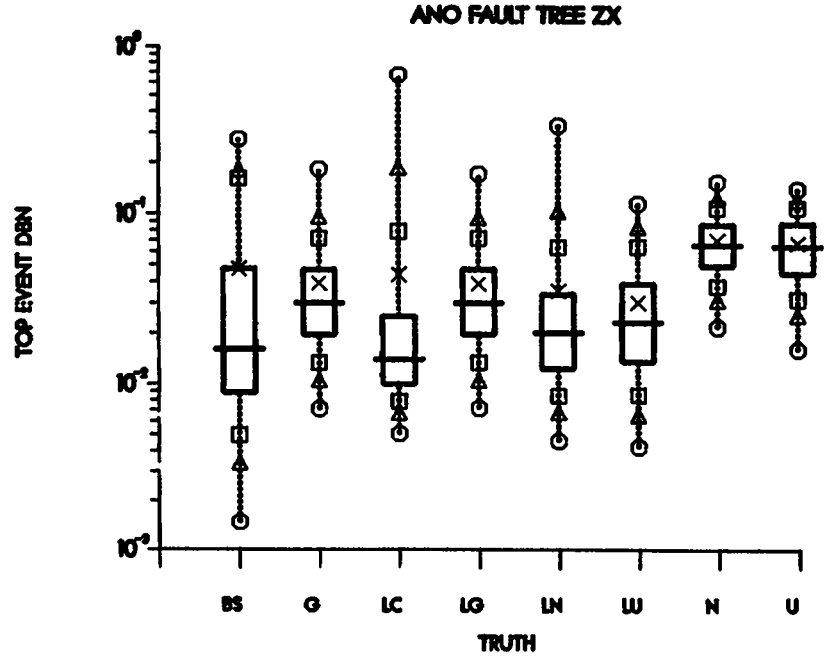

Fig. 11.

Sensitivity to basic event distributions for fault tree ZX (log scale).

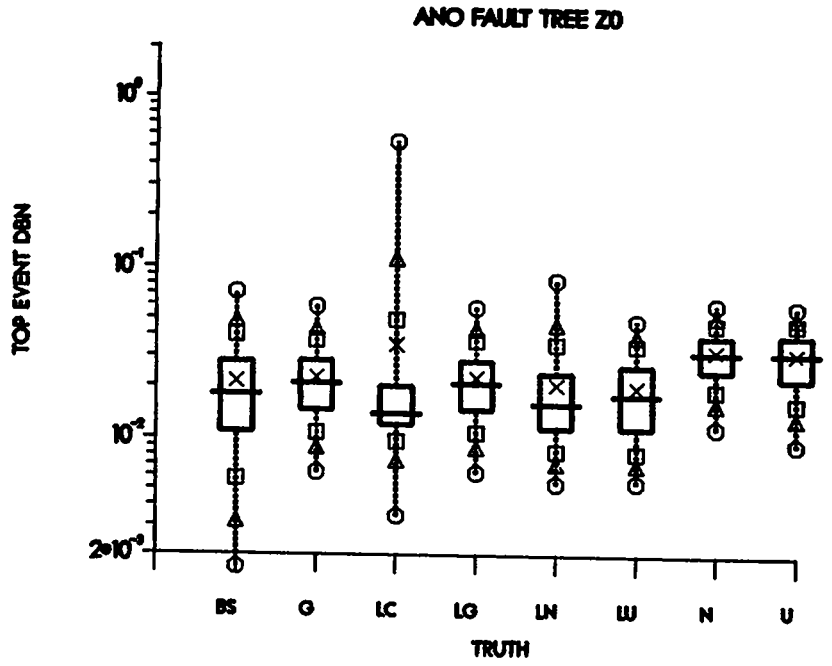

Fig. 12.

Sensitivity to basic event distributions for fault tree Z0 (log scale).

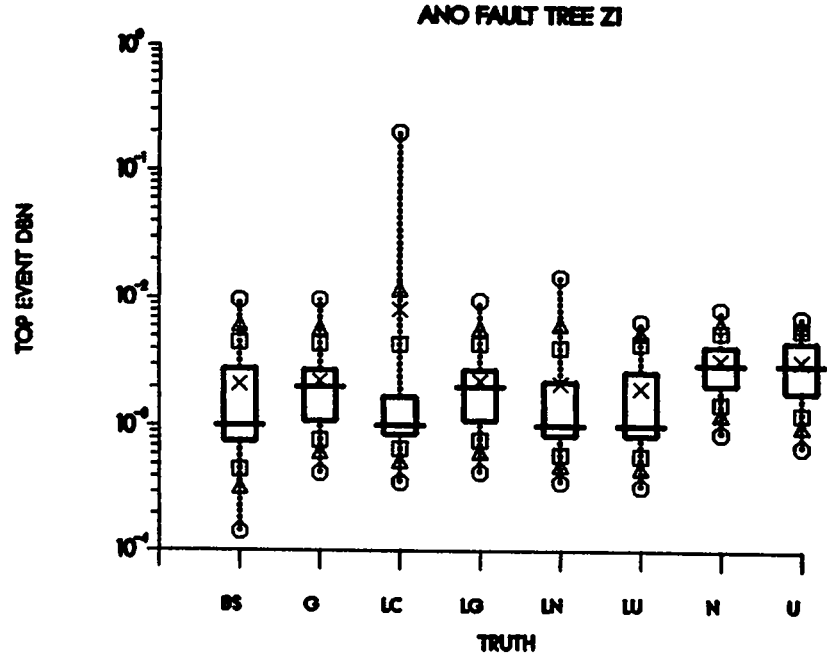

Fig. 13.

Sensitivity to basic event distributions for fault tree Z1 (log scale).

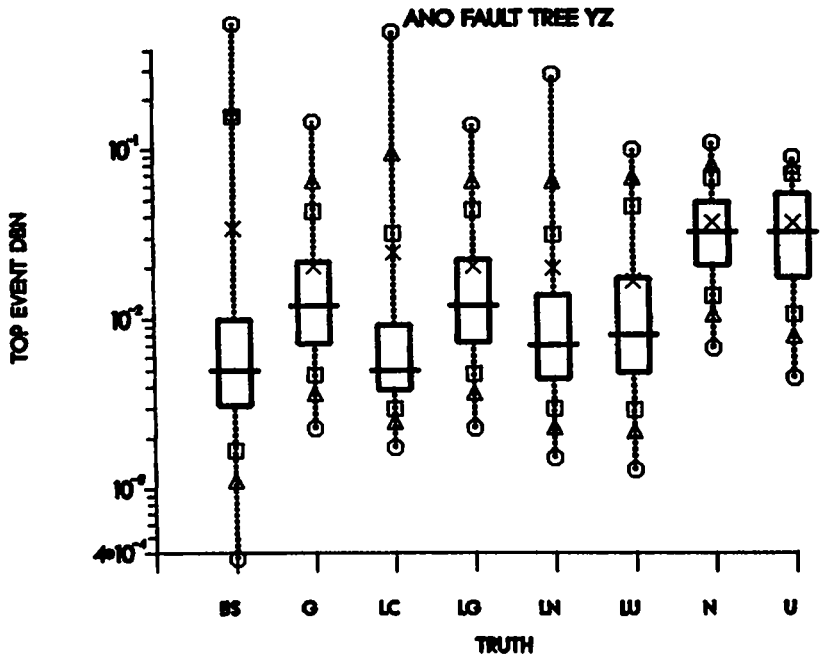

Fig. 14.

Sensitivity to basic event distributions for fault tree YZ (log scale).

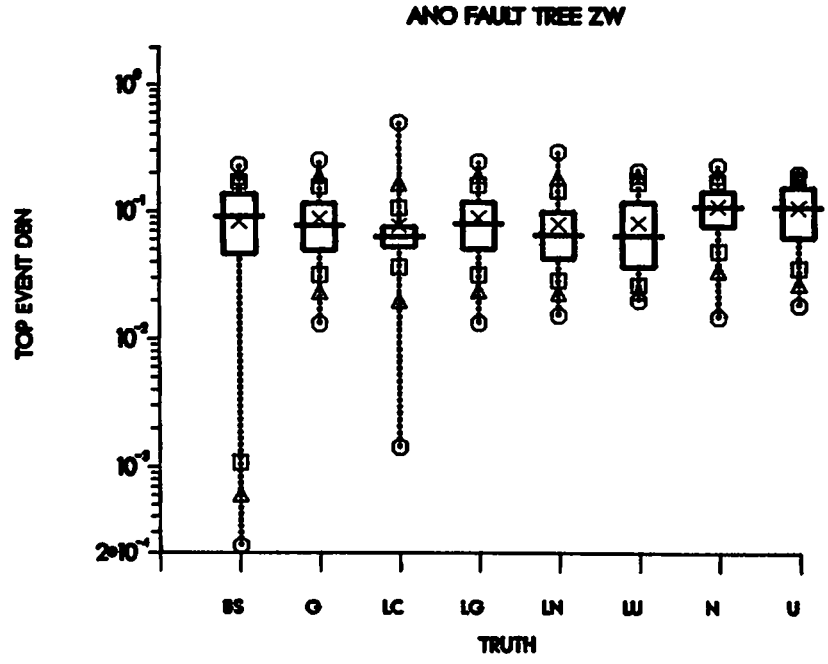

Fig. 15.

Sensitivity to basic event distributions for fault tree ZW (log scale).

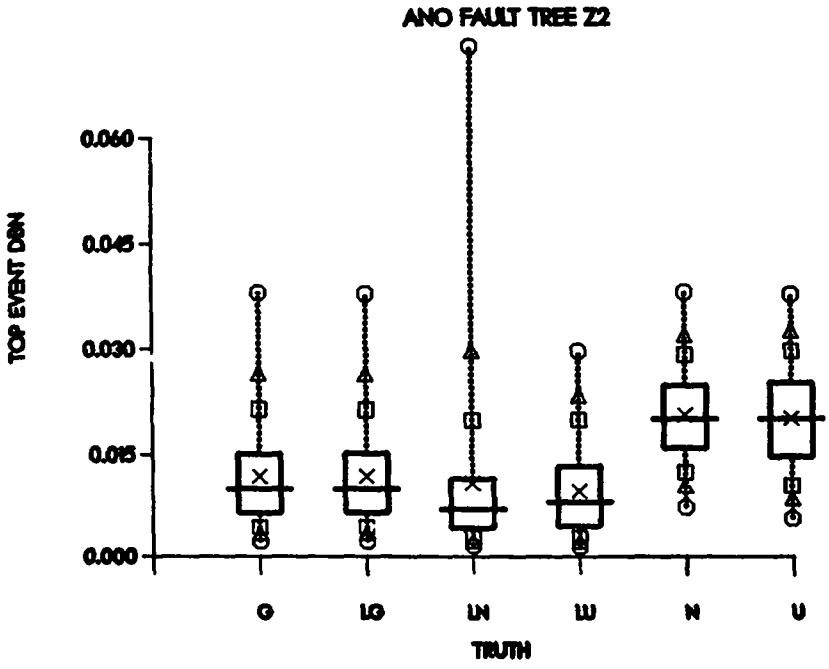

Fig. 16.

Sensitivity to basic event distributions for fault tree Z2 (linear scale).

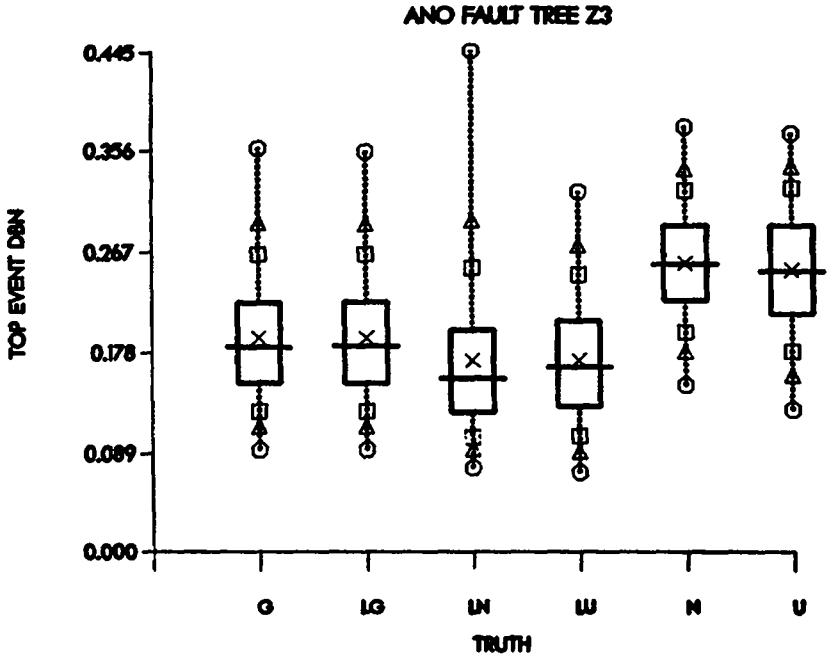

Fig. 17.

Sensitivity to basic event distributions for fault tree Z3 (linear scale).

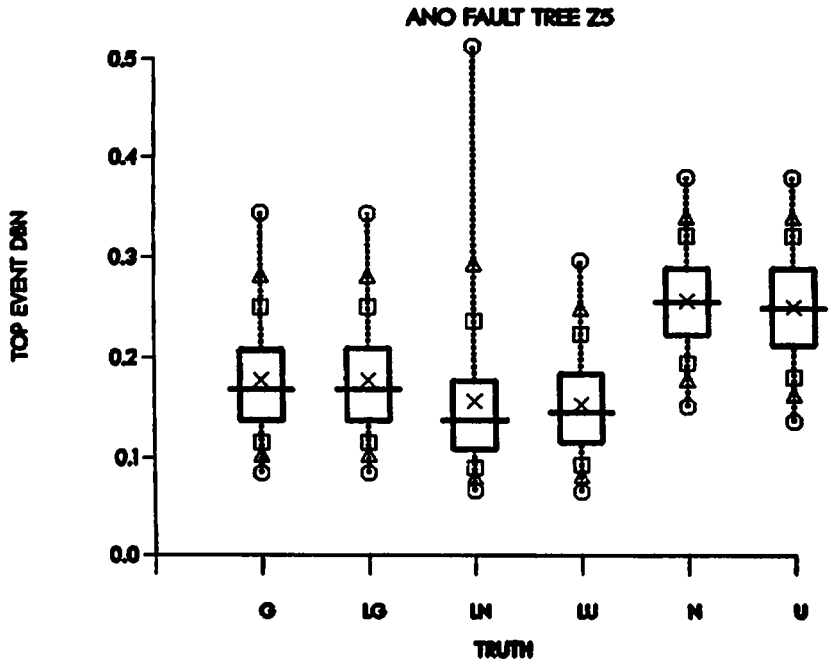

Fig. 18.

Sensitivity to basic event distributions for fault tree Z5 (linear scale).

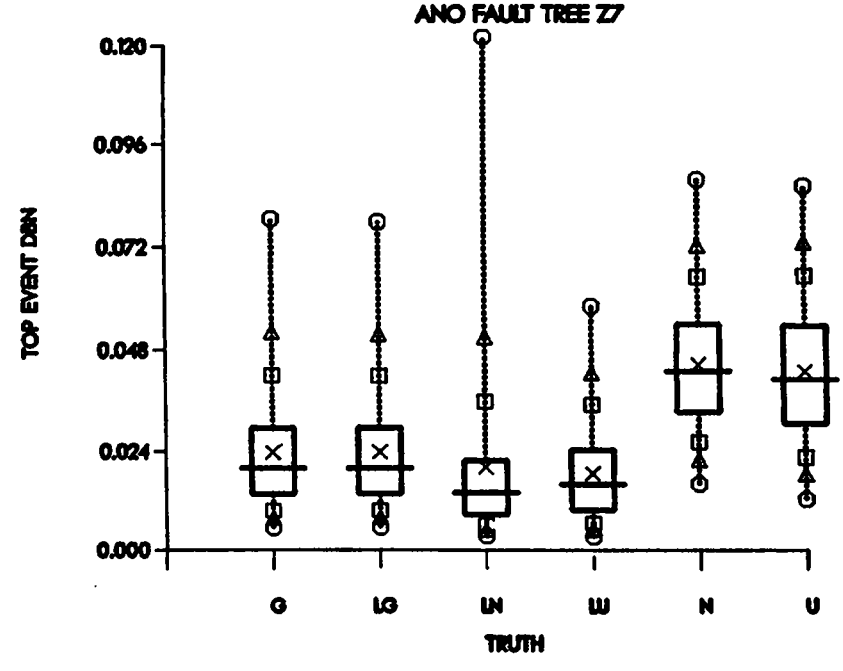

Fig. 19.

Sensitivity to basic event distributions for fault tree Z7 (linear scale).

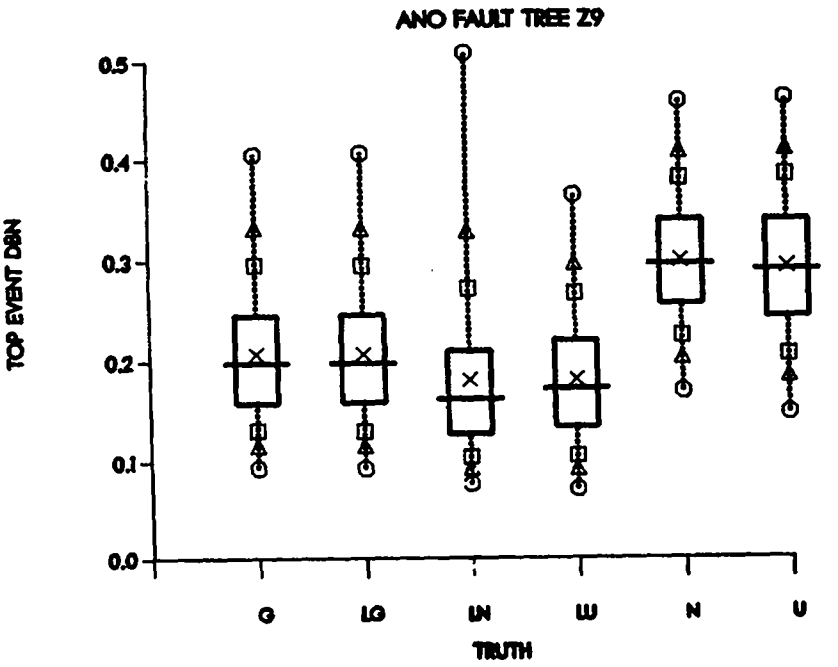

Fig. 20.

Sensitivity to basic event distributions for fault tree Z9 (linear scale).

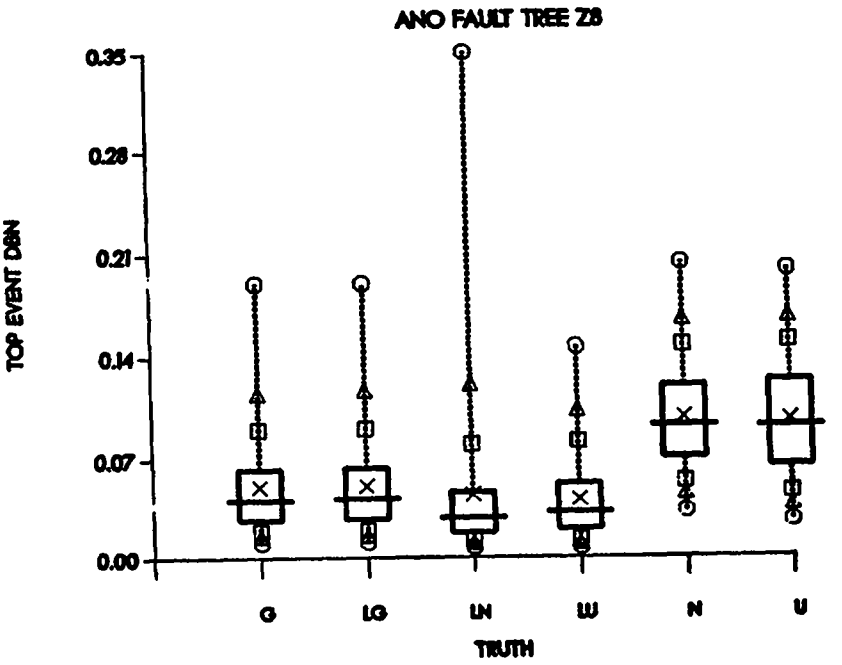

Fig. 21.

Sensitivity to basic event distributions for fault tree Z8 (linear scale).

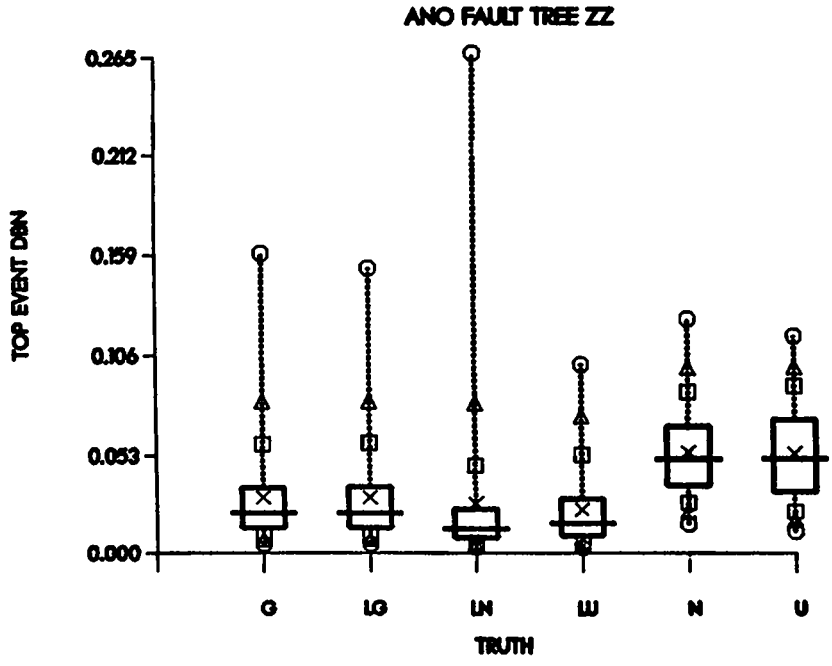

Fig. 22.

Sensitivity to basic event distributions for fault tree ZZ (linear scale).

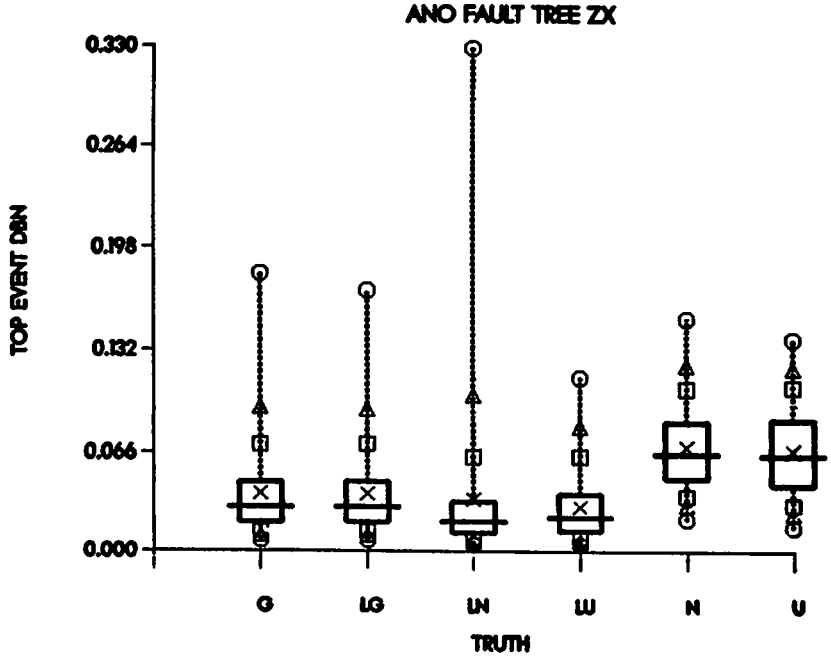

Fig. 23.

Sensitivity to basic event distributions for fault tree ZX (linear scale).

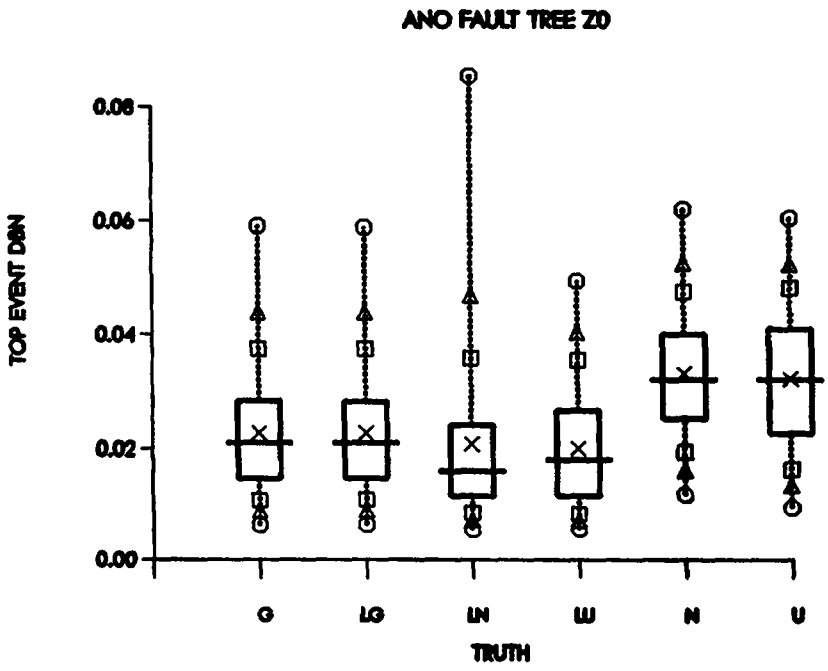

Fig. 24.
Sensitivity to basic event distributions for fault tree Z0 (linear scale).

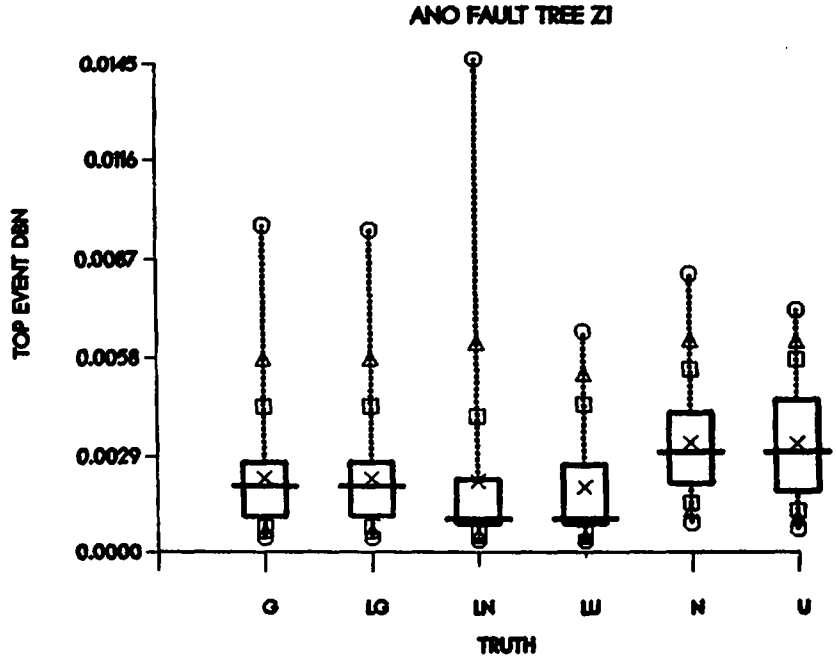

Fig. 25.
Sensitivity to basic event distributions for fault tree Z1 (linear scale).

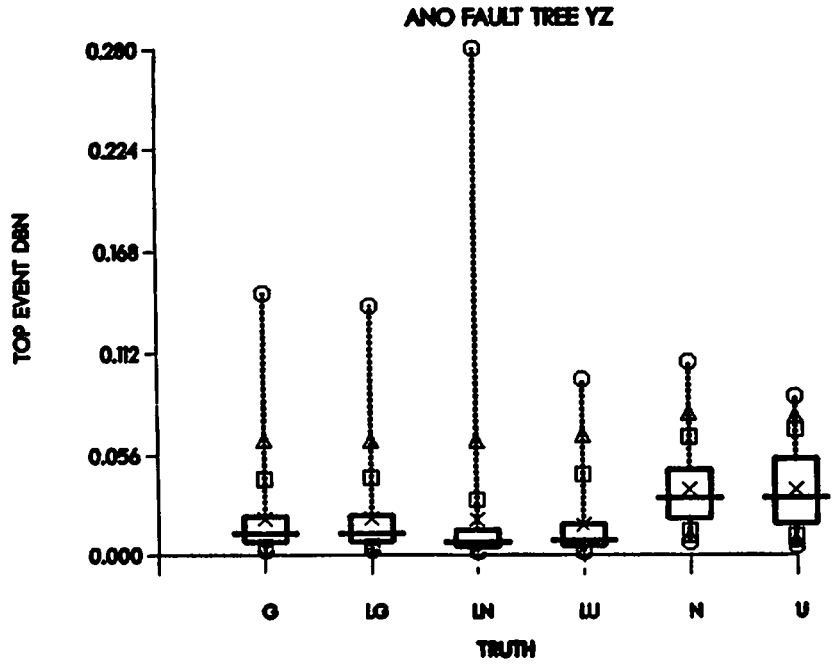

Fig. 26.

Sensitivity to basic event distributions for fault tree YZ (linear scale).

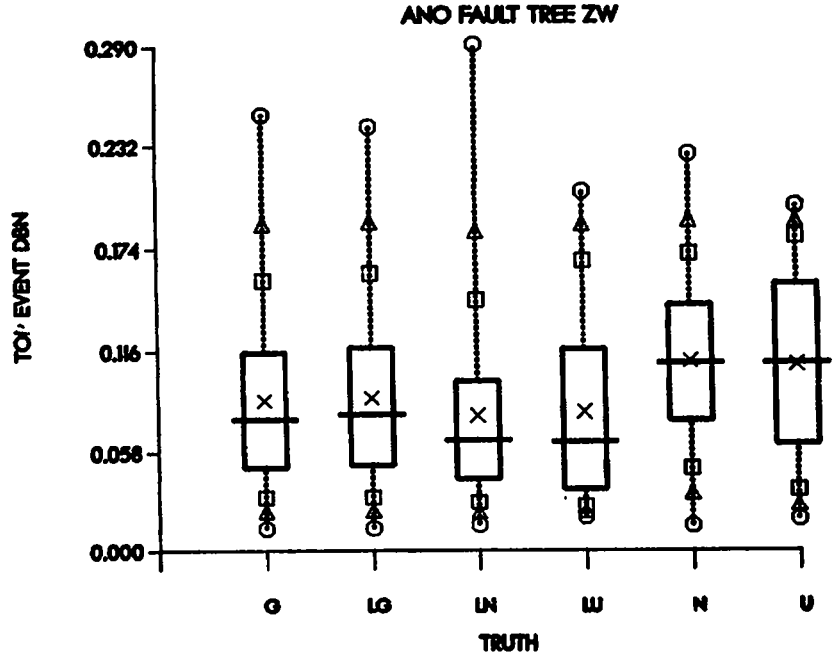

Fig. 27.

Sensitivity to basic event distributions for fault tree ZW (linear scale).

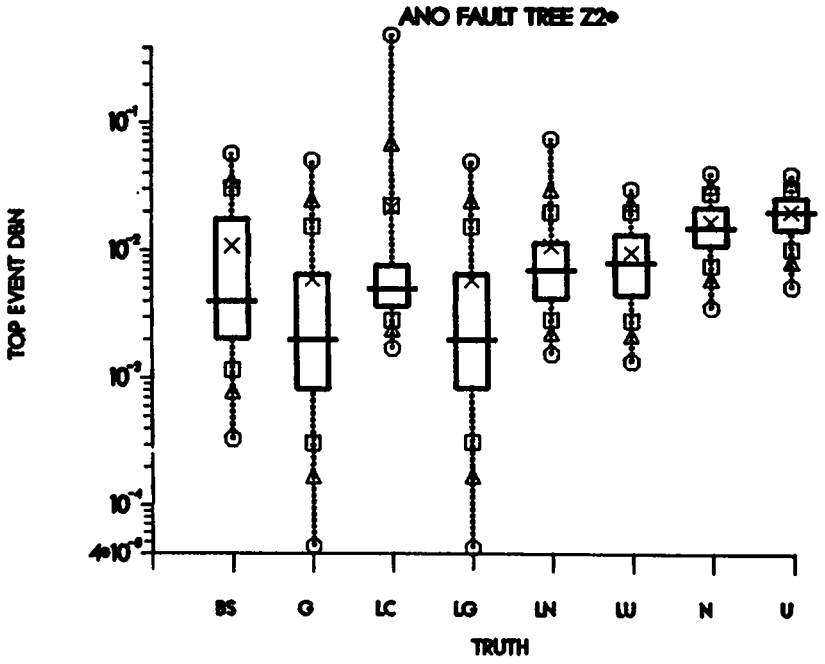

Fig. 28.
Sensitivity to basic event distributions for fault tree Z2 with matched median and 95th percentiles (log scale).

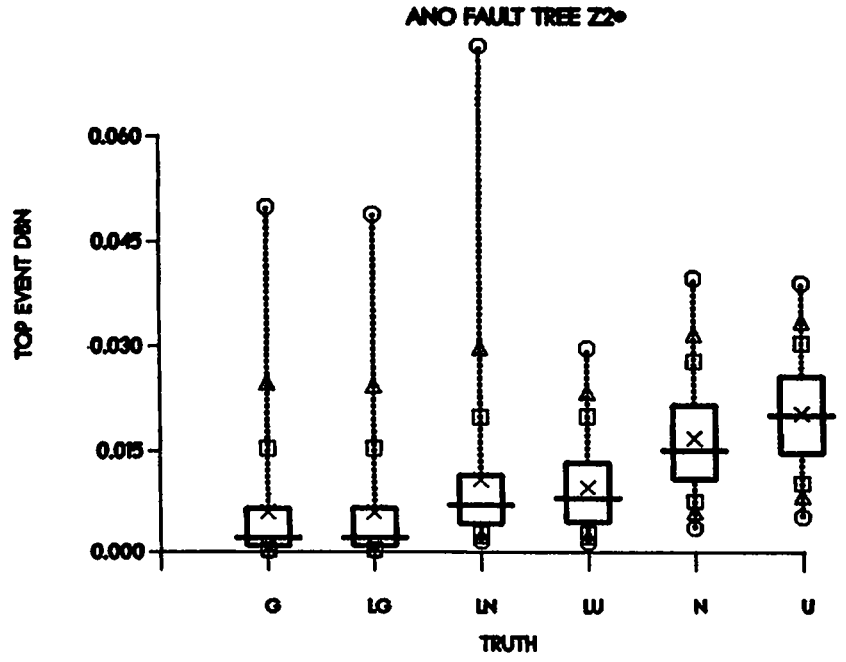

Fig. 29.
Sensitivity to basic event distributions for fault tree Z2 with matched median and 95th percentiles (linear scale).

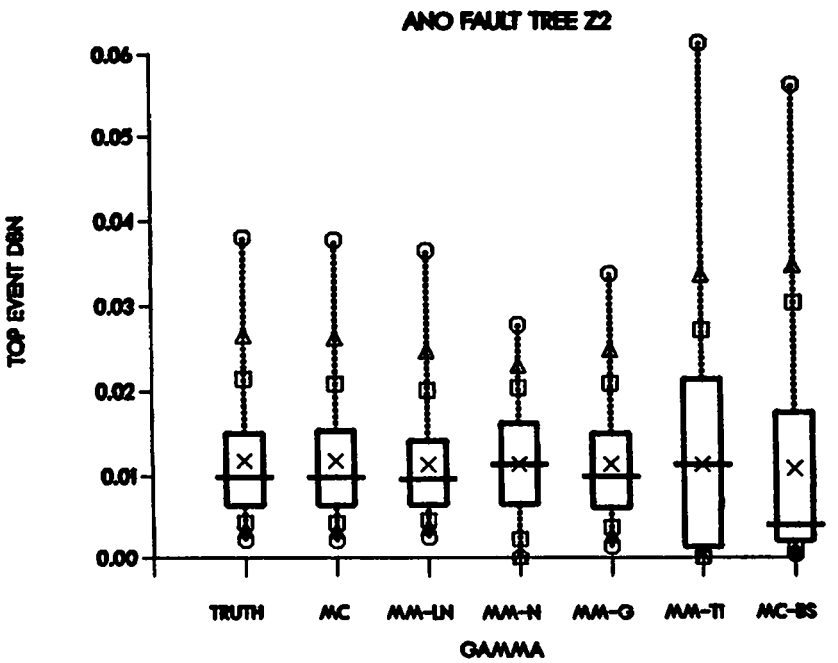

Fig. 30.

Comparative performance of the methods for fault tree Z2 and gamma basic event distributions.

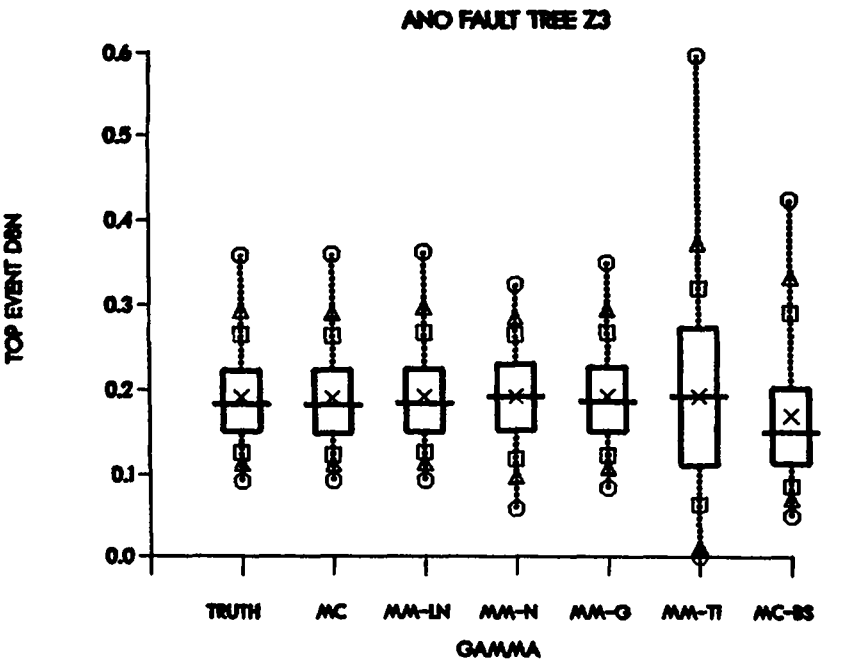

Fig. 31.
Comparative performance of the methods for fault tree Z3 and gamma basic event distributions.

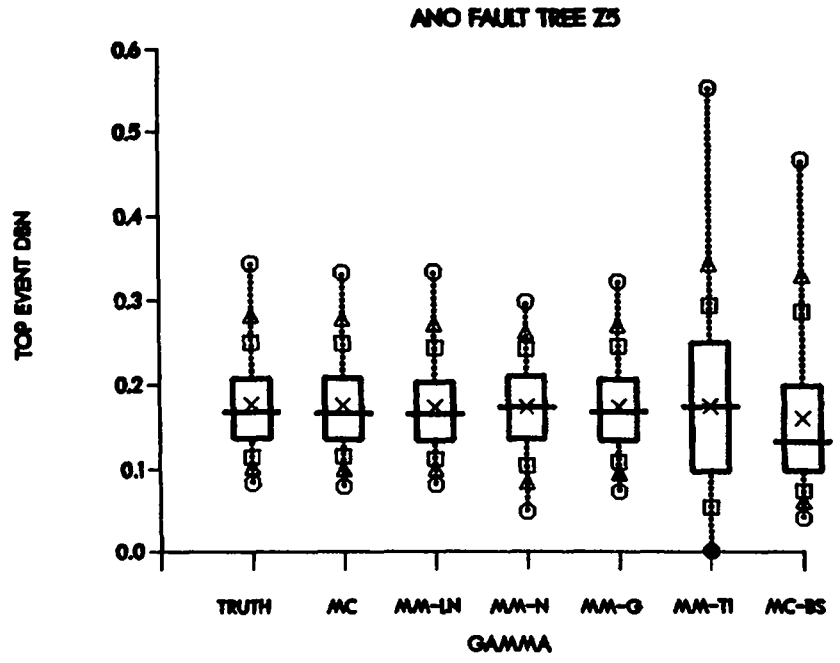

Fig. 32.
Comparative performance of the methods for fault tree Z5 and gamma basic event distributions.

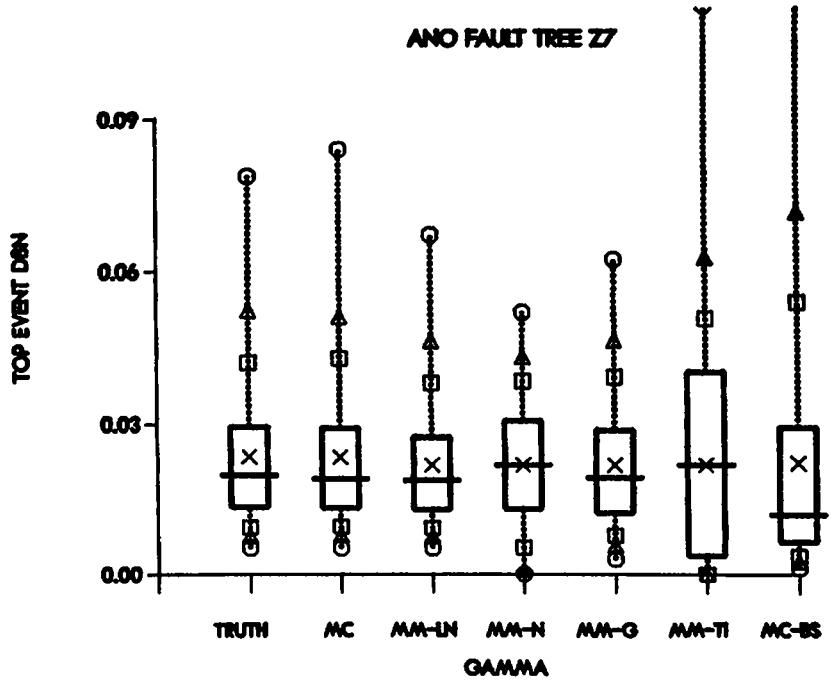

Fig. 33.

Comparative performance of the methods for fault tree Z7 and gamma basic event distributions.

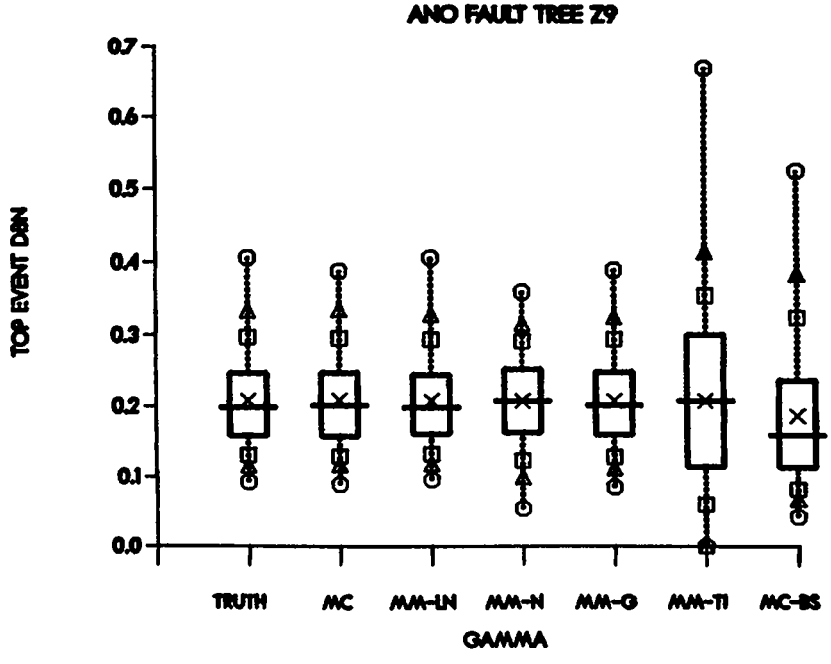

Fig. 34.

