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Evaluation of Severe Accident Risks: Grand Gulf, Unit 1

Appendices

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APPENDIX A
SUPPORTING INFORMATION FOR THE ACCIDENT PROGRESSION ANALYSIS

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FIGURES

FIGURES (continued)

TABLE

APPENDIX A

SUPPORTING INFORMATION FOR THE ACCIDENT PROGRESSION ANALYSIS

INTRODUCTION

Appendix A contains information and details about the accident progression analysis. Subsection A.1 contains a detailed description and listing of the accident progression event tree (APET) and the binners that group the outcomes of evaluating the APET. Subsection A.2 contains a description and listing of the user function. The user function is a FORTRAN function subprogram called by EVNTRE when instructed to do so by the event tree. Subsection A.3 contains additional information about the accident progression analysis: basic information about the plant, a listing of the initialization questions (1 through 15) in the APET for each plant damage state (PDS), a discussion of the time periods used in the APET, and a description of the ac power recovery data used in this analysis.

A.1 ACCIDENT PROGRESSION EVENT TREE

A brief description of the Grand Gulf APET is given in Section 2.3 of the main body of this report, and the binner is treated in Section 2.4. The material in these sections is not repeated here. The 125 questions in the Grand Gulf APET are listed concisely in Table 2.3-1. This appendix consists of four subsections. Subsection A.1.1 discusses each question in the Grand Gulf APET. The event tree itself is too large to be depicted graphically and exists only in computer input format, which appears in Subsection A.1.2. Subsection A.1.3 discusses the binner in detail, and Subsection A.1.4 lists the binner, which, like the APET itself, exists only in computer input format.

A.1.1 Description of the Grand Gulf APET

Question 1. What Is the Initiating Event?
3 Branches, Type 1

The branches for this question are:

1.	TLOSP	Loss of offsite power transient.
2.	T2	Transient with loss of the power conversion system.
3.	TC	ATWS (Anticipated transient without scram).

The branch taken in this question depends solely on the first PDS characteristic (i.e., B1, B2, T2, or TC).

This question defines the initiating event. Three initiating events were passed from the accident frequency analysis to the accident progression analysis. The three that have been retained for further analysis are: loss of offsite power, transient with loss of the power conversion system (PCS), and ATWS. All of the TC PDSs involve failure of the standby liquid control system (SLC).

For PDSs 1 through 8, all the probability is assigned to Branch 1, TLOSP. For PDSs 9 and 10, all the probability is assigned to Branch 3, TC. Finally, for PDSs 11 and 12, all the probability is assigned to Branch 2, T2.

Question 2. Is There a Station Blackout (Diesel Generators Fail)?
2 Branches, Type 1

The branches for this question are:

1.	SB	This is a station blackout (SBO).
2.	nSB	This is not an SBO.

The branch taken in this question depends on the first PDS characteristic.

This question determines whether there is any emergency ac power on Divisions 1 and 2. An SBO means that there is no offsite power and the diesel generators are not supplying power to the emergency buses (i.e., neither of the two diesel generators for Divisions 1 and 2 is running). All safety-related ac equipment in the plant, except for the high-pressure core spray (HPCS) system, is powered from Divisions 1 and 2.

For the PDSs considered in this study, all of the loss of off-site power transients are SBOs. The T2 and TC transients do not involve losses of Division 1 or 2 power. Thus, Branch 1, SB, is taken for PDSs 1 through 8, and Branch 2 is taken for the remaining PDSs, 9 through 12.

Question 3. **Is DC Power Available?**
2 Branches, Type 1

The branches for this question are:

1. ElfDC No dc power on Divisions 1,2, and 3.
2. El-DC DC power is available from Division 3 and either Division 1 or Division 2.

The branch taken for this question depends on the first PDS characteristic.

This question determines whether emergency dc power is available on either Divisions 1 or 2 at the time of core damage. The station batteries supply dc power to the following critical equipment: (1) vessel instrumentation (level, pressure, etc.), (2) pilot valves on the safety/relief valves (SRVs) (allow automatic depressurization and relief function), (3) vessel injection from the reactor core isolation cooling (RCIC) system, and (4) diesel-generator starters.

For the PDSs analyzed in this study, ac power on either Division 1 or 2 assures that dc power will be available on either Division 1 or 2.

For PDSs 7 and 8, all the probability is assigned to Branch 1, ElfDC. For the remaining PDSs all the probability is assigned to Branch 2, El-DC.

Question 4. **Do One or More Safety Relief Valves Fail to Reclose?**
2 Branches, Type 1

The branches for this question are:

1. ElSORV One or more safety relief valves (SRVs) fail to reclose.
2. ElnSORV No SRVs fail to reclose.

The branching ratio for this question is sampled; the distribution is obtained from TEMAC4 and is the ratio of cut sets with stuck-open SRVs to the total number of cut sets for a given PDS.

Failure of an SRV to reclose will result in the depressurization of the reactor pressure vessel (RPV) during core degradation. In this study, only the short-term station blackout PDSs have some probability of having a stuck-open SRV valve. For all of the other PDSs, the probability of having a stuck-open SRV is negligible.

For PDS 1, the TEMAC4 mean value quantification for this question is:

Branch 1: ElSORV - 0.052
Branch 2: ElnSORV - 0.948

For PDS 2, the TEMAC4 mean value quantification for this question is:

Branch 1: ElSORV - 0.088
Branch 2: ElnSORV - 0.912

For PDS 3, the TEMAC4 mean value quantification for this question is:

Branch 1: E1SORV = 0.054
Branch 2: E1nSORV = 0.946

For PDS 7, the TEMAC4 mean value quantification for this question is:

Branch 1: E1SORV = 0.040
Branch 2: E1nSORV = 0.960

For all of the other PDSs, all the probability is assigned to Branch 2, E1NSORV.

Question 5. Does High-Pressure Core Spray Fail to Inject?
3 Branches, Type 1

The branches for this question are:

1. E1fHPInj The High-Pressure Core Spray (HPCS) system is failed and cannot be recovered.

2. E1rHPInj The HPCS system is failed but can be recovered with recovery of ac power.

3. E1-HPInj The HPCS system is available.

The branch taken for this question depends on the PDS definition.

The HPCS system provides coolant to the reactor vessel during accidents in which pressure remains high. The HPCS system consists of a single train with motor-operated valves and a motor driven pump. Division 3 (ac and dc power) is dedicated to the HPCS system and its supports. Suction is taken from either the condensate storage tank (CST) or the suppression pool. Injection to the reactor vessel is via a spray ring mounted inside the core shroud. The pump can deliver 550 gpm against a reactor pressure of 1177 psig and a full flow of 7115 gpm against a reactor pressure of 200 psig.

The HPCS system is recoverable in PDSs 1, 2, 4, and 5. Thus, for these four PDSs, all the probability is assigned to Branch 2, E1rHPInj. In all the other PDSs, the HPCS system has failed, and therefore, Branch 1, E1fHPInj, is assigned to these PDSs.

Question 6. Does RCIC Fail to Inject Initially?
2 Branches, Type 1

The branches for this question are:

1. E1fRCIC RCIC fails during core degradation.

2. E1-RCIC RCIC provides coolant injection during core degradation.

This question is not used in the analysis and has been included only for completeness. There are some sequences in which RCIC would be available during core degradation, but its flow rate is insufficient to prevent core damage. For these sequences it was estimated that the effect of RCIC on accident progression was negligible.

The RCIC system provides coolant to the reactor vessel during accidents in which system pressure remains high. The RCIC system consists of a single train with motor-operated valves and a turbine-driven pump that draws steam from the main steam lines. Turbine exhaust is dumped to the suppression pool. Suction for this system is initially from the CST. Suction will switch to the suppression pool on either low CST level or high suppression pool level. RCIC requires dc power to function. The RCIC pump can deliver 825 gpm at any pressure greater than 200 psig. RCIC is isolated by high steam-line space temperature, steam-line high differential pressure, high turbine exhaust pressure, or low steam supply pressure.

For all the PDSs, except PDS 9, all the probability is assigned to Branch 1, E1fRCIC. For PDS 9, all the probability is assigned to Branch 2, E1-RCIC. The effect of RCIC on the accident progression for this PDS is negligible and, therefore, is not explicitly modeled in subsequent sections of this tree.

Question 7. **Does the CRD Hydraulic System Fail to Inject?**
3 Branches, Type 1

The branches for this question are:

1. E1fCRD The control rod drive (CRD) hydraulic system is failed and cannot be recovered.

2. E1rCRD The CRD hydraulic system is recoverable when ac power is restored.

3. E1-CRD The CRD hydraulic system is providing coolant injection to the reactor pressure vessel (RPV).

This question is not used in the analysis and has only been included for completeness. The availability of this system was assessed not to be important to the accident progression because of the availability of other injection systems. First, the HPCS system is recoverable when ac power is restored in the dominant PDS, so the availability of the CRD hydraulic system is not important. Second, in most SBO sequences, the RPV is depressurized by the time ac power is recovered. Once the RPV is at low pressure, a variety of systems can provide low pressure coolant injection.

This question determines whether the CRD hydraulic system is used as a backup source of high pressure injection. The CRD pumps together can achieve a flow rate of approximately 238 gpm with the reactor at 1103 psia. This requires that the discharge path is through the hydraulic control units' (HCUs) cooling headers. If instrument air is lost, the discharge path is through the HCU charging headers, which restricts the flow to approximately 165 gpm. The flow rate through this second path is assumed to be insufficient for core cooling.

Because this question is not used in subsequent sections of this tree, for all the PDSs, all the probability has been assigned to Branch 1, E1fCRD.

Question 8. **Does the Condensate System Fail?**
3 Branches, Type 1

The branches for this question are:

1. E1fCond The condensate system fails and is not recoverable.

2. E1rCond The condensate system is recoverable when ac power is restored.

3. E1aCond The condensate system is available to inject coolant into the RPV.

The branch taken for this question depends on the PDS definition.

This question determines whether the condensate system is available for low pressure injection. The condensate system has three condensate pumps and three condensate booster pumps. Since the condensate and condensate booster pumps are rated at 9170 gpm and 9130 gpm respectively, flow from any of the six pumps will result in core cooling. The condensate pumps are powered by the nonsafety related buses. To use the condensate system as emergency low pressure injection to the reactor vessel, the operator must open the air-operated feedwater startup valve.

The availability of this system is important only if HPCS, low-pressure core spray (LPCS), and low-pressure coolant injection (LPCI) have all failed.

For PDSs 7, 6, and 8, the condensate system has failed, Branch 1. For PDSs 1 through 5, the condensate system is recoverable when ac power is restored, Branch 2. For PDSs 9 through 12, the condensate system is available and can be used as a source of coolant injection once the RPV is depressurized.

Question 9. **Do the LPCS and LPCI Systems Fail?**
4 Branches, Type 1

The branches for this question are:

1. E1fLPC Both LPCS and LPCI are failed and are not recoverable.

2. E1rLPC Either LPCS or LPCI is recoverable when ac power is restored.

3. E1aLPC Either LPCS or LPCI is available to inject coolant into the RPV.

4. E1-LPC Either LPCS or LPCI is providing coolant injection to the RPV.

The branch taken for this question depends on the third PDS characteristic (i.e., I1 - I6).

Both the LPCS and LPCI systems provide coolant to the reactor vessel during accidents in which system pressure is low. The LPCS is a single-train system consisting of motor-operated valves and a motor-driven pump. The LPCS pump is rated at 7115 gpm, with a discharge head of 319 psig. The LPCI system is a three-train system consisting of motor-operated valves and motor operated pumps. The three LPCI pumps are each rated at 7450 gpm. Division 1 provides ac and dc power to the LPCS train and LPCI train A. Similarly, Division 2 provides power to LPCI Trains A and B. Suction is normally drawn from the suppression pool.

The LPCS system and the LPCI system are both automatically initiated on the receipt of either a low reactor water level signal (-150 inches) or a high drywell pressure signal (+2 psig).

The LPCI system and the different modes of the RHR system share many components. The residual heat removal (RHR) pumps A and B are common to the LPCI, Suppression Pool Cooling (SPC), Shutdown Cooling (SDC), and Containment Spray (CS) modes.

For PDSs 2, 3, 6, 7, and 8, all the probability is assigned to Branch 1, E1fLPC. For PDSs 1, 4, and 5, all the probability is assigned to Branch 2, E1rLPC. For PDSs 9 through 12, all the probability is assigned to Branch 3, E1aLPC.

Question 10. **Does RHR Fail (Heat Exchangers Not Available)?**
4 Branches, Type 1

The branches for this question are:

1. E1fRHR **The SPC mode is failed and cannot be recovered.**

2. E1rRHR **The SPC mode can be recovered when ac power is restored.**

3. E1aRHR **The SPC mode is available but not operating.**

4. E1-RHR **The SPC mode is operating.**

The branch taken for this question depends upon the fourth PDS characteristic (i.e., H1, H2, or H3)

This question determines the status of the RHR heat exchangers. The SPC and CS systems are two modes of the RHR system. In either the SPC or the CS modes of operation, the RHR system can remove heat from the suppression pool by passing water from the pool through heat exchangers (with service water on the shell side). In the CS mode, water is sprayed into the containment. The SPC system is manually initiated and controlled. The CS system, on the other hand, is automatically initiated and controlled.

For PDSs 2, 3, and 5 through 8, all the probability is assigned to Branch 1, E1fRHR. For PDSs 1 and 4, all the probability is assigned to Branch 2, E1rRHR. For PDSs 9 through 12, all the probability is assigned to Branch 3, E1aRHR.

Question 11. **Does the Service Water System Cross-tie to LPCI Fail?**
3 Branches, Type 1

The branches for this questions are:

1. ElfSSW The standby service water (SSW) cross-tie is unavailable and cannot be recovered.
2. ElrSSW The SSW cross-tie is recoverable when ac power is restored.
3. ElaSSW The SSW cross-tie is available.

This question is not used in the analysis and has been included only for completeness. The availability of this system was assessed not to be important to the accident progression because of the [illegible] of other injection systems. Grand Gulf has a variety of [illegible] provide LPCI.

The SSW cross-tie system is used to provide a coolant make-up source to reactor vessel during accidents in which normal sources of emergency injection have failed. The SSW cross-tie system uses SSW Pump B to inject water into the reactor via the LPCI system Train B injection lines. The SSW cross-tie system has no automatic actuation. The system must be manually aligned and manually actuated.

Because this question is not used in this analysis, for all the PDSs, all the probability is assigned to Branch 1, ElfSSW.

Question 12. **Does the Firewater System Cross-tie to LPCI Fail?**
3 Branches, Type 1

The branches for this question are:

1. ElfFWS The firewater system (FWS) cross-tie is unavailable and cannot be recovered.
2. ElofFWS The FWS cross-tie is unavailable because of operator error.
3. ElaFWS The FWS cross-tie is available (but not operating).

The branch taken for this question depends on the PDS definition.

This question determines whether the FWS is used as a backup source of low-pressure injection. The FWS is a three-train system, consisting of one motor driven pump and two diesel-driven pumps. The pumps can each provide 1500 gpm at 125 psig. During an SBO only the two diesel-driven pumps are available. The FWS, when used for injection, must be manually initiated and controlled. The operator is required to align the system and to start the pumps.

For PDSs 1 through 3 and 7 through 12, all the probability is assigned to Branch 2, ElaFWS. For PDSs 4, 5, and 6, all the probability is assigned to Branch 2, ElofFWS.

Question 13. **Are the Containment (Wetwell) Sprays Failed?**
4 Branches, Type 1

The branches for this question are:

1. ElfCSS The CS system is failed and cannot be recovered.
2. ElrCSS The CS system is unavailable but can be recovered when ac power is restored.
3. ElaCSS The CS system is available, but not currently operating.
4. El-CSS The CS system is operating.

The branch taken for this question depends on the fourth PDS characteristic (i.e., H1, H2, or H3).

The containment spray system is used to suppress the pressure in the containment during accidents. The CS system is but one mode of the RHR system and, as such, shares components with other modes.

The CS system is a two-loop system consisting of motor-operated valves and motor-driven pumps. There are two heat exchangers in series per loop. Power is provided by Divisions 1 and 2 (ac and dc). Water for the sprays is taken from the suppression pool, passed through the RHR heat exchangers, and returned through spray headers in the containment dome. There are no sprays in the drywell.

The CS system is automatically initiated and controlled. The CS system is initiated by a high containment pressure, with a 10-minute time delay. At this time, if containment pressure is +9 psig and drywell pressure is +2 psig, the CS system will initiate: first Train A and, 90 seconds later, Train B. Manual actuation is also possible.

For PDSs 2, 3, and 5 through 8, all the probability is assigned to Branch 1, ElfCSS. For PDSs 1 and 4, all the probability is assigned to Branch 2, ElrCSS. For PDSs 9, 11, and 12, all the probability is assigned to Branch 3, ElaCSS, and for PDS 10, all the probability is assigned to Branch 4, El-CSS.

Question 14. **What Is the Status of Vessel Depressurization?**
4 Branches, Type 1

The branches for this question are:

1. ElfDep The RPV cannot be depressurized.
2. ElofDep The RPV has not been depressurized because of operator error.
3. ElnDep The RPV has not been depressurized although depressurization is still possible.
4. El-Dep The RPV was depressurized before core damage.

The branch taken for this question depends on the second PDS characteristic (i.e., P1, P2, P3, or P4).

The RPV can be depressurized by using either the automatic depressurization system (ADS) (automatic or manual) or by manually actuating the 12 SRVs that are not connected to the ADS logic. DC electric power is required to open the SRVs. Therefore, if dc power is not available, the RPV cannot be depressurized.

During some accident sequences, an SRV may fail to reclose. Reactor depressurization by this mechanism is considered in Question 26.

For PDSs 7 and 8, all the probability is assigned to Branch 1, ElfDep. For PDSs 9 through 12, all the probability is assigned to Branch 2, ElofDep. For PDSs 1, 2, and 3, all the probability is assigned to Branch 3, ElnDep. For PDSs 4, 5, and 6, all the probability is assigned to Branch 4, El-Dep.

Question 15. When Does Core Damage Occur?
2 Branches, Type 1

The branches for this question are:

1. CD-Fst Core damage occurs in the short term (approximately 1 hour).

2. CD-Slw Core damage occurs in the long term (approximately 12 hours).

The branches taken for this question depend on the sixth PDS characteristic.

When core damage occurs in the short term, the plant damage states are characterized by an early loss of all coolant injection to the RPV, a subcooled suppression pool, and a relatively dry containment atmosphere. On the other hand, when core damage occurs in the long term, the PDSs have characteristics that include several hours of coolant injection to the RPV, a saturated suppression pool, and a relatively high steam concentration in the containment.

The times used to represent the start of core damage were estimated from BWR-LTAS code calculations presented in NUREG/CR-4550[A-1] and are consistent with the times used in the accident frequency analysis. Core damage is assumed to begin when the collapsed water level is 2 feet above the bottom of the active fuel (BAF). For Branch 1, core damage in the short term, it is assumed that core damage begins approximately 1 hour after the initiating event. For Branch 2, core damage in the long term, it is assumed that core damage begins approximately 12 hours after the initiating event.

For the short-term PDSs (i.e., PDSs 1, 2, 3, 7, 9, and 11), all the probability is assigned to Branch 1, CD-Fst. Similarly, for the long-term PDSs (i.e., PDSs 4, 5, 6, 8, 10, and 12), all the probability is assigned to Branch 2, CD-Slw.

Question 16. What Is the Level of Pre-existing Leakage of Isolation Failure?
3 Branches, Type 1

The branches for this question are:

1. E1nL Nominal leakage from the containment. Leakage from the containment is insufficient to prevent long-term pressurization.

2. E1L2 There is a pre-existing leak that will slowly depressurize the containment (requires more than 2 hours).

3. E1L3 There is a large, pre-existing leak that will rapidly depressurize the containment (requires less than 2 hours).

This question is not sampled. The quantification of this question was based on discussions with the system analyst and personnel at System Energy Resources, Inc. (SERI).

This question defines the initial containment leakage level. While the containment isolation system is generally fail-safe (air operated valves are used that require power to remain open), some small lines may not be closed off (particularly in an SBO). However, after review of appropriate systems by the systems analyst, it was concluded that there was a negligible probability of isolation failures. There is, however, some probability that either a personnel hatch or the equipment hatch will not be properly sealed. There are two personnel hatches. Each personnel hatch has four inflatable seals and is tested once every 72 hours (technical specification verification). The equipment hatch has a mechanical seal but has no 72-hour test. The quantification of this question is driven by operator error. Thus, the probability that the operator fails to seal one of these hatches properly was quantified using the procedures outlined in the ASEP HRA guide.[A-2] The probability that one of these hatches is not sealed correctly is 0.0065. It is assumed that failure to seal the hatches properly will result in a leak (second branch) rather than a rupture (third branch).

The quantification for this question is:

Branch 1: E1nL = 0.9935
Branch 2: E1L1 = 0.0065
Branch 3: E1L3 = 0.0000

Question 17. What Is the Level of Pre-existing Suppression Pool Bypass?
3 Branches, Type 1

The branches for this question are:

1. E1nSPB There is no bypass of the suppression pool (drywell to containment air space) in excess of the nominal level. For Grand Gulf, the nominal level corresponds to an equivalent leakage area of 0.017 ft^2.

2. E1-SPB2 Suppression pool bypass is larger than the nominal value but within technical specifications.

3. E1-SPB3 There is a large pre-existing pool bypass. The leakage is large enough to prevent vent clearing for slow pressurization for the drywell.

This question is not sampled.

This question determines the level of pre-existing leakage from the drywell to the containment (wetwell) atmosphere (i.e., suppression pool bypass level). The allowable (technical specification) limit is determined based on containment spray performance following a large-break loss-of-coolant accident (LOCA). The nominal level, determined by test, is significantly lower than the allowable technical specification level.

Failures of the drywell vacuum breakers and the personnel hatch were both considered. The Grand Gulf plant has separate normal and post-LOCA vacuum breaker systems. The normal vacuum breaker system consists of an 8-inch line with two air-operated valves in series. This system would be closed upon the receipt of a LOCA signal. The post-LOCA vacuum breaker system consists of a 10-inch line through the drywell boundary with two branches in the containment. At each end of the two branches is a motor-operated valve in series with a check valve. Failure to close the drywell vacuum breakers was assessed to have a negligible probability. The drywell has one personnel hatch, which is very similar to the containment personnel hatch. The drywell personnel hatch has four inflatable seals and is tested once every 72 hours. Furthermore, this hatch is opened only during refueling outages. The same method was used to quantify the failure to seal this hatch properly as was used to quantify the failure of the containment personnel hatch. The probability that the operator fails to seal the drywell personnel hatch properly is 0.0004.

The quantification for this question is:

Branch 1:	E1nSPB	-	0.9996
Branch 2:	E1-SPB2	-	0.0004
Branch 3:	E1-SPB3	-	0.0000

Question 18. What Is the Structural Capacity of the Containment?
1 Branch, Type 3, 4 Parameters

The branch for this question is:

1. Contain The structural capacity of the containment for both quasi-static pressurization and dynamic loads.

The parameters initialized in this question are:

P21 PCFail The containment failure pressure (kPa) is read in as Parameter 21.

P22 CFRan	A random number between 0 and 1 is read in as Parameter 22. This number is used to determine the mode of containment failure (from quasi-static pressurization)
P24 IMPCF	The containment failure impulse (kPa-S) is read in as Parameter 24.
P25 IMRanC	A random number between 0 and 1 is read in as Parameter 25. This number is used to determine the mode of containment failure (from dynamic loads).

All the parameters initialized in this question are sampled. The distribution for the containment failure pressure, PCFail, is discussed in Volume 2, Part VI, of this report. The distribution for containment failure impulse, IMPCF, was provided by the Structural Response Expert Panel. The distributions for the parameters CFRan and IMRanC are described by uniform distributions between 0 and 1. The comparison of the failure pressure with the load pressure, and the determination of the mode of failure, take place in the user function called in a later question.

The assignment of the parameters based on the mean values of the aggregate distributions is:

Parameter 21: PCFail = 383. kPa
Parameter 22: CFRan = 0.50
Parameter 24: IMPCF = 19.5 kPa-S
Parameter 25: IMRanC = 0.50

Question 19. What Is the Structural Capacity of the Drywell?
1 Branch, Type 3, 5 Parameters

The branch for this question is:

1. Drywell The structural capacity of the drywell for both quasi-static pressurization and dynamic loading.

The parameters initialized in this question are:

P26 IPDWF	The internal drywell failure pressure (kPa) is read in as Parameter 26.
P30 EPDWF	The external drywell failure pressure (kPa) is read in as Parameter 30.
P31 DWFRan	A random number between 0 and 1 is read in as Parameter 31. This number is used to determine the mode of drywell failure (from both internal and external quasi-static pressurization).
P34 IMPDWF	The external drywell failure impulse (kPa-S) is read in as Parameter 34.

P35 IMRanD	A random number between 0 and 1 is read in as Parameter 35. This number is used to determine the mode of drywell failure (from dynamic loads).

All of the parameters initialized in this question are sampled. The distributions for both the internal and external drywell failure pressure, IPDWF and EPDWF respectively, are discussed in Volume 2, Part VI, of this report. The internal drywell failure pressure distribution represents the structural strength of the drywell to loads inside the drywell (e.g., quasi-static loads at VB). Similarly, the external drywell failure distributions (static pressurization and dynamic) represent the structural strength of the drywell to loads in the wetwell (e.g., loads from hydrogen deflagrations or detonations). In the assessment of the structural capacity of the drywell, several components of the structure were reviewed. These components included the cylindrical wall, the drywell roof, and the drywell head. Based on this review, the drywell structure's weakest component was assessed to be the cylindrical wall. The distribution for the external drywell failure impulse, IMPDWF, was provided by the Structural Response Expert Panel. The distributions for the parameters DWFRan and IMRanD are described by uniform distributions between 0 and 1.

The comparison of the failure pressure with the load pressure and the determination of the mode of failure take place in the user function, which is called in a later question.

The assignment of the parameters based on the mean values of the aggregate distributions is:

Parameter 26:	IPDWF	-	588 kPa
Parameter 30:	EPDWF	-	588 kPa
Parameter 31:	DWFRan	-	0.50
Parameter 34:	IMPDWF	-	33 kPa-S
Parameter 35:	IMRanD	-	0.50

Question 20. **What Type of Sequence Is This (Summary of PDS)?**
6 Branches, Type 2, 6 Cases

The branches for this question are:

1.	Fst-SB	Station blackout PDS in which core damage occurs in approximately 1 hour.
2.	Slw-SB	Slow station blackout PDS in which core damage occurs in approximately 12 hours.
3.	Fst-T2	Fast T2 transient PDS in which core damage occurs in approximately 1 hour.
4.	Slw-T2	Slow T2 transient PDS in which core damage occurs in approximately 12 hours.
5.	Fst-TC	Fast ATWS PDS in which core damage occurs in approximately 1 hour.

6. Slw-TC Slow ATWS PDS in which core damage occurs in approximately 12 hours.

This question is not sampled. The branching at this question depends upon the branch taken at Questions 1, 2, and 15.

This is a summary question, and groups the PDS based on the initiator and the time of core damage.

Case 1: This is an SBO that has core damage in the short term (approximately 1 hour). For this case, all the probability is assigned to Branch 1, Fst-SB.

Case 2: This is an SBO that has core damage in the long term (approximately 12 hours). For this case, all the probability is assigned to Branch 2, Slw-SB.

Case 3: This is a T2 transient that has core damage in the short term (approximately 1 hour). For this case, all the probability is assigned to Branch 3, Fst-T2.

Case 4: This is a T2 transient that has core damage in the long term (approximately 12 hours). For this case, all the probability is assigned to Branch 4, Slw-T2.

Case 5: This is an ATWS transient that has core damage in the short term (approximately 1 hour). For this case, all the probability is assigned to Branch 5, Fst-TC.

Case 6: This is an ATWS transient that has core damage in the long term (approximately 12 hours). For this case, all the probability is assigned to Branch 6, Slw-TC.

Question 21. Do the Operators Turn on the Hydrogen Ignition System Before Core Damage?
2 Branches, Type 2, 2 Cases

The branches for this question are:

1. E2-HIS The operators turn the hydrogen ignition system (HIS) on before core degradation.
2. E2nHIS The operators do not turn the HIS on before core degradation.

This question is not sampled. The branching at this question depends upon the branch taken at Question 2.

This question considers the status of the hydrogen igniters. The Grand Gulf containment has a distributed HIS. Igniters are located throughout the containment and drywell volumes. The function of the HIS is to prevent the buildup of large quantities of hydrogen inside the containment during accident conditions. This is accomplished by igniting, via a spark, small amounts of hydrogen before it has had a chance to accumulate. The HIS consists of 90 General Motors ac Division glow plugs (Model 7G), 45 powered by each division. The HIS is manually actuated. The glow plugs would not perform their function without ac power (i.e., in a blackout).

This is the first question in a series of questions that involve operator actions. The other questions that involve operator actions are Questions 22, 26, 27, and 28. The reliability of the operator to perform various tasks depends on his previous performance. The likelihood that an operator will perform a task correctly decreases as the number of previous errors increases. Therefore, it is necessary to keep track of the number of operator errors when quantifying these types of questions. In addition, the performance of the operator before core damage is also important because it indicates whether the operator is susceptible to these types of errors. For example, core damage occurs in the T2, ATWS, and long-term SBO PDSs because the operator failed to perform some task correctly. Therefore, operator errors are more likely to occur in accident progressions associated with these PDSs than in accident progressions associated with a short-term SBO that did not occur because of operator error. The relationships among these questions and the human reliability analysis (HRA) used to quantify these questions are discussed in Subsection A.3.3.

Case 1: In this case, there is no SBO. If core damage is incipient, the emergency operating procedures (EOPs) instruct the operators to turn on the igniters. A high probability of compliance is expected. The quantification for this case is:

Branch 1: E2-HIS - 0.84
Branch 2: E2nHIS - 0.16

Case 2: In this case, there is an SBO. For this case, it is not clear what the operators will do. The EOPs instruct the operator to turn on the HIS when the RPV level drops below the top of active fuel (TAF). Discussions with SERI personnel, however, indicate that operators are trained not to actuate equipment that they know to be inoperable (HIS requires ac power). Furthermore, because there is no ac power (SBO), the operator will not know the containment hydrogen concentration. It is highly uncertain what the operator will do in this situation. The quantification for this case is:

Branch 1: E2-HIS - 0.50
Branch 2: E2nHIS - 0.50

Question 22. Is the Containment Not Vented Before Core Degradation?
2 Branches, Type 2, 5 Cases

The branches for this question are:

1. E3nVent The containment is not vented before core damage.

2. E3-Vent The containment is vented before core damage.

This question is not sampled. The branching at this question depends upon the branch taken at Questions 1, 2, 6, 15, and 21.

This question determines whether the operator successfully vents the containment when suppression pool cooling and containment sprays have failed to reduce the primary containment pressure. The venting procedure requires containment venting when the pressure exceeds 17.25 psig.

The vent path is a 20-inch-diameter purge exhaust line that is part of the containment ventilation and filtration system. Containment venting requires instrument air for opening the air-operated dampers. The dampers also require power from emergency ac Division 1 and 2 for operation of the solenoids. Therefore, containment venting is not possible during a station blackout. The HRA used to quantify Cases 1 and 2 is discussed in Subsection A.3.3.

Case 1: In this case, the accident sequence is a long-term ATWS and the operators have failed to turn on the HIS. The HPCS system provided initial coolant injection to the RPV. Because this is an ATWS sequence, the rate at which energy is released to the suppression pool is greater than the capacity of the RHR system. Thus, the suppression pool becomes saturated, and the containment is pressurized. Because the containment pressure will reach 17.25 psig and ac power is available, venting procedures would instruct the operator to vent the containment. However, because the ATWS sequence is dominated by operator errors and for this case the operator also failed to turn on the HIS, it is very unlikely that the procedures will be followed and the containment vented. The quantification for this case is:

Branch 1: E3nVENT - 1.0
Branch 2: E3VENT - 0.0

Case 2: In this case, the accident sequence is a long-term ATWS, but the operators successfully turn on the HIS. This case is identical to the previous case except that the operators do not fail to turn on the HIS. Thus, there is a greater likelihood that the venting procedures will be followed. The probability is still low, however, because the ATWS sequence is dominated by previous operator errors. The quantification for this case is:

Branch 1: E3nVENT - 0.805
Branch 2: E3VENT - 0.195

Case 3: In this case, the accident sequence is a short-term ATWS with some coolant injection provided by RCIC. The capacity of RCIC for this case, however, is insufficient to prevent core damage. It was estimated that coolant injection provided by RCIC would not result in significant suppression pool heating, so the containment pressure would remain low. Thus, the containment is not vented. The quantification for this case is:

Branch 1: E3nVENT - 1.0
Branch 2: E3VENT - 0.0

Case 4: This case includes all other sequences that are not SBOs. In these sequences, either core damage occurs in the short term, or containment heat removal is available. In either case, the suppression pool remains subcooled, and the containment is not pressurized. Thus, the containment is not vented. The quantification for this case is:

Branch 1: E3nVENT - 1.0
Branch 2: E3VENT - 0.0

Case 5: This case includes all the SBO sequences. AC power is not available in this case, so the containment cannot be vented. The quantification for this case is:

Branch 1: E3nVENT - 1.0
Branch 2: E3VENT - 0.0

Question 23. **Do Any SRV Tailpipe Vacuum Breakers Stick Open?**
2 Branches, Type 2, 5 Cases

The branches for this question are:

1. oSRVBkr At least one SRV tailpipe vacuum breaker sticks open.

2. cSRVBkr There are no stuck-open SRV tailpipe vacuum breakers.

Cases 2, 3, 4, and 5 of this question are sampled; the distributions were quantified internally. The branching at this question depends upon the branch taken at Questions 4, 14, and 20.

This question determines whether one or more of the vacuum breakers on the SRV tailpipes are stuck open. A stuck-open tailpipe vacuum breaker provides a pathway for suppression pool bypass, since gases released from the vessel down the tailpipe would pass directly into the drywell. If the drywell is failed, these releases will then pass directly into the containment and bypass the suppression pool. On the other hand, if the drywell has not failed, these releases will enter the suppression pool through the horizontal vents. Tailpipe vacuum breakers will open after the associated SRV discharges steam through the tailpipe into the suppression pool. When the steam in the tailpipe condenses on the pipe walls, a vacuum is formed. The vacuum breaker prevents the tailpipe from drawing suppression pool water into it. A stuck-open tailpipe vacuum breaker is significant only if it is the vacuum breaker on the tailpipe for an SRV that is expected to be open after core damage occurs. Thus, the cases below consider which vacuum breakers are challenged by the sequence during the boil-down phase of the accident. This question reflects only significant vacuum breakers sticking open (i.e., ones that will result in fission product releases bypassing the suppression pool).

Case 1: There is a stuck-open SRV, so the SRV tailpipe vacuum breakers are not repeatedly opened and closed. The probability of a stuck-open tailpipe vacuum breaker is negligible for this case The quantification for this case is:

Branch 1: oSRVBkr - 0.00
Branch 2: cSRVBkr - 1.00

Case 2: This case includes SBOs and T2 transients in which core damage occurs in the short term. The RPV is at high pressure. The SRVs are cycled to maintain the RPV pressure. Because the SRVs are repeatedly opened and closed, the SRV tailpipe vacuum breakers are demanded to open and close a number of times. Thus, the probability that a tailpipe vacuum breaker will stick open is not negligible. The mean value of the distribution used to determine the branching gives the following quantification:

Branch 1: oSRVBkr - 0.25
Branch 2: cSRVBkr - 0.75

Case 3: This case includes all the accident sequences in which core damage occurs in the long term and the RPV is at high pressure. As in Case 2, the SRVs are cycled to maintain the RPV pressure. The difference in the number of times the SRVs are demanded in Case 2 and this case is not appreciable. Thus, the quantification for Case 2 was also applied to this case, which gives the following quantification:

Branch 1: oSRVBkr - 0.25
Branch 2: cSRVBkr - 0.75

Case 4: The accident sequence is an ATWS in which core damage occurs in the short term. The RPV is at high pressure. Because of the rapid boil-off rate resulting from the ATWS, the low-low-set SRV is held wide open prior to core damage, so its tailpipe vacuum breaker does not cycle. Thus, the probability of the tailpipe vacuum breaker sticking open in this case is reduced accordingly. The mean value of the distribution used to determine the branching gives the following quantification:

Branch 1: oSRVBkr - 0.055
Branch 2: cSRVBkr - 0.945

Case 5: The RPV has been depressurized prior to core damage, so the SRVs are not cycled repeatedly. It is unlikely that an SRV tailpipe vacuum breaker will stick open. The quantification for Case 4 was also applied to this case, which gives the following quantification:

Branch 1: oSRVBkr - 0.055
Branch 2: cSRVBkr - 0.945

Question 24. Does AC Power Remain Lost During Core Degradation?
2 Branches, Type 2, 4 Cases

The branches for this question are:

1. E4fAC AC power is not recovered prior to VB.

2. E4-AC AC power is recovered during core degradation.

Cases 2 and 3 of this question are sampled; the distributions sampled were obtained from the offsite power recovery curves for the Grand Gulf plant.

The branching at this question depends upon the branch taken at Questions 2, 3, 15, and 24.

The probability of power recovery here is the probability that offsite electrical power is recovered in the period in question given that power was not recovered prior to the period (see Subsection A.3).

This question accounts for the delay recovery of offsite power. The time period of interest here begins roughly when the collapsed water level is 2 feet above the BAF and ends approximately 15 minutes before vessel breach (VB). There must be no gap between the time to which the systems analysis considered power recovery and the time at which this period starts in this analysis. Thus, the start of this power recovery period is the time at which the system analysts terminated their consideration of power recovery, which is roughly the onset of core degradation.

Case 1: DC power is not available. Without dc power, it is assumed that ac power cannot be restored within the time frame considered in this analysis. The quantification for this case is:

Branch 1: E4fAC - 1.0
Branch 2: E4-AC - 0.0

Case 2: This case is an SBO that has core damage in the long term. Power was not initially available, but recovery was possible. For the long-term sequences, the system analysts terminated their consideration of power recovery 12 hours after the initiating event. Code calculations (see Volume 2, Part V, of this report) indicate that significant core collapse will occur 2.7 hours after core damage begins. Thus, the recovery period for this case is 12 hours to 14.7 hours. The mean value for power recovery during this time period is:

Branch 1: E4fAC - 0.81
Branch 2: E4-AC - 0.19

Case 3: This case is an SBO that has core damage in the short term. Power was not initially available, but recovery was possible. For the short term sequences, the system analysts terminated their consideration of power recovery 1 hour after the initiating event. Code calculations (see Volume 2, Part V, of this report) indicate that significant core collapse will occur 2.35 hours after core damage begins. Thus, the recovery period for this case is 1 hour to 3.35 hours. The mean value for power recovery during this time period is:

Branch 1: E4fAC - 0.38
Branch 2: E4-AC - 0.62

Case 4: Power was previously available and therefore is still available. The quantification for this case is:

Branch 1: E4fAC - 0.0
Branch 2: E4-AC - 1.0

Question 25. Is DC Power Available During Core Degradation?
2 Branches, Type 2, 4 Cases

The branches for this question are:

1. E4fDC DC power is not available before VB.
2. E4-DC DC power is available during core degradation.

This question is not sampled. The branching at this question depends upon the branch taken at Questions 2, 3, 15, and 24.

The station battery depletion time was internally quantified by the system analyst[A-3]. A distribution was developed for Grand Gulf to model the failure probability of the station batteries versus time for SBO sequences. From this distribution, the conditional probability of battery failure for a given time interval was obtained. The median battery depletion time is 18 hours. Because of this long depletion time, battery failure is important only for SBO sequences that have core damage in the long term and for time periods late in the accident progression.