Comparative performance of the methods for fault tree Z9 and gamma basic event distributions.

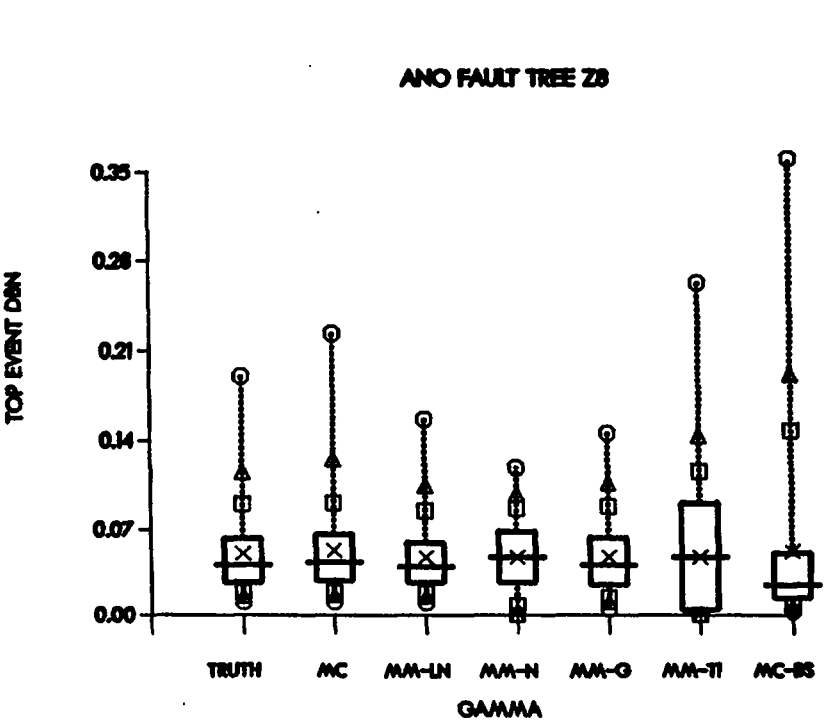

Fig. 35.
Comparative performance of the methods for fault tree Z8 and gamma basic event distributions.

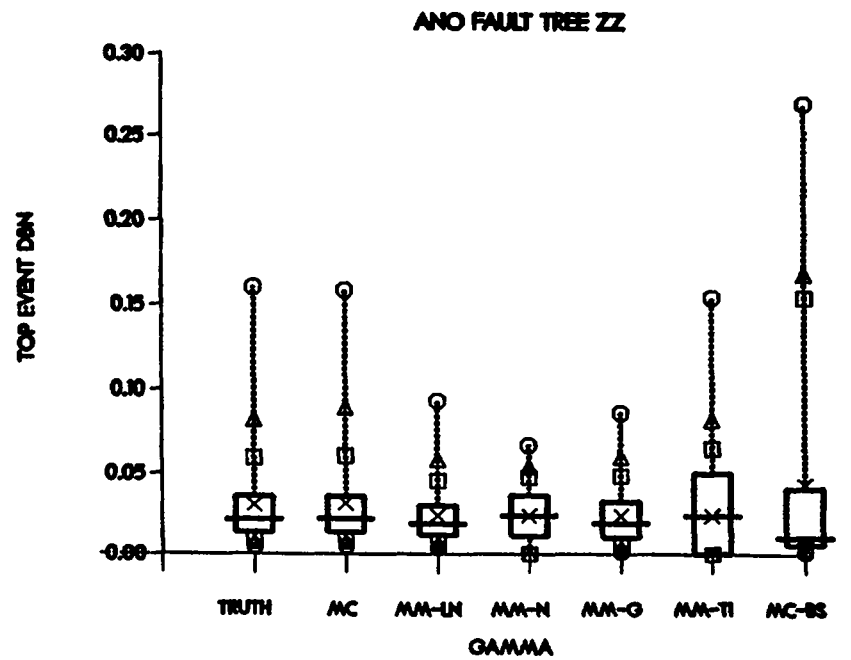

Fig. 36.
Comparative performance of the methods for fault tree ZZ and gamma basic event distributions.

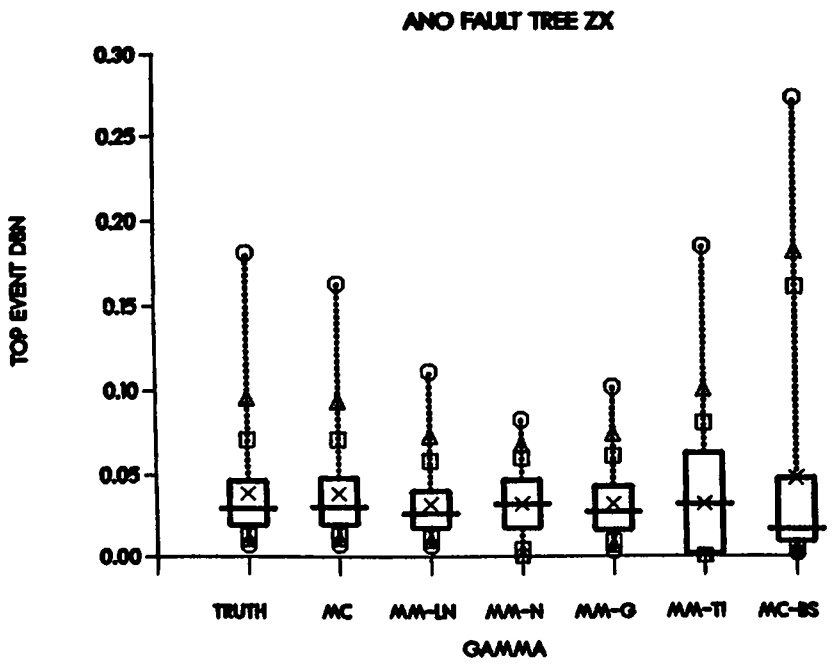

Fig. 37.

Comparative performance of the methods for fault tree ZX and gamma basic event distributions.

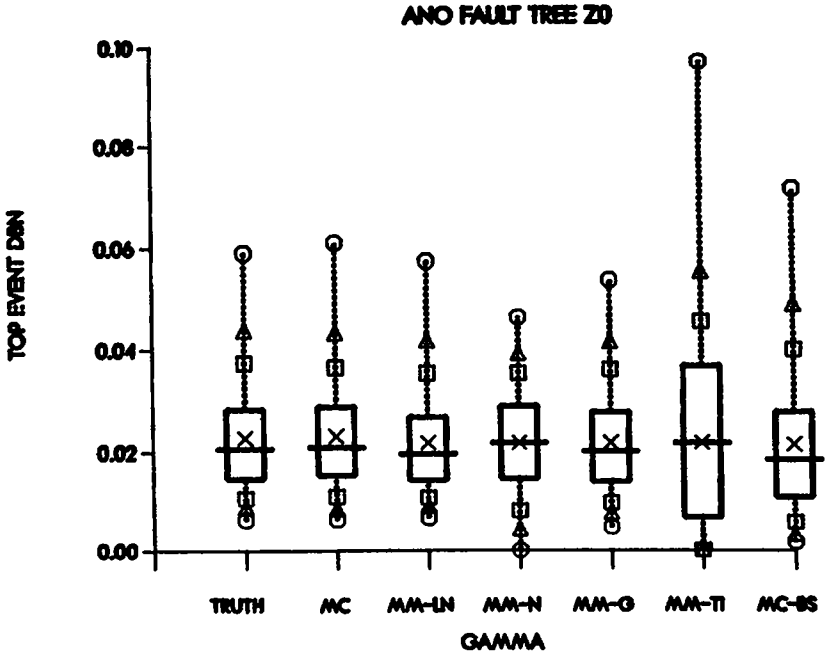

Fig. 38.

Comparative performance of the methods for fault tree Z0 and gamma basic event distributions.

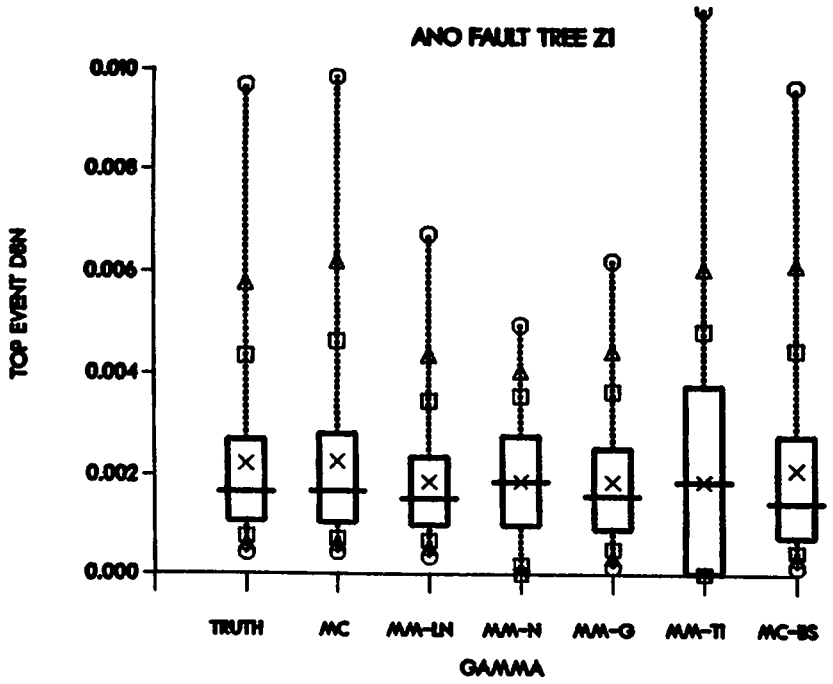

Fig. 39.
Comparative performance of the methods for fault tree Z1 and gamma basic event distributions.

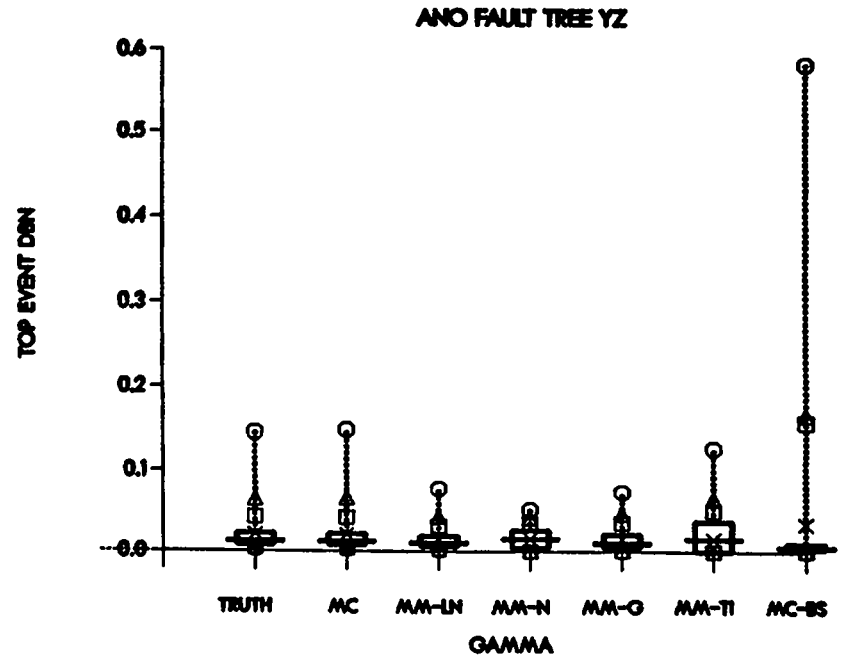

Fig. 40.
Comparative performance of the methods for fault tree YZ and gamma basic event distributions.

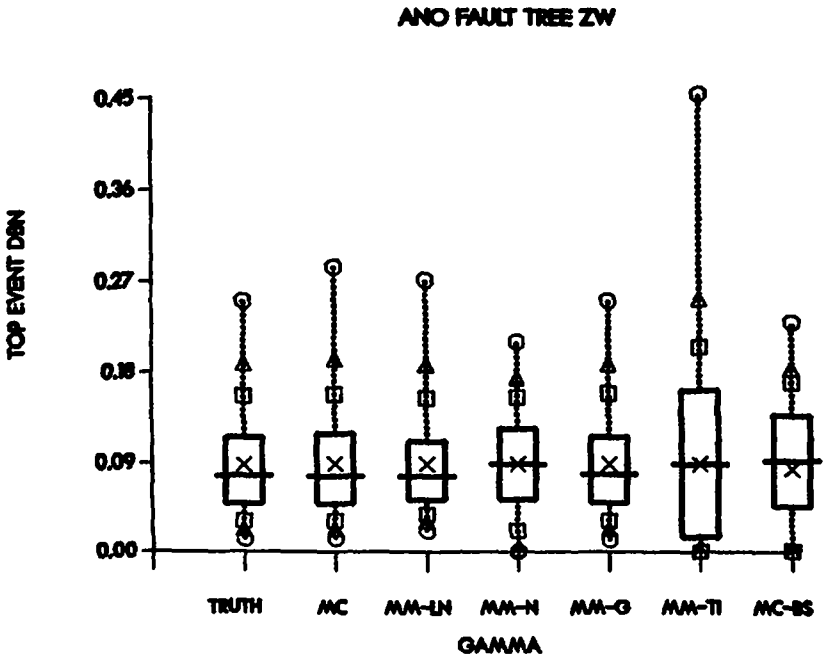

Fig. 41.
Comparative performance of the methods for fault tree ZW and gamma basic event distributions.

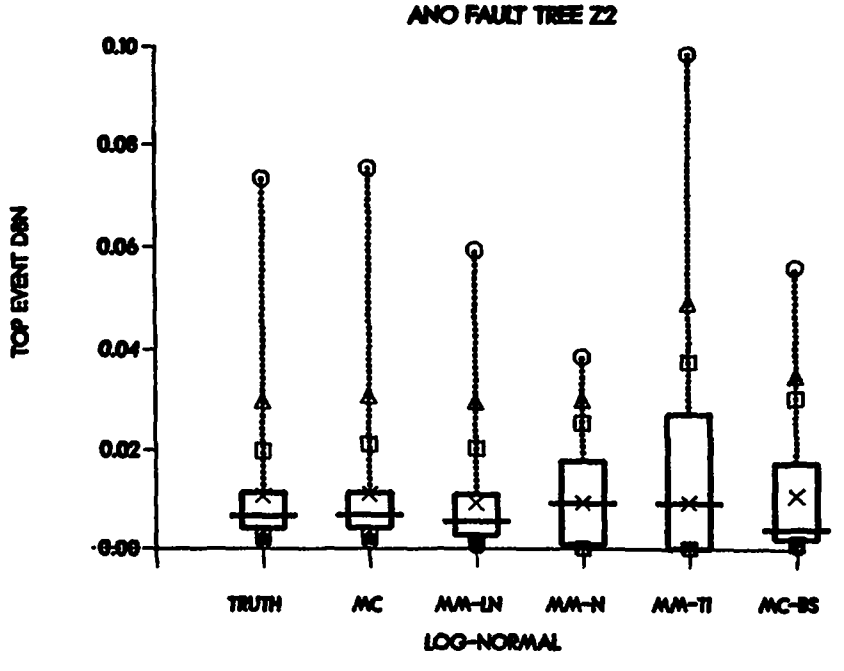

Fig. 42.
Comparative performance of the methods for fault tree Z2 and log normal basic event distributions.

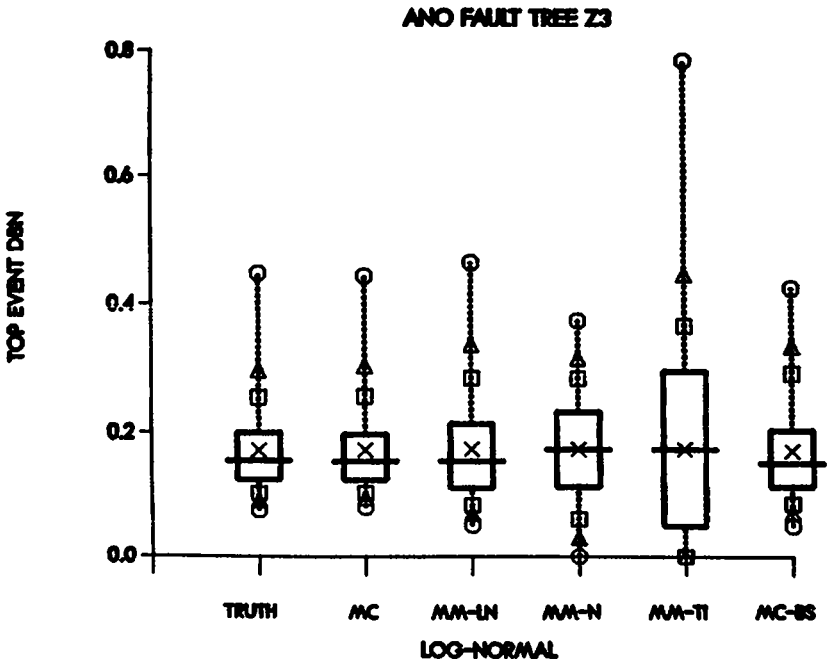

Fig. 43.
Comparative performance of the methods for fault tree Z3 and log normal basic event distributions.

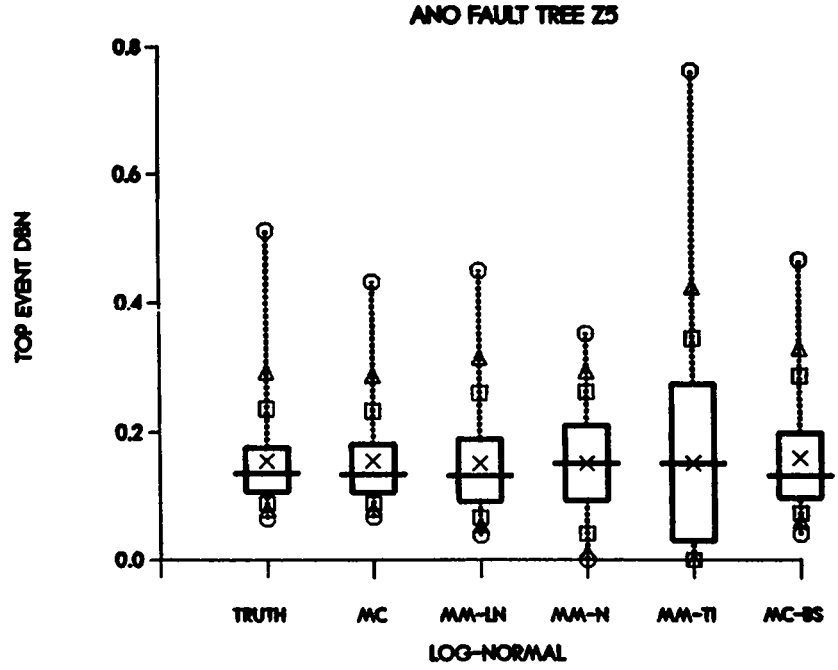

Fig. 44.
Comparative performance of the methods for fault tree Z5 and log normal basic event distributions.

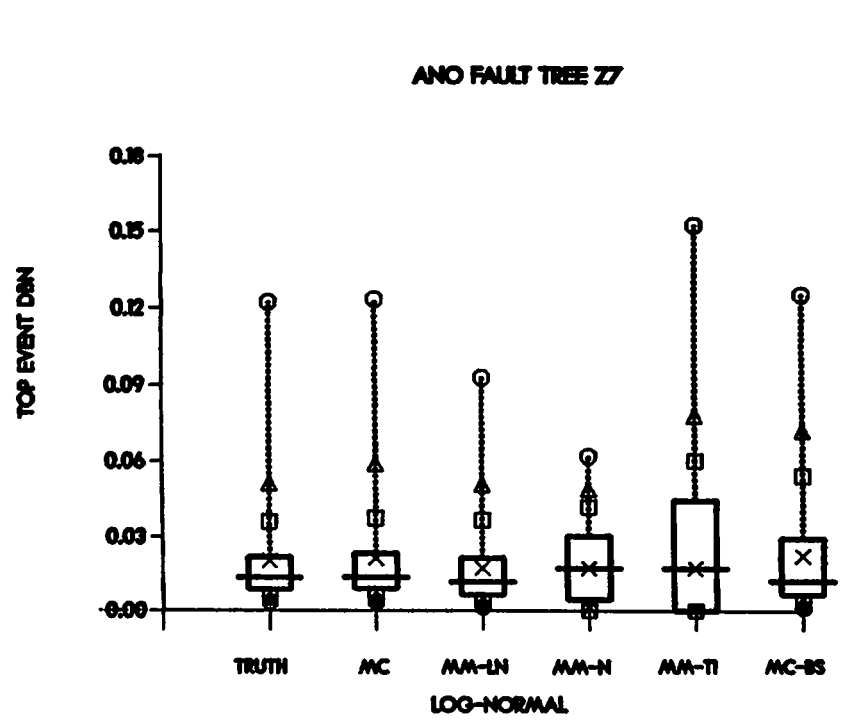

Fig. 45.
Comparative performance of the methods for fault tree Z7 and log normal basic event distributions.

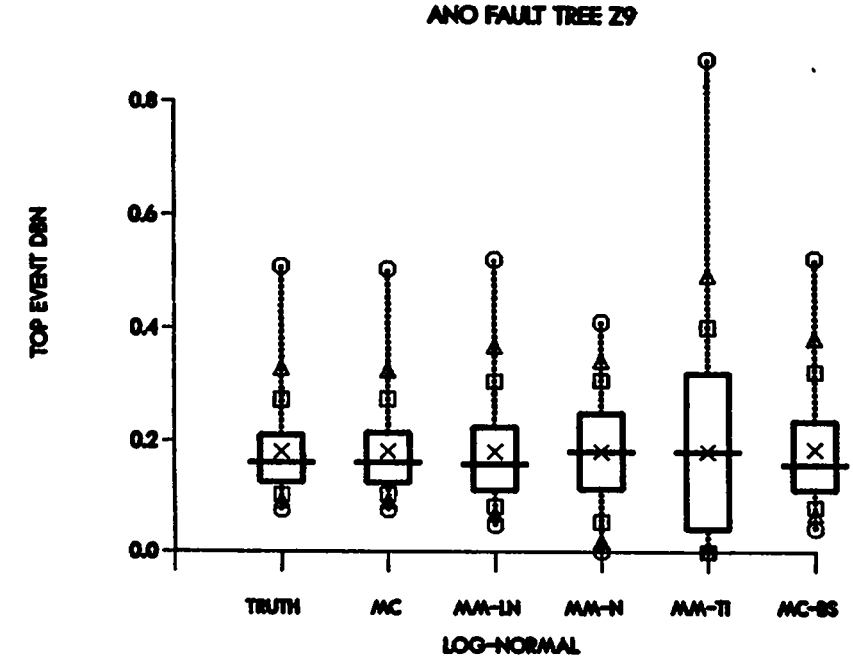

Fig. 46.
Comparative performance of the methods for fault tree Z9 and log normal basic event distributions.

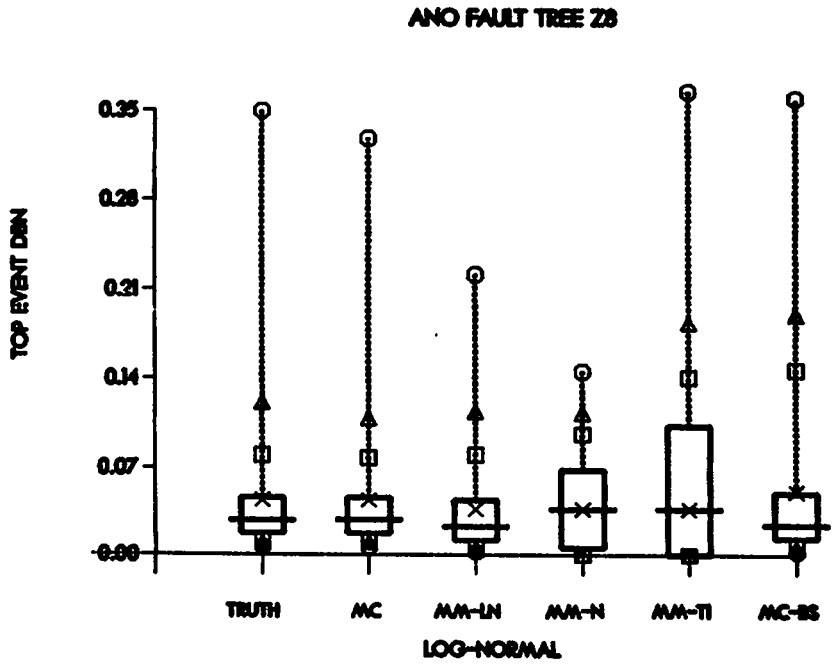

Fig. 47.
Comparative performance of the methods for fault tree Z8 and log normal basic event distributions.

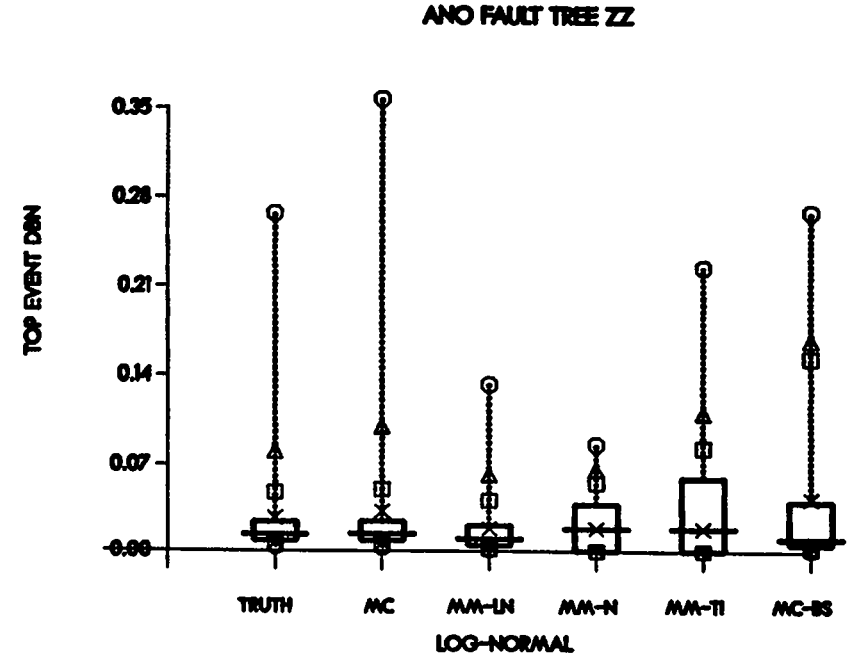

Fig. 48.
Comparative performance of the methods for fault tree ZZ and log normal basic event distributions.

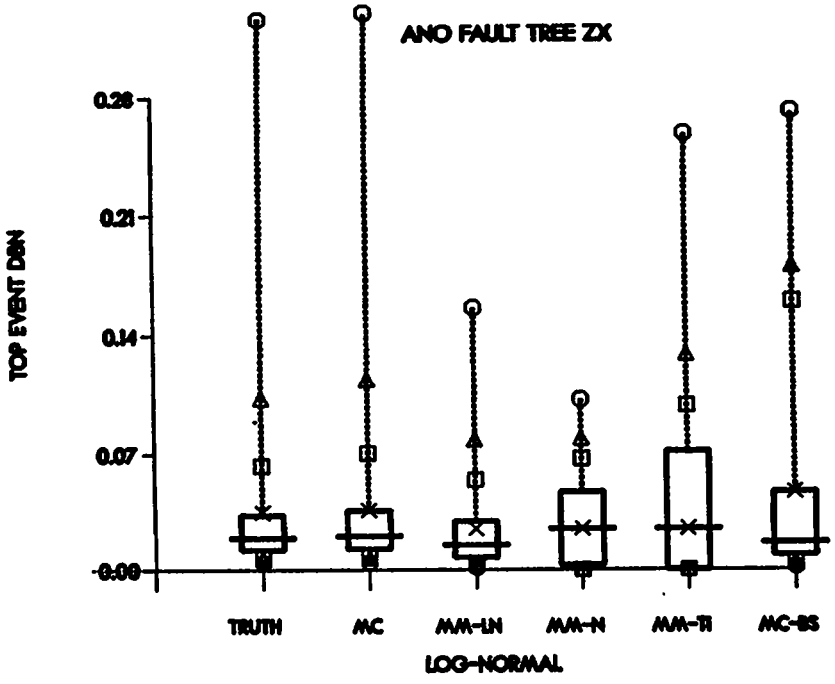

Fig. 49.

Comparative performance of the methods for fault tree ZX and log normal basic event distributions.

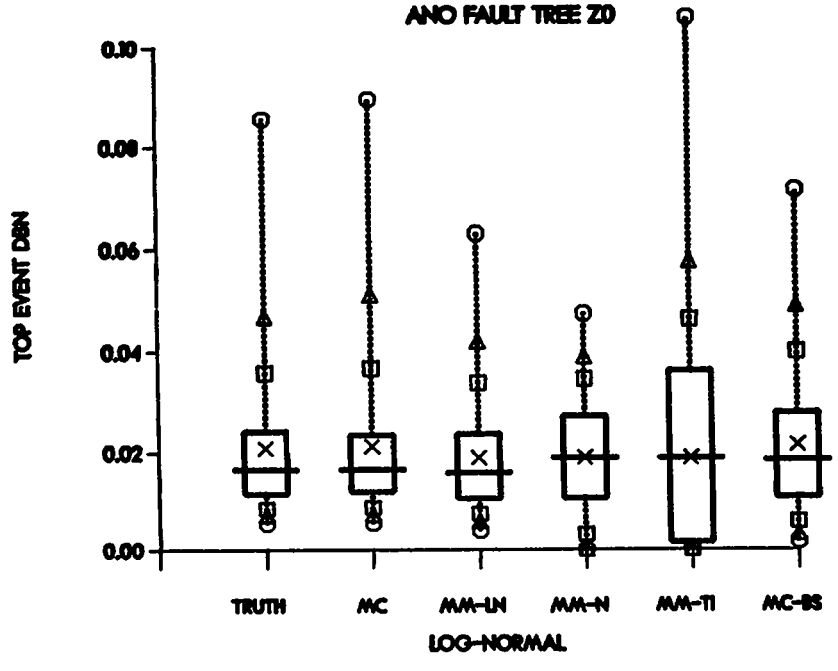

Fig. 50.

Comparative performance of the methods for fault tree Z0 and log normal basic event distributions.

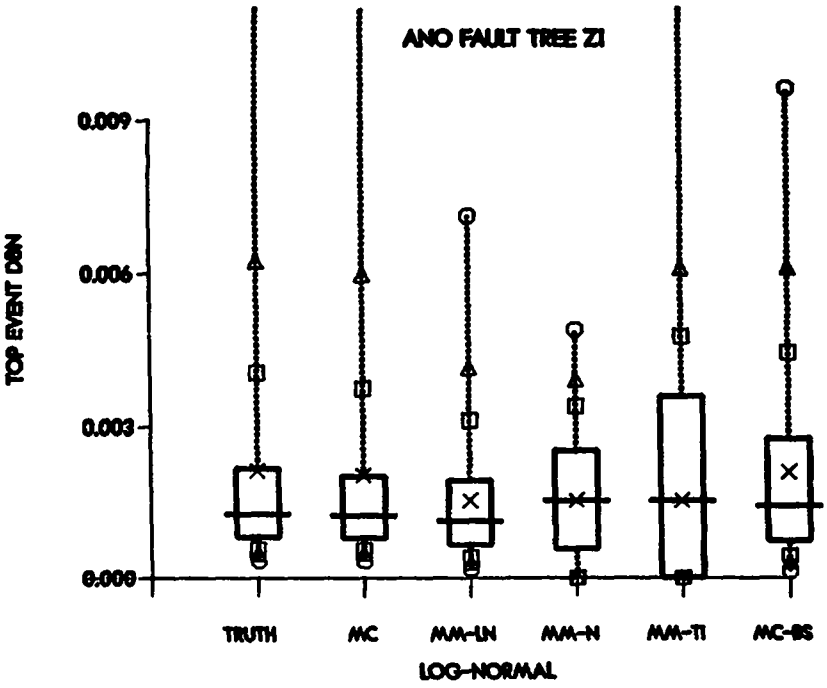

Fig. 51.

Comparative performance of the methods for fault tree Z1 and log normal basic event distributions.

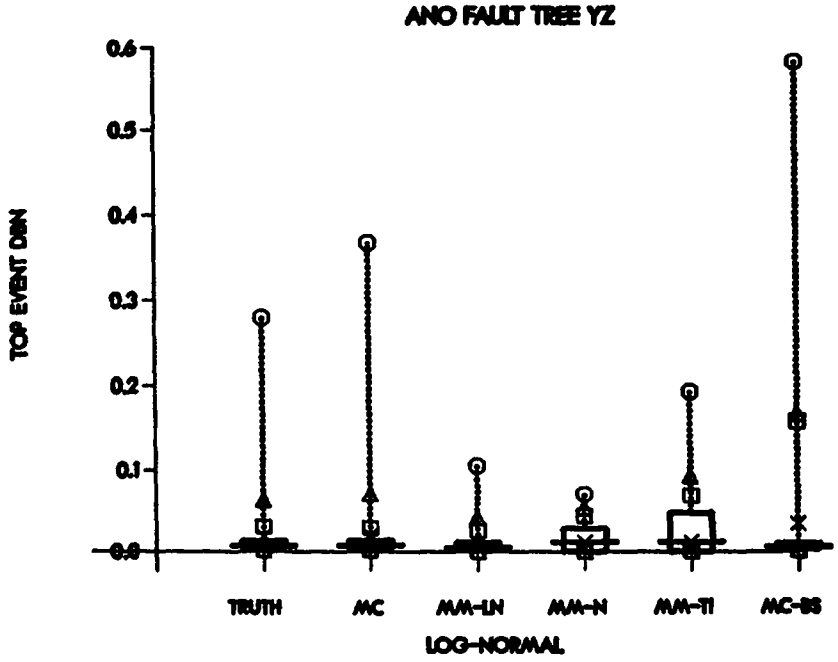

Fig. 52.

Comparative performance of the methods for fault tree YZ and log normal basic event distributions.

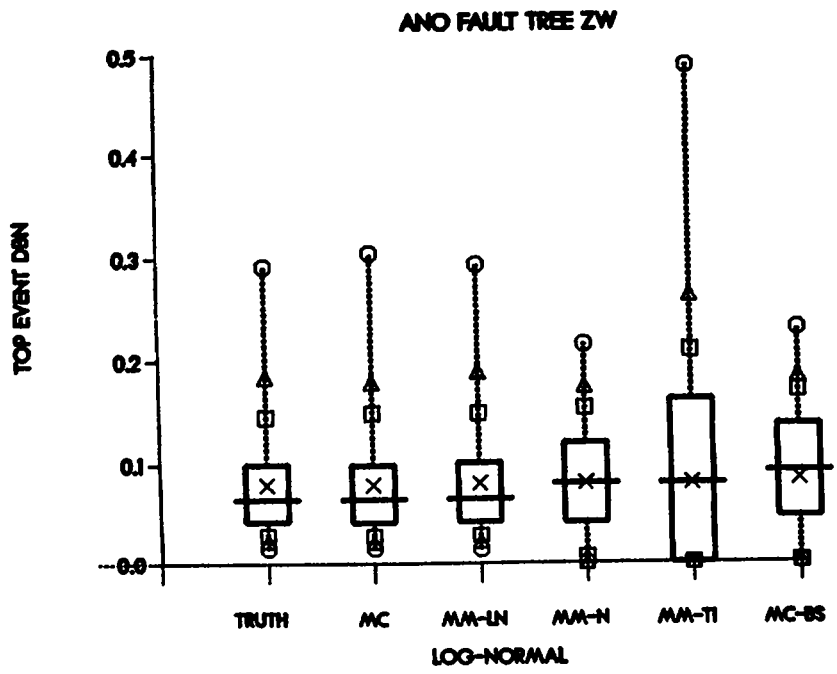

Fig. 53.

Comparative performance of the methods for fault tree ZW and log normal basic event distributions.

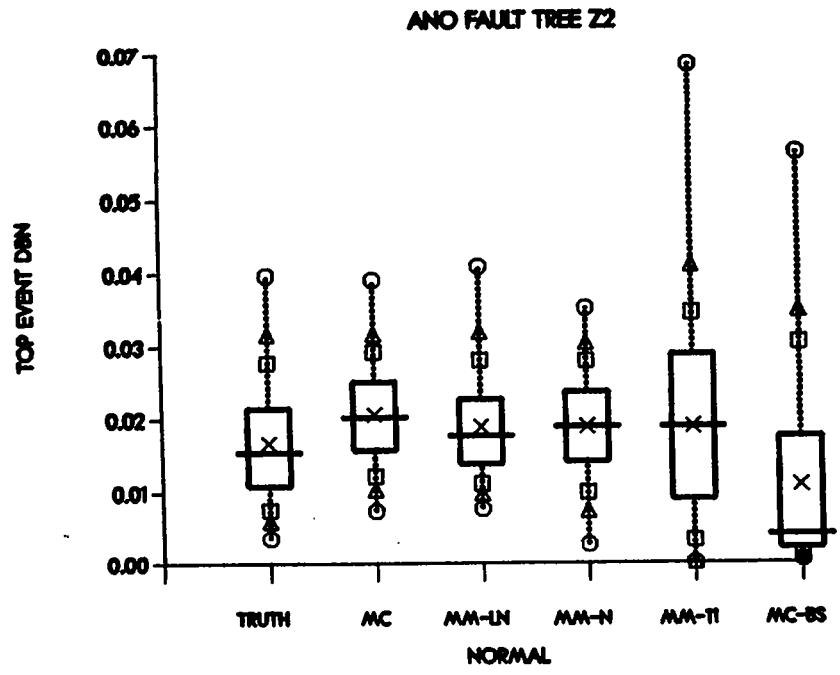

Fig. 54.

Comparative performance of the methods for fault tree Z2 and normal basic event distributions.

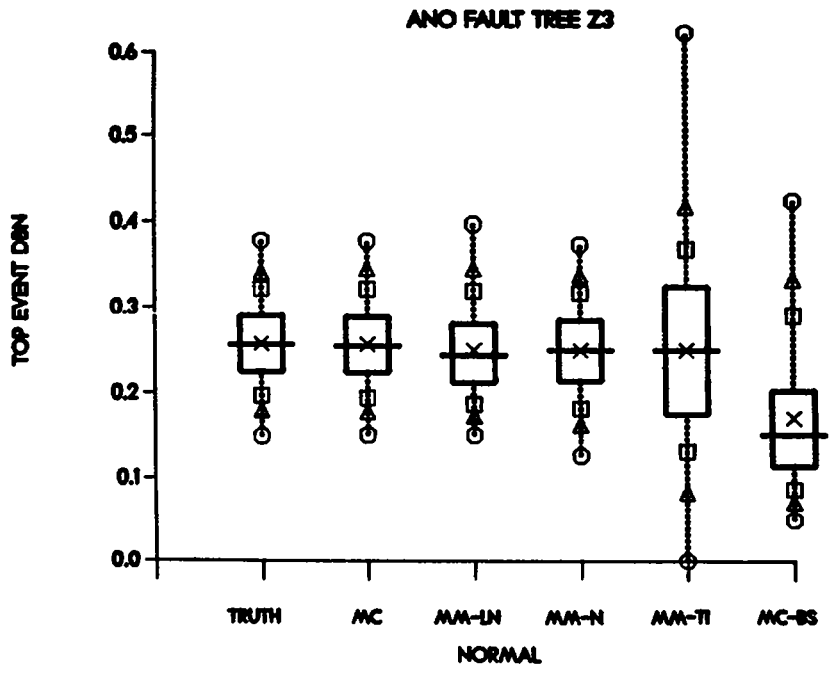

Fig. 55.
Comparative performance of the methods for fault tree Z3 and normal basic event distributions.

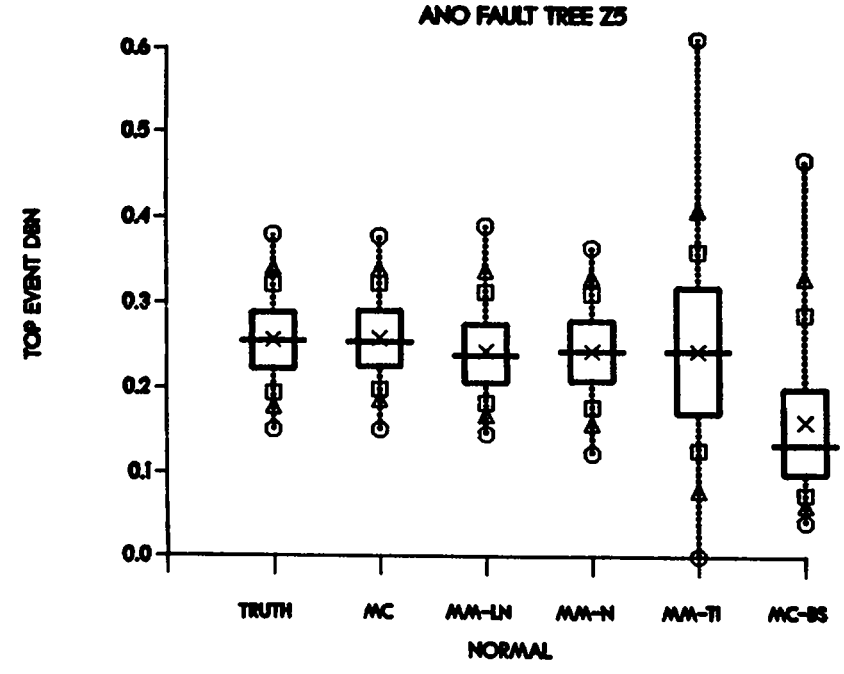

Fig. 56.
Comparative performance of the methods for fault tree Z5 and normal basic event distributions.

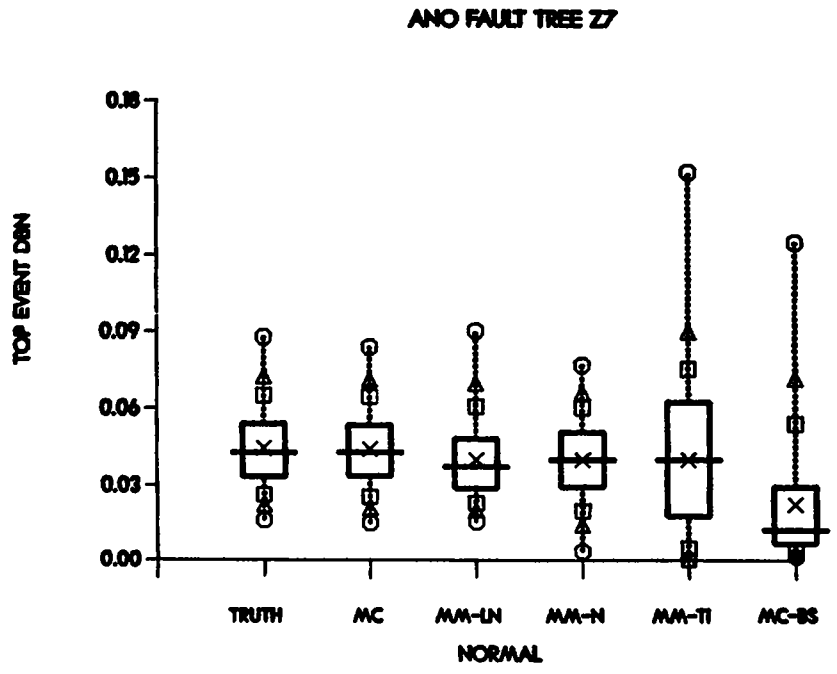

Fig. 57.

Comparative performance of the methods for fault tree Z7 and normal basic event distributions.

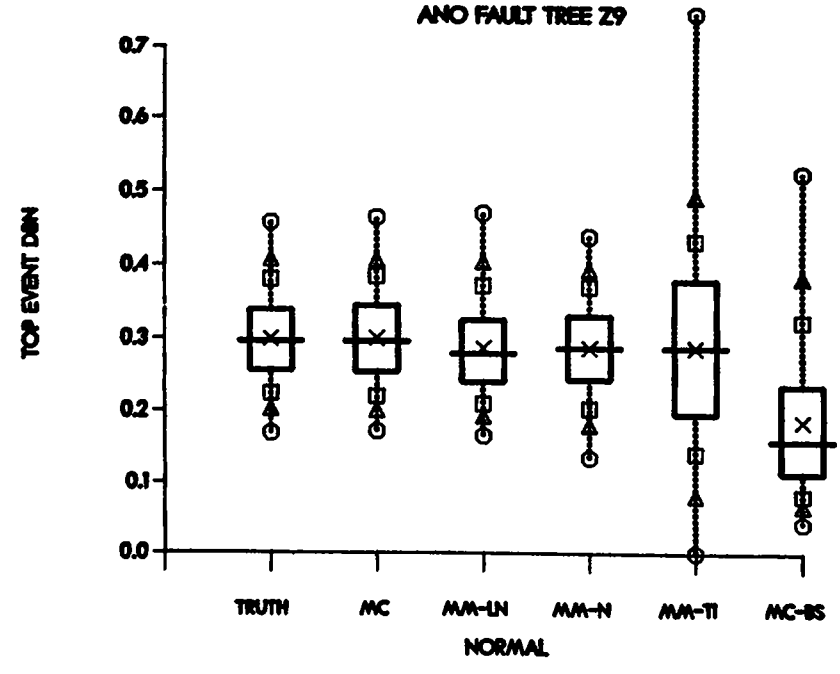

Fig. 58.

Comparative performance of the methods for fault tree Z9 and normal basic event distributions.

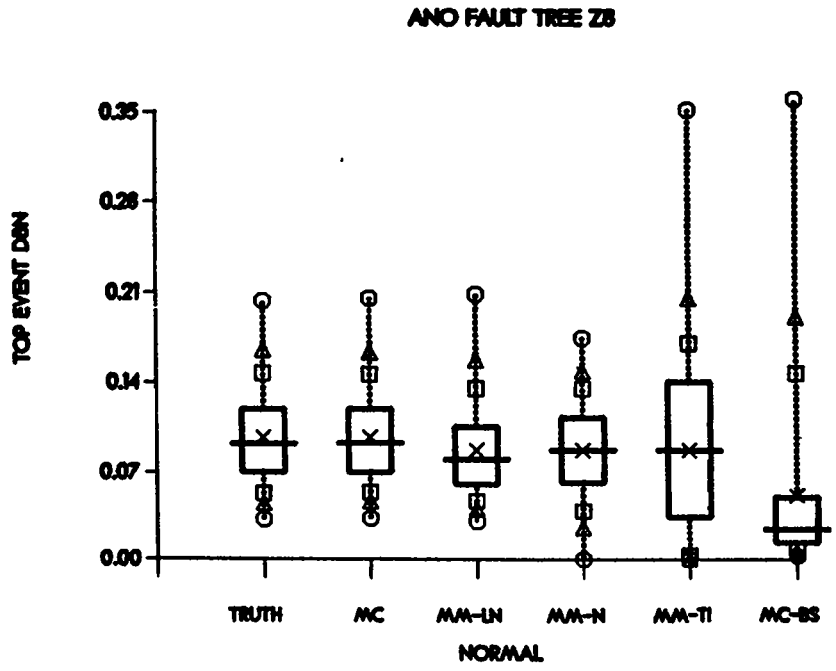

Fig. 59.
Comparative performance of the methods for fault tree Z8 and normal basic event distributions.

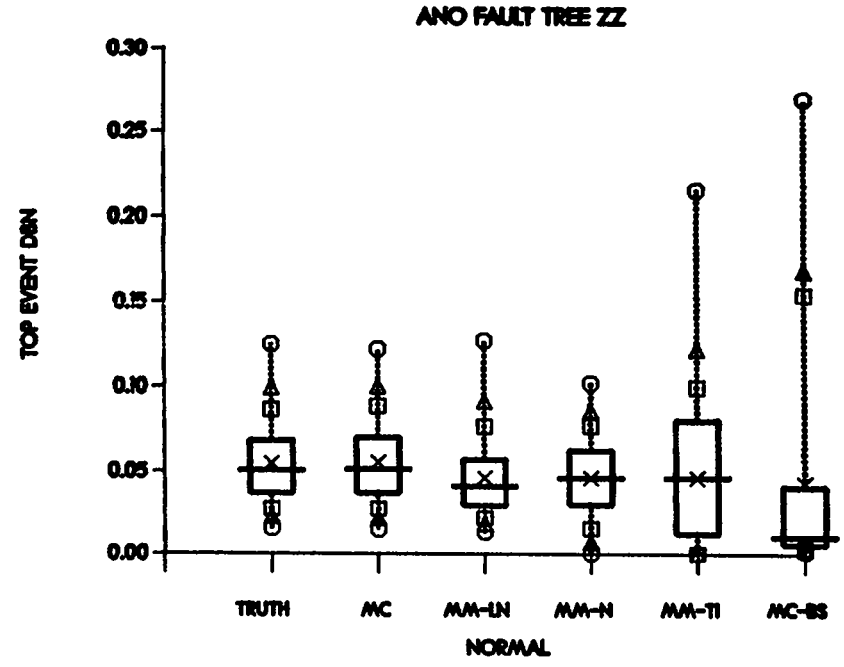

Fig. 60.
Comparative performance of the methods for fault tree ZZ and normal basic event distributions.

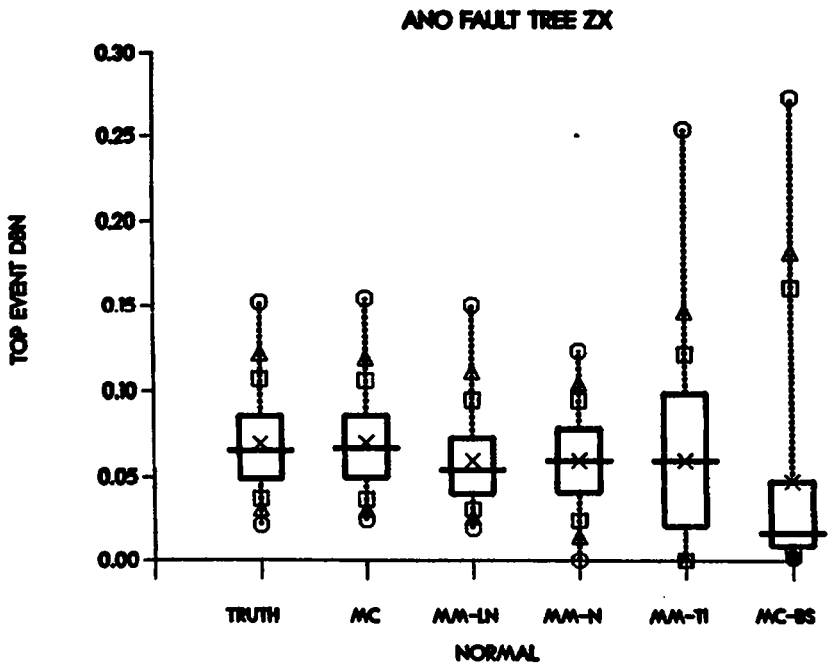

Fig. 61.

Comparative performance of the methods for fault tree ZX and normal basic event distributions.

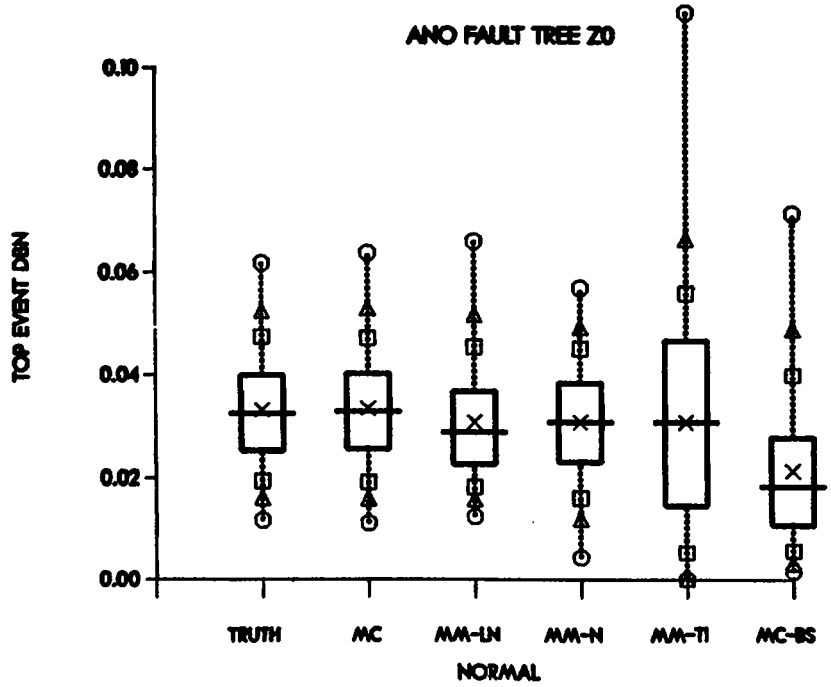

Fig. 62.

Comparative performance of the methods for fault tree Z0 and normal basic event distributions.

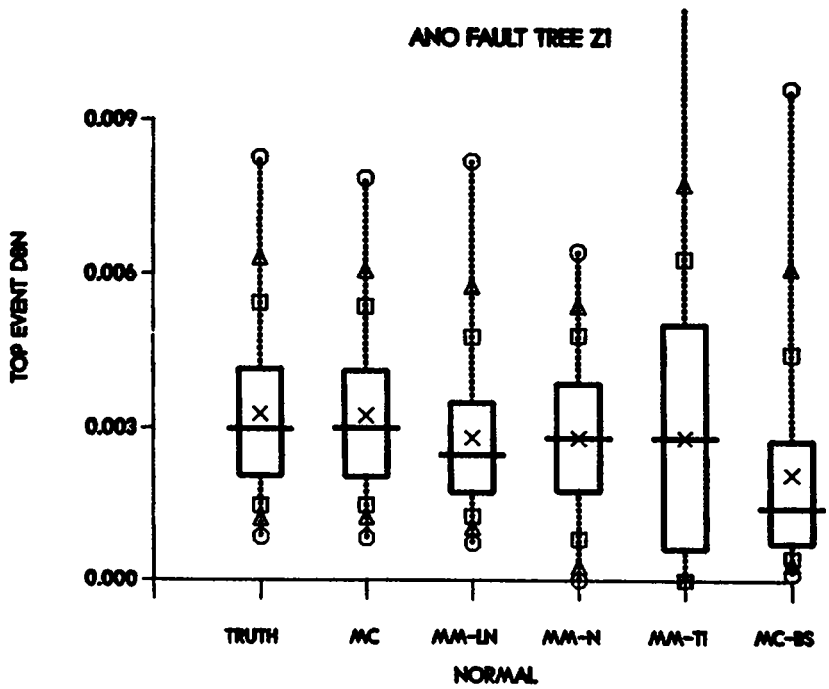

Fig. 63.
Comparative performance of the methods for fault tree Z1 and normal basic event distributions.

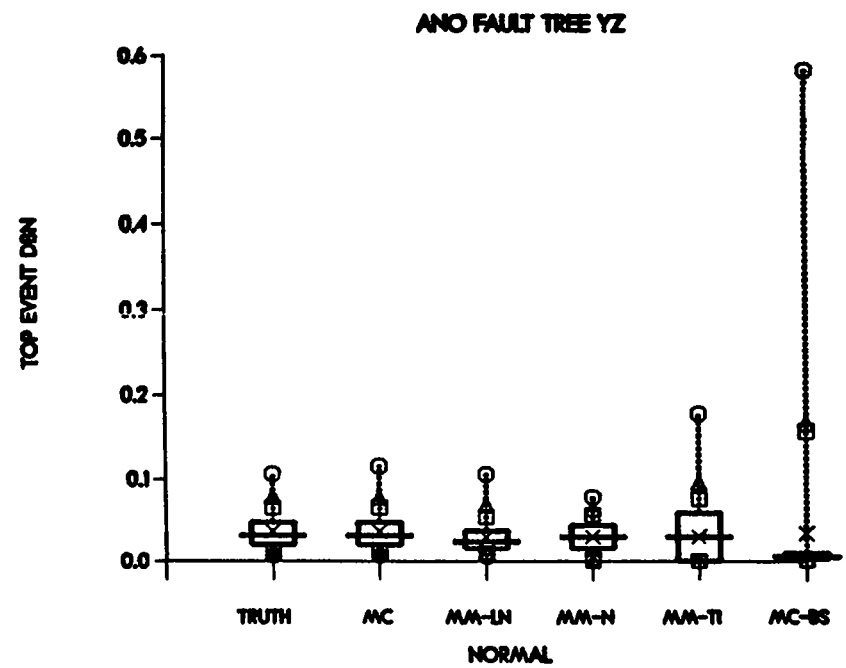

Fig. 64.
Comparative performance of the methods for fault tree YZ and normal basic event distributions.

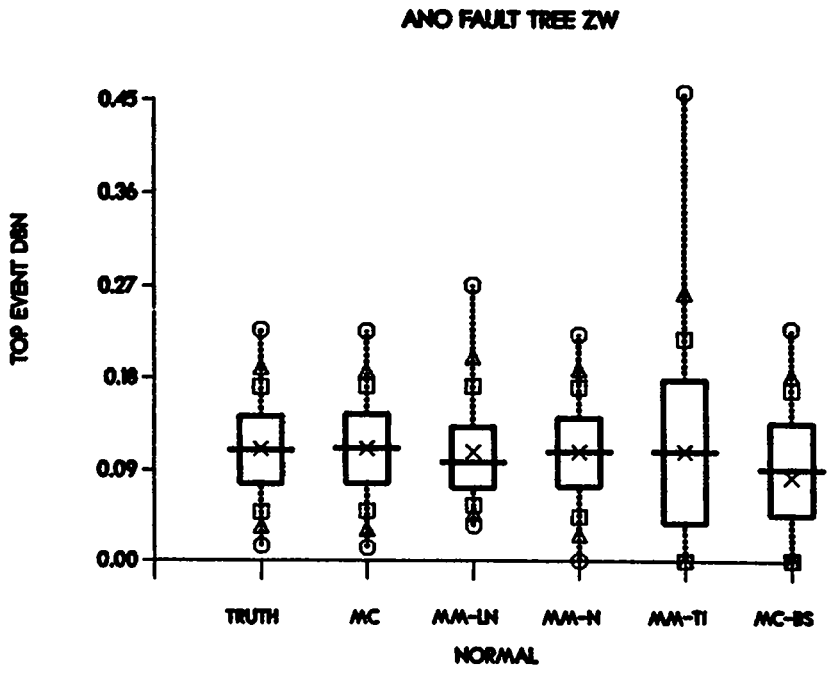

Fig. 65.
Comparative performance of the methods for fault tree ZW and normal basic event distributions.

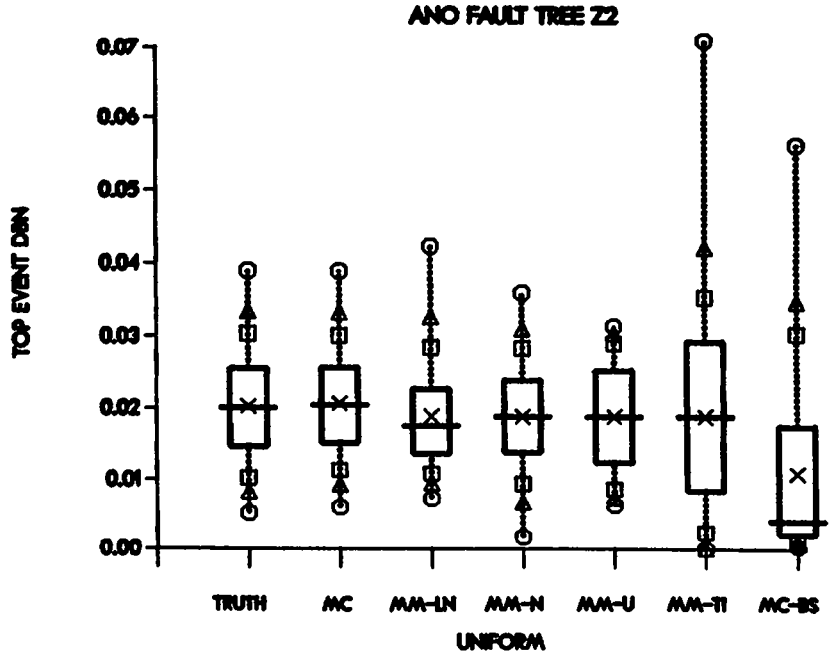

Fig. 66.
Comparative performance of the methods for fault tree Z2 and uniform basic event distributions.

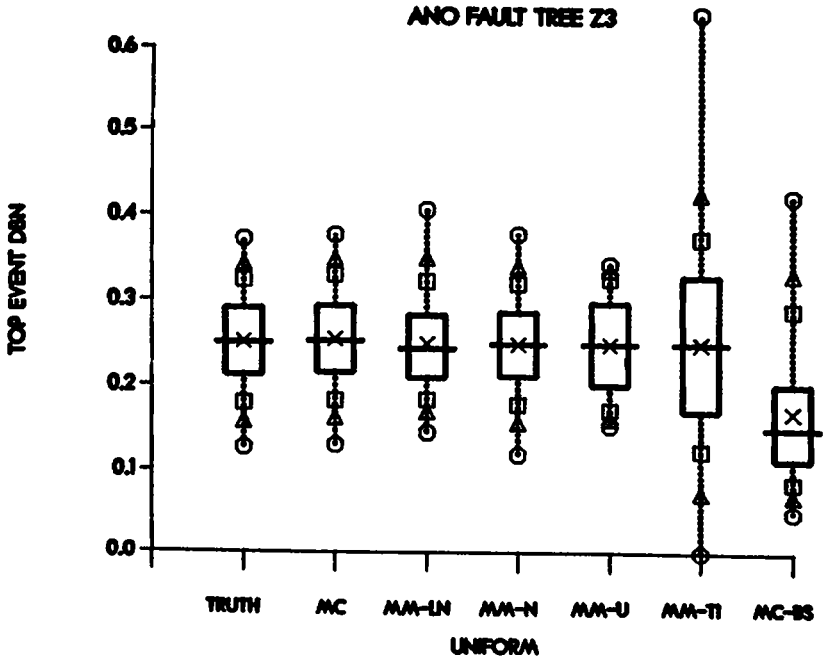

Fig. 67.
Comparative performance of the methods for fault tree Z3 and uniform basic event distributions.

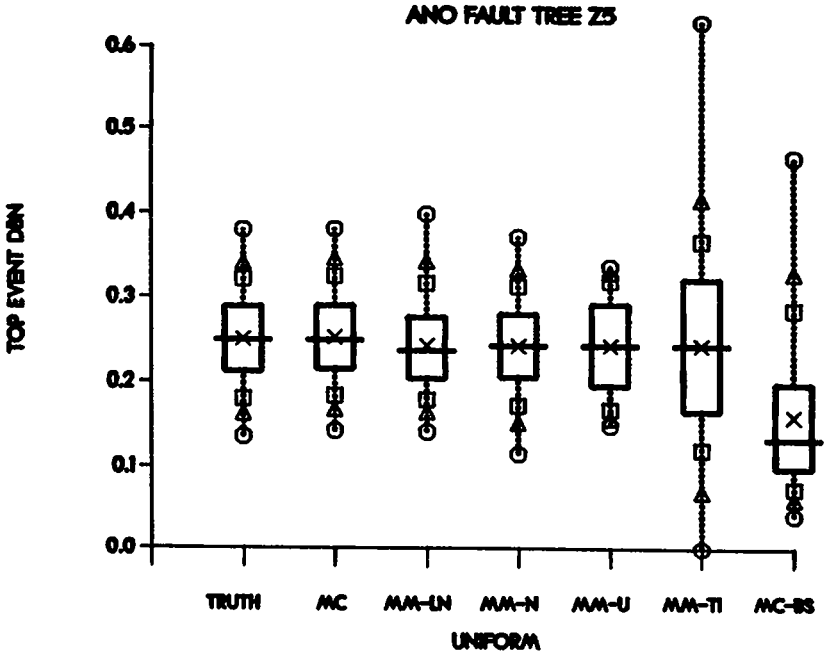

Fig. 68.
Comparative performance of the methods for fault tree Z5 and uniform basic event distributions.

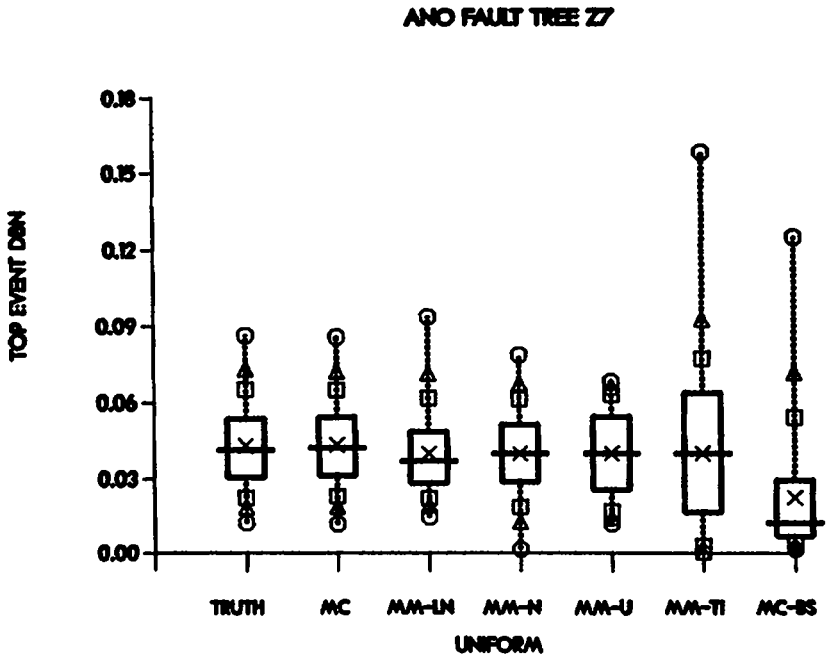

Fig. 69.
Comparative performance of the methods for fault tree Z7 and uniform basic event distributions.

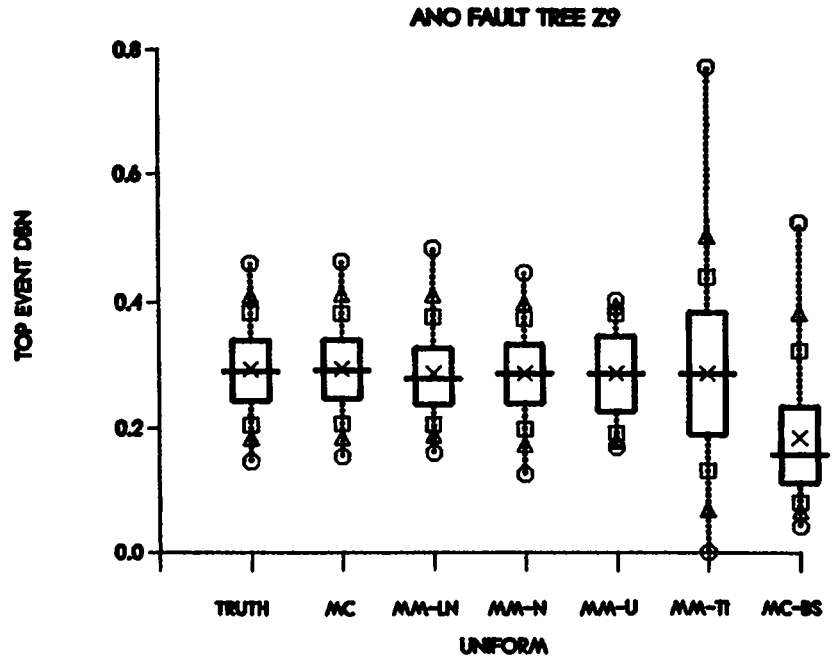

Fig. 70.
Comparative performance of the methods for fault tree Z9 and uniform basic event distributions.

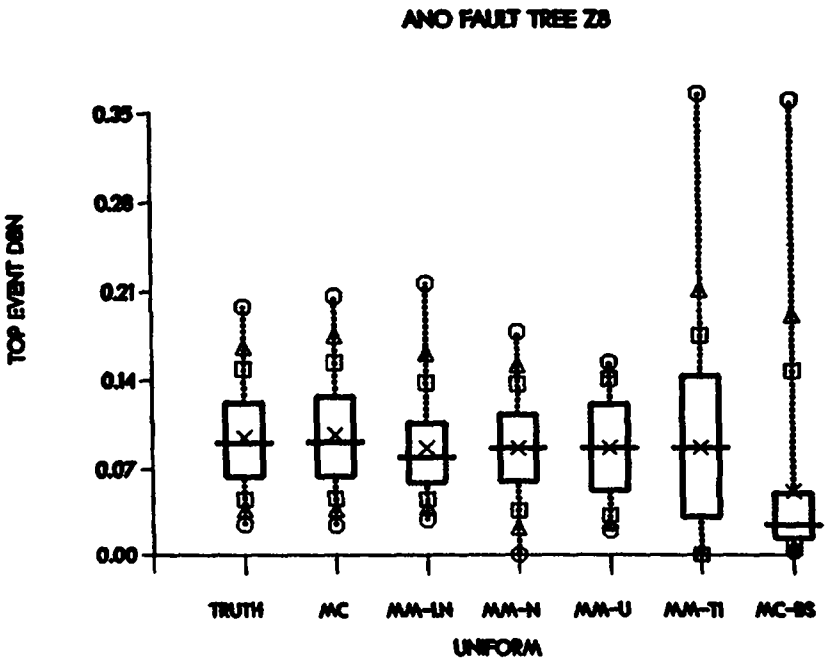

Fig. 71.

Comparative performance of the methods for fault tree Z8 and uniform basic event distributions.

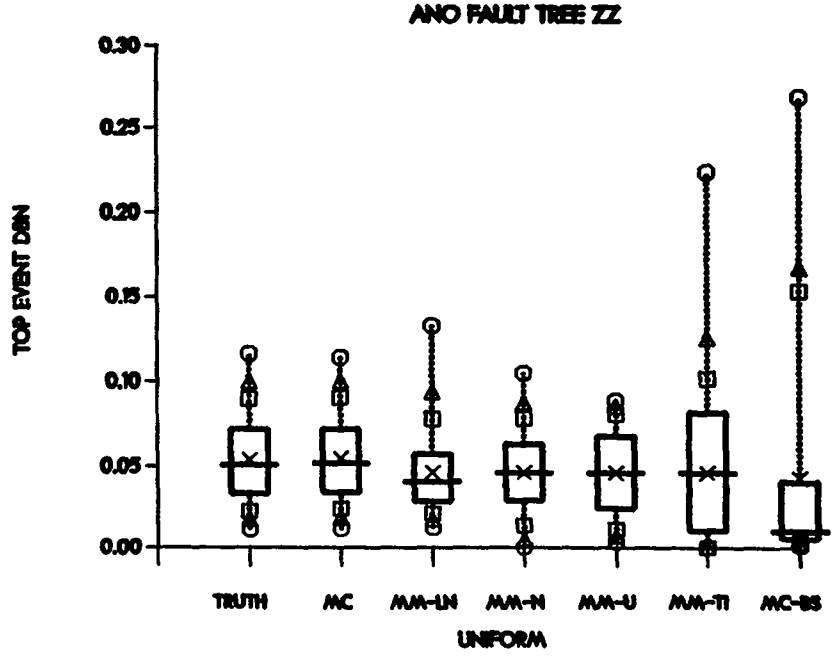

Fig. 72.

Comparative performance of the methods for fault tree ZZ and uniform basic event distributions.

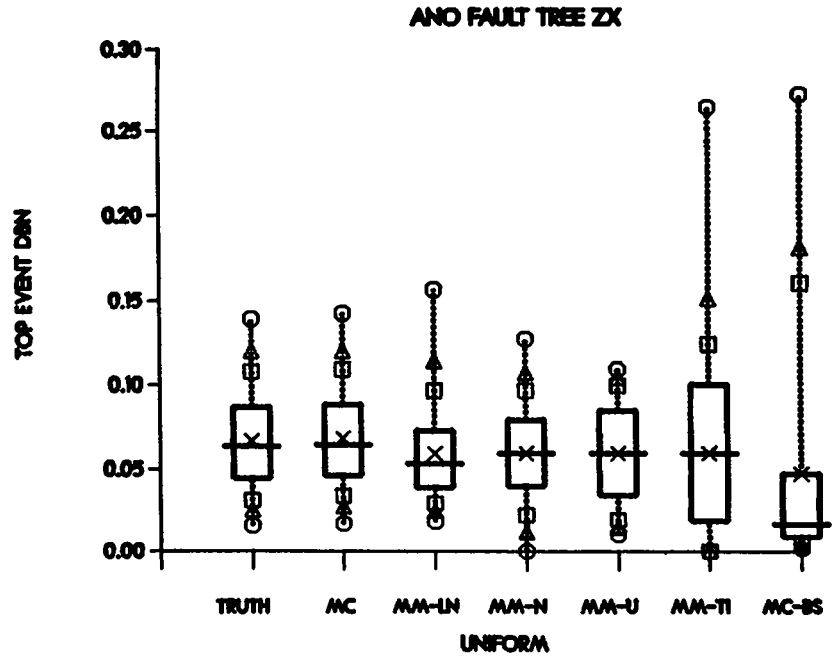

Fig. 73.

Comparative performance of the methods for fault tree ZX and uniform basic event distributions.

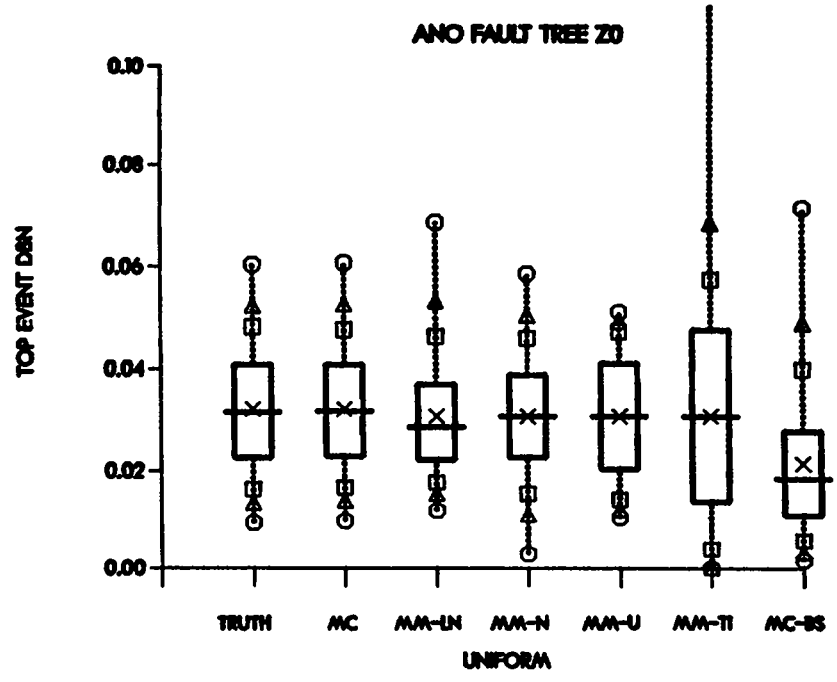

Fig. 74.

Comparative performance of the methods for fault tree Z0 and uniform basic event distributions.

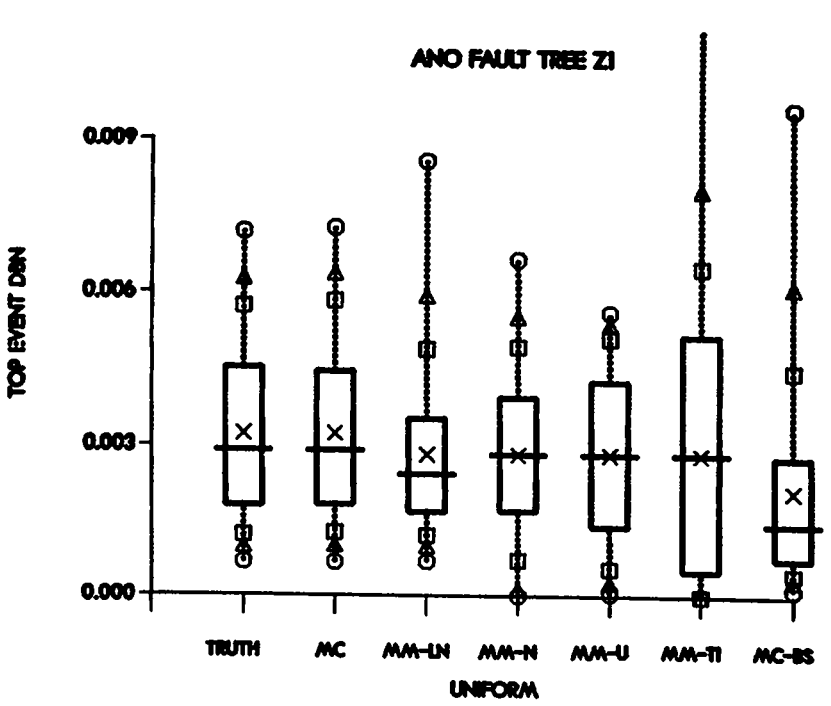

Fig. 75.
Comparative performance of the methods for fault tree Z1 and uniform basic event distributions.

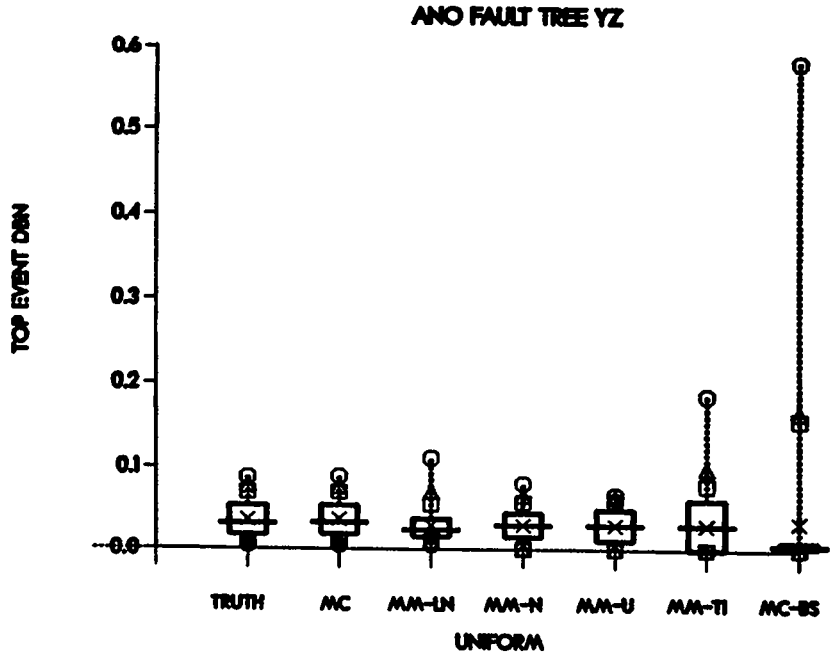

Fig. 76.
Comparative performance of the methods for fault tree YZ and uniform basic event distributions.

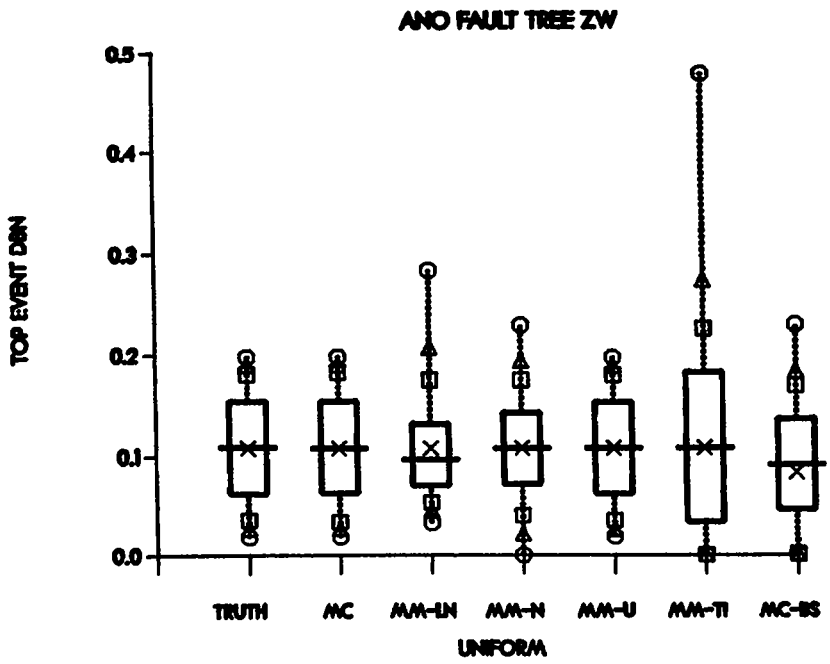

Fig. 77.

Comparative performance of the methods for fault tree ZW and uniform basic event distributions.

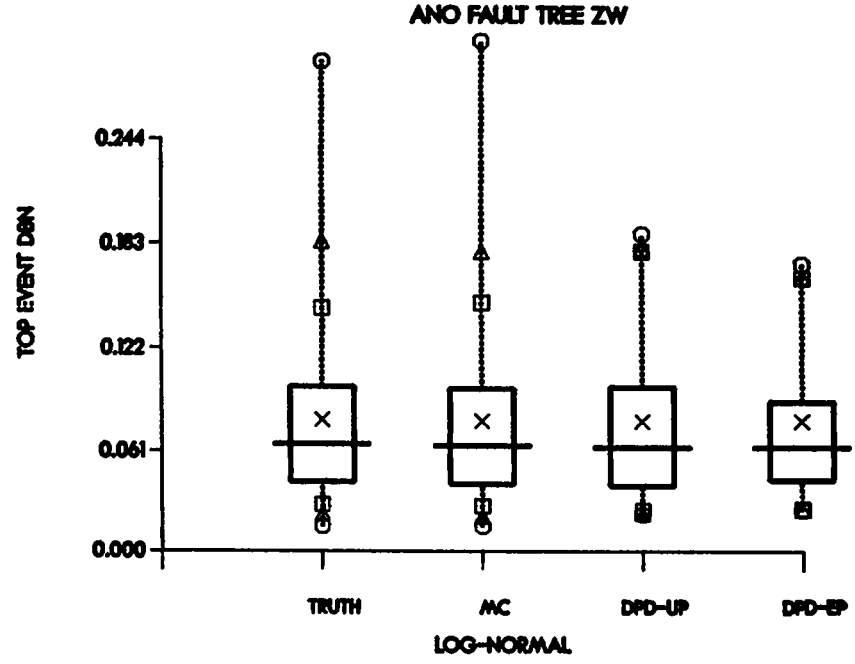

Fig. 78.

Comparative performance of the DPD methods for fault tree ZW and log normal basic event distributions.

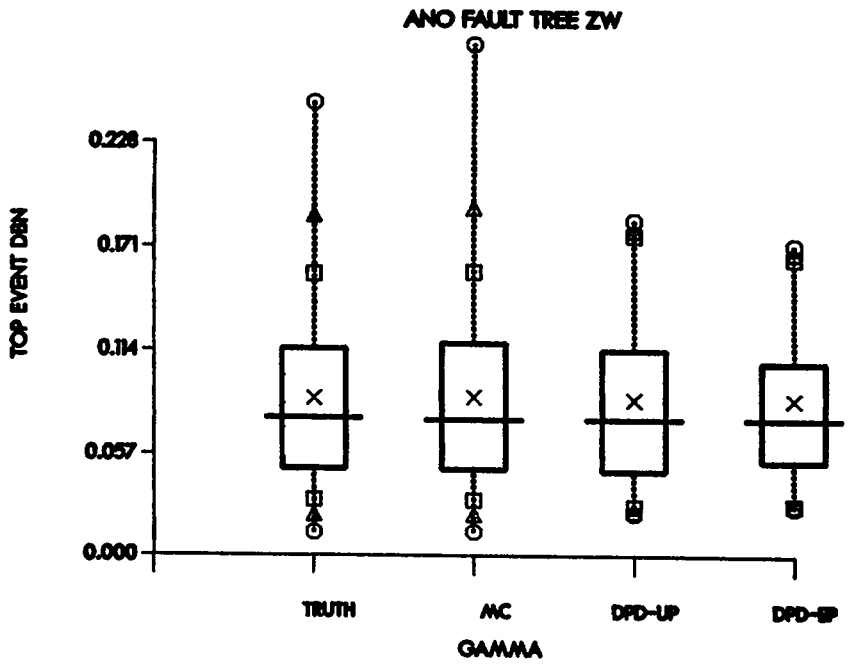

Fig. 79.

Comparative performance of the DPD methods for fault tree ZW and gamma basic event distributions.

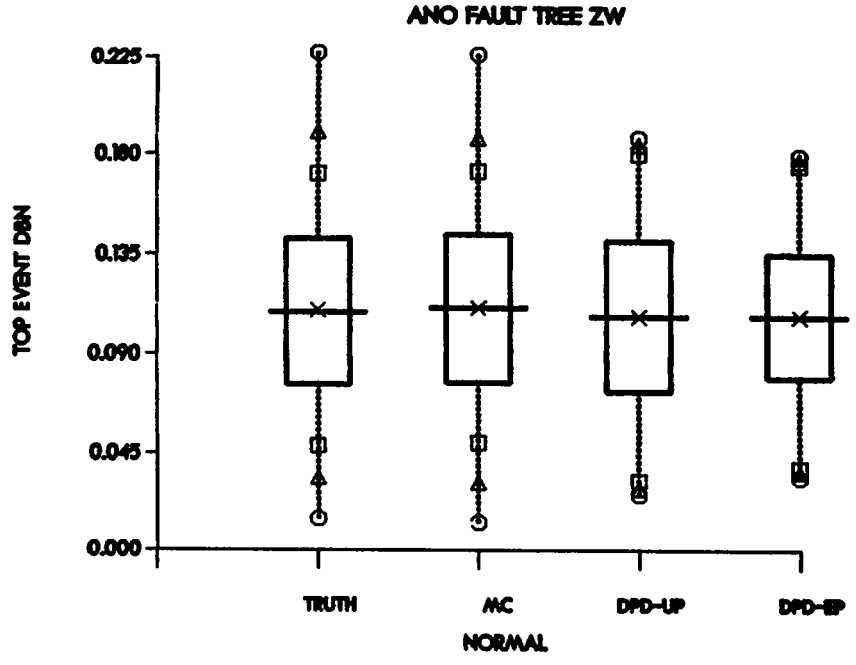

Fig. 80.

Comparative performance of the DPD methods for fault tree ZW and normal basic event distributions.