Several assumptions are made with regard to the relationship between ac and dc power. If ac power is available, the emergency power system (EPS) battery chargers are operational and will supply the dc power. Thus, if ac power is available, it is assumed that dc power is available. On the other hand, because dc power is required for circuit breaker control power, once the station batteries have failed, it is very difficult to get ac power back to the safety systems. The circuit breakers can be moved manually, but this is a very complicated and slow procedure. Thus, for the time frame considered in this analysis, it is assumed that once dc power is lost ac power cannot be recovered. Without ac power, dc power cannot be recovered.

The time periods used for battery depletion are the same as the time periods used for ac power recovery.

Case 1: DC power has already been lost. Once dc power is lost, it is assumed that it cannot be recovered. The quantification for this case is:

Branch 1: E4fDC - 1.0
Branch 2: E4-DC - 0.0

Case 2: AC power is available and, therefore, dc power is available. The quantification for this case is:

Branch 1: E4fDC - 0.0
Branch 2: E4-DC - 1.0

Case 3: This case is an SBO that has core damage in the long term. Thus, the time period is from 12 hours to 14.7 hours. The quantification for this case is:

Branch 1: E4fDC - 0.2
Branch 2: E4-DC - 0.8

Case 4: The plant damage state is an SBO that has core damage in the short term. Thus, the time period is from 1 hour to 3.35 hours. The probability that the station batteries fail in this interval is negligible. The quantification for this case is:

Branch 1: E4fDC - 0.0
Branch 2: E4-DC - 1.0

Question 26. What Is the RPV Pressure During Core Degradation?

2 Branches, Type 2, 6 Cases

The branches for this question are:

1. E4-HiP The RPV is at high pressure (approximately 1055 psia) during core degradation.
2. E4-LoP The RPV has been depressurized prior to VB (less than 200 psia).

This question is not sampled and was quantified internally. The branching at this question depends upon the branch taken at Questions 1, 2, 4, 14, 15, 21, 22, and 25.

This question determines whether the RPV was depressurized during core degradation. To depressurize the RPV during this time regime requires operator action. The HRA analysis used to quantify this question is discussed in more detail in Subsection A.3.3.

Case 1: The RPV was depressurized prior to core damage and dc power is still available. DC power is required to keep the SRVs open. Without dc power, the SRV would close, and the RPV would repressurize. The quantification for this case is:

Branch 1: E4-HiP - 0.0
Branch 2: E4-LoP - 1.0

Case 2: There is at least one stuck-open SRV. The RPV will depressurize through the stuck-open SRV and will be at low pressure prior to VB. The quantification for this case is:

Branch 1: E4-HiP - 0.0
Branch 2: E4-LoP - 1.0

Case 3: The reactor vessel cannot be depressurized because either there is a hardware failure or dc power was lost. In either case, the SRVs cannot be kept open. The quantification for this case is:

Branch 1: E4-HiP - 1.0
Branch 2: E4-LoP - 0.0

Case 4: The accident sequence is a station blackout in which the operators failed to depressurize the RPV prior to core damage. There is some probability that the operators will fail to depressurize the RPV during core degradation. The quantification for this case is:

Branch 1: E4-HiP - 0.26
Branch 2: E4-LoP - 0.74

Case 5: The accident sequences are T2 and ATWS in which the operators succeed in turning on the HIS. In addition, for the long-term ATWS, the operators successfully vent the containment. Although the T2 and ATWS sequences are dominated by previous operator errors, for this case the operators do not commit any additional errors during core damage. The quantification for this case is:

Branch 1: E4-HiP - 0.805
Branch 2: E4-LoP - 0.195

Case 6: The accident sequences are T2 and ATWS in which the operators committed additional errors during core damage. The operators either failed to turn on the HIS prior to core damage or for the long-term ATWS they failed to vent the containment. The quantification for this case is:

Branch 1: E4-HiP - 1.0
Branch 2: E4-LoP - 0.0

Question 27. What Is the Status of the HIS Before VB?
2 Branches, Type 2, 7 Cases

The branches for this question are:

1. E4-HIS The HIS operates during core degradation.
2. E4nHIS The HIS is inoperative during core degradation.

This question is not sampled and was quantified internally. The branching at this question depends upon the branch taken at Questions 2, 14, 20, 21, 24, 25, and 26.

This question determines the status of the HIS during core degradation. The HRA analysis used to quantify this question is discussed in more detail in Subsection A.3.3.

Case 1: The HIS was not turned on before core damage. If the HIS were to be turned on during core degradation, it would provide a global ignition source for the hydrogen already accumulated in the containment. Depending on the hydrogen concentration, the loads from the burn could be quite severe and could threaten the integrity of the containment, thereby exacerbating the consequences. Thus, allowing the operator to turn on the HIS during core degradation would be an error of commission, which this analysis does not consider. The quantification for this case is:

Branch 1: E4-HIS - 0.0
Branch 2: E4nHIS - 1.0

Case 2: This case considers accident sequences that are not SBOs and for which the HIS was turned on prior to core damage. There is no reason for the operators to turn the HIS off. The quantification for this case is:

Branch 1: E4-HIS - 1.0
Branch 2: E4nHIS - 0.0

Case 3: The accident sequence is an SBO in which ac power is not recovered prior to vessel breach (VB). The HIS was turned on prior to core damage but is not functioning because there is no ac power. Nothing has changed that would make the operators turn the HIS off. The quantification for this case is:

Branch 1: E4-HIS - 1.0
Branch 2: E4nHIS - 0.0

Case 4: The accident sequence is a short-term SBO in which ac power is recovered during core degradation. The operators have already failed to depressurize the RPV. Because ac power was lost initially, the operators do not know what the hydrogen concentration is in the containment. Therefore, to avoid the possibility of a severe hydrogen combustion event, the operators should turn the HIS off upon recovery of ac power. However, because of the previous operator error, there is an substantial likelihood that the operator will fail to turn off the HIS. The quantification for this case is:

Branch 1: E4-HIS - 0.128
Branch 2: E4nHIS - 0.872

Case 5: The accident sequence is a short-term SBO in which ac power is recovered during core degradation. The operators have successfully depressurized the RPV. This case is the same as Case 4 except that the operators have not committed a previous error. Thus, there is an increased likelihood that the operators will turn the HIS off. The quantification for this case is:

Branch 1: E4-HIS - 0.064
Branch 2: E4nHIS - 0.936

Case 6: The accident sequence is a long-term SBO in which ac power is recovered during core degradation. Previous operator errors resulted in core damage. Thus, there is a substantial likelihood that the operator will fail to turn off the HIS. The quantification for this case is:

Branch 1: E4-HIS - 0.16
Branch 2: E4nHIS - 0.84

Case 7: All of the accident sequences should correspond to one of the previous six cases, so this case is not used. The quantification for this case is:

Branch 1: E4-HIS - 0.0
Branch 2: E4nHIS - 1.0

Question 28. Is RPV Injection Restored During Core Degradation?
3 Branches, Type 2, 10 Cases

The branches for this question are:

1. E4nLPI There is no coolant injection into the RPV.
2. E4-LPI There is low-pressure coolant injection to the RPV.
3. E4-HPI There is high-pressure coolant injection to the RPV.

This question is not sampled and was internally quantified. The branching at this question depends upon the branch taken at Questions 5, 8, 9, 12, 20, 24, 26, and 27.

This question determines whether coolant injection is restored during core degradation. The HRA analysis used to quantify this question is discussed in more detail in Subsection A.3.3.

Case 1: AC power, which was initially unavailable, is now restored. Because HPCS is recoverable once ac power is restored, there is a high probability that coolant injection will be supplied to the RPV. The quantification for this case is:

Branch 1: E4nLPI - 0.0
Branch 2: E4-LPI - 0.0
Branch 3: E4-HPI - 1.0

Case 2: The RPV remains pressurized, and there are no high-pressure injection systems available. Thus, there is no injection to the RPV. The quantification for this case is:

Branch 1: E4nLPI - 1.0
Branch 2: E4-LPI - 0.0
Branch 3: E4-HPI - 0.0

Case 3: The RPV is at low pressure and ac power is available. Because either LPCS or LPCI is available, there is a high probability that coolant injection will be supplied to the RPV. The quantification for this case is:

Branch 1: E4nLPI - 0.0
Branch 2: E4-LPI - 1.0
Branch 3: E4-HPI - 0.0

Case 4: The RPV is at low pressure, and ac power, which was initially unavailable, is now restored. HPCS, LPCS, and LPCI have all failed. The condensate system is available, but the operators must manually align the system before coolant can be provided to the RPV. This accident sequence is a long-term SBO. In this accident sequence, core damage occurs because of operator error. Nevertheless, the operators successfully turned the HIS off once ac power was recovered. Thus, the operators have not committed any additional errors since core damage. The quantification for this case is:

Branch 1: E4nLPI - 0.161
Branch 2: E4-LPI - 0.839
Branch 3: E4-HPI - 0.000

Case 5: This case is the same as the previous case except that the operators failed to turn the HIS off once ac power was restored. Thus, an additional operator error has been committed since core damage. The probability that the operators successfully align the condensate system is lower for this case than for the previous case. The quantification for this case is:

Branch 1: E4nLPI - 0.322
Branch 2: E4-LPI - 0.678
Branch 3: E4-HPI - 0.000

Case 6: The accident sequence is a short-term SBO. The RPV is at low pressure, and ac power, which was initially unavailable, is now restored. HPCS, LPCS, and LPCI have all failed. The condensate system is available, but the operators must manually align the system before coolant can be provided to the RPV. The operators successfully turned the HIS off once ac power was recovered. Thus, there have not been any previous operator errors, and there is a high probability that the operators will successfully align the condensate system. The quantification for this case is:

Branch 1: E4nLPI - 0.064
Branch 2: E4-LPI - 0.936
Branch 3: E4-HPI - 0.000

Case 7: This case is the same as the previous case except that the operators failed to turn the HIS off once ac power was restored. Thus, an operator error has been committed since core damage. The probability that the operators successfully align the condensate system is lower for this case than for the previous case. The quantification for this case is:

Branch 1: E4nLPI - 0.128
Branch 2: E4-LPI - 0.872
Branch 3: E4-HPI - 0.000

Case 8: The accident sequence is a short-term SBO. The RPV is at low pressure and either ac power is unavailable or HPCS, LPCS, LPCI, and the condensate system have all failed. The FWS is the only remaining backup coolant injection system that is available. The operators must manually align this system. For the case in which ac power is recovered, the operators turned off the HIS. Thus, there have not been any previous operator errors, and there is a high probability that the operators will successfully align the FWS. The quantification for this case is:

Branch 1: E4nLPI - 0.128
Branch 2: E4-LPI - 0.872
Branch 3: E4-HPI - 0.000

Case 9: The accident sequence is a short-term SBO. The RPV is at low pressure, and ac power has been restored. HPCS, LPCS, LPCI, and the condensate system have all failed. The FWS is the only remaining backup coolant injection system that is available. This case is similar to the previous case except that the operators failed to turn the HIS off once ac power was recovered. Because of this previous operator error, the probability that the operator will successfully align the FWS is reduced. The quantification for this case is:

Branch 1: E4nLPI - 0.256
Branch 2: E4-LPI - 0.744
Branch 3: E4-HPI - 0.000

Case 10: This case includes short-term SBOs that have no available coolant injection systems and long-term SBOs that do not have ac power. For the long-term SBOs the FWS may be available, but the probability that the operators will use it in this sequence is assumed to be negligible. To get to core damage in a long-term SBO, the operators have already failed to use the FWS as an injection source. The quantification for this case is:

Branch 1: E4nLPI - 1.0
Branch 2: E4-LPI - 0.0
Branch 3: E4-HPI - 0.0

Question 29. Is the Core in a Critical Configuration Following Injection Recovery?
2 Branches, Type 2, 3 Cases

The branches for this question are:

1. E4-Crit The core becomes critical following injection recovery.

2. E4nCrit The core is subcritical.

This question is not sampled and was internally quantified. The branching at this question depends upon the branch taken at Questions 1, 2, 3, and 28.

This question determines whether the core becomes critical following coolant injection recovery. In a boiling water reactor (BWR), the control rods consist of boron carbide (B_4C) compacted in stainless steel tubes. The control rod material melts at approximately 1500 K, considerably lower than the core relocation temperature (approximately 2450 K). Therefore, during core degradation, it is expected that the control blades will be among the first material to relocate. With a significant fraction of the control blades removed and the core geometry intact, the potential exists for the core to go critical once water is restored to the vessel. This situation will always arise during an ATWS event when coolant injection is restored to the RPV (the control rods are never in the core during an ATWS event). There are several mechanisms, however, that will tend to reduce the probability that the core will become recritical. First, when the cold water is injected into the hot core, it is likely that the core will shatter and form a rubble bed. Similarly, if coolant is not restored to the RPV until after core collapse, the core will again be in the form of a rubble bed. The probability that the resulting rubble bed of core debris will become recritical is low because it is more likely to be undermoderated than the nominal geometry. Finally, the SLC system can be used to inject boron into the vessel and thereby bring the core to a subcritical condition. If the core does become critical, it is assumed that the accident progresses to vessel failure (i.e., the core is not coolable). (A detailed discussion of this subject and the case structure used in this question can be found in Volume 2, Part VI, of this report.)

Case 1: The accident sequence is an ATWS that has had coolant injection restored to the core. Because the control rods fail to insert during the ATWS event and the operators have failed to initiate the SLC system, the possibility exists that the core will go critical. The quantification for this case is:

Branch 1:	E4-Crit	-	0.1
Branch 2:	E4nCrit	-	0.9

Case 2: This case includes all accident sequences that are not initiated by an ATWS event and that have had coolant injection restored to the core. In this case, the operators can use the SLC as a method to control the core reactivity. There is some small probability, however, that the operators will fail to use this system. The quantification for this case is:

Branch 1:	E4-Crit	-	0.01
Branch 2:	E4nCrit	-	0.99

Case 3: Coolant injection has not been restored to the core, and therefore, recriticality is not a concern. Because the core is not

being cooled, this case will always lead to vessel failure. The quantification for this case is:

Branch 1: E4-Crit - 0.0
Branch 2: E4nCrit - 1.0

Question 30. What Is the Status of Containment Sprays?
4 Branches, Type 2, 5 Cases

The branches for this question are:

1. E4fCS The containment sprays are failed and cannot be recovered.

2. E4rCS The sprays are recoverable when ac power is restored.

3. E4aCS The sprays are available but not currently operating.

4. E4-CS The sprays are operating.

This question is not sampled and was internally quantified. The branching at this question depends upon the branch taken at Questions 1, 13, 15, 20, and 24.

This question determines the status of the CS during core damage. A description of CS system is presented in Question 13.

Case 1: The CS system failed before core damage and is therefore not available during core damage. The quantification for this case is:

Branch 1: E4fCS - 1.00
Branch 2: E4rCS - 0.00
Branch 3: E4aCS - 0.00
Branch 4: E4-CS - 0.00

Case 2: The CS system was in recoverable condition before core damage. Because ac power is not recovered during core damage, this system remains recoverable. The quantification for this case is:

Branch 1: E4fCS - 0.00
Branch 2: E4rCS - 1.00
Branch 3: E4aCS - 0.00
Branch 4: E4-CS - 0.00

Case 3: The PDS is a long-term ATWS, and the containment sprays were previously available. Thus, a considerable amount of steam has been generated from the hot pool, and the containment pressure is high enough to trigger the sprays. There is some small probability that this system will fail. The quantification for this case is:

Branch 1: E4fCS - 0.00
Branch 2: E4rCS - 0.00

Branch 3: E4aCS - 0.01
Branch 4: E4-CS - 0.99

Case 4: The CS system was either previously available; or the system was recoverable, and ac power has been restored. The PDS is a long-term SBO. Thus, a considerable amount of steam has been generated from the hot pool, and the containment pressure is high enough to trigger the sprays. There is some small probability that this system will fail. The quantification for this case is:

Branch 1: E4fCS - 0.00
Branch 2: E4rCS - 0.00
Branch 3: E4aCS - 0.01
Branch 4: E4-CS - 0.99

Case 5: This case includes all of the short-term PDSs and the long-term T2. In the short-term PDSs, the suppression pool remains subcooled. In the long-term T2, the RHR system is used to cool the pool. Thus, the containment pressure is not high enough to require the sprays. The quantification for this case is:

Branch 1: E4fCS - 0.00
Branch 2: E4rCS - 0.00
Branch 3: E4aCS - 1.00
Branch 4: E4-CS - 0.00

Question 31. What Amount of Oxygen Is in the Wetwell During Core Degradation?
1 Branch, Type 3, 2 Parameters

The branch for this question is:

1. O2WW The amount of oxygen in the wetwell during core degradation.

The parameters initialized in this question are:

P9 O2WW The amount of oxygen in the wetwell (kg-moles) is read in as Parameter 9.

P44 N2WW The amount of nitrogen in the wetwell (kg-moles) is read in as Parameter 44.

This question is not sampled and was internally quantified. To determine the amount of oxygen and nitrogen in the containment, it was assumed that the containment atmosphere was an ideal gas that consisted of air with a relative humidity of 100%. Also, it was assumed that the containment pressure and temperature were 14.7 psia and 90°F, respectively.

The assignment of the parameters (kg-moles) is:

Parameter 9: O2WW - 316
Parameter 44: N2WW - 1191

Question 32. What Amount of Oxygen Is in the Drywell During Core Damage?
1 Branch, Type 3, 1 Parameter

The branch for this question is:

1. O2DW The amount of oxygen in the drywell during core degradation.

The parameter initialized in this question is:

P10 O2DW The amount of oxygen in the drywell (kg-moles) is read in as Parameter 10.

This question is not sampled and was internally quantified. The amount of oxygen in the drywell was determined by multiplying the amount of oxygen in the containment by the ratio of the drywell volume to the wetwell volume. This neglects the temperature difference between the two volumes, but this is a relatively minor effect.

The value assigned to the parameter (kg-moles) is:

Parameter 10: O2DW - 61

Question 33. What Amount of Steam Is Present in the Containment at Core Damage?
1 Branch, Type 4, 1 Parameter, 6 Cases

The branch for this question is:

1. H2OWW The amount of steam in the wetwell during core degradation.

The parameter initialized in this question is:

P1 H2OWW The amount of steam in the wetwell (kg-moles) is read in as Parameter 1.

This question is not sampled and was internally quantified. The parameter initialized in this question depends upon the branch taken at Questions 1, 2, 10, 13, 14, 15, 16, 20, and 22.

This question initializes the amount of steam in the containment during core damage.

Case 1: There is a pre-existing rupture or the operators vented the containment before core degradation. For this analysis, it was estimated that there are no pre-existing containment failures (i.e., isolation failure) that are the size of a rupture. In addition, in this analysis, the only scenario in which the operators will vent the containment before core degradation is during a long-term ATWS PDS. The only other scenarios that would require venting are the long-term SBOs, and in these plant damage states, ac power is not available before core degradation. Thus, this case corresponds to a long-term ATWS PDS in which the containment was vented before core damage. Because the containment has been vented, it is assumed to be at atmospheric pressure. In addition, it is assumed that the air has been purged out of the containment by the steam. Thus, the containment atmosphere consists only of steam. The value assigned to the parameter (kPa) is:

Parameter 1: H2OWW - 1582

Case 2: The PDS is a long-term ATWS in which the operators have failed to vent the containment. Because the energy input to the suppression pool during this accident exceeds the capacity of the suppression pool cooling system, the pool becomes saturated. The steam released from the saturated pool pressurizes the containment to the point that it eventually fails. The failure of the containment occurs before core damage. Because the containment has failed, it is assumed to be at atmospheric pressure. In addition, it is assumed that the air has been purged out of the containment by the steam. Thus, the containment atmosphere consists only of steam. The value assigned to the parameter (kPa) is:

Parameter 1: H2OWW - 1582

Case 3: The containment spray system in conjunction with the RHR heat exchangers is used to cool the containment atmosphere. Because the containment atmosphere is being cooled, it is assumed that the containment pressure and temperature are 14.7 psia and 90°F, respectively. To estimate the amount of steam in the containment, it is assumed that the atmosphere behaves as an ideal gas and that it consists of air with a relative humidity of 100%. The value assigned to the parameter (kPa) is:

Parameter 1: H2OWW - 75

Case 4: The PDS is a very long-term SBO (core damage occurs in approximately 18 hours) in which ac and dc power are lost and cannot be recovered. Because this is a long-term SBO, the suppression pool cooling system is not available, and the pool becomes saturated before core damage. Extrapolation of a BWRLTAS run with RCIC injection, presented in NUREG/CR-4550^{A-1}, indicates that the containment pressure will be 498 kPa after 18 hours. To estimate the amount of steam in the containment, it is assumed that the total pressure is the sum of the partial pressures of air and steam, that the air behaves as an ideal gas, and that the pool and the containment atmosphere are in equilibrium. The partial pressure of steam is assumed to correspond to the saturation pressure of steam based on the temperature of the pool. The temperature of the pool is determined such that when the saturation pressure of steam is added to the partial pressure of air, both of which are based on the pool temperature, the sum equals the total pressure in the containment. The value assigned to the parameter (kPa) is:

Parameter 1: H2OWW - 4235

Case 5: The PDS is a long-term SBO (core damage occurs in approximately 12 hours) and the containment sprays are not operating. The containment pressure at 12 hours is obtained from a BWRLTAS run with RCIC injection presented in NUREG/CR 4550.[A-1] The amount of steam in the containment is obtained using the same method that was applied in the previous case. The value assigned to the parameter (kPa) is:

Parameter 1: H2OWW - 2200

Case 6: Core damage occurs in the short term (in approximately 1 hour), so the suppression pool remains subcooled. Because the containment atmosphere remains cool, it is assumed that the containment pressure and temperature are 14.7 psia and 90°F, respectively. To estimate the amount of steam in the containment, it is assumed that the atmosphere behaves as an ideal gas and that it consists of air with a relative humidity of 100%. The value assigned to the parameter (kPa) is:

Parameter 1: H2OWW - 75

Question 34. What Amount of Steam Is Present in the Drywell at Core Damage?
1 Branch, Type 4, 1 Parameter, 6 Cases

The branch for this question is:

1. H2ODW The amount of steam in the drywell during core degradation.

The parameter initialized in this question is:

P6 H2ODW The amount of steam in the drywell (kg-moles) is read in as Parameter 1.

This question is not sampled and was internally quantified. The parameter initialized in this question depends upon the branch taken at Questions 1, 2, 10, 13, 14, 15, 20, and 23.

This question initializes the amount of steam in the drywell during core damage. In all the cases except for the first, the amount of steam in the drywell was determined by multiplying the amount of steam in the containment by the ratio of the drywell volume to the wetwell volume. This neglects the temperature difference between the two volumes, but this is a relatively minor effect. The assumptions used in Case 1 are discussed in the description of the case. This question's case structure is very similar to that used in Question 33. The only difference is the first case in both questions. Thus, for a detailed description of the cases the reader is directed to Question 33.

Case 1: A SRV tailpipe vacuum breaker is stuck open. This vacuum breaker is located in the drywell. Some of the steam that is being blown down to the suppression pool enters the drywell through this vacuum breaker. It is assumed that this steam purges all of the air out of the drywell such that the drywell atmosphere consists only of steam. The pressure in the drywell is assumed to be atmospheric. The value assigned to the parameter (kPa) is:

Parameter 6: H2ODW - 305

Case 2: The PDS is a long-term ATWS. This case is the same as Case 2 in Question 33. The value assigned to the parameter (kPa) is:

Parameter 6: H2ODW - 223

Case 3: The containment spray system is operating with water passed through the RHR heat exchangers (i.e., cold spray). The PDS is not a long-term ATWS. Thus, the suppression pool is subcooled and the sprays are removing most of the steam from the containment atmosphere. This case is the same as Case 3 in Question 33. The value assigned to the parameter (kPa) is:

Parameter 6: H2ODW - 14.5

Case 4: This case corresponds to a very long-term SBO. This case is the same as Case 4 in Question 33. The value assigned to the parameter (kPa) is:

Parameter 6: H2ODW - 817

Case 5: This case corresponds to a long-term SBO in which the containment sprays are not available. This case is the same as Case 5 in Question 33. The value assigned to the parameter (kPa) is:

Parameter 6: H2ODW - 424

Case 6: This case includes accidents in which core damage occurs in the short term (i.e., 1 hour). For these accidents, the suppression pool remains subcooled, so there is only a small amount of steam in the containment atmosphere. This case is the same as Case 6 in Question 33. The value assigned to the parameter (kPa) is:

Parameter 6: H2ODW - 14.5

Question 35. What Is the Total Amount of Hydrogen Released In-Vessel During Core Degradation?
1 Branch, Type 4, 1 Parameter, 6 Cases

The branch for this question is:

1. H2INVES The amount of hydrogen released in-vessel during core degradation.

The parameter initialized in this question is:

P2 H2INVES The amount of hydrogen release in-vessel (kg-moles) is read in as Parameter 2.

The parameter initialized in this question is sampled. The distribution for the amount of hydrogen release in-vessel was provided by the In-Vessel Phenomenology Expert Panel. (A discussion of this issue is presented in Volume 2, Part I, of this report). The parameter initialized in this question depends upon the branch taken at Questions 1, 14, 26, and 28.

The expert panel considered only hydrogen production for short-term SBOs and short-term ATWSs. It is estimated that differences in the in-vessel phenomenology associated with short-term PDSs and long-term PDSs are minor in terms of their effect on hydrogen production. In addition, the melt progression for the T2 PDSs is essentially the same as the SBOs. Thus, the distributions provided by the experts for the short-term accidents are also used for the equivalent long-term accidents. Furthermore, the distributions used for SBO PDSs are also used for T2 PDSs.

Case 1: The PDS is either a short-term or a long-term ATWS. The RPV is at high pressure and the high pressure injection systems are not available. Thus, core damage begins with the RPV at high pressure. During core damage, the operators depressurize the RPV, which allows the low pressure injection systems to provide coolant to the core. The mean value (kg-moles) of the aggregate distribution provided by the expert panel for this case is:

Parameter 2: H2INVES - 222

Case 2: This case is the same as the previous case except that the operators do not depressurize the RPV, so the low-pressure injection system cannot be used to provide coolant to the RPV. Thus, core damage proceeds to VB without injection being restored to the RPV. The mean value (kg-moles) of the aggregate distribution provided by the expert panel for this case is:

Parameter 2: H2INVES - 461

Case 3: The PDS is not an ATWS. The RPV is at high pressure at the onset of core damage. During core damage (i.e., the time period from the onset of core damage to the time that VB would have occurred if injection had not been restore) however, the vessel is depressurized, and coolant injection is restored to the RPV. The restoration of coolant injection to the RPV during core damage does not necessarily preclude VB. The issue of VB is considered by Questions 62 and 63. The mean value (kg-moles) of the aggregate distribution provided by the expert panel for this case is:

Parameter 2: H2INVES - 333

Case 4: The PDS is not an ATWS. The RPV is depressurized at the onset of core damage. Coolant injection is restored to the RPV during core damage. The mean value (kg-moles) of the aggregate distribution provided by the expert panel for this case is:

Parameter 2: H2INVES - 283

Case 5: The PDS is not an ATWS. The RPV is at high pressure, and coolant injection is not restored before VB. The mean value (kg-moles) of the aggregate distribution provided by the expert panel for this case is:

Parameter 2: H2INVES = 450

Case 6: The PDS is not an ATWS. The RPV is at low pressure, and coolant injection is not restored before VB. The mean value (kg-moles) of the aggregate distribution provided by the expert panel for this case is:

Parameter 2: H2INVES = 466

Question 36. What Is the Level of In-Vessel Zirconium Oxidation?
7 Branches, Type 5, 1 Case

The branches for this question are:

1.	ZrOx75	More than 75% of the in-vessel zirconium is oxidized before VB.
2.	ZrOx50	Between 50% and 75% of the in-vessel zirconium is oxidized before VB.
3.	ZrOx40	Between 40% and 50% of the in-vessel zirconium is oxidized before VB.
4.	ZrOx30	Between 30% and 40% of the in-vessel zirconium is oxidized before VB.
5.	ZrOx21	Between 21% and 30% of the in-vessel zirconium is oxidized before VB.
6.	ZrOx10	Between 10% and 21% of the in-vessel zirconium is oxidized before VB.
7.	ZrOx<10	Less than 10% of the in-vessel zirconium is oxidized before VB.

This question is a summary of the amount of hydrogen produced in-vessel before VB. The amount of hydrogen produced is represented by the equivalent amount of zirconium that must be oxidized to produce this amount of hydrogen. In this question, the range of possible zirconium oxidation is divided into discrete levels represented by the seven branches. The various amounts of hydrogen produced in-vessel (Parameter 2) are then grouped into the appropriate levels. To do this grouping, the amount of hydrogen, Parameter 2, is compared with a series of comparison parameters that represent various levels of zirconium oxidation. By doing this grouping, the probabilities of the various levels of zirconium oxidation can be determined. Furthermore, by representing zirconium oxidation by a branch in this question, zirconium oxidation can be used in the case structure in subsequent questions (i.e., the probability or parameter assigned in a subsequent question can be made dependent on the level of zirconium oxidized assigned in this question). It should be noted that the overpressure associated with a hydrogen burn is determined by the actual value assigned to Parameter 2 and not by a level defined in this question. These levels are used only to summarize the amount of hydrogen produced.

Question 37. What Is the Containment Pressure During Core Damage?
3 Branches, Type 6, 7 Cases

The branches for this question are:

1. E1P>3 The containment pressure during core damage is greater than 300 kPa.

2. E1P>2 The containment pressure is between 200 kPa and 300 kPa.

3. E1P>1 The containment pressure is between 100 kPa and 200 kPa.

This question is not sampled and was internally quantified. The branching at this question depends upon the branch taken at Questions 1, 2, 10, 13, 14, 15, 16, 20, 22, and 30. The containment pressure is based on the amount of air, steam, and hydrogen present in the containment volume. Modules in the user function subroutine are used to calculate the pressure.

Case 1: There is either a pre-existing rupture, or the operators vented the containment before core degradation. The containment pressure is assumed to be at atmospheric pressure (14.7 psia).

Case 2: The PDS is a long-term ATWS in which the operators have failed to vent the containment. Because the energy input to the suppression pool during this accident exceeds the capacity of the suppression pool cooling system, the pool becomes saturated. The steam released from the saturated pool pressurizes the containment to the point that it eventually fails. The failure of the containment occurs before core damage. Because the containment has failed, it is assumed to be at atmospheric pressure.

Case 3: The CS system in conjunction with the RHR heat exchangers is used to cool the containment atmosphere. Because the containment atmosphere is being cooled, it is assumed that its temperature is 90°F. To estimate the containment pressure, it is assumed that the containment atmosphere behaves as an ideal gas that consists of air (Parameters 9 and 44), steam (Parameter 1), and hydrogen (Parameter 2).

Case 4: The PDS is a long-term SBO (core damage occurs in approximately 12 hours), and for this case, the containment sprays are recovered during core degradation. The sprays are accounted for in this question by making sure that the steam concentration is less than 55%, which then allows for the possibility of a hydrogen deflagration. The containment pressure at 12 hours (i.e., without hydrogen) was obtained from a BWRLTAC run with RCIC injection.[A-1] The amount of steam in the containment was determined in Question 33 (Parameter 1). If the concentration of steam is above 55% after the hydrogen is release to the containment, the amount of steam is reduced until its concentration is 55%. The pressure in the containment is then adjusted to account for this reduction in steam and also for the addition of the hydrogen.

Case 5: The PDS is a very long-term SBO (core damage occurs in approximately 18 hours) in which ac and dc power are lost and cannot be recovered. The containment pressure at 18 hours (i.e, without hydrogen) was based on an extrapolation of a BWRLTAS run with RCIC injection.[A-1] The amount of steam in the containment was determined in Question 33 (Parameter 1). The ratio of the number of moles in the containment after the hydrogen is released to the number of moles in the containment without the hydrogen is used to adjust the pressure to account for the addition of the hydrogen.

Case 6: The PDS is a long-term SBO (core damage occurs in approximately 12 hours), and the containment sprays are not operating. The containment pressure at 12 hours (i.e., without hydrogen) was obtained from a BWRLTAS run with RCIC injection.[A-1] The ratio of the number of moles in the containment after the hydrogen is released to the number of moles in the containment without the hydrogen is used to adjust the pressure to account for the addition of the hydrogen.

Case 7: Core damage occurs in the short term (in approximately 1 hour), so the suppression pool remains subcooled. Because the containment atmosphere is being cooled, it is assumed that its temperature is 90°F. To estimate the containment pressure, it is assumed that the containment atmosphere behaves as an ideal gas that consists of air (Parameters 9 and 44), steam (Parameter 1), and hydrogen (Parameter 2).

Question 38. **What Is the Level of Containment Leakage due to Slow Pressurization Before VB?**
4 Branches, Type 6, 4 Cases

The branches for this question are:

1. ESPnCL The containment does not fail from slow pressurization.
2. ESP-CL2 The containment fails in the leak mode; nominal hole size is 0.1 ft^2.
3. ESP-CL3 The containment fails by rupture; nominal hole size is 7 ft^2.
4. ESP-CL4 The containment fails by catastrophic rupture. This failure mechanism does not occur in this analysis but has been retained in the tree for completeness.

The branching at this question depends upon the branch taken at Questions 1, 2, 14, 15, 16, and 22. A module in the user function is used to determine whether the containment fails and, if so, the mode of failure. In the user function, the containment pressure (Parameter 5) is compared to the containment failure pressure (Parameter 21).

The way the random number is used to determine the mode of containment failure is described in Subsection A.2. The method differs depending on whether the rate of pressure rise is fast or slow relative to the rate at which a leak depressurizes the containment. For slow pressure rise, which this question corresponds to, there is a conditional probability for each failure mode that is a function of failure pressure. The random number is used to select the mode based on these conditional probabilities. For fast pressure rise, the conditional probability for each failure mode depends on both the failure pressure and the load pressure, since the development of a leak at the failure pressure will not arrest the pressure rise.

Case 1: There is either a pre-existing rupture or the operators vented the containment before core degradation. In either case, the hole size corresponds to a rupture.

Case 2: The PDS is a long-term ATWS in which the operators have failed to vent the containment. Because the energy input to the suppression pool during this accident exceeds the capacity of the suppression pool cooling system, the pool becomes saturated. The steam released from the saturated pool pressurizes the containment to the point where it eventually fails. The user function is used to determine the mode of failure.

Case 3: The PDS is a very long-term SBO (core damage occurs in approximately 18 hours) in which ac and dc power are lost and cannot be recovered.

Case 4: This case covers all of remaining PDSs. In these PDSs, the initial pressure is not high enough to threaten the containment.

Question 39. **What Is the Maximum Hydrogen Concentration in the Wetwell Before VB?**
6 Branches, Type 6, 7 Cases

The branches for this question are:

1.	HWW>20	The H_2 concentration is in the range $H_2 \geq 20\%$.
2.	HWW>16	The H_2 concentration is in the range $16\% \leq H_2 < 20\%$.
3.	HWW>12	The H_2 concentration is in the range $12\% \leq H_2 < 16\%$.
4.	HWW>8	The H_2 concentration is in the range $8\% \leq H_2 < 12\%$.
5.	HWW>4	The H_2 concentration is in the range $4\% \leq H_2 < 8\%$.
6.	NoHWW	The H_2 concentration is in the range $H_2 < 4\%$.

The branching at this question depends upon the branch taken at Questions 16, 17, 20, 23, and 38. A module in the user function is used to determine the hydrogen concentration in the wetwell based on the amount of air (Parameters 9 and 44), steam (Parameter 1), and hydrogen (Parameter 2), and on the condition of the containment and drywell. The amount of hydrogen that remains in the wetwell is stored as Parameter 3

It is assumed that all the hydrogen generated in the RPV before VB is released from the vessel. Typically, the hydrogen released from the vessel passes through the SRV tailpipes and is discharged into the suppression pool. Once in the suppression pool, the hydrogen passes directly into the wetwell volume. However, there are several pathways from which the hydrogen can leave or be diverted from the wetwell. Some of the hydrogen can enter the drywell, or if there is a failure of the containment structure, it can leak out to the atmosphere. There are two ways that hydrogen can enter the drywell before VB. The first path is through the SRV tailpipe vacuum breakers. On each SRV tailpipe is a vacuum breaker used to prevent pool water from being sucked up into the tailpipe. These vacuum breakers are located in the drywell. If a vacuum breaker sticks open, a portion of the hydrogen passed through the tailpipe is released directly into the drywell. The second way hydrogen can enter the drywell is if there is a large, pre-existing hole in the drywell structure (e.g., failure of the drywell vacuum breakers). Hydrogen that is in the wetwell can pass back into the drywell via this path. If there is only a small hole in the drywell, the amount of hydrogen leaked from the wetwell is negligible and has therefore been neglected. Similarly, if the mode of containment failure is a leak, the amount of gases released from the containment to the atmosphere has been neglected.

Case 1: The PDS is a long-term ATWS, so the containment is failed. In addition, for this case, a tailpipe vacuum breaker is stuck open. Because the containment failed early, it is assumed that all of the air has been purged out of the containment and that a fraction of the hydrogen is also released from the containment. The effect of the stuck-open tailpipe vacuum breaker is that some of the hydrogen is released directly to the drywell volume.

Case 2: The containment has been ruptured, and there is a stuck-open tailpipe vacuum breaker. As in the previous case, the effect is that some of the hydrogen is released directly to the drywell volume. Because the containment failed during core damage, a fraction of the gases in the wetwell were released from the containment. It is assumed that all of the hydrogen is released to the wetwell volume before the containment fails. Once the containment fails, a portion of the wetwell gas is released from the containment such that the containment pressure is reduced to atmospheric. The composition of the released gas is the same as that of the gas that remains in the containment.

Case 3: The PDS is a slow ATWS, and there are no stuck-open tailpipe vacuum breakers. This case is the same as Case 1 except that none of the hydrogen is released directly to the drywell volume.

Case 4: The containment has been ruptured, and there are no stuck-open tailpipe vacuum breakers. This case is the same as Case 2 except that none of the hydrogen is released directly to the drywell volume.

Case 5: The containment is intact or only leaking, and there is a stuck-open tailpipe vacuum breaker. Thus, some of the hydrogen is released directly to the drywell volume.

Case 6: The drywell structure has been ruptured. Thus, some the hydrogen initially released to the wetwell volume leaks into the drywell volume.

Case 7: Both the containment and the drywell are intact or have only a small leak, and there are no stuck-open tailpipe vacuum breakers. Thus, the hydrogen that is released from the vessel into the wetwell remains in the wetwell.

Question 40. **To What Level Is the Wetwell Inert During Core Degradation?**
3 Branches, Type 5, 1 Case

The branches for this question are:

1.	E4nWIn	The wetwell is not inert; both hydrogen deflagrations and detonations are possible.
2.	E4-WIn2	The wetwell is inert to hydrogen detonations.
3.	E4-WIn3	The wetwell is inert to both hydrogen detonations and deflagrations.

This question determines whether hydrogen detonations or deflagrations are possible in the wetwell before VB. A module in the user function is used to calculate the mole fraction of steam, Y_{steam}, in the wetwell. Sherman and Slezak[A-4] report that experimental results indicate that stoichiometric hydrogen-air-steam mixtures with up to 35% steam can detonate. They also report that the inerting mole fraction of steam, which is believed to be independent of scale, is about 55%. Based on these values, the inerting limits used in this analysis are:

$Y_{steam} \geq 0.55$; Inert to detonations and deflagrations

$0.55 > Y_{steam} \geq 0.35$; Inert to detonations

$0.35 > Y_{steam}$; Both detonations and deflagrations are possible

The wetwell is also considered inert to hydrogen combustion if the mole fraction of oxygen is less than 0.05.

Question 41. **Do Diffusion Flames Consume the Hydrogen Released Before VB?**
2 Branches, Type 2, 6 Cases

The branches for this question are:

1.	E4-Dif	The hydrogen burns as a diffusion flame.
2.	E4nDif	The hydrogen does not burn as a diffusion flame.

Cases 3, 4, and 5 of this question are sampled; the distributions were quantified internally. The branching at this question depends upon the branch taken at Questions 2, 20, 21, 24, 27, and 40.