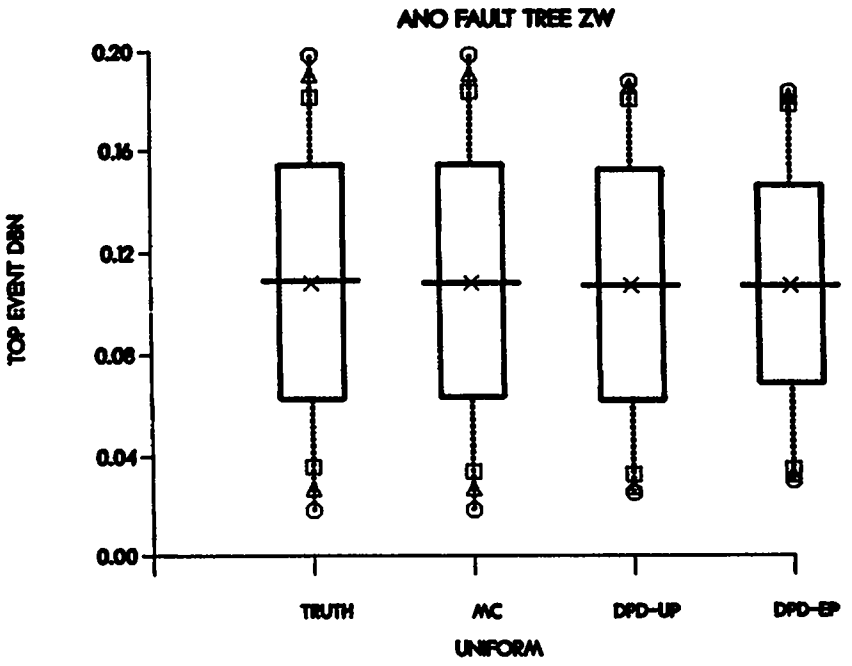

Fig. 81.

Comparative performance of the DPD methods for fault tree ZW and uniform basic event distributions.

APPENDIX A

ANO-1 FRONT-LINE SYSTEM FAULT TREE EQUIVALENT BOOLEAN EXPRESSIONS AND QUANTIFICATION DATA

TABLE A-I

EQUIVALENT BOOLEAN EXPRESSION FOR HIGH-PRESSURE INJECTION SYSTEM, 2-OF-3 PUMPS CRITERION (TRUNCATED AT 1.0E-6)

X = (A306A-CBL-LF + HPIP36AA-PMD-LF + HPIA306A-B00-CC + HPIA306A-B00-LF + SWS3808A-VCC-LF + SWS5214A-B00-CC + SWS5214A-B00-LF + 5214A-CBL-LF) * (HPIA307A-B00-CC + A307A-CBL-LF) + (A306A-CBL-LF + HPIA306A-B00-CC + SWS3808A-VCC-LF + SWS5214A-B00-CC + 5214A-CBL-LF) * (HPIA307A-B00-LF + HPIP36BA-PMD-LF) + (ECS5136A-B00-CC + ECS5136A-B00-LF + 5136A-CBL-LF + ECSC14DA-FAN-LF) * (ECS5516A-B00-CC + ECSVE1AA-RFU-LF) + (HPI5152A-B00-CC + HPI5152A-B00-LF + 5152A-CBL-LF + HPI1220A-VCC-LF) * (HPI5151A-B00-CC + 5151A-CBL-LF + HPI1219A-VCC-LF) + (HPI6152B-B00-CC + HPI6152B-B00-LF + 6152B-CBL-LF + HPI1228B-VCC-LF) * (HPI6151B-B00-CC + 6151B-CBL-LF + HPI1227B-VCC-LF) + ECS5516A-B00-LF * (ECS5136A-B00-CC + 5136A-CBL-LF) + ECSVE1BA-RFU-LF * (ECS6135B-B00-CC + ECS6135B-B00-LF + ECSC14AB-FAN-LF) + HPI6151B-B00-LF * (HPI6152B-B00-CC + 6152B-CBL-LF + HPI1228B-VCC-LF) + HPI5151A-B00-LF * (HPI5152A-B00-CC + 5152A-CBL-LF + HPI1220A-VCC-LF) + LOSS-OSP * (SWS3807B-VCC-LF + SWS3806A-VCC-LF + SWS6231B-B00-CC + SWS5231A-B00-CC + 6231B-CBL-LF +

TABLE A-I (Cont)

5231A-CBL-LF + IED0D06B-BAT-LF + IED0D07A-BAT-LF + A-IEA-2 + A-IEA-1 + IEAP16BB-PMD + IEAP16AA-PMD + IEA0DG2B-GEN-LF + IEA0DG1A-GEN-LF) + HPI0BW3X-X0C-LF + HPI0BW2X-X0C-LF + HPIU19CX-CCC-LF + LPI0BW1X-X0C-LF + IED0D02B-BC0-LF + IED0D01A-BC0-LF + A-HPI-4 + A-HPI-5 + A-HPI-2 + A-HPI-6 + A-HPI-3 + HPI-PUMP-CM + HPIU18CX-X0C-LF + HPIU20CX-X0C-LF + A406B-CBL-LF + HPIP36CB-PMD-LF + A-LPI-7 + A-LPI-14 + A-LPI-5 + A-LPI-12 + IEDD114A-B00 + D114A-CBL-LF + IEDD214B-B00 + D214B-CBL-LF + LPI1408B-VCC-LF + LPI1407A-VCC-LF + 6164B-CBL-LF + 5164A-CBL-LF + LPI6164B-B00-CC + LPI6164B-B00-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + A-ECS-2 + A-ECS-3 + ECS206BX-X0C-LF + ECS206AX-X0C-LF + IEA00A4B-416-LF + IEA00A3A-416-LF + A-ECS-15 + A-ECS-14 + ECS602BX-X0C-LF + ECS600BX-X0C-LF + ECS601BX-X0C-LF + ECS200BX-X0C-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + 5254A-CBL-LF + ECS604BX-CCC-LF + ECSCH4BA-CWU-LF + ECSC45BX-X0C-LF + ECSC44BX-X0C-LF + ECSC41BX-X0C-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + ECSUC2BA-FAN-LF + ECS602AX-X0C-LF + ECS600AX-X0C-LF + ECS601AX-X0C-LF + ECS200AX-X0C-LF + ECSC45DX-X0C-LF + ECSC44DX-X0C-LF + ECSC41DX-X0C-LF + ECS6034B-DPC-LF + ECS6034B-BPC-LF + ECS6254B-B00-CC + ECS6254B-B00-LF + ECS6246B-B00-CC + ECS6246B-B00-LF + 6254B-CBL-LF + 6246B-CBL-LF + ECS6254B-B-AASF + ECS604AX-CCC-LF + ECSCH4AB-CWU-LF + ECSC2DB-FAN-LF + ECS6135B-B00-CC * ECS5515A-B00-LF + A-ESF-7 + A-ESF-6 + A-ESF-2 + A-ESF-1 + ESFPUC2B-CBL-LF + ESFPUC1A-CBL-LF + ESFRA205-REC-LF + ESFXA205-TFM-LF + ESFRS202-BC0 + ESFRS202-CBL-LF + ESFRA105-REC-LF + ESFXA105-TFM-LF + ESFRS102-BC0 + ESFRS102-CBL-LF + A-SWS-14 + A-SWS-1 + A-SWS-3 + ESFU113-UCT-LF + SWS3902X-X0C-LF +

TABLE A-I (Cont)

SWS606BX-X0C-LF + SWS3900X-X0C-LF + SWS608BX-X0C-LF + SWS3905X-X0C-LF + SWS606AX-X0C-LF + SWS3903X-X0C-LF + SWS608AX-X0C-LF + SWS018CX-X0C-LF + SWS3810B-VCC-LF + SWS3641B-V0C-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS6214B-B00-CC + SWS6214B-B00-LF + SWS0402B-B00-CC + SWS0402B-B00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 6214B-CBL-LF + 0402-CBL-LF + 0303A-CBL-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4CB-PMD-LF + SWS0P4BA-PMD-LF + A-IED-6 + A-IED-7 + A-IED-2 + A-IED-3 + IED0D02B-125-LF + IED0RS2B-120-LF + IED0D21B-125-LF + IED0D01A-125-LF + IED0RS1A-120-LF + IED0D11A-125-LF + IED0D02B-CBL-LF + IED0D01A-CBL-LF + A-IEA-4 + A-IEA-10 + A-IEA-11 + A-IEA-3 + A-IEA-7 + A-IEA-8 + IEA00B6B-480-LF + IEA00B5A-480-LF + IEA0B61B-480-LF + IEA0B62B-480-LF + IEA0B51A-480-LF + IEA0B52A-480-LF + IEA00X6B-TFM-LF + IEA0401B-CBL-LF + IEA00X5A-TFM-LF + IEA0301A-CBL-LF + IEA0621B-CBL-LF + IEA0614B-CBL-LF + IEA0521A-CBL-LF + IEA0532A-CBL-LF + IEA0401B-BC0-LF + IEA0612B-BC0-LF + IEA0621B-BC0-LF + IEA0614B-BC0-LF + IEA0301A-BC0-LF + IEA0512A-BC0-LF + IEA0521A-BC0-LF + IEA0532A-BC0-LF

TABLE A-II

DATA FOR QUANTIFICATION OF FAULT TREE Z3

Basic Event	Median Unavailability	EF	CG
A306A-CBL-LF	0.11000000E-02	3	1
HPIP36AA-PMD-LF	0.10000000E-02	3	13
HPIA306A-B00-CC	0.20000001E-02	3	2
HPIA306A-B00-LF	0.10000000E-02	3	11
SWS3808A-VCC-LF	0.40000002E-02	3	8
SWS5214A-B00-CC	0.20000001E-02	3	2
SWS5214A-B00-LF	0.10000000E-02	3	11
5214A-CBL-LF	0.11000000E-02	3	1
HPIA307A-B00-CC	0.20000001E-02	3	2
A307A-CBL-LF	0.11000000E-02	3	1
HPIA307A-B00-LF	0.10000000E-02	3	11
HPIP36BA-PMD-LF	0.10000000E-02	3	13
ECS5136A-B00-CC	0.20000001E-02	3	2
ECS5136A-B00-LF	0.10000000E-02	3	11
5136A-CBL-LF	0.11000000E-02	3	1
ECSC14DA-FAN-LF	0.53999998E-03	3	12
ECS5516A-B00-CC	0.20000001E-02	3	2
ECSVE1AA-RFU-LF	0.34000000E-02	3	13
HPI5152A-B00-CC	0.20000001E-02	3	2
HPI5152A-B00-LF	0.10000000E-02	3	11
5152A-CBL-LF	0.33000000E-02	3	1
HPI1220A-VCC-LF	0.41000000E-02	3	8
HPI5151A-B00-CC	0.20000001E-02	3	2
5151A-CBL-LF	0.33000000E-02	3	1
HPI1219A-VCC-LF	0.41000000E-02	3	8
HPI6152B-B00-CC	0.20000001E-02	3	2
HPI6152B-B00-LF	0.10000000E-02	3	11
6152B-CBL-LF	0.33000000E-02	3	1
HPI1228B-VCC-LF	0.41000000E-02	3	8
HPI6151B-B00-CC	0.20000001E-02	3	2
6151B-CBL-LF	0.33000000E-02	3	1
HPI1227B-VCC-LF	0.41000000E-02	3	8
ECS5516A-B00-LF	0.10000000E-02	3	11
ECSVE1BA-RFU-LF	0.34000000E-02	3	13
ECS6135B-B00-CC	0.20000001E-02	3	2
ECS6135B-B00-LF	0.10000000E-02	3	11
ECSC14AB-FAN-LF	0.53999998E-03	3	12
HPI6151B-B00-LF	0.10000000E-02	3	11
HPI5151A-B00-LF	0.10000000E-02	3	11
LOSS-OSP	0.10000000E-02	10	48
SWS3807B-VCC-LF	0.41000000E-02	3	8
SWS3806A-VCC-LF	0.41000000E-02	3	8
SWS6231B-B00-CC	0.20000001E-02	3	2
SWS5231A-B00-CC	0.20000001E-02	3	2
6231B-CBL-LF	0.11000000E-02	3	1
5231A-CBL-LF	0.11000000E-02	3	1

TABLE A-II (Cont)

Basic Event	Median Unavailability	EF	CG
IED0D06B-BAT-LF	0.11000000E-02	3	17
IED0D07A-BAT-LF	0.11000000E-02	3	17
A-IEA-2	0.15000000E-02	3	33
A-IEA-1	0.15000000E-02	3	33
IEAP16BB-PMD	0.11000000E-02	3	13
IEAP16AA-PMD	0.11000000E-02	3	13
IEA0DG2B-GEN-LF	0.33000000E-01	10	23
IEA0DG1A-GEN-LF	0.33000000E-01	10	23
HPI0BW3X-X0C-LF	0.99999997E-04	3	5
HPI0BW2X-X0C-LF	0.99999997E-04	3	5
HPIU19CX-CCC-LF	0.99999997E-04	3	6
LPI0BW1X-X0C-LF	0.99999997E-04	3	5
IED0D02B-BC0-LF	0.24000001E-04	3	10
IED0D01A-BC0-LF	0.24000001E-04	3	10
A-HPI-4	0.22000000E-03	3	26
A-HPI-5	0.16000000E-05	3	27
A-HPI-2	0.16000000E-05	3	27
A-HPI-6	0.16000000E-05	3	27
A-HPI-3	0.16000000E-05	3	27
HPI-PUMP-CM	0.17000000E-02	10	50
HPIU18CX-X0C-LF	0.99999997E-04	3	5
HPIU20CX-X0C-LF	0.99999997E-04	3	5
A406B-CBL-LF	0.11000000E-02	3	1
HPIP36CB-PMD-LF	0.10000000E-02	3	13
A-LPI-7	0.16000000E-05	3	27
A-LPI-14	0.16000000E-05	3	27
A-LPI-5	0.16000000E-05	3	27
A-LPI-12	0.16000000E-05	3	27
IEDD114A-B00	0.10000000E-02	3	11
D114A-CBL-LF	0.11000000E-02	3	1
IEDD214B-B00	0.10000000E-02	3	11
D214B-CBL-LF	0.11000000E-02	3	1
LPI1408B-VCC-LF	0.41000000E-02	3	8
LPI1407A-VCC-LF	0.41000000E-02	3	8
6164B-CBL-LF	0.11000000E-02	3	1
5164A-CBL-LF	0.11000000E-02	3	1
LPI6164B-B00-CC	0.20000001E-02	3	2
LPI6164B-B00-LF	0.10000000E-02	3	11
LPI5164A-B00-CC	0.20000001E-02	3	2
LPI5164A-B00-LF	0.10000000E-02	3	11
A-ECS-2	0.42999999E-03	3	26
A-ECS-3	0.42999999E-03	3	26
ECS206BX-X0C-LF	0.99999997E-04	3	5
ECS206AX-X0C-LF	0.99999997E-04	3	5
IEA00A4B-416-LF	0.72000003E-04	3	1
IEA00A3A-416-LF	0.72000003E-04	3	1
A-ECS-15	0.73000001E-05	3	27
A-ECS-14	0.73000001E-05	3	27

TABLE A-II (Cont)

Basic Event	Median Unavailability	EF	CG
ECS602BX-X0C-LF	0.99999997E-04	3	5
ECS600BX-X0C-LF	0.99999997E-04	3	5
ECS601BX-X0C-LF	0.99999997E-04	3	5
ECS200BX-X0C-LF	0.99999997E-04	3	5
ECS6036A-DPC-LF	0.41000000E-02	3	8
ECS6036A-BPC-LF	0.41000000E-02	3	8
ECS5254A-B-AASF	0.54000001E-02	10	4
ECS5254A-B00-CC	0.20000001E-02	3	2
ECS5254A-B00-LF	0.10000000E-02	3	11
5254A-CBL-LF	0.11000000E-02	3	1
ECS604BX-CCC-LF	0.99999997E-04	3	6
ECSCH4BA-CWU-LF	0.37000000E-02	3	13
ECSC45BX-X0C-LF	0.99999997E-04	3	5
ECSC44BX-X0C-LF	0.99999997E-04	3	5
ECSC41BX-X0C-LF	0.99999997E-04	3	5
ECS5246A-B00-CC	0.20000001E-02	3	2
ECS5246A-B00-LF	0.10000000E-02	3	11
5246A-CBL-LF	0.11000000E-02	3	1
ECSUC2BA-FAN-LF	0.53999998E-03	3	12
ECS602AX-X0C-LF	0.99999997E-04	3	5
ECS600AX-X0C-LF	0.99999997E-04	3	5
ECS601AX-X0C-LF	0.99999997E-04	3	5
ECS200AX-X0C-LF	0.99999997E-04	3	5
ECSC45DX-X0C-LF	0.99999997E-04	3	5
ECSC44DX-X0C-LF	0.99999997E-04	3	5
ECSC41DX-X0C-LF	0.99999997E-04	3	5
ECS6034B-DPC-LF	0.41000000E-02	3	8
ECS6034B-BPC-LF	0.41000000E-02	3	8
ECS6254B-B00-CC	0.20000001E-02	3	2
ECS6254B-B00-LF	0.10000000E-02	3	11
ECS6246B-B00-CC	0.20000001E-02	3	2
ECS6246B-B00-LF	0.10000000E-02	3	11
6254B-CBL-LF	0.11000000E-02	3	1
6246B-CBL-LF	0.11000000E-02	3	1
ECS6254B-B-AASF	0.54000001E-02	10	4
ECS604AX-CCC-LF	0.99999997E-04	3	6
ECSCH4AB-CWU-LF	0.37000000E-02	3	13
ECSC2DB-FAN-LF	0.53999998E-03	3	12
ECS5515A-B00-LF	0.10000000E-02	3	11
A-ESF-7	0.26000000E-04	3	31
A-ESF-6	0.52000000E-05	3	30
A-ESF-2	0.26000000E-04	3	31
A-ESF-1	0.52000000E-05	3	30
ESFPUC2B-CBL-LF	0.12000000E-04	3	1
ESFPUC1A-CBL-LF	0.12000000E-04	3	1
ESFRA205-REC-LF	0.40000000E-05	10	16
ESFXA205-TFM-LF	0.40000000E-05	3	15
ESFRS202-BC0	0.40000000E-05	3	10

TABLE A-II (Cont)

Basic Event	Median Unavailability	EF	CG
ESFRS202-CBL-LF	0.12000000E-04	3	1
ESFRA105-REC-LF	0.40000000E-05	10	16
ESFXA105-TFM-LF	0.40000000E-05	3	15
ESFRS102-BCO	0.40000000E-05	3	10
ESFRS102-CBL-LF	0.12000000E-04	3	1
A-SWS-14	0.16000000E-05	3	27
A-SWS-1	0.22000000E-03	3	26
A-SWS-3	0.22000000E-03	3	26
ESFU113-UCT-LF	0.99999997E-04	3	3
SWS3902X-XOC-LF	0.99999997E-04	3	5
SWS606BX-XOC-LF	0.99999997E-04	3	5
SWS3900X-XOC-LF	0.99999997E-04	3	5
SWS608BX-XOC-LF	0.99999997E-04	3	5
SWS3905X-XOC-LF	0.99999997E-04	3	5
SWS606AX-XOC-LF	0.99999997E-04	3	5
SWS3903X-XOC-LF	0.99999997E-04	3	5
SWS608AX-XOC-LF	0.99999997E-04	3	5
SWS018CX-XOC-LF	0.99999997E-04	3	5
SWS3810B-VCC-LF	0.41000000E-02	3	8
SWS3641B-VOC-LF	0.99999997E-04	3	9
SWS3643A-VOO-LF	0.40000002E-02	3	8
SWS3820A-VOO-LF	0.40000002E-02	3	8
SWS6214B-BOO-CC	0.20000001E-02	3	2
SWS6214B-BOO-LF	0.10000000E-02	3	11
SWS0402B-BOO-CC	0.20000001E-02	3	2
SWS0402B-BOO-LF	0.10000000E-02	3	11
SWS0303A-BOO-CC	0.20000001E-02	3	2
SWS0303A-BOO-LF	0.10000000E-02	3	11
SWS5653A-BOO-CC	0.20000001E-02	3	2
SWS5653A-BOO-LF	0.10000000E-02	3	11
SWS5181A-BOO-CC	0.20000001E-02	3	2
SWS5181A-BOO-LF	0.10000000E-02	3	11
6214B-CBL-LF	0.11000000E-02	3	1
0402-CBL-LF	0.72000003E-04	3	1
0303A-CBL-LF	0.72000003E-04	3	1
5653A-CBL-LF	0.33000000E-02	3	1
5181A-CBL-LF	0.33000000E-02	3	1
SWSOP4CB-PMD-LF	0.17000000E-02	3	13
SWSOP4BA-PMD-LF	0.17000000E-02	3	13
A-IED-6	0.29999999E-04	3	36
A-IED-7	0.80000000E-05	3	37
A-IED-2	0.29999999E-04	3	36
A-IED-3	0.80000000E-05	3	37
IEDOD02B-125-LF	0.72000003E-04	3	1
IEDORS2B-120-LF	0.72000003E-04	3	1
IEDOD21B-125-LF	0.72000003E-04	3	1
IEDOD01A-125-LF	0.72000003E-04	3	1
IEDORS1A-120-LF	0.72000003E-04	3	1

TABLE A-II (Cont)

Basic Event	Median Unavailability	EF	CG
IED0D11A-125-LF	0.72000003E-04	3	1
IED0D02B-CBL-LF	0.72000003E-04	3	1
IED0D01A-CBL-LF	0.72000003E-04	3	1
A-IEA-4	0.13000000E-03	3	34
A-IEA-10	0.40000000E-05	3	32
A-IEA-11	0.40000000E-05	3	32
A-IEA-3	0.13000000E-03	3	34
A-IEA-7	0.40000000E-05	3	32
A-IEA-8	0.40000000E-05	3	32
IEA00B6B-480-LF	0.72000003E-04	3	1
IEA00B5A-480-LF	0.72000003E-04	3	1
IEA0B61B-480-LF	0.72000003E-04	3	1
IEA0B62B-480-LF	0.72000003E-04	3	1
IEA0B51A-480-LF	0.72000003E-04	3	1
IEA0B52A-480-LF	0.72000003E-04	3	1
IEA00X6B-TFM-LF	0.48000002E-04	3	15
IEA0401B-CBL-LF	0.72000003E-04	3	1
IEA00X5A-TFM-LF	0.48000002E-04	3	15
IEA0301A-CBL-LF	0.72000003E-04	3	1
IEA0621B-CBL-LF	0.72000003E-04	3	1
IEA0614B-CBL-LF	0.72000003E-04	3	1
IEA0521A-CBL-LF	0.72000003E-04	3	1
IEA0532A-CBL-LF	0.72000003E-04	3	1
IEA0401B-BC0-LF	0.24000001E-04	3	10
IEA0612B-BC0-LF	0.24000001E-04	3	10
IEA0621B-BC0-LF	0.24000001E-04	3	10
IEA0614B-BC0-LF	0.24000001E-04	3	10
IEA0301A-BC0-LF	0.24000001E-04	3	10
IEA0512A-BC0-LF	0.24000001E-04	3	10
IEA0521A-BC0-LF	0.24000001E-04	3	10
IEA0532A-BC0-LF	0.24000001E-04	3	10

TABLE A-III

EQUIVALENT BOOLEAN EXPRESSION FOR
HIGH-PRESSURE RECIRCULATION SYSTEM
(TRUNCATED AT 1.0E-6)

X = (HPRDH7AX-XCC-LF + LPA-CM + A-LPI-11 + 5132A-CBL-LF + IEDD114A-B00
+ D114A-CBL-LF + VUC1A-FAN-LF + FAN5132A-B00-CC + FAN5132A-B00-LF +
LPR1405A-VCC-LF + LPI1407A-VCC-LF + 51112A-CBL-LF + 5164A-CBL-LF +
LPR0P34A-PMD-LF + LP51112A-B00-CC + LP51112A-B00-LF + LPI5164A-B00-CC +
LPI5164A-B00-LF + SW1-CM + A-1104-04-1 + SWS3803A-VCC-LF +
SWS5232A-B00-CC + SWS5232A-B00-LF + LPIA305A-B00-CC + LPIA305A-B00-LF +
LPIE35AX-HTX-LFB + R-HCP-020A-S + R-110404-A-22A + R-HCP-022A-S +
R-110404-B-38B + R-HCP-038B-9 + SWS3822A-VCC-LF + SWS5182A-B00-CC +
SWS5182A-B00-LF + 5182A-CBL-LF + SWSRS17A-B00 + RS17A-CBL-LF +
SWS3840A-NCC-CC + SWS3840A-NCC-LF) * (R-110404-B-22B + R-1104-A-38A)
+ (HPRDH7BX-XCC-LF + LPB-CM + A-LPI-4 + 6132B-CBL-LF + IEDD214B-B00 +
D214B-CBL-LF + VUC1C-FAN-LF + FAN6132B-B00-CC + FAN6132B-B00-LF +
LPR1406B-VCC-LF + LPI1408B-VCC-LF + 6166B-CBL-LF + 6164B-CBL-LF +
LPR0P34B-PMD-LF + LPI6164B-B00-CC + LPI6164B-B00-LF + LPR6166B-B00-CC +
LPR6166B-B00-LF + SW2-CM + A-1104-04-2 + SWS3802B-VCC-LF +
SWS6232B-B00-CC + SWS6232B-B00-LF + 6232B-CBL-LF + HPRE35BX-HTX-LFI +
HPRE35BX-HTX-LFB + R-HCP-BW8B-5 + A405B-CBL-LF + LPI0P34B-PMD-LF +
LPIA405B-B00-CC + LPIA405B-B00-LF + LPIE35BX-HTX-LFB + R-HCP-020C-S +
R-HCP-022B-S + R-HCP-038A-10 + SWS3821B-VCC-LF + SWS6183B-B00-CC +
SWS6183B-B00-LF + 6183B-CBL-LF + SWSRS27B-B00 + RS27B-CBL-LF +
SWS3841B-NCC-CC + SWS3841B-NCC-LF) * (R-110404-A-22A + R-110404-B-38B

TABLE A-III (Cont)

) + (LPI1408B-VCC-LF + 6166B-CBL-LF + LPI6164B-B00-CC + LPR6166B-B00-CC + SWS3802B-VCC-LF + SWS6232B-B00-CC + LPIA405B-B00-CC + SWS3821B-VCC-LF + SWS6183B-B00-CC + 6183B-CBL-LF + SWSRS27B-B00 + SWS3841B-NCC-CC + SWS3841B-NCC-LF) * (5132A-CBL-LF + VUC1A-FAN-LF) + (ECS5136A-B00-CC + ECS5136A-B00-LF + 5136A-CBL-LF + ECSC14DA-FAN-LF) * (ECS5516A-B00-CC + ECSVE1AA-RFU-LF) + (LPB-CM + 6132B-CBL-LF + IEDD214B-B00 + D214B-CBL-LF + VUC1C-FAN-LF + FAN6132B-B00-CC + FAN6132B-B00-LF + LPR1406B-VCC-LF + LPI1408B-VCC-LF + 6166B-CBL-LF + 6164B-CBL-LF + LPR0P34B-PMD-LF + LPI6164B-B00-CC + LPI6164B-B00-LF + LPR6166B-B00-CC + LPR6166B-B00-LF + SW2-CM + A-1104-04-2 + SWS3802B-VCC-LF + SWS6232B-B00-CC + SWS6232B-B00-LF + 6232B-CBL-LF + HPRE35BX-HTX-LFI + HPRE35BX-HTX-LFB + A405B-CBL-LF + LPI0P34B-PMD-LF + LPIA405B-B00-CC + LPIA405B-B00-LF + LPIE35BX-HTX-LFB + R-HCP-022B-S + SWS3821B-VCC-LF + SWS6183B-B00-CC + SWS6183B-B00-LF + 6183B-CBL-LF + SWSRS27B-B00 + RS27B-CBL-LF + SWS3841B-NCC-CC + SWS3841B-NCC-LF) * (LPI1407A-VCC-LF + SWS3803A-VCC-LF + SWS3822A-VCC-LF) + (FAN5132A-B00-CC + HPRE35AX-HTX-LFI + HPRE35AX-HTX-LFB + LPIE35AX-HTX-LFB) * (LPI1408B-VCC-LF + SWS3802B-VCC-LF + SWS3821B-VCC-LF) + (LPB-CM + IEDD214B-B00 + D214B-CBL-LF + FAN6132B-B00-LF + LPR1406B-VCC-LF + LPI1408B-VCC-LF + 6166B-CBL-LF + 6164B-CBL-LF + LPI6164B-B00-CC + LPI6164B-B00-LF + LPR6166B-B00-CC + LPR6166B-B00-LF + SW2-CM + A-1104-04-2 + SWS3802B-VCC-LF + SWS6232B-B00-CC + SWS6232B-B00-LF + 6232B-CBL-LF + A405B-CBL-LF + LPI0P34B-PMD-LF + LPIA405B-B00-CC + LPIA405B-B00-LF + R-HCP-022B-S + SWS3821B-VCC-LF + SWS6183B-B00-CC + SWS6183B-B00-LF + 6183B-CBL-LF +

TABLE A-III (Cont)

SWSRS27B-B00 + RS27B-CBL-LF + SWS3841B-NCC-CC + SWS3841B-NCC-LF) * (LPR1405A-VCC-LF + 5164A-CBL-LF + SW1-CM + A-1104-04-1 + 5232A-CBL-LF + A305A-CBL-LF + RS17A-CBL-LF) + (LPB-CM + D214B-CBL-LF + LPR1406B-VCC-LF + LPI1408B-VCC-LF + 6166B-CBL-LF + 6164B-CBL-LF + LPI6164B-B00-CC + LPR6166B-B00-CC + SW2-CM + A-1104-04-2 + SWS3802B-VCC-LF + SWS6232B-B00-CC + 6232B-CBL-LF + A405B-CBL-LF + LPIA405B-B00-CC + R-HCP-022B-S + SWS3821B-VCC-LF + SWS6183B-B00-CC + 6183B-CBL-LF + SWSRS27B-B00 + RS27B-CBL-LF + SWS3841B-NCC-CC + SWS3841B-NCC-LF) * (FAN5132A-B00-LF + LP51112A-B00-LF + LPI5164A-B00-LF + SWS5232A-B00-LF + LPIOP34A-PMD-LF + LPIA305A-B00-LF + SWS5182A-B00-LF) + (LPB-CM + 6132B-CBL-LF + IEDD214B-B00 + D214B-CBL-LF + VUC1C-FAN-LF + FAN6132B-B00-LF + LPR1406B-VCC-LF + LPI1408B-VCC-LF + 6166B-CBL-LF + 6164B-CBL-LF + LPROP34B-PMD-LF + LPI6164B-B00-CC + LPI6164B-B00-LF + LPR6166B-B00-CC + LPR6166B-B00-LF + SW2-CM + A-1104-04-2 + SWS3802B-VCC-LF + SWS6232B-B00-CC + SWS6232B-B00-LF + 6232B-CBL-LF + A405B-CBL-LF + LPIOP34B-PMD-LF + LPIA405B-B00-CC + LPIA405B-B00-LF + R-HCP-022B-S + SWS3821B-VCC-LF + SWS6183B-B00-CC + SWS6183B-B00-LF + 6183B-CBL-LF + SWSRS27B-B00 + RS27B-CBL-LF + SWS3841B-NCC-CC + SWS3841B-NCC-LF) * (51112A-CBL-LF + LP51112A-B00-CC + LPI5164A-B00-CC + SWS5232A-B00-CC + LPIA305A-B00-CC + SWS5182A-B00-CC + 5182A-CBL-LF + SWSRS17A-B00 + SWS3840A-NCC-CC + SWS3840A-NCC-LF) + ECS5516A-B00-LF * (ECS5136A-B00-CC + 5136A-CBL-LF) + ECSVE1BA-RFU-LF * (ECS6135B-B00-CC + ECS6135B-B00-LF + ECSC14AB-FAN-LF) + LOSS-OSP * (SWS3807B-VCC-LF + SWS3806A-VCC-LF + SWS6231B-B00-CC + SWS5231A-B00-CC + 6231B-CBL-LF + 5231A-CBL-LF +

TABLE A-III (Cont)

IED0D06B-BAT-LF + IED0D07A-BAT-LF + A-IEA-2 + A-IEA-1 + IEAP16BB-PMD + IEAP16AA-PMD + IEA0DG2B-GEN-LF + IEA0DG1A-GEN-LF) + LPR0P34A-PMD-LF * (LPI1408B-VCC-LF + 6166B-CBL-LF + LPI6164B-B00-CC + LPR6166B-B00-CC + SWS3802B-VCC-LF + SWS6232B-B00-CC + LPIA405B-B00-CC + R-HCP-022B-S + SWS3821B-VCC-LF + SWS6183B-B00-CC + 6183B-CBL-LF + SWSRS27B-B00 + SWS3841B-NCC-CC + SWS3841B-NCC-LF) + IEDD114A-B00 * (A406B-CBL-LF + LPB-CM + D214B-CBL-LF + LPR1406B-VCC-LF + LPI1408B-VCC-LF + 6166B-CBL-LF + 6164B-CBL-LF + LPI6164B-B00-CC + LPR6166B-B00-CC + SW2-CM + A-1104-04-2 + SWS3802B-VCC-LF + SWS6232B-B00-CC + 6232B-CBL-LF + HPIA406B-B00-CC + A405B-CBL-LF + LPIA405B-B00-CC + R-HCP-022B-S + SWS3821B-VCC-LF + SWS3810B-VCC-LF + SWS6183B-B00-CC + SWS6214B-B00-CC + 6183B-CBL-LF + 6214B-CBL-LF + SWSRS27B-B00 + RS27B-CBL-LF + SWS3841B-NCC-CC + SWS3841B-NCC-LF) + LPA-CM * (LPB-CM + R-110404-B-DH8B + IEDD214B-B00 + D214B-CBL-LF + FAN6132B-B00-LF + LPR1406B-VCC-LF + LPI1408B-VCC-LF + 6166B-CBL-LF + 6164B-CBL-LF + LPI6164B-B00-CC + LPI6164B-B00-LF + LPR6166B-B00-CC + LPR6166B-B00-LF + SW2-CM + A-1104-04-2 + SWS3802B-VCC-LF + SWS6232B-B00-CC + SWS6232B-B00-LF + 6232B-CBL-LF + A405B-CBL-LF + LPI0P34B-PMD-LF + LPIA405B-B00-CC + LPIA405B-B00-LF + R-HCP-022B-S + SWS3821B-VCC-LF + SWS6183B-B00-CC + SWS6183B-B00-LF + 6183B-CBL-LF + SWSRS27B-B00 + RS27B-CBL-LF + SWS3841B-NCC-CC + SWS3841B-NCC-LF) + D114A-CBL-LF * (A406B-CBL-LF + HPIP36CB-PMD-LF + LPB-CM + IEDD214B-B00 + D214B-CBL-LF + FAN6132B-B00-LF + LPR1406B-VCC-LF + LPI1408B-VCC-LF + 6166B-CBL-LF + 6164B-CBL-LF + LPI6164B-B00-CC + LPI6164B-B00-LF + LPR6166B-B00-CC + LPR6166B-B00-LF + SW2-CM + A-1104-04-2 + SWS3802B-VCC-LF +

TABLE A-III (Cont)

SWS6232B-B00-CC + SWS6232B-B00-LF + 6232B-CBL-LF + HPIA406B-B00-CC + HPIA406B-B00-LF + A405B-CBL-LF + LPI0P34B-PMD-LF + LPIA405B-B00-CC + LPIA405B-B00-LF + R-HCP-022B-S + SWS3821B-VCC-LF + SWS3810B-VCC-LF + SWS6183B-B00-CC + SWS6183B-B00-LF + SWS6214B-B00-CC + SWS6214B-B00-LF + 6183B-CBL-LF + 6214B-CBL-LF + SWSRS27B-B00 + RS27B-CBL-LF + SWS3841B-NCC-CC + SWS3841B-NCC-LF) + HPRS-CM + HPI-PUMP-CM + 5646B-CBL-LF + VUC7B-FAN-LF + R-110404-A-DH8A * LPB-CM + SL-SUMP-CM + A-ECS-2 + A-ECS-3 + ECS206BX-X0C-LF + ECS206AX-X0C-LF + A-SWS-11 + IEA00A4B-416-LF + IEA00A3A-416-LF + LPI0BW1X-X0C-LF + R-HCP-037B-11 + IED0D02B-BC0-LF + IED0D01A-BC0-LF + R-HCP-VCH4B-2 + R-HCP-VCH4A-3 + A-ECS-11 + A-ECS-8 + A-ECS-15 + A-ECS-14 + ECS602BX-X0C-LF + ECS600BX-X0C-LF + ECS601BX-X0C-LF + ECS200BX-X0C-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + 5254A-CBL-LF + ECS604BX-CCC-LF + ECSCH4BA-CWU-LF + ECSC45BX-X0C-LF + ECSC44BX-X0C-LF + ECSC41BX-X0C-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + ECSUC2BA-FAN-LF + ECS602AX-X0C-LF + ECS600AX-X0C-LF + ECS601AX-X0C-LF + ECS200AX-X0C-LF + ECSC45DX-X0C-LF + ECSC44DX-X0C-LF + ECSC41DX-X0C-LF + ECS6034B-DPC-LF + ECS6034B-BPC-LF + ECS6254B-B00-CC + ECS6254B-B00-LF + ECS6246B-B00-CC + ECS6246B-B00-LF + 6254B-CBL-LF + 6246B-CBL-LF + ECS6254B-B-AASF + ECS604AX-CCC-LF + ECSCH4AB-CWU-LF + ECSC2DB-FAN-LF + ECS6135B-B00-CC * ECS5515A-B00-LF + A-ESF-2 + A-ESF-1 + ESFPUC1A-CBL-LF + ESFRA105-REC-LF + ESFXA105-TFM-LF + ESFRS102-BC0 + ESFRS102-CBL-LF + A-SWS-14 + A-SWS-1 + A-SWS-3 + ESFU113-UCT-LF + SWS3902X-X0C-LF + SWS606BX-X0C-LF + SWS3900X-X0C-LF + SWS608BX-X0C-LF + SWS3905X-X0C-LF + SWS606AX-X0C-LF + SWS3903X-X0C-LF + SWS608AX-X0C-LF +

TABLE A-III (Cont)

SWS3641B-V0C-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0402B-B00-CC + SWS0402B-B00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 0402-CBL-LF + 0303A-CBL-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4CB-PMD-LF + SWS0P4BA-PMD-LF + A-IED-6 + A-IED-2 + A-IED-3 + IED0D02B-125-LF + IED0D21B-125-LF + IED0D01A-125-LF + IED0RS1A-120-LF + IED0D11A-125-LF + IED0D02B-CBL-LF + IED0D01A-CBL-LF + A-IEA-4 + A-IEA-11 + A-IEA-3 + A-IEA-7 + A-IEA-8 + IEA00B6B-480-LF + IEA00B5A-480-LF + IEA0B62B-480-LF + IEA0B51A-480-LF + IEA0B52A-480-LF + IEA0B56S-480-LF + IEA00X6B-TFM-LF + IEA0401B-CBL-LF + IEA00X5A-TFM-LF + IEA0301A-CBL-LF + IEA0622B-CBL-LF + IEA0614B-CBL-LF + IEA0521A-CBL-LF + IEA0532A-CBL-LF + IEA0401B-BC0-LF + IEA0612B-BC0-LF + IEA0622B-BC0-LF + IEA0614B-BC0-LF + IEA0301A-BC0-LF + IEA0512A-BC0-LF + IEA0521A-BC0-LF + IEA0532A-BC0-LF

TABLE A-IV

DATA FOR QUANTIFICATION OF FAULT TREE Z5

Basic Event	Median Unavailability	EF	CG
HPRDH7AX-XCC-LF	0.19999999E-03	3	7
LPA-CM	0.11000000E-02	10	39
A-LPI-11	0.22000000E-03	3	26
5132A-CBL-LF	0.55000000E-03	3	1
IEDD114A-B00	0.10000000E-02	3	11
D114A-CBL-LF	0.11000000E-02	3	1
VUC1A-FAN-LF	0.53999998E-03	3	12
FAN5132A-B00-CC	0.28000001E-03	3	2
FAN5132A-B00-LF	0.10000000E-02	3	11
LPR1405A-VCC-LF	0.11000000E-02	3	8
LPI1407A-VCC-LF	0.41000000E-02	3	8
51112A-CBL-LF	0.33000000E-02	3	1
5164A-CBL-LF	0.11000000E-02	3	1
LPR0P34A-PMD-LF	0.72000001E-03	10	46
LP51112A-B00-CC	0.20000001E-02	3	2
LP51112A-B00-LF	0.10000000E-02	3	11
LPI5164A-B00-CC	0.20000001E-02	3	2
LPI5164A-B00-LF	0.10000000E-02	3	11
SW1-CM	0.11000000E-02	10	43
A-1104-04-1	0.11000000E-02	3	29
SWS3803A-VCC-LF	0.41000000E-02	3	8
SWS5232A-B00-CC	0.20000001E-02	3	2
SWS5232A-B00-LF	0.10000000E-02	3	11
LPIA305A-B00-CC	0.20000001E-02	3	2
LPIA305A-B00-LF	0.10000000E-02	3	11
LPIE35AX-HTX-LFB	0.30000001E-03	3	21
R-HCP-020A-S	0.18000000E-03	10	41
R-110404-A-22A	0.80000004E-02	10	40
R-HCP-022A-S	0.18000000E-03	10	41
R-110404-B-38B	0.80000004E-02	10	40
R-HCP-038B-9	0.18000000E-03	10	41
SWS3822A-VCC-LF	0.41000000E-02	3	8
SWS5182A-B00-CC	0.20000001E-02	3	2
SWS5182A-B00-LF	0.10000000E-02	3	11
5182A-CBL-LF	0.33000000E-02	3	1
SWSRS17A-B00	0.20000001E-02	3	11
RS17A-CBL-LF	0.11000000E-02	3	1
SWS3840A-NCC-CC	0.20000001E-02	3	2
SWS3840A-NCC-LF	0.31000001E-02	3	47
R-110404-B-22B	0.80000004E-02	10	40
R-1104-A-38A	0.80000004E-02	10	40
HPRDH7BX-XCC-LF	0.19999999E-03	3	7
LPB-CM	0.11000000E-02	10	39
A-LPI-4	0.22000000E-03	3	26
6132B-CBL-LF	0.55000000E-03	3	1
IEDD214B-B00	0.10000000E-02	3	11

TABLE A-IV (Cont)

Basic Event	Median Unavailability	EF	CG
D214B-CBL-LF	0.11000000E-02	3	1
VUC1C-FAN-LF	0.53999998E-03	3	12
FAN6132B-B00-CC	0.28000001E-03	3	2
FAN6132B-B00-LF	0.10000000E-02	3	11
LPR1406B-VCC-LF	0.11000000E-02	3	8
LPI1408B-VCC-LF	0.41000000E-02	3	8
6166B-CBL-LF	0.33000000E-02	3	1
6164B-CBL-LF	0.11000000E-02	3	1
LPR0P34B-PMD-LF	0.72000001E-03	10	46
LPI6164B-B00-CC	0.20000001E-02	3	2
LPI6164B-B00-LF	0.10000000E-02	3	11
LPR6166B-B00-CC	0.20000001E-02	3	2
LPR6166B-B00-LF	0.10000000E-02	3	11
SW2-CM	0.11000000E-02	10	43
A-1104-04-2	0.11000000E-02	3	29
SWS3802B-VCC-LF	0.41000000E-02	3	8
SWS6232B-B00-CC	0.20000001E-02	3	2
SWS6232B-B00-LF	0.10000000E-02	3	11
6232B-CBL-LF	0.11000000E-02	3	1
HPRE35BX-HTX-LFI	0.30000001E-03	3	21
HPRE35BX-HTX-LFB	0.30000001E-03	3	21
R-HCP-BW8B-5	0.19000001E-03	10	41
A405B-CBL-LF	0.11000000E-02	3	1
LPI0P34B-PMD-LF	0.10000000E-02	3	13
LPIA405B-B00-CC	0.20000001E-02	3	2
LPIA405B-B00-LF	0.10000000E-02	3	11
LPIE35BX-HTX-LFB	0.30000001E-03	3	21
R-HCP-020C-S	0.18000000E-03	10	41
R-HCP-022B-S	0.18000000E-02	10	41
R-HCP-038A-10	0.18000000E-03	10	41
SWS3821B-VCC-LF	0.41000000E-02	3	8
SWS6183B-B00-CC	0.20000001E-02	3	2
SWS6183B-B00-LF	0.10000000E-02	3	11
6183B-CBL-LF	0.33000000E-02	3	1
SWSRS27B-B00	0.20000001E-02	3	11
RS27B-CBL-LF	0.11000000E-02	3	1
SWS3841B-NCC-CC	0.20000001E-02	3	2
SWS3841B-NCC-LF	0.31000001E-02	3	47
ECS5136A-B00-CC	0.20000001E-02	3	2
ECS5136A-B00-LF	0.10000000E-02	3	11
5136A-CBL-LF	0.11000000E-02	3	1
ECSC14DA-FAN-LF	0.53999998E-03	3	12
ECS5516A-B00-CC	0.20000001E-02	3	2
ECSVE1AA-RFU-LF	0.34000000E-02	3	13
HPRE35AX-HTX-LFI	0.30000001E-03	3	21
HPRE35AX-HTX-LFB	0.30000001E-03	3	21
5232A-CBL-LF	0.11000000E-02	3	1
A305A-CBL-LF	0.11000000E-02	3	1