This question determines whether the hydrogen ignites sufficiently early, that is, before a large amount of hydrogen accumulates in the wetwell, such that the pressure rise associated with the combustion is benign. Once a diffusion flame occurs, there will be numerous ignition sources in the containment (hot surfaces, burning debris). Thus, if a diffusion flame occurs, all the hydrogen released to the wetwell before VB is burned benignly. If the HIS is operating before core damage, the hydrogen will burn as a diffusion flame.

Case 1: Either the wetwell is inert to hydrogen combustion, or the PDS is a long-term ATWS. All the oxygen is purged out of the containment before core damage during a long-term ATWS. In either case, diffusion flames are not possible. The quantification for this case is:

Branch 1: E4-Dif	-	0.00
Branch 2: E4nDif	-	1.00

Case 2: The PDS is not an SBO, and the HIS was turned on before core damage. Thus, the HIS is operating while the hydrogen is being released to the wetwell. The hydrogen will therefore burn as a diffusion flame. The quantification for this case is:

Branch 1: E4-Dif	-	1.00
Branch 2: E4nDif	-	0.00

Case 3: The PDS is not an SBO. Thus, ac power is available, but the operators failed to turn the HIS on. The hydrogen can still be ignited by ac sources. However, it is not certain that the hydrogen will be ignited before a large amount of hydrogen accumulates in the containment. Although it is felt that the hydrogen is more likely than not to burn as a diffusion flame, it is still possible that the hydrogen will not be ignited until a large amount of it has accumulated in the containment. Thus, for this case, a uniform distribution between 0.5 and 1.0 was used to characterize the probability that the hydrogen will burn as a diffusion flame. The quantification for this case, based on the mean value of this distribution, is:

Branch 1: E4-Dif	-	0.75
Branch 2: E4nDif	-	0.25

Case 4: The PDS is an SBO. AC power is recovered during core damage, and the operators turned the HIS on. Thus, if ac power is recovered early enough, the hydrogen will be burned benignly. If, however, ac power is recovered after a substantial amount of hydrogen has accumulated in the wetwell, the burn could threaten the integrity of the containment. It is estimated that from the start of core damage, there is a 15-minute time window in which the hydrogen can be ignited and still burn as a diffusion flame. After this point, there is a rapid escalation in the production of hydrogen. The probability that

the hydrogen will burn as a diffusion flame is based on the probability that ac power is recovered within 15 minutes from the start of core damage. This probability is calculated from the offsite power recovery curves for the Grand Gulf plant. The quantification for this case, based on the mean value of the distribution, is:

Branch 1: E4-Dif - 0.12
Branch 2: E4nDif - 0.88

Case 5: The PDS is an SBO. AC power is recovered during core damage, but the HIS is not operating. Thus, the ignition sources are those associated with ac power. To reflect the fact that the ac sources are not as reliable an ignition source as the HIS, the probability of a diffusion flame for this case is half the probability used in the previous case. The quantification for this case, based on the mean value of the distribution, is:

Branch 1: E4-Dif - 0.06
Branch 2: E4nDif - 0.94

Case 6: The PDS is an SBO, and ac power is not recovered during core damage. Thus, there are only random ignition sources. The probability that the hydrogen is ignited at a low concentration from these sources is negligible. The quantification for this case is:

Branch 1: E4-Dif - 0.00
Branch 2: E4nDif - 1.00

Question 42. What Is the Maximum Hydrogen Concentration in the Drywell Before VB?
6 Branches, Type 6, 6 Cases

The branches for this question are:

1. HDW>20 The H_2 concentration is in the range $H_2 \geq 20\%$.
2. HDW>16 The H_2 concentration is in the range $16\% \leq H_2 < 20\%$.
3. HDW>12 The H_2 concentration is in the range $12\% \leq H_2 < 16\%$.
4. HDW>8 The H_2 concentration is in the range $8\% \leq H_2 < 12\%$.
5. HDW>4 The H_2 concentration is in the range $4\% \leq H_2 < 8\%$.
6. NoHDW The H_2 concentration is in the range $H_2 < 4\%$.

The branching at this question depends upon the branch taken at Questions 16, 17, 20, 23, 38, and 41. A module in the user function is used to determine the hydrogen concentration in the drywell based on the amount of air (Parameter 10), steam (Parameter 6), and hydrogen (Parameter 2), and on the condition of the containment and drywell. The amount of hydrogen that remains in the drywell is stored as Parameter 4.

There are two ways that hydrogen can enter the drywell before VB. The first path is through the SRV tailpipe vacuum breakers. On each SRV tailpipe is a vacuum breaker used to prevent pool water from being sucked up into the tailpipe. These vacuum breakers are located in the drywell. If a vacuum breaker sticks open, a portion of the hydrogen being passed through the tailpipe is released directly into the drywell. The second way hydrogen can enter the drywell is if there is a pre-existing hole in the drywell structure (e.g., failure of the drywell vacuum breakers). Hydrogen that is in the wetwell can pass back into the drywell via this path. However, if the hydrogen in the wetwell burns as a diffusion flame, it is assumed that none of the hydrogen is able to leak back into the drywell before the burn occurs.

It is estimated that significant hydrogen burns will not occur in the drywell during core damage, regardless of the hydrogen concentration. If the HIS is operating (there are igniters in the drywell), the hydrogen will be burned as it accumulates, and the pressure rise will be negligible. The dominant pathway for a large amount of hydrogen to enter the drywell is through a stuck-open tailpipe vacuum breaker. Not only does hydrogen enter the drywell via this pathway, but so does a large amount of steam. As the drywell is pressurized, this mixture of steam, hydrogen, and air is vented through the suppression pool and into the wetwell. Thus, the oxygen is being depleted from the drywell. Scoping calculations performed with MELCOR[A-5] indicate that there is only a very brief period of time in which the drywell atmosphere would be combustible. The probability that the hydrogen would ignite during this time period is estimated to be negligible. It is also possible that the hydrogen will autoignite as it is released from the hot vacuum breaker. If it does burn as it is released from the vacuum breakers, the accompanying pressure rise will be relatively benign (i.e., will not threaten the drywell structure). In this analysis, there are no pre-existing ruptures. Although a pre-existing rupture could potentially result in a significant quantity of hydrogen in the drywell, a burn in the drywell for this case is not important because the drywell is already ruptured. For these reasons, burns in the drywell before VB are not explicitly treated.

The case structure used in this question is very similar to the case structure used in Question 39. Question 39 determined the hydrogen concentration in the wetwell, whereas this question determines the hydrogen concentration in the drywell.

Case 1: The PDS is a long-term ATWS in which a tailpipe vacuum breaker is stuck open. In this PDS, the containment fails before core damage. Thus, it is assumed that all of the air has been purged out of both the wetwell and the drywell. The effect of the stuck open tailpipe vacuum breaker is that some of the hydrogen is released directly to the drywell volume. Thus, the drywell atmosphere is at atmospheric pressure and consists of hydrogen and steam.

Case 2: The containment has been ruptured, and there is a stuck-open tailpipe vacuum breaker. As in the previous case, the effect of the stuck-open tailpipe vacuum breaker is that some of the hydrogen is released directly to the drywell volume. Because the containment fails during core damage, a fraction of the gases in the drywell are removed such that the pressure of the drywell is reduced to atmospheric. It is assumed that all of the hydrogen released to the drywell volume enters the drywell before the containment fails. Thus, the composition of the drywell atmosphere does not change after the containment fails. Only the total number of moles of gas changes.

Case 3: The containment is intact or only leaking, but there is a stuck-open tailpipe vacuum breaker. Thus, some of the hydrogen is released directly to the drywell volume.

Case 4: The drywell structure has been ruptured, and the hydrogen does not burn as diffusion flame in the wetwell. Thus, some the hydrogen initially released to the wetwell volume leaks into the drywell volume.

Case 5: This case is the same as the previous case except that drywell structure has a leak in it rather than a rupture. Thus, the amount of hydrogen leaked back into the drywell is less for this case than it was for the previous case.

Case 6: The drywell structure is intact, and there are no stuck-open tailpipe vacuum breakers. Thus, a negligible amount of hydrogen enters the drywell.

Question 43. Do Deflagrations Occur in the Wetwell Prior To VB?
2 Branches, Type 2, 13 Cases

The branches for this question are:

1. E4-WWDf A deflagration occurs in the wetwell before VB.

2. E4nWWDf The hydrogen does not burn as a deflagration.

Cases 5 through 12 of this question are sampled. Distributions for the ignition probability were provided by the Containment Loads Expert Panel. (A discussion of this issue is presented in Volume 2, Part II, of this report). The branching at this question depends upon the branch taken at Questions 4, 14, 20, 24, 26, 39, 40, and 41.

Once the production of hydrogen begins, it continues at a rapid rate. Most of the hydrogen is produced over a fairly short time period. In this analysis, the probability of ignition and the resulting pressure rise are therefore based on the total amount of hydrogen released to the wetwell before VB. In this question, the probability of ignition depends on the following three factors: availability of ac sources, the global hydrogen concentration, and the RPV pressure. When ac power is available, numerous ac sources are potential ignition sources. Thus, it is assumed that if ac power is available and the hydrogen is in a combustible regime, it will ignite. This assumption was reviewed by the Containment Loads Expert Panel, and there were no objections. If ac power is not available, then only random ignition sources are present. The probability of ignition from random sources is a function of hydrogen concentration. The ignition probability increases with an increase in global hydrogen concentration.

To calculate the global hydrogen concentration, it is assumed that the total amount of hydrogen released to the wetwell before VB is dispersed throughout the wetwell volume. The RPV pressure affects the way the hydrogen is released from the vessel into the containment. When the RPV is at high pressure, the hydrogen is periodically released through one SRV tailpipe, so local "pockets" of hydrogen form that have hydrogen concentration higher than the global hydrogen concentration in the containment. When the RPV is at low pressure, the hydrogen is released uniformly in the suppression pool, and the size of hydrogen "pockets" is reduced accordingly. Thus, the ignition probability is generally higher when the RPV is at high pressure than when it is at low pressure.

Case 1: Either the hydrogen burned as a diffusion flame, the wetwell is inert to hydrogen combustion, or the PDS is a long-term ATWS. In any case, the hydrogen does not burn as a deflagration. The quantification for this case is:

Branch 1: E4-WWDf - 0.00
Branch 2: E4nWWDf - 1.00

Case 2: The RPV has been depressurized using the ADS, and the concentration of hydrogen in the containment is less than 4%. For this case, there is a negligible probability that the hydrogen will ignite. The quantification for this case is:

Branch 1: E4-WWDf - 0.00
Branch 2: E4nWWDf - 1.00

Case 3: AC power is available during core damage, and there is sufficient hydrogen in the wetwell to support a deflagration. Because of the availability of ac sources, it is assumed that the hydrogen will ignite. The quantification for this case is:

Branch 1: E4-WWDf - 1.00
Branch 2: E4nWWDf - 0.00

Case 4: The RPV is at high pressure or was blown down through a stuck-open SRV, and there are no ac ignition sources. The global concentration of hydrogen in the containment is less than 4%. However, because the hydrogen is being released from one SRV, the potential exists that the local concentration of hydrogen is greater than 4%. Thus, there is some probability that the hydrogen will ignite in this range. The quantification for this case, based on the mean value of the distribution, is:

Branch 1: E4-WWDf - 0.18
Branch 2: E4nWWDf - 0.82

Case 5: This case is the same as the previous case except that the global concentration of hydrogen is between 4% and 8%. The quantification for this case, based on the mean value of the distribution, is:

Branch 1: E4-WWDf - 0.23
Branch 2: E4nWWDf - 0.77

Case 6: The RPV has been depressurized using the ADS, and there are no ac ignition sources. The global concentration of hydrogen in the containment is between 4% and 8%. The quantification for this case, based on the mean value of the distribution, is:

Branch 1: E4-WWDf - 0.21
Branch 2: E4nWWDf - 0.79

Case 7: This case is the same as the Case 5 except that the global concentration of hydrogen is between 8% and 12%. The quantification for this case, based on the mean value of the distribution, is:

Branch 1: E4-WWDf - 0.28
Branch 2: E4nWWDf - 0.72

Case 8: This case is the same as Case 6 except that the global concentration of hydrogen is between 8% and 12%. The quantification for this case, based on the mean value of the distribution, is:

Branch 1: E4-WWDf - 0.28
Branch 2: E4nWWDf - 0.72

Case 9: This case is the same as Case 5 except that the global concentration of hydrogen is between 12% and 16%. The quantification for this case, based on the mean value of the distribution, is:

Branch 1: E4-WWDf - 0.39
Branch 2: E4nWWDf - 0.61

Case 10: This case is the same as Case 6 except that the global concentration of hydrogen is between 12% and 16%. The quantification for this case, based on the mean value of the distribution, is:

Branch 1: E4-WWDf - 0.38
Branch 2: E4nWWDf - 0.62

Case 11: This case is the same as Case 5 except that the global concentration of hydrogen is greater than 16%. The quantification for this case, based on the mean value of the distribution, is:

Branch 1: E4-WWDf - 0.50
Branch 2: E4nWWDf - 0.50

Case 12: This case is the same as Case 6 except that the global concentration of hydrogen is greater than 16%. The quantification for this case, based on the mean value of the distribution, is:

Branch 1: E4-WWDf - 0.49
Branch 2: E4nWWDf - 0.51

Case 13: All of the possible cases were considered by the previous 12 cases. Thus, this case should not be used.

Question 44. Is There a Detonation in the Wetwell Prior To VB?
2 Branches, Type 4, 1 Parameter, 8 Cases

The branches for this question are:

1. E4-WWDt There is a detonation in the wetwell prior to VB.

2. E4nWWDt A significant detonation does not occur in the wetwell before VB.

The parameter initialized in this question is:

P20 ImpLoad The impulse loading from a detonation (kPa-S) is read in as Parameter 20.

The detonation probabilities and the parameter initialized in this question are sampled. The distributions for the detonation frequency and the accompanying impulse load were provided by the Containment Loads Expert Panel. (A discussion of this issue is presented in Volume 2, Part II, of this report.) The branching at this question depends upon the branch taken at Questions 30, 39, 40, and 43.

The detonation probabilities used in this question are conditional on the hydrogen having already been ignited (Question 43). In this question, the probability of a detonation is a function the hydrogen concentration and the amount of steam in the wetwell atmosphere. The Containment Loads Expert Panel indicated that there was a negligible probability of a significant hydrogen detonation if the hydrogen concentration was below 12%. High and low levels of steam were considered. The high steam level corresponds to the case in which the wetwell atmosphere was initially inert to detonations (i.e., mole fraction of steam was greater than 0.35); however, the steam is slowly condensed and brought into the detonable regime by the recovery of sprays. The low steam level corresponds to the case in which the steam concentration is low enough initially to allow a detonable mixture to form.

The expert panel provided distributions for the impulse load on the drywell structure from a detonation in the wetwell. Because of the uncertainties involved with this issue and the range of the distribution, it is estimated that these distributions can also be used to characterize the load on the containment structure. Thus, Parameter 20 is not only used to quantify the impulse load on the drywell structure, it is also used to quantify the impulse load on the containment structure.

Case 1: Either the wetwell is inert to hydrogen detonations (i.e., mole fraction of steam is greater than 0.35), or the global concentration of hydrogen in the wetwell is below 12%. In either case, a hydrogen detonation is not possible. The quantification for this case is:

Branch 1: E4-WWDt - 0.00
Branch 2: E4nWWDt - 1.00

Because Branch 1 is never taken, the value assigned to the parameter for this branch is irrelevant. Because Branch 2 represents the situation in which the hydrogen does not detonate, the value for the impulse load assigned to this parameter is 0.0. In all the remaining cases, the impulse load assigned to Branch 2 will also be 0.0.

Case 2: The wetwell has a high steam concentration (i.e., slowly decreasing below 35%), and the hydrogen concentration is in the range $12\% \le H_2 \le 16\%$. The quantification for this case, based on the mean value of the distribution, is:

Branch 1: E4-WWDt - 0.22
Branch 2: E4nWWDt - 0.78

For Branch 1, the value assigned to the parameter (kPa-S), based on the mean value of the distribution, is:

Parameter 20: ImpLoad - 5.8

Case 3: The wetwell has a low steam concentration, and the hydrogen concentration is in the range $12\% \le H_2 < 16\%$. The quantification for this case is:

Branch 1: E4-WWDt - 0.00
Branch 2: E4nWWDt - 1.00

Because Branch 1 is never taken, the value assigned to the parameter for this branch is irrelevant. As explained above, the impulse load assigned to Branch 2 is 0.0.

Case 4: This case is the same as Case 2 except that the hydrogen concentration is in the range $16\% \le H_2 < 20$. The quantification for this case, based on the mean value of the distribution, is:

Branch 1: E4-WWDt - 0.25
Branch 2: E4nWWDt - 0.75

For Branch 1, the value assigned to the parameter (kPa-S), based on the mean value of the distribution, is:

Parameter 20: ImpLoad - 5.8

Case 5: This case is the same as Case 3 except that the hydrogen concentration is in the range $16\% \le H_2 < 20\%$. The quantification for this case, based on the mean value of the distribution, is:

Branch 1: E4-WWDt - 0.26
Branch 2: E4nWWDt - 0.74

For Branch 1, the value assigned to the parameter (kPa-S), based on the mean value of the distribution, is:

Parameter 20: ImpLoad - 12.4

Case 6: This case is the same as Case 2 except that the hydrogen concentration is in the range $H_2 \geq 20\%$. The quantification for this case, based on the mean value of the distribution, is:

Branch 1: E4-WWDt - 0.25
Branch 2: E4nWWDt - 0.75

For Branch 1, the value assigned to the parameter (kPa-S), based on the mean value of the distribution, is:

Parameter 20: ImpLoad - 5.8

Case 7: This case is the same as Case 3 except that the hydrogen concentration is in the range $H_2 \geq 20\%$. The quantification for this case, based on the mean value of the distribution, is:

Branch 1: E4-WWDt - 0.45
Branch 2: E4nWWDt - 0.55

For Branch 1, the value assigned to the parameter (kPa-S), based on the mean value of the distribution, is:

Parameter 20: ImpLoad - 12.4

Case 8: The hydrogen in the wetwell did not ignite before VB. Thus, a detonation is not possible. The quantification for this case is:

Branch 1: E4-WWDt - 0.00
Branch 2: E4nWWDt - 1.00

Because Branch 1 is never taken, the value assigned to the parameter for this branch is irrelevant.

Question 45. **What Is the Level of the Containment Impulse Load Before VB?**
7 Branches, Type 5, 1 Case

The branches for this question are:

1. E-Ip>60 The impulse is greater than 60 kPa-S.

2. E-Ip>50 The impulse is in the range 50 ≤ Impulse < 60 kPa-S.

3. E-Ip>40 The impulse is in the range 40 ≤ Impulse < 50 kPa-S.

4. E-Ip>30 The impulse is in the range 30 ≤ Impulse < 40 kPa-S.

5. E-Ip>20 The impulse is in the range 20 ≤ Impulse < 30 kPa-S.

6. E-Ip>10 The impulse is in the range 10 ≤ Impulse < 20 kPa-S.

7. E-Ip<10 The impulse is less than 10 kPa-S.

This question is a summary of the detonation impulse loads (Parameter 20) initialized in the previous question (Question 44). In this question, the range of possible impulse loads is divided into discrete levels represented by the seven branches. The various impulse loads are then grouped into the appropriate levels. To do this grouping, the impulse load, Parameter 20, is compared with a series of parameters that define the various levels. By doing this grouping, the probability of obtaining an impulse within a given range can be determined. Furthermore, by representing the impulse load by a branch in this question, the impulse load can be used in the case structure in subsequent questions (i.e., the probability or parameter assigned in a subsequent question can be made dependent on the level of impulse assigned in this question). It should be noted that structural failure due to a detonation is determined by the actual value assigned to Parameter 20 and not by a level defined in this question. These levels are used only to summarize the magnitude of the impulse.

Question 46. With What Efficiency Is Hydrogen Burned Prior To VB?
1 Branch, Type 4, 2 Parameters, 12 Cases

The branch for this question is:

1. H2EfBVB The hydrogen burn efficiency before VB.

The parameters initialized in this question are:

P18 H2EfVB1 The effective efficiency of a hydrogen combustion before VB.

P19 H2EfVB2 The actual efficiency of a hydrogen combustion before VB.

The parameters initialized in this question are sampled. The distributions for Parameters 18 and 19 were provided by the Containment Loads Expert Panel. A discussion of this issue is presented in Volume 2, Part II, of this report. The parameters initialized in this question depend upon the branch taken at Questions 39, 40, and 43.

The effective efficiency of a hydrogen burn, Parameter 18, is the ratio of the peak overpressure, assigned by the expert panel, to the AICC pressure for the same set of conditions. The expert panel provided peak overpressures for various values of hydrogen concentration and for two levels of steam concentration. However, the conditions in the wetwell do not always correspond to the conditions considered by the expert panel. Therefore, to generalize this information, the peak overpressure assigned to a set of conditions was divided by the appropriate AICC pressure. This ratio represents an effective efficiency of the hydrogen burn. The peak overpressure is less than the AICC pressure because of incomplete combustion, heat transfer to surrounding structures, and venting of wetwell gases into the drywell volume. To calculate the overpressure for a different set of conditions, the AICC pressure was calculated for the new set of conditions and then was multiplied by the effective burn efficiency, Parameter 18. By doing this, the actual composition of the wetwell atmosphere is properly accounted for as well as the pressure reduction factors considered by the expert panel.

The actual efficiency of the hydrogen burn, Parameter 19, is the ratio of the amount of hydrogen burned to the amount of hydrogen that was available to be burned. This parameter is used to account for the amount of hydrogen consumed during a hydrogen combustion event properly.

In this question, which is based on the results from the Containment Loads Expert Panel, the effective efficiency of a hydrogen burn is a function of both the hydrogen concentration and the steam concentration in the wetwell. The actual hydrogen burn efficiency is a function of only the hydrogen concentration.

Case 1: There was no hydrogen deflagration in the wetwell before VB. Because a burn does not occur, it follows that there is no peak overpressure or burn completeness. The values assigned to the parameters are:

Parameter 18: H2EfVB1 - 0.00
Parameter 19: H2EfVB2 - 0.00

Case 2: The steam concentration in the wetwell is high (i.e., between 35% and 55% steam), and the hydrogen concentration is less than 4%. The mean values of the distributions assigned to these parameters are:

Parameter 18: H2EfVB1 - 0.079
Parameter 19: H2EfVB2 - 0.27

Case 3: In this case, the steam concentration is low (i.e., less than 35% steam), and the hydrogen concentration is less than 4%. The mean values of the distributions assigned to these parameters are:

Parameter 18: H2EfVB1 - 0.00
Parameter 19: H2EfVB2 - 0.27

Case 4: The steam concentration in the wetwell is high (i.e., between 35% and 55% steam), and the hydrogen concentration is between 4% and 8%. The mean values of the distributions assigned to these parameters are:

Parameter 18: H2EfVB1 - 0.28
Parameter 19: H2EfVB2 - 0.27

Case 5: In this case, the steam concentration is low (i.e., less than 35% steam), and the hydrogen concentration is between 4% and 8%. The mean values of the distributions assigned to these parameters are:

Parameter 18: H2EfVB1 - 0.28
Parameter 19: H2EfVB2 - 0.27

Case 6: The steam concentration in the wetwell is high (i.e., between 35% and 55% steam), and the hydrogen concentration is between 8% and 12%. The mean values of the distributions assigned to these parameters are:

Parameter 18: H2EfVB1 - 0.46
Parameter 19: H2EfVB2 - 0.74

Case 7: In this case, the steam concentration is low (i.e., less than 35% steam), and the hydrogen concentration is between 8% and 12%. The mean values of the distributions assigned to these parameters are:

Parameter 18: H2EfVB1 - 0.57
Parameter 19: H2EfVB2 - 0.74

Case 8: The steam concentration in the wetwell is high (i.e., between 35% and 55% steam), and the hydrogen concentration is between 12% and 16%. The mean values of the distributions assigned to these parameters are:

Parameter 18: H2EfVB1 - 0.48
Parameter 19: H2EfVB2 - 0.88

Case 9: In this case, the steam concentration is low (i.e., less than 35% steam), and the hydrogen concentration is between 12% and 16%. The mean values of the distributions assigned to these parameters are:

Parameter 18: H2EfVB1 - 0.73
Parameter 19: H2EfVB2 - 0.88

Case 10: The steam concentration in the wetwell is high (i.e., between 35% and 55% steam), and the hydrogen concentration is greater than 16%. The mean values of the distributions assigned to these parameters are:

Parameter 18: H2EfVB1 - 0.49
Parameter 19: H2EfVB2 - 0.93

Case 11: In this case, the steam concentration is low (i.e., less than 35% steam), and the hydrogen concentration is greater than 16%. The mean values of the distributions assigned to these parameters are:

Parameter 18: H2EfVB1 - 0.75
Parameter 19: H2EfVB2 - 0.93

Case 12: All the possible cases have been considered by the previous cases. Thus, this case should not used.

Question 47. What Is the Peak Pressure in the Containment from a Hydrogen Burn?

6 Branches, Type 6, 4 Cases

The branches for this question are:

1. PBrn>7 The peak overpressure is greater than 700 kPa.

2. PBrn>6 The peak overpressure is in the range 600 ≤ P < 700 kPa.

3. PBrn>5 The peak overpressure is in the range 500 ≤ P < 600 kPa.

4. PBrn>4 The peak overpressure is in the range 400 ≤ P < 500 kPa.

5. PBrn>3 The peak overpressure is in the range 300 ≤ P < 400 kPa.

6. PBrn<3 The peak overpressure is less than 300 kPa.

The branching at this question depends upon the branch taken at Questions 16, 22, 38, 41, 43, and 44. In this question, a module in the user function is used to determine the peak overpressure in the containment from a hydrogen deflagration in the wetwell. The peak wetwell overpressure is used to determine the load on the containment structure. The calculations are based on the composition of the wetwell atmosphere (i.e., moles of hydrogen, air, and steam) and on the effectiveness of the burn (Parameters 18 and 19). In addition to determining the burn overpressure, this module also adjusts the number of moles of hydrogen, oxygen, and steam that are present in the wetwell after the burn based on the actual efficiency of the burn.

The load on the drywell structure is the peak wetwell/drywell pressure differential. The peak wetwell/drywell pressure difference that results from a hydrogen deflagration is extrapolated from the wetwell peak overpressure. Calculations performed previously with HECTR[A-6] relate the peak wetwell/drywell pressure differential to the peak wetwell overpressure as a function of hydrogen concentration. These relationships were incorporated into the user function. Thus, the peak wetwell/drywell pressure differential is determined using the relationships extracted from the HECTR calculations in conjunction with the wetwell overpressure calculated in this question. If a detonation occurs, the peak pressure will occur well before the suppression pool vents clear. Therefore, if a detonation occurs, it is assumed that the peak wetwell/drywell pressure differential is the same as the peak wetwell overpressure.

The module of the user function used in this question returns the peak wetwell overpressure in Parameter 11 and the peak wetwell/drywell pressure differential in Parameter 12.

> Case 1: The hydrogen in the wetwell does not ignite. Thus, there is no overpressure and none of the hydrogen is consumed.

> Case 2: The hydrogen ignites, and there is either a large hole in the containment or the hydrogen burns as a diffusion flame. In either

case, the pressure rise is negligible and does not threaten the drywell structure. The moles of hydrogen, oxygen, and steam are adjusted to account for the burn.

Case 3: The hydrogen in the wetwell detonates. [illegible] the peak wetwell/drywell pressure differential is the same as [illegible] peak wetwell overpressure.

Case 4: The hydrogen in the wetwell burns as a deflagration, and there are no large holes in the containment.

Question 48. **What Is the Level of Drywell Leakage Induced by an Early Detonation in the Containment?**
3 Branches, Type 6, 2 Cases

The branches for this question are:

1. EnDWDt The drywell does not fail from a detonation.
2. E-DWDt2 A detonation induces a leak in the drywell.
3. E-DWDt3 A detonation induces a rupture in the drywell.

The branching at this question depends upon the branch taken at Question 44. A module in the user function is used to determine whether the drywell fails, and the mode of failure. In the user function, the impulse from the detonation (Parameter 20) is compared to the structural capacity of the drywell to dynamic loads (Parameter 34).

The way in which the random number (Parameter 35) is used to determine the mode of drywell failure is described in Subsection A.2. The method differs depending on whether the rate of pressure rise is fast or slow relative to the rate at which a leak depressurizes the drywell. For detonations, the fast pressure rise method is used. For fast pressure rise, the conditional probability for each failure mode depends on both the failure pressure and the load pressure, since the development of a leak at the failure pressure will not arrest the pressure rise.

Case 1: There is a detonation in the wetwell. The impulse from the detonation is compared to the structural capacity of the drywell to determine whether the drywell fails.

Case 2: A detonation does not occur in the wetwell before VB. Thus, the drywell does not fail from a detonation.

Question 49. **What Is the Level of Containment Leakage Induced by an Early Detonation in the Containment?**
3 Branches, Type 6, 3 Cases

The branches for this question are:

1. E4nDtF The containment does not fail from a detonation.

2. E4-Dt2 A detonation induces a leak in the containment.

3. E4-Dt3 A detonation induces a rupture in the containment.

The branching at this question depends upon the branch taken at Questions 44 and 48. A module in the user function is used to determine whether the containment fails and the mode of failure. In the user function, the impulse from the detonation (Parameter 20) is compared to the structural capacity of the containment to dynamic loads (Parameter 24).

The way in which the random number (Parameter 25) is used to determine the mode of containment failure is described in Subsection A.2. The method differs depending on whether the rate of pressure rise is fast or slow relative to the rate at which a leak depressurizes the containment. For detonations, the fast pressure rise method is used.

> Case 1: The drywell failed (either a leak or a rupture) from a detonation in containment. This case was included in this question to allow coupling between the drywell response to a detonation and the containment response. In this analysis, the structural response of the drywell to dynamic loads (Parameter 34) was correlated to the structural capacity of the containment (Parameter 24). Thus, this coupling has already been taken into account, and no additional coupling is applied in this case.
>
> Case 2: There is a detonation in the wetwell, and it does not fail the drywell. However, because the containment is not as strong as the drywell, there is still some probability that the containment will fail.
>
> Case 3: A detonation does not occur in the wetwell before VB. Thus, containment does not fail from a detonation.

Question 50. What Is the Level of Containment Leakage Before VB?
4 Branches, Type 6, 4 Cases

The branches for this question are:

1. E5nCL The containment does not fail before VB.

2. E5-CL2 The containment fails in the leak mode; nominal hole size is 0.1 ft^2.

3. E5-CL3 The containment fails by rupture; nominal hole size is 7 ft^2.

4. E5-CL4 The containment fails by catastrophic rupture. This failure mechanism does not occur in this analysis but has been retained in the tree for completeness.

The branching at this question depends upon the branch taken at Questions 16, 22, 38, 43, and 49. A module in the user function is used to determine whether the containment fails, and the mode of failure. In the user function, the peak pressure in the containment (Parameter 11) is compared to the containment failure pressure (Parameter 21).

The way in which the random number (Parameter 22) is used to determine the mode of containment failure is described in Subsection A.2. The method differs depending on whether the rate of pressure rise is fast or slow relative to the rate at which a leak depressurizes the containment. The fast pressure rise method is used when the loading on the containment is from a hydrogen burn.

Case 1: The containment either had a pre-existing rupture, was vented before core damage, was ruptured by a slow pressurization event during core damage, or was ruptured by a detonation. In any case, the containment is ruptured.

Case 2: There were no deflagrations in the wetwell before VB. The containment is, however, leaking. The leak is either from a pre-existing leak or was caused by a slow pressurization event in the containment (e.g., accumulation of steam). Thus, no events have occurred that would cause the leak to expand into a rupture.

Case 3: A deflagration occurred in the wetwell before VB. The containment has failed in the leak mode either by a pre-existing leak, by a slow pressurization event or by a detonation. Because a leak will not arrest the pressure rise associated with a hydrogen deflagration, the containment can still fail in the rupture mode for this case. Thus, it is certain that the containment failure mode will at least be a leak, and there is some probability that the failure mode will be a rupture.

Case 4: A deflagration occurred in the wetwell before VB, and the containment was intact before the burn. Thus, depending on the pressure rise associated with the burn, the containment can either remain intact, fail in the leak mode, or fail in the rupture mode.

Question 51. **What Is the Level of Drywell Leakage Induced by Containment Pressurization?**
5 Branches, Type 6, 5 Cases

The branches for this question are:

1. EnDWDf The drywell does not fail before VB.
2. E-DWDf2 The drywell fails in the leak mode at the drywell wall.
3. E-DWHDf2 The drywell fails in the leakage mode at the drywell head. In this analysis, it was assessed that there was a negligible probability that the drywell head would fail before the drywell wall. Thus, this failure location does not occur in this analysis but has been retained in the tree for completeness.

4. E-DWDf3 The drywell fails in the rupture mode at the drywell wall.

5. E-DWHDf3 The drywell fails in the rupture mode at the drywell head. In this analysis, it was assessed that there was a negligible probability that the drywell head would fail before the drywell wall. Thus, this failure location does not occur in this analysis but has been retained in the tree for completeness.

The branching at this question depends upon the branch taken at questions 17, 46, and 50. A module in the user function is used to determine whether the drywell fails and the mode of failure. In the user function, the peak wetwell/drywell pressure differential (Parameter 12) is compared to the drywell failure pressure (Parameter 30).

The way in which the random number (Parameter 31) is used to determine the mode of containment failure is described in Subsection A.2. The method differs depending on whether the rate of pressure rise is fast or slow relative to the rate at which a leak depressurizes the containment (or pressurizes the drywell). The fast pressure rise method is used when the loading on the drywell is from a hydrogen burn.

Containment failure by rupture has been included in the case structure for this question to allow for the load on the drywell structure to be reduced because of the pressure relaxation associated with the containment failure. A scoping study was performed with MELCOR[A-5] to investigate the effect containment failure has on the peak wetwell/drywell pressure differential. The hydrogen concentrations typically encountered in this analysis result in very rapid hydrogen burns. Because the pressure rise associated with these burns is rapid, the effect of the containment failure on the peak wetwell/drywell pressure differential is minor. Thus, the cases with containment failure are not handled any differently than those without containment failure. These cases have been retained only for the sake of completeness.

Case 1: The drywell has already failed in the rupture mode. The failure is caused by either a pre-existing failure or by a detonation.

Case 2: The drywell has already failed in the leak mode, and the containment has failed in the rupture mode. Depending on the pressure rise from the deflagration, it is possible that the drywell leak will increase to a rupture.

Case 3: The drywell was intact before the burn, but the containment has failed in the rupture mode.

Case 4: The drywell has already failed in the leak mode. The containment is either intact or has failed in the leak mode.

Case 5: The drywell was intact before the burn, and the containment is either intact or failed in the leak mode.

Question 52. What Is the Level of Suppression Pool Bypass Following Early Combustion Events?
3 Branches, Type 2, 5 Cases

The branches for this question are:

1. E5nSPB The drywell is intact before VB.

2. E5-SPB2 The drywell fails by the leak mode before VB.

3. E5-SPB3 The drywell has failed by rupture before VB.

Cases 2 and 4 of this question are sampled. Distribution for the drywell failure induced by vacuum breaker failure was internally quantified. The branching at this question depends upon the branch taken at Questions 17, 24, 41, 43, 48, and 51.

This question summarizes the levels of drywell failure (e.g., from detonations and deflagrations) that occur before VB. In addition, drywell failures from failed drywell vacuum breakers are considered.

Case 1: The drywell was ruptured by either a pre-existing failure, a detonation, or a deflagration. The quantification for this case is:

Branch 1: E5nSPB - 0.0
Branch 2: E5-SPB2 - 0.0
Branch 3: E5-SPB3 - 1.0

Case 2: The drywell has a pre-existing leak, and ac power is available during core damage. A hydrogen burn occurs in the wetwell before VB which pressurizes the wetwell. In response to this pressurization, the drywell vacuum breakers (which are ac powered valves) will open in an attempt to equalize the pressure difference between the wetwell and drywell. As the hot gases pass through the vacuum breakers, the valves are exposed to a severe thermal environment. However, these valves are designed to pass high temperature gases, so it is unlikely that they will fail during a hydrogen burn. It was estimated that the failure probability of the valve under these conditions is 0.05. As this case is sampled zero-one, that means that 5% of the observations have 1.0 for Branch 3 and 0.0 for Branches 1 and 2, and 95% of the observations have 1.0 for Branch 2 (there is a pre-existing leak), and 0.0 for Branches 2 and 3. Based on the mean value of the sample, the quantification for this case is:

Branch 1: E5nSPB - 0.0
Branch 2: E5-SPB2 - 0.95
Branch 3: E5-SPB3 - 0.05

Case 3: Either a pre-existing failure, a detonation, or a deflagration failed the drywell in the leak mode before VB. The quantification for this case is:

Branch 1: E5nSPB - 0.0
Branch 2: E5-SPB2 - 1.0
Branch 3: E5-SPB3 - 0.0

Case 4: This case is the same as Case 2 except that the drywell does not have a pre-existing leak. This case is quantified using the same distribution that was used in Case 2. This case is sampled zero-one. Based on the mean value of the sample, the quantification for this case is:

Branch 1: E5nSPB - 0.95
Branch 2: E5-SPB2 - 0.00
Branch 3: E5-SPB3 - 0.05

Case 5: The drywell does not fail before VB. The quantification for this case is:

Branch 1: E5nSPB - 1.0
Branch 2: E5-SPB2 - 0.0
Branch 3: E5-SPB3 - 0.0

Question 53. **Has the Upper Pool Dumped?**
2 Branches, Type 2, 2 Cases

The branches for this question are:

1. UPDmp Water from the upper pool has been dumped into the suppression pool.

2. noUPDmp The upper pool has not been dumped.

This question is not sampled and was internally quantified. The branching at this question depends upon the branch taken at Question 24.

The suppression pool makeup system provides water from the upper containment pool to the suppression pool following a LOCA. Although gravity is the motive force used to transport the water, ac power must be available to open the discharge valves. The capacity of the upper pool is sufficient to keep the uppermost drywell vents covered for all conceivable accidents. It is assumed that if ac power is available, the upper pool will be dumped.

Case 1: AC power is available during core damage, so it is assumed that the upper pool is dumped before VB. The quantification for this case is:

Branch 1: UPDmp - 1.0
Branch 2: noUPDmp - 0.0

Case 2: AC power is not available before VB. Therefore, the suppression pool makeup system discharge valves cannot be opened, and the upper containment pool cannot be drained into the suppression pool. The quantification for this case is:

Branch 1: UPDmp - 0.0
Branch 2: noUPDmp - 1.0

Question 54. **Is There Water in the Reactor Cavity?**
3 Branches, Type 2, 9 Cases

The branches for this question are:

1. E5-DFld The drywell is flooded with water.

2. E5-DWet The reactor cavity is wet (less than 100 M^3 of water).

3. E5-DDry The reactor cavity is essentially dry.

Cases 4, 5, and 8 of this question are sampled. This question was internally quantified. The branching at this question depends upon the branch taken at Questions 16, 17, 20, 22, 24, 30, 38, 39, 41, 43, 50, 51, and 53.

Before VB, there are primarily three sources of water that can enter the reactor cavity. The first source is the suppression pool. If the suppression pool is depressed sufficiently in the wetwell, water will be pushed up over the weir wall and into the drywell. The second source is the upper containment pool. If the drywell head fails, water from the upper pool will drain into the drywell. The third source is leakage from the equipment in the drywell (e.g., CRD system, recirculation pumps). There are two pathways by which water in the drywell can enter the reactor cavity. The first pathway is through the drywell floor drains. There are four 4-inch drains on the drywell floor that connect to the equipment drain sump in the pedestal. The second pathway is through a door (3 ft by 7 ft) in the pedestal located 3'-4" above the drywell floor.

Case 1: There is a rupture in the drywell head. A sufficient amount of water from the upper containment pool will drain into the drywell and flood the cavity. The quantification for this case is:

Branch 1: E5-DFld - 1.00
Branch 2: E5-DWet - 0.00
Branch 3: E5-DDry - 0.00

Case 2: A combustion event in the wetwell ruptures the containment. It is assumed that a burn of this magnitude will push a significant amount of suppression pool water into the drywell. It is very likely that the drywell will be flooded. The quantification for this case is:

Branch 1: E5-DFld - 0.99
Branch 2: E5-DWet - 0.01
Branch 3: E5-DDry - 0.00

Case 3: A significant hydrogen deflagration in the wetwell fails to rupture the containment. Thus, the wetwell will pressurize, and suppression pool water will be pushed into the drywell. It is very likely that the drywell will be flooded. The quantification for this case is:

Branch 1: E5-DFld = 0.999
Branch 2: E5-DWet = 0.001
Branch 3: E5-DDry = 0.000

Case 4: A significant amount of hydrogen, equivalent to a wetwell hydrogen concentration of more than 8%, is burned as a diffusion flame. Because there were no pre-existing containment or drywell ruptures and ac power is not available (i.e., no containment sprays and no drywell vacuum breakers), the wetwell will pressurize from the burn. Some water will likely be pushed from the suppression pool into the drywell. It is uncertain whether the drywell will be flooded or only wet. This case was sampled zero-one, so each observation had all the probability assigned to one of these three branches. Taking the mean value of the observations in the sample, the quantification for this case is:

Branch 1: E5-DFld = 0.45
Branch 2: E5-DWet = 0.45
Branch 3: E5-DDry = 0.10

Case 5: The upper containment pool was dumped into the suppression pool, and enough hydrogen was released from the vessel that the hydrogen concentration in the wetwell is greater than 12%. Because there were no pre-existing containment or drywell ruptures, the wetwell will be pressurized by the addition of the hydrogen. This pressurization when combined with a high pool level is sufficient to push suppression pool water into the drywell. It is uncertain whether the drywell will be flooded or only wet. This case was sampled zero-one. Taking the mean value of the observations in the sample, the quantification for this case is:

Branch 1: E5-DFld = 0.50
Branch 2: E5-DWet = 0.50
Branch 3: E5-DDry = 0.00

Case 6: The PDS is a long-term SBO. There is a nominal amount of leakage associated with equipment in the drywell. This leakage rate, when combined with long time period between the initiation of the accident and VB (approximately 14.5 hours for this PDS), will lead to a wet cavity. The quantification for this case is:

Branch 1: E5-DFld = 0.00
Branch 2: E5-DWet = 1.00
Branch 3: E5-DDry = 0.00

Case 7: The upper pool was dumped into the suppression pool. The combination of the high pool level and the discharge of gases from the RPV into the suppression pool will result in water being sloshed into the drywell. The drywell will very likely be wet. The quantification for this case is:

Branch 1: E5-DFld - 0.00
Branch 2: E5-DWet - 1.00
Branch 3: E5-DDry - 0.00

Case 8: Enough hydrogen was released from the vessel that the hydrogen concentration in the wetwell is greater than 12%. Because there were no pre-existing containment or drywell ruptures, the wetwell will be pressurized by the addition of the hydrogen. This case is similar to Case 5 except that ac power is not available, so the upper pool was not dumped. Because the pool level is not as high as it was in Case 5, the wetwell may not be pressurized sufficiently to push suppression pool water into the drywell. Thus, it is uncertain as to whether the drywell will be dry or wet. This case is sampled zero-one. Based on the mean value of the sample, the quantification for this case is:

Branch 1: E5-DFld - 0.00
Branch 2: E5-DWet - 0.50
Branch 3: E5-DDry - 0.50

Case 9: Either the containment or the drywell is ruptured, or there was no significant hydrogen generation. In any case, the wetwell does not pressurize, so water is not pushed from the suppression pool into the drywell. The quantification for this case is:

Branch 1: E5-DFld - 0.00
Branch 2: E5-DWet - 0.00
Branch 3: E5-DDry - 1.00

Question 55. What Is the Containment Pressure Before VB?
3 Branches, Type 6, 5 Cases

The branches for this question are:

1. E5P>3 The containment pressure during core damage is greater than 300 kPa.

2. E5P>2 The containment pressure is between 200 kPa and 300 kPa.

3. E5P>1 The containment pressure is between 100 kPa and 200 kPa.

This question is not sampled and was internally quantified. The branching at this question depends upon the branch taken at Questions 30, 50, and 52. In this question, the containment pressure is adjusted to account for changes in the number of moles of air, steam, and hydrogen that are present in the containment just before VB. Burns in the containment will consume hydrogen and air, the operation of sprays will condense steam, and failure of the containment boundary will result in a reduction in the number of moles in the containment. Modules in the user function subroutine are used to calculate the pressure.

Case 1: The containment is failed (either a leak or a rupture). Thus, the pressure in the containment (and drywell) is set to atmospheric pressure. The total number of moles in the containment is reduced to reflect the reduction in pressure. It is assumed that the composition of the gas removed from the containment is the same as that of the gas remaining in the containment.

Case 2: The containment is intact, but the drywell structure has been ruptured (e.g., a drywell vacuum breaker can fail open). The containment sprays operate during core damage. Because the drywell structure has been ruptured, it is assumed that the drywell and the wetwell atmospheres are well mixed. The effect of the sprays is to condense the steam in the containment. The pressure in the containment is lowered to account for the steam that has been condensed.

Case 3: This case is similar to Case 2 except that the containment sprays do not operate during core damage.

Case 4: The containment is intact and the drywell has not been ruptured. Most of the steam in the containment is condensed by the containment sprays, which operate during core damage.

Case 5: The containment is intact and the drywell has not been ruptured. The containment sprays do not operate during core damage.

Question 56. To What Level Is the Drywell Steam Inert at VB?

3 Branches, Type 5, 1 Case

The branches for this question are:

1. E5nDIn The drywell is not inert; both hydrogen deflagrations and detonations are possible.
2. E5-DIn2 The drywell is inert to hydrogen detonations.
3. E5-DIn3 The drywell is inert to both hydrogen detonations and deflagrations.

This question is used to determine whether the drywell is steam inert at VB. A module in the user function is used to calculate the mole fraction of steam, Y_{steam}, in the drywell. A discussion of the inerting limits is presented in Question 40. The inerting limits used in this analysis are:

$Y_{steam} \geq 0.55$; inert to detonations and deflagrations.

$0.55 > Y_{steam} \geq 0.35$; inert to detonations.

$0.35 > Y_{steam}$; both detonations and deflagrations are possible.

Question 57. Is There Sufficient Hydrogen for Combustion/Detonation in the Drywell Before VB?
3 Branches, Type 5, 1 Case

The branches for this question are:

1. E5cDWDt There is sufficient hydrogen and oxygen in the drywell to support a detonation.
2. E5cDWDf There is sufficient hydrogen and oxygen in the drywell to support a deflagration but not enough to support a detonation.
3. E5nDWC There is either insufficient hydrogen or oxygen to support a burn in the drywell.

This question is used to determine whether there is sufficient hydrogen and oxygen in the drywell just before vessel to support either a hydrogen detonation or deflagration. A module in the user function is used to calculate the mole fraction of hydrogen, Y_{H2}, and the mole fraction of oxygen, Y_{O2}, in the drywell. The combustion limits used in this question are:

$Y_{H2} \geq 0.16$; detonations and deflagrations are possible.

$0.16 > Y_{H2} \geq 0.06$; insufficient hydrogen for a detonation but deflagrations are possible.

$0.06 > Y_{H2}$; insufficient hydrogen for a deflagration.

In addition to the requirement that a certain level of hydrogen must be present in each of the regimes defined above, there must also be enough oxygen to support a burn at this level. For example, the first branch, E5cDWDt, will be selected only if the concentration of hydrogen is above 16% and there is enough oxygen to allow this amount of hydrogen to be burned. This question does not consider the possibility that the drywell may be steam inert. This issue is handled in the previous question.

Question 58. Does an Alpha Mode Event Fail Both the Vessel and the Containment?
2 Branches, Type 2, 2 Cases

The branches for this question are:

1. Alpha A very energetic molten fuel-coolant interaction (steam explosion) in the vessel fails the vessel and generates a missile that fails the containment as well.
2. noAlpha There is no Alpha Mode event.

Cases 1 and 2 of this question are sampled. The distributions used to quantify this question were developed internally from the opinions expressed by the Steam Explosion Review Group (SERG) (NUREG-1116).[A-7] (The experts' individual distributions and the aggregation of them are presented in Volume 2, Part VI, of this report.) The branching at this question depends upon the branch taken at Question 26.

Case 1: The RPV is at system pressure. Steam explosions are less likely at high pressure. The aggregate distribution utilized for low pressure (see the next case) was decreased by an order of magnitude for use in this case. The quantification for this case, based on the mean value of the distribution, is:

Branch 1: Alpha - 0.001
Branch 2: E4nWWDf - 0.999

Case 2: The RPV is at low pressure (< 200 psia). Steam explosions are more likely when the RPV is at low pressure than when the RPV is at some higher pressure. The aggregate distribution developed from distributions in the SERG was used for this case. This distribution covers many orders of magnitude. The quantification for this case, based on the mean value of the distribution, is:

Branch 1: E4-WWDf - 0.01
Branch 2: E4nWWDf - 0.99

Question 59. What Fraction of the Core Participates in Core Slump?
3 Branches, Type 2, 7 Cases

The branches for this question are:

1. HiSL More than 50% of the core is molten at core slump.

2. MedSL Between 10% and 50% of the core is molten at core slump.

3. LowSL Less than 10% of the core is molten at core slump.

This question is not sampled and was internally quantified. The branching at this question depends upon the branch taken at Questions 7, 24, 26, 28, and 58.

This question is not referenced by any subsequent question and has only been included for the sake of completeness.

Case 1: An Alpha Mode event occurs and fails the vessel. An Alpha Mode event is a very energetic molten fuel-coolant interaction, which implies that a large fraction of the core is molten at the time of core slump. The quantification for this case is:

Branch 1: HiSL - 1.0
Branch 2: MedSL - 0.0
Branch 3: LowSL - 0.0

Case 2: The RPV is at high pressure, and the HPCS system is being used to inject coolant into the vessel. An Alpha Mode event does not occur. Because coolant is being supplied to the core, only a small fraction of core will likely be molten at the time of VB. The quantification for this case is:

Branch 1: HiSL - 0.0
Branch 2: MedSL - 0.0
Branch 3: LowSL - 1.0

Case 3: The RPV is at high pressure, and the CRD system is being used to supply high pressure coolant injection to the RPV. An Alpha Mode event does not occur. Because coolant is being supplied to the core, only a small fraction of core will likely be molten at VB. The quantification for this case is:

Branch 1: HiSL - 0.0
Branch 2: MedSL - 0.0
Branch 3: LowSL - 1.0

Case 4: The RPV is at high pressure, and coolant injection is not supplied to the core. An Alpha Mode event does not occur. The quantification for this case is:

Branch 1: HiSL - 1.0
Branch 2: MedSL - 0.0
Branch 3: LowSL - 0.0

Case 5: The RPV is at low pressure, and coolant is injected into the vessel. An Alpha Mode event does not occur. Because coolant is supplied to the core, there will likely be only a small fraction of core molten at VB. The quantification for this case is:

Branch 1: HiSL - 0.0
Branch 2: MedSL - 0.0
Branch 3: LowSL - 1.0

Case 6: The RPV is at low pressure, and the CRD system supplies coolant injection to the RPV. An Alpha Mode event does not occur. Because coolant is supplied to the core, only a small fraction of core will likely be molten at VB. The quantification for this case is:

Branch 1: HiSL - 0.0
Branch 2: MedSL - 0.0
Branch 3: LowSL - 1.0

Case 7: The RPV is at low pressure, and coolant injection is supplied to the core. An Alpha Mode event does not occur. The quantification for this case is:

Branch 1: HiSL - 1.0
Branch 2: MedSL - 0.0
Branch 3: LowSL - 0.0

Question 60. Is There a Large In-Vessel Steam Explosion?
2 Branches, Type 2, 3 Cases

The branches for this question are:

1. VesStx There is a large in-vessel steam explosion.

2. nVesStx A large in-vessel steam explosion does not occur.

This question is not sampled and was internally quantified. The branching at this question depends upon the branch taken at Questions 26 and 58. (A discussion of the quantification of this issue is presented in Volume 2, Part VI, of this report.)

Case 1: A large in-vessel steam explosion resulted in an Alpha Mode event (see Question 58). The quantification for this case is:

Branch 1: VesStx = 1.00
Branch 2: nVesStx = 0.00

Case 2: The RPV is at system pressure. Steam explosions are less likely at high pressure than they are at low pressure. Thus, it is unlikely that a large in-vessel steam explosion will occur. The quantification for this case is:

Branch 1: VesStx = 0.10
Branch 2: nVesStx = 0.90

Case 3: The RPV is at low pressure (less than 200 psia). Steam explosions are more likely when the RPV is at low pressure than when the RPV is at some higher pressure. The quantification for this case is:

Branch 1: VesStx = 0.86
Branch 2: nVesStx = 0.14

Question 61. What Fraction of Core Debris Would be Mobile at VB?
2 Branches, Type 4, 1 Parameter, 3 Cases

The branches for this question are:

1. HiLiqVB A large amount of core debris (40%) is mobile when VB occurs.

2. LoLiqVB A small amount of core debris (10%) is mobile when VB occurs.

The parameters initialized in this question are:

P46 Fraction of the core ejected at VB.

The branch probabilities in this question are sampled; the distributions were quantified internally. (A discussion of the quantification of this issue is presented in Volume 2, Part VI, of this report.) The branching at this question depends upon the branch taken at Questions 7, 24, 26, and 28.

Nominal values are used to characterize the amount of material mobile at VB. A nominal value of 10% represents low mobility, whereas a nominal value of 40% represents high mobility. The 10% value represents the range from 0 to 20% molten, and the 40% value represents any larger quantities.

It was felt that the amount of material molten at VB was tightly coupled to the mode of vessel failure. If the vessel fails early, then the mobility will be low. In BWRs, early vessel failure would be due to melt flowing through an instrument tube and failing the tube outside the vessel. If the melt were to freeze and plug the tube, then vessel failure would be delayed until a massive creep rupture occurs. Hence, the major uncertainty is whether the melt flowing in the instrument tube will freeze. If the vessel fails by a massive creep rupture and water is being injected into the vessel, it is likely that it will fail with a low mobility. On the other hand, if there is no water injection and a massive creep rupture occurs, it is uncertain as to how much core debris will be molten.

During the quantification of this question, it was felt that the RPV pressure would have a negligible effect on the amount of core debris that is molten at VB. Therefore, Cases 2 and 3 use the same quantification.

Case 1: Water is injected into the RPV before VB by the CRD system, the low pressure injection systems, or the high pressure injection systems. The RPV can be at either high or low pressure. The branch probabilities in this case are sampled zero-one, so each observation had all the probability assigned to one of the branches. Based on the mean value of the sample, the quantification for this case is:

branch 1: HiLiqVB - 0.025
Branch 2: LoLiqVB - 0.975

For Branch 1, the value assigned to the parameter is:

Parameter 46: - 0.40

For Branch 2 the value assigned to the parameter is:

Parameter 46: - 0.10

Case 2: The RPV is at system pressure before VB, and water is not injected into the vessel. This case is sampled zero-one. Based on the mean value of the sample, the quantification for this case is:

Branch 1: HiLiqVB - 0.10
Branch 2: LoLiqVB - 0.90

For Branch 1, the value for the fraction of core debris molten at VB that is assigned to the parameter is:

Parameter 46: - 0.40

For Branch 2, the value assigned to the parameter is:

Parameter 46: - 0.10

Case 3: The RPV is at low pressure (less than 200 psia) before VB, and water is not injected into the vessel. This case is quantified using the same distributions that were used to quantify Case 2. Thus, based on the mean value of the sample, the quantification for this case is:

Branch 1: HiLiqVB - 0.10
Branch 2: LoLiqVB - 0.90

For Branch 1, the value that is assigned to the parameter is:

Parameter 46: - 0.40

For Branch 2, the value assigned to the parameter is:

Parameter 46: - 0.10

Question 62. Does a Large In-Vessel Steam Explosion Fail the Vessel?
5 Branches, Type 2, 3 Cases

The branches for this question are:

1. SE-Alpha An Alpha Mode event failed the vessel.
2. SE-BtHd An in-vessel steam explosion fails the bottom head of the vessel (32 M^2).
3. SE-LgBrch An in-vessel steam explosion results in vessel failure. The size of the failure is a large hole (2 M^2).
4. SE-SmBrch An in-vessel steam explosion results in vessel failure. The size of the failure is a small hole (0.1 M^2).
5. SE-nFail The vessel does not fail from an in-vessel steam explosion.

Case 2 of this question is sampled; the distribution was quantified internally. (A discussion of the quantification of this issue is presented in Volume 2, Part VI, of this report.) The branching at this question depends upon the branch taken at Questions 26 and 58.

Case 1: An Alpha Mode event occurred. Thus, by definition of this type of event, the vessel fails (see Question 58). The quantification for this case is:

Branch 1: SE-Alpha - 1.00
Branch 2: SE-BtHd - 0.00
Branch 3: SE-LgBrch - 0.00
Branch 4: SE-SmBrch - 0.00
Branch 5: SE-nFail - 0.00

Case 2: A large in-vessel steam explosion occurs. The failure mode of the vessel is uncertain. Thus, maximum uncertainty has been used to quantify the various failure modes. The branch probabilities in this case are sampled zero-one, so each observation had all the probability assigned to one of the branches. Based on the mean value of the sample, the quantification for this case is:

Branch 1: SE-Alpha = 0.00
Branch 2: SE-BtHd = 0.20
Branch 3: SE-LgBrch = 0.20
Branch 4: SE-SmBrch = 0.30
Branch 5: SE-nFail = 0.30

Case 3: An in-vessel steam explosion does not occur, so the vessel does not fail from an in-vessel steam explosion. The quantification for this case is:

Branch 1: SE-Alpha = 0.00
Branch 2: SE-BtHd = 0.00
Branch 3: SE-LgBrch = 0.00
Branch 4: SE-SmBrch = 0.00
Branch 5: SE-nFail = 1.00

Question 63. What Is the Mode of VB?
5 Branches, Type 2, 3 Cases

The branches for this question are:

1. A-Fail An Alpha Mode event failed the vessel.

2. BH-Fail The bottom head of the vessel (32 M^2) fails at VB.

3. LgBrch The reactor pressure vessel fails. The size of the failure is a large hole (2 M^2).

4. SmBrch The reactor pressure vessel fails. The size of the failure is a small hole (0.1 M^2).

5. nBreach The reactor pressure vessel does not fail.

Cases 5 through 10 of this question are sampled; the distribution were quantified internally. (A discussion of the quantification of this issue is presented in Volume 2, Part VI, of this report.) The branching at this question depends upon the branch taken at Questions 26, 28, 29, 58, 61, and 62.

This question summarizes previous vessel failure modes (e.g., steam explosions) as well as considers vessel failure from core debris attack.

The vessel is predicted to fail if coolant is not supplied to the vessel or if the core is in an critical configuration following coolant injection (Question 29). In either case, the heat generated by the core debris will fail the vessel. If water is injected into the vessel during core damage, the probability of vessel failure depends on whether the core debris is coolable (the core debris is not coolable if it is in a critical configuration). If the core forms as a debris bed in the bottom of the vessel, it is very likely that the core debris will be cooled and prevent vessel failure. If, on the other hand, the core forms as a dense layer on the bottom head, the coolability of the debris depends on the amount of material involved in the pour. It is very unlikely that a large pour will be coolable, and it is uncertain whether a small pour will be coolable. In this analysis, equal probability was given to the formation of a debris bed and to the formation of a dense layer during core relocation.

Given that the vessel fails from core debris attack, the following modes of vessel failure were considered:

1. Global thermally induced fracture/creep-rupture of the lower head;

2. Ejection of an in-core instrument guide tube or CRD; and

3. Flow of molten core materials through a guide tube, CRD, or drain line leading to their thermally induced rupture below the bottom head.

The most likely failure mode is flow-induced thermal failure of a guide tube or drain. Molten material can enter the tube and flow beyond the vessel wall. Thermal weakening followed by rupture of the wall can occur if the melt gives up its latent and sensible heat to the guide tube or drain walls. It is uncertain whether the presence of water in these tubes will prevent tube failure. This uncertainty has been included in the probability assigned to this mode of failure. This failure mode will result in a small hole (i.e., Branch 4). It was assessed that there is a very small probability of multiple tube failures resulting in a large hole. It was also estimated that thermally induced binding between the guide tube and the vessel will prevent pressure ejection of the in-core instrument guide tube.

Case 1: An Alpha Mode event failed the vessel. The quantification for this case is:

Branch 1: A-Fail - 1.00
Branch 2: BH-Fail - 0.00
Branch 3: LgBrch - 0.00
Branch 4: SmBrch - 0.00
Branch 5: nBreach - 0.00

Case 2: An in-vessel steam explosion fails the bottom head of the vessel. The quantification for this case is:

Branch 1: A-Fail - 0.00
Branch 2: BH-Fail - 1.00
Branch 3: LgBrch - 0.00
Branch 4: SmBrch - 0.00
Branch 5: nBreach - 0.00

Case 3: A large in-vessel steam explosion fails the vessel. The size of the failure is a large hole. The quantification for this case is:

Branch 1: A-Fail - 0.00
Branch 2: BH-Fail - 0.00
Branch 3: LgBrch - 1.00
Branch 4: SmBrch - 0.00
Branch 5: nBreach - 0.00

Case 4: A large in-vessel steam explosion fails the vessel. The size of the failure is a small hole. The quantification for this case is:

Branch 1: A-Fail - 0.00
Branch 2: BH-Fail - 0.00
Branch 3: LgBrch - 0.00
Branch 4: SmBrch - 1.00
Branch 5: nBreach - 0.00

Case 5: Coolant is injected into the RPV during core damage, but a large amount of material is molten at VB. The core is not in a critical configuration. Because water is being supplied to the vessel, there is some probability that VB will not occur. The branch probabilities in this case are sampled zero-one, so each observation had all the probability assigned to one of the branches. Based on the mean value of the sample, the quantification for this case is:

Branch 1: A-Fail - 0.000
Branch 2: BH-Fail - 0.124
Branch 3: LgBrch - 0.005
Branch 4: SmBrch - 0.371
Branch 5: nBreach - 0.500

Case 6: The RPV is at system pressure and there is a large amount of core debris molten at VB. Either water is not injected into the RPV, or the core is in a critical configuration. In either case, the vessel fails. During the quantification of this question, it was felt that if water is not injected into the RPV, neither the RPV pressure nor the amount of core debris molten at VB will have a major effect on vessel failure. Therefore, Cases 6, 7, 9, and 10 all use the same quantification. These cases have been retained for the sake of completeness. This case is sampled zero-one. Based on the mean value of the sample, the quantification for this case is:

Branch 1: A-Fail - 0.000
Branch 2: BH-Fail - 0.249
Branch 3: LgBrch - 0.005
Branch 4: SmBrch - 0.746
Branch 5: nBreach - 0.000

Case 7: The RPV is at low pressure (less than 200 psia), and there is a large amount of core debris molten at VB. Either water is not injected into the RPV, or the core is in a critical configuration. In either case, the vessel fails. This case uses the same quantification as Case 6, so its quantification is:

Branch 1: A-Fail - 0.000
Branch 2: BH-Fail - 0.249
Branch 3: LgBrch - 0.005
Branch 4: SmBrch - 0.746
Branch 5: nBreach - 0.000

Case 8: Coolant is injected into the RPV during core damage, and a small amount of material is molten at VB. The core is not in a critical configuration. Because water is supplied to the vessel, there is some probability that VB will not occur. In addition, because less material is molten in this case than in Case 5, the probability of no VB is higher for this case. This case is sampled zero-one. Based on the mean value of the sample, the quantification for this case is:

Branch 1: A-Fail - 0.000
Branch 2: BH-Fail - 0.062
Branch 3: LgBrch - 0.005
Branch 4: SmBrch - 0.188
Branch 5: nBreach - 0.745

Case 9: The RPV is at system pressure, and there is a small amount of core debris molten at VB. Either water is not being injected into the RPV, or the core is in a critical configuration. In either case, the vessel fails. This case uses the same quantification as that for Case 6, so the quantification for this case is:

Branch 1: A-Fail - 0.000
Branch 2: BH-Fail - 0.249
Branch 3: LgBrch - 0.005
Branch 4: SmBrch - 0.746
Branch 5: nBreach - 0.000

Case 10: The RPV is at low pressure (less than 200 psia), and there is a small amount of core debris is molten at VB. Either water is not being injected into the RPV, or the core is in a critical configuration. In either case, the vessel fails. This case uses the same quantification as that for Case 6, so the quantification for this case is:

Branch 1: A-Fail - 0.000
Branch 2: BH-Fail - 0.249
Branch 3: LgBrch - 0.005
Branch 4: SmBrch - 0.746
Branch 5: nBreach - 0.000

Question 64. Does a High Pressure Melt Ejection Occur?

2 Branches, Type 2, 5 Cases

The branches for this question are:

1. HPME A high pressure melt ejection occurs at VB.

2. nHPME A high pressure melt ejection does not occur at VB.

Cases 2 through 5 of this question are sampled; the distribution were quantified internally. The branching at this question depends upon the branch taken at Questions 26, 58, 61, and 63.

This question does not address loads associated with HPME/DCH. The loads accompanying VB were addressed by the Containment Loads Expert Panel. The distributions provided by the expert panel include the contribution from HPME/DCH. Loads accompanying VB are addressed in Questions 70 and 71. This question is used by subsequent questions to help quantify the probability of an ex-vessel steam explosion and to determine the amount of hydrogen produced and consumed at VB. This question is also referenced in the source term analysis to determine the source term associated with VB. If HPME occurs, fraction of radionuclides released during DCH, FDCH, is applied to the core debris ejected at VB.

If the RPV is at high pressure when the vessel fails, the core debris will likely be ejected at a high velocity. Because of its high velocity, it is expected that the ejected material will undergo extensive fragmentation, and the result will be an HPME event. Thus, if the RPV is at high pressure, HPME is likely. This conclusion is consistent with the values in the pressurized water reactor (PWR) analyses (Volume 2, Part 1, of this report) and with discussions with members of the Containment Modeling Division at Sandia National Laboratories who are knowledgeable in this subject. Cases 2 through 5 are used to distinguish between vessel failure size and the amount of material molten at VB. During quantification, however, it was determined that these cases should be quantified the same.

Case 1: An HPME does not occur because the vessel is at low pressure, the vessel does not fail, or there was an Alpha Mode event. The quantification for this case is:

Branch 1: HPME - 0.00
Branch 2: nHPME - 1.00

Case 2: The vessel fails at high pressure; the size of the failure is a large hole. There is a large amount of core debris molten in the bottom head. The branch probabilities in this case are sampled zero-one, so each observation had all the probability assigned to one of the branches. Based on the mean value of the sample, the quantification for this case is:

Branch 1: HPME - 0.80
Branch 2: nHPME - 0.20

Case 3: The vessel fails at high pressure; the size of the failure is a large hole. There is a small amount of core debris molten in the bottom head. This case uses the same quantification as Case 2. Thus, the quantification for this case is:

Branch 1: HPME - 0.80
Branch 2: nHPME - 0.10

Case 4: The vessel fails at high pressure; the size of the failure is a small hole. There is a large amount of core debris molten in the bottom head. This case uses the same quantification as Case 2. Thus, the quantification for this case is:

Branch 1: HPME - 0.80
Branch 2: nHPME - 0.10

Case 5: The vessel fails at high pressure; the size of the failure is a small hole. There is a small amount of core debris molten in the bottom head. This case uses the same quantification as Case 2. Thus, the quantification for this case is:

Branch 1: HPME - 0.80
Branch 2: nHPME - 0.10

Question 65. Does a Detonation Occur in the Drywell at VB?
2 Branches, Type 4, 1 Parameters, 2 Cases

The branches for this question are:

1.	I-DWDt	A detonation occurs in the drywell at VB.
2.	InDWDt	There are no detonations in the drywell at VB.

The parameters initialized in this question are:

P36	Impulse load (kPa-S) from a drywell detonation.

This question is not sampled and was internally quantified. The branching at this question depends upon the branch taken at Questions 56, 57, and 63. For a detonation to occur, there must be a pre-existing detonable mixture (i.e., just before VB) in the drywell, and the vessel must fail. Vessel failure provides an ignition source. Accompanying VB is the release of a large amount of steam from the vessel into the drywell. This release of steam will not only tend to inert the drywell but will also push the drywell oxygen into the wetwell. Thus, if the drywell could not support a detonation just before VB, it is very unlikely that a detonable mixture would form at the time of VB.

It was assumed that the impulse load from a detonation in the drywell is similar to the impulse load from a detonation in the wetwell. Therefore, the mean value for the impulse associated with a detonation that occurs in the wetwell when the hydrogen concentration is above 16% (see Question [illegible], Case 5) was used to quantify Parameter 36.

Case 1: The drywell is not steam inert, and there is sufficient hydrogen and oxygen in the drywell to support a detonation. Vessel failure supplies an ignition source. Thus, a detonation occurs at VB. The quantification for this case is:

Branch 1: I-DWDt - 1.0
Branch 2: InDWDt - 0.0

For Branch 1, the value assigned to the parameter (kPa-S) is:

Parameter 36: DW-DtILd - 12.0

Because Branch 2 is never taken in this case, the value assigned to the parameter for this case is irrelevant.

Case 2: Either a detonable mixture does not exist in the drywell just before VB, or the vessel does not fail. In either case, a detonation does not occur. The quantification for this case is:

Branch 1: I-DWDt - 0.0
Branch 2: InDWDt - 1.0

Because Branch 1 is never taken in this case, the value assigned to the parameter for this case is irrelevant. For Branch 2, the value assigned to the parameter (kPa-S) is:

Parameter 36: DW-DtILd - 0.0

Question 66. Does a Deflagration Occur in the Drywell at VB?
2 Branches, Type 2, 2 Cases

The branches for this question are:

1. I-DWDf A deflagration occurs in the drywell at VB.

2. InDWDf A deflagration does not occur in the drywell at VB.

This question is not sampled and was internally quantified. The branching at this question depends upon the branch taken at Questions 56, 57, 63, and 65. This question is similar to the previous question in that it addresses ignition of a combustible mixture that exists in the drywell just before VB. This question is primarily used to determine whether this pre-existing hydrogen is burned or is pushed into the wetwell. The load associated with the hydrogen burned in the drywell at VB is addressed by the Containment Loads Expert Panel (see Question 70).

Case 1: The drywell is not steam inert, and there is sufficient hydrogen and oxygen in the drywell to support a deflagration. Vessel failure supplies an ignition source. Thus, a deflagration occurs at VB. The quantification for this case is:

Branch 1: I-DWDf - 1.0
Branch 2: InDWDf - 0.0

Case 2: Either a combustible mixture does not exist in the drywell just before VB, or the vessel does not fail. In either case, a deflagration does not occur. The quantification for this case is:

Branch 1:	I-DWDf	-	0.0
Branch 2:	InDWDf	-	1.0

Question 67. Does a Large Ex-Vessel Steam Explosion Occur?
2 Branches, Type 2, 3 Cases

The branches for this question are:

1. ExSE A large ex-vessel steam explosion occurs shortly after VB.

2. nExSE A large ex-vessel steam explosion does not occur.

This question is not sampled and was internally quantified. The branching at this question depends upon the branch taken at Questions 28, 58, 63, and 64. (A discussion of the quantification of this issue is presented in Volume 2, Part VI, of this report.)

The dropping of hot metal into water has been observed to cause energetic and violent reactions commonly known as steam explosions. They appear to be more likely when the water is considerably below the saturation temperature. At Sandia National Laboratories, steam explosions were observed in 86% of the tests in which hot metal was dropped into water. Some of these explosions were extremely energetic, others were not very energetic. For an ex-vessel steam explosion to occur in a severe reactor accident, there must either be water in the pedestal cavity before VB or injection of water into the RPV at the time of VB, and the vessel must fail, allowing core debris to enter the pedestal cavity.

This question determines whether an ex-vessel steam explosion occurs at VB. This question is referenced by subsequent questions to determine whether the reactor pedestal fails from dynamic loading associated with an ex-vessel steam explosion and to determine the amount of hydrogen produced and consumed at VB. This question is also referenced in the source term analysis to determine the source term associated with VB. This question does not, however, address the quasi-static loads associated with an ex-vessel steam explosion. The loads accompanying VB were addressed by the Containment Loads Expert Panel. The distributions provided by the expert panel include the contribution from an ex-vessel steam explosion. Loads accompanying VB are addressed in Questions 70 and 71.

Case 1: The pedestal cavity is dry with no coolant injection into the RPV, the vessel does not fail, or an Alpha Mode event occurred. In any case, an ex-vessel steam explosion does not occur. Alpha Mode event fails both the drywell and the containment and any consequences associated with an ex-vessel steam explosion would be negligible. The quantification for this case is:

Branch 1:	ExSE	-	0.00
Branch 2:	nExSE	-	1.00

Case 2: The core debris is released from the vessel as a high pressure melt ejection, HPME. The pedestal cavity contains water or water is released from the vessel at VB. It is likely that an ex-vessel steam explosion will occur. The quantification for this case is:

Branch 1:	ExSE	-	0.80
Branch 2:	nExSE	-	0.20

Case 3: The pedestal cavity contains water, or water is released from the vessel at VB. The core debris is not released as a HPME. Based on experiments referenced above, it is likely that an ex-vessel steam explosion will occur. The quantification for this case is:

Branch 1:	ExSE	-	0.86
Branch 2:	nExSE	-	0.14

Question 68. What Amount of Hydrogen Is Released at VB?
1 Branch, Type 4, 1 Parameter, 7 Cases

The branch for this question is:

1. H2VB The amount of hydrogen released during blowdown at VB.

The parameter initialized in this question is:

P7 H2AVB The amount of hydrogen release during blowdown at VB (kg-moles) is read in as Parameter 7.

The parameter initialized in this question is sampled. The distributions for the amount of hydrogen released during the blowdown at VB were provided by the In-vessel Phenomenology Expert Panel. (A discussion of this issue is presented in Volume 2, Part I, of this report.) The parameter initialized in this question depends upon the branch taken at Questions 1, 14, 26, 28, and 63.

The expert panel provided distributions for the total amount of hydrogen generated in the vessel. This amount included the hydrogen released during core damage and the amount released at VB. In addition to the total amount of hydrogen generated, the experts indicated the fraction that is released during core damage and the fraction that is released at VB. The amount of hydrogen generated during core damage was addressed in Question 35. In this question, the amount of hydrogen generated at VB is considered. To insure that the total amount of hydrogen produced is consistent with the experts' distributions, the amount of hydrogen released at VB, Parameter 7, is correlated with Parameter 2, amount of hydrogen generated during core degradation. Furthermore, to insure that the accidents being considered before VB are consistent with the accidents being addressed in this question, Cases 2 through 7 in this question are identical to Cases 1 through 6 in Question 35. The experts only considered RPV blowdown as a mechanism for hydrogen generation at VB; they did not consider HPME/DCH or ex-vessel steam explosions. Hydrogen production by these last two events is addressed in the next question.

Case 1: An Alpha Mode event occurred, or the vessel did not fail. If the vessel does not fail, there is no additional hydrogen production. An Alpha Mode event fails both the drywell and the containment, so hydrogen production is not important for this case. The value assigned to the parameter (kg-moles) for this case is:

Parameter 7: H2AVB - 0.0

Case 2: The PDS is either a short-term or a long-term ATWS. The RPV is at high pressure and the high pressure injection systems are not available. Thus, core damage begins with the RPV at high pressure. During core damage, the operators depressurize the RPV, which allows the low pressure injection systems to provide coolant to the core. Despite the restoration of coolant injection to the RPV during core damage, the vessel fails. The mean value (kg-moles) of the aggregate distribution provided by the expert panel for this case is:

Parameter 7: H2AVB - 61

Case 3: This case is the same as the previous case except that the operators do not depressurize the RPV, so the low pressure injection system cannot be used to provide coolant to the RPV. Thus, core damage proceeds to VB without injection being restored to the RPV. The mean value (kg-moles) of the aggregate distribution provided by the expert panel for this case is:

Parameter 7: H2AVB - 89

Case 4: The PDS is not an ATWS. The RPV is at high pressure at the onset of core damage. During core damage (i.e., the time from the onset of core damage to VB), but the vessel is depressurized and coolant injection is restored to the RPV. Despite the restoration of coolant injection to the RPV during core damage, the vessel fails. The mean value (kg-moles) of the aggregate distribution provided by the expert panel for this case is:

Parameter 7: H2AVB - 53

Case 5: The PDS is not an ATWS. The RPV is depressurized at the onset of core damage. Coolant injection is restored to the RPV during core damage. Despite the restoration of coolant injection to the RPV during core damage, the vessel fails. The mean value (kg-moles) of the aggregate distribution provided by the expert panel for this case is:

Parameter 7: H2AVB - 27

Case 6: The PDS is not an ATWS. The RPV is at high pressure and coolant injection is not restored before VB. The mean value (kg-moles) of the aggregate distribution provided by the expert panel for this case is:

Parameter 7: H2AVB - 234

Case 7: The PDS is not an ATWS. The RPV is at low pressure and coolant injection is not restored before VB. The mean value (kg-moles) of the aggregate distribution provided by the expert panel for this case is:

Parameter 7: H2AVB - 62

Question 69. **How Much Hydrogen Is Released at VB?**
4 Branches, Type 6, 2 Cases

The branches for this question are:

1.	H2VB>50	Greater than 50% of the total in-vessel zirconium is oxidized at VB.
2.	H2VB>25	Between 25% and 50% of the total in-vessel zirconium is oxidized at VB.
3.	H2VB>10	Between 10% and 25% of the total in-vessel zirconium is oxidized at VB.
4.	H2VB<10	Less than 10% of the total in-vessel zirconium is oxidized at VB.

This question is not sampled and was internally quantified. The branching at this question depends upon the branch taken at Questions 64 and 67. In this question, the amount of hydrogen released at VB is adjusted to account for hydrogen that may be generated from a HPME/DCH or from an ex-vessel steam explosion, ExSE. Modules in the user function subroutine are used to calculate the amount of hydrogen released at VB.

In the previous question, the hydrogen generated during RPV blowdown was considered. If the core debris is released from the vessel as an HPME or if an ex-vessel steam explosion occurs, additional hydrogen may be generated. Results from the FITS-D series experiments[A-8] indicate that considerable amounts of hydrogen can be generated during these types of events. Similar results are presented in the Parametric CONTAIN study that was performed to investigate the loads in the Grand Gulf containment that result when the vessel fails at high pressure. (These calculations are discussed in Volume 2, Part 2, of this report.) It was found that in almost all of the cases studied, nearly all the zirconium in the debris that participated in HPME was oxidized. In addition to the zirconium that was oxidized, a considerable fraction of the iron in the debris was also oxidized. Based in part on these experiments and calculations, it was assumed that if an HPME or an ex-vessel steam explosion occurs, 51% of the unoxidized Zirconium in the ejected core debris will be oxidized.

Case 1: The core debris is released from the vessel as a high pressure melt ejection, HPME, or an ex-vessel steam explosion occurs at VB. In the user function subroutine the amount of hydrogen generated from an HPME/ex-vessel steam explosion is calculated. This value is then compared with the amount of hydrogen released during the RPV blowdown (quantified in the previous question), and the maximum of these two values is used to quantify the amount of hydrogen released at VB. The two values are not added together because in both cases core debris that is released from the vessel is being oxidized

Case 2: There is no HPME and no ex-vessel steam explosion at VB. The hydrogen generated at VB is caused by the RPV blowdown, which was addressed in the previous question.