TABLE A-IV (Cont)

Basic Event	Median Unavailability	EF	CG
LPIOP34A-PMD-LF	0.10000000E-02	3	13
ECS5516A-BOO-LF	0.10000000E-02	3	11
ECSVE1BA-RFU-LF	0.34000000E-02	3	13
ECS6135B-BOO-CC	0.20000001E-02	3	2
ECS6135B-BOO-LF	0.10000000E-02	3	11
ECSC14AB-FAN-LF	0.53999998E-03	3	12
LOSS-OSP	0.10000000E-02	10	48
SWS3807B-VCC-LF	0.41000000E-02	3	8
SWS3806A-VCC-LF	0.41000000E-02	3	8
SWS6231B-BOO-CC	0.20000001E-02	3	2
SWS5231A-BOO-CC	0.20000001E-02	3	2
6231B-CBL-LF	0.11000000E-02	3	1
5231A-CBL-LF	0.11000000E-02	3	1
IED0D06B-BAT-LF	0.11000000E-02	3	17
IED0D07A-BAT-LF	0.11000000E-02	3	17
A-IEA-2	0.15000000E-02	3	33
A-IEA-1	0.15000000E-02	3	33
IEAP16BB-PMD	0.11000000E-02	3	13
IEAP16AA-PMD	0.11000000E-02	3	13
IEA0DG2B-GEN-LF	0.33000000E-01	10	23
IEA0DG1A-GEN-LF	0.33000000E-01	10	23
A406B-CBL-LF	0.11000000E-02	3	1
HPIA406B-BOO-CC	0.20000001E-02	3	2
SWS3810B-VCC-LF	0.41000000E-02	3	8
SWS6214B-BOO-CC	0.20000001E-02	3	2
6214B-CBL-LF	0.11000000E-02	3	1
R-110404-B-DH8B	0.80000004E-02	10	40
HPIP36CB-PMD-LF	0.10000000E-02	3	13
HPIA406B-BOO-LF	0.10000000E-02	3	11
SWS6214B-BOO-LF	0.10000000E-02	3	11
HPRS-CM	0.16000000E-02	10	51
HPI-PUMP-CM	0.17000000E-02	10	50
5646B-CBL-LF	0.72000003E-04	3	1
VUC7B-FAN-LF	0.53999998E-03	3	12
R-110404-A-DH8A	0.80000004E-02	10	40
SL-SUMP-CM	0.14000000E-03	10	49
A-ECS-2	0.42999999E-03	3	26
A-ECS-3	0.42999999E-03	3	26
ECS206BX-XOC-LF	0.99999997E-04	3	5
ECS206AX-XOC-LF	0.99999997E-04	3	5
A-SWS-11	0.16000000E-05	3	27
IEA00A4B-416-LF	0.72000003E-04	3	1
IEA00A3A-416-LF	0.72000003E-04	3	1
LPIOBW1X-XOC-LF	0.99999997E-04	3	5
R-HCP-037B-11	0.21000000E-03	10	41
IED0D02B-BCO-LF	0.24000001E-04	3	10
IED0D01A-BCO-LF	0.24000001E-04	3	10
R-HCP-VCH4B-2	0.18000000E-03	10	41

TABLE A-IV (Cont)

Basic Event	Median Unavailability	EF	CG
R-HCP-VCH4A-3	0.18000000E-03	10	41
A-ECS-11	0.16000000E-05	3	27
A-ECS-8	0.16000000E-05	3	27
A-ECS-15	0.73000001E-05	3	27
A-ECS-14	0.73000001E-05	3	27
ECS602BX-X0C-LF	0.99999997E-04	3	5
ECS600BX-X0C-LF	0.99999997E-04	3	5
ECS601BX-X0C-LF	0.99999997E-04	3	5
ECS200BX-X0C-LF	0.99999997E-04	3	5
ECS6036A-DPC-LF	0.41000000E-02	3	8
ECS6036A-BPC-LF	0.41000000E-02	3	8
ECS5254A-B-AASF	0.54000001E-02	10	4
ECS5254A-B00-CC	0.20000001E-02	3	2
ECS5254A-B00-LF	0.10000000E-02	3	11
5254A-CBL-LF	0.11000000E-02	3	1
ECS604BX-CCC-LF	0.99999997E-04	3	6
ECSCH4BA-CWU-LF	0.37000000E-02	3	13
ECSC45BX-X0C-LF	0.99999997E-04	3	5
ECSC44BX-X0C-LF	0.99999997E-04	3	5
ECSC41BX-X0C-LF	0.99999997E-04	3	5
ECS5246A-B00-CC	0.20000001E-02	3	2
ECS5246A-B00-LF	0.10000000E-02	3	11
5246A-CBL-LF	0.11000000E-02	3	1
ECSUC2BA-FAN-LF	0.53999998E-03	3	12
ECS602AX-X0C-LF	0.99999997E-04	3	5
ECS600AX-X0C-LF	0.99999997E-04	3	5
ECS601AX-X0C-LF	0.99999997E-04	3	5
ECS200AX-X0C-LF	0.99999997E-04	3	5
ECSC45DX-X0C-LF	0.99999997E-04	3	5
ECSC44DX-X0C-LF	0.99999997E-04	3	5
ECSC41DX-X0C-LF	0.99999997E-04	3	5
ECS6034B-DPC-LF	0.41000000E-02	3	8
ECS6034B-BPC-LF	0.41000000E-02	3	8
ECS6254B-B00-CC	0.20000001E-02	3	2
ECS6254B-B00-LF	0.10000000E-02	3	11
ECS6246B-B00-CC	0.20000001E-02	3	2
ECS6246B-B00-LF	0.10000000E-02	3	11
6254B-CBL-LF	0.11000000E-02	3	1
6246B-CBL-LF	0.11000000E-02	3	1
ECS6254B-B-AASF	0.54000001E-02	10	4
ECS604AX-CCC-LF	0.99999997E-04	3	6
ECSCH4AB-CWU-LF	0.37000000E-02	3	13
ECSC2DB-FAN-LF	0.53999998E-03	3	12
ECS5515A-B00-LF	0.10000000E-02	3	11
A-ESF-2	0.26000000E-04	3	31
A-ESF-1	0.52000000E-05	3	30
ESFPUC1A-CBL-LF	0.12000000E-04	3	1
ESFRA105-REC-LF	0.40000000E-05	10	16

TABLE A-IV (Cont)

Basic Event	Median Unavailability	EF	CG
ESFXA105-TFM-LF	0.40000000E-05	3	15
ESFRS102-BC0	0.40000000E-05	3	10
ESFRS102-CBL-LF	0.12000000E-04	3	1
A-SWS-14	0.16000000E-05	3	27
A-SWS-1	0.22000000E-03	3	26
A-SWS-3	0.22000000E-03	3	26
ESFU113-UCT-LF	0.99999997E-04	3	3
SWS3902X-X0C-LF	0.99999997E-04	3	5
SWS606BX-X0C-LF	0.99999997E-04	3	5
SWS3900X-X0C-LF	0.99999997E-04	3	5
SWS608BX-X0C-LF	0.99999997E-04	3	5
SWS3905X-X0C-LF	0.99999997E-04	3	5
SWS606AX-X0C-LF	0.99999997E-04	3	5
SWS3903X-X0C-LF	0.99999997E-04	3	5
SWS608AX-X0C-LF	0.99999997E-04	3	5
SWS3641B-V0C-LF	0.99999997E-04	3	9
SWS3643A-V00-LF	0.40000002E-02	3	8
SWS3820A-V00-LF	0.40000002E-02	3	8
SWS0402B-B00-CC	0.20000001E-02	3	2
SWS0402B-B00-LF	0.10000000E-02	3	11
SWS0303A-B00-CC	0.20000001E-02	3	2
SWS0303A-B00-LF	0.10000000E-02	3	11
SWS5653A-B00-CC	0.20000001E-02	3	2
SWS5653A-B00-LF	0.10000000E-02	3	11
SWS5181A-B00-CC	0.20000001E-02	3	2
SWS5181A-B00-LF	0.10000000E-02	3	11
0402-CBL-LF	0.72000003E-04	3	1
0303A-CBL-LF	0.72000003E-04	3	1
5653A-CBL-LF	0.33000000E-02	3	1
5181A-CBL-LF	0.33000000E-02	3	1
SWS0P4CB-PMD-LF	0.17000000E-02	3	13
SWS0P4BA-PMD-LF	0.17000000E-02	3	13
A-IED-6	0.29999999E-04	3	36
A-IED-2	0.29999999E-04	3	36
A-IED-3	0.80000000E-05	3	37
IED0D02B-125-LF	0.72000003E-04	3	1
IED0D21B-125-LF	0.72000003E-04	3	1
IED0D01A-125-LF	0.72000003E-04	3	1
IED0RS1A-120-LF	0.72000003E-04	3	1
IED0D11A-125-LF	0.72000003E-04	3	1
IED0D02B-CBL-LF	0.72000003E-04	3	1
IED0D01A-CBL-LF	0.72000003E-04	3	1
A-IEA-4	0.13000000E-03	3	34
A-IEA-11	0.40000000E-05	3	32
A-IEA-3	0.13000000E-03	3	34
A-IEA-7	0.40000000E-05	3	32
A-IEA-8	0.40000000E-05	3	32
IEA00B6B-480-LF	0.72000003E-04	3	1

TABLE A-IV (Cont)

Basic Event	Median Unavailability	EF	CG
IEA00B5A-480-LF	0.72000003E-04	3	1
IEA0B62B-480-LF	0.72000003E-04	3	1
IEA0B51A-480-LF	0.72000003E-04	3	1
IEA0B52A-480-LF	0.72000003E-04	3	1
IEA0B56S-480-LF	0.72000003E-04	3	1
IEA00X6B-TFM-LF	0.48000002E-04	3	15
IEA0401B-CBL-LF	0.72000003E-04	3	1
IEA00X5A-TFM-LF	0.48000002E-04	3	15
IEA0301A-CBL-LF	0.72000003E-04	3	1
IEA0622B-CBL-LF	0.72000003E-04	3	1
IEA0614B-CBL-LF	0.72000003E-04	3	1
IEA0521A-CBL-LF	0.72000003E-04	3	1
IEA0532A-CBL-LF	0.72000003E-04	3	1
IEA0401B-BCO-LF	0.24000001E-04	3	10
IEA0612B-BCO-LF	0.24000001E-04	3	10
IEA0622B-BCO-LF	0.24000001E-04	3	10
IEA0614B-BCO-LF	0.24000001E-04	3	10
IEA0301A-BCO-LF	0.24000001E-04	3	10
IEA0512A-BCO-LF	0.24000001E-04	3	10
IEA0521A-BCO-LF	0.24000001E-04	3	10
IEA0532A-BCO-LF	0.24000001E-04	3	10

TABLE A-V

EQUIVALENT BOOLEAN EXPRESSION FOR
LOW-PRESSURE INJECTION SYSTEM
(TRUNCATED AT 1.0E-6)

X = (LPA-CM + IEDD114A-B00 + D114A-CBL-LF + LPI1407A-VCC-LF + LPI1401A-VCC-LF + 5164A-CBL-LF + 51114-CBL-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + LP51114A-B00-CC + LP51114A-B00-LF + A-ECS-2 + SW1-CM + A-1104-04-1 + A305A-CBL-LF + LPI0P34A-PMD-LF + LPIA305A-B00-CC + LPIA305A-B00-LF + LPIE35AX-HTX-LFB + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + 5254A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + ECSUC2BA-FAN-LF + R-110404-B-38B + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWSRS17A-B00 + RS17A-CBL-LF + SWS3840A-NCC-CC + SWS3840A-NCC-LF + SWS0P4BA-PMD-LF) * (LPI1408B-VCC-LF + LPI1400B-VCC-LF) + (LPA-CM + IEDD114A-B00 + D114A-CBL-LF + LPI1407A-VCC-LF + LPI1401A-VCC-LF + 5164A-CBL-LF + 51114-CBL-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + LP51114A-B00-CC + LP51114A-B00-LF + A-ECS-2 + SW1-CM + A-1104-04-1 + A305A-CBL-LF + LPI0P34A-PMD-LF + LPIA305A-B00-CC + LPIA305A-B00-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + 5254A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + ECSUC2BA-FAN-LF + R-110404-B-38B + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF +

TABLE A-V (Cont)

5653A-CBL-LF + 5181A-CBL-LF + SWSRS17A-B00 + RS17A-CBL-LF + SWS3840A-NCC-CC + SWS3840A-NCC-LF + SWS0P4BA-PMD-LF) * (6161B-CBL-LF + SWS3841B-NCC-LF) + (LPA-CM + IEDD114A-B00 + D114A-CBL-LF + LPI1407A-VCC-LF + LPI1401A-VCC-LF + 5164A-CBL-LF + 51114-CBL-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + LP51114A-B00-CC + LP51114A-B00-LF + A-ECS-2 + SW1-CM + A-1104-04-1 + A305A-CBL-LF + LPI0P34A-PMD-LF + LPIA305A-B00-CC + LPIA305A-B00-LF + LPIE35AX-HTX-LFB + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + ECS5136A-B00-CC + ECS5136A-B00-LF + 5254A-CBL-LF + 5136A-CBL-LF + ECSCH4BA-CWU-LF + ECSC14DA-FAN-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + ECSUC2BA-FAN-LF + R-110404-B-38B + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWSRS17A-B00 + RS17A-CBL-LF + SWS3840A-NCC-CC + SWS3840A-NCC-LF + SWS0P4BA-PMD-LF) * (ECS6034B-DPC-LF + ECS6034B-BPC-LF + ECSCH4AB-CWU-LF) + (LPA-CM + IEDD114A-B00 + D114A-CBL-LF + LPI1407A-VCC-LF + LPI1401A-VCC-LF + 5164A-CBL-LF + 51114-CBL-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + LP51114A-B00-CC + LP51114A-B00-LF + SW1-CM + A-1104-04-1 + A305A-CBL-LF + LPI0P34A-PMD-LF + LPIA305A-B00-CC + LPIA305A-B00-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + ECS5136A-B00-CC + ECS5136A-B00-LF + 5254A-CBL-LF + 5136A-CBL-LF + ECSCH4BA-CWU-LF + ECSC14DA-FAN-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + ECSUC2BA-FAN-LF + R-110404-B-38B + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF +

TABLE A-V (Cont)

SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWSRS17A-B00 + RS17A-CBL-LF + SWS3840A-NCC-CC + SWS3840A-NCC-LF + SWS0P4BA-PMD-LF) * (ECS6254B-B00-CC + ECS6246B-B00-CC + SWS0402B-B00-CC) + (LPA-CM + IEDD114A-B00 + D114A-CBL-LF + LPI1407A-VCC-LF + LPI1401A-VCC-LF + 5164A-CBL-LF + 51114-CBL-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + LP51114A-B00-CC + LP51114A-B00-LF + SW1-CM + A-1104-04-1 + A305A-CBL-LF + LPI0P34A-PMD-LF + LPIA305A-B00-CC + LPIA305A-B00-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + ECS5136A-B00-CC + ECS5136A-B00-LF + 5254A-CBL-LF + 5136A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + R-110404-B-38B + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWSRS17A-B00 + RS17A-CBL-LF + SWS3840A-NCC-CC + SWS3840A-NCC-LF + SWS0P4BA-PMD-LF) * (6254B-CBL-LF + 6246B-CBL-LF + SWS0P4CB-PMD-LF) + (LPA-CM + D114A-CBL-LF + LPI1407A-VCC-LF + LPI1401A-VCC-LF + 5164A-CBL-LF + 51114-CBL-LF + LPI5164A-B00-CC + LP51114A-B00-CC + SW1-CM + A-1104-04-1 + A305A-CBL-LF + LPIA305A-B00-CC + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5136A-B00-CC + 5254A-CBL-LF + 5136A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + 5246A-CBL-LF + R-110404-B-38B + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS5653A-B00-CC + SWS5181A-B00-CC + 5653A-CBL-LF + 5181A-CBL-LF + SWSRS17A-B00 + RS17A-CBL-LF + SWS3840A-NCC-CC + SWS3840A-NCC-LF + SWS0P4BA-PMD-LF) * (ECS6254B-B00-LF + ECS6246B-B00-LF + SWS0402B-B00-LF) + (LPA-CM +

TABLE A-V (Cont)

IEDD114A-B00 + D114A-CBL-LF + LPI1407A-VCC-LF + LPI1401A-VCC-LF + 5164A-CBL-LF + 51114-CBL-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + LP51114A-B00-CC + LP51114A-B00-LF + SW1-CM + A-1104-04-1 + A305A-CBL-LF + LPI0P34A-PMD-LF + LPIA305A-B00-CC + LPIA305A-B00-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + 5254A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + ECSUC2BA-FAN-LF + R-110404-B-38B + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWSRS17A-B00 + RS17A-CBL-LF + SWS3840A-NCC-CC + SWS3840A-NCC-LF + SWS0P4BA-PMD-LF) * (LPI6164B-B00-CC + LPI6161B-B00-CC + LPIA405B-B00-CC + SWSRS27B-B00 + SWS3841B-NCC-CC) + (LPA-CM + D114A-CBL-LF + LPI1407A-VCC-LF + LPI1401A-VCC-LF + 5164A-CBL-LF + 51114-CBL-LF + LPI5164A-B00-CC + LP51114A-B00-CC + SW1-CM + A-1104-04-1 + A305A-CBL-LF + LPIA305A-B00-CC + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + 5254A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + 5246A-CBL-LF + R-110404-B-38B + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS5653A-B00-CC + SWS5181A-B00-CC + 5653A-CBL-LF + 5181A-CBL-LF + SWSRS17A-B00 + RS17A-CBL-LF + SWS3840A-NCC-CC + SWS3840A-NCC-LF + SWS0P4BA-PMD-LF) * (IEDD214B-B00 + LPI6164B-B00-LF + LPI6161B-B00-LF + LPI0P34B-PMD-LF + LPIA405B-B00-LF) + (LPA-CM + IEDD114A-B00 + D114A-CBL-LF + LPI1407A-VCC-LF + LPI1401A-VCC-LF + 5164A-CBL-LF + 51114-CBL-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + LP51114A-B00-CC + LP51114A-B00-LF + SW1-CM + A-1104-04-1 + A305A-CBL-LF + LPI0P34A-PMD-LF + LPIA305A-B00-CC

TABLE A-V (Cont)

+ LPIA305A-B00-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + 5254A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + R-110404-B-38B + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWSRS17A-B00 + RS17A-CBL-LF + SWS3840A-NCC-CC + SWS3840A-NCC-LF + SWS0P4BA-PMD-LF) * (D214B-CBL-LF + 6164B-CBL-LF + SW2-CM + A-1104-04-2 + A405B-CBL-LF + RS27B-CBL-LF) + ECS5254A-B-AASF * (A-LPI-4 + R-HCP-BW8B-5 + A-SWS-1) + R-110404-B-38B * (A-LPI-4 + R-HCP-BW8B-5 + R-HCP-VCH4A-3 + R-HCP-038A-10 + A-SWS-1 + A-IEA-4) + LPIE35BX-HTX-LFB * (LPI1407A-VCC-LF + LPI1401A-VCC-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECSCH4BA-CWU-LF + R-110404-B-38B + SWS3643A-V00-LF + SWS3820A-V00-LF) + A-ECS-3 * (LPI1407A-VCC-LF + LPI1401A-VCC-LF + 51114-CBL-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECSCH4BA-CWU-LF + R-110404-B-38B + SWS3643A-V00-LF + SWS3820A-V00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWS3840A-NCC-LF) + ECSC2DB-FAN-LF * (LPI1407A-VCC-LF + LPI1401A-VCC-LF + 51114-CBL-LF + LPI5164A-B00-CC + LP51114A-B00-CC + LPIA305A-B00-CC + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5136A-B00-CC + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + R-110404-B-38B + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS5653A-B00-CC + SWS5181A-B00-CC + 5653A-CBL-LF + 5181A-CBL-LF + SWSRS17A-B00 + SWS3840A-NCC-CC + SWS3840A-NCC-LF) + LPB-CM * (LPA-CM + R-110404-A-DH8A + IEDD114A-B00 + D114A-CBL-LF + LPI1407A-VCC-LF + LPI1401A-VCC-LF + 5164A-CBL-LF + 51114-CBL-LF + LPI5164A-B00-CC +

TABLE A-V (Cont)

LPI5164A-B00-LF + LP51114A-B00-CC + LP51114A-B00-LF + SW1-CM + A-1104-04-1 + A305A-CBL-LF + LPI0P34A-PMD-LF + LPIA305A-B00-CC + LPIA305A-B00-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + 5254A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + R-110404-B-38B + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWSRS17A-B00 + RS17A-CBL-LF + SWS3840A-NCC-CC + SWS3840A-NCC-LF + SWS0P4BA-PMD-LF) + R-1104-A-38A * (LPA-CM + A-LPI-11 + IEDD114A-B00 + D114A-CBL-LF + LPI1407A-VCC-LF + LPI1401A-VCC-LF + 5164A-CBL-LF + 51114-CBL-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + LP51114A-B00-CC + LP51114A-B00-LF + A-ECS-2 + SW1-CM + A-1104-04-1 + R-HCP-BW8A-12 + A305A-CBL-LF + LPI0P34A-PMD-LF + LPIA305A-B00-CC + LPIA305A-B00-LF + LPIE35AX-HTX-LFB + R-HCP-VCH4B-2 + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + 5254A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + ECSUC2BA-FAN-LF + R-110404-B-38B + R-HCP-038B-9 + A-SWS-3 + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWSRS17A-B00 + RS17A-CBL-LF + SWS3840A-NCC-CC + SWS3840A-NCC-LF + SWS0P4BA-PMD-LF + A-IEA-3) + ECS6254B-B-AASF * (LPA-CM + A-LPI-11 + IEDD114A-B00 + D114A-CBL-LF + LPI1407A-VCC-LF + LPI1401A-VCC-LF + 5164A-CBL-LF + 51114-CBL-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + LP51114A-B00-CC + LP51114A-B00-LF + A-ECS-2 + SW1-CM + A-1104-04-1 +

TABLE A-V (Cont)

R-HCP-BW8A-12 + A305A-CBL-LF + LPIOP34A-PMD-LF + LPIA305A-BOO-CC + LPIA305A-BOO-LF + LPIE35AX-HTX-LFB + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-BOO-CC + ECS5254A-BOO-LF + ECS5136A-BOO-CC + ECS5136A-BOO-LF + 5254A-CBL-LF + 5136A-CBL-LF + ECSCH4BA-CWU-LF + ECSC14DA-FAN-LF + ECS5246A-BOO-CC + ECS5246A-BOO-LF + 5246A-CBL-LF + ECSUC2BA-FAN-LF + R-110404-B-38B + A-SWS-3 + SWS3643A-VOO-LF + SWS3820A-VOO-LF + SWS0303A-BOO-CC + SWS0303A-BOO-LF + SWS5653A-BOO-CC + SWS5653A-BOO-LF + SWS5181A-BOO-CC + SWS5181A-BOO-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWSRS17A-BOO + RS17A-CBL-LF + SWS3840A-NCC-CC + SWS3840A-NCC-LF + SWSOP4BA-PMD-LF) + LPIOBW1X-XOC-LF + LPA-CM * R-110404-B-DH8B + IEAODG1A-GEN-LF * IEAODG2B-GEN-LF * LOSS-OSP

TABLE A-VI

DATA FOR QUANTIFICATION OF FAULT TREE Z7

Basic Event	Median Unavailability	EF	CG
LPA-CM	0.11000000E-02	10	39
IEDD114A-B00	0.10000000E-02	3	11
D114A-CBL-LF	0.11000000E-02	3	1
LPI1407A-VCC-LF	0.41000000E-02	3	8
LPI1401A-VCC-LF	0.41000000E-02	3	8
5164A-CBL-LF	0.11000000E-02	3	1
51114-CBL-LF	0.33000000E-02	3	1
LPI5164A-B00-CC	0.20000001E-02	3	2
LPI5164A-B00-LF	0.10000000E-02	3	11
LP51114A-B00-CC	0.20000001E-02	3	2
LP51114A-B00-LF	0.10000000E-02	3	11
A-ECS-2	0.42999999E-03	3	26
SW1-CM	0.11000000E-02	10	43
A-1104-04-1	0.11000000E-02	3	29
A305A-CBL-LF	0.11000000E-02	3	1
LPI0P34A-PMD-LF	0.10000000E-02	3	13
LPIA305A-B00-CC	0.20000001E-02	3	2
LPIA305A-B00-LF	0.10000000E-02	3	11
LPIE35AX-HTX-LFB	0.30000001E-03	3	21
ECS6036A-DPC-LF	0.41000000E-02	3	8
ECS6036A-BPC-LF	0.41000000E-02	3	8
ECS5254A-B-AASF	0.54000001E-02	10	4
ECS5254A-B00-CC	0.20000001E-02	3	2
ECS5254A-B00-LF	0.10000000E-02	3	11
5254A-CBL-LF	0.11000000E-02	3	1
ECSCH4BA-CWU-LF	0.37000000E-02	3	13
ECS5246A-B00-CC	0.20000001E-02	3	2
ECS5246A-B00-LF	0.10000000E-02	3	11
5246A-CBL-LF	0.11000000E-02	3	1
ECSUC2BA-FAN-LF	0.53999998E-03	3	12
R-110404-B-38B	0.80000004E-02	10	40
SWS3643A-V00-LF	0.40000002E-02	3	8
SWS3820A-V00-LF	0.40000002E-02	3	8
SWS0303A-B00-CC	0.20000001E-02	3	2
SWS0303A-B00-LF	0.10000000E-02	3	11
SWS5653A-B00-CC	0.20000001E-02	3	2
SWS5653A-B00-LF	0.10000000E-02	3	11
SWS5181A-B00-CC	0.20000001E-02	3	2
SWS5181A-B00-LF	0.10000000E-02	3	11
5653A-CBL-LF	0.33000000E-02	3	1
5181A-CBL-LF	0.33000000E-02	3	1
SWSRS17A-B00	0.20000001E-02	3	11
RS17A-CBL-LF	0.11000000E-02	3	1
SWS3840A-NCC-CC	0.20000001E-02	3	2
SWS3840A-NCC-LF	0.31000001E-02	3	47
SWS0P4BA-PMD-LF	0.17000000E-02	3	13

TABLE A-VI (Cont)

Basic Event	Median Unavailability	EF	CG
LPI1408B-VCC-LF	0.41000000E-02	3	8
LPI1400B-VCC-LF	0.41000000E-02	3	8
6161B-CBL-LF	0.33000000E-02	3	1
SWS3841B-NCC-LF	0.31000001E-02	3	47
ECS5136A-B00-CC	0.20000001E-02	3	2
ECS5136A-B00-LF	0.10000000E-02	3	11
5136A-CBL-LF	0.11000000E-02	3	1
ECSC14DA-FAN-LF	0.53999998E-03	3	12
ECS6034B-DPC-LF	0.41000000E-02	3	8
ECS6034B-BPC-LF	0.41000000E-02	3	8
ECSCH4AB-CWU-LF	0.37000000E-02	3	13
ECS6254B-B00-CC	0.20000001E-02	3	2
ECS6246B-B00-CC	0.20000001E-02	3	2
SWS0402B-B00-CC	0.20000001E-02	3	2
6254B-CBL-LF	0.11000000E-02	3	1
6246B-CBL-LF	0.11000000E-02	3	1
SWS0P4CB-PMD-LF	0.17000000E-02	3	13
ECS6254B-B00-LF	0.10000000E-02	3	11
ECS6246B-B00-LF	0.10000000E-02	3	11
SWS0402B-B00-LF	0.10000000E-02	3	11
LPI6164B-B00-CC	0.20000001E-02	3	2
LPI6161B-B00-CC	0.20000001E-02	3	2
LPIA405B-B00-CC	0.20000001E-02	3	2
SWSRS27B-B00	0.20000001E-02	3	11
SWS3841B-NCC-CC	0.20000001E-02	3	2
IEDD214B-B00	0.10000000E-02	3	11
LPI6164B-B00-LF	0.10000000E-02	3	11
LPI6161B-B00-LF	0.10000000E-02	3	11
LPI0P34B-PMD-LF	0.10000000E-02	3	13
LPIA405B-B00-LF	0.10000000E-02	3	11
D214B-CBL-LF	0.11000000E-02	3	1
6164B-CBL-LF	0.11000000E-02	3	1
SW2-CM	0.11000000E-02	10	43
A-1104-04-2	0.11000000E-02	3	29
A405B-CBL-LF	0.11000000E-02	3	1
RS27B-CBL-LF	0.11000000E-02	3	1
A-LPI-4	0.22000000E-03	3	26
R-HCP-BW8B-5	0.19000001E-03	10	41
A-SWS-1	0.22000000E-03	3	26
R-HCP-VCH4A-3	0.18000000E-03	10	41
R-HCP-038A-10	0.18000000E-03	10	41
A-IEA-4	0.13000000E-03	3	34
LPIE35BX-HTX-LFB	0.30000001E-03	3	21
A-ECS-3	0.42999999E-03	3	26
ECSC2DB-FAN-LF	0.53999998E-03	3	12
LPB-CM	0.11000000E-02	10	39
R-110404-A-DH8A	0.80000004E-02	10	40
R-1104-A-38A	0.80000004E-02	10	40

TABLE A-VI (Cont)

Basic Event	Median Unavailability	EF	CG
A-LPI-11	0.22000000E-03	3	26
R-HCP-BW8A-12	0.19000001E-03	10	41
R-HCP-VCH4B-2	0.18000000E-03	10	41
R-HCP-038B-9	0.18000000E-03	10	41
A-SWS-3	0.22000000E-03	3	26
A-IEA-3	0.13000000E-03	3	34
ECS6254B-B-AASF	0.54000001E-02	10	4
LPI0BW1X-X0C-LF	0.99999997E-04	3	5
R-110404-B-DH8B	0.80000004E-02	10	40
IEA0DG1A-GEN-LF	0.33000000E-01	10	23
IEA0DG2B-GEN-LF	0.33000000E-01	10	23
LOSS-0SP	0.10000000E-02	10	48

TABLE A-VII

EQUIVALENT BOOLEAN EXPRESSION FOR
LOW-PRESSURE RECIRCULATION SYSTEM
(TRUNCATED AT 1.0E-6)

X = (LPA-CM + IEDD114A-B00 + D114A-CBL-LF + FAN5132A-B00-LF + LPR1405A-VCC-LF + LPI1407A-VCC-LF + LPI1401A-VCC-LF + 51112A-CBL-LF + 5164A-CBL-LF + 51114-CBL-LF + LP51112A-B00-CC + LP51112A-B00-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + LP51114A-B00-CC + LP51114A-B00-LF + SW1-CM + A-1104-04-1 + SWS3803A-VCC-LF + SWS5232A-B00-CC + SWS5232A-B00-LF + 5232A-CBL-LF + A305A-CBL-LF + LPIOP34A-PMD-LF + LPIA305A-B00-CC + LPIA305A-B00-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + ECS5136A-B00-CC + ECS5136A-B00-LF + 5254A-CBL-LF + 5136A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + R-110404-B-38B + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWSRS17A-B00 + RS17A-CBL-LF + SWS3840A-NCC-CC + SWS3840A-NCC-LF + SWS0P4BA-PMD-LF) * (6254B-CBL-LF + 6246B-CBL-LF) + (LPI1407A-VCC-LF + LPI1401A-VCC-LF + 51112A-CBL-LF + 51114-CBL-LF + LP51112A-B00-CC + LPI5164A-B00-CC + LP51114A-B00-CC + SWS3803A-VCC-LF + SWS5232A-B00-CC + LPIA305A-B00-CC + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + R-110404-B-38B + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS5653A-B00-CC + SWS5181A-B00-CC + 5653A-CBL-LF + 5181A-CBL-LF + SWSRS17A-B00 + SWS3840A-NCC-CC + SWS3840A-NCC-LF) * (

TABLE A-VII (Cont)

6132B-CBL-LF + VUC1C-FAN-LF) + (LPI1407A-VCC-LF + LPI1401A-VCC-LF + SWS3803A-VCC-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECSCH4BA-CWU-LF + R-110404-B-38B + SWS3643A-V00-LF + SWS3820A-V00-LF) * (FAN6132B-B00-CC + LPIE35BX-HTX-LFB) + (LPA-CM + 5132A-CBL-LF + IEDD114A-B00 + D114A-CBL-LF + VUC1A-FAN-LF + FAN5132A-B00-CC + FAN5132A-B00-LF + LPR1405A-VCC-LF + LPI1407A-VCC-LF + LPI1401A-VCC-LF + 51112A-CBL-LF + 5164A-CBL-LF + 51114-CBL-LF + LPR0P34A-PMD-LF + LP51112A-B00-CC + LP51112A-B00-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + LP51114A-B00-CC + LP51114A-B00-LF + A-ECS-2 + SW1-CM + A-1104-04-1 + SWS3803A-VCC-LF + SWS5232A-B00-CC + SWS5232A-B00-LF + 5232A-CBL-LF + A305A-CBL-LF + LPI0P34A-PMD-LF + LPIA305A-B00-CC + LPIA305A-B00-LF + LPIE35AX-HTX-LFB + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + ECS5136A-B00-CC + ECS5136A-B00-LF + 5254A-CBL-LF + 5136A-CBL-LF + ECSCH4BA-CWU-LF + ECSC14DA-FAN-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + ECSUC2BA-FAN-LF + R-110404-B-38B + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWSRS17A-B00 + RS17A-CBL-LF + SWS3840A-NCC-CC + SWS3840A-NCC-LF + SWS0P4BA-PMD-LF) * (ECS6034B-DPC-LF + ECS6034B-BPC-LF + ECSCH4AB-CWU-LF) + (LPA-CM + 5132A-CBL-LF + IEDD114A-B00 + D114A-CBL-LF + VUC1A-FAN-LF + FAN5132A-B00-LF + LPR1405A-VCC-LF + LPI1407A-VCC-LF + LPI1401A-VCC-LF + 51112A-CBL-LF + 5164A-CBL-LF + 51114-CBL-LF + LPR0P34A-PMD-LF + LP51112A-B00-CC + LP51112A-B00-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + LP51114A-B00-CC + LP51114A-B00-LF + SW1-CM + A-1104-04-1 +

TABLE A-VII (Cont)

SWS3803A-VCC-LF + SWS5232A-B00-CC + SWS5232A-B00-LF + 5232A-CBL-LF + A305A-CBL-LF + LPI0P34A-PMD-LF + LPIA305A-B00-CC + LPIA305A-B00-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + ECS5136A-B00-CC + ECS5136A-B00-LF + 5254A-CBL-LF + 5136A-CBL-LF + ECSCH4BA-CWU-LF + ECSC14DA-FAN-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + ECSUC2BA-FAN-LF + R-110404-B-38B + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWSRS17A-B00 + RS17A-CBL-LF + SWS3840A-NCC-CC + SWS3840A-NCC-LF + SWS0P4BA-PMD-LF) * (ECS6254B-B00-CC + ECS6246B-B00-CC + SWS0402B-B00-CC) + (LPA-CM + 5132A-CBL-LF + IEDD114A-B00 + D114A-CBL-LF + VUC1A-FAN-LF + FAN5132A-B00-CC + FAN5132A-B00-LF + LPR1405A-VCC-LF + LPI1407A-VCC-LF + LPI1401A-VCC-LF + 51112A-CBL-LF + 5164A-CBL-LF + 51114-CBL-LF + LPR0P34A-PMD-LF + LP51112A-B00-CC + LP51112A-B00-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + LP51114A-B00-CC + LP51114A-B00-LF + A-ECS-2 + SW1-CM + A-1104-04-1 + SWS3803A-VCC-LF + SWS5232A-B00-CC + SWS5232A-B00-LF + 5232A-CBL-LF + A305A-CBL-LF + LPI0P34A-PMD-LF + LPIA305A-B00-CC + LPIA305A-B00-LF + LPIE35AX-HTX-LFB + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + 5254A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + ECSUC2BA-FAN-LF + R-110404-B-38B + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWSRS17A-B00 + RS17A-CBL-LF + SWS3840A-NCC-CC + SWS3840A-NCC-LF +

TABLE A-VII (Cont)

SWS0P4BA-PMD-LF) * (LPI1408B-VCC-LF + LPI1400B-VCC-LF + SWS3802B-VCC-LF) + (LPA-CM + 5132A-CBL-LF + IEDD114A-B00 + D114A-CBL-LF + VUC1A-FAN-LF + FAN5132A-B00-LF + LPR1405A-VCC-LF + LPI1407A-VCC-LF + LPI1401A-VCC-LF + 51112A-CBL-LF + 5164A-CBL-LF + 51114-CBL-LF + LPR0P34A-PMD-LF + LP51112A-B00-CC + LP51112A-B00-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + LP51114A-B00-CC + LP51114A-B00-LF + A-ECS-2 + SW1-CM + A-1104-04-1 + SWS3803A-VCC-LF + SWS5232A-B00-CC + SWS5232A-B00-LF + 5232A-CBL-LF + A305A-CBL-LF + LPI0P34A-PMD-LF + LPIA305A-B00-CC + LPIA305A-B00-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + 5254A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + ECSUC2BA-FAN-LF + R-110404-B-38B + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 6166B-CBL-LF + 6161B-CBL-LF + SWS3841B-NCC-LF) + (LPA-CM + D114A-CBL-LF + LPR1405A-VCC-LF + LPI1407A-VCC-LF + LPI1401A-VCC-LF + 51112A-CBL-LF + 5164A-CBL-LF + 51114-CBL-LF + LP51112A-B00-CC + LPI5164A-B00-CC + LP51114A-B00-CC + SW1-CM + A-1104-04-1 + SWS3803A-VCC-LF + SWS5232A-B00-CC + 5232A-CBL-LF + A305A-CBL-LF + LPIA305A-B00-CC + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5136A-B00-CC + 5254A-CBL-LF + 5136A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + 5246A-CBL-LF + R-110404-B-38B + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS5653A-B00-CC + SWS5181A-B00-CC + 5653A-CBL-LF + 5181A-CBL-LF + SWSRS17A-B00 + RS17A-CBL-LF + SWS3840A-NCC-CC + SWS3840A-NCC-LF + SWS0P4BA-PMD-LF) * (ECS6254B-B00-LF + ECS6246B-B00-LF +

TABLE A-VII (Cont)

SWS0402B-B00-LF) + (LPA-CM + 5132A-CBL-LF + IEDD114A-B00 + D114A-CBL-LF + VUC1A-FAN-LF + FAN5132A-B00-LF + LPR1405A-VCC-LF + LPI1407A-VCC-LF + LPI1401A-VCC-LF + 51112A-CBL-LF + 5164A-CBL-LF + 51114-CBL-LF + LPR0P34A-PMD-LF + LP51112A-B00-CC + LP51112A-B00-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + LP51114A-B00-CC + LP51114A-B00-LF + SW1-CM + A-1104-04-1 + SWS3803A-VCC-LF + SWS5232A-B00-CC + SWS5232A-B00-LF + 5232A-CBL-LF + A305A-CBL-LF + LPI0P34A-PMD-LF + LPIA305A-B00-CC + LPIA305A-B00-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + 5254A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + ECSUC2BA-FAN-LF + R-110404-B-38B + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWSRS17A-B00 + RS17A-CBL-LF + SWS3840A-NCC-CC + SWS3840A-NCC-LF + SWS0P4BA-PMD-LF) * (LPI6164B-B00-CC + LPI6161B-B00-CC + LPR6166B-B00-CC + SWS6232B-B00-CC + LPIA405B-B00-CC + SWSRS27B-B00 + SWS3841B-NCC-CC) + (LPA-CM + IEDD114A-B00 + D114A-CBL-LF + FAN5132A-B00-LF + LPR1405A-VCC-LF + LPI1407A-VCC-LF + LPI1401A-VCC-LF + 51112A-CBL-LF + 5164A-CBL-LF + 51114-CBL-LF + LP51112A-B00-CC + LP51112A-B00-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + LP51114A-B00-CC + LP51114A-B00-LF + SW1-CM + A-1104-04-1 + SWS3803A-VCC-LF + SWS5232A-B00-CC + SWS5232A-B00-LF + 5232A-CBL-LF + A305A-CBL-LF + LPI0P34A-PMD-LF + LPIA305A-B00-CC + LPIA305A-B00-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + 5254A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + ECS5246A-B00-LF +

TABLE A-VII (Cont)

5246A-CBL-LF + R-110404-B-38B + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWSRS17A-B00 + RS17A-CBL-LF + SWS3840A-NCC-CC + SWS3840A-NCC-LF + SWS0P4BA-PMD-LF) * (D214B-CBL-LF + LPR1406B-VCC-LF + 6164B-CBL-LF + SW2-CM + A-1104-04-2 + 6232B-CBL-LF + A405B-CBL-LF + RS27B-CBL-LF) + (LPA-CM + D114A-CBL-LF + LPR1405A-VCC-LF + LPI1407A-VCC-LF + LPI1401A-VCC-LF + 51112A-CBL-LF + 5164A-CBL-LF + 51114-CBL-LF + LP51112A-B00-CC + LPI5164A-B00-CC + LP51114A-B00-CC + SW1-CM + A-1104-04-1 + SWS3803A-VCC-LF + SWS5232A-B00-CC + 5232A-CBL-LF + A305A-CBL-LF + LPIA305A-B00-CC + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + 5254A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + 5246A-CBL-LF + R-110404-B-38B + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS5653A-B00-CC + SWS5181A-B00-CC + 5653A-CBL-LF + 5181A-CBL-LF + SWSRS17A-B00 + RS17A-CBL-LF + SWS3840A-NCC-CC + SWS3840A-NCC-LF + SWS0P4BA-PMD-LF) * (IEDD214B-B00 + FAN6132B-B00-LF + LPI6164B-B00-LF + LPI6161B-B00-LF + LPR6166B-B00-LF + SWS6232B-B00-LF + LPI0P34B-PMD-LF + LPIA405B-B00-LF) + ECS5254A-B-AASF * (A-LPI-4 + R-HCP-BW8B-5 + A-SWS-1) + R-110404-B-38B * (A-LPI-4 + R-HCP-BW8B-5 + R-HCP-VCH4A-3 + R-HCP-020C-S + R-HCP-038A-10 + A-SWS-1 + A-IEA-4) + A-ECS-3 * (LPI1407A-VCC-LF + LPI1401A-VCC-LF + 51112A-CBL-LF + 51114-CBL-LF + SWS3803A-VCC-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECSCH4BA-CWU-LF + R-110404-B-38B + SWS3643A-V00-LF + SWS3820A-V00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWS3840A-NCC-LF) + ECSC2DB-FAN-LF * (LPI1407A-VCC-LF +

TABLE A-VII (Cont)