Question 70. **What Is the Peak Drywell/Wetwell Pressure Difference Resulting from VB?**
1 Branch, Type 4, 1 Parameter, 14 Cases

The branch for this question is:

1. DPDWVB The peak drywell/wetwell pressure difference at VB.

The parameter initialized in this question is:

P13 DPDWVB The peak drywell/wetwell pressure difference at VB (kPa) is read in as Parameter 13.

The parameter initialized in this question is sampled. The distributions for the peak drywell/wetwell pressure differential was provided by the Containment Loads Expert Panel. (A discussion of this issue is presented in Volume 2, Part II, of this report.) The parameter initialized in this question depends upon the branch taken at Questions 26, 54, 61, and 63.

In this question, the peak drywell/wetwell pressure differential accompanying VB is quantified. This value is then compared, in a subsequent question, with the drywell structural capacity to determine whether the drywell fails from quasi-static overpressure.

When the RPV fails, steam and core debris are released from the vessel. The release of this material from the vessel can pressurize the drywell. The drywell and wetwell volumes communicate through horizontal vents located in the suppression pool. When the drywell is pressurized (relative to the wetwell), the suppression pool is depressed in the drywell, and the vents are exposed. The drywell pressure is then relieved through these vents. Thus, to establish a significant pressure differential between the drywell and the wetwell, the drywell volume must be pressurized before the vents clear. Energetic events that lead to rapid pressurization of the drywell volume include hydrogen burns in the drywell, DCH, ex-vessel steam explosions, and to a lesser extent RPV blowdown from high pressure.

Factors that affect the pressurization of the drywell include the pressure of the RPV at VB (i.e., DCH can only occur when the RPV is at high pressure), the amount of water in the pedestal cavity (i.e., for an ex-vessel steam explosion to occur there must be water in the cavity), vessel failure size (i.e., hole size), and the amount of core debris ejected at VB.

Case 1: Either an Alpha Mode event occurred, or the vessel did not fail. If an Alpha Mode event occurred, both the drywell and the containment structures have already failed, so the loading on the drywell structure is not important. If the vessel did not fail there would not be any significant drywell pressurization. The value (kPa) assigned to the parameter in this case is:

Parameter 13: DPDWVB - 0.0

Case 2: The RPV failure mode is a large hole. A large amount of molten core debris is released from the vessel at high pressure into a wet or flooded cavity. The mean value (kPa) of the aggregate distribution provided by the expert panel for this case is:

Parameter 13: DPDWVB - 434

Case 3: The RPV failure mode is a small hole. A large amount of molten core debris is released from the vessel at high pressure into a wet or flooded cavity. The mean value (kPa) of the aggregate distribution provided by the expert panel for this case is:

Parameter 13: DPDWVB - 332

Case 4: The RPV failure mode is a large hole. A large amount of molten core debris is released from the vessel at high pressure into a dry cavity. The mean value (kPa) of the aggregate distribution provided by the expert panel for this case is:

Parameter 13: DPDWVB - 392

Case 5: The RPV failure mode is a small hole. A large amount of molten core debris is released from the vessel at high pressure into a dry cavity. The mean value (kPa) of the aggregate distribution provided by the expert panel for this case is:

Parameter 13: DPDWVB - 242

Case 6: The RPV failure mode is a large hole. A small amount of molten core debris is released from the vessel at high pressure into a wet or flooded cavity. The mean value (kPa) of the aggregate distribution provided by the expert panel for this case is:

Parameter 13: DPDWVB - 425

Case 7: The RPV failure mode is a small hole. A small amount of molten core debris is released from the vessel at high pressure into a wet or flooded cavity. The mean value (kPa) of the aggregate distribution provided by the expert panel for this case is:

Parameter 13: DPDWVB - 311

Case 8: The RPV failure mode is a large hole. A small amount of molten core debris is released from the vessel at high pressure into a dry cavity. The mean value (kPa) of the aggregate distribution provided by the expert panel for this case is:

Parameter 13: DPDWVB - 336

Case 9: The RPV failure mode is a small hole. A small amount of molten core debris is released from the vessel at high pressure into a dry cavity. The mean value (kPa) of the aggregate distribution provided by the expert panel for this case is:

Parameter 13: DPDWVB - 222

Case 10: The RPV failure mode is a large hole. A large amount of molten core debris is released from the vessel at low pressure into a wet or flooded cavity. The mean value (kPa) of the aggregate distribution provided by the expert panel for this case is:

Parameter 13: DPDWVB - 295

Case 11: The RPV failure mode is a small hole. A large amount of molten core debris is released from the vessel at low pressure into a wet or flooded cavity. The mean value (kPa) of the aggregate distribution provided by the expert panel for this case is:

Parameter 13: DPDWVB - 242

Case 12: The RPV failure mode is a large hole. A small amount of molten core debris is released from the vessel at low pressure into a wet or flooded cavity. The mean value (kPa) of the aggregate distribution provided by the expert panel for this case is:

Parameter 13: DPDWVB - 290

Case 13: The RPV failure mode is a small hole. A small amount of molten core debris is released from the vessel at low pressure into a wet or flooded cavity. The mean value (kPa) of the aggregate distribution provided by the expert panel for this case is:

Parameter 13: DPDWVB - 239

Case 14: The RPV is at low pressure at the time of vessel failure and the core debris is released into a dry cavity. Because the vessel fails at low pressure, DCH does not occur. Similarly, because the cavity is dry, there are no ex-vessel steam explosions. Thus, loads associated with this case are negligible when compared to the structural capacity of the drywell. The value (kPa) assigned to the parameter for this case is:

Parameter 13: DPDWVB - 0.0

Question 71. **What Is the Peak Pedestal Pressure at VB?**
1 Branch, Type 4, 1 Parameter, 18 Cases

The branch for this question is:

1. Ped-VBP The peak pressure in the reactor cavity at VB.

The parameter initialized in this question is:

P39 Ped-VBP The peak pedestal pressure at VB (kPa) is read in as Parameter 39.

The parameter initialized in this question is sampled. The distributions for the peak pressure in the reactor pedestal cavity were provided by the Containment Loads Expert Panel. (A discussion of this issue is presented in Volume 2, Part II of this report.) The parameter initialized in this question depends upon the branch taken at Questions 26, 36, 54, 61, and 63.

In this question, the peak pedestal pressure accompanying VB is quantified. This value is then compared, in a subsequent question, with the pedestal structural capacity to determine whether the pedestal fails from quasi-static overpressure. Pedestal failure and the loss of RPV support can induce drywell failure. This issue is addressed in Question 76.

When the RPV fails, steam and core debris are released from the vessel into the pedestal cavity below the vessel. Energetic events that lead to rapid pressurization of the pedestal cavity include DCH, ex-vessel steam explosions, and to a lesser extent RPV blowdown from high pressure.

Factors that affect the pressurization of the pedestal cavity include the pressure of the RPV at VB (i.e., DCH can occur only when the RPV is at high pressure), the amount of water in the pedestal cavity (i.e., for an ex-vessel steam explosion to occur, there must be water in the cavity), vessel failure size (i.e., hole size), the amount of core debris ejected at VB, and the amount of oxidized metal in the ejected debris.

Case 1: Either an Alpha Mode event occurred, or the vessel did not fail. If an Alpha Mode event occurred, both the drywell and the containment structures have already failed, so the loading on the pedestal structure is not important. If the vessel did not fail, there would be no significant pressurization of the pedestal cavity. The value (kPa) assigned to the parameter in this case is:

Parameter 39: Ped-VBP - 0.0

Case 2: The RPV failure mode is a large hole. A large amount of molten core debris is released from the vessel at high pressure into a wet or flooded cavity. The mean value (kPa) of the aggregate distribution provided by the expert panel for this case is:

Parameter 39: Ped-VBP - 3580

Case 3: The RPV failure mode is a small hole. A large amount of molten core debris is released from the vessel at high pressure into a wet or flooded cavity. The mean value (kPa) of the aggregate distribution provided by the expert panel for this case is:

Parameter 39: Ped-VBP - 2780

Case 4: The RPV failure mode is a large hole. A large amount of molten core debris is released from the vessel at high pressure into a dry cavity. The mean value (kPa) of the aggregate distribution provided by the expert panel for this case is:

Parameter 39: Ped-VBP - 3080

Case 5: The RPV failure mode is a small hole. A large amount of molten core debris is released from the vessel at high pressure into a dry cavity. The mean value (kPa) of the aggregate distribution provided by the expert panel for this case is:

Parameter 39: Ped-VBP - 1720

Case 6: The RPV failure mode is a large hole. A small amount of molten core debris is released from the vessel at high pressure into a wet or flooded cavity. The mean value (kPa) of the aggregate distribution provided by the expert panel for this case is:

Parameter 39: Ped-VBP - 3250

Case 7: The RPV failure mode is a small hole. A small amount of molten core debris is released from the vessel at high pressure into a wet or flooded cavity. The mean value (kPa) of the aggregate distribution provided by the expert panel for this case is:

Parameter 39: Ped-VBP - 2170

Case 8: The RPV failure mode is a large hole. A small amount of molten core debris is released from the vessel at high pressure into a dry cavity. The mean value (kPa) of the aggregate distribution provided by the expert panel for this case is:

Parameter 39: Ped-VBP - 2850

Case 9: The RPV failure mode is a small hole. A small amount of molten core debris is released from the vessel at high pressure into a dry cavity. The mean value (kPa) of the aggregate distribution provided by the expert panel for this case is:

Parameter 39: Ped-VBP - 1440

Case 10: The RPV failure mode is a large hole. A large amount of molten core debris is released from the vessel at low pressure into a wet or flooded cavity. The core debris ejected at VB contains a large amount of oxidized zirconium. The mean value (kPa) of the aggregate distribution provided by the expert panel for this case is:

Parameter 39: Ped-VBP - 1120

Case 11: The RPV failure mode is a small hole. A large amount of molten core debris is released from the vessel at low pressure into a wet or flooded cavity. The core debris ejected at VB contains a large amount of oxidized zirconium. The mean value (kPa) of the aggregate distribution provided by the expert panel for this case is:

Parameter 39: Ped-VBP - 734

Case 12: The RPV failure mode is a large hole. A large amount of molten core debris is released from the vessel at low pressure into a wet or flooded cavity. The core debris ejected at VB contains a small amount of oxidized zirconium. The distribution that was used to quantify Case 10 is also used to quantify this case. Thus, the mean value (kPa) of the aggregate distribution provided by the expert panel for this case is:

Parameter 39: Ped-VBP - 3580

Case 13: The RPV failure mode is a small hole. A large amount of molten core debris is released from the vessel at low pressure into a wet or flooded cavity. The core debris ejected at VB contains a small amount of oxidized zirconium. The mean value (kPa) of the aggregate distribution provided by the expert panel for this case is:

Parameter 39: Ped-VBP - 557

Case 14: The RPV failure mode is a large hole. A small amount of molten core debris is released from the vessel at low pressure into a wet or flooded cavity. The core debris ejected at VB contains a large amount of oxidized zirconium. The mean value (kPa) of the aggregate distribution provided by the expert panel for this case is:

Parameter 39: Ped-VBP - 1000

Case 15: The RPV failure mode is a small hole. A small amount of molten core debris is released from the vessel at low pressure into a wet or flooded cavity. The core debris ejected at VB contains a large amount of oxidized zirconium. The mean value (kPa) of the aggregate distribution provided by the expert panel for this case is:

Parameter 39: Ped-VBP - 606

Case 16: The RPV failure mode is a large hole. A small amount of molten core debris is released from the vessel at low pressure into a wet or flooded cavity. The core debris ejected at VB contains a small amount of oxidized zirconium. The distribution used to quantify Case 15 is also used to quantify this case. Thus, the mean value (kPa) of the aggregate distribution provided by the expert panel for this case is.

Parameter 39: Ped-VBP - 606

Case 17: The RPV failure mode is a small hole. A small amount of molten core debris is released from the vessel at low pressure into a wet or flooded cavity. The core debris ejected at VB contains a small amount of oxidized zirconium. The mean value (kPa) of the aggregate distribution provided by the expert panel for this case is:

Parameter 39: Ped-VBP - 436

Case 18: The RPV is at low pressure at the time of vessel failure, and the core debris is released into a dry cavity. Because the vessel fails at low pressure, DCH does not occur. Similarly, because the cavity is dry, there are no ex-vessel steam explosions. Thus, loads associated with this case are negligible when compared to the structural capacity of the pedestal. The value (kPa) assigned to the parameter for this case is:

Parameter 39: Ped-VBP - 0.0

Question 72. Is the Impulse Loading to the Drywell at VB Sufficient to Cause Failure?
3 Branches, Type 6, 2 Cases

The branches for this question are:

1.	InDWFI	The drywell does not fail from an impulse load at VB.
2.	I-DWFI2	An impulse load in the drywell at VB results in a leak in the drywell.
3.	I-DWFI3	An impulse load in the drywell at VB results in a rupture in the drywell.

The branching at this question depends upon the branch taken at Question 65. A module in the user function is used to determine whether the drywell fails and, if so, the mode of failure. In the user function, the impulse load (Parameter 36) is compared to the structural capacity of the drywell to dynamic loads (Parameter 34). The way in which the random number (Parameter 35) is used to determine the mode of drywell failure is described in Subsection A.2. The method differs depending on whether the rate of pressure rise is fast or slow relative to the rate at which a leak depressurizes the containment (or pressurizes the drywell). The fast pressure rise method is used in this question.

> Case 1: The hydrogen in the drywell detonates at VB. A module in the user function is used to determine whether the drywell fails and the mode of failure.
>
> Case 2: A hydrogen detonation does not occur in the drywell, and there are no other energetic events in the drywell at VB that lead to an impulsive load on the drywell structure. Impulsive loads from ex-vessel steam explosions are a threat only to the pedestal structure. Thus, the drywell does not fail from an impulsive load.

Question 73. **Is Drywell Pressurization at VB Sufficient to Cause Failure?**
5 Branches, Type 5, 1 Case

The branches for this question are:

1. InDWOP The drywell does not fail at VB from quasi-static overpressure.
2. E-DWOP2 The drywell fails in the leak mode at the drywell wall.
3. E-DWHOP2 The drywell fails in the leakage mode at the drywell head. In this analysis, it was assessed that there was a negligible probability that the drywell head would fail before the drywell wall. Thus, this failure location does not occur in this analysis but has been retained in the tree for completeness.
4. E-DWOP3 The drywell fails in the rupture mode at the drywell wall.
5. E-DWHOP3 The drywell fails in the rupture mode at the drywell head. In this analysis, it was assessed that there was a negligible probability that the drywell head would fail before the drywell wall. Thus, this failure location does not occur in this analysis but has been retained in the tree for completeness.

A module in the user function is used to determine whether the drywell fails and, if so, the mode of failure. In the user function, the peak drywell/wetwell pressure differential that occurs at VB (Parameter 1[illegible] is compared to the drywell failure pressure (Parameter 26). The way in which the random number (Parameter 31) is used to determine the mode of containment failure is described in Subsection A.2. The method differs depending on whether the rate of pressure rise is fast or slow relative to the rate at which a leak depressurizes the containment (or pressurizes the drywell). The fast pressure rise method is used in this question.

Question 74. Does the RPV Pedestal Fail Due to Pressurization at VB?
2 Branches, Type 5, 1 Case

The branches for this question are:

1. I-PedFP The reactor pedestal fails from quasi-static loads accompanying VB.

2. InPedFP The reactor pedestal does not fail.

The reactor pedestal failure pressure (incorporated into this question as a comparison parameter) is sampled in this question; the distribution was quantified internally. (A discussion of the quantification of this issue is presented in Volume 2, Part VI, of this report.) In this question, it is determined whether the reactor pedestal fails from quasi-static pressurization of the pedestal cavity during VB. The peak pedestal cavity pressure that occurs at VB (Parameter 39) is compared to the pedestal failure pressure (comparison parameter). If the cavity pressure is greater than the pedestal failure pressure, the pedestal fails. Failure of the pedestal implies loss of support to the RPV. The mean value (kPa) of the aggregate distribution for the pedestal failure pressure is:

Comparison Parameter: - 1300

Question 75. Does the RPV Pedestal Fail from an Ex-Vessel Steam Explosion (Impulse Loading)?
2 Branches, Type 2, 3 Cases

The branches for this question are:

1. I-PedFI The pedestal fails from an impulsive load that originated from an ex-vessel steam explosion.

2. InPedFI The pedestal does not fail from an impulsive load at VB.

Case 2 of this question is sampled; the distribution was quantified internally. The branching at this question depends upon the branch taken at Questions 67 and 74. (A discussion of the quantification of this issue is presented in Volume 2, Part VI, of this report.)

In this question, only pedestal failure from a dynamic load is addressed. Pedestal failure from quasi-static pressurization was addressed in the previous question. In this analysis, the only significant impulsive load on the pedestal is from an ex-vessel steam explosion. (The quasi-static load on the pedestal from an ex-vessel steam explosion was considered in Question 71).

The magnitude of the dynamic load associated with the steam explosion and the structural response of the pedestal to the load depend on a number of parameters, a number of which are uncertain. To reflect this uncertainty, pedestal failure and no pedestal failure have been quantified with equal probability (i.e., it is equally as likely that the pedestal will fail as remain intact).

Case 1: The reactor pedestal failed from quasi-static pressurization of the pedestal cavity during VB. Thus, the pedestal has already failed and does not fail from an impulse load. The quantification for this case is:

Branch 1: I-PedFI - 0.0
Branch 2: InPedFI - 1.0

Case 2: There was a large ex-vessel steam explosion in the pedestal cavity during VB. The pedestal did not fail from quasi-static pressurization. It is uncertain whether the impulse load associated with the steam explosion fails the pedestal. The quantification for this case, based on the mean value of this distribution, is:

Branch 1: I-PedFI - 0.5
Branch 2: InPedFI - 0.5

Case 3: The pedestal did not fail from quasi-static pressurization at VB and an ex-vessel steam explosion did not occur. Thus, the pedestal does not fail at VB. The quantification for this case is:

Branch 1: I-PedFI - 0.0
Branch 2: InPedFI - 1.0

Question 76. **Does the RPV Pedestal Failure Induce Drywell Failure?**
2 Branches, Type 2, 3 Cases

The branches for this question are:

1. I-DWFPed Pedestal failure induces drywell failure.

2. InDWFPed Pedestal failure does not induce drywell failure.

Case 2 of this question is sampled. The distribution for the probability that pedestal failure induces drywell failure was provided by the Structural Response Expert Panel. The branching at this question depends upon the branch taken at Questions 52, 58, 72, 73, 74, and 75. (A discussion of the quantification of this issue is presented in Volume 2, Part III, of this report.)

The RPV is supported by the reactor pedestal. Failure of the pedestal will result in gross motion of the RPV. Several large pipes are attached to the RPV that penetrate the drywell (e.g., steam lines and feedwater line). The motion of the RPV and hence the motion of these pipes can damage the penetrations and fail the drywell boundary. The integrity of the drywell boundary can also be impaired by damage to the steel drywell liner that results from the RPV motion. The combination of these events can establish pathways that bypass the suppression pool. It is assumed that drywell failure by this mechanism will result in a pathway that allows fission products to bypass the suppression pool completely (i.e, rupture of the drywell).

Case 1: Either an Alpha Mode event occurred, or the drywell has already failed in the rupture mode. In either case, the drywell gases can already completely bypass the suppression pool. The quantification for this case is:

Branch 1: I-DWFPed - 0.0
Branch 2: InDWFPed - 1.0

Case 2: The drywell was not ruptured before VB and drywell pressurization at VB did not rupture the drywell. The pedestal failed at VB from either quasi-static pressurization of the cavity or from a dynamic load associated with an ex-vessel steam explosion. This case is sampled zero-one. Based on the mean value of the sample, the quantification for this case is:

Branch 1: I-DWFPed - 0.175
Branch 2: InDWFPed - 0.825

Case 3: The reactor pedestal does not fail at VB. Thus, the quantification for this case is:

Branch 1: I-DWFPed - 0.0
Branch 2: InDWFPed - 1.0

Question 77. What Is the Pressure in the Containment at VB Prior To a Hydrogen Burn?
1 Branch, Type 4, 1 Parameter, 8 Cases

The branch for this question is:

1. CP-VB Containment pressure at VB prior to a hydrogen burn.

The parameter initialized in this question is:

P40 CP-VB The containment pressure (kPa) at VB prior to a hydrogen burn is read in as Parameter 40.

The parameter initialized in this question is sampled. The distributions for the pressure in the containment prior to a hydrogen burn were quantified internally. The parameter initialized in this question depends upon the branch taken at Questions 26, 50, 52, 54, 61, 63, 64, 67, 72, and 73.

In this question, the pressure rise in the containment from energetic events in the drywell is determined. The loads accompanying VB (see Question 70) pressurize the drywell. This pressure is relieved through the suppression pool vents. If, on the other hand, the drywell is ruptured, the suppression pool is completely bypassed, and the drywell atmosphere is vented directly into the wetwell volume. The release of drywell gases into the wetwell at VB will increase the wetwell baseline pressure. It is this increase in the baseline pressure that is determined in this question.

The increase in the base line pressure is based on the peak drywell pressure loads (Question 70) assigned by the Containment Loads Expert Panel. If the drywell has been ruptured (i.e., complete bypass of the suppression pool), the drywell atmosphere (at its peak pressure) is isentropically expanded into the wetwell volume with the requirement that after the expansion, the pressure in the drywell and the wetwell is the same. The subcases considered by the experts (e.g., the effects of RPV hole size and the amount of core ejected) have been averaged together. The effects of RPV pressure and cavity water have still been retained. It should be noted that this case is generally not important because most events that would have resulted in a drywell rupture would have also caused the containment to rupture. If the drywell is not ruptured, the drywell atmosphere will be vented through the suppression pool where the steam will be condensed, and the hot gases will be cooled. The pressure rise in the wetwell for this case is therefore expected to be negligible. A possible exception to this conclusion is the case in which a very energetic event in the drywell causes hot gases/particles to "punch through" (i.e., rapidly pass through the pool without being affected by it) the suppression pool. Events that could result in punch-through are HPME and ex-vessel steam explosions. Although the pressure rise in the wetwell for the punch-through case is expected to be less than for the complete bypass case, the amount of punch-through and the effectiveness of the suppression pool under these conditions is very uncertain. To quantify this case, the maximum pressure rise was assumed to be half of the maximum pressure rise associated with complete bypass. To reflect the large amount of uncertainty associated with the effectiveness of the suppression pool under these conditions, a uniform distribution between 0 and this maximum value was assigned to this case.

Case 1: An Alpha Mode event occurred, there was no vessel failure, or the containment has been ruptured. If the containment has been ruptured, the pressure rise in the containment will be negligible because the wetwell pressure can be relieved to the outside atmosphere. If the vessel does not fail, there will be no significant pressure rise in the drywell. In any case, the wetwell is not pressurized. The value (kPa) assigned to the parameter for this case is:

Parameter 40: CP-VB · 0.0

Case 2: The drywell has been ruptured, which results in complete bypass of the suppression pool. The vessel fails at high pressure and the core is released into a wet or flooded pedestal cavity. The peak drywell pressure initialized in Cases 2, 3, 6, and 7 in Question 70 were averaged together. Based on this drywell pressure, the drywell atmosphere was isentropically expanded into the wetwell to determine the pressure rise in the containment. The mean value (kPa) of the distribution used to quantify the parameter for this case is:

Parameter 40: CP-VB · 50

Case 3: The drywell has been ruptured, which results in complete bypass of the suppression pool. The vessel fails at high pressure and the core is released into a dry pedestal cavity. The peak drywell pressure initialized in Cases 4, 5, 8, and 9 in Question 70 were averaged together. Based on this drywell pressure, the drywell atmosphere was isentropically expanded into the wetwell to determine the pressure rise in the containment. The mean value (kPa) of the distribution used to quantify the parameter for this case is:

Parameter 40: CP-VB - 41

Case 4: The drywell has been ruptured, which results in complete bypass of the suppression pool. The vessel fails at low pressure, and the core is released into a wet or flooded pedestal cavity. The peak drywell pressures initialized in Cases 10 through 13 in Question 70 were averaged together. Based on this drywell pressure, the drywell atmosphere was isentropically expanded into the wetwell to determine the pressure rise in the containment. The mean value (kPa) of the distribution used to quantify the parameter for this case is:

Parameter 40: CP-VB - 35

Case 5: The drywell has been ruptured, which results in complete bypass of the suppression pool. The vessel fails at low pressure, and the core is released into a dry pedestal cavity. The pressure rise in the containment for this case is negligible. The value (kPa) assigned to the parameter for this case is:

Parameter 40: CP-VB - 5.0

Case 6: A large amount of core is released from the vessel. Either the core is ejected as an HPME or an ex-vessel steam explosion occurs in the pedestal cavity. The drywell has not been ruptured, so the drywell gases will be directed into the suppression pool. The possibility exists that the drywell gases will punch-through the suppression pool. The mean value (kPa) of the distribution used to quantify the parameter for this case is:

Parameter 40: CP-VB - 57

Case 7: A small amount of core is released from the vessel. Either the core is ejected as a HPME, or an ex-vessel steam explosion occurs in the pedestal cavity. The drywell has not been ruptured, so the drywell gases will be directed into the suppression pool. The possibility exists that the drywell gases will punch through the suppression pool. This case is quantified the same as the previous case. Thus, mean value (kPa) of the distribution used to quantify the parameter for this case is:

Parameter 40: CP-VB - 57

Case 8: The drywell has not been ruptured, and there was not a large energetic event in the drywell at VB. Thus, the suppression pool is not bypassed, and the pressure rise in the wetwell is negligible. The value (kPa) assigned to the parameter for this case is:

Parameter 40: CP-VB - 0.0

Question 78. What Is the Concentration of Hydrogen in the Containment Immediately After VB?
6 Branches, Type 6, 7 Cases

The branches for this question are:

1. IHWW>20 The H_2 concentration is in the range $H_2 \geq 20\%$.
2. IHWW>16 The H_2 concentration is in the range $16\% \leq H_2 < 20\%$.
3. IHWW>12 The H_2 concentration is in the range $12\% \leq H_2 < 16\%$.
4. IHWW>8 The H_2 concentration is in the range $8\% \leq H_2 < 12\%$.
5. IHWW>4 The H_2 concentration is in the range $4\% \leq H_2 < 8\%$.
6. I-NoH The H_2 concentration is in the range $H_2 < 4\%$.

The branching at this question depends upon the branch taken at Questions 28, 50, 54, 58, 63, 64, 65, 66, and 67. A module in the user function is used to determine the hydrogen concentration in the wetwell based on the gaseous constituents in the drywell and the wetwell and on the condition of the containment and drywell. The amount of hydrogen that remains in the wetwell is stored as Parameter 3.

In this question, the hydrogen (either pre-existing or generated at VB) and oxygen in the drywell are either passed to the wetwell or are consumed by burns at VB. The loads from these burns were considered by the Containment Loads Expert Panel and are therefore reflected in the distributions provided by this expert panel for the peak drywell pressure. The number of moles in the containment is also adjusted to account for leakage from the containment. The wetwell hydrogen concentrations calculated in this question are used in subsequent questions to determine the ignition probabilities, detonation probabilities, and the resulting loads from either a deflagration or detonation.

Case 1: Either an Alpha Mode event occurred, or the vessel did not fail. If an Alpha Mode event occurred, the concentration of hydrogen in the wetwell is not particularly important because both the drywell and the containment have already failed. If the vessel does not fail, the amount of hydrogen in the drywell and wetwell remain unchanged.

Case 2: There is an energetic event in the drywell at VB and the containment has been ruptured. The energetic events considered in this question include HPME, ex-vessel steam explosions, hydrogen detonations, and deflagrations. It is assumed that if one of these energetic events occurs at VB, the hydrogen in the drywell will be ignited. The amount of oxygen in the drywell will limit the amount of hydrogen that is allowed to burn in the drywell. After the burn, the remaining gaseous constituents are passed to the wetwell. Because the containment is ruptured, it is at atmospheric pressure and will not pressurize. Therefore, to satisfy this pressure requirement, it is necessary to release a fraction of the wetwell gas to the outside atmosphere.

Case 3: This case is the same as the previous case except that the containment is not ruptured. Thus, all of the wetwell gases remain in the containment.

Case 4: There are no large energetic events in the drywell at VB, but there is water in the pedestal cavity. The containment has been ruptured. When the core debris contacts the water, the steam generated will be voluminous. Because there are no energetic events and the drywell will quickly fill with steam, it is believed that the hydrogen will not burn in the drywell but instead will be driven into the wetwell. Because the containment is ruptured, it is at atmospheric pressure and will not pressurize. Therefore, to satisfy this pressure requirement, it is necessary to release a fraction of the wetwell gas to the outside atmosphere.

Case 5: This case is the same as the previous case except that the containment is not ruptured. Thus, all the wetwell gases remain in the containment.

Case 6: There are no large energetic events in the drywell at VB, and the drywell is dry. The containment however has been ruptured. Because there are no energetic events and large amounts of steam will not be generated, it is assumed that a fraction of the hydrogen and oxygen remains in the drywell. Because the containment is ruptured, it is at atmospheric pressure. Therefore, to satisfy this pressure requirement it is necessary to release a fraction of the wetwell gas to the outside atmosphere.

Case 7: This case is the same as the previous case except that the containment is not ruptured. Thus, all of the wetwell gases remain in the containment.

Question 79. Is AC Power Not Recovered Following VB?
2 Branches, Type 2, 4 Cases

The branches for this question are:

1. If AC power is not recovered shortly after VB.
2. I-AC AC power is recovered following VB.

Cases 3 and 4 of this question are sampled; the distributions sampled were obtained from the offsite power recovery curves for the Grand Gulf plant. The branching at this question depends upon the branch taken at Questions 2, 15, 24, and 25.

The probability of power recovery is that offsite electrical power is recovered in the period in question, given that power was not recovered prior to the period (see the discussion in Subsection A.3).

This question accounts for the delay in recovery of offsite power. The time period of interest here begins roughly 15 minutes before VB (when the last time period ended) and ends approximately 2 hours after VB.

Case 1: Power was previously available and is therefore still available. The quantification for this case is:

Branch 1:	IfAC	-	0.0
Branch 2:	I-AC	-	1.0

Case 2: DC power is not available. Without dc power, it is assumed that ac power cannot be restored within the timeframe considered in this analysis. The quantification for this case is:

Branch 1:	IfAC	-	1.0
Branch 2:	I-AC	-	0.0

Case 3: This case is an SBO that has core damage in the long term. Power was not initially available, but recovery was possible. For the long-term sequences, the previous time period was terminated 14.7 hours after the initiating event. Thus, the recovery period for this case is 14.7 hours to 17 hours. The mean value for power recovery during this time period is:

Branch 1:	IfAC	-	0.90
Branch 2:	I-AC	-	0.10

Case 4: This case is an SBO that has core damage in the short term. Power was not initially available, but recovery was possible. For the short-term sequences, the previous time period terminated 3.35 hours after the initiating event. Thus, the recovery period for this case is 3.35 hours to 5.6 hours. The mean value for power recovery during this time period is:

Branch 1:	IfAC	-	0.62
Branch 2:	I-AC	-	0.38

Question 80. **Is DC Power Available Following VB?**
2 Branches, Type 2, 4 Cases

The branches for this question are:

1. IfDC DC power is not available shortly after VB.

2. I-DC DC power is available following VB.

This question is not sampled and was internally quantified. The branching at this question depends upon the branch taken at Questions 2, 15, 24, and

25. A discussion of this issue and the assumptions about the relationship between ac and dc power is presented in Question 25.

The time periods used for battery depletion are the same as the time periods used for ac power recovery.

Case 1: DC power has already been lost. Once dc power is lost it is assumed that it cannot be recovered. The quantification for this case is:

Branch 1: IfDC - 1.0
Branch 2: I-DC - 0.0

Case 2: AC power is available, so dc power is available. The quantification for this case is:

Branch 1: IfDC - 0.0
Branch 2: I-DC - 1.0

Case 3: This case is an SBO that has core damage in the long term. Thus, the time period is from 14.7 hours to 17 hours. The quantification for this case is:

Branch 1: IfDC - 0.21
Branch 2: I-DC - 0.79

Case 4: The PDS is an SBO that has core damage in the short term. Thus, the time period is from 3.35 hours to 5.6 hours. The quantification for this case is:

Branch 1: IfDC - 0.01
Branch 2: I-DC - 0.99

Question 81. What Is the Status of the Containment Sprays Following VB?
4 Branches, Type 2, 8 Cases

The branches for this question are:

1.	IfCS	The containment sprays are failed and cannot be recovered.
2.	IrCS	The sprays are recoverable when ac power is restored.
3.	IaCS	The sprays are available but not currently operating.
4.	I-CS	The sprays are operating.

Cases 2, 4, and 6 of this question are sampled; the distributions were quantified internally. The branching at this question depends upon the branch taken at Questions 16, 22, 30, 50, and 79.

This question determines the status of the CS system during the time period shortly after VB. A description of containment spray system is presented in Question 13. In this question, failure of the CS system by energetic events in the containment is addressed.

Case 1: The CS system failed before VB and is therefore not available after VB. The quantification for this case is:

Branch 1: IfCS - 1.00
Branch 2: IrCS - 0.00
Branch 3: IaCS - 0.00
Branch 4: I-CS - 0.00

Case 2: The CS system was recoverable before VB, and ac power is not recovered in the time period shortly after VB. The containment was ruptured by an energetic event before VB (most likely a deflagration or a detonation). Because the event that failed the containment was severe enough to cause a rupture, it is possible that it also failed the CS system. Failure of the CS system is defined in this question as failure to provide adequate coverage to insure that the steam in the wetwell atmosphere is condensed. There is a large amount of uncertainty associated with the magnitude of the load that failed the containment and the location of the load (particularly in the case of a detonation). For this case, it is uncertain whether the CS system will fail or still be in a recoverable condition. This case is sampled zero-one. Based on the mean value of the sample, the quantification for this case is:

Branch 1: IfCS - 0.50
Branch 2: IrCS - 0.50
Branch 3: IaCS - 0.00
Branch 4: I-CS - 0.00

Case 3: The CS system was recoverable before VB, and ac power is not recovered in the time period shortly after VB. Because the containment was not ruptured before VB, the CS system remains recoverable. The quantification for this case is:

Branch 1: IfCS - 0.00
Branch 2: IrCS - 1.00
Branch 3: IaCS - 0.00
Branch 4: I-CS - 0.00

Case 4: The CS system was operating before VB, but the containment was ruptured by an energetic event before VB (most likely a deflagration or a detonation). The quantification for this case is the same as for Case 2, except that it is uncertain whether the CS system is failed or is still operating. This case is sampled zero-one. Based on the mean value of the sample, the quantification for this case is:

Branch 1: IfCS - 0.50
Branch 2: IrCS - 0.00
Branch 3: IaCS - 0.00
Branch 4: I-CS - 0.50

Case 5: The CS system was operating before VB. Because the containment was not ruptured before VB, it is expected that the CS system will still be operating. The quantification for this case is:

Branch 1: IfCS - 0.00
Branch 2: IrCS - 0.00
Branch 3: IaCS - 0.00
Branch 4: I-CS - 1.00

Case 6: The CS system was either available or recoverable before VB and ac power is available following VB. An energetic event (most likely a deflagration or a detonation) ruptured the containment before VB. The quantification for this case is the same as for Case 2, except that it is uncertain whether the CS system is failed or will be available. Because the containment has been ruptured, it will be near atmospheric pressure. Furthermore, because the containment is not pressurized, it is felt that if the CS system does not fail, there is only a small probability that the operators will actuate this system. This case is sampled zero-one. Based on the mean value of the sample, the quantification for this case is:

Branch 1: IfCS - 0.50
Branch 2: IrCS - 0.00
Branch 3: IaCS - 0.45
Branch 4: I-CS - 0.05

Case 7: AC power is available following VB, and the CS system has not failed. Because the containment was not ruptured by an energetic event before VB, it is very likely that the sprays will be operating. The quantification for this case is the same as the quantification in Case 4 of Question 30. The quantification for this case is:

Branch 1: IfCS - 0.00
Branch 2: IrCS - 0.00
Branch 3: IaCS - 0.01
Branch 4: I-CS - 0.99

Case 8: All the potential cases are addressed in the preceding cases. Thus, this case is not used.

Question 82. To What Level Is the Wetwell Inert After VB?
3 Branches, Type 5, 1 Case

The branches for this question are:

1. InWWIn The wetwell is not inert; both hydrogen deflagrations and detonations are possible.

2. I-WWIn2 The wetwell is inert to hydrogen detonations.

3. I-WWIn3 The wetwell is inert to both hydrogen detonations and deflagrations.

This question is used to determine whether hydrogen detonations or deflagrations are possible in the wetwell shortly after VB. A module in the user function is used to calculate the mole fraction of steam, Y_{steam}, in the wetwell. A discussion of the inerting limits is presented in Question 40. The combustion limits used in this analysis are:

$Y_{steam} \geq 0.55$; inert to detonations and deflagrations.

$0.55 > Y_{steam} \geq 0.35$; inert to detonations.

$0.35 > Y_{steam}$; both detonations and deflagrations are possible.

Question 83. Is There Sufficient Oxygen in the Containment to Support Combustion?
5 Branches, Type 5, 1 Case

The branches for this question are:

1.	O2Det20	There is enough oxygen in the wetwell to support a detonation of a mixture with 20% hydrogen.
2.	O2Det16	There is enough oxygen in the wetwell to support a detonation of a mixture with 16% hydrogen.
3.	O2Det12	There is enough oxygen in the wetwell to support a detonation of a mixture with 12% hydrogen.
4.	WWO2	There is enough oxygen in the wetwell to support a deflagration but not a detonation.
5.	nWWO2	There is not enough oxygen in the wetwell to support a deflagration.

This question determines the amount of hydrogen that can be burned based on the amount of oxygen available in the wetwell shortly after VB. This is not an important issue before VB because the wetwell initially has an abundance of oxygen. After VB, however, the amount of oxygen in the containment may have been depleted by previous burns and/or by containment failure. A module in the user function is used to calculate the mole fraction of oxygen in the containment. This question is used by subsequent questions to help determine the probabilities of hydrogen deflagrations and detonations.

Question 84. Does Ignition Occur in the Containment at VB?
2 Branches, Type 2, 8 Cases

The branches for this question are:

1.	I-CIgn	The hydrogen in the wetwell is ignited at VB.
2.	InCIgn	The hydrogen does not ignite at VB.

Cases 3 through 7 of this question are sampled. The distributions for ignition probability at VB were provided by the Containment Loads Expert Panel. (A discussion of this issue is provided in Volume 2, Part II, of this report.) The branching at this question depends upon the branch taken at Questions 24, 26, 52, 67, 72, 73, 78, 82, and 83.

In this question, the probability of hydrogen ignition in the wetwell at VB is determined. The ignition sources are the hot gases and hot debris particles either released from the vessel or generated in the drywell at VB. If the drywell is failed, some hot gases and/or hot particles can pass from the drywell directly into the wetwell. Because of the abundance of ignition sources present in the wetwell when the drywell boundary is failed, it is assumed that a combustible wetwell mixture will always ignite if the drywell is failed. If the drywell is not failed, the hot gases and particles will pass into the suppression pool where they will be cooled. If core debris is released from the vessel at high pressure, it is possible that hot gases and/or particles will pass through the suppression pool and provide a ignition source in the wetwell. Although the expert panel did not explicitly consider ex-vessel steam explosions in their case structure, it is assumed that this energetic event will provide the same ignition potential as debris release from the vessel at high pressure.

Case 1: The wetwell atmosphere is not combustible (i.e., not enough hydrogen, not enough oxygen, or too much steam). Thus, the hydrogen does not ignite. The quantification for this case is:

Branch 1:	I-CIgn	-	0.0
Branch 2:	InCIgn	-	1.0

Case 2: The wetwell atmosphere is combustible and either the drywell is failed (i.e., hot drywell gases bypass the suppression pool and enter the wetwell) or ac power is available. In either case, there will be numerous ignition sources in the wetwell. Thus, ignition is certain. The quantification for this case is:

Branch 1:	I-CIgn	-	1.0
Branch 2:	InCIgn	-	0.0

Case 3: The wetwell atmosphere is combustible and the drywell is intact. In addition, either the RPV fails at high pressure, or there is an ex-vessel steam explosion. The concentration of hydrogen in the wetwell is greater than 16%. The quantification for this case, based on the mean value of the aggregate distribution provided by the expert panel, is:

Branch 1:	I-CIgn	-	0.63
Branch 2:	InCIgn	-	0.37

Case 4: This case is the same as Case 3 except that the concentration of hydrogen in the wetwell is between 12% and 16%. The quantification

for this case, based on the mean value of the aggregate distribution provided by the expert panel, is:

Branch 1:	I-CIgn	-	0.56
Branch 2:	InCIgn	-	0.44

Case 5: This case is the same as Case 3 except that the concentration of hydrogen in the wetwell is between 8% and 12%. The quantification for this case, based on the mean value of the aggregate distribution provided by the expert panel, is:

Branch 1:	I-CIgn	-	0.43
Branch 2:	InCIgn	-	0.57

Case 6: This case is the same as Case 3 except that the concentration of hydrogen in the wetwell is between 4% and 8%. The quantification for this case, based on the mean value of the aggregate distribution provided by the expert panel, is:

Branch 1:	I-CIgn	-	0.29
Branch 2:	InCIgn	-	0.71

Case 7: This case is the same as Case 3 except that the concentration of hydrogen in the wetwell is less than 4%. Because of the low hydrogen concentration, it is very unlikely that the hydrogen will ignite. The quantification for this case, based on the mean value of the aggregate distribution provided by the expert panel, is:

Branch 1:	I-CIgn	-	0.035
Branch 2:	InCIgn	-	0.965

Case 8: The drywell is intact and the RPV fails at low pressure. Furthermore, there are no ex-vessel steam explosions in the drywell. Without an energetic event in the drywell, the probability that gas hot enough to ignite the hydrogen will enter the wetwell is negligible. The quantification for this case is:

Branch 1:	I-CIgn	-	0.01
Branch 2:	InCIgn	-	0.99

Question 85. Does Ignition Occur in the Containment Following VB?
2 Branches, Type 2, 6 Cases

The branches for this question are:

1.	IgnFVB	The hydrogen in the wetwell is ignited shortly after VB.
2.	nIgnFVB	The hydrogen does not ignite shortly after VB.

Cases 3 through 6 of this question are sampled. The distributions for ignition probability following VB were based on distributions provided by the Containment Loads Expert Panel for hydrogen ignition before VB. The branching at this question depends upon the branch taken at Questions 78, 79, 81, 82, 83, and 84.

In this question, the ignition probability of hydrogen in the wetwell during the time period shortly after VB is addressed. The previous question only considered the ignition probability from sources associated with the energetic events that accompany VB. The sources of ignition considered in this question, random ignition sources, are essentially the same sources that were considered by the Containment Loads Expert Panel for ignition before VB (Question 43). Therefore, the ignition probability distributions used in Question 43 are also used to quantify the cases in this question. In Question 43, the ignition probabilities were a function of the RPV pressure and the concentration of hydrogen in the wetwell. Before VB, the RPV pressure affects the hydrogen distribution in the containment. When the RPV is at low pressure, the hydrogen is released uniformly throughout the suppression pool. This pathway is similar to the way hydrogen will enter the wetwell from the drywell at VB. Thus, only the low-pressure RPV distributions used in Question 43 are used in this question. The ignition probability is, however, still a function of the hydrogen concentration.

Case 1: Either the wetwell atmosphere is not combustible (i.e., not enough hydrogen, not enough oxygen, or too much steam), or it ignited at VB (previous question). In either case, the wetwell atmosphere does not ignite during the time period considered in this question. If the wetwell atmosphere was inert at VB but the containment sprays are recovered during this time period, then ignition is not precluded. The quantification for this case is:

Branch 1:	IgnFVB	-	0.0
Branch 2:	nIgnFVB	-	1.0

Case 2: AC power is available following VB, and the wetwell atmosphere is combustible. Because of the availability of ac sources, it is assumed that the hydrogen will ignite. The quantification for this case is:

Branch 1:	IgnFVB	-	1.0
Branch 2:	nIgnFVB	-	0.0

Case 3: AC power is not available shortly following VB. Thus, there are only random ignition sources. The concentration of hydrogen in the wetwell is greater than 16%. The quantification for this case, based on the mean value of the distribution, is:

Branch 1:	IgnFVB	-	0.49
Branch 2:	nIgnFVB	-	0.51

Case 4: This case is the same as Case 3 except that the concentration of hydrogen in the wetwell is between 12% and 16%. The quantification for this case, based on the mean value of the distribution, is:

Branch 1:	IgnFVB	-	0.38
Branch 2:	nIgnFVB	-	0.62

Case 5: This case is the same as Case 3 except that the concentration of hydrogen in the wetwell is between 8% and 12%. The quantification for this case, based on the mean value of the distribution, is:

Branch 1: IgnFVB - 0.28
Branch 2: nIgnFVB - 0.72

Case 6: This case is the same as Case 3 except that the concentration of hydrogen in the wetwell is between 4% and 8%. The quantification for this case, based on the mean value of the distribution, is:

Branch 1: IgnFVB - 0.21
Branch 2: nIgnFVB - 0.79

Question 86. Is There a Detonation in the Wetwell Following VB?
2 Branches, Type 4, 1 Parameter, 10 Cases

The branches for this question are:

1.	I-WWDt	There is a detonation in the wetwell following VB.
2.	InWWDt	A significant detonation does not occur in the wetwell following VB.

The parameter initialized in this question is:

P20 ImpLoad	The impulse loading from a detonation (kPa-S) is read in as Parameter 20. This parameter was previously the impulse load from a detonation that occurred before VB (Question 44). This parameter is reinitialized in this question.

The detonation probabilities for Cases 4, 6, 7, 8, and 9 and the parameter initialized in Cases 2, 3, 4, 6, 7, 8, and 9 are sampled. The distributions for the detonation probability and the accompanying impulse load are based on distributions provided by the Containment Loads Expert Panel for hydrogen detonations before VB. The branching at this question depends upon the branch taken at Questions 24, 27, 39, 43, 52, 72, 73, 78, 81, 82, 83, 84, and 85.

The detonation probabilities used in this question are conditional on the hydrogen having already been ignited (Questions 84 and 85). In this question, the probability of a detonation is a function the hydrogen concentration, the oxygen concentration, and the amount of steam in the wetwell atmosphere. The distributions for the detonation probability and the accompanying impulse load provided by the Containment Loads Expert Panel for hydrogen detonations before VB (Question 44) are also used to quantify the cases in this question. The Containment Loads Expert Panel indicated that there was a negligible probability of a significant hydrogen detonation if the hydrogen concentration was below 12%. Two levels of steam were considered: high and low. The high steam level corresponds to the case in which a wetwell atmosphere initially inert to detonations (i.e., mole fraction of steam was greater than [illegible]5) is slowly condensed and brought into the detonable regime by the recovery of sprays. The low steam level corresponds to the case in which the steam concentration is low enough initially to allow a detonable mixture to form.

Case 1: The hydrogen was not ignited, the wetwell is inert to hydrogen detonations (i.e., mole fraction of steam greater than 0.35 and the containment sprays are not operating), or the global concentration of hydrogen in the wetwell is below 12%. In any case, a hydrogen detonation is not possible. The quantification for this case is:

Branch 1: I-WWDt - 0.00
Branch 2: InWWDt - 1.00

Because Branch 1 is never taken, the value assigned to the parameter for this branch is irrelevant. Because Branch 2 represents the situation in which the hydrogen does not detonate, the value for the impulse load assigned to this parameter is 0.0. In all the remaining cases, the impulse load assigned to Branch 2 will also be 0.0.

Case 2: There is enough hydrogen and oxygen in the wetwell to support a detonation, but the HIS has been operating since before VB. It is very unlikely that a detonable mixture would be able to form in the wetwell before the hydrogen was burned. The quantification for this case is:

Branch 1: I-WWDt - 0.01
Branch 2: InWWDt - 0.99

The parameter initialized in Branch 1 uses the same distribution that was used to quantify this same parameter in Question 44, Case 5, Branch 1. The value (kPa-S) assigned to the parameter, based on the mean value of the distribution, is:

Parameter 20: ImpLoad - 12.4

Case 3: The drywell is failed (i.e., some of the hot drywell gases bypass the suppression pool at VB), so there are numerous ignition sources in the wetwell. However, there was insufficient hydrogen in the wetwell just prior to VB to support a detonation. Assuming that the hydrogen generated at VB can accumulate in the wetwell, there is enough hydrogen to support a detonation in the wetwell following VB. However, because a pre-existing detonable mixture did not exist in the wetwell and there are numerous ignition sources, it is very likely that the hydrogen will be burned before a detonable mixture can be formed. Thus, it is very unlikely that a detonation will occur in wetwell following VB. The quantification for this case is:

Branch 1: I-WWDt - 0.01
Branch 2: InWWDt - 0.99

The parameter initialized in Branch 1 uses the same distribution that was used to quantify this same parameter in Question 44, Case 5, Branch 1. The value (kPa-S) assigned to the parameter, based on the mean value of the distribution, is:

Parameter 20: ImpLoad - 12.4

Case 4: The wetwell has a high steam concentration (i.e., slowly decreasing below 35%), and there is sufficient oxygen in the wetwell to support a detonation. The hydrogen concentration is between 12% and 16%. This case is quantified using the same distributions used to quantify Question 44, Case 2. Thus, the quantification for this case, based on the mean value of the distribution, is:

Branch 1: I-WWDt - 0.22
Branch 2: InWWDt - 0.78

For Branch 1, the value (kPa-S) assigned to the parameter, based on the mean value of the distributions, is:

Parameter 20: ImpLoad - 5.8

Case 5: The wetwell has a low steam concentration, and there is sufficient oxygen in the wetwell to support a detonation. The hydrogen concentration is between 12% and 16%. This case is quantified using the same distributions used to quantify Question 44, Case 3. Thus, the quantification for this case is:

Branch 1: I-WWDt - 0.0
Branch 2: InWWDt - 1.0

Because Branch 1 is never taken, the parameter value for this branch is irrelevant, and as discussed in Case 1, the value assigned to Branch 2 is 0.0.

Case 6: The wetwell has a high steam concentration (i.e., slowly decreasing below 35%), and there is sufficient oxygen in the wetwell to support a detonation. The hydrogen concentration is between 16% and 20%. This case is quantified using the same distributions used to quantify Question 44, Case 4. Thus, the quantification for this case, based on the mean value of the distribution, is:

Branch 1: I-WWDt - 0.25
Branch 2: InWWDt - 0.75

For Branch 1, the value (kPa-S) assigned to the parameter, based on the mean value of the distributions, is:

Parameter 20: ImpLoad - 5.8

Case 7: The wetwell has a low steam concentration, and there is sufficient oxygen in the wetwell to support a detonation. The hydrogen concentration is between 16% and 20%. This case is quantified using the same distributions used to quantify Question 44, Case 5. Thus, the quantification for this case, based on the mean value of the distribution, is:

Branch 1: I-WWDt - 0.26
Branch 2: InWWDt - 0.74

For Branch 1, the value (kPa-S) assigned to the parameter, based on the mean value of the distributions, is:

Parameter 20: ImpLoad - 12.4

Case 8: The wetwell has a high steam concentration (i.e., slowly decreasing below 35%), and there is sufficient oxygen in the wetwell to support a detonation. The hydrogen concentration is greater than 20%. This case is quantified using the same distributions used to quantify Question 44, Case 6. Thus, the quantification for this case, based on the mean value of the distribution, is:

Branch 1: I-WWDt - 0.25
Branch 2: InWWDt - 0.75

For Branch 1, the value (kPa-S) assigned to the parameter, based on the mean value of the distributions, is:

Parameter 20: ImpLoad - 5.8

Case 9: The wetwell has a low steam concentration, and there is sufficient oxygen in the wetwell to support a detonation. The hydrogen concentration is greater than 20%. This case is quantified using the same distributions that were used to quantify Question 44, Case 7. Thus, the quantification for this case, based on the mean value of the distribution, is:

Branch 1: I-WWDt - 0.45
Branch 2: InWWDt - 0.55

For Branch 1, the value (kPa-S) assigned to the parameter, based on the mean value of the distributions, is:

Parameter 20: ImpLoad - 12.4

Case 10: There is not enough oxygen in the wetwell to support a detonation. Thus, the quantification for this case is:

Branch 1: I-WWDt - 0.0
Branch 2: InWWDt - 1.0

Because Branch 1 is never taken, the parameter value for this branch is irrelevant, and as discussed in Case 1, the value assigned to Branch 2 is 0.0.

Question 87. What Is the Level of the Containment Impulse Load Following VB?

7 Branches, Type 5, 1 Case

The branches for this question are:

1. I-Ip>60 The impulse is greater than 60 kPa-S.
2. I-Ip>50 The impulse is in the range 50 ≤ Impulse < 60 kPa-S.
3. I-Ip>40 The impulse is in the range 40 ≤ Impulse < 50 kPa-S.
4. I-Ip>30 The impulse is in the range 30 ≤ Impulse < 40 kPa-S.
5. I-Ip>20 The impulse is in the range 20 ≤ Impulse < 30 kPa-S.
6. I-Ip>10 The impulse is in the range 10 ≤ Impulse < 20 kPa-S.
7. I-Ip<10 The impulse is less than 10 kPa-S.

This question is a summary of the detonation impulse loads (Parameter 20) initialized in the previous question (Question 86). The range of possible impulse loads is divided into discrete levels represented by the seven branches. The various impulse loads are then grouped into the appropriate levels. To do this grouping, the impulse load, Parameter 20, is compared with a series of comparison parameters that define the various levels. It should be noted that structural failure caused by a detonation is determined by the actual value assigned to Parameter 20 and not by a level defined in this question. These levels are used only to summarize the magnitude of the impulse.

Question 88. With What Efficiency Is Hydrogen Burned Following VB?

1 Branch, Type 4, 2 Parameters, 9 Cases

The branch for this question is:

1. H2Ef@VB The hydrogen burn efficiency at VB.

The parameters initialized in this question are:

P18 H2EfVB1 The effective efficiency of a hydrogen burn following VB. Although this parameter was first initialized in Question 46, it is reinitialized in this question.

P19 H2EfVB2 The actual efficiency of a hydrogen burn following VB. Although this parameter was first initialized in Question 46, it is reinitialized in this question.

The parameters initialized in this question are sampled. The distributions for Parameters 18 and 19 are based on distributions provided by the Containment Loads Expert Panel for hydrogen burns before VB. The parameters initialized in this question depend upon the branch taken at Questions 78, 81, 82, 84, and 85.

The distributions for the effective and the actual burn efficiencies provided by the Containment Loads Expert Panel for hydrogen burns before VB (Question 46) are also used to quantify the cases in this question. Definitions of these parameters and a discussion of how they are used in this analysis are presented in Question 46. In this question, which is based on the results from the Containment Loads Expert Panel, the effective efficiency of a hydrogen burn is a function of both the hydrogen concentration and the steam concentration in the wetwell. The actual hydrogen burn efficiency is only a function of the hydrogen concentration.

Case 1: The hydrogen in the wetwell is ignited following VB. The steam concentration in the wetwell is high (i.e., between 35% and 55% steam), and the hydrogen concentration is less than 8%. This case is quantified using the same distributions used to quantify Question 46, Case 4. The mean values of the distributions assigned to these parameters are:

Parameter 18: H2EfVB1 - 0.28
Parameter 19: H2EfVB2 - 0.27

Case 2: This case is the same as Case 1 except that the steam concentration is low (i.e., less than 35% steam). This case is quantified using the same distributions used to quantify Question 46, Case 5. The mean values of the distributions assigned to these parameters are:

Parameter 18: H2EfVB1 - 0.28
Parameter 19: H2EfVB2 - 0.27

Case 3: The hydrogen in the wetwell is ignited following VB. The steam concentration in the wetwell is high (i.e., between 35% and 55% steam), and the hydrogen concentration is between 8% and 12%. This case is quantified using the same distributions used to quantify Question 46, Case 6. The mean values of the distributions assigned to these parameters are:

Parameter 18: H2EfVB1 - 0.46
Parameter 19: H2EfVB2 - 0.74

Case 4: This case is the same as Case 3 except that the steam concentration is low (i.e., less than 35% steam). This case is quantified using the same distributions used to quantify Question 46, Case 7. The mean values of the distributions assigned to these parameters are:

Parameter 18: H2EfVB1 - 0.57
Parameter 19: H2EfVB2 - 0.74

Case 5: The hydrogen in the wetwell is ignited following VB. The steam concentration in the wetwell is high (i.e., between 35% and 55%

steam), and the hydrogen concentration is between 12% and 16%. This case is quantified using the same distributions used to quantify Question 46, Case 8. The mean values of the distributions assigned to these parameters are:

Parameter 18: H2EfVB1 - 0.48
Parameter 19: H2EfVB2 - 0.88

Case 6: This case is the same as Case 5 except that the steam concentration is low (i.e., less than 35% steam). This case is quantified using the same distributions used to quantify Question 46, Case 9. The mean values of the distributions assigned to these parameters are:

Parameter 18: H2EfVB1 - 0.73
Parameter 19: H2EfVB2 - 0.88

Case 7: The hydrogen in the wetwell is ignited following VB. The steam concentration in the wetwell is high (i.e., between 35% and 55% steam), and the hydrogen concentration is greater than 16%. This case is quantified using the same distributions used to quantify Question 46, Case 10. The mean values of the distributions assigned to these parameters are:

Parameter 18: H2EfVB1 - 0.49
Parameter 19: H2EfVB2 - 0.93

Case 8: This case is the same as Case 7 except that the steam concentration is low (i.e., less than 35% steam). This case is quantified using the same distributions used to quantify Question 46, Case 11. The mean values of the distributions assigned to these parameters are:

Parameter 18: H2EfVB1 - 0.75
Parameter 19: H2EfVB2 - 0.93

Case 9: The hydrogen does not burn in the wetwell shortly after VB. The values assigned to the parameters are:

Parameter 18: H2EfVB1 - 0.0
Parameter 19: H2EfVB2 - 0.0

Question 89. What Would Be the Peak Pressure in the Containment from a Hydrogen Burn at VB?
6 Branches, Type 6, 4 Cases

The branches for this question are:

1. I-PBrn>7 The peak overpressure is greater than 700 kPa.
2. I-PBrn>6 The peak overpressure is in the range 600 ≤ P < 700 kPa.

3. I-PBrn>5 The peak overpressure is in the range 500 ≤ P < 600 kPa.

4. I-PBrn>4 The peak overpressure is in the range 400 ≤ P < 500 kPa.

5. I-PBrn>3 The peak overpressure is in the range 300 ≤ P < 400 kPa.

6. I-PBrn<3 The peak overpressure is less than 300 kPa.

The branching at this question depends upon the branch taken at Questions 50, 58, 84, 85, and 86. In this question, a module in the user function is used to determine the peak overpressure in the containment and the peak wetwell/drywell pressure differential from a hydrogen deflagration in the wetwell. The peak wetwell overpressure is used to determine the load on the containment structure, whereas the peak wetwell/drywell pressure differential is used to determine the load on the drywell structure. The calculations are based on the composition of the wetwell atmosphere (i.e., moles of hydrogen, air, and steam) and on the effectiveness of the burn (Parameters 18 and 19). In addition to determining the burn overpressure, this module also adjusts the number of moles of hydrogen, oxygen, and steam that are present in the wetwell after the burn based on the actual efficiency of the burned. The same user function module used in Question 47 is used in this question.

The module of the user function in this question returns the peak wetwell overpressure in Parameter 11 and the peak wetwell/drywell pressure differential in Parameter 12.

Case 1: The hydrogen in the wetwell does not ignite. Thus, there is no overpressure, and none of the hydrogen is consumed.

Case 2: The hydrogen ignites, and there is a large hole in the containment. Because the containment is ruptured, the pressure rise is negligible and does not threaten the drywell structure. The moles of hydrogen, oxygen, and steam are adjusted to account for the burn.

Case 3: The hydrogen in the wetwell detonates. Thus, the peak wetwell/drywell pressure differential is the same as the peak wetwell overpressure.

Case 4: The hydrogen in the wetwell burns as a deflagration, and there are no large holes in the containment.

Question 90. What Is the Level of Containment Pressurization at VB?
6 Branches, Type 6, 4 Cases

The branches for this question are:

1. I-CP>7 The peak containment pressure following VB is greater than 700 kPa.

2. I-CP>6 The peak containment pressure following VB is between 600 kPa and 700 kPa.

3. I-CP>5 The peak containment pressure following VB is between 500 kPa and 600 kPa.

4. I-CP>4 The peak containment pressure following VB is between 400 kPa and 500 kPa.

5. I-CP>3 The peak containment pressure following VB is between 300 kPa and 400 kPa.

6. I-CP<3 The peak containment pressure following VB is less than 300 kPa.

This question is not sampled and was quantified internally. The branching at this question depends upon the branch taken at Questions 56, 58, 84, and 85. In this question, a module in the user function is used to determined the peak pressure in the containment following VB. The peak pressure is affected by the time interval between VB and the occurrence of a hydrogen burn and the integrity of the containment boundary. The peak overpressure in the wetwell following VB is initialized as Parameter 41.

Although the Containment Loads Expert Panel provided distributions for the peak pressure in the containment following VB, these distributions were not used in this analysis. The primary reason these distributions were not used is that the hydrogen and oxygen concentrations in the wetwell could not be explicitly connected with the peak pressure provided by the experts. The experts indicated that hydrogen burns were the primary cause for wetwell pressurization. Without a hydrogen burn in the wetwell, the pressurization in the containment at VB would not be sufficient to pose a significant threat to the containment structure. If the drywell is intact, the suppression pool condenses most of the steam and cools the hot gases. Thus, the pressure rise in the containment from energetic events in the drywell is small. The experts folded into their distributions their uncertainty in the amount of hydrogen and oxygen that is present in the wetwell at the time of VB. This added uncertainty is not needed, however, because the APET, through a series of questions and user functions, keeps track of the composition of the wetwell atmosphere. In addition, without explicit consideration of the composition of the wetwell atmosphere, it is possible, using these distributions, to predict a containment pressure that is not consistent with the progression of the accident up to this point. Because the experts felt the pressure rise is dominated by hydrogen burns, it was decided that the peak containment pressure should be calculated using the same method used to calculated the pressure rise from a burn before VB (see Question 46 and 47). By using this method, which is also based on distributions provided by the Containment Loads Expert Panel, the peak containment pressure is consistent with the amounts of hydrogen and oxygen in the wetwell at VB.

Case 1: The containment was ruptured before VB. Thus, the containment is at atmospheric pressure and the pressure, rise is negligible (i.e., containment atmosphere is vented to the outside atmosphere).

Case 2: The containment has not been ruptured prior to VB. The hydrogen is ignited in the containment at VB. Because the hydrogen is burned at VB, the pressure rise from a burn, Parameter 11, is added to the pressure rise associated with drywell gases expanding into the wetwell, Parameter 40.

Case 3: The containment has not been ruptured prior to VB. The hydrogen in the containment does not burn at VB but is ignited shortly after VB. Because the hydrogen is burned shortly after VB, the pressure rise associated with drywell gases expanding into the wetwell, Parameter 40, will have decayed by the time the hydrogen burns. Thus, the peak pressure in the containment following VB is the maximum of the pressure rise from a burn, Parameter 11, and pressure rise associated with the expansion of drywell gases into the wetwell.

Case 4: The containment has not been ruptured prior to VB, and the hydrogen in the containment does not burn. Thus, the peak containment pressure is based only on the pressure rise associated with the expansion of drywell gases into the wetwell, Parameter 40.

Question 91. What Is the Level of Drywell Leakage Induced by a Detonation in the Containment at VB?
3 Branches, Type 6, 2 Cases

The branches for this question are:

1. InDWDt The drywell does not fail from a detonation.
2. I-DWDt2 A detonation induces a leak in the drywell.
3. I-DWDt3 A detonation induces a rupture in the drywell.

The branching at this question depends upon the branch taken at Question 86. A module in the user function is used to determine whether the drywell fails and, if so, the mode of failure. In the user function, the impulse from the detonation (Parameter 20) is compared to the structural capacity of the drywell to dynamic loads (Parameter 34). The way in which the random number (Parameter 35) is used to determine the mode of drywell failure is described in Subsection A.2. The method differs depending on whether the rate of pressure rise is fast or slow relative to the rate at which a leak depressurizes the drywell. For detonations, the fast pressure rise method is used.

Case 1: There is a detonation in the wetwell.

Case 2: A detonation does not occur in the wetwell following VB. Thus, drywell does not fail from a detonation.

Question 92. What Is the Level of Containment Leakage Induced by a Detonation at VB?
3 Branches, Type 6, 3 Cases

The branches for this question are:

1. InDtF The containment does not fail from a detonation.

2. I-DtF2 A detonation induces a leak in the containment.

3. I-DtF3 A detonation induces a rupture in the containment.

The branching at this question depends upon the branch taken at Questions 86 and 92. A module in the user function is used to determine whether the containment fails and, if so, the mode of failure. In the user function, the impulse from the detonation (Parameter 20) is compared to the structural capacity of the containment to dynamic loads (Parameter 24). The way in which the random number (Parameter 25) is used to determine the mode of containment failure is described in Subsection A.2. The method differs depending on whether the rate of pressure rise is fast or slow relative to the rate at which a leak depressurizes the containment. For detonations, the fast pressure rise method is used.

Case 1: The drywell failed (either a leak or a rupture) from a detonation in containment. This case was included in this question to allow coupling between the drywell response to a detonation and the containment response. In this analysis, the structural response of the drywell to dynamic loads (Parameter 34) was correlated to the structural capacity of the containment (Parameter 24). Thus, this coupling has already been taken into account and no additional coupling is applied in this case.

Case 2: There is a detonation in the wetwell, and it does not fail the drywell. However, because the containment is not as strong as the drywell, there is still some probability that the containment will fail.

Case 3: A detonation does not occur in the wetwell following VB. Thus, containment does not fail from a detonation.

Question 93. What Is the Level of Containment Leakage Following VB?
4 Branches, Type 6, 4 Cases

The branches for this question are:

1. InCL The containment does not fail shortly after VB.

2. I-CL2 The containment fails in the leak mode; nominal hole size is 0.1 ft^2.

3. I-CL3 The containment fails by rupture; nominal hole size is 7 ft^2.

4. I-CL4 The containment fails by catastrophic rupture. This failure mechanism does not occur in this analysis but has been retained in the tree for completeness.

The branching at this question depends upon the branch taken at Questions 50, 58, and 92. A module in the user function is used to determine whether the containment fails and, if so, the mode of failure. In the user function, the peak pressure in the containment (Parameter 41) is compared to the containment failure pressure (Parameter 21). The way in which the random number (Parameter 22) is used to determine the mode of containment failure is described in Subsection A.2. The method differs depending on whether the rate of pressure rise is fast or slow relative to the rate at which a leak depressurizes the containment. The fast pressure rise method is used when the loading on the containment is from a hydrogen burn.

Case 1: The containment either failed before VB by a catastrophic rupture, or an Alpha Mode event occurred. In either case the containment is ruptured.

Case 2: The containment was either ruptured before VB or was ruptured by a detonation following VB. In either case, the containment is already ruptured.

Case 3: The containment failed in the leak mode either before VB or from a detonation following VB. Because a leak will not arrest a fast pressure rise, the containment can still fail in the rupture mode from the pressure rise in the containment at VB. Thus, it is certain that the containment failure mode will at least be a leak, and there is some probability that the failure mode will be a rupture.

Case 4: The containment was intact before VB and did not fail from a detonation (if one occurred) following VB. Thus, depending on the pressure rise in the containment following VB, the containment can remain intact, fail in the leak mode, or fail in the rupture mode.

Question 94. **What Is the Level of Drywell Leakage Induced by Containment Pressurization at VB?**
5 Branches, Type 6, 10 Cases

The branches for this question are:

1. InDWDf The drywell does not fail shortly after VB.

2. I-DWDf2 The drywell fails in the leak mode at the drywell wall.

3. I-DWHDf2 The drywell fails in the leakage mode at the drywell head. In this analysis, it was assessed that there was a negligible probability that the drywell head would fail before the drywell wall. Thus, this failure location does not occur in this analysis but has been retained in the tree for completeness.

4. I-DWDf3 The drywell fails in the rupture mode at the drywell wall.

5. I-DWHDf3 The drywell fails in the rupture mode at the drywell head. In this analysis, it was assessed that there was a negligible probability that the drywell head would fail before the drywell wall. Thus, this failure location does not occur in this analysis but has been retained in the tree for completeness.

The branching at this question depends upon the branch taken at Questions 51, 72, 73, 76, 85, 91, and 93. A module in the user function is used to determine whether the drywell fails, and the mode of failure. In the user function, the peak wetwell/drywell pressure differential is compared to the drywell failure pressure (Parameter 30). The peak wetwell/drywell pressure differential is the difference between the peak containment pressure, Parameter 41, and the drywell pressure, Parameter 40. This pressure differential is calculated only when the hydrogen burns in the containment shortly after VB. If the hydrogen burns at VB, the drywell is still pressurized from the loads accompanying VB, and a large pressure differential is not established across the drywell wall. The way in which the random number (Parameter 31) is used to determine the mode of containment failure is described in Subsection A.2. The method differs depending on whether the rate of pressure rise is fast or slow relative to the rate at which a leak depressurizes the containment (or pressurizes the drywell). The fast pressure rise method is used when the loading on the drywell is from a hydrogen burn.

Containment failure by rupture has been included in the case structure for this question to allow for the load on the drywell structure to be reduced because of the pressure relaxation associated with the containment failure. However, as explained in Question 51, the pressure rise associated with burns typically encountered in this analysis is very rapid, and the effect that containment failure has on the peak wetwell/drywell pressure differential is minor. Thus, the cases with containment failure are not handled any differently than the cases without containment failure. These cases have only been retained for the sake of completeness.

Case 1: The drywell has already failed in the rupture mode. The failure is caused by a failure before VB, drywell pressurization at VB, a detonation in the drywell at VB, pedestal failure, or a detonation in the wetwell following VB.

Case 2: The drywell head was ruptured before VB.

Case 3: The hydrogen does not burn in the containment at VB but rather shortly after VB. The drywell wall has already failed in the leak mode, and the containment is ruptured. The drywell wall failure precludes failure of the head. Depending on the pressure rise in the containment, it is possible that the drywell wall leak will increase to a rupture.

Case 4: The hydrogen does not burn in the containment at VB but rather shortly after VB. The drywell wall has already failed in the leak mode, but the containment is either intact or only leaking. The drywell wall failure precludes failure of the head. Depending on the pressure rise in the containment, it is possible that the drywell wall leak will increase to a rupture.

Case 5: The hydrogen does not burn in the containment at VB but rather shortly after VB. The drywell head has already failed in the leak mode, and the containment is ruptured. Depending on the pressure rise in the containment, it is possible that the drywell leak will increase to a rupture.

Case 6: The hydrogen does not burn in the containment at VB but rather shortly after VB. The drywell head has already failed in the leak mode, but the containment is either intact or only leaking. Depending on the pressure rise in the containment, it is possible that the drywell leak will increase to a rupture.

Case 7: The hydrogen does not burn in the containment at VB but rather shortly after VB. The drywell is intact, and the containment is either intact or only leaking.

Case 8: The hydrogen does not burn in the containment following VB, but the drywell wall has already failed in the leak mode. Because there are no energetic events in the containment shortly after VB, the drywell failure remains in the leak mode.

Case 9: This case is the same as the previous case except that the drywell head has failed rather than the drywell wall.

Case 10: The hydrogen does not burn in the containment following VB, and the drywell is intact. Because there are no energetic events in the containment shortly after VB, the drywell remains intact.

Question 95. What Is the Level of Suppression Pool Bypass Following VB?
3 Branches, Type 2, 5 Cases

The branches for this question are:

1. InSPB The drywell is intact shortly after VB.
2. I-SPB2 The drywell has failed by the leak mode.
3. I-SPB3 The drywell has failed by rupture.

Cases 2 and 4 of this question are sampled. The distribution for the drywell failure caused by vacuum breaker failure was internally quantified. The branching at this question depends upon the branch taken at Questions 52, 58, 79, 84, 85, and 94.

This question summarizes the level of drywell failure (e.g., from detonations and deflagrations) that occurred following VB. In addition, drywell failures from failed drywell vacuum breakers are considered.

Case 1: The drywell was ruptured by a failure before VB, a failure following VB, or an Alpha Mode event. The quantification for this case is:

Branch 1: InSPB - 0.0
Branch 2: I-SPB2 - 0.0
Branch 3: I-SPB3 - 1.0

Case 2: The drywell has a leak and ac power is available following VB. A hydrogen burn that pressurizes the wetwell occurs either at VB or shortly after VB. In response to this pressurization, the drywell vacuum breakers (which are ac powered valves) will open in an attempt to equalize the pressure difference between the wetwell and drywell. Because the vacuum breakers are exposed to severe thermal environments as the hot gases pass through them, these valves may potentially fail during a hydrogen burn. This case is quantified using the same distribution used in Question 52, Case 2. This case is sampled zero-one. Based on the mean value of the sample, the quantification for this case is:

Branch 1: E5nSPB - 0.00
Branch 2: E5-SPB2 - 0.95
Branch 3: E5-SPB3 - 0.05

Case 3: The drywell has already failed in the leak mode. Either ac power is not available, or the hydrogen in the wetwell did not burn. The quantification for this case is:

Branch 1: InSPB - 0.0
Branch 2: I-SPB2 - 1.0
Branch 3: I-SPB3 - 0.0

Case 4: This case is the same as Case 2 except that the drywell is intact. This case is quantified using the same distribution used in Case 2, Question 52. This case is sampled zero-one. Based on the mean value of the sample, the quantification for this case is:

Branch 1: E5nSPB - 0.95
Branch 2: E5-SPB2 - 0.00
Branch 3: E5-SPB3 - 0.05

Case 5: The drywell does not fail following VB. The quantification for this case is:

Branch 1: InSPB - 1.0
Branch 2: I-SPB2 - 0.0
Branch 3: I-SPB3 - 0.0

Question 96. What Is the Containment Pressure After VB?
4 Branches, Type 6, 3 Cases

The branches for this question are:

1. IP>4 The containment pressure after VB is greater than 400 kPa.
2. IP>3 The containment pressure is between 300 kPa and 400 kPa.
3. IP>2 The containment pressure is between 200 kPa and 300 kPa.
4. IP>1 The containment pressure is between 100 kPa and 200 kPa.

This question is not sampled and was internally quantified. The branching at this question depends upon the branch taken at Questions 81 and 93. In this question, the containment pressure is adjusted to account for changes in the number of moles of air, steam, and hydrogen present in the containment following VB. Burns in the containment will consume hydrogen and air, the operation of sprays will condense steam, and failure of the containment boundary will result in a reduction in the number of moles in the containment. Modules in the user function subroutine are used to calculate the pressure.

Case 1: The containment is failed (either a leak or a rupture). Thus, the pressure in the containment (and drywell) is set to atmospheric pressure. The total number moles in the containment and drywell is reduced to reflect the reduction in pressure. It is assumed that the composition of the gas removed from the containment is the same as that of the gas that remains in the containment.

Case 2: The containment is intact, and the containment sprays operate following VB to condense the steam in the containment. The pressure in the containment is lowered to account for the steam that has been condensed.

Case 3: The containment is intact, but the containment sprays do not operate following VB. The pressure is adjusted to account for any change in the total number of moles (e.g., reduction in the number of moles of hydrogen and oxygen because of a burn).

Question 97. Is Water Not Supplied to the Debris Late?
3 Branches, Type 2, 6 Cases

The branches for this question are:

1. nLDBWat No water is supplied to the core debris in the pedestal cavity following VB.
2. S-LDBWat A small amount of water (i.e., partial flow from a coolant injection system) is supplied to the core debris in the pedestal cavity.

3. L-LDBWat A large amount of water (i.e., full flow from a coolant injection system) is supplied to the core debris in the pedestal cavity.

Cases 2, 4, and 5 of this question are sampled. Distribution for the probability of late water injection was internally quantified. The branching at this question depends upon the branch taken at Questions 5, 7, 8, 9, 11, 12, 28, 63, and 79.

In this question, it is determined whether a continuous supply of water is injected on the core debris following VB. The sources of the water are the coolant injection systems. Although these systems inject water into the RPV, the hole that resulted in vessel failure will provide a pathway for the water to exit the RPV and enter the pedestal cavity. The availability of an injection system does not, however, guarantee that water will be supplied to the core debris. It is not certain what condition the reactor internals will be in at VB. Energetic events (e.g., steam explosions and core slump) that occur in the RPV prior to and at VB can impair or even fail the injection systems. Furthermore, the initiation of an injection system after VB may cause molten debris to freeze and plug the hole in the vessel.

If the core debris in the pedestal cavity is in a coolable configuration, the presences of water in the cavity will preclude CCIs. The injection of water on the hot core debris will also produce vast quantities of steam. If the suppression pool is bypassed, the steam produced from the interaction of the water and the core debris in the drywell can pressurize and steam inert the containment. Although a distinction is made in this question between partial injection and complete injection, both modes of injection are treated the same in the subsequent questions that reference this question.

Case 1: The vessel does not fail. For the vessel to remain intact, a large amount of water had to be injected into the RPV during core damage. The quantification for this case is:

Branch 1: nLDBWat - 0.00
Branch 2: S-LDBWat - 0.00
Branch 3: L-LDBWat - 1.00

Case 2: AC power is not available shortly after VB. Thus, the only available injection system is the FWS. It is uncertain whether the operators will actuate this system after the vessel fails, and if they do actuate the system, it is uncertain whether it will inject water (system may have failed during VB) and, if it does operate, how much water will be injected. The branch probabilities in this case are sampled zero-one, so each observation had all the probability assigned to one of the branches. Based on the mean value of the sample, the quantification for this case is:

Branch 1: nLDBWat - 0.50
Branch 2: S-LDBWat - 0.25
Branch 3: L-LDBWat - 0.25

Case 3: AC power is not available shortly after VB and the FWS is also not available. Without ac power, none of the remaining injection systems are available. The quantification for this case is:

Branch 1: nLDBWat - 1.00
Branch 2: S-LDBWat - 0.00
Branch 3: L-LDBWat - 0.00

Case 4: AC power is available and either the emergency low pressure injection systems or the high pressure injection system was operating during core damage. Because of the uncertainties associated with the condition of the RPV at VB, it is uncertain whether these systems will inject water and, if they do operate, how much water will be injected. This case is sampled zero-one. Based on the mean value of the sample, the quantification for this case is:

Branch 1: nLDBWat - 0.333
Branch 2: S-LDBWat - 0.333
Branch 3: L-LDBWat - 0.334

Case 5: AC power is available, but the emergency low pressure and high pressure injection systems were not operating prior to VB. One of these systems or the condensate system, the CRD system, or the service water cross-tie was available before VB. Because of the uncertainties associated with the condition of the RPV at VB, it is uncertain whether these systems will inject water and, if they do operate, how much water will be injected. This case is sampled zero-one. Based on the mean value of the sample, the quantification for this case is:

Branch 1: nLDBWat - 0.333
Branch 2: S-LDBWat - 0.333
Branch 3: L-LDBWat - 0.334

Case 6: All the injection systems have failed. Thus, water is not being supplied to the core debris following VB. The quantification for this case is:

Branch 1: nLDBWat - 1.00
Branch 2: S-LDBWat - 0.00
Branch 3: L-LDBWat - 0.00

Question 98. Is There Water in the Reactor Cavity After VB?
3 Branches, Type 2, 7 Cases

The branches for this question are:

1. LDWFld The drywell is flooded with water after VB.
2. LRCDWet The reactor cavity is wet (< 100 M^3 of water).
3. LRCDry The reactor cavity is essentially dry.