LPI1401A-VCC-LF + 51112A-CBL-LF + 51114-CBL-LF + LP51112A-B00-CC + LPI5164A-B00-CC + LP51114A-B00-CC + SWS3803A-VCC-LF + SWS5232A-B00-CC + LPIA305A-B00-CC + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + SWS0303A-B00-CC + SWS5653A-B00-CC + SWS5181A-B00-CC + 5653A-CBL-LF + 5181A-CBL-LF + SWSRS17A-B00 + SWS3840A-NCC-CC + SWS3840A-NCC-LF) + LPR0P34B-PMD-LF * (LPI1407A-VCC-LF + LPI1401A-VCC-LF + 51112A-CBL-LF + 51114-CBL-LF + LP51112A-B00-CC + LPI5164A-B00-CC + LP51114A-B00-CC + SWS3803A-VCC-LF + SWS5232A-B00-CC + LPIA305A-B00-CC + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + R-110404-B-38B + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS5653A-B00-CC + SWS5181A-B00-CC + 5653A-CBL-LF + 5181A-CBL-LF + SWSRS17A-B00 + SWS3840A-NCC-CC + SWS3840A-NCC-LF + SWS0P4BA-PMD-LF) + LPB-CM * (LPA-CM + R-110404-A-DH8A + IEDD114A-B00 + D114A-CBL-LF + FAN5132A-B00-LF + LPR1405A-VCC-LF + LPI1407A-VCC-LF + LPI1401A-VCC-LF + 51112A-CBL-LF + 5164A-CBL-LF + 51114-CBL-LF + LP51112A-B00-CC + LP51112A-B00-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + LP51114A-B00-CC + LP51114A-B00-LF + SW1-CM + A-1104-04-1 + SWS3803A-VCC-LF + SWS5232A-B00-CC + SWS5232A-B00-LF + 5232A-CBL-LF + A305A-CBL-LF + LPI0P34A-PMD-LF + LPIA305A-B00-CC + LPIA305A-B00-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + 5254A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + R-110404-B-38B + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF +

TABLE A-VII (Cont)

SWSRS17A-B00 + RS17A-CBL-LF + SWS3840A-NCC-CC + SWS3840A-NCC-LF + SWS0P4BA-PMD-LF) + SWS0P4CB-PMD-LF * (LPA-CM + IEDD114A-B00 + D114A-CBL-LF + FAN5132A-B00-LF + LPR1405A-VCC-LF + LPI1407A-VCC-LF + LPI1401A-VCC-LF + 51112A-CBL-LF + 5164A-CBL-LF + 51114-CBL-LF + LPR0P34A-PMD-LF + LP51112A-B00-CC + LP51112A-B00-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + LP51114A-B00-CC + LP51114A-B00-LF + SW1-CM + A-1104-04-1 + SWS3803A-VCC-LF + SWS5232A-B00-CC + SWS5232A-B00-LF + 5232A-CBL-LF + A305A-CBL-LF + LPI0P34A-PMD-LF + LPIA305A-B00-CC + LPIA305A-B00-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + ECS5136A-B00-CC + ECS5136A-B00-LF + 5254A-CBL-LF + 5136A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + R-110404-B-38B + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWSRS17A-B00 + RS17A-CBL-LF + SWS3840A-NCC-CC + SWS3840A-NCC-LF + SWS0P4BA-PMD-LF) + R-1104-A-38A * (LPA-CM + A-LPI-11 + 5132A-CBL-LF + IEDD114A-B00 + D114A-CBL-LF + VUC1A-FAN-LF + FAN5132A-B00-CC + FAN5132A-B00-LF + LPR1405A-VCC-LF + LPI1407A-VCC-LF + LPI1401A-VCC-LF + 51112A-CBL-LF + 5164A-CBL-LF + 51114-CBL-LF + LPR0P34A-PMD-LF + LP51112A-B00-CC + LP51112A-B00-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + LP51114A-B00-CC + LP51114A-B00-LF + A-ECS-2 + SW1-CM + A-1104-04-1 + SWS3803A-VCC-LF + SWS5232A-B00-CC + SWS5232A-B00-LF + 5232A-CBL-LF + R-HCP-BW8A-12 + A305A-CBL-LF + LPI0P34A-PMD-LF + LPIA305A-B00-CC + LPIA305A-B00-LF + LPIE35AX-HTX-LFB + R-HCP-VCH4B-2 + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC +

TABLE A-VII (Cont)

ECS5254A-B00-LF + 5254A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + ECSUC2BA-FAN-LF + R-HCP-020A-S + R-110404-B-38B + R-HCP-038B-9 + A-SWS-3 + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWSRS17A-B00 + RS17A-CBL-LF + SWS3840A-NCC-CC + SWS3840A-NCC-LF + SWS0P4BA-PMD-LF + A-IEA-3) + ECS6254B-B-AASF * (LPA-CM + A-LPI-11 + 5132A-CBL-LF + IEDD114A-B00 + D114A-CBL-LF + VUC1A-FAN-LF + FAN5132A-B00-CC + FAN5132A-B00-LF + LPR1405A-VCC-LF + LPI1407A-VCC-LF + LPI1401A-VCC-LF + 51112A-CBL-LF + 5164A-CBL-LF + 51114-CBL-LF + LPR0P34A-PMD-LF + LP51112A-B00-CC + LP51112A-B00-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + LP51114A-B00-CC + LP51114A-B00-LF + A-ECS-2 + SW1-CM + A-1104-04-1 + SWS3803A-VCC-LF + SWS5232A-B00-CC + SWS5232A-B00-LF + 5232A-CBL-LF + R-HCP-BW8A-12 + A305A-CBL-LF + LPI0P34A-PMD-LF + LPIA305A-B00-CC + LPIA305A-B00-LF + LPIE35AX-HTX-LFB + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + ECS5136A-B00-CC + ECS5136A-B00-LF + 5254A-CBL-LF + 5136A-CBL-LF + ECSCH4BA-CWU-LF + ECSC14DA-FAN-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + ECSUC2BA-FAN-LF + R-110404-B-38B + A-SWS-3 + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWSRS17A-B00 + RS17A-CBL-LF + SWS3840A-NCC-CC + SWS3840A-NCC-LF + SWS0P4BA-PMD-LF) + LPI0BW1X-X0C-LF + LPA-CM * R-110404-B-DH8B + SL-SUMP-CM + IEA0DG1A-GEN-LF * IEA0DG2B-GEN-LF * LOSS-0SP

TABLE A-VIII

DATA FOR QUANTIFICATION OF FAULT TREE Z9

Basic Event	Median Unavailability	EF	CG
LPA-CM	0.11000000E-02	10	39
IEDD114A-B00	0.10000000E-02	3	11
D114A-CBL-LF	0.11000000E-02	3	1
FAN5132A-B00-LF	0.10000000E-02	3	11
LPR1405A-VCC-LF	0.11000000E-02	3	8
LPI1407A-VCC-LF	0.41000000E-02	3	8
LPI1401A-VCC-LF	0.41000000E-02	3	8
51112A-CBL-LF	0.33000000E-02	3	1
5164A-CBL-LF	0.11000000E-02	3	1
51114-CBL-LF	0.33000000E-02	3	1
LP51112A-B00-CC	0.20000001E-02	3	2
LP51112A-B00-LF	0.10000000E-02	3	11
LPI5164A-B00-CC	0.20000001E-02	3	2
LPI5164A-B00-LF	0.10000000E-02	3	11
LP51114A-B00-CC	0.20000001E-02	3	2
LP51114A-B00-LF	0.10000000E-02	3	11
SW1-CM	0.11000000E-02	10	43
A-1104-04-1	0.11000000E-02	3	29
SWS3803A-VCC-LF	0.41000000E-02	3	8
SWS5232A-B00-CC	0.20000001E-02	3	2
SWS5232A-B00-LF	0.10000000E-02	3	11
5232A-CBL-LF	0.11000000E-02	3	1
A305A-CBL-LF	0.11000000E-02	3	1
LPI0P34A-PMD-LF	0.10000000E-02	3	13
LPIA305A-B00-CC	0.20000001E-02	3	2
LPIA305A-B00-LF	0.10000000E-02	3	11
ECS6036A-DPC-LF	0.41000000E-02	3	8
ECS6036A-BPC-LF	0.41000000E-02	3	8
ECS5254A-B-AASF	0.54000001E-02	10	4
ECS5254A-B00-CC	0.20000001E-02	3	2
ECS5254A-B00-LF	0.10000000E-02	3	11
ECS5136A-B00-CC	0.20000001E-02	3	2
ECS5136A-B00-LF	0.10000000E-02	3	11
5254A-CBL-LF	0.11000000E-02	3	1
5136A-CBL-LF	0.11000000E-02	3	1
ECSCH4BA-CWU-LF	0.37000000E-02	3	13
ECS5246A-B00-CC	0.20000001E-02	3	2
ECS5246A-B00-LF	0.10000000E-02	3	11
5246A-CBL-LF	0.11000000E-02	3	1
R-110404-B-38B	0.80000004E-02	10	40
SWS3643A-V00-LF	0.40000002E-02	3	8
SWS3820A-V00-LF	0.40000002E-02	3	8
SWS0303A-B00-CC	0.20000001E-02	3	2
SWS0303A-B00-LF	0.10000000E-02	3	11
SWS5653A-B00-CC	0.20000001E-02	3	2
SWS5653A-B00-LF	0.10000000E-02	3	11

TABLE A-VIII (Cont)

Basic Event	Median Unavailability	EF	CG
SWS5181A-B00-CC	0.20000001E-02	3	2
SWS5181A-B00-LF	0.10000000E-02	3	11
5653A-CBL-LF	0.33000000E-02	3	1
5181A-CBL-LF	0.33000000E-02	3	1
SWSRS17A-B00	0.20000001E-02	3	11
RS17A-CBL-LF	0.11000000E-02	3	1
SWS3840A-NCC-CC	0.20000001E-02	3	2
SWS3840A-NCC-LF	0.31000001E-02	3	47
SWS0P4BA-PMD-LF	0.17000000E-02	3	13
6254B-CBL-LF	0.11000000E-02	3	1
6246B-CBL-LF	0.11000000E-02	3	1
6132B-CBL-LF	0.55000000E-03	3	1
VUC1C-FAN-LF	0.53999998E-03	3	12
FAN6132B-B00-CC	0.28000001E-03	3	2
LPIE35BX-HTX-LFB	0.30000001E-03	3	21
5132A-CBL-LF	0.55000000E-03	3	1
VUC1A-FAN-LF	0.53999998E-03	3	12
FAN5132A-B00-CC	0.28000001E-03	3	2
LPR0P34A-PMD-LF	0.72000001E-03	10	46
A-ECS-2	0.42999999E-03	3	26
LPIE35AX-HTX-LFB	0.30000001E-03	3	21
ECSC14DA-FAN-LF	0.53999998E-03	3	12
ECSUC2BA-FAN-LF	0.53999998E-03	3	12
ECS6034B-DPC-LF	0.41000000E-02	3	8
ECS6034B-BPC-LF	0.41000000E-02	3	8
ECSCH4AB-CWU-LF	0.37000000E-02	3	13
ECS6254B-B00-CC	0.20000001E-02	3	2
ECS6246B-B00-CC	0.20000001E-02	3	2
SWS0402B-B00-CC	0.20000001E-02	3	2
LPI1408B-VCC-LF	0.41000000E-02	3	8
LPI1400B-VCC-LF	0.41000000E-02	3	8
SWS3802B-VCC-LF	0.41000000E-02	3	8
6166B-CBL-LF	0.33000000E-02	3	1
6161B-CBL-LF	0.33000000E-02	3	1
SWS3841B-NCC-LF	0.31000001E-02	3	47
ECS6254B-B00-LF	0.10000000E-02	3	11
ECS6246B-B00-LF	0.10000000E-02	3	11
SWS0402B-B00-LF	0.10000000E-02	3	11
LPI6164B-B00-CC	0.20000001E-02	3	2
LPI6161B-B00-CC	0.20000001E-02	3	2
LPR6166B-B00-CC	0.20000001E-02	3	2
SWS6232B-B00-CC	0.20000001E-02	3	2
LPIA405B-B00-CC	0.20000001E-02	3	2
SWSRS27B-B00	0.20000001E-02	3	11
SWS3841B-NCC-CC	0.20000001E-02	3	2
D214B-CBL-LF	0.11000000E-02	3	1
LPR1406B-VCC-LF	0.11000000E-02	3	8
6164B-CBL-LF	0.11000000E-02	3	1

TABLE A-VIII (Cont)

Basic Event	Median Unavailability	EF	CG
SW2-CM	0.11000000E-02	10	43
A-1104-04-2	0.11000000E-02	3	29
6232B-CBL-LF	0.11000000E-02	3	1
A405B-CBL-LF	0.11000000E-02	3	1
RS27B-CBL-LF	0.11000000E-02	3	1
IEDD214B-B00	0.10000000E-02	3	11
FAN6132B-B00-LF	0.10000000E-02	3	11
LPI6164B-B00-LF	0.10000000E-02	3	11
LPI6161B-B00-LF	0.10000000E-02	3	11
LPR6166B-B00-LF	0.10000000E-02	3	11
SWS6232B-B00-LF	0.10000000E-02	3	11
LPI0P34B-PMD-LF	0.10000000E-02	3	13
LPIA405B-B00-LF	0.10000000E-02	3	11
A-LPI-4	0.22000000E-03	3	26
R-HCP-BW8B-5	0.19000001E-03	10	41
A-SWS-1	0.22000000E-03	3	26
R-HCP-VCH4A-3	0.18000000E-03	10	41
R-HCP-020C-S	0.18000000E-03	10	41
R-HCP-038A-10	0.18000000E-03	10	41
A-IEA-4	0.13000000E-03	3	34
A-ECS-3	0.42999999E-03	3	26
ECSC2DB-FAN-LF	0.53999998E-03	3	12
LPR0P34B-PMD-LF	0.72000001E-03	10	46
LPB-CM	0.11000000E-02	10	39
R-110404-A-DH8A	0.80000004E-02	10	40
SWS0P4CB-PMD-LF	0.17000000E-02	3	13
R-1104-A-38A	0.80000004E-02	10	40
A-LPI-11	0.22000000E-03	3	26
R-HCP-BW8A-12	0.19000001E-03	10	41
R-HCP-VCH4B-2	0.18000000E-03	10	41
R-HCP-020A-S	0.18000000E-03	10	41
R-HCP-038B-9	0.18000000E-03	10	41
A-SWS-3	0.22000000E-03	3	26
A-IEA-3	0.13000000E-03	3	34
ECS6254B-B-AASF	0.54000001E-02	10	4
LPI0BW1X-X0C-LF	0.99999997E-04	3	5
R-110404-B-DH8B	0.80000004E-02	10	40
SL-SUMP-CM	0.14000000E-03	10	49
IEA0DG1A-GEN-LF	0.33000000E-01	10	23
IEA0DG2B-GEN-LF	0.33000000E-01	10	23
LOSS-0SP	0.10000000E-02	10	48

TABLE A-IX

EQUIVALENT BOOLEAN EXPRESSION FOR
LOW-PRESSURE RECIRCULATION SYSTEM,
CONTAINMENT HEAT REMOVAL MODE
(TRUNCATED AT 1.0E-6)

X = (LPA-CM + A-LPI-11 + 5132A-CBL-LF + IEDD114A-B00 + D114A-CBL-LF +
VUC1A-FAN-LF + FAN5132A-B00-CC + FAN5132A-B00-LF + LPR1405A-VCC-LF +
LPI1407A-VCC-LF + LPI1401A-VCC-LF + 51112A-CBL-LF + 5164A-CBL-LF +
51114-CBL-LF + LPR0P34A-PMD-LF + LP51112A-B00-CC + LP51112A-B00-LF +
LPI5164A-B00-CC + LPI5164A-B00-LF + LP51114A-B00-CC + LP51114A-B00-LF +
A-ECS-2 + SW1-CM + A-1104-04-1 + SWS3803A-VCC-LF + SWS5232A-B00-CC +
SWS5232A-B00-LF + 5232A-CBL-LF + HPRE35AX-HTX-LFI + HPRE35AX-HTX-LFB +
R-HCP-BW8A-12 + A305A-CBL-LF + LPI0P34A-PMD-LF + LPIA305A-B00-CC +
LPIA305A-B00-LF + LPIE35AX-HTX-LFB + R-HCP-VCH4B-2 + ECS6036A-DPC-LF +
ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF +
5254A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + ECS5246A-B00-LF +
5246A-CBL-LF + ECSUC2BA-FAN-LF + R-HCP-020A-S + R-110404-A-22A +
R-HCP-022A-S + R-110404-B-38B + R-HCP-038B-9 + A-SWS-3 +
SWS3822A-VCC-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS5182A-B00-CC +
SWS5182A-B00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC +
SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5182A-CBL-LF +
5653A-CBL-LF + 5181A-CBL-LF + SWSRS17A-B00 + RS17A-CBL-LF +
SWS3840A-NCC-CC + SWS3840A-NCC-LF + SWS0P4BA-PMD-LF + A-IEA-3) * (
R-110404-B-22B + R-1104-A-38A) + (LPA-CM + IEDD114A-B00 +
D114A-CBL-LF + FAN5132A-B00-LF + LPR1405A-VCC-LF + LPI1407A-VCC-LF +
LPI1401A-VCC-LF + 51112A-CBL-LF + 5164A-CBL-LF + 51114-CBL-LF +

TABLE A-IX (Cont)

LP51112A-B00-CC + LP51112A-B00-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + LP51114A-B00-CC + LP51114A-B00-LF + SW1-CM + A-1104-04-1 + SWS3803A-VCC-LF + SWS5232A-B00-CC + SWS5232A-B00-LF + 5232A-CBL-LF + A305A-CBL-LF + LPI0P34A-PMD-LF + LPIA305A-B00-CC + LPIA305A-B00-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + ECS5136A-B00-CC + ECS5136A-B00-LF + 5254A-CBL-LF + 5136A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + R-110404-A-22A + R-110404-B-38B + SWS3822A-VCC-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS5182A-B00-CC + SWS5182A-B00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5182A-CBL-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWSRS17A-B00 + RS17A-CBL-LF + SWS3840A-NCC-CC + SWS3840A-NCC-LF + SWS0P4BA-PMD-LF) * (6254B-CBL-LF + 6246B-CBL-LF) + (LPI1407A-VCC-LF + LPI1401A-VCC-LF + 51112A-CBL-LF + 51114-CBL-LF + LP51112A-B00-CC + LPI5164A-B00-CC + LP51114A-B00-CC + SWS3803A-VCC-LF + SWS5232A-B00-CC + LPIA305A-B00-CC + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + R-110404-A-22A + R-110404-B-38B + SWS3822A-VCC-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS5182A-B00-CC + SWS0303A-B00-CC + SWS5653A-B00-CC + SWS5181A-B00-CC + 5182A-CBL-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWSRS17A-B00 + SWS3840A-NCC-CC + SWS3840A-NCC-LF) * (6132B-CBL-LF + VUC1C-FAN-LF) + (A-LPI-4 + R-HCP-BW8B-5 + R-HCP-VCH4A-3 + R-HCP-020C-S + R-HCP-038A-10 + A-SWS-1 + A-IEA-4) * (R-110404-A-22A + R-110404-B-38B) + (LPA-CM + 5132A-CBL-LF + IEDD114A-B00 + D114A-CBL-LF + VUC1A-FAN-LF + FAN5132A-B00-CC + FAN5132A-B00-LF +

TABLE A-IX (Cont)

LPR1405A-VCC-LF + LPI1407A-VCC-LF + LPI1401A-VCC-LF + 51112A-CBL-LF + 5164A-CBL-LF + 51114-CBL-LF + LPROP34A-PMD-LF + LP51112A-B00-CC + LP51112A-B00-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + LP51114A-B00-CC + LP51114A-B00-LF + A-ECS-2 + SW1-CM + A-1104-04-1 + SWS3803A-VCC-LF + SWS5232A-B00-CC + SWS5232A-B00-LF + 5232A-CBL-LF + HPRE35AX-HTX-LFI + HPRE35AX-HTX-LFB + A305A-CBL-LF + LPI0P34A-PMD-LF + LPIA305A-B00-CC + LPIA305A-B00-LF + LPIE35AX-HTX-LFB + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + ECS5136A-B00-CC + ECS5136A-B00-LF + 5254A-CBL-LF + 5136A-CBL-LF + ECSCH4BA-CWU-LF + ECSC14DA-FAN-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + ECSUC2BA-FAN-LF + R-110404-A-22A + R-110404-B-38B + SWS3822A-VCC-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS5182A-B00-CC + SWS5182A-B00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5182A-CBL-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWSRS17A-B00 + RS17A-CBL-LF + SWS3840A-NCC-CC + SWS3840A-NCC-LF + SWS0P4BA-PMD-LF) * (ECS6034B-DPC-LF + ECS6034B-BPC-LF + ECSCH4AB-CWU-LF) + (LPA-CM + 5132A-CBL-LF + IEDD114A-B00 + D114A-CBL-LF + VUC1A-FAN-LF + FAN5132A-B00-LF + LPR1405A-VCC-LF + LPI1407A-VCC-LF + LPI1401A-VCC-LF + 51112A-CBL-LF + 5164A-CBL-LF + 51114-CBL-LF + LPROP34A-PMD-LF + LP51112A-B00-CC + LP51112A-B00-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + LP51114A-B00-CC + LP51114A-B00-LF + SW1-CM + A-1104-04-1 + SWS3803A-VCC-LF + SWS5232A-B00-CC + SWS5232A-B00-LF + 5232A-CBL-LF + A305A-CBL-LF + LPI0P34A-PMD-LF + LPIA305A-B00-CC + LPIA305A-B00-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF +

TABLE A-IX (Cont)

ECS5136A-B00-CC + ECS5136A-B00-LF + 5254A-CBL-LF + 5136A-CBL-LF +
ECSCH4BA-CWU-LF + ECSC14DA-FAN-LF + ECS5246A-B00-CC + ECS5246A-B00-LF +
5246A-CBL-LF + ECSUC2BA-FAN-LF + R-110404-A-22A + R-110404-B-38B +
SWS3822A-VCC-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS5182A-B00-CC +
SWS5182A-B00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC +
SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5182A-CBL-LF +
5653A-CBL-LF + 5181A-CBL-LF + SWSRS17A-B00 + RS17A-CBL-LF +
SWS3840A-NCC-CC + SWS3840A-NCC-LF + SWS0P4BA-PMD-LF) * (
ECS6254B-B00-CC + ECS6246B-B00-CC + SWS0402B-B00-CC) + (LPA-CM +
D114A-CBL-LF + LPR1405A-VCC-LF + LPI1407A-VCC-LF + LPI1401A-VCC-LF +
51112A-CBL-LF + 5164A-CBL-LF + 51114-CBL-LF + LP51112A-B00-CC +
LPI5164A-B00-CC + LP51114A-B00-CC + SW1-CM + A-1104-04-1 +
SWS3803A-VCC-LF + SWS5232A-B00-CC + 5232A-CBL-LF + A305A-CBL-LF +
LPIA305A-B00-CC + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF +
ECS5254A-B00-CC + ECS5136A-B00-CC + 5254A-CBL-LF + 5136A-CBL-LF +
ECSCH4BA-CWU-LF + ECS5246A-B00-CC + 5246A-CBL-LF + R-110404-A-22A +
R-110404-B-38B + SWS3822A-VCC-LF + SWS3643A-V00-LF + SWS3820A-V00-LF +
SWS5182A-B00-CC + SWS0303A-B00-CC + SWS5653A-B00-CC + SWS5181A-B00-CC +
5182A-CBL-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWSRS17A-B00 +
RS17A-CBL-LF + SWS3840A-NCC-CC + SWS3840A-NCC-LF + SWS0P4BA-PMD-LF) *
(ECS6254B-B00-LF + ECS6246B-B00-LF + SWS0402B-B00-LF) + (LPA-CM +
5132A-CBL-LF + IEDD114A-B00 + D114A-CBL-LF + VUC1A-FAN-LF +
FAN5132A-B00-CC + FAN5132A-B00-LF + LPR1405A-VCC-LF + LPI1407A-VCC-LF +
LPI1401A-VCC-LF + 51112A-CBL-LF + 5164A-CBL-LF + 51114-CBL-LF +
LPR0P34A-PMD-LF + LP51112A-B00-CC + LP51112A-B00-LF + LPI5164A-B00-CC +

TABLE A-IX (Cont)

LPI5164A-B00-LF + LP51114A-B00-CC + LP51114A-B00-LF + A-ECS-2 + SW1-CM + A-1104-04-1 + SWS3803A-VCC-LF + SWS5232A-B00-CC + SWS5232A-B00-LF + 5232A-CBL-LF + HPRE35AX-HTX-LFI + HPRE35AX-HTX-LFB + A305A-CBL-LF + LPI0P34A-PMD-LF + LPIA305A-B00-CC + LPIA305A-B00-LF + LPIE35AX-HTX-LFB + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + 5254A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + ECSUC2BA-FAN-LF + R-110404-A-22A + R-110404-B-38B + SWS3822A-VCC-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS5182A-B00-CC + SWS5182A-B00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5182A-CBL-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWSRS17A-B00 + RS17A-CBL-LF + SWS3840A-NCC-CC + SWS3840A-NCC-LF + SWS0P4BA-PMD-LF) * (LPI1408B-VCC-LF + LPI1400B-VCC-LF + SWS3802B-VCC-LF + SWS3821B-VCC-LF) + (LPA-CM + 5132A-CBL-LF + IEDD114A-B00 + D114A-CBL-LF + VUC1A-FAN-LF + FAN5132A-B00-LF + LPR1405A-VCC-LF + LPI1407A-VCC-LF + LPI1401A-VCC-LF + 51112A-CBL-LF + 5164A-CBL-LF + 51114-CBL-LF + LPR0P34A-PMD-LF + LP51112A-B00-CC + LP51112A-B00-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + LP51114A-B00-CC + LP51114A-B00-LF + A-ECS-2 + SW1-CM + A-1104-04-1 + SWS3803A-VCC-LF + SWS5232A-B00-CC + SWS5232A-B00-LF + 5232A-CBL-LF + A305A-CBL-LF + LPI0P34A-PMD-LF + LPIA305A-B00-CC + LPIA305A-B00-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + 5254A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + ECSUC2BA-FAN-LF + R-110404-A-22A + R-110404-B-38B + SWS3822A-VCC-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS5182A-B00-CC + SWS5182A-B00-LF + SWS0303A-B00-CC +

TABLE A-IX (Cont)

SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5182A-CBL-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWSRS17A-B00 + RS17A-CBL-LF + SWS3840A-NCC-CC + SWS3840A-NCC-LF + SWS0P4BA-PMD-LF) * (6166B-CBL-LF + 6161B-CBL-LF + 6183B-CBL-LF + SWS3841B-NCC-LF) + (LPI1407A-VCC-LF + LPI1401A-VCC-LF + SWS3803A-VCC-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECSCH4BA-CWU-LF + R-110404-A-22A + R-110404-B-38B + SWS3822A-VCC-LF + SWS3643A-V00-LF + SWS3820A-V00-LF) * (FAN6132B-B00-CC + HPRE35BX-HTX-LFI + HPRE35BX-HTX-LFB + LPIE35BX-HTX-LFB) + (LPA-CM + 5132A-CBL-LF + IEDD114A-B00 + D114A-CBL-LF + VUC1A-FAN-LF + FAN5132A-B00-LF + LPR1405A-VCC-LF + LPI1407A-VCC-LF + LPI1401A-VCC-LF + 51112A-CBL-LF + 5164A-CBL-LF + 51114-CBL-LF + LPR0P34A-PMD-LF + LP51112A-B00-CC + LP51112A-B00-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + LP51114A-B00-CC + LP51114A-B00-LF + SW1-CM + A-1104-04-1 + SWS3803A-VCC-LF + SWS5232A-B00-CC + SWS5232A-B00-LF + 5232A-CBL-LF + A305A-CBL-LF + LPI0P34A-PMD-LF + LPIA305A-B00-CC + LPIA305A-B00-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + 5254A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + ECSUC2BA-FAN-LF + R-110404-A-22A + R-110404-B-38B + SWS3822A-VCC-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS5182A-B00-CC + SWS5182A-B00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5182A-CBL-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWSRS17A-B00 + RS17A-CBL-LF + SWS3840A-NCC-CC + SWS3840A-NCC-LF + SWS0P4BA-PMD-LF) * (LPI6164B-B00-CC + LPI6161B-B00-CC + LPR6166B-B00-CC + SWS6232B-B00-CC

TABLE A-IX (Cont)

+ LPIA405B-B00-CC + SWS6183B-B00-CC + SWSRS27B-B00 + SWS3841B-NCC-CC)
+ (LPA-CM + IEDD114A-B00 + D114A-CBL-LF + FAN5132A-B00-LF +
LPR1405A-VCC-LF + LPI1407A-VCC-LF + LPI1401A-VCC-LF + 51112A-CBL-LF +
5164A-CBL-LF + 51114-CBL-LF + LP51112A-B00-CC + LP51112A-B00-LF +
LPI5164A-B00-CC + LPI5164A-B00-LF + LP51114A-B00-CC + LP51114A-B00-LF +
SW1-CM + A-1104-04-1 + SWS3803A-VCC-LF + SWS5232A-B00-CC +
SWS5232A-B00-LF + 5232A-CBL-LF + A305A-CBL-LF + LPIOP34A-PMD-LF +
LPIA305A-B00-CC + LPIA305A-B00-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF +
ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + 5254A-CBL-LF +
ECSCH4BA-CWU-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF +
R-110404-A-22A + R-110404-B-38B + SWS3822A-VCC-LF + SWS3643A-V00-LF +
SWS3820A-V00-LF + SWS5182A-B00-CC + SWS5182A-B00-LF + SWS0303A-B00-CC +
SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC +
SWS5181A-B00-LF + 5182A-CBL-LF + 5653A-CBL-LF + 5181A-CBL-LF +
SWSRS17A-B00 + RS17A-CBL-LF + SWS3840A-NCC-CC + SWS3840A-NCC-LF +
SWS0P4BA-PMD-LF) * (D214B-CBL-LF + LPR1406B-VCC-LF + 6164B-CBL-LF +
SW2-CM + A-1104-04-2 + 6232B-CBL-LF + A405B-CBL-LF + RS27B-CBL-LF) + (
LPA-CM + D114A-CBL-LF + LPR1405A-VCC-LF + LPI1407A-VCC-LF +
LPI1401A-VCC-LF + 51112A-CBL-LF + 5164A-CBL-LF + 51114-CBL-LF +
LP51112A-B00-CC + LPI5164A-B00-CC + LP51114A-B00-CC + SW1-CM +
A-1104-04-1 + SWS3803A-VCC-LF + SWS5232A-B00-CC + 5232A-CBL-LF +
A305A-CBL-LF + LPIA305A-B00-CC + ECS6036A-DPC-LF + ECS6036A-BPC-LF +
ECS5254A-B-AASF + ECS5254A-B00-CC + 5254A-CBL-LF + ECSCH4BA-CWU-LF +
ECS5246A-B00-CC + 5246A-CBL-LF + R-110404-A-22A + R-110404-B-38B +
SWS3822A-VCC-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS5182A-B00-CC +

TABLE A-IX (Cont)

SWS0303A-B00-CC + SWS5653A-B00-CC + SWS5181A-B00-CC + 5182A-CBL-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWSRS17A-B00 + RS17A-CBL-LF + SWS3840A-NCC-CC + SWS3840A-NCC-LF + SWS0P4BA-PMD-LF) * (IEDD214B-B00 + FAN6132B-B00-LF + LPI6164B-B00-LF + LPI6161B-B00-LF + LPR6166B-B00-LF + SWS6232B-B00-LF + LPI0P34B-PMD-LF + LPIA405B-B00-LF + SWS6183B-B00-LF) + ECS5254A-B-AASF * (A-LPI-4 + R-HCP-BW8B-5 + A-SWS-1) + A-ECS-3 * (LPI1407A-VCC-LF + LPI1401A-VCC-LF + 51112A-CBL-LF + 51114-CBL-LF + SWS3803A-VCC-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECSCH4BA-CWU-LF + R-110404-A-22A + R-110404-B-38B + SWS3822A-VCC-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + 5182A-CBL-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWS3840A-NCC-LF) + ECSC2DB-FAN-LF * (LPI1407A-VCC-LF + LPI1401A-VCC-LF + 51112A-CBL-LF + 51114-CBL-LF + LP51112A-B00-CC + LPI5164A-B00-CC + LP51114A-B00-CC + SWS3803A-VCC-LF + SWS5232A-B00-CC + LPIA305A-B00-CC + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5136A-B00-CC + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + R-110404-A-22A + R-110404-B-38B + SWS3822A-VCC-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS5182A-B00-CC + SWS0303A-B00-CC + SWS5653A-B00-CC + SWS5181A-B00-CC + 5182A-CBL-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWSRS17A-B00 + SWS3840A-NCC-CC + SWS3840A-NCC-LF) + LPR0P34B-PMD-LF * (LPI1407A-VCC-LF + LPI1401A-VCC-LF + 51112A-CBL-LF + 51114-CBL-LF + LP51112A-B00-CC + LPI5164A-B00-CC + LP51114A-B00-CC + SWS3803A-VCC-LF + SWS5232A-B00-CC + LPIA305A-B00-CC + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + R-110404-A-22A + R-110404-B-38B + SWS3822A-VCC-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS5182A-B00-CC + SWS0303A-B00-CC + SWS5653A-B00-CC +

TABLE A-IX (Cont)

SWS5181A-B00-CC + 5182A-CBL-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWSRS17A-B00 + SWS3840A-NCC-CC + SWS3840A-NCC-LF + SWS0P4BA-PMD-LF) + R-HCP-022B-S * (LPA-CM + IEDD114A-B00 + D114A-CBL-LF + FAN5132A-B00-LF + LPR1405A-VCC-LF + LPI1407A-VCC-LF + LPI1401A-VCC-LF + 51112A-CBL-LF + 5164A-CBL-LF + 51114-CBL-LF + LPR0P34A-PMD-LF + LP51112A-B00-CC + LP51112A-B00-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + LP51114A-B00-CC + LP51114A-B00-LF + SW1-CM + A-1104-04-1 + SWS3803A-VCC-LF + SWS5232A-B00-CC + SWS5232A-B00-LF + 5232A-CBL-LF + A305A-CBL-LF + LPI0P34A-PMD-LF + LPIA305A-B00-CC + LPIA305A-B00-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + 5254A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + R-110404-A-22A + R-110404-B-38B + SWS3822A-VCC-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS5182A-B00-CC + SWS5182A-B00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5182A-CBL-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWSRS17A-B00 + RS17A-CBL-LF + SWS3840A-NCC-CC + SWS3840A-NCC-LF + SWS0P4BA-PMD-LF) + LPB-CM * (LPA-CM + R-110404-A-DH8A + IEDD114A-B00 + D114A-CBL-LF + FAN5132A-B00-LF + LPR1405A-VCC-LF + LPI1407A-VCC-LF + LPI1401A-VCC-LF + 51112A-CBL-LF + 5164A-CBL-LF + 51114-CBL-LF + LP51112A-B00-CC + LP51112A-B00-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + LP51114A-B00-CC + LP51114A-B00-LF + SW1-CM + A-1104-04-1 + SWS3803A-VCC-LF + SWS5232A-B00-CC + SWS5232A-B00-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + 5254A-CBL-LF + ECSCH4BA-CWU-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS5182A-B00-CC + SWS5182A-B00-LF + SWS0303A-B00-CC +

TABLE A-IX (Cont)

SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5182A-CBL-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWSRS17A-B00 + RS17A-CBL-LF + SWS3840A-NCC-CC + SWS3840A-NCC-LF + SWS0P4BA-PMD-LF) + SWS0P4CB-PMD-LF * (LPA-CM + IEDD114A-B00 + D114A-CBL-LF + FAN5132A-B00-LF + LPR1405A-VCC-LF + LPI1407A-VCC-LF + LPI1401A-VCC-LF + 51112A-CBL-LF + 5164A-CBL-LF + 51114-CBL-LF + LPR0P34A-PMD-LF + LP51112A-B00-CC + LP51112A-B00-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + LP51114A-B00-CC + LP51114A-B00-LF + SW1-CM + A-1104-04-1 + SWS3803A-VCC-LF + SWS5232A-B00-CC + SWS5232A-B00-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + ECS5136A-B00-CC + ECS5136A-B00-LF + 5254A-CBL-LF + 5136A-CBL-LF + ECSCH4BA-CWU-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS5182A-B00-CC + SWS5182A-B00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5182A-CBL-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWSRS17A-B00 + RS17A-CBL-LF + SWS3840A-NCC-CC + SWS3840A-NCC-LF + SWS0P4BA-PMD-LF) + ECS6254B-B-AASF * (LPA-CM + A-LPI-11 + 5132A-CBL-LF + IEDD114A-B00 + D114A-CBL-LF + VUC1A-FAN-LF + FAN5132A-B00-CC + FAN5132A-B00-LF + LPR1405A-VCC-LF + LPI1407A-VCC-LF + LPI1401A-VCC-LF + 51112A-CBL-LF + 5164A-CBL-LF + 51114-CBL-LF + LPR0P34A-PMD-LF + LP51112A-B00-CC + LP51112A-B00-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + LP51114A-B00-CC + LP51114A-B00-LF + A-ECS-2 + SW1-CM + A-1104-04-1 + SWS3803A-VCC-LF + SWS5232A-B00-CC + SWS5232A-B00-LF + 5232A-CBL-LF + HPRE35AX-HTX-LFI + HPRE35AX-HTX-LFB + R-HCP-BW8A-12 + A305A-CBL-LF + LPI0P34A-PMD-LF + LPIA305A-B00-CC + LPIA305A-B00-LF + LPIE35AX-HTX-LFB + ECS6036A-DPC-LF + ECS6036A-BPC-LF

TABLE A-IX (Cont)

+ ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + ECS5136A-B00-CC + ECS5136A-B00-LF + 5254A-CBL-LF + 5136A-CBL-LF + ECSCH4BA-CWU-LF + ECSC14DA-FAN-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + ECSUC2BA-FAN-LF + R-110404-A-22A + R-110404-B-38B + A-SWS-3 + SWS3822A-VCC-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS5182A-B00-CC + SWS5182A-B00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5182A-CBL-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWSRS17A-B00 + RS17A-CBL-LF + SWS3840A-NCC-CC + SWS3840A-NCC-LF + SWS0P4BA-PMD-LF) + LPA-CM * R-110404-B-DH8B + SL-SUMP-CM + IEA0DG1A-GEN-LF * IEA0DG2B-GEN-LF * LOSS-OSP + LPI0BW1X-X0C-LF

TABLE A-X

DATA FOR QUANTIFICATION OF FAULT TREE Z8

Basic Event	Median Unavailability	EF	CG
LPA-CM	0.11000000E-02	10	39
A-LPI-11	0.22000000E-03	3	26
5132A-CBL-LF	0.55000000E-03	3	1
IEDD114A-B00	0.10000000E-02	3	11
D114A-CBL-LF	0.11000000E-02	3	1
VUC1A-FAN-LF	0.53999998E-03	3	12
FAN5132A-B00-CC	0.28000001E-03	3	2
FAN5132A-B00-LF	0.10000000E-02	3	11
LPR1405A-VCC-LF	0.11000000E-02	3	8
LPI1407A-VCC-LF	0.41000000E-02	3	8
LPI1401A-VCC-LF	0.41000000E-02	3	8
51112A-CBL-LF	0.33000000E-02	3	1
5164A-CBL-LF	0.11000000E-02	3	1
51114-CBL-LF	0.33000000E-02	3	1
LPR0P34A-PMD-LF	0.72000001E-03	10	46
LP51112A-B00-CC	0.20000001E-02	3	2
LP51112A-B00-LF	0.10000000E-02	3	11
LPI5164A-B00-CC	0.20000001E-02	3	2
LPI5164A-B00-LF	0.10000000E-02	3	11
LP51114A-B00-CC	0.20000001E-02	3	2
LP51114A-B00-LF	0.10000000E-02	3	11
A-ECS-2	0.42999999E-03	3	26
SW1-CM	0.11000000E-02	10	43
A-1104-04-1	0.11000000E-02	3	29
SWS3803A-VCC-LF	0.41000000E-02	3	8
SWS5232A-B00-CC	0.20000001E-02	3	2
SWS5232A-B00-LF	0.10000000E-02	3	11
5232A-CBL-LF	0.11000000E-02	3	1
HPRE35AX-HTX-LFI	0.30000001E-03	3	21
HPRE35AX-HTX-LFB	0.30000001E-03	3	21
R-HCP-BW8A-12	0.19000001E-03	10	41
A305A-CBL-LF	0.11000000E-02	3	1
LPI0P34A-PMD-LF	0.10000000E-02	3	13
LPIA305A-B00-CC	0.20000001E-02	3	2
LPIA305A-B00-LF	0.10000000E-02	3	11
LPIE35AX-HTX-LFB	0.30000001E-03	3	21
R-HCP-VCH4B-2	0.18000000E-03	10	41
ECS6036A-DPC-LF	0.41000000E-02	3	8
ECS6036A-BPC-LF	0.41000000E-02	3	8
ECS5254A-B-AASF	0.54000001E-02	10	4
ECS5254A-B00-CC	0.20000001E-02	3	2
ECS5254A-B00-LF	0.10000000E-02	3	11
5254A-CBL-LF	0.11000000E-02	3	1
ECSCH4BA-CWU-LF	0.37000000E-02	3	13
ECS5246A-B00-CC	0.20000001E-02	3	2
ECS5246A-B00-LF	0.10000000E-02	3	11

TABLE A-X (Cont)

Basic Event	Median Unavailability	EF	CG
5246A-CBL-LF	0.11000000E-02	3	1
ECSUC2BA-FAN-LF	0.53999998E-03	3	12
R-HCP-020A-S	0.18000000E-03	10	41
R-110404-A-22A	0.80000004E-02	10	40
R-HCP-022A-S	0.18000000E-03	10	41
R-110404-B-38B	0.80000004E-02	10	40
R-HCP-038B-9	0.18000000E-03	10	41
A-SWS-3	0.22000000E-03	3	26
SWS3822A-VCC-LF	0.41000000E-02	3	8
SWS3643A-V00-LF	0.40000002E-02	3	8
SWS3820A-V00-LF	0.40000002E-02	3	8
SWS5182A-B00-CC	0.20000001E-02	3	2
SWS5182A-B00-LF	0.10000000E-02	3	11
SWS0303A-B00-CC	0.20000001E-02	3	2
SWS0303A-B00-LF	0.10000000E-02	3	11
SWS5653A-B00-CC	0.20000001E-02	3	2
SWS5653A-B00-LF	0.10000000E-02	3	11
SWS5181A-B00-CC	0.20000001E-02	3	2
SWS5181A-B00-LF	0.10000000E-02	3	11
5182A-CBL-LF	0.33000000E-02	3	1
5653A-CBL-LF	0.33000000E-02	3	1
5181A-CBL-LF	0.33000000E-02	3	1
SWSRS17A-B00	0.20000001E-02	3	11
RS17A-CBL-LF	0.11000000E-02	3	1
SWS3840A-NCC-CC	0.20000001E-02	3	2
SWS3840A-NCC-LF	0.31000001E-02	3	47
SWS0P4BA-PMD-LF	0.17000000E-02	3	13
A-IEA-3	0.13000000E-03	3	34
R-110404-B-22B	0.80000004E-02	10	40
R-1104-A-38A	0.80000004E-02	10	40
ECS5136A-B00-CC	0.20000001E-02	3	2
ECS5136A-B00-LF	0.10000000E-02	3	11
5136A-CBL-LF	0.11000000E-02	3	1
6254B-CBL-LF	0.11000000E-02	3	1
6246B-CBL-LF	0.11000000E-02	3	1
6132B-CBL-LF	0.55000000E-03	3	1
VUC1C-FAN-LF	0.53999998E-03	3	12
A-LPI-4	0.22000000E-03	3	26
R-HCP-BW8B-5	0.19000001E-03	10	41
R-HCP-VCH4A-3	0.18000000E-03	10	41
R-HCP-020C-S	0.18000000E-03	10	41
R-HCP-038A-10	0.18000000E-03	10	41
A-SWS-1	0.22000000E-03	3	26
A-IEA-4	0.13000000E-03	3	34
ECSC14DA-FAN-LF	0.53999998E-03	3	12
ECS6034B-DPC-LF	0.41000000E-02	3	8
ECS6034B-BPC-LF	0.41000000E-02	3	8
ECSCH4AB-CWU-LF	0.37000000E-02	3	13