This question is not sampled and was internally quantified. The branching at this question depends upon the branch taken at Questions 54, 64, 65, 66, 67, 79, 84, 85, 94, and 95.

In this question, the amount of water in the reactor cavity after VB is summarized. The amount of water that was in the reactor cavity before VB is considered as well as additional sources of water. However, this question does not consider the injection of water from the RPV. This issue was addressed in the previous question.

Two sources of water are considered in this question. The first source is the suppression pool. If the suppression pool is depressed sufficiently in the wetwell or if the drywell pressure drops considerable below the wetwell pressure, water will be pushed up over the weir wall and into the drywell. The second source is the upper containment pool. If the drywell head fails, water from the upper pool will drain into the drywell. There are two pathways by which water in the drywell can enter the reactor cavity. The first pathway is through the drywell floor drains. There are four 4-inch drains on the drywell floor that connect to the equipment drain sump in the pedestal. The second pathway is through a door (3 ft by 7 ft) in the pedestal located 3'-4" above the drywell floor.

A flooded cavity in conjunction with a debris bed that is coolable will preclude CCIs. A wet cavity in conjunction with a coolable debris bed will only delay CCI. The amount of water overlaying the core debris also effects the DF that is applied to the CCI releases in the source term analysis. A flooded cavity will have a larger DF than an wet cavity. However, a wet cavity with a replenishable supply of water is treated the same as a flooded cavity.

Case 1: Either the reactor cavity was flooded before VB, or the drywell head was ruptured following VB. If the drywell head is ruptured, a sufficient amount of water from the upper containment pool will drain into the drywell and flood the cavity. The quantification for this case is:

Branch 1:	LDWFld	-	1.00
Branch 2:	LRCWet	-	0.00
Branch 3:	LRCDry	-	0.00

Case 2: At VB an energetic event (i.e., HPME, ex-vessel steam explosion, or a hydrogen burn) occurred in the drywell. This energetic event in combination with a wet reactor cavity purged most of the noncondensibles from the drywell and left the drywell filled with extremely hot steam (and some other gaseous species). As the drywell atmosphere cools, the steam will condense, and the pressure in the drywell will drop below the wetwell. Because the drywell vacuum breakers cannot open (AC power was not available at VB in this case) and the drywell was not ruptured at VB, the suppression pool will be depressed in the wetwell, causing pool water to be pushed over the weir wall and into the drywell. This scenario is supported by calculations that were performed with CONTAIN for Containment Loads Expert Panel. (See Volume 2, Part VI, of this report.) It is expected that for this

case, the drywell will be flooded. The quantification for this case is:

Branch 1: LDWFld - 1.00
Branch 2: LRCWet - 0.00
Branch 3: LRCDry - 0.00

Case 3: The hydrogen in the containment burns following VB. Because in this case the drywell has not been ruptured, the pressure rise in the containment that accompanies the burn will depress the level of the suppression pool sufficiently to flood the drywell. The quantification for this case is:

Branch 1: LDWFld - 1.00
Branch 2: LRCWet - 0.00
Branch 3: LRCDry - 0.00

Case 4: This case is the same as the previous case except that the drywell has been ruptured. Although it is still likely that the drywell will be flooded, it is possible that the rupture in the drywell will reduce the pressure differential between the two volumes sufficiently to avoid flooding the drywell. If the drywell is not flooded in this case, the burn will still push enough water into the drywell to result in a wet cavity. The quantification for this case is:

Branch 1: LDWFld - 0.90
Branch 2: LRCWet - 0.10
Branch 3: LRCDry - 0.00

Case 5: This case is the same as Case 2 except that the reactor cavity was dry at VB. The drywell will still be filled with extremely hot steam and other gaseous species after VB. However, because the reactor cavity was dry, the amount of steam produced at VB will be less in this case than in Case 2. Thus, the drywell atmosphere will contain a greater concentration of noncondensibles in this case. As the drywell atmosphere cools there will be less steam to condense, so the pressure differential may not be as great in this case as it was in Case 2. Although it is still likely that the drywell will be flooded, there is some chance that the drywell will be wet instead of flooded. The quantification for this case is:

Branch 1: LDWFld - 0.90
Branch 2: LRCWet - 0.10
Branch 3: LRCDry - 0.00

Case 6: The reactor cavity was wet before VB. Nothing happened during VB to change the amount of water in the reactor cavity. The quantification for this case is:

Branch 1: LDWFld - 0.00
Branch 2: LRCWet - 1.00
Branch 3: LRCDry - 0.00

Case 7: The reactor cavity was dry before VB. Nothing happened during VB to change the amount of water in the reactor cavity. The quantification for this case is:

Branch 1: LDWFld - 0.00
Branch 2: LRCWet - 0.00
Branch 3: LRCDry - 1.00

Question 99. **What Is the Nature of the CCI?**
5 Branches, Type 2, 11 Cases

The branches for this question are:

1. CCI — CCIs begin shortly after VB in a dry reactor cavity.

2. WetCCI — CCIs begin shortly after VB in a wet reactor cavity.

3. FldCCI — CCIs begin shortly after VB in a flooded reactor cavity.

4. DlyCCI — CCIs are delayed for approximately 3 hours after VB. The reactor cavity is essentially dry at the time CCI begins.

5. noCCI — There are no CCIs in the reactor cavity following VB.

This question is not sampled and was internally quantified. (A discussion of this issue is presented in Volume 2, Part VI, of this report.) The branching at this question depends upon the branch taken at Questions 9, 24, 26, 28, 61, 63, 97, and 98.

In this question, the likelihood that CCIs will occur in the reactor cavity following VB is determined. CCIs will not occur if the debris is in a coolable configuration and there is water in the cavity to cool it. The debris bed will not be coolable if it is finely fragmented or if the debris reagglomerates after VB. The coolability of the debris that is released at VB as well as that of the debris slowly released following VB is considered in this question. The core debris must be coolable in both cases if the CCI is not to occur. If any of the core debris released to the cavity, either at VB or after VB, is not coolable, CCI will be initiated. Once CCI has been established, it is assumed that all of the material in the reactor cavity participates in CCI. Thus, the coolability of the debris released after VB is important only if the debris released at VB is coolable.

The likelihood that the debris released after VB is coolable is the same for all the cases that have water in the cavity. The debris released after VB was most likely solid at VB. As the decay heat melts this remaining debris, it is released from the vessel. Thus, it is likely that this debris will be released with a low amount of superheat. It is expected that the debris bed that forms from this material will consist of large particles that may not be entirely molten. Assuming there is water in the cavity, it is likely that the debris bed will be coolable.

If the RPV fails at high pressure, most of the debris will be ejected from the cavity. Although this material will be finely fragmented, it will be coolable because it is spread throughout the drywell in a thin layer. Thus, the coolability of the debris in the cavity is based on the material that is released after VB.

Case 1: The vessel does not fail. Thus, there are no CCIs in the reactor cavity. The quantification for this case is:

Branch 1: CCI - 0.00
Branch 2: WetCCI - 0.00
Branch 3: FldCCI - 0.00
Branch 4: DlyCCI - 0.00
Branch 5: noCCI - 1.00

Case 2: The core debris is released from the vessel into a dry cavity. In addition, water is not being supplied to the RPV (i.e., or the cavity) at VB. Because there is no water in the cavity, it is certain that CCIs will occur in a dry cavity. The quantification for this case is:

Branch 1: CCI - 1.00
Branch 2: WetCCI - 0.00
Branch 3: FldCCI - 0.00
Branch 4: DlyCCI - 0.00
Branch 5: noCCI - 0.00

Case 3: The core debris is released from the vessel at high pressure into a dry cavity. Although the cavity is dry, a replenishable supply of water is released from the vessel coincident with the debris. Because the RPV fails at high pressure, most of the debris released at VB is ejected from the cavity. Thus, the coolability of the debris in the cavity is based on the material released after VB. As explained above, it is likely that the debris released after VB is coolable. If the debris bed is not cooled, CCI will occur in a flooded cavity (i.e., a replenishable supply of water is released from the vessel into the cavity). The quantification for this case is:

Branch 1: CCI - 0.00
Branch 2: WetCCI - 0.00
Branch 3: FldCCI - 0.20
Branch 4: DlyCCI - 0.00
Branch 5: noCCI - 0.80

Case 4: The core debris is released from the vessel at low pressure into a dry cavity. Although the cavity is dry, a replenishable supply of water is released from the vessel coincident with the debris. Because the RPV fails at low pressure, most of the debris released at VB will remain in the cavity. Even though water is released from the RPV at VB, the debris will contact essentially a dry floor, and CCI is likely to initiate. Once CCI is established, gases and steam flow upward through the debris and create a resistance to water that would penetrate and cool the debris. If the debris bed is not cooled, which is likely, CCI will occur in a flooded cavity (i.e., a replenishable supply of water is released from the vessel into the cavity). The quantification for this case is:

Branch 1: CCI - 0.00
Branch 2: WetCCI - 0.00
Branch 3: FldCCI - 0.84
Branch 4: DlyCCI - 0.00
Branch 5: noCCI - 0.16

Case 5: The core debris is released from the vessel into a dry cavity. Following VB (i.e., not coincident with VB), water is supplied to the core debris. Because the core debris is released into a dry cavity, it is certain that CCI will begin. It is uncertain at what time water will be supplied to the core debris. If the water enters the cavity shortly after VB, CCI will occur in a flooded cavity. On the other hand, if it takes several hours for the water to be supplied to the debris, CCI will have essentially occurred in a dry cavity. Thus, dry CCI and flooded CCI have been given equal probabilities of occurrence. The quantification for this case is:

Branch 1: CCI - 0.50
Branch 2: WetCCI - 0.00
Branch 3: FldCCI - 0.50
Branch 4: DlyCCI - 0.00
Branch 5: noCCI - 0.00

Case 6: The core debris is released from the vessel at high pressure into either a flooded or a wet cavity. If the cavity is wet, a replenishable supply of water enters the cavity after VB. Because the RPV fails at high pressure, the coolability of the debris in the cavity is based on the material released after VB (see Case 3). As explained above, it is likely that the debris released after VB is coolable. If the debris bed is not cooled, CCI will occur in a flooded cavity (i.e., a replenishable supply of water is being released from the vessel into the cavity). The quantification for this case is:

Branch 1: CCI - 0.00
Branch 2: WetCCI - 0.00
Branch 3: FldCCI - 0.20
Branch 4: DlyCCI - 0.00
Branch 5: noCCI - 0.80

Case 7: The core debris with a large amount of superheat is released from the vessel at low pressure into either a flooded or a wet cavity. If the cavity is wet, there is a replenishable supply of water that enters the cavity after VB. Because the RPV fails at low pressure, most of the debris released at VB will remain in the cavity. Even though there is water in the cavity, it is likely that the core debris will agglomerate because of its high superheat. Thus, it is likely that the core debris released at VB will not be coolable. Thus, even though it is likely that the debris released after VB is coolable, it is likely that CCI will be initiated by the debris released at VB. If the debris bed is not cooled, which is likely, CCI will occur in a flooded cavity (i.e., a replenishable supply of water is being released from the vessel into the cavity). The quantification for this case is:

Branch 1: CCI - 0.00
Branch 2: WetCCI - 0.00
Branch 3: FldCCI - 0.84
Branch 4: DlyCCI - 0.00
Branch 5: noCCI - 0.16

Case 8: Core debris with a small amount of superheat is released from the vessel at low pressure into either a flooded or a wet cavity. If the cavity is wet, there is a replenishable supply of water that enters the cavity after VB. Because the RPV fails at low pressure, most of the debris released at VB will remain in the cavity. Even though the debris has a low amount of superheat and was released at low pressure, it is uncertain whether the debris released at VB will be coolable. If the debris bed is not cooled, CCI will occur in a flooded cavity (i.e., a replenishable supply of water is released from the vessel into the cavity). The quantification for this case is:

Branch 1: CCI - 0.00
Branch 2: WetCCI - 0.00
Branch 3: FldCCI - 0.60
Branch 4: DlyCCI - 0.00
Branch 5: noCCI - 0.40

Case 9: The core debris is released from the vessel at high pressure into a wet cavity. The water in the cavity is not replenished after VB. Because the RPV fails at high pressure, the coolability of the debris in the cavity is based on the material that is released after VB (see Case 3). However, because the cavity water is not replenished, the cavity will eventually be boiled dry. Thus, if the debris is initially coolable, CCI will be delayed. Once the cavity water has been removed, CCI will begin. On the other hand, if the debris is not coolable, CCI will occur in a wet cavity. The quantification for this case is:

Branch 1: CCI - 0.00
Branch 2: WetCCI - 0.20
Branch 3: FldCCI - 0.00
Branch 4: DlyCCI - 0.80
Branch 5: noCCI - 0.00

Case 10: The core debris with a large amount of superheat is released from the vessel at low pressure into a wet cavity. The water in the cavity is not replenished after VB. Because the RPV fails at low pressure and the core debris has a large amount of superheat, it is likely that the debris will not be coolable (see Case 7). However, in the unlikely event the debris is initially coolable, CCI will be delayed by the presence of the cavity water. Once the cavity water has been removed, CCI will begin. On the other hand, if the debris is not coolable, CCI will occur in a wet cavity. The quantification for this case is:

Branch 1:	CCI	-	0.00
Branch 2:	WetCCI	-	0.84
Branch 3:	FldCCI	-	0.00
Branch 4:	DlyCCI	-	0.16
Branch 5:	noCCI	-	0.00

Case 11: The core debris with a small amount of superheat is released from the vessel at low pressure into a wet cavity. The water in the cavity is not replenished after VB. Even though the debris has a low amount of superheat and was released at low pressure, it is uncertain whether the debris released at VB will be coolable (see Case 8). If the debris is initially coolable, CCI will be delayed by the presence of the cavity water. Once the cavity water has been removed, CCI will begin. On the other hand, if the debris is not coolable, CCI will occur in a wet cavity. The quantification for this case is:

Branch 1:	CCI	-	0.00
Branch 2:	WetCCI	-	0.60
Branch 3:	FldCCI	-	0.00
Branch 4:	DlyCCI	-	0.40
Branch 5:	noCCI	-	0.00

Question 100. What Fraction of Core Not Participating in HPME Participates in CCI?
2 Branches, Type 4, 1 Parameter, 4 Cases

The branches for this question are:

1.	HiFCCI	A large fraction of the core participates in CCI. A nominal value of 95% is used for this branch.
2.	LoFCCI	A small fraction of the core participates in CCI. A nominal value of 80% is used for this branch.

The parameter initialized in this question is:

P45 FCCI	The fraction of the core not participating in HPME that participates in CCI is read in as Parameter 45.

The parameter initialized in Cases 2 and 3 of this question is sampled. The distributions for Parameter 45 were internally quantified. The parameter initialized in this question depends upon the branch taken at Questions 61, 63, and 67.

In this question, the fraction of the core that remains in the reactor cavity is quantified. If the core is released from the vessel as an HPME, it is assumed that all this material is ejected from the cavity and is spread throughout the drywell (e.g., floor, walls, and equipment). Because this material will be spread in a thin layer, it will be cooled and will not participate in CCI (see the previous question for a discussion on debris coolability). It must be remembered that only the fraction of the core released from the RPV at VB is available to participate in HPME. The remaining fraction of the core released after VB will enter the reactor cavity and is available to participate in CCI.

If HPME does not occur at VB, some core debris may still be ejected from the cavity by an ex-vessel steam explosion. It is this fraction of the core that remains in the cavity after an ex-vessel steam explosion that is quantified in this question. The amount of core debris that is released from the vessel at the time of VB was determined in Question 61. Two levels were used to characterize the amount of material released at VB. A nominal value of 10% represents a small release from the vessel, whereas a nominal value of 40% represents a large release from the vessel. Thus, if a large amount of the core is released at VB (i.e., 40%) and an ex-vessel steam explosion occurs, it is possible that up to 40% of the core will be ejected from the cavity. It therefore follows that if 40% of the core is ejected from the cavity, only 60% of the core is available for CCI. Because of the uncertainties associated with the amount of core released from the vessel, the amount of released material that actually participates in an ex-vessel steam explosion, and the fraction of the core that would be ejected from the cavity, a uniform distribution between 0.6 and 1.0 represents the amount of core debris available to participate in CCI. The low end of the range represents complete ejection from the cavity of the core debris released at VB, whereas the high end of the range corresponds to the case in which all the debris remains in the cavity. A similar approach is used for the case in which only a small fraction of the core is released at VB.

Case 1: Either an Alpha Mode event occurred or the vessel did not fail. Naturally, there will be no core debris in the cavity if the vessel does not fail. If Alpha Mode event occurred, it is likely that the core debris will be spread throughout the drywell and containment. The quantification for this case is:

Branch 1: HiFCCI - 0.0
Branch 2: LoFCCI - 1.0

In this case, the core debris does not participate in CCI, so the value assigned to Parameter 45 for both branches is 0.0.

Case 2: A large amount of core debris was released from the RPV at VB and subsequently participated in an ex-vessel steam explosion. Thus, up to 40% of the core may have been ejected from the cavity. The quantification for this case is:

Branch 1: HiFCCI - 0.0
Branch 2: LoFCCI - 1.0

Because Branch 1 is never taken in this case, the value assigned to the parameter is irrelevant. For Branch 2, the value assigned to the parameter, based on the mean value of the distribution, is:

Parameter 45: FCCI - 0.8

Case 3: This case is the same as the previous case except that a small amount of core debris was released from the RPV at VB. Thus, up to 10% of the core may have been ejected from the cavity. The quantification for this case is:

Branch 1: HiFCCI - 1.0
Branch 2: LoFCCI - 0.0

For Branch 1, the value assigned to the parameter, based on the mean value of the distribution, is:

Parameter 45: FCCI - 0.95

Because Branch 2 is never taken in this case, the value assigned to the parameter is irrelevant.

Case 4: There were no ex-vessel steam explosions following VB. Thus, all the core debris that does not participate in HPME is available to participate in CCI. The quantification for this case is:

Branch 1: HiFCCI - 1.0
Branch 2: LoFCCI - 0.0

For Branch 1, the value assigned to the parameter is:

Parameter 45: FCCI - 1.0

Because Branch 2 is never taken in this case, the value assigned to the parameter is irrelevant.

Question 101. How Much Hydrogen (and Equivalent Carbon Monoxide) and Carbon Dioxide are Produced During CCI?
4 Branches, Type 6, 2 Cases

The branches for this question are:

1. H2CCI4 The amount of hydrogen (and equivalent carbon monoxide) generated during CCI is equivalent to the oxidation of more than 50% of the total in-vessel zirconium.

2. H2CCI3 The amount of hydrogen (and equivalent carbon monoxide) generated during CCI is equivalent to the oxidation of between 25% and 50% of the total in-vessel zirconium.

3. H2CCI2 The amount of hydrogen (and equivalent carbon monoxide) generated during CCI is equivalent to the oxidation of between 10% and 25% of the total in-vessel zirconium.

4. H2CCI1 The amount of hydrogen (and equivalent carbon monoxide) generated during CCI is equivalent to the oxidation of less than 10% of the total in-vessel zirconium.

This question is not sampled and was internally quantified. The branching at this question depends upon the branch taken at Questions 63, 64, and 99. In this question, the amount of hydrogen, carbon monoxide (CO), and carbon dioxide (CO_2) generated during CCI is determined. A simple correlation that relates hydrogen production to the amount of unoxidized zirconium in the core debris is used to estimate the hydrogen production during CCI. Similar correlations were used to estimate the production of carbon monoxide and carbon dioxide. These correlations are based on results obtained from relevant CORCON calculations. (A discussion of this issue may be found in Volume 2, Part VI, of this report.) Modules in the user function subroutine are used to calculate the amount of hydrogen, carbon monoxide, and carbon dioxide produced during CCI.

For the sake of simplicity, moles of carbon monoxide are converted into equivalent moles of hydrogen. The conversion factor is based on the number of moles of H_2 that must be burned to equal the energy released when one mole of carbon monoxide is burned. The conversion is:

$$N_{H2} = 1.17\ N_{CO},$$

where N_{H2} is the equivalent number of moles of hydrogen and N_{CO} is the number of moles of carbon monoxide.

Case 1: There was an Alpha Mode event, the vessel did not fail, or the core debris in the reactor cavity was coolable. In all of these cases, there were no CCIs. Thus, no H_2, carbon monoxide, or carbon dioxide was produced from the core debris after VB. In all the subsequent cases, the core debris in the cavity participates in CCI.

Case 2: The core debris was released from the vessel as an HPME. If HPME occurs, it is assumed that all of the core debris that is released at VB is ejected from the cavity. Thus, only the material released after VB participates in CCI and is involved in the production of H_2, carbon monoxide, and carbon dioxide.

Case 3: The core debris was not released from the vessel as an HPME. However, core debris can still be ejected from the cavity if an ex-vessel steam explosion occurs in the cavity at VB. The fraction of the core left in the cavity and available to participate in CCI was determined in the previous question. The production of H_2, carbon monoxide, and carbon dioxide is based on the core debris that remains in the cavity.

Question 102. What Is the Level of Zirconium Oxidation in the Reactor Cavity Before CCI?
7 Branches, Type 5, 1 Case

The branches for this question are:

1. ZrOx75 More than 75% of the zirconium in the core debris available to participate in CCI has been oxidized before CCI begins.

2. ZrOx50 Between 50% and 75% of the zirconium in the core debris available to participate in CCI has been oxidized before CCI begins.

3. ZrOx40 Between 40% and 50% of the zirconium in the core debris available to participate in CCI has been oxidized before CCI begins.

4. ZrOx30 Between 30% and 40% of the zirconium in the core debris available to participate in CCI has been oxidized before CCI begins.

5. ZrOx21 Between 21% and 30% of the zirconium in the core debris available to participate in CCI has been oxidized before CCI begins.

6. ZrOx10 Between 10% and 21% of the zirconium in the core debris available to participate in CCI has been oxidized before CCI begins.

7. ZrOx<10 Less than 10% of the zirconium in the core debris available to participate in CCI has been oxidized before CCI begins.

This question summarizes of the fraction of oxidized zirconium that is in the core debris. In this question, only the core debris available to participate in CCI (i.e., the core debris that remains in the reactor cavity) is considered. The range of possible zirconium oxidation is divided into discrete levels represented by the seven branches. The fraction of oxidized zirconium in the core debris (Parameter 17) is then assigned to the appropriate level. To do this assignment, the fraction of zirconium oxidized, Parameter 17, is compared with a series of comparison parameters that represent various levels of zirconium oxidation. By doing this grouping, the probabilities of the various levels of zirconium oxidation can be determined. Furthermore, by representing zirconium oxidation by a branch in this question, zirconium oxidation can be used in the case structure in subsequent questions (i.e., the probability or parameter assigned in a subsequent question can be made dependent on the level of zirconium oxidized assigned in this question).

Question 103. Is the Containment Not Vented Following VB?
2 Branches, Type 2, 3 Cases

The branches for this question are:

1. InVent The containment is not vented following VB.

2. I-Vent The containment is vented following VB.

This question is not sampled. The branch taken at this question depends upon the branches previously taken at Questions 63, 79, 81, 93, 95, and 99.

This question determines whether the operator vents the containment following VB. A description of the venting system is presented in Question

22. Although the venting procedure requires containment venting when the pressure exceeds 17.25 psig, these procedures are only applicable before core damage. During core damage, VB, and after VB, a large inventory of radionuclides will accumulate in the containment. It is unlikely that the operators will vent the containment and release these radionuclides to the atmosphere.

Case 1: Either ac power is not available shortly after VB or the containment has been ruptured. Without ac power the containment cannot be vented. If the containment is ruptured, it will not pressurize following VB. Thus, venting is not necessary. The quantification for this case is:

Branch 1: InVENT - 1.0
Branch 2: I-VENT - 0.0

Case 2: AC power is available and the containment has not been ruptured. Thus, the containment can be pressurized and the venting system is available to relieve the pressure. However, there are no CCIs following VB because either the vessel did not fail or the debris bed was coolable. If the RPV remains intact, the steam generated in the vessel is condensed in the suppression pool. In this case, if the vessel fails, either the suppression pool is not completely bypassed (i.e., the drywell is not ruptured) or the containment sprays are operating. Thus, the steam generated from the interaction of the hot debris and water is condensed either in the suppression pool or by the containment sprays. For this case the containment pressure does not increase significantly following VB, venting is not necessary. The quantification for this case is:

Branch 1: InVENT - 1.0
Branch 2: I-VENT - 0.0

Case 3: AC power is available and the containment has not been ruptured. Thus, the containment can be pressurized and the venting system is available to relieve the pressure. In this case, the steam and/or noncondensibles will pressurize the containment following VB. If the core debris is coolable, the drywell is ruptured and the containment sprays are not operating. Thus, the steam generated from the interaction of the hot debris with the water will bypass the suppression pool and accumulate in the containment. If the core debris is not coolable, a significant amount of noncondensibles will be released during CCIs. These noncondensibles will accumulate in the containment regardless of whether the sprays are operating or the pool is bypassed. However, in addition to steam and noncondensibles, radionuclides will accumulate in the containment. Thus, it is unlikely that the operators will vent the containment and release these radionuclides to the atmosphere. The quantification for this case is:

Branch 1: InVENT - 0.9
Branch 2: I-VENT - 0.1

Question 104. Is AC Power Not Recovered Late in the Accident?
2 Branches, Type 2, 4 Cases

The branches for this question are:

1. LfAC AC power is not recovered late in the accident.

2. L-AC AC power is recovered late in the accident.

Cases 3 and 4 of this question are sampled; the distributions sampled were obtained from the offsite power recovery curves for the Grand Gulf plant. The branching at this question depends upon the branch taken at Questions 2, 15, 79, and 80.

The probability of power recovery as defined in this analysis is the probability that offsite electrical power is recovered in the period in question given that power was not recovered prior to the period. (See the discussion in Subsection A.3).

This question accounts for the delay recovery of offsite power. In this question, the time period of interest begins approximately 2 hours after VB (when the last time period ended) and ends 24 hours after the initiation of the accident. The end of this time period was arbitrarily set at 24 hours because, except for very unusual accidents, almost all of the fission products that are going to be released from the containment will have been released.

Case 1: Power was previously available and is therefore still available. The quantification for this case is:

Branch 1: LfAC = 0.0
Branch 2: L-AC = 1.0

Case 2: DC power is not available. Without dc power, it is assumed that ac power cannot be restored within the timeframe considered in this analysis. The quantification for this case is:

Branch 1: LfAC = 1.0
Branch 2: L-AC = 0.0

Case 3: This case is an SBO that has core damage in the long term. Power was not previously available, but recovery was possible. For the long-term sequences, the previous time period was terminated 17 hours after the initiating event. Thus, the recovery period for this case is 17 hours to 24 hours. The mean value for power recovery during this time period is:

Branch 1: IfAC = 0.91
Branch 2: I-AC = 0.09

Case 4: This case is an SBO that has core damage in the short term. Power was not previously available, but recovery was possible. For the short-term sequences the previous time period terminated 5.6 hours after the initiating event. Thus, the recovery period for this case is 5.6 hours to 24 hours. The mean value for power recovery during this time period is:

Branch 1: IfAC - 0.23
Branch 2: I-AC - 0.77

Question 105. Is DC Power Available Late in the Accident?

2 Branches, Type 2, 4 Cases

The branches for this question are:

1. LfDC DC power is not available late in the accident.

2. L-DC DC power is available late in the accident.

This question is not sampled and was internally quantified. The branching at this question depends upon the branch taken at Questions 2, 15, 79, and 80. A discussion of this issue and the assumptions made with regard to the relationship between ac and dc power is presented in Question 25.

The time periods used for battery depletion are the same as the time periods used for ac power recovery. A description of the late time period may be found in the previous question.

Case 1: DC power has already been lost. Once dc power is lost, it is assumed that it cannot be recovered. The quantification for this case is:

Branch 1: LfDC - 1.0
Branch 2: L-DC - 0.0

Case 2: AC power is available, so dc power is available. The quantification for this case is:

Branch 1: LfDC - 0.0
Branch 2: L-DC - 1.0

Case 3: This case is an SBO that has core damage in the long term. Thus, the time period is from 17 hours to 24 hours. The quantification for this case is:

Branch 1: LfDC - 0.33
Branch 2: L-DC - 0.67

Case 4: The PDS is an SBO that has core damage in the short term. Thus, the time period is from 5.6 hours to 24 hours. The quantification for this case is:

Branch 1: LfDC - 0.06
Branch 2: L-DC - 0.94

Question 106. What Is the Status of the Containment Sprays Late in the Accident?

4 Branches, Type 2, 8 Cases

The branches for this question are:

1. LfCS The containment sprays are failed and cannot be recovered.

2. LrCS The sprays are recoverable when ac power is restored.

3. LaCS The sprays are available but not currently operating.

4. L-CS The sprays are operating during the late time period.

Cases 2, 4, and 6 of this question are sampled; the distributions were quantified internally. The branching at this question depends upon the branch taken at Questions 50, 81, 93, and 104.

This question determines the status of the CS system during the late time period. A description of CS system is presented in Question 13. In this question failure of the CS system by energetic events in the containment is addressed.

Case 1: The CS system failed previously and is therefore not available after VB. The quantification for this case is:

Branch 1: LfCS - 1.0
Branch 2: LrCS - 0.0
Branch 3: LaCS - 0.0
Branch 4: L-CS - 0.0

Case 2: The CS system was in a recoverable condition shortly after VB, and ac power is not recovered during the late time period. The containment was ruptured by an energetic event at VB or shortly after VB (most likely a deflagration or a detonation). Because the event that failed the containment was severe enough to cause a rupture, it is possible that it also failed the CS system. Failure of the CS system is defined in this question as failure to provide adequate coverage to insure that the steam in the wetwell atmosphere is condensed. There is a large amount of uncertainty associated with the magnitude of the load that failed the containment and the location of the load (particularly in the case of a detonation). For this case, it is uncertain whether the CS system will fail or still be in a recoverable condition. This case is sampled zero-one. The distribution used to quantify this case is the same that was used to quantify Case 2 in Question 81. Based on the mean value of the sample, the quantification for this case is:

Branch 1: LfCS - 0.5
Branch 2: LrCS - 0.5
Branch 3: LaCS - 0.0
Branch 4: L-CS - 0.0

In the late time period, the distinction between a failed CS system and a recoverable system is not important because in either case the sprays will not operate. This distinction was important in the previous time periods because if the CS system had not failed, it could be recovered during a subsequent time period. This distinction has been retained for completeness.

Case 3: The CS system was recoverable shortly after VB, but ac power is not recovered during the late time period. Because the containment was not ruptured at VB (or shortly after VB), the CS system remains recoverable. The quantification for this case is:

Branch 1. LfCS = 0.0
Branch 2: LrCS = 1.0
Branch 3: LaCS = 0.0
Branch 4: L-CS = 0.0

Case 4: The CS system was operating shortly after VB, but the containment was ruptured by an energetic event around the time of VB (most likely a deflagration or a detonation). It is uncertain whether the CS system is failed or is still operating. This case is sampled zero-one. The distribution used to quantify this case is the same distribution that was used to quantify Case 4 in Question 81. Based on the mean value of the sample, the quantification for this case is:

Branch 1: LfCS = 0.5
Branch 2: LrCS = 0.0
Branch 3: LaCS = 0.0
Branch 4: L-CS = 0.5

Case 5: The CS system was operating shortly after VB. Because the containment was not ruptured following VB, it is expected that the CS system will still be operating. The quantification for this case is:

Branch 1: LfCS = 0.0
Branch 2: LrCS = 0.0
Branch 3: LaCS = 0.0
Branch 4: L-CS = 1.0

Case 6: The CS system was either available or recoverable shortly after VB, and ac power is available late in the accident. An energetic event (most likely a deflagration or a detonation) ruptured the containment following VB. The quantification for this case is similar to that in Case 2, except in this case it is uncertain whether the CS system is failed or will be available. Because the containment has been ruptured and is therefore not pressurized, it is felt that if the CS system does not fail, there is only a small probability that the operators will actuate this system. This case is sampled zero-one. The distribution used to quantify this case is the same distribution that was used to quantify Case 6 in Question 81. Based on the mean value of the sample, the quantification for this case is:

Branch 1: LfCS - 0.50
Branch 2: LrCS - 0.00
Branch 3: LaCS - 0.45
Branch 4: L-CS - 0.05

Case 7: AC power is available late in the accident and the CS system has not failed. Because the containment was not ruptured by an energetic event following VB, it is very likely that the sprays will be operating. The quantification for this case is the same as the quantification used in Case 4, Question 30. The quantification for this case is:

Branch 1: LfCS - 0.00
Branch 2: LrCS - 0.00
Branch 3: LaCS - 0.01
Branch 4: L-CS - 0.99

Case 8: All the potential cases are addressed in the preceding cases, so this case is not used.

Question 107. What Is the Concentration of Combustible Gases in the Containment Late in the Accident?
6 Branches, Type 6, 4 Cases

The branches for this question are:

1. LGWW>20 The concentration of combustible gases is greater than 20%.
2. LGWW>16 The concentration of combustible gases is between 16% and 20%.
3. LGWW>12 The concentration of combustible gases is between 12% and 16%.
4. LGWW>8 The concentration of combustible gases is between 8% and 12%.
5. LGWW>4 The concentration of combustible gases is between 4% and 8%.
6. L-NoGWW The concentration of combustible gases is less than 4%.

The branching at this question depends upon the branch taken at Questions 63, 93, 95, 97, 98, 103, and 106. A module in the user function is used to determine the hydrogen concentration in the wetwell during the late time period. The amount of hydrogen that remains in the wetwell is stored as Parameter 3.

In this question, the hydrogen generated from CCI is added to hydrogen that already exists in the wetwell. Because the beginning of this time period corresponds approximately with the peak in CCI gas production, it is assumed that all of the noncondensibles generated during CCI, except for a small fraction that remains in the drywell, enter the wetwell near the beginning of the late time period. Furthermore, it is assumed that any hydrogen and air in the drywell before CCI is pushed into the wetwell during CCI. Thus, the combustible gases that existed in the drywell before CCI and the gases generated during CCI can participate in combustion events during the late time period. The carbon dioxide generated during CCI is treated as steam. It is assumed that the inerting qualities of carbon dioxide are similar to steam. Unlike the steam, however, the carbon dioxide is not removed from the wetwell when the containment sprays are operating. Containment failure and the operation of the containment sprays will also affect the wetwell hydrogen concentration. If the containment fails, the number of moles in the containment are reduced to account for leakage. If the containment sprays operate, the steam in the wetwell is condensed. The wetwell hydrogen concentration calculated in this question is used in subsequent questions to determine the ignition probabilities, detonation probabilities, and the resulting loads from either a deflagration or detonation.

Case 1: The vessel fails, and the core debris that enters the reactor cavity comes into contact with water. The interaction of the core debris with the water generates copious amounts of steam. In this case, the suppression pool is bypassed, and the containment sprays do not operate. A large amount of steam will thus enter and inert the wetwell. In the user function, the amount of steam required to inert the wetwell, based on the amount of hydrogen in the containment, is calculated. The amount of steam in the wetwell is reinitialized with this value. Thus, subsequent burns are precluded.

Case 2: The containment either failed or was vented following VB. Because the containment pressure boundary is not intact, the pressure in the containment will remain near atmospheric pressure. Therefore, to satisfy this pressure requirement, it is necessary to release a fraction of the wetwell gas to the outside atmosphere.

Case 3: The containment is intact and the containment sprays are operating during the late time period. The containment sprays remove the steam from the wetwell atmosphere, but they do not affect the concentration of carbon dioxide in the wetwell. Thus, the gaseous species that existed in the drywell before CCI, as well as the noncondensibles generated during CCI, are added to the wetwell atmosphere. Most of the steam, however, is removed from the wetwell.

Case 4: This case is the same as the previous case except that the containment sprays do not operate during the late time period, so the steam in the wetwell is not condensed.

Question 108. To What Level is the Wetwell Inert Late in the Accident?
3 Branches, Type 5, 1 Case

The branches for this question are:

1. LnWWIn The wetwell is not inert; both hydrogen deflagrations and detonations are possible.

2. L-WWIn2 The wetwell is inert to hydrogen detonations during the late time period.

3. L-WWIn3 The wetwell is inert to both hydrogen detonations and deflagrations during the late time period.

This question is used to determine whether hydrogen detonations or deflagrations are possible in the wetwell during the late time period. A module in the user function is used to calculate the mole fraction of steam, Y_{steam}, in the wetwell. A discussion of the inerting limits is presented in Question 40. The combustion limits used in this analysis are:

$Y_{steam} \geq 0.55$; inert to detonations and deflagrations.

$0.55 > Y_{steam} \geq 0.35$; inert to detonations.

$0.35 > Y_{steam}$; both detonations and deflagrations are possible.

Question 109. Is there Sufficient Oxygen in the Containment to Support Late Combustion?
5 Branches, Type 5, 1 Case

The branches for this question are:

1. LO2Det20 There is enough oxygen in the wetwell to support a detonation of a mixture with 20% hydrogen.

2. LO2Det16 There is enough oxygen in the wetwell to support a detonation of a mixture with 16% hydrogen.

3. LO2Det12 There is enough oxygen in the wetwell to support a detonation of a mixture with 12% hydrogen.

4. LWWO2 There is enough oxygen in the wetwell to support a deflagration but not a detonation.

5. LnWWO2 There is not enough oxygen in the wetwell to support a deflagration.

This question is used to determine the amount of hydrogen that can be burned based on the amount of oxygen available in the wetwell during the late time period. Late in the accident, the amount of oxygen in the containment may have been depleted by previous burns and/or by containment failure. A module in the user function is used to calculate the mole fraction of oxygen in the containment. This question is used by subsequent questions to help determine the probabilities of hydrogen deflagrations and detonations.

Question 110. Does Ignition Occur in the Containment Late in the Accident?
2 Branches, Type 2, 7 Cases

The branches for this question are:

1. L-CIgn The hydrogen in the wetwell is ignited during the late time period.

2. LnCIgn The hydrogen does not ignite during the late time period.

Cases 4 through 7 of this question are sampled. The distributions for ignition probability following VB were based on distributions provided by the Containment Loads Expert Panel for hydrogen ignition before VB. The branching at this question depends upon the branch taken at Questions 82, 83, 84, 85, 104, 106, 107, 108, and 109.

In this question, the ignition probability of hydrogen in the wetwell during the late time period is addressed. The sources of ignition considered in this question, random ignition sources, are essentially the same sources that were considered by the Containment Loads Expert Panel for ignition before VB (Question 43). The late time period is, however, much longer than the time period during core degradation. Thus, if an expert's distribution for ignition probability was an explicit function of time, the distribution was modified accordingly. Therefore, the ignition probability distributions used in this question are similar to, but not identical to, the distributions used in Question 43. In Question 43, the ignition probabilities were a function of the RPV pressure, and the concentration of hydrogen in the wetwell. Before VB, the RPV pressure affects the hydrogen distribution in the containment. When the RPV is at low pressure, the hydrogen is released uniformly throughout the suppression pool. This pathway is similar to the way the hydrogen generated during CCI will enter the wetwell. Thus, only the low-pressure RPV distributions used in Question 43 were modified and used in this question. However, the ignition probability is still a function of the hydrogen concentration.

Hydrogen burns in the drywell are not considered during the late time period because the large amount of steam generated at VB and during CCI will inert the drywell. In addition, most of the oxygen originally in the drywell will have either been consumed by burns at VB or will have been pushed into the wetwell.