TABLE A-X (Cont)

Basic Event	Median Unavailability	EF	CG
ECS6254B-B00-CC	0.20000001E-02	3	2
ECS6246B-B00-CC	0.20000001E-02	3	2
SWS0402B-B00-CC	0.20000001E-02	3	2
ECS6254B-B00-LF	0.10000000E-02	3	11
ECS6246B-B00-LF	0.10000000E-02	3	11
SWS0402B-B00-LF	0.10000000E-02	3	11
LPI1408B-VCC-LF	0.41000000E-02	3	8
LPI1400B-VCC-LF	0.41000000E-02	3	8
SWS3802B-VCC-LF	0.41000000E-02	3	8
SWS3821B-VCC-LF	0.41000000E-02	3	8
6166B-CBL-LF	0.33000000E-02	3	1
6161B-CBL-LF	0.33000000E-02	3	1
6183B-CBL-LF	0.33000000E-02	3	1
SWS3841B-NCC-LF	0.31000001E-02	3	47
FAN6132B-B00-CC	0.28000001E-03	3	2
HPRE35BX-HTX-LFI	0.30000001E-03	3	21
HPRE35BX-HTX-LFB	0.30000001E-03	3	21
LPIE35BX-HTX-LFB	0.30000001E-03	3	21
LPI6164B-B00-CC	0.20000001E-02	3	2
LPI6161B-B00-CC	0.20000001E-02	3	2
LPR6166B-B00-CC	0.20000001E-02	3	2
SWS6232B-B00-CC	0.20000001E-02	3	2
LPIA405B-B00-CC	0.20000001E-02	3	2
SWS6183B-B00-CC	0.20000001E-02	3	2
SWSRS27B-B00	0.20000001E-02	3	11
SWS3841B-NCC-CC	0.20000001E-02	3	2
D214B-CBL-LF	0.11000000E-02	3	1
LPR1406B-VCC-LF	0.11000000E-02	3	8
6164B-CBL-LF	0.11000000E-02	3	1
SW2-CM	0.11000000E-02	10	43
A-1104-04-2	0.11000000E-02	3	29
6232B-CBL-LF	0.11000000E-02	3	1
A405B-CBL-LF	0.11000000E-02	3	1
RS27B-CBL-LF	0.11000000E-02	3	1
IEDD214B-B00	0.10000000E-02	3	11
FAN6132B-B00-LF	0.10000000E-02	3	11
LPI6164B-B00-LF	0.10000000E-02	3	11
LPI6161B-B00-LF	0.10000000E-02	3	11
LPR6166B-B00-LF	0.10000000E-02	3	11
SWS6232B-B00-LF	0.10000000E-02	3	11
LPIOP34B-PMD-LF	0.10000000E-02	3	13
LPIA405B-B00-LF	0.10000000E-02	3	11
SWS6183B-B00-LF	0.10000000E-02	3	11
A-ECS-3	0.42999999E-03	3	26
ECSC2DB-FAN-LF	0.53999998E-03	3	12
LPROP34B-PMD-LF	0.72000001E-03	10	46
R-HCP-022B-S	0.18000000E-02	10	41
LPB-CM	0.11000000E-02	10	39

TABLE A-X (Cont)

Basic Event	Median Unavailability	EF	CG
R-110404-A-DH8A	0.80000004E-02	10	40
SWS0P4CB-PMD-LF	0.17000000E-02	3	13
ECS6254B-B-AASF	0.54000001E-02	10	4
R-110404-B-DH8B	0.80000004E-02	10	40
SL-SUMP-CM	0.14000000E-03	10	49
IEA0DG1A-GEN-LF	0.33000000E-01	10	23
IEA0DG2B-GEN-LF	0.33000000E-01	10	23
LOSS-OSP	0.10000000E-02	10	48
LPI0BW1X-X0C-LF	0.99999997E-04	3	5

TABLE A-XI

EQUIVALENT BOOLEAN EXPRESSION FOR
REACTOR BUILDING SPRAY INJECTION SYSTEM
(TRUNCATED AT 1.0E-6)

X = (RBI0035A-PMD-LF + RBI5171A-B00-CC + RBI5171A-B00-LF +
0304X-CBL-LF + 5151X-CBL-LF + RBI2401A-VCC-LF + LPI1407A-VCC-LF +
5164A-CBL-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + A-ECS-2 +
A-1104-05-1 + SWS1B32A-B00 + 1B32A-CBL-LF + SWS3804A-NCC-CC +
SWS3804A-NCC-LF + R-110405-3-21A + RBI0304A-B00-CC + RBI0304A-B00-LF +
ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC +
ECS5254A-B00-LF + ECS5136A-B00-CC + ECS5136A-B00-LF + 5254A-CBL-LF +
5136A-CBL-LF + ECSCH4BA-CWU-LF + ECSC14DA-FAN-LF + ECS5246A-B00-CC +
ECS5246A-B00-LF + 5246A-CBL-LF + ECSUC2BA-FAN-LF + SWS3643A-V00-LF +
SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC +
SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF +
5181A-CBL-LF + SWS0P4BA-PMD-LF) * (ECS6034B-DPC-LF + ECS6034B-BPC-LF
+ ECSCH4AB-CWU-LF) + (RBI0035A-PMD-LF + RBI5171A-B00-CC +
RBI5171A-B00-LF + 0304X-CBL-LF + 5151X-CBL-LF + RBI2401A-VCC-LF +
LPI1407A-VCC-LF + 5164A-CBL-LF + LPI5164A-B00-CC + LPI5164A-B00-LF +
A-1104-05-1 + SWS1B32A-B00 + 1B32A-CBL-LF + SWS3804A-NCC-CC +
SWS3804A-NCC-LF + R-110405-3-21A + RBI0304A-B00-CC + RBI0304A-B00-LF +
ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC +
ECS5254A-B00-LF + ECS5136A-B00-CC + ECS5136A-B00-LF + 5254A-CBL-LF +
5136A-CBL-LF + ECSCH4BA-CWU-LF + ECSC14DA-FAN-LF + ECS5246A-B00-CC +
ECS5246A-B00-LF + 5246A-CBL-LF + ECSUC2BA-FAN-LF + SWS3643A-V00-LF +

TABLE A-XI (Cont)

SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF) * (ECS6254B-B00-CC + ECS6246B-B00-CC + SWS0402B-B00-CC) + (RBI0035A-PMD-LF + RBI5171A-B00-CC + RBI5171A-B00-LF + 0304X-CBL-LF + 5151X-CBL-LF + RBI2401A-VCC-LF + LPI1407A-VCC-LF + 5164A-CBL-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + A-1104-05-1 + SWS1B32A-B00 + 1B32A-CBL-LF + SWS3804A-NCC-CC + SWS3804A-NCC-LF + R-110405-3-21A + RBI0304A-B00-CC + RBI0304A-B00-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + ECS5136A-B00-CC + ECS5136A-B00-LF + 5254A-CBL-LF + 5136A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF) * (6254B-CBL-LF + 6246B-CBL-LF + SWS0P4CB-PMD-LF) + (RBI0035A-PMD-LF + RBI5171A-B00-CC + RBI5171A-B00-LF + 0304X-CBL-LF + 5151X-CBL-LF + RBI2401A-VCC-LF + LPI1407A-VCC-LF + 5164A-CBL-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + A-1104-05-1 + SWS1B32A-B00 + 1B32A-CBL-LF + SWS3804A-NCC-CC + SWS3804A-NCC-LF + R-110405-3-21A + RBI0304A-B00-CC + RBI0304A-B00-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + 5254A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF) * (0404X-CBL-LF + 6164B-CBL-LF +

TABLE A-XI (Cont)

2B32B-CBL-LF) + (RBI5171A-B00-CC + 0304X-CBL-LF + 5151X-CBL-LF + RBI2401A-VCC-LF + LPI1407A-VCC-LF + 5164A-CBL-LF + LPI5164A-B00-CC + SWS1B32A-B00 + 1B32A-CBL-LF + SWS3804A-NCC-CC + SWS3804A-NCC-LF + R-110405-3-21A + RBI0304A-B00-CC + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5136A-B00-CC + 5254A-CBL-LF + 5136A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + 5246A-CBL-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS5653A-B00-CC + SWS5181A-B00-CC + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF) * (ECS6254B-B00-LF + ECS6246B-B00-LF + SWS0402B-B00-LF) + (RBI0035A-PMD-LF + RBI5171A-B00-CC + RBI5171A-B00-LF + 0304X-CBL-LF + 5151X-CBL-LF + RBI2401A-VCC-LF + LPI1407A-VCC-LF + 5164A-CBL-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + A-ECS-2 + A-1104-05-1 + SWS1B32A-B00 + 1B32A-CBL-LF + SWS3804A-NCC-CC + SWS3804A-NCC-LF + R-110405-3-21A + RBI0304A-B00-CC + RBI0304A-B00-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + 5254A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + ECSUC2BA-FAN-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF) * (6171X-CBL-LF + RBI2400B-VCC-LF + LPI1408B-VCC-LF + SWS3805B-NCC-LF) + (RBI0035A-PMD-LF + RBI5171A-B00-CC + RBI5171A-B00-LF + 0304X-CBL-LF + 5151X-CBL-LF + RBI2401A-VCC-LF + LPI1407A-VCC-LF + 5164A-CBL-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + A-1104-05-1 + SWS1B32A-B00 + 1B32A-CBL-LF + SWS3804A-NCC-CC + SWS3804A-NCC-LF + R-110405-3-21A + RBI0304A-B00-CC + RBI0304A-B00-LF +

TABLE A-XI (Cont)

ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + 5254A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + ECSUC2BA-FAN-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF) * (RBI6171B-B00-CC + LPI6164B-B00-CC + SWS2B32B-B00 + SWS3805B-NCC-CC + RBI0404B-B00-CC) + (RBI5171A-B00-CC + 0304X-CBL-LF + 5151X-CBL-LF + RBI2401A-VCC-LF + LPI1407A-VCC-LF + 5164A-CBL-LF + LPI5164A-B00-CC + SWS1B32A-B00 + 1B32A-CBL-LF + SWS3804A-NCC-CC + SWS3804A-NCC-LF + R-110405-3-21A + RBI0304A-B00-CC + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + 5254A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + 5246A-CBL-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS5653A-B00-CC + SWS5181A-B00-CC + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF) * (RBI0035B-PMD-LF + RBI6171B-B00-LF + LPI6164B-B00-LF + A-1104-05-0 + RBI0404B-B00-LF) + ECS5254A-B-AASF * (CSB-CM + A-RBI-1 + A-SWS-1) + R-110405-3-21A * (CSB-CM + A-RBI-1 + R-HCP-021B-8 + R-HCP-VCH4A-3 + A-SWS-1 + A-IEA-4) + ESFA120X-BTU-LF * (ESFA323X-LOG-LF + ESFA223X-LOG-LF + R-PR130451-3 + R-PR130450-3 + R-PR130451-2 + R-PR130450-2 + R-PR130453-1 + R-PR130454-1 + ESFP2407-ASP-LF + ESFP2406-ASP-LF) + ESFA220X-BTU-LF * (ESFA323X-LOG-LF + ESFA123X-LOG-LF + R-PR130451-3 + R-PR130449-3 + R-PR130451-2 + R-PR130449-1 + R-PR130452-1 + R-PR130454-1 + ESFP2407-ASP-LF + ESFP2405-ASP-LF + ESFA120X-BTU-LF) + ESFA320X-BTU-LF * (ESFA223X-LOG-LF + ESFA123X-LOG-LF + R-PR130450-3 + R-PR130449-3 +

TABLE A-XI (Cont)

R-PR130450-2 + R-PR130449-1 + R-PR130452-1 + R-PR130453-1 + ESFP2406-ASP-LF + ESFP2405-ASP-LF + ESFA220X-BTU-LF + ESFA120X-BTU-LF) + A-ECS-3 * (5151X-CBL-LF + RBI2401A-VCC-LF + LPI1407A-VCC-LF + SWS3804A-NCC-LF + R-110405-3-21A + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECSCH4BA-CWU-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + 5653A-CBL-LF + 5181A-CBL-LF) + ECSC2DB-FAN-LF * (RBI5171A-B00-CC + 5151X-CBL-LF + RBI2401A-VCC-LF + LPI1407A-VCC-LF + LPI5164A-B00-CC + SWS1B32A-B00 + SWS3804A-NCC-CC + SWS3804A-NCC-LF + R-110405-3-21A + RBI0304A-B00-CC + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5136A-B00-CC + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS5653A-B00-CC + SWS5181A-B00-CC + 5653A-CBL-LF + 5181A-CBL-LF) + R-110405-5-21B * (CSA-CM + A-RBI-3 + RBI0035A-PMD-LF + RBI5171A-B00-CC + RBI5171A-B00-LF + 0304X-CBL-LF + 5151X-CBL-LF + RBI2401A-VCC-LF + LPI1407A-VCC-LF + 5164A-CBL-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + A-ECS-2 + A-1104-05-1 + SWS1B32A-B00 + 1B32A-CBL-LF + SWS3804A-NCC-CC + SWS3804A-NCC-LF + R-110405-3-21A + R-HCP-021A-7 + RBI0304A-B00-CC + RBI0304A-B00-LF + R-HCP-VCH4B-2 + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + 5254A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + ECSUC2BA-FAN-LF + A-SWS-3 + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF + A-IEA-3) + ECS6254B-B-AASF * (CSA-CM + A-RBI-3 + RBI0035A-PMD-LF + RBI5171A-B00-CC + RBI5171A-B00-LF + 0304X-CBL-LF +

TABLE A-XI (Cont)

5151X-CBL-LF + RBI2401A-VCC-LF + LPI1407A-VCC-LF + 5164A-CBL-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + A-ECS-2 + A-1104-05-1 + SWS1B32A-B00 + 1B32A-CBL-LF + SWS3804A-NCC-CC + SWS3804A-NCC-LF + R-110405-3-21A + RBI0304A-B00-CC + RBI0304A-B00-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + ECS5136A-B00-CC + ECS5136A-B00-LF + 5254A-CBL-LF + 5136A-CBL-LF + ECSCH4BA-CWU-LF + ECSC14DA-FAN-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + ECSUC2BA-FAN-LF + A-SWS-3 + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF) + R-110405-5-BS2B * CSA-CM + CSB-CM * R-110405-3-BS2A + IEA0DG1A-GEN-LF * IEA0DG2B-GEN-LF * LOSS-OSP + LPI0BW1X-X0C-LF

TABLE A-XII

DATA FOR QUANTIFICATION OF FAULT TREE ZZ

Basic Event	Median Unavailability	EF	CG
RBI0035A-PMD-LF	0.10000000E-02	3	13
RBI5171A-B00-CC	0.20000001E-02	3	2
RBI5171A-B00-LF	0.10000000E-02	3	11
0304X-CBL-LF	0.11000000E-02	3	1
5151X-CBL-LF	0.33000000E-02	3	1
RBI2401A-VCC-LF	0.41000000E-02	3	8
LPI1407A-VCC-LF	0.41000000E-02	3	8
5164A-CBL-LF	0.11000000E-02	3	1
LPI5164A-B00-CC	0.20000001E-02	3	2
LPI5164A-B00-LF	0.10000000E-02	3	11
A-ECS-2	0.42999999E-03	3	26
A-1104-05-1	0.10000000E-02	3	28
SWS1B32A-B00	0.20000001E-02	3	11
1B32A-CBL-LF	0.11000000E-02	3	1
SWS3804A-NCC-CC	0.20000001E-02	3	2
SWS3804A-NCC-LF	0.31000001E-02	3	47
R-110405-3-21A	0.80000004E-02	10	40
RBI0304A-B00-CC	0.20000001E-02	3	2
RBI0304A-B00-LF	0.10000000E-02	3	11
ECS6036A-DPC-LF	0.41000000E-02	3	8
ECS6036A-BPC-LF	0.41000000E-02	3	8
ECS5254A-B-AASF	0.54000001E-02	10	4
ECS5254A-B00-CC	0.20000001E-02	3	2
ECS5254A-B00-LF	0.10000000E-02	3	11
ECS5136A-B00-CC	0.20000001E-02	3	2
ECS5136A-B00-LF	0.10000000E-02	3	11
5254A-CBL-LF	0.11000000E-02	3	1
5136A-CBL-LF	0.11000000E-02	3	1
ECSCH4BA-CWU-LF	0.37000000E-02	3	13
ECSC14DA-FAN-LF	0.53999998E-03	3	12
ECS5246A-B00-CC	0.20000001E-02	3	2
ECS5246A-B00-LF	0.10000000E-02	3	11
5246A-CBL-LF	0.11000000E-02	3	1
ECSUC2BA-FAN-LF	0.53999998E-03	3	12
SWS3643A-V00-LF	0.40000002E-02	3	8
SWS3820A-V00-LF	0.40000002E-02	3	8
SWS0303A-B00-CC	0.20000001E-02	3	2
SWS0303A-B00-LF	0.10000000E-02	3	11
SWS5653A-B00-CC	0.20000001E-02	3	2
SWS5653A-B00-LF	0.10000000E-02	3	11
SWS5181A-B00-CC	0.20000001E-02	3	2
SWS5181A-B00-LF	0.10000000E-02	3	11
5653A-CBL-LF	0.33000000E-02	3	1
5181A-CBL-LF	0.33000000E-02	3	1
SWS0P4BA-PMD-LF	0.17000000E-02	3	13
ECS6034B-DPC-LF	0.41000000E-02	3	8

TABLE A-XII (Cont)

Basic Event	Median Unavailability	EF	CG
ECS6034B-BPC-LF	0.41000000E-02	3	8
ECSCH4AB-CWU-LF	0.37000000E-02	3	13
ECS6254B-B00-CC	0.20000001E-02	3	2
ECS6246B-B00-CC	0.20000001E-02	3	2
SWS0402B-B00-CC	0.20000001E-02	3	2
6254B-CBL-LF	0.11000000E-02	3	1
6246B-CBL-LF	0.11000000E-02	3	1
SWS0P4CB-PMD-LF	0.17000000E-02	3	13
0404X-CBL-LF	0.11000000E-02	3	1
6164B-CBL-LF	0.11000000E-02	3	1
2B32B-CBL-LF	0.11000000E-02	3	1
ECS6254B-B00-LF	0.10000000E-02	3	11
ECS6246B-B00-LF	0.10000000E-02	3	11
SWS0402B-B00-LF	0.10000000E-02	3	11
6171X-CBL-LF	0.33000000E-02	3	1
RBI2400B-VCC-LF	0.41000000E-02	3	8
LPI1408B-VCC-LF	0.41000000E-02	3	8
SWS3805B-NCC-LF	0.31000001E-02	3	47
RBI6171B-B00-CC	0.20000001E-02	3	2
LPI6164B-B00-CC	0.20000001E-02	3	2
SWS2B32B-B00	0.20000001E-02	3	11
SWS3805B-NCC-CC	0.20000001E-02	3	2
RBI0404B-B00-CC	0.20000001E-02	3	2
RBI0035B-PMD-LF	0.10000000E-02	3	13
RBI6171B-B00-LF	0.10000000E-02	3	11
LPI6164B-B00-LF	0.10000000E-02	3	11
A-1104-05-0	0.10000000E-02	3	28
RBI0404B-B00-LF	0.10000000E-02	3	11
CSB-CM	0.19999999E-03	10	38
A-RBI-1	0.22000000E-03	3	26
A-SWS-1	0.22000000E-03	3	26
R-HCP-021B-8	0.18000000E-03	10	41
R-HCP-VCH4A-3	0.18000000E-03	10	41
A-IEA-4	0.13000000E-03	3	34
ESFA120X-BTU-LF	0.12000000E-01	10	4
ESFA323X-LOG-LF	0.99999997E-04	3	3
ESFA223X-LOG-LF	0.99999997E-04	3	3
R-PR130451-3	0.99999997E-04	10	42
R-PR130450-3	0.99999997E-04	10	42
R-PR130451-2	0.99999997E-04	10	42
R-PR130450-2	0.99999997E-04	10	42
R-PR130453-1	0.99999997E-04	10	42
R-PR130454-1	0.99999997E-04	10	42
ESFP2407-ASP-LF	0.25000001E-03	10	4
ESFP2406-ASP-LF	0.25000001E-03	10	4
ESFA220X-BTU-LF	0.12000000E-01	10	4
ESFA123X-LOG-LF	0.99999997E-04	3	3
R-PR130449-3	0.99999997E-04	10	42

TABLE A-XII (Cont)

Basic Event	Median Unavailability	EF	CG
R-PR130449-1	0.99999997E-04	10	42
R-PR130452-1	0.99999997E-04	10	42
ESFP2405-ASP-LF	0.25000001E-03	10	4
ESFA320X-BTU-LF	0.12000000E-01	10	4
A-ECS-3	0.42999999E-03	3	26
ECSC2DB-FAN-LF	0.53999998E-03	3	12
R-110405-5-21B	0.80000004E-02	10	40
CSA-CM	0.19999999E-03	10	38
A-RBI-3	0.22000000E-03	3	26
R-HCP-021A-7	0.18000000E-03	10	41
R-HCP-VCH4B-2	0.18000000E-03	10	41
A-SWS-3	0.22000000E-03	3	26
A-IEA-3	0.13000000E-03	3	34
ECS6254B-B-AASF	0.54000001E-02	10	4
R-110405-5-BS2B	0.80000004E-02	10	40
R-110405-3-BS2A	0.80000004E-02	10	40
IEA0DG1A-GEN-LF	0.33000000E-01	10	23
IEA0DG2B-GEN-LF	0.33000000E-01	10	23
LOSS-0SP	0.10000000E-02	10	48
LPI0BW1X-X0C-LF	0.99999997E-04	3	5

TABLE A-XIII

EQUIVALENT BOOLEAN EXPRESSION FOR
REACTOR BUILDING SPRAY RECIRCULATION SYSTEM
(TRUNCATED AT 1.0E-6)

X = (RBI0035A-PMD-LF + RBI5171A-B00-CC + RBI5171A-B00-LF +
0304X-CBL-LF + 5151X-CBL-LF + RBI2401A-VCC-LF + FAN5132A-B00-LF +
LPR1405A-VCC-LF + LPI1407A-VCC-LF + 51112A-CBL-LF + 5164A-CBL-LF +
LP51112A-B00-CC + LP51112A-B00-LF + LPI5164A-B00-CC + LPI5164A-B00-LF +
R-110405-3-21A + A-1104-05-1 + SWS3803A-VCC-LF + SWS5232A-B00-CC +
SWS5232A-B00-LF + 5232A-CBL-LF + SWS1B32A-B00 + 1B32A-CBL-LF +
SWS3804A-NCC-CC + SWS3804A-NCC-LF + RBI0304A-B00-CC + RBI0304A-B00-LF +
ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC +
ECS5254A-B00-LF + ECS5136A-B00-CC + ECS5136A-B00-LF + 5254A-CBL-LF +
5136A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + ECS5246A-B00-LF +
5246A-CBL-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC +
SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC +
SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF) * (
6254B-CBL-LF + 6246B-CBL-LF) + (RBI5171A-B00-CC + 5151X-CBL-LF +
RBI2401A-VCC-LF + LPI1407A-VCC-LF + 51112A-CBL-LF + LP51112A-B00-CC +
LPI5164A-B00-CC + R-110405-3-21A + SWS3803A-VCC-LF + SWS5232A-B00-CC +
SWS1B32A-B00 + SWS3804A-NCC-CC + SWS3804A-NCC-LF + RBI0304A-B00-CC +
ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC +
ECSCH4BA-CWU-LF + ECS5246A-B00-CC + SWS3643A-V00-LF + SWS3820A-V00-LF +
SWS0303A-B00-CC + SWS5653A-B00-CC + SWS5181A-B00-CC + 5653A-CBL-LF +
5181A-CBL-LF) * (6132B-CBL-LF + VUC1C-FAN-LF) + (RBR0035A-PMD-LF +

TABLE A-XIII (Cont)

RBI0035A-PMD-LF + RBI5171A-B00-CC + RBI5171A-B00-LF + 0304X-CBL-LF + 5151X-CBL-LF + RBI2401A-VCC-LF + 5132A-CBL-LF + VUC1A-FAN-LF + FAN5132A-B00-CC + FAN5132A-B00-LF + LPR1405A-VCC-LF + LPI1407A-VCC-LF + 51112A-CBL-LF + 5164A-CBL-LF + LP51112A-B00-CC + LP51112A-B00-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + A-ECS-2 + R-110405-3-21A + A-1104-05-1 + SWS3803A-VCC-LF + SWS5232A-B00-CC + SWS5232A-B00-LF + 5232A-CBL-LF + SWS1B32A-B00 + 1B32A-CBL-LF + SWS3804A-NCC-CC + SWS3804A-NCC-LF + RBI0304A-B00-CC + RBI0304A-B00-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + ECS5136A-B00-CC + ECS5136A-B00-LF + 5254A-CBL-LF + 5136A-CBL-LF + ECSCH4BA-CWU-LF + ECSC14DA-FAN-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + ECSUC2BA-FAN-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF) * (ECS6034B-DPC-LF + ECS6034B-BPC-LF + ECSCH4AB-CWU-LF) + (RBR0035A-PMD-LF + RBI0035A-PMD-LF + RBI5171A-B00-CC + RBI5171A-B00-LF + 0304X-CBL-LF + 5151X-CBL-LF + RBI2401A-VCC-LF + 5132A-CBL-LF + VUC1A-FAN-LF + FAN5132A-B00-LF + LPR1405A-VCC-LF + LPI1407A-VCC-LF + 51112A-CBL-LF + 5164A-CBL-LF + LP51112A-B00-CC + LP51112A-B00-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + R-110405-3-21A + A-1104-05-1 + SWS3803A-VCC-LF + SWS5232A-B00-CC + SWS5232A-B00-LF + 5232A-CBL-LF + SWS1B32A-B00 + 1B32A-CBL-LF + SWS3804A-NCC-CC + SWS3804A-NCC-LF + RBI0304A-B00-CC + RBI0304A-B00-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + ECS5136A-B00-CC + ECS5136A-B00-LF + 5254A-CBL-LF +

TABLE A-XIII (Cont)

5136A-CBL-LF + ECSCH4BA-CWU-LF + ECSC14DA-FAN-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + ECSUC2BA-FAN-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF) * (ECS6254B-B00-CC + ECS6246B-B00-CC + SWS0402B-B00-CC) + (RBR0035A-PMD-LF + RBI0035A-PMD-LF + RBI5171A-B00-CC + RBI5171A-B00-LF + 0304X-CBL-LF + 5151X-CBL-LF + RBI2401A-VCC-LF + 5132A-CBL-LF + VUC1A-FAN-LF + FAN5132A-B00-CC + FAN5132A-B00-LF + LPR1405A-VCC-LF + LPI1407A-VCC-LF + 51112A-CBL-LF + 5164A-CBL-LF + LP51112A-B00-CC + LP51112A-B00-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + A-ECS-2 + R-110405-3-21A + A-1104-05-1 + SWS3803A-VCC-LF + SWS5232A-B00-CC + SWS5232A-B00-LF + 5232A-CBL-LF + SWS1B32A-B00 + 1B32A-CBL-LF + SWS3804A-NCC-CC + SWS3804A-NCC-LF + RBI0304A-B00-CC + RBI0304A-B00-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + 5254A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + ECSUC2BA-FAN-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF) * (RBI2400B-VCC-LF + LPI1408B-VCC-LF + SWS3802B-VCC-LF) + (RBR0035A-PMD-LF + RBI0035A-PMD-LF + RBI5171A-B00-CC + RBI5171A-B00-LF + 0304X-CBL-LF + 5151X-CBL-LF + RBI2401A-VCC-LF + 5132A-CBL-LF + VUC1A-FAN-LF + FAN5132A-B00-LF + LPR1405A-VCC-LF + LPI1407A-VCC-LF + 51112A-CBL-LF + 5164A-CBL-LF + LP51112A-B00-CC + LP51112A-B00-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + A-ECS-2 + R-110405-3-21A +

TABLE A-XIII (Cont)

A-1104-05-1 + SWS3803A-VCC-LF + SWS5232A-B00-CC + SWS5232A-B00-LF + 5232A-CBL-LF + SWS1B32A-B00 + 1B32A-CBL-LF + SWS3804A-NCC-CC + SWS3804A-NCC-LF + RBI0304A-B00-CC + RBI0304A-B00-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + 5254A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + ECSUC2BA-FAN-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF) * (6171X-CBL-LF + 6166B-CBL-LF + SWS3805B-NCC-LF) + (RBI5171A-B00-CC + 0304X-CBL-LF + 5151X-CBL-LF + RBI2401A-VCC-LF + LPR1405A-VCC-LF + LPI1407A-VCC-LF + 51112A-CBL-LF + 5164A-CBL-LF + LP51112A-B00-CC + LPI5164A-B00-CC + R-110405-3-21A + SWS3803A-VCC-LF + SWS5232A-B00-CC + 5232A-CBL-LF + SWS1B32A-B00 + 1B32A-CBL-LF + SWS3804A-NCC-CC + SWS3804A-NCC-LF + RBI0304A-B00-CC + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5136A-B00-CC + 5254A-CBL-LF + 5136A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + 5246A-CBL-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS5653A-B00-CC + SWS5181A-B00-CC + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF) * (ECS6254B-B00-LF + ECS6246B-B00-LF + SWS0402B-B00-LF) + (RBI0035A-PMD-LF + RBI5171A-B00-CC + RBI5171A-B00-LF + 0304X-CBL-LF + 5151X-CBL-LF + RBI2401A-VCC-LF + FAN5132A-B00-LF + LPR1405A-VCC-LF + LPI1407A-VCC-LF + 51112A-CBL-LF + 5164A-CBL-LF + LP51112A-B00-CC + LP51112A-B00-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + R-110405-3-21A + A-1104-05-1 + SWS3803A-VCC-LF + SWS5232A-B00-CC + SWS5232A-B00-LF + 5232A-CBL-LF + SWS1B32A-B00 +

TABLE A-XIII (Cont)

1B32A-CBL-LF + SWS3804A-NCC-CC + SWS3804A-NCC-LF + RBI0304A-B00-CC + RBI0304A-B00-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + 5254A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF) * (0404X-CBL-LF + LPR1406B-VCC-LF + 6164B-CBL-LF + 6232B-CBL-LF + 2B32B-CBL-LF) + (RBR0035A-PMD-LF + RBI0035A-PMD-LF + RBI5171A-B00-CC + RBI5171A-B00-LF + 0304X-CBL-LF + 5151X-CBL-LF + RBI2401A-VCC-LF + 5132A-CBL-LF + VUC1A-FAN-LF + FAN5132A-B00-LF + LPR1405A-VCC-LF + LPI1407A-VCC-LF + 51112A-CBL-LF + 5164A-CBL-LF + LP51112A-B00-CC + LP51112A-B00-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + R-110405-3-21A + A-1104-05-1 + SWS3803A-VCC-LF + SWS5232A-B00-CC + SWS5232A-B00-LF + 5232A-CBL-LF + SWS1B32A-B00 + 1B32A-CBL-LF + SWS3804A-NCC-CC + SWS3804A-NCC-LF + RBI0304A-B00-CC + RBI0304A-B00-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + 5254A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + ECSUC2BA-FAN-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF) * (RBI6171B-B00-CC + LPI6164B-B00-CC + LPR6166B-B00-CC + SWS6232B-B00-CC + SWS2B32B-B00 + SWS3805B-NCC-CC + RBI0404B-B00-CC) + (RBI5171A-B00-CC + 0304X-CBL-LF + 5151X-CBL-LF + RBI2401A-VCC-LF + LPR1405A-VCC-LF + LPI1407A-VCC-LF + 51112A-CBL-LF + 5164A-CBL-LF + LP51112A-B00-CC + LPI5164A-B00-CC +

TABLE A-XIII (Cont)

R-110405-3-21A + SWS3803A-VCC-LF + SWS5232A-B00-CC + 5232A-CBL-LF + SWS1B32A-B00 + 1B32A-CBL-LF + SWS3804A-NCC-CC + SWS3804A-NCC-LF + RBI0304A-B00-CC + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + 5254A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + 5246A-CBL-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS5653A-B00-CC + SWS5181A-B00-CC + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF) * (RBI0035B-PMD-LF + RBI6171B-B00-LF + FAN6132B-B00-LF + LPI6164B-B00-LF + LPR6166B-B00-LF + A-1104-05-0 + SWS6232B-B00-LF + RBI0404B-B00-LF) + ECS5254A-B-AASF * (CSB-CM + A-RBI-1 + A-SWS-1) + R-110405-3-21A * (CSB-CM + A-RBI-1 + R-HCP-021B-8 + R-HCP-VCH4A-3 + R-HCP-020C-S + A-SWS-1 + A-IEA-4) + ESFA120X-BTU-LF * (ESFA323X-LOG-LF + ESFA223X-LOG-LF + R-PR130451-3 + R-PR130450-3 + R-PR130451-2 + R-PR130450-2 + R-PR130453-1 + R-PR130454-1 + ESFP2407-ASP-LF + ESFP2406-ASP-LF) + FAN6132B-B00-CC * (RBI2401A-VCC-LF + LPI1407A-VCC-LF + R-110405-3-21A + SWS3803A-VCC-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECSCH4BA-CWU-LF + SWS3643A-V00-LF + SWS3820A-V00-LF) + ESFA220X-BTU-LF * (ESFA323X-LOG-LF + ESFA123X-LOG-LF + R-PR130451-3 + R-PR130449-3 + R-PR130451-2 + R-PR130449-1 + R-PR130452-1 + R-PR130454-1 + ESFP2407-ASP-LF + ESFP2405-ASP-LF + ESFA120X-BTU-LF) + ESFA320X-BTU-LF * (ESFA223X-LOG-LF + ESFA123X-LOG-LF + R-PR130450-3 + R-PR130449-3 + R-PR130450-2 + R-PR130449-1 + R-PR130452-1 + R-PR130453-1 + ESFP2406-ASP-LF + ESFP2405-ASP-LF + ESFA220X-BTU-LF + ESFA120X-BTU-LF) + A-ECS-3 * (5151X-CBL-LF + RBI2401A-VCC-LF + LPI1407A-VCC-LF + 51112A-CBL-LF + R-110405-3-21A + SWS3803A-VCC-LF + SWS3804A-NCC-LF +

TABLE A-XIII (Cont)

ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECSCH4BA-CWU-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + 5653A-CBL-LF + 5181A-CBL-LF) + ECSC2DB-FAN-LF * (RBI5171A-B00-CC + 5151X-CBL-LF + RBI2401A-VCC-LF + LPI1407A-VCC-LF + 51112A-CBL-LF + LP51112A-B00-CC + LPI5164A-B00-CC + R-110405-3-21A + SWS3803A-VCC-LF + SWS5232A-B00-CC + SWS1B32A-B00 + SWS3804A-NCC-CC + SWS3804A-NCC-LF + RBI0304A-B00-CC + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5136A-B00-CC + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS5653A-B00-CC + SWS5181A-B00-CC + 5653A-CBL-LF + 5181A-CBL-LF) + RBR0035B-PMD-LF * (RBI5171A-B00-CC + 5151X-CBL-LF + RBI2401A-VCC-LF + LPI1407A-VCC-LF + 51112A-CBL-LF + LP51112A-B00-CC + LPI5164A-B00-CC + R-110405-3-21A + SWS3803A-VCC-LF + SWS5232A-B00-CC + SWS1B32A-B00 + SWS3804A-NCC-CC + SWS3804A-NCC-LF + RBI0304A-B00-CC + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + SWS5653A-B00-CC + SWS5181A-B00-CC + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF) + SWS0P4CB-PMD-LF * (RBR0035A-PMD-LF + RBI0035A-PMD-LF + RBI5171A-B00-CC + RBI5171A-B00-LF + 0304X-CBL-LF + 5151X-CBL-LF + RBI2401A-VCC-LF + FAN5132A-B00-LF + LPR1405A-VCC-LF + LPI1407A-VCC-LF + 51112A-CBL-LF + 5164A-CBL-LF + LP51112A-B00-CC + LP51112A-B00-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + R-110405-3-21A + A-1104-05-1 + SWS3803A-VCC-LF + SWS5232A-B00-CC + SWS5232A-B00-LF + 5232A-CBL-LF + SWS1B32A-B00 + 1B32A-CBL-LF + SWS3804A-NCC-CC + SWS3804A-NCC-LF + RBI0304A-B00-CC + RBI0304A-B00-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + ECS5136A-B00-CC + ECS5136A-B00-LF + 5254A-CBL-LF + 5136A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC +

TABLE A-XIII (Cont)

ECS5246A-B00-LF + 5246A-CBL-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF) + ECS6254B-B-AASF * (CSA-CM + A-RBI-3 + RBR0035A-PMD-LF + RBI0035A-PMD-LF + RBI5171A-B00-CC + RBI5171A-B00-LF + 0304X-CBL-LF + 5151X-CBL-LF + RBI2401A-VCC-LF + 5132A-CBL-LF + VUC1A-FAN-LF + FAN5132A-B00-CC + FAN5132A-B00-LF + LPR1405A-VCC-LF + LPI1407A-VCC-LF + 51112A-CBL-LF + 5164A-CBL-LF + LP51112A-B00-CC + LP51112A-B00-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + A-ECS-2 + R-110405-3-21A + A-1104-05-1 + SWS3803A-VCC-LF + SWS5232A-B00-CC + SWS5232A-B00-LF + 5232A-CBL-LF + SWS1B32A-B00 + 1B32A-CBL-LF + SWS3804A-NCC-CC + SWS3804A-NCC-LF + RBI0304A-B00-CC + RBI0304A-B00-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + ECS5136A-B00-CC + ECS5136A-B00-LF + 5254A-CBL-LF + 5136A-CBL-LF + ECSCH4BA-CWU-LF + ECSC14DA-FAN-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + ECSUC2BA-FAN-LF + A-SWS-3 + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF) + R-110405-5-21B * (CSA-CM + A-RBI-3 + RBR0035A-PMD-LF + RBI0035A-PMD-LF + RBI5171A-B00-CC + RBI5171A-B00-LF + 0304X-CBL-LF + 5151X-CBL-LF + RBI2401A-VCC-LF + 5132A-CBL-LF + VUC1A-FAN-LF + FAN5132A-B00-CC + FAN5132A-B00-LF + LPR1405A-VCC-LF + LPI1407A-VCC-LF + 51112A-CBL-LF + 5164A-CBL-LF + LP51112A-B00-CC + LP51112A-B00-LF + LPI5164A-B00-CC + LPI5164A-B00-LF + A-ECS-2 + R-110405-3-21A + A-1104-05-1 + R-HCP-021A-7 + SWS3803A-VCC-LF

TABLE A-XIII (Cont)

+ SWS5232A-B00-CC + SWS5232A-B00-LF + 5232A-CBL-LF + SWS1B32A-B00 + 1B32A-CBL-LF + SWS3804A-NCC-CC + SWS3804A-NCC-LF + RBI0304A-B00-CC + RBI0304A-B00-LF + R-HCP-VCH4B-2 + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + 5254A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + ECSUC2BA-FAN-LF + R-HCP-020A-S + A-SWS-3 + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF + A-IEA-3) + R-110405-5-BS2B * CSA-CM + CSB-CM * R-110405-3-BS2A + SL-SUMP-CM + LPI0BW1X-X0C-LF + IEA0DG1A-GEN-LF * IEA0DG2B-GEN-LF * L0SS-0SP

TABLE A-XIV

DATA FOR QUANTIFICATION OF FAULT TREE ZX

Basic Event	Median Unavailability	EF	CG
RBI0035A-PMD-LF	0.10000000E-02	3	13
RBI5171A-B00-CC	0.20000001E-02	3	2
RBI5171A-B00-LF	0.10000000E-02	3	11
0304X-CBL-LF	0.11000000E-02	3	1
5151X-CBL-LF	0.33000000E-02	3	1
RBI2401A-VCC-LF	0.41000000E-02	3	8
FAN5132A-B00-LF	0.10000000E-02	3	11
LPR1405A-VCC-LF	0.11000000E-02	3	8
LPI1407A-VCC-LF	0.41000000E-02	3	8
51112A-CBL-LF	0.33000000E-02	3	1
5164A-CBL-LF	0.11000000E-02	3	1
LP51112A-B00-CC	0.20000001E-02	3	2
LP51112A-B00-LF	0.10000000E-02	3	11
LPI5164A-B00-CC	0.20000001E-02	3	2
LPI5164A-B00-LF	0.10000000E-02	3	11
R-110405-3-21A	0.80000004E-02	10	40
A-1104-05-1	0.10000000E-02	3	28
SWS3803A-VCC-LF	0.41000000E-02	3	8
SWS5232A-B00-CC	0.20000001E-02	3	2
SWS5232A-B00-LF	0.10000000E-02	3	11
5232A-CBL-LF	0.11000000E-02	3	1
SWS1B32A-B00	0.20000001E-02	3	11
1B32A-CBL-LF	0.11000000E-02	3	1
SWS3804A-NCC-CC	0.20000001E-02	3	2
SWS3804A-NCC-LF	0.31000001E-02	3	47
RBI0304A-B00-CC	0.20000001E-02	3	2
RBI0304A-B00-LF	0.10000000E-02	3	11
ECS6036A-DPC-LF	0.41000000E-02	3	8
ECS6036A-BPC-LF	0.41000000E-02	3	8
ECS5254A-B-AASF	0.54000001E-02	10	4
ECS5254A-B00-CC	0.20000001E-02	3	2
ECS5254A-B00-LF	0.10000000E-02	3	11
ECS5136A-B00-CC	0.20000001E-02	3	2
ECS5136A-B00-LF	0.10000000E-02	3	11
5254A-CBL-LF	0.11000000E-02	3	1
5136A-CBL-LF	0.11000000E-02	3	1
ECSCH4BA-CWU-LF	0.37000000E-02	3	13
ECS5246A-B00-CC	0.20000001E-02	3	2
ECS5246A-B00-LF	0.10000000E-02	3	11
5246A-CBL-LF	0.11000000E-02	3	1
SWS3643A-V00-LF	0.40000002E-02	3	8
SWS3820A-V00-LF	0.40000002E-02	3	8
SWS0303A-B00-CC	0.20000001E-02	3	2
SWS0303A-B00-LF	0.10000000E-02	3	11
SWS5653A-B00-CC	0.20000001E-02	3	2
SWS5653A-B00-LF	0.10000000E-02	3	11

TABLE A-XIV (Cont)