Case 1: The wetwell atmosphere is not combustible (i.e., either not enough hydrogen, not enough oxygen, or too much steam). Thus, the hydrogen in the wetwell does not burn late in the accident. However, if the wetwell atmosphere was inert following VB, but the containment sprays are recovered during this time period, then ignition is not precluded. The quantification for this case is:

Branch 1:	L-CIgn	-	0.00
Branch 2:	LnCIgn	-	1.00

Case 2: A combustible mixture existed in the wetwell following VB, but it did not burn. Thus, the containment and the wetwell atmosphere are

in a condition that makes ignition from random sources extremely unlikely. Therefore, without ac power to provide additional ignition sources, it is extremely unlikely that the hydrogen will burn during the late time period. The quantification for this case is:

Branch 1: L-CIgn = 0.00
Branch 2: LnCIgn = 1.00

Case 3: AC power is available late in the accident, and the wetwell atmosphere is combustible. Because of the availability of ac sources, it is assumed that the hydrogen will ignite. The quantification for this case is:

Branch 1: L-CIgn = 1.00
Branch 2: LnCIgn = 0.00

Case 4: AC power is not available late in the accident. Thus, there are only random ignition sources. The concentration of hydrogen in the wetwell is greater than 16%. The quantification for this case, based on the mean value of the distribution, is:

Branch 1: L-CIgn = 0.51
Branch 2: LnCIgn = 0.49

Case 5: This case is the same as Case 4 except that the concentration of hydrogen in the wetwell is between 12% and 16%. The quantification for this case, based on the mean value of the distribution, is:

Branch 1: L-CIgn = 0.42
Branch 2: LnCIgn = 0.58

Case 6: This case is the same as Case 4 except that the concentration of hydrogen in the wetwell is between 8% and 12%. The quantification for this case, based on the mean value of the distribution, is:

Branch 1: L-CIgn = 0.33
Branch 2: LnCIgn = 0.67

Case 7: This case is the same as Case 4 except that the concentration of hydrogen in the wetwell is between 4% and 8%. The quantification for this case, based on the mean value of the distribution, is:

Branch 1: L-CIgn = 0.29
Branch 2: LnCIgn = 0.71

Question 111. Is There a Detonation in the Wetwell Late in the Accident?
2 Branches, Type 4, 1 Parameter, 9 Cases

The branches for this question are:

1. L-WWDt There is a detonation in the wetwell during the late time period.

2. LnWWDt A significant detonation does not occur in the wetwell during the late time period.

The parameter initialized in this question is:

P20 ImpLoad The impulse loading from a detonation (kPa·S) is read in as Parameter 20. This parameter was previously initialized in Question 44 and Question 86. This parameter is reinitialized in this question.

This question is not sampled. The detonation probabilities and accompanying impulse loads are based on distributions provided by the Containment Loads Expert Panel for hydrogen detonations before VB. The branching at this question depends upon the branch taken at Questions 27, 79, 106, 107, 108, 109, and 110.

The detonation probabilities used in this question are conditional on the hydrogen having already been ignited (Question 110). In this question, the probability of a detonation is a function of the hydrogen concentration, the oxygen concentration, and the amount of steam in the wetwell atmosphere. The detonation probabilities and the accompanying impulse loads are quantified using the means of the distributions provided by the Containment Loads Expert Panel for hydrogen detonations before VB (Question 44). The Containment Loads Expert Panel indicated that there was a negligible probability of a significant hydrogen detonation if the hydrogen concentration was below 12%. Two levels of steam were considered: high and low. The high steam level corresponds to the case in which a wetwell atmosphere initially inert to detonations (i.e., mole fraction of steam was greater than 0.35) is slowly condensed and brought into the detonable regime by the recovery of sprays. The low steam level corresponds to the case in which the steam concentration is low enough initially to allow a detonable mixture to form.

Case 1: The hydrogen was not ignited, the wetwell is inert to hydrogen detonations (i.e., mole fraction of steam greater than 0.35 and the containment sprays are not operating), or the global concentration of hydrogen in the wetwell is below 12%. In any case, a hydrogen detonation is not possible. The quantification for this case is:

Branch 1:	L-WWDt	-	0.00
Branch 2:	LnWWDt	-	1.00

Because Branch 1 is never taken, the value assigned to the parameter for this branch is irrelevant. Because Branch 2 represents the situation in which the hydrogen does not detonate, the value for the impulse load assigned to this parameter is 0.0. In all the remaining cases, the impulse load assigned to Branch 2 will also be 0.0.

Case 2: The hydrogen ignition system has been operating since VB. Thus, the hydrogen generated during CCI will be burned as it is released to the wetwell, which will preclude the formation of a detonable mixture in the containment. The quantification for this case is:

Branch 1: L-WWDt - 0.00
Branch 2: LnWWDt - 1.00

Because Branch 1 is never taken, the value assigned to the parameter for this branch is irrelevant, and for Branch 2, the value assigned to the parameter is 0.0.

Case 3: The wetwell has a high steam concentration (i.e., slowly decreasing below 35%), and there is sufficient oxygen in the wetwell to support a detonation. The hydrogen concentration is between 12% and 16%. The quantification for this case is:

Branch 1: E4-WWDt - 0.22
Branch 2: E4nWWDt - 0.78

For Branch 1, the value assigned to the parameter (kPa-S) is:

Parameter 20: ImpLoad - 5.8

Case 4: The wetwell has a low steam concentration, and there is sufficient oxygen in the wetwell to support a detonation. The hydrogen concentration is between 12% and 16%. The quantification for this case is:

Branch 1: L-WWDt - 0.00
Branch 2: LnWWDt - 1.00

Because Branch 1 is never taken, the value assigned to the parameter for this branch is irrelevant, and for Branch 2, the value assigned to the parameter is 0.0.

Case 5: The wetwell has a high steam concentration (i.e., slowly decreasing below 35%), and sufficient oxygen is in the wetwell to support a detonation. The hydrogen concentration is between 16% and 20%. The quantification for this case is:

Branch 1: E4-WWDt - 0.25
Branch 2: E4nWWDt - 0.75

For Branch 1, the value assigned to the parameter (kPa-S) is:

Parameter 20: ImpLoad - 5.8

Case 6: The wetwell has a low steam concentration, and there is sufficient oxygen in the wetwell to support a detonation. The hydrogen concentration is between 16% and 20%. The quantification for this case is:

Branch 1: E4-WWDt - 0.26
Branch 2: E4nWWDt - 0.74

For Branch 1, the value assigned to the parameter (kPa-S) is:

Parameter 20: ImpLoad = 12.4

Case 7: The wetwell has a high steam concentration (i.e., slowly decreasing below 35%), and there is sufficient oxygen in the wetwell to support a detonation. The hydrogen concentration is greater than 20%. The quantification for this case is:

Branch 1: E4-WWDt = 0.25
Branch 2: E4nWWDt = 0.75

For Branch 1, the value assigned to the parameter (kPa-S) is:

Parameter 20: ImpLoad = 5.8

Case 8: The wetwell has a low steam concentration, and there is sufficient oxygen in the wetwell to support a detonation. The hydrogen concentration is greater than 20%. The quantification for this case is:

Branch 1: E4-WWDt = 0.45
Branch 2: E4nWWDt = 0.55

For Branch 1, the value assigned to the parameter (kPa-S) is:

Parameter 20: ImpLoad = 12.4

Case 10: There is not enough oxygen in the wetwell to support a detonation. Thus, the quantification for this case is:

Branch 1: L-WWDt = 0.00
Branch 2: LnWWDt = 1.00

Because Branch 1 is never taken, the value assigned to the parameter for this branch is irrelevant and for Branch 2, the value assigned to the parameter is 0.0.

Question 112. What Is the Level of the Containment Impulse Load Late in the Accident?
7 Branches, Type 5, 1 Case

The branches for this question are:

1. L-Ip>60 The impulse is greater than 60 kPa-S.

2. L-Ip>50 The impulse is in the range 50 ≤ Impulse < 60 kPa-S.

3. L-Ip>40 The impulse is in the range 40 ≤ Impulse < 50 kPa-S.

4. L-Ip>30 The impulse is in the range 30 ≤ Impulse < 40 kPa-S.

5.	L-Ip>20	The impulse is in the range 20 ≤ Impulse < 30 kPa-S.
6.	L-Ip>10	The impulse is in the range 10 ≤ Impulse < 20 kPa-S.
7.	L-Ip<10	The impulse is less than 10 kPa-S.

This question is a summary of the detonation impulse loads (Parameter 20) initialized in the previous question (Question 111). In this question, the range of possible impulse loads is divided into discrete levels represented by the seven branches. The various impulse loads are then grouped into the appropriate levels. To do this grouping, the impulse load, Parameter 20, is compared with a series of comparison parameters that define the various levels. It should be noted that structural failure to a detonation is determined by the actual value assigned to Parameter 20 and not by a level defined in this question. These levels are only used to summarize the magnitude of the impulse.

Question 113. With What Efficiency Is Hydrogen Burned Late in the Accident?
1 Branch, Type 4, 2 Parameters, 9 Cases

The branch for this question is:

1.	H2Ef@VB	The hydrogen burn efficiency late in the accident.

The parameters initialized in this question are:

P18 H2EfVB1	The effective efficiency of a hydrogen burn late in the accident. Although this parameter was initialized in Question 46 and Question 88, it is reinitialized in this question.
P19 H2EfVB2	The actual efficiency of a hydrogen burn late in the accident. Although this parameter was initialized in Question 46 and Question 88, it is reinitialized in this question.

This question is not sampled. The effective and the actual combustion efficiencies (Parameters 18 and 19, respectively) are based on distributions provided by the Containment Loads Expert Panel for hydrogen burns before VB. The parameters initialized in this question depend upon the branch taken at Questions 106, 107, 108, and 110.

The effective and the actual combustion efficiencies (Parameters 18 and 19, respectively) are quantified using the means of the distributions provided by the Containment Loads Expert Panel for hydrogen burns before VB (Question 46). Definitions of these parameters and a discussion of how they are used in this analysis is presented in Question 46. In this question, which is based on the results from the Containment Loads Expert Panel, the effective efficiency of a hydrogen burn is a function of both the hydrogen concentration and the steam concentration in the wetwell. The actual hydrogen burn efficiency is only a function of the hydrogen concentration.

Case 1: The hydrogen in the wetwell is ignited late in the accident. The steam concentration in the wetwell is high (i.e., between 35% and 55% steam), and the hydrogen concentration is less than 8%. The values assigned to the parameters are:

Parameter 18: H2EfVB1 - 0.28
Parameter 19: H2EfVB2 - 0.27

Case 2: This case is the same as Case 1 except that the steam concentration is low (i.e., less than 35% steam). The values assigned to the parameters are:

Parameter 18: H2EfVB1 - 0.28
Parameter 19: H2EfVB2 - 0.27

Case 3: The hydrogen in the wetwell is ignited late in the accident. The steam concentration in the wetwell is high (i.e., between 35% and 55% steam), and the hydrogen concentration is between 8% and 12%. The values assigned to the parameters are:

Parameter 18: H2EfVB1 - 0.46
Parameter 19: H2EfVB2 - 0.74

Case 4: This case is the same as Case 3 except that the steam concentration is low (i.e., less than 35% steam). The values assigned to the parameters are:

Parameter 18: H2EfVB1 - 0.57
Parameter 19: H2EfVB2 - 0.74

Case 5: The hydrogen in the wetwell is ignited late in the accident. The steam concentration in the wetwell is high (i.e., between 35% and 55% steam), and the hydrogen concentration is between 12% and 16%. The values assigned to the parameters are:

Parameter 18: H2EfVB1 - 0.48
Parameter 19: H2EfVB2 - 0.88

Case 6: This case is the same as Case 5 except that the steam concentration is low (i.e., less than 35% steam). The values assigned to the parameters are:

Parameter 18: H2EfVB1 - 0.73
Parameter 19: H2EfVB2 - 0.88

Case 7: The hydrogen in the wetwell is ignited late in the accident. The steam concentration in the wetwell is high (i.e., between 35% and 55% steam), and the hydrogen concentration is greater than 16%. The values assigned to the parameters are:

Parameter 18: H2EfVB1 - 0.49
Parameter 19: H2EfVB2 - 0.93

Case 8: This case is the same as Case 7 except that the steam concentration is low (i.e., less than 35% steam). The values assigned to the parameters are:

Parameter 18: H2EfVB1 - 0.75
Parameter 19: H2EfVB2 - 0.93

Case 9: The hydrogen does not burn in the wetwell during the late time period. The values assigned to the parameters are:

Parameter 18: H2EfVB1 - 0.00
Parameter 19: H2EfVB2 - 0.00

Question 114. What Is the Peak Pressure in the Containment from a Late Hydrogen Burn?
6 Branches, Type 6, 4 Cases

The branches for this question are:

1. L-PBrn>7 The peak overpressure is greater than 700 kPa.
2. L-PBrn>6 The peak overpressure is in the range 600 kPa ≤ P < 700 kPa.
3. L-PBrn>5 The peak overpressure is in the range 500 kPa ≤ P < 600 kPa.
4. L-PBrn>4 The peak overpressure is in the range 400 ≤ P < 500 kPa.
5. L-PBrn>3 The peak overpressure is in the range 300 ≤ P < 400 kPa.
6. L-PBrn<3 The peak overpressure is less than 300 kPa.

The branching at this question depends upon the branch taken at Questions 27, 79, 93, 110, and 111. In this question, a module in the user function is used to determine the peak overpressure in the containment and the peak wetwell/drywell pressure differential from a hydrogen deflagration in the wetwell. The peak wetwell overpressure is used to determine the load on the containment structure, whereas the peak wetwell/drywell pressure differential is used to determine the load on the drywell structure. The calculations are based on the composition of the wetwell atmosphere (i.e., moles of hydrogen, air, and steam) and on the effectiveness of the burn (Parameters 18 and 19). In addition to determining the burn overpressure, this module also adjusts the number of moles of hydrogen, oxygen, and steam present in the wetwell after the burn based on the actual efficiency of the burn. The same user function module used in Questions 47 and 89 is used in this question.

The module of the user function used in this question returns the peak wetwell overpressure in Parameter 11 and the peak wetwell/drywell pressure differential in Parameter 12.

Case 1: The hydrogen in the wetwell does not ignite late in the accident. Thus, there is no overpressure and none of the hydrogen is consumed.

Case 2: Either the hydrogen ignites and there is a large hole in the containment, or the HIS has been operating since VB. If the containment is ruptured, the pressure rise is negligible and does not threaten the drywell structure. Similarly, if the HIS has been operating, the hydrogen generated during CCI is burned as it is released to the wetwell, which also results in a negligible overpressure. The moles of hydrogen, oxygen, and steam are adjusted to account for the burn.

Case 3: The hydrogen in the wetwell detonates. Thus, the peak wetwell/drywell pressure differential is the same as the peak wetwell overpressure.

Case 4: The hydrogen in the wetwell burns as a deflagration and there are no large holes in the containment.

Question 115. **What Is the Level of Drywell Leakage Induced by a Late Detonation in the Containment?**
3 Branches, Type 6, 2 Cases

The branches for this question are:

1. LnDWDt The drywell does not fail from a detonation.
2. L-DWDt2 A detonation induces a leak in the drywell.
3. L-DWDt3 A detonation induces a rupture in the drywell.

The branching at this question depends upon the branch taken at Question 111. A module in the user function is used to determine whether the drywell fails, and the mode of failure. In the user function, the impulse from the detonation (Parameter 20) is compared to the structural capacity of the drywell to dynamic loads (Parameter 34). The way in which the random number (Parameter 35) is used to determine the mode of drywell failure is described in Subsection A.2. The method differs depending on whether the rate of pressure rise is fast or slow relative to the rate at which a leak depressurizes the drywell. For detonations the fast pressure rise method is used.

Case 1: There is a detonation in the wetwell.

Case 2: A detonation does not occur in the wetwell during the late time period. Thus, drywell does not fail from a detonation.

Question 116. **What Is the Level of Containment Leakage Induced by a Late Detonation?**
3 Branches, Type 6, 3 Cases

The branches for this question are:

1. LnDtF The containment does not fail from a detonation.
2. L-DtF2 A detonation induces a leak in the containment.

3. L-DtF3 A detonation induces a rupture in the containment.

The branching at this question depends upon the branch taken at Questions 111 and 115. A module in the user function is used to determine whether the containment fails, and the mode of failure. In the user function, the impulse from the detonation (Parameter 20) is compared to the structural capacity of the containment to dynamic loads (Parameter 24). The way in which the random number (Parameter 25) is used to determine the mode of containment failure is described in Subsection A.2. The method differs depending on whether the rate of pressure rise is fast or slow relative to the rate at which a leak depressurizes the containment. For detonations the fast pressure rise method is used.

> Case 1: The drywell failed (either a leak or a rupture) from a detonation in containment. This case was included in this question to allow coupling between the drywell response to a detonation and the containment response. In this analysis, the structural response of the drywell to dynamic loads (Parameter 34) was correlated to the structural capacity of the containment (Parameter 24). Thus, this coupling has already been taken into account, and no additional coupling is applied in this case.
>
> Case 2: There is a detonation in the wetwell, and it does not fail the drywell. However, because the containment is not as strong as the drywell, there is still some probability that the containment will fail.
>
> Case 3: A detonation does not occur in the wetwell during the late time period. Thus, containment does not fail from a detonation.

Question 117. What Is the Level of Containment Leakage Induced by Late Combustion Events?
4 Branches, Type 6, 4 Cases

The branches for this question are:

1. LnCL The containment does not fail from a combustion event during the late time period.

2. L-CL2 The containment fails in the leak mode; nominal hole size is 0.1 ft^2.

3. L-CL3 The containment fails by rupture; nominal hole size is 7 ft^2.

4. L-CL4 The containment fails by catastrophic rupture. This failure mechanism does not occur in this analysis but has been retained in the tree for completeness.

The branching at this question depends upon the branch taken at Questions 93, 103, and 116. A module in the user function is used to determine whether the containment fails, and the mode of failure. In the user function, the peak pressure in the containment from a combustion event (Parameter 11) is compared to the containment failure pressure (Parameter

21). The way in which the random number (Parameter 22) is used to determine the mode of containment failure is described in Subsection A.2. The method differs depending on whether the rate of pressure rise is fast or slow relative to the rate at which a leak depressurizes the containment. The fast pressure rise method is used when the loading on the containment is from a hydrogen burn.

Case 1: The containment failed following VB by a catastrophic rupture.

Case 2: The containment was either ruptured or vented following VB or was ruptured by a detonation during the late time period. In any case, the containment is already ruptured.

Case 3: The containment failed in the leak mode either following VB or from a detonation late in the accident. Because a leak will not arrest a fast pressure rise, the containment can still fail in the rupture mode from the pressure rise in the containment from a late combustion event. Thus, the containment failure mode will at least be a leak, and there is some probability that the failure mode will be a rupture.

Case 4: The containment was intact following VB and did not fail from a detonation (if one occurred) late in the accident. Thus, depending on the pressure rise in the containment from a late combustion event, the containment can either remain intact, fail in the leak mode, or fail in the rupture mode.

Question 118. **What Is the Level of Drywell Leakage Induced by Late Combustion Events in the Containment?**
5 Branches, Type 6, 7 Cases

The branches for this question are:

1.	LnDWDf	The drywell does not fail late in the accident.
2.	L-DWDf2	The drywell fails in the leak mode at the drywell wall.
3.	L-DWHDf2	The drywell fails in the leakage mode at the drywell head. In this analysis, it was assessed that there was a negligible probability that the drywell head would fail before the drywell wall. Thus, this failure location does not occur in this analysis but has been retained in the tree for completeness.
4.	L-DWDf3	The drywell fails in the rupture mode at the drywell wall.
5.	L-DWHDf3	The drywell fails in the rupture mode at the drywell head. In this analysis, it was assessed that there was a negligible probability that the drywell head would fail before the drywell wall. Thus, this failure location does not occur in this analysis but has been retained in the tree for completeness.

The branching at this question depends upon the branch taken at Questions 94, 115, and 117. A module in the user function is used to determine whether the drywell fails, and the mode of failure. In the user function the peak wetwell/drywell pressure differential (Parameter 12) is compared to the drywell failure pressure (Parameter 30). The way in which the random number (Parameter 31) is used to determine the mode of containment failure is described in Subsection A.2 The method differs depending on whether the rate of pressure rise is fast or slow relative to the rate at which a leak depressurizes the containment (or pressurizes the drywell). The fast pressure rise method is used when the loading on the drywell is from a hydrogen burn.

Containment failure by rupture has been included in the case structure for this question to allow for the load on the drywell structure to be reduced because of the pressure relaxation associated with the containment failure. However, as explained in Question 51, the pressure rise associated with burns typically encountered in this analysis is very rapid, and the effect that the containment failure has on the peak wetwell/drywell pressure differential is minor. Thus, the cases with containment failure are not handled any differently than the cases without containment failure. These cases have only been retained for the sake of completeness.

Case 1: The drywell has already failed in the rupture mode. The failure is caused by either a failure at VB or a detonation in the wetwell late in the accident.

Case 2: The drywell head was ruptured before vessel. Thus, all other drywell failure modes are precluded.

Case 3: The drywell wall has already failed in the leak mode, and the containment is ruptured. The drywell wall failure precludes failure of the head. Depending on the pressure rise in the containment, the drywell wall leak will possibly increase to a rupture.

Case 4: The drywell wall has already failed in the leak mode, but the containment is either intact or only leaking. The drywell wall failure precludes failure of the head. Depending on the pressure rise in the containment, the drywell wall leak will possibly increase to a rupture.

Case 5: The drywell head has already failed in the leak mode, and the containment is ruptured. Depending on the pressure rise in the containment, it is possible that the drywell leak will increase to a rupture.

Case 6: The drywell head has already failed in the leak mode, but the containment is either intact or only leaking. Depending on the pressure rise in the containment, it is possible that the drywell leak will increase to a rupture.

Case 7: The drywell was intact before the late combustion event. Thus, depending on the pressure rise in the containment from a late combustion event, the drywell can either remain intact, fail in the leak mode, or fail in the rupture mode.

Question 119. Is the Containment Not Vented Late in the Accident?
2 Branches, Type 2, 4 Cases

The branches for this question are:

1. LnVent The containment is not vented late in the accident.

2. L-Vent The containment is vented late in the accident.

This question is not sampled. The branch taken at this question depends upon the branches previously taken at Questions 63, 81, 95, 99, 104, 106, 117, and 118.

This question determines whether the operator vents the containment late in the accident. A description of the venting system is presented in Question 22. Although the venting procedure requires containment venting when the pressure exceeds 17.25 psig, these procedures are applicable only before core damage. During core damage, VB, and after VB, a large inventory of radionuclides will accumulate in the containment. It is unlikely that the operators will vent the containment and release these radionuclides to the atmosphere.

Case 1: Either ac power is not available late in the accident, or the containment has been ruptured. If the containment was vented shortly after VB, it is included as a containment rupture. Without ac power, the containment cannot be vented. If the containment is ruptured, it will not pressurize following VB. Thus, venting is not necessary. The quantification for this case is:

Branch 1: LnVENT - 1.0
Branch 2: L-VENT - 0.0

Case 2: AC power is available, and the containment has not been ruptured. Thus, the containment can be pressurized, and the venting system is available to relieve the pressure. However, there are no core-concrete interactions following VB because either the vessel did not fail or the debris bed was coolable. If the RPV remains intact, the steam generated in the vessel is condensed in the suppression pool. In this case, if the vessel fails, either the suppression pool is not completely bypassed (i.e., the drywell is not ruptured) or the containment sprays have been operating since VB. Thus, the steam generated from the interaction of the hot debris and water is condensed either in the suppression pool or by the containment sprays. Therefore, for this case, the containment pressure does not increase significantly following VB, so venting is not necessary. The quantification for this case is:

Branch 1: LnVENT - 1.0
Branch 2: L-VENT - 0.0

Case 3: AC power is available and the containment has not been ruptured. Thus, the containment can be pressurized, and the venting system is available to relieve the pressure. However, there are no

CCIs following VB because the debris bed was coolable. In this case, either the containment sprays were not operating at VB but were recovered late in the accident, or the suppression pool is not completely bypassed (i.e., the drywell is not ruptured). Although some steam may accumulate in the containment, its pressure will not be high enough to justify venting the containment. The quantification for this case is:

Branch 1:	LnVENT	1.0
Branch 2:	L-VENT	0.0

Case 4: AC power is available, and the containment has not been ruptured. Thus, the containment can be pressurized, and the venting system is available to relieve the pressure. In this case, the steam and/or noncondensibles will pressurize the containment following VB. If the core debris is coolable, the drywell is ruptured, and the containment sprays are not operating. Thus, the steam generated from the interaction of the hot debris with the water will bypass the suppression pool and accumulate in the containment. If the core debris is not coolable, a significant amount of noncondensibles will be released during CCIs. These noncondensibles will accumulate in the containment regardless of whether the sprays are operating or the pool is bypassed. However, in addition to steam and noncondensibles, radionuclides will accumulate in the containment. Thus, it is unlikely that the operators will vent the containment and release these radionuclides to the atmosphere. The quantification for this case is:

Branch 1:	LnVENT	-	0.9
Branch 2:	L-VENT	-	0.1

Question 120. How Much Concrete Must be Eroded to Cause Pedestal Failure?
1 Branch, Type 3, 1 Parameter

The branch for this question is:

1. ConErPed The amount of concrete that must be eroded to cause reactor pedestal failure.

The parameter initialized in this question is:

P43 ConErPed The depth of concrete that must be eroded (m) to cause reactor pedestal failure is read in as Parameter 43.

The parameter initialized in this question is sampled. The distribution for the amount of concrete that must be eroded to cause reactor pedestal failure was provided by the Structural Response Expert Panel. (A discussion of this issue is presented in Volume 2, Part III, of this report.)

The expert panel provided the probability of pedestal failure as a function of erosion depth. Pedestal failure is defined as the loss of support to the RPV such that gross motion of the vessel results. If the vessel fails, core debris is released into the reactor cavity. Assuming the debris is not coolable, it will participate in CCIs. During CCI, both the concrete and the extensive mesh of rebar in the pedestal are eroded. If the erosion into the pedestal wall is extensive, the pedestal may collapse from the load imposed by the RPV and the shield wall. To assess the probability of pedestal failure, the experts considered loss of support due to both ablation and thermal penetration. However, the Molten Core-Concrete Expert Panel indicated that the thermal front is only slightly ahead of the erosion front, so the difference between these two fronts is not particularly important.

The pedestal failure depth, Parameter 43, in conjunction with the pedestal erosion depth that results from CCI, is used in a subsequent question to determine whether the pedestal fails. The importance of pedestal failure is that it can induce drywell failure that results in pathway from the drywell to the wetwell that completely bypasses the suppression pool. The value (m) assigned to the parameter, based on the mean value of the distribution, is:

Parameter 43: ConErPed - 1.1

Question 121. **At What Time Does Pedestal Failure Occur?**
6 Branches, Type 6, 9 Cases

The branches for this question are:

1. PedF@VB The reactor pedestal failed at VB. The failure was from either the quasi-static loads accompanying VB or the dynamic loads from an EVSE.
2. PedF@10 The pedestal fails from CCI erosion more than 10 hours after VB.
3. PedF@6 The pedestal fails from CCI erosion between 6 and 10 hours after VB.
4. PedF@3 The pedestal fails from CCI erosion between 3 and 6 hours after VB.
5. PedF@1 The pedestal fails from CCI erosion between 1 and 3 hours after VB.
6. NoPedF The pedestal does not fail.

The reactor pedestal erosion depth (incorporated into this question as a comparison parameter) is sampled in this question; the distributions were provided by the Molten Core-Concrete Interaction Panel. (A discussion of this issue is presented in Volume, Part II, of this report.) The comparison parameters initialized in this question depend upon the branch taken at Questions 61, 63, 74, 75, 99, and 102.

In this question, the depth of concrete erosion that will fail the reactor pedestal, Parameter 43, is compared to the erosion depths that result during CCI. To determine the time at which the pedestal fails, this comparison is made using four different time intervals. The time intervals are defined by the various branches (see description above). If the failure depth is greater than or equal to the erosion depth for a given time (i.e., comparison parameter), then the pedestal fails in that time interval. Pedestal failure is defined as the loss of support to the RPV such that gross motion of the vessel results. The importance of pedestal failure is that it can induce drywell failure that results in pathway from the drywell to the wetwell that completely bypasses the suppression pool.

The experts felt that the presence of water in the reactor cavity, the amount of unoxidized metal in the debris, the amount of superheat associated with debris, and the flow rate of the debris from the vessel were important parameters that would influence the erosion rate of the pedestal. Thus, the following cases are various combinations of these parameters.

Case 1: An Alpha Mode event occurred, the vessel did not fail, there was no CCI, or the onset of CCI was delayed. An Alpha Mode event fails the drywell, so for this case, this question is not important. If the vessel does not fail or the debris is coolable, there will be no pedestal erosion. If the debris bed is initially coolable (i.e., delayed CCI), it is assumed that pedestal failure, if it occurs at all, is delayed sufficiently long that it is not an important failure mechanism during the time regime considered in this analysis. For this case, values are assigned to the comparsion parameters to force Branch 6, no pedestal failure, to be taken.

Case 2: The reactor pedestal failed at VB. The failure was from either the quasi-static loads accompanying VB or the dynamic loads from an ex-vessel steam explosion. For this case, values are assigned to the comparsion parameters to force Branch 1, pedestal failure at VB, to be taken.

Case 3: At VB, the debris is released from the RPV into a wet cavity. Initially, the debris in the cavity has a large amount of superheat and contains a large amount of unoxidized metal (i.e., at least 50% of the zirconium in the debris has not been oxidized). The large amount of molten material at VB is characteristic of debris with a large amount of superheat. For this case, the flow rate from the vessel is not important. The values (m) assigned to the comparison parameters, based on the mean value of the distributions, are:

Branch 1: PedF@VB - 9999
Branch 2: PedF@10 - 0.83
Branch 3: PedF@6 - 0.55
Branch 4: PedF@3 - 0.32
Branch 5: NoPedF - 0.19

Case 4: At VB, the debris is released from the RPV into a wet cavity. Initially, the debris in the cavity has a small amount of superheat and contains a small amount of unoxidized metal (i.e., at least 50% of the zirconium in the debris has been oxidized). For this case, the flow rate from the vessel is not important. The values (m) assigned to the comparison parameters, based on the mean value of the distributions, are:

Branch 1: PedF@VB - 9999
Branch 2: PedF@10 - 0.79
Branch 3: PedF@6 - 0.52
Branch 4: PedF@3 - 0.29
Branch 5: NoPedF - 0.16

Case 5: At VB, the debris is released from the RPV into a wet cavity. Either the debris in the cavity has a large amount of superheat and has a small amount of unoxidized metal or it has a small amount of superheat and a large amount of unoxidized metal. The flow rate from the vessel is not important for this case. The values (m) assigned to the comparison parameters, based on the mean value of the distributions, are:

Branch 1: PedF@VB - 9999
Branch 2: PedF@10 - 0.74
Branch 3: PedF@6 - 0.49
Branch 4: PedF@3 - 0.26
Branch 5: NoPedF - 0.14

Case 6: At VB, the debris is released from the RPV at a high flow rate into a dry cavity. The combination of a large amount of molten material with a large failure results in a high flow rate. Initially, the debris in the cavity contains a large amount of unoxidized metal (i.e., at least 50% of the zirconium in the debris has not been oxidized). The values (m) assigned to the comparison parameters, based on the mean value of the distributions, are:

Branch 1: PedF@VB - 9999
Branch 2: PedF@10 - 0.83
Branch 3: PedF@6 - 0.66
Branch 4: PedF@3 - 0.41
Branch 5: NoPedF - 0.20

Case 7: This case is the same as the previous case except that the debris contains only a small amount of unoxidized metal. The values (m) assigned to the comparison parameters, based on the mean value of the distributions, are:

Branch 1: PedF@VB - 9999
Branch 2: PedF@10 - 0.92
Branch 3: PedF@6 - 0.73
Branch 4: PedF@3 - 0.47
Branch 5: NoPedF - 0.26

Case 8: This case is the same as Case 6 except that the flow rate from the vessel is not as high (i.e., a medium flow rate). The values (m) assigned to the comparison parameters, based on the mean value of the distributions, are:

Branch 1: PedF@VB - 9999
Branch 2: PedF@10 - 0.92
Branch 3: PedF@6 - 0.71
Branch 4: PedF@3 - 0.47
Branch 5: NoPedF - 0.26

Case 9: At VB, the debris is released from the RPV into a dry cavity. The flow rate of the material from the vessel is either low or medium. If the flow rate is medium, there is only a small amount of unoxidized metal in the debris. The values (m) assigned to the comparison parameters, based on the mean value of the distributions, are:

Branch 1: PedF@VB - 9999
Branch 2: PedF@10 - 0.82
Branch 3: PedF@6 - 0.62
Branch 4: PedF@3 - 0.40
Branch 5: NoPedF - 0.20

Question 122. **What Is the Level of Suppression Pool Bypass Late in the Accident?**
3 Branches, Type 2, 7 Cases

The branches for this question are:

1. LnSPB The drywell is intact late in the accident.

2. L-SPB2 By late in the accident, the drywell has failed by the leak mode.

3. L-SPB3 By late in the accident, the drywell has failed by rupture.

Cases 2, 3, 5, and 6 of this question are sampled. The distribution for drywell failure induced by pedestal failure was provided by the Structural Response Expert Panel. (A discussion of this issue is presented in Volume 2, Part III, of this report.) The distribution for the drywell failure caused by vacuum breaker failure was internally quantified. The branching at this question depends upon the branch taken at Questions 95, 104, 110, 118, and 121.

This question summarizes the level of drywell failure (e.g., from detonations and deflagrations) late in the accident. Drywell failure from failed drywell vacuum breakers and drywell failure induced by pedestal failure during the late time period are also considered.

Case 1: The drywell was either previously ruptured or was ruptured by a burn (detonation or deflagration) late in the accident. The quantification for this case is:

Branch 1: Ln3BP - 0.00
Branch 2: L-SBP2 - 0.00
Branch 3: L-SBP3 - 1.00

Case 2: The drywell has a leak, and the reactor pedestal failed late in the accident from CCI erosion. The RPV is supported by the reactor pedestal. Failure of the pedestal will result in gross motion of the RPV. Several large pipes are attached to the RPV that penetrate the drywell (e.g., steam lines and feedwater line). The motion of the RPV, and hence the motion of these pipes, can damage the penetrations and fail the drywell boundary. The integrity of the drywell boundary can also be impaired by damage to the steel drywell liner that results from the RPV motion. The combination of these events can establish pathways that bypass the suppression pool. It is assumed that drywell failure by this mechanism will result in a pathway that allows fission products to bypass the suppression pool completely (i.e., rupture of the drywell). If pedestal failure does not induce drywell failure, the drywell will still be leaking from previous failures. This case is quantified using the same distribution that was used in Question 76, Case 2. This case is sampled zero-one. Based on the mean value of the sample, the quantification for this case is:

Branch 1: E5nSPB - 0.000
Branch 2: E5-SPB2 - 0.825
Branch 3: E5-SPB3 - 0.175

Case 3: The drywell has a leak, and ac power is available late in the accident. A hydrogen burn that pressurizes the wetwell occurs late in the accident. In response to this pressurization, the drywell vacuum breakers (which are ac powered valves) will open in an attempt to equalize the pressure difference between the wetwell and drywell. Because the vacuum breakers are exposed to severe thermal environments as the hot gases pass through them, the potential exists that these valves will fail during a hydrogen burn. This case is quantified using the same distribution used in Case 2, Question 52. This case is sampled zero-one. Based on the mean value of the sample, the quantification for this case is:

Branch 1: E5nSPB - 0.00
Branch 2: E5-SPB2 - 0.95
Branch 3: E5-SPB3 - 0.05

Case 4: The drywell has already failed in the leak mode. Either ac power is not available or the hydrogen in the wetwell did not burn. In either case, the vacuum breakers do not operate. In addition, the reactor pedestal did not fail, so drywell rupture from the mechanism is not possible. Thus, the drywell failure mode remains as a leak. The quantification for this case is:

Branch 1: LnSBP - 0.00
Branch 2: L-SBP2 - 1.00
Branch 3: L-SBP3 - 0.00

Case 5: This case is the same as Case 2 except that the drywell was previously intact. The distribution used to quantify Case 2 was also used to quantify this case. The only difference is that if pedestal failure does not induce drywell failure, the drywell remains intact. Based on the mean value of the sample, the quantification for this case is:

Branch 1: E5nSPB - 0.825
Branch 2: E5-SPB2 - 0.000
Branch 3: E5-SPB3 - 0.175

Case 6: This case is the same as Case 3 except that the drywell is intact. This case is quantified using the same distribution used in Case 2, Question 52. This case is sampled zero-one. Based on the mean value of the sample, the quantification for this case is:

Branch 1: E5nSPB - 0.95
Branch 2: E5-SPB2 - 0.00
Branch 3: E5-SPB3 - 0.05

Case 7: The drywell does not fail late in the accident. The quantification for this case is:

Branch 1: LnSBP - 1.00
Branch 2: L-SBP2 - 0.00
Branch 3: L-SBP3 - 0.00

Question 123. What Is the Late Containment Pressure due to Noncondensibles or Steam?
2 Branches, Type 4, 1 Parameter, 4 Cases

The branches for this question are:

1. LT-Pres Noncondensibles pressurize the containment during the late time period.

2. nLT-Pres The containment does not pressurize significantly during the late time period.

The parameter initialized in this question is:

P47 LT-Pres The peak containment pressure late in the accident (kPa) is read in as Parameter 47.

The parameter initialized in Case 2, 3, and 4 of this question are sampled; the distributions were quantified internally. The branching at this question depends upon the branch taken at Questions 63, 95, 97, 98, 99, 106, 117, 118, and 119.

In this question, the pressure in the containment during the late time period is determined. The noncondensibles and steam generated by the CCI taking place in the reactor cavity (i.e., in the drywell) are vented from the drywell to the wetwell. The accumulation of the noncondensibles/steam in the containment during the late time period will pressurize this volume. Because Grand Gulf has a fairly weak containment (mean failure pressure is 334 kPa, gage), pressurization from noncondensibles/steam late in the accident is possibly sufficient to fail the containment. The drywell is, however, essentially at the same pressure as the containment, so a significant load is not placed on the drywell structure.

Case 1: The containment has either already failed or was vented late in the accident. Containment failure will preclude any additional pressurization of the containment. The quantification for this case is:

Branch 1: LT-Pres - 0.00
Branch 2: nLT-Pres - 1.00

Because Branch 1 is never taken, the value assigned to the parameter for this branch is irrelevant. Because Branch 2 represents the situation in which there is no significant accumulation of noncondensibles or steam, the value for the late pressure assigned to this parameter is 0.0. In all the remaining cases, the value for the late pressure assigned to Branch 2 will also be 0.0.

Case 2: There are no CCIs following VB because either the vessel did not fail or the debris bed was coolable. In this case, either the containment sprays are operating late in the accident or the suppression pool is not completely bypassed (i.e., the drywell is not ruptured). Because the core debris does not participate in CCI, there will not be a significant generation of noncondensibles late in the accident. Furthermore, most of the steam generated from the interaction between the hot debris and the water used to cool it will be condensed either in the suppression pool or by the containment sprays. Thus, the containment pressure will not be high enough late in the accident to threaten the structure. The quantification for this case is:

Branch 1: LT-Pres - 0.00
Branch 2: nLT-Pres - 1.00

Because Branch 1 is never taken, the value assigned to the parameter for this branch is irrelevant. For Branch 2, the value (kPa) assigned to the parameter, based on the mean value of the distribution, is:

Parameter 47: LT-Pres - 0.00

Case 3: The vessel fails, and the core debris released to the cavity is covered by water. The