Basic Event	Median Unavailability	EF	CG
SWS5181A-B00-CC	0.20000001E-02	3	2
SWS5181A-B00-LF	0.10000000E-02	3	11
5653A-CBL-LF	0.33000000E-02	3	1
5181A-CBL-LF	0.33000000E-02	3	1
SWS0P4BA-PMD-LF	0.17000000E-02	3	13
6254B-CBL-LF	0.11000000E-02	3	1
6246B-CBL-LF	0.11000000E-02	3	1
6132B-CBL-LF	0.55000000E-03	3	1
VUC1C-FAN-LF	0.53999998E-03	3	12
RBR0035A-PMD-LF	0.72000001E-03	10	46
5132A-CBL-LF	0.55000000E-03	3	1
VUC1A-FAN-LF	0.53999998E-03	3	12
FAN5132A-B00-CC	0.28000001E-03	3	2
A-ECS-2	0.42999999E-03	3	26
ECSC14DA-FAN-LF	0.53999998E-03	3	12
ECSUC2BA-FAN-LF	0.53999998E-03	3	12
ECS6034B-DPC-LF	0.41000000E-02	3	8
ECS6034B-BPC-LF	0.41000000E-02	3	8
ECSCH4AB-CWU-LF	0.37000000E-02	3	13
ECS6254B-B00-CC	0.20000001E-02	3	2
ECS6246B-B00-CC	0.20000001E-02	3	2
SWS0402B-B00-CC	0.20000001E-02	3	2
RBI2400B-VCC-LF	0.41000000E-02	3	8
LPI1408B-VCC-LF	0.41000000E-02	3	8
SWS3802B-VCC-LF	0.41000000E-02	3	8
6171X-CBL-LF	0.33000000E-02	3	1
6166B-CBL-LF	0.33000000E-02	3	1
SWS3805B-NCC-LF	0.31000001E-02	3	47
ECS6254B-B00-LF	0.10000000E-02	3	11
ECS6246B-B00-LF	0.10000000E-02	3	11
SWS0402B-B00-LF	0.10000000E-02	3	11
0404X-CBL-LF	0.11000000E-02	3	1
LPR1406B-VCC-LF	0.11000000E-02	3	8
6164B-CBL-LF	0.11000000E-02	3	1
6232B-CBL-LF	0.11000000E-02	3	1
2B32B-CBL-LF	0.11000000E-02	3	1
RBI6171B-B00-CC	0.20000001E-02	3	2
LPI6164B-B00-CC	0.20000001E-02	3	2
LPR6166B-B00-CC	0.20000001E-02	3	2
SWS6232B-B00-CC	0.20000001E-02	3	2
SWS2B32B-B00	0.20000001E-02	3	11
SWS3805B-NCC-CC	0.20000001E-02	3	2
RBI0404B-B00-CC	0.20000001E-02	3	2
RBI0035B-PMD-LF	0.10000000E-02	3	13
RBI6171B-B00-LF	0.10000000E-02	3	11
FAN6132B-B00-LF	0.10000000E-02	3	11
LPI6164B-B00-LF	0.10000000E-02	3	11
LPR6166B-B00-LF	0.10000000E-02	3	11

TABLE A-XIV (Cont)

Basic Event	Median Unavailability	EF	CG
A-1104-05-0	0.10000000E-02	3	28
SWS6232B-B00-LF	0.10000000E-02	3	11
RBI0404B-B00-LF	0.10000000E-02	3	11
CSB-CM	0.19999999E-03	10	38
A-RBI-1	0.22000000E-03	3	26
A-SWS-1	0.22000000E-03	3	26
R-HCP-021B-8	0.18000000E-03	10	41
R-HCP-VCH4A-3	0.18000000E-03	10	41
R-HCP-020C-S	0.18000000E-03	10	41
A-IEA-4	0.13000000E-03	3	34
ESFA120X-BTU-LF	0.12000000E-01	10	4
ESFA323X-LOG-LF	0.99999997E-04	3	3
ESFA223X-LOG-LF	0.99999997E-04	3	3
R-PR130451-3	0.99999997E-04	10	42
R-PR130450-3	0.99999997E-04	10	42
R-PR130451-2	0.99999997E-04	10	42
R-PR130450-2	0.99999997E-04	10	42
R-PR130453-1	0.99999997E-04	10	42
R-PR130454-1	0.99999997E-04	10	42
ESFP2407-ASP-LF	0.25000001E-03	10	4
ESFP2406-ASP-LF	0.25000001E-03	10	4
FAN6132B-B00-CC	0.28000001E-03	3	2
ESFA220X-BTU-LF	0.12000000E-01	10	4
ESFA123X-LOG-LF	0.99999997E-04	3	3
R-PR130449-3	0.99999997E-04	10	42
R-PR130449-1	0.99999997E-04	10	42
R-PR130452-1	0.99999997E-04	10	42
ESFP2405-ASP-LF	0.25000001E-03	10	4
ESFA320X-BTU-LF	0.12000000E-01	10	4
A-ECS-3	0.42999999E-03	3	26
ECSC2DB-FAN-LF	0.53999998E-03	3	12
RBR0035B-PMD-LF	0.72000001E-03	10	46
SWS0P4CB-PMD-LF	0.17000000E-02	3	13
ECS6254B-B-AASF	0.54000001E-02	10	4
CSA-CM	0.19999999E-03	10	38
A-RBI-3	0.22000000E-03	3	26
A-SWS-3	0.22000000E-03	3	26
R-110405-5-21B	0.80000004E-02	10	40
R-HCP-021A-7	0.18000000E-03	10	41
R-HCP-VCH4B-2	0.18000000E-03	10	41
R-HCP-020A-S	0.18000000E-03	10	41
A-IEA-3	0.13000000E-03	3	34
R-110405-5-BS2B	0.80000004E-02	10	40
R-110405-3-BS2A	0.80000004E-02	10	40
SL-SUMP-CM	0.14000000E-03	10	49
LPI0BW1X-X0C-LF	0.99999997E-04	3	5
IEA0DG1A-GEN-LF	0.33000000E-01	10	23
IEA0DG2B-GEN-LF	0.33000000E-01	10	23
LOSS-0SP	0.10000000E-02	10	48

TABLE A-XV

EQUIVALENT BOOLEAN EXPRESSION FOR
EMERGENCY FEEDWATER SYSTEM,
ENGINEERED SAFEGUARDS CONDITION
(TRUNCATED AT 1.0E-6)

X = (EFICP7B3-CBL + EFICVC25-CBL + EFICVC12-CBL + 0311A-CBL-LF + EFW0311A-B00-CC + EFW0311A-B00-LF + EFW0P7BA-PMD-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + 5254A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + ECSUC2BA-FAN-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF) * (EFICVD25-CBL + EFICVD12-CBL) + (ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + 5254A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + 5246A-CBL-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS5653A-B00-CC + SWS5181A-B00-CC + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF) * (EFW0D02B-CBL-LF + EFW0D02B-B00-LF) + (ECS6036A-DPC-LF + ECS6036A-BPC-LF + EFICVD27-CBL + A-ECS-3) + (EFICAC06-CBL + EFICBD06-CBL + EFICAC04-1AC-LF + EFICBD04-1BD-LF + EFICVE04-CBL) * (EFICCD04-1CD-LF + EFICAB04-1AB-LF) + (EFICAC06-CBL + EFICBD06-CBL + EFICAC04-1AC-LF + EFICBD04-1BD-LF) * (EFICCD06-CBL + EFICAB06-CBL) + (A-ECS-2 + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + ECS5136A-B00-CC + ECS5136A-B00-LF + 5254A-CBL-LF + 5136A-CBL-LF + ECSCH4BA-CWU-LF + ECSC14DA-FAN-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + ECSUC2BA-FAN-LF + SWS3643A-V00-LF + SWS3820A-V00-LF +

TABLE A-XV (Cont)

SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF) * (ECS6034B-DPC-LF + ECS6034B-BPC-LF + ECSCH4AB-CWU-LF) + (ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + ECS5136A-B00-CC + ECS5136A-B00-LF + 5254A-CBL-LF + 5136A-CBL-LF + ECSCH4BA-CWU-LF + ECSC14DA-FAN-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + ECSUC2BA-FAN-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF) * (ECS6254B-B00-CC + ECS6246B-B00-CC + SWS0402B-B00-CC) + (ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + ECS5136A-B00-CC + ECS5136A-B00-LF + 5254A-CBL-LF + 5136A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF) * (6254B-CBL-LF + 6246B-CBL-LF + SWS0P4CB-PMD-LF) + (ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5136A-B00-CC + 5254A-CBL-LF + 5136A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + 5246A-CBL-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS5653A-B00-CC + SWS5181A-B00-CC + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF) * (ECS6254B-B00-LF + ECS6246B-B00-LF + SWS0402B-B00-LF) + (A-ECS-2 + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + 5254A-CBL-LF +

TABLE A-XV (Cont)

ECSCH4BA-CWU-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF +
ECSUC2BA-FAN-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC +
SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC +
SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF) * (
EFICVD24-CBL + EFICVD22-CBL + EFICVD41-CBL + EFW00X1A-V0C-LF +
EFW2620B-VCC-LF) + ECS5254A-B-AASF * (EFICVD23-CBL + A-SWS-1) +
EFICVE02-CBL * (EFICAC04-1AC-LF + EFICBD04-1BD-LF + EFICVE04-CBL) +
ECSC2DB-FAN-LF * (ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF
+ ECS5254A-B00-CC + ECS5136A-B00-CC + ECSCH4BA-CWU-LF + ECS5246A-B00-CC
+ SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS5653A-B00-CC
+ SWS5181A-B00-CC + 5653A-CBL-LF + 5181A-CBL-LF) + EFW0D02B-B00-CC * (
ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC +
ECS5254A-B00-LF + 5254A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC +
ECS5246A-B00-LF + 5246A-CBL-LF + ECSUC2BA-FAN-LF + SWS3643A-V00-LF +
SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC +
SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF +
5181A-CBL-LF + SWS0P4BA-PMD-LF) + ECS6254B-B-AASF * (A-ECS-2 +
ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC +
ECS5254A-B00-LF + ECS5136A-B00-CC + ECS5136A-B00-LF + 5254A-CBL-LF +
5136A-CBL-LF + ECSCH4BA-CWU-LF + ECSC14DA-FAN-LF + ECS5246A-B00-CC +
ECS5246A-B00-LF + 5246A-CBL-LF + ECSUC2BA-FAN-LF + A-SWS-3 +
SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF +
SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF +
5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF) + EFW0P7AX-PTD-LF * (
EFICP7B3-CBL + EFICVC27-CBL + EFICVC25-CBL + EFICVC12-CBL +

TABLE A-XV (Cont)

0311A-CBL-LF + EFW0311A-B00-CC + EFW0311A-B00-LF + EFW0P7BA-PMD-LF + A-ECS-2 + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + 5254A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + ECSUC2BA-FAN-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF) + IEA0DG1A-GEN-LF * IEA0DG2B-GEN-LF * LOSS-0SP + EFW0099X-CCC-LF + EFW0098X-CCC-LF + EFW0019X-X0C-LF

TABLE A-XVI

DATA FOR QUANTIFICATION OF FAULT TREE ZO

Basic Event	Median Unavailability	EF	CG
EFICP7B3-CBL	0.15000000E-02	3	1
EFICVC25-CBL	0.23000001E-02	3	1
EFICVC12-CBL	0.19000000E-02	10	45
0311A-CBL-LF	0.10000000E-02	3	1
EFW0311A-B00-CC	0.20000001E-02	3	2
EFW0311A-B00-LF	0.10000000E-02	3	11
EFW0P7BA-PMD-LF	0.11000000E-02	3	13
ECS6036A-DPC-LF	0.41000000E-02	3	8
ECS6036A-BPC-LF	0.41000000E-02	3	8
ECS5254A-B-AASF	0.54000001E-02	10	4
ECS5254A-B00-CC	0.20000001E-02	3	2
ECS5254A-B00-LF	0.10000000E-02	3	11
5254A-CBL-LF	0.11000000E-02	3	1
ECSCH4BA-CWU-LF	0.37000000E-02	3	13
ECS5246A-B00-CC	0.20000001E-02	3	2
ECS5246A-B00-LF	0.10000000E-02	3	11
5246A-CBL-LF	0.11000000E-02	3	1
ECSUC2BA-FAN-LF	0.53999998E-03	3	12
SWS3643A-V00-LF	0.40000002E-02	3	8
SWS3820A-V00-LF	0.40000002E-02	3	8
SWS0303A-B00-CC	0.20000001E-02	3	2
SWS0303A-B00-LF	0.10000000E-02	3	11
SWS5653A-B00-CC	0.20000001E-02	3	2
SWS5653A-B00-LF	0.10000000E-02	3	11
SWS5181A-B00-CC	0.20000001E-02	3	2
SWS5181A-B00-LF	0.10000000E-02	3	11
5653A-CBL-LF	0.33000000E-02	3	1
5181A-CBL-LF	0.33000000E-02	3	1
SWS0P4BA-PMD-LF	0.17000000E-02	3	13
EFICVD25-CBL	0.23000001E-02	3	1
EFICVD12-CBL	0.19000000E-02	10	45
EFW0D02B-CBL-LF	0.10000000E-02	3	1
EFW0D02B-B00-LF	0.10000000E-02	3	11
EFICVD27-CBL	0.36000001E-03	3	3
A-ECS-3	0.42999999E-03	3	26
EFICAC06-CBL	0.27000001E-02	3	1
EFICBD06-CBL	0.27000001E-02	3	1
EFICAC04-1AC-LF	0.55000000E-02	3	1
EFICBD04-1BD-LF	0.55000000E-02	3	1
EFICVE04-CBL	0.51000002E-02	3	1
EFICCD04-1CD-LF	0.55000000E-02	3	1
EFICAB04-1AB-LF	0.55000000E-02	3	1
EFICCD06-CBL	0.27000001E-02	3	1
EFICAB06-CBL	0.27000001E-02	3	1
A-ECS-2	0.42999999E-03	3	26
ECS5136A-B00-CC	0.20000001E-02	3	2

TABLE A-XVI (Cont)

Basic Event	Median Unavailability	EF	CG
ECS5136A-B00-LF	0.10000000E-02	3	11
5136A-CBL-LF	0.11000000E-02	3	1
ECSC14DA-FAN-LF	0.53999998E-03	3	12
ECS6034B-DPC-LF	0.41000000E-02	3	8
ECS6034B-BPC-LF	0.41000000E-02	3	8
ECSCH4AB-CWU-LF	0.37000000E-02	3	13
ECS6254B-B00-CC	0.20000001E-02	3	2
ECS6246B-B00-CC	0.20000001E-02	3	2
SWS0402B-B00-CC	0.20000001E-02	3	2
6254B-CBL-LF	0.11000000E-02	3	1
6246B-CBL-LF	0.11000000E-02	3	1
SWS0P4CB-PMD-LF	0.17000000E-02	3	13
ECS6254B-B00-LF	0.10000000E-02	3	11
ECS6246B-B00-LF	0.10000000E-02	3	11
SWS0402B-B00-LF	0.10000000E-02	3	11
EFICVD24-CBL	0.24000001E-02	3	1
EFICVD22-CBL	0.27000001E-02	3	1
EFICVD41-CBL	0.41000000E-02	3	1
EFW00X1A-V0C-LF	0.41000000E-02	3	8
EFW2620B-VCC-LF	0.41000000E-02	3	8
EFICVD23-CBL	0.19999999E-03	10	4
A-SWS-1	0.22000000E-03	3	26
EFICVE02-CBL	0.51000002E-02	3	1
ECSC2DB-FAN-LF	0.53999998E-03	3	12
EFW0D02B-B00-CC	0.20000001E-02	3	2
ECS6254B-B-AASF	0.54000001E-02	10	4
A-SWS-3	0.22000000E-03	3	26
EFW0P7AX-PTD-LF	0.37000000E-02	3	14
EFICVC27-CBL	0.36000001E-03	3	3
IEA0DG1A-GEN-LF	0.33000000E-01	10	23
IEA0DG2B-GEN-LF	0.33000000E-01	10	23
LOSS-0SP	0.10000000E-02	10	48
EFW0099X-CCC-LF	0.99999997E-04	3	6
EFW0098X-CCC-LF	0.99999997E-04	3	6
EFW0019X-X0C-LF	0.99999997E-04	3	5

TABLE A-XVII

EQUIVALENT BOOLEAN EXPRESSION FOR
EMERGENCY FEEDWATER SYSTEM,
NONENGINEERED SAFEGUARDS CONDITION
(TRUNCATED AT 1.0E-6)

X = (EFICP7B3-CBL + EFICVC25-CBL + EFICVC19-CBL + EFICVC12-CBL + EFICVC18-CBL + EFICVC39-CBL + EFW51XXA-CBL-LF + EFW51XXA-B00-CC + EFW51XXA-B00-LF + EFW2670A-VCC-LF + EFW00X3A-V0C-LF + 0311A-CBL-LF + EFW0311A-B00-CC + EFW0311A-B00-LF + EFW0P7BA-PMD-LF) * (EFICVD25-CBL + EFICVD12-CBL) + (EFICAC06-CBL + EFICBD06-CBL + EFICAC04-1AC-LF + EFICBD04-1BD-LF + EFICVE04-CBL) * (EFICCD04-1CD-LF + EFICAB04-1AB-LF) + (EFICAC06-CBL + EFICBD06-CBL + EFICAC04-1AC-LF + EFICBD04-1BD-LF) * (EFICCD06-CBL + EFICAB06-CBL) + EFICVE02-CBL * (EFICAC04-1AC-LF + EFICBD04-1BD-LF + EFICVE04-CBL) + EFICVD27-CBL * (EFICVC39-CBL + EFW2670A-VCC-LF + EFW00X3A-V0C-LF) + EFW0P7AX-PTD-LF * (EFICP7B3-CBL + EFICVC27-CBL + EFICVC25-CBL + EFICVC19-CBL + EFICVC12-CBL + EFICVC18-CBL + EFICVC39-CBL + EFW51XXA-CBL-LF + EFW51XXA-B00-CC + EFW51XXA-B00-LF + EFW2670A-VCC-LF + EFW00X3A-V0C-LF + 0311A-CBL-LF + EFW0311A-B00-CC + EFW0311A-B00-LF + EFW0P7BA-PMD-LF) + EFW0099X-CCC-LF + EFW0098X-CCC-LF + EFW0019X-X0C-LF

TABLE A-XVIII

DATA FOR QUANTIFICATION OF FAULT TREE Z1

Basic Event	Median Unavailability	EF	CG
EFICP7B3-CBL	0.15000000E-02	3	1
EFICVC25-CBL	0.23000001E-02	3	1
EFICVC19-CBL	0.24000001E-02	3	1
EFICVC12-CBL	0.19000000E-02	10	45
EFICVC18-CBL	0.27000001E-02	3	1
EFICVC39-CBL	0.41000000E-02	3	1
EFW51XXA-CBL-LF	0.10000000E-02	3	1
EFW51XXA-B00-CC	0.20000001E-02	3	2
EFW51XXA-B00-LF	0.10000000E-02	3	11
EFW2670A-VCC-LF	0.41000000E-02	3	8
EFW00X3A-V0C-LF	0.41000000E-02	3	8
0311A-CBL-LF	0.10000000E-02	3	1
EFW0311A-B00-CC	0.20000001E-02	3	2
EFW0311A-B00-LF	0.10000000E-02	3	11
EFW0P7BA-PMD-LF	0.11000000E-02	3	13
EFICVD25-CBL	0.23000001E-02	3	1
EFICVD12-CBL	0.19000000E-02	10	45
EFICAC06-CBL	0.27000001E-02	3	1
EFICBD06-CBL	0.27000001E-02	3	1
EFICAC04-1AC-LF	0.55000000E-02	3	1
EFICBD04-1BD-LF	0.55000000E-02	3	1
EFICVE04-CBL	0.51000002E-02	3	1
EFICCD04-1CD-LF	0.55000000E-02	3	1
EFICAB04-1AB-LF	0.55000000E-02	3	1
EFICCD06-CBL	0.27000001E-02	3	1
EFICAB06-CBL	0.27000001E-02	3	1
EFICVE02-CBL	0.51000002E-02	3	1
EFICVD27-CBL	0.36000001E-03	3	3
EFW0P7AX-PTD-LF	0.37000000E-02	3	14
EFICVC27-CBL	0.36000001E-03	3	3
EFW0099X-CCC-LF	0.99999997E-04	3	6
EFW0098X-CCC-LF	0.99999997E-04	3	6
EFW0019X-X0C-LF	0.99999997E-04	3	5

TABLE A-XIX

EQUIVALENT BOOLEAN EXPRESSION FOR
REACTOR BUILDING COOLING SYSTEM
(TRUNCATED AT 1.0E-6)

X = ((RBCSF1BB-FAN-LF + 5222-CBL-LF) * (RBCSF1AA-FAN-LF + 5244-CBL-LF) + RBC814RA-F-RI + RBC3814A-NCC-LF + RBC3812A-VCC-LF + RBC5334A-B00-CC + RBC5334A-B00-LF + 3814-CBL-LF + 5334-CBL-LF + A-ECS-2 + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + ECS5136A-B00-CC + ECS5136A-B00-LF + 5254A-CBL-LF + 5136A-CBL-LF + ECSCH4BA-CWU-LF + ECSC14DA-FAN-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + ECSUC2BA-FAN-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF) * (ECS6034B-DPC-LF + ECS6034B-BPC-LF + ECSCH4AB-CWU-LF) + ((RBCSF1BB-FAN-LF + 5222-CBL-LF) * (RBCSF1AA-FAN-LF + 5244-CBL-LF) + RBC814RA-F-RI + RBC3814A-NCC-LF + RBC3812A-VCC-LF + RBC5334A-B00-CC + RBC5334A-B00-LF + 3814-CBL-LF + 5334-CBL-LF + A-ECS-2 + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + 5254A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + ECSUC2BA-FAN-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF) * (RBC3815B-NCC-LF + RBC3813B-VCC-LF + 3815-CBL-LF + 3813-CBL-LF) + (RBCSF1AA-FAN-LF * (RBCSF1BB-FAN-LF + 5222-CBL-LF) + RBC814RA-F-RI +

TABLE A-XIX (Cont)

5244-CBL-LF * RBCSF1BB-FAN-LF + RBC3814A-NCC-LF + RBC3812A-VCC-LF + RBC5334A-B00-CC + RBC5334A-B00-LF + 3814-CBL-LF + 5334-CBL-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + 5254A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + ECSUC2BA-FAN-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF) * (RBC815RB-F-RI + RB61103B-B00-CC) + (RBCSF1AA-FAN-LF * (RBCSF1BB-FAN-LF + 5222-CBL-LF) + RBC814RA-F-RI + 5244-CBL-LF * RBCSF1BB-FAN-LF + RBC3814A-NCC-LF + RBC3812A-VCC-LF + RBC5334A-B00-CC + RBC5334A-B00-LF + 3814-CBL-LF + 5334-CBL-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + ECS5136A-B00-CC + ECS5136A-B00-LF + 5254A-CBL-LF + 5136A-CBL-LF + ECSCH4BA-CWU-LF + ECSC14DA-FAN-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + ECSUC2BA-FAN-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF) * (ECS6254B-B00-CC + ECS6246B-B00-CC + SWS0402B-B00-CC) + ECS6254B-B-AASF * ((RBCSF1BB-FAN-LF + 5222-CBL-LF) * (RBCSF1AA-FAN-LF + 5244-CBL-LF) + RBC814RA-F-RI + RBC3814A-NCC-LF + RBC3812A-VCC-LF + RBC5334A-B00-CC + RBC5334A-B00-LF + 3814-CBL-LF + 5334-CBL-LF + A-ECS-2 + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + ECS5136A-B00-CC + ECS5136A-B00-LF + 5254A-CBL-LF + 5136A-CBL-LF + ECSCH4BA-CWU-LF + ECSC14DA-FAN-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF +

TABLE A-XIX (Cont)

ECSUC2BA-FAN-LF + A-SWS-3 + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF) + (RBC814RA-F-RI + RBC3814A-NCC-LF + RBC3812A-VCC-LF + RBC5334A-B00-CC + 3814-CBL-LF + 5334-CBL-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS5653A-B00-CC + SWS5181A-B00-CC + 5653A-CBL-LF + 5181A-CBL-LF) * (6222-CBL-LF * RBCSF1DB-FAN-LF + 6252-CBL-LF * RBCSF1CB-FAN-LF) + (RBC3814A-NCC-LF + RBC3812A-VCC-LF + 3814-CBL-LF + 5334-CBL-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECSCH4BA-CWU-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + 5653A-CBL-LF + 5181A-CBL-LF) * (6222-CBL-LF * 6252-CBL-LF + A-ECS-3) + (RBC814RA-F-RI + RBC3814A-NCC-LF + RBC3812A-VCC-LF + RBC5334A-B00-CC + RBC5334A-B00-LF + 3814-CBL-LF + 5334-CBL-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + ECS5136A-B00-CC + ECS5136A-B00-LF + 5254A-CBL-LF + 5136A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF) * (6254B-CBL-LF + 6246B-CBL-LF) + (RBC814RA-F-RI + RBC3814A-NCC-LF + RBC3812A-VCC-LF + RBC5334A-B00-CC + 3814-CBL-LF + 5334-CBL-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5136A-B00-CC + 5254A-CBL-LF + 5136A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + 5246A-CBL-LF +

TABLE A-XIX (Cont)

SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS5653A-B00-CC + SWS5181A-B00-CC + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF) * (ECS6254B-B00-LF + ECS6246B-B00-LF + SWS0402B-B00-LF) + ESFA119X-BTU-LF * (ESFA322X-L0G-LF + ESFA222X-L0G-LF + R-PR130450-4 + R-PR130451-4 + R-PR130451-2 + R-PR130450-2 + R-PR130453-1 + R-PR130454-1 + ESFP2407-ASP-LF + ESFP2406-ASP-LF) + ESFA219X-BTU-LF * (ESFA322X-L0G-LF + ESFA122X-L0G-LF + R-PR130449-4 + R-PR130451-4 + R-PR130451-2 + R-PR130449-1 + R-PR130452-1 + R-PR130454-1 + ESFP2407-ASP-LF + ESFP2405-ASP-LF + ESFA119X-BTU-LF) + ESFA319X-BTU-LF * (ESFA222X-L0G-LF + ESFA122X-L0G-LF + R-PR130449-4 + R-PR130450-4 + R-PR130450-2 + R-PR130449-1 + R-PR130452-1 + R-PR130453-1 + ESFP2406-ASP-LF + ESFP2405-ASP-LF + ESFA219X-BTU-LF + ESFA119X-BTU-LF) + ECSC2DB-FAN-LF * (RBC814RA-F-RI + RBC3814A-NCC-LF + RBC3812A-VCC-LF + RBC5334A-B00-CC + 3814-CBL-LF + 5334-CBL-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5136A-B00-CC + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS5653A-B00-CC + SWS5181A-B00-CC + 5653A-CBL-LF + 5181A-CBL-LF) + RB61103B-B00-LF * (RBC814RA-F-RI + RBC3814A-NCC-LF + RBC3812A-VCC-LF + RBC5334A-B00-CC + 3814-CBL-LF + 5334-CBL-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + 5254A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + 5246A-CBL-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS5653A-B00-CC + SWS5181A-B00-CC + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF) + SWS0P4CB-PMD-LF * (RBC814RA-F-RI + RBCSF1BB-FAN-LF * RBCSF1AA-FAN-LF + RBC3814A-NCC-LF + RBC3812A-VCC-LF + RBC5334A-B00-CC + RBC5334A-B00-LF +

TABLE A-XIX (Cont)

3814-CBL-LF + 5334-CBL-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECS5254A-B00-LF + ECS5136A-B00-CC + ECS5136A-B00-LF + 5254A-CBL-LF + 5136A-CBL-LF + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + ECS5246A-B00-LF + 5246A-CBL-LF + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS0303A-B00-LF + SWS5653A-B00-CC + SWS5653A-B00-LF + SWS5181A-B00-CC + SWS5181A-B00-LF + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF) + RBCSF1CB-FAN-LF * RBCSF1DB-FAN-LF * (RBC814RA-F-RI + RBC3814A-NCC-LF + RBC3812A-VCC-LF + RBC5334A-B00-CC + 3814-CBL-LF + 5334-CBL-LF + ECS6036A-DPC-LF + ECS6036A-BPC-LF + ECS5254A-B-AASF + ECS5254A-B00-CC + ECSCH4BA-CWU-LF + ECS5246A-B00-CC + SWS3643A-V00-LF + SWS3820A-V00-LF + SWS0303A-B00-CC + SWS5653A-B00-CC + SWS5181A-B00-CC + 5653A-CBL-LF + 5181A-CBL-LF + SWS0P4BA-PMD-LF) + IEA0DG1A-GEN-LF * IEA0DG2B-GEN-LF * LOSS-0SP + A-SWS-1 * ECS5254A-B-AASF

TABLE A-XX

DATA FOR QUANTIFICATION OF FAULT TREE YZ

Basic Event	Median Unavailability	EF	CG
RBCSF1BB-FAN-LF	0.25000000E-01	3	12
5222-CBL-LF	0.22000000E-01	3	1
RBCSF1AA-FAN-LF	0.25000000E-01	3	12
5244-CBL-LF	0.22000000E-01	3	1
RBC814RA-F-RI	0.20000001E-02	10	4
RBC3814A-NCC-LF	0.31000001E-02	3	47
RBC3812A-VCC-LF	0.41000000E-02	3	8
RBC5334A-B00-CC	0.20000001E-02	3	2
RBC5334A-B00-LF	0.10000000E-02	3	11
3814-CBL-LF	0.35999999E-02	3	1
5334-CBL-LF	0.35999999E-02	3	1
A-ECS-2	0.42999999E-03	3	26
ECS6036A-DPC-LF	0.41000000E-02	3	8
ECS6036A-BPC-LF	0.41000000E-02	3	8
ECS5254A-B-AASF	0.54000001E-02	10	4
ECS5254A-B00-CC	0.20000001E-02	3	2
ECS5254A-B00-LF	0.10000000E-02	3	11
ECS5136A-B00-CC	0.20000001E-02	3	2
ECS5136A-B00-LF	0.10000000E-02	3	11
5254A-CBL-LF	0.11000000E-02	3	1
5136A-CBL-LF	0.11000000E-02	3	1
ECSCH4BA-CWU-LF	0.37000000E-02	3	13
ECSC14DA-FAN-LF	0.53999998E-03	3	12
ECS5246A-B00-CC	0.20000001E-02	3	2
ECS5246A-B00-LF	0.10000000E-02	3	11
5246A-CBL-LF	0.11000000E-02	3	1
ECSUC2BA-FAN-LF	0.53999998E-03	3	12
SWS3643A-V00-LF	0.40000002E-02	3	8
SWS3820A-V00-LF	0.40000002E-02	3	8
SWS0303A-B00-CC	0.20000001E-02	3	2
SWS0303A-B00-LF	0.10000000E-02	3	11
SWS5653A-B00-CC	0.20000001E-02	3	2
SWS5653A-B00-LF	0.10000000E-02	3	11
SWS5181A-B00-CC	0.20000001E-02	3	2
SWS5181A-B00-LF	0.10000000E-02	3	11
5653A-CBL-LF	0.33000000E-02	3	1
5181A-CBL-LF	0.33000000E-02	3	1
SWS0P4BA-PMD-LF	0.17000000E-02	3	13
ECS6034B-DPC-LF	0.41000000E-02	3	8
ECS6034B-BPC-LF	0.41000000E-02	3	8
ECSCH4AB-CWU-LF	0.37000000E-02	3	13
RBC3815B-NCC-LF	0.31000001E-02	3	47
RBC3813B-VCC-LF	0.41000000E-02	3	8
3815-CBL-LF	0.35999999E-02	3	1
3813-CBL-LF	0.35999999E-02	3	1
RBC815RB-F-RI	0.20000001E-02	10	4

TABLE A-XX (Cont)

Basic Event	Median Unavailability	EF	CG
RB61103B-B00-CC	0.20000001E-02	3	2
ECS6254B-B00-CC	0.20000001E-02	3	2
ECS6246B-B00-CC	0.20000001E-02	3	2
SWS0402B-B00-CC	0.20000001E-02	3	2
ECS6254B-B-AASF	0.54000001E-02	10	4
A-SWS-3	0.22000000E-03	3	26
6222-CBL-LF	0.22000000E-01	3	1
RBCSF1DB-FAN-LF	0.25000000E-01	3	12
6252-CBL-LF	0.22000000E-01	3	1
RBCSF1CB-FAN-LF	0.25000000E-01	3	12
A-ECS-3	0.42999999E-03	3	26
6254B-CBL-LF	0.11000000E-02	3	1
6246B-CBL-LF	0.11000000E-02	3	1
ECS6254B-B00-LF	0.10000000E-02	3	11
ECS6246B-B00-LF	0.10000000E-02	3	11
SWS0402B-B00-LF	0.10000000E-02	3	11
ESFA119X-BTU-LF	0.12000000E-01	10	4
ESFA322X-LOG-LF	0.99999997E-04	3	3
ESFA222X-LOG-LF	0.99999997E-04	3	3
R-PR130450-4	0.99999997E-04	10	42
R-PR130451-4	0.99999997E-04	10	42
R-PR130451-2	0.99999997E-04	10	42
R-PR130450-2	0.99999997E-04	10	42
R-PR130453-1	0.99999997E-04	10	42
R-PR130454-1	0.99999997E-04	10	42
ESFP2407-ASP-LF	0.25000001E-03	10	4
ESFP2406-ASP-LF	0.25000001E-03	10	4
ESFA219X-BTU-LF	0.12000000E-01	10	4
ESFA122X-LOG-LF	0.99999997E-04	3	3
R-PR130449-4	0.99999997E-04	10	42
R-PR130449-1	0.99999997E-04	10	42
R-PR130452-1	0.99999997E-04	10	42
ESFP2405-ASP-LF	0.25000001E-03	10	4
ESFA319X-BTU-LF	0.12000000E-01	10	4
ECSC2DB-FAN-LF	0.53999998E-03	3	12
RB61103B-B00-LF	0.10000000E-02	3	11
SWSOP4CB-PMD-LF	0.17000000E-02	3	13
IEA0DG1A-GEN-LF	0.33000000E-01	10	23
IEA0DG2B-GEN-LF	0.33000000E-01	10	23
LOSS-0SP	0.10000000E-02	10	48
A-SWS-1	0.22000000E-03	3	26

TABLE A-XXI

EQUIVALENT BOOLEAN EXPRESSION FOR
POWER-CONVERSION SYSTEM
(TRUNCATED AT 1.0E-6)

X = PCS-IND + IEA00A3A-416-LF + LOSS-0SP + A-IED-6 + A-IED-2 +
IED0D02B-125-LF + IED0D01A-125-LF + A-IEA-3 + IEA00B5A-480-LF +
IEA00X5A-TFM-LF + IEA0301A-CBL-LF + IEA0301A-BC0-LF + IEA0512A-BC0-LF

TABLE A-XXII

DATA FOR QUANTIFICATION OF FAULT TREE ZW

Basic Event	Median Unavailability	EF	CG
PCS-IND	0.61000001E-01	3	24
IEA00A3A-416-LF	0.72000003E-04	3	1
LOSS-0SP	0.10000000E-02	10	48
A-IED-6	0.29999999E-04	3	36
A-IED-2	0.29999999E-04	3	36
IED0D02B-125-LF	0.72000003E-04	3	1
IED0D01A-125-LF	0.72000003E-04	3	1
A-IEA-3	0.13000000E-03	3	34
IEA00B5A-480-LF	0.72000003E-04	3	1
IEA00X5A-TFM-LF	0.48000002E-04	3	15
IEA0301A-CBL-LF	0.72000003E-04	3	1
IEA0301A-BC0-LF	0.24000001E-04	3	10
IEA0512A-BC0-LF	0.24000001E-04	3	10

APPENDIX B

PARAMETERS OF THE DISTRIBUTIONS

In this study, a central value and an error factor were used to represent the uncertainty in the probability (the unavailability) of the basic events. These parameters were used to derive distributions on the probabilities. This was accomplished by equating the central value to the median of a log normal distribution, and the error factor was taken to be the ratio of the 95th percentile of the log normal to its median. Other distributions were derived by matching their 5th and 95th percentiles to that of the log normal, a procedure that assured fairly uniform control of the tail areas of the distributions. Each distribution will now be considered.

B.1 Log Normal Distribution

Let x_{med} be the central value and x_{RF} the error factor. If $Y = \log(X)$ is a normal random variable, with mean μ and variance σ^2, then X is log normal. Then, letting x_{med} be the median of the variable X, we obtain $\mu = \log(x_{med})$. The parameter σ^2 is given by $\sigma^2 = [\log(x_{RF})/1.645]^2$.

Using the values of μ and σ^2 computed above, the 5th and 95th percentiles of the underlying log normal distribution are

$$E_1 = \exp(\mu - 1.645\sigma)$$

and

$$E_2 = \exp(\mu + 1.645\sigma) \quad ,$$

respectively.

The values of E_1 and E_2 are equated to the 5th and 95th percentiles of the other distributions considered in this study.

B.2 Normal Distribution

If Z is normal with mean μ_Z and variance σ_Z^2, its 5th and 95th percentiles are $\mu_Z - 1.645\sigma_Z$ and $\mu_Z + 1.645\sigma_Z$. Equating these to E_1 and E_2 and solving, we obtain

$$\mu_Z = (E_1+E_2)/2$$

and

$$\sigma_Z = (E_2-E_1)/3.29 \quad .$$

B.3 Uniform Distribution

If Z is uniform between A and B, then it has 5th and 95th percentiles of

$$E_1 = A + 0.05(B-A)$$

and

$$E_2 = A + 0.95(B-A) \quad .$$

Solving for A and B, we obtain

$$A = E_1 + E_2 - B$$

and

$$B = (0.95E_2 - 0.05E_1)/0.90 \quad .$$

B.4 Log Uniform Distribution

If W is uniform between A and B, then $Z = e^W$ is log uniform. The 5th and 95th percentiles of Z are given by

$$E_1 = \exp(0.95A + 0.05B)$$

and

$$E_2 = \exp(0.05A + 0.95B) \quad .$$

Solving for A and B,

$$A = \log(E_1) + \log(E_2) - B$$

and

$$B = (0.95 \log E_2 - 0.05 \log E_1)/0.90 \quad .$$

B.5 Gamma and Log Gamma Distributions

If Z follows either a gamma or log gamma distribution, there is no closed form for the 5th and 95th percentiles of Z. For this study, the parameters of the two distributions, which have predetermined percentiles E_1 and E_2, were found by appropriate computer search methods. It is noted that a variable Z is said to have a log gamma distribution if $W = -\log(1-Z)$ has a gamma distribution.

B.6 Log Cauchy Distribution

If a variable Z is such that $X = \log(Z)$ is a Cauchy variable with the density function

$$f(x) = (\pi\sigma)^{-1}[1 + (x - \mu)^2/\sigma^2]^{-1} \quad ,$$

then Z is said to have a log Cauchy distribution. For the log Cauchy, the 5th and 95th percentiles are

$$E_1 = \exp[\mu - \tan(9\pi/20)\sigma]$$

and

$$E_2 = \exp[\mu + \tan(9\pi/20)\sigma] \quad .$$

The solutions for μ and σ are

$$\mu = \frac{\log E_2 + \log E_1}{2}$$

and

$$\sigma = \frac{\log E_2 - \log E_1}{2 \tan(9\pi/20)} \quad .$$

APPENDIX C

A LISTING OF COMPUTER CODES FOR PROPAGATING UNCERTAINTIES IN FAULT TREE MODELS

Table C-I presents a listing of several computer codes, grouped according to method, for use in propagating uncertainties in fault tree and accident sequence models. A primary reference to each code is also included. A brief description of the features and capabilities of the codes SAMPLE, STADIC-II, MOCARS, PROSA-2, RALLY, BOUNDS, SPASM, DPD, and PUFD may be found in Chapter 6 of the PRA Procedures Guide.[9] Similarly, a brief description of LIMITS, PATREC-MC, PL-MODMC, RANGE, SOERP, COSMOS, and SCORE is provided by Jackson, Hockenbury, and Yeater.[3]

TABLE C-I

SEVERAL COMPUTER CODES FOR UNCERTAINTY ANALYSIS IN FAULT TREE MODELS

METHOD	CODE	REFERENCE
Monte Carlo Simulation	SAMPLE	Reactor Safety Study[11]
	LIMITS	Lee and Salem[20]
	STADIC-II	Orvis and Frank[21]
	PATREC-MC	Kalli and Lanore[22]
	MOCARS	Matthews[23]
	PL-MODMC	Modarres, Rasmussen, and Wolf[24]
	PROSA-2	Vaurio[25]
	RANGE	Jackson, Hockenbury, and Yeater[3]
	RALLY	Gesellschaft fuer Reaktorsicherheit[26]
Method of Moments	BOUNDS	Lee and Apostolakis[27]
	SOERP	Cox and Miller[28]
	SPASM	Leverenz[29]
	COSMOS	Jackson et al.[30]
Histogram Combination (Discrete Probability Distributions)	DPD	Kaplan[31]
	PUFD	Ahmed and Metcalf[32]
	SCORE	Colombo and Jaarsma[33]

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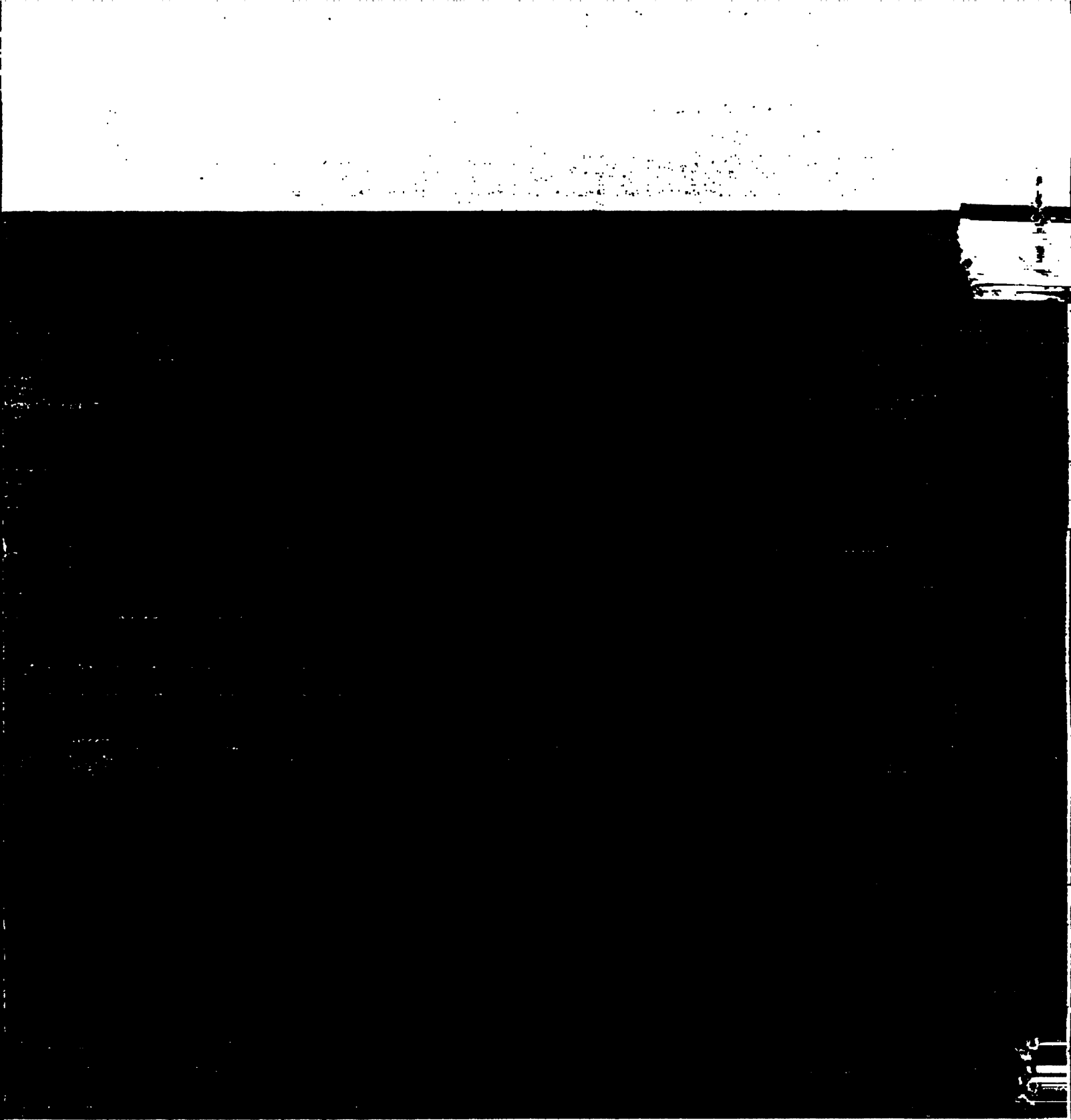

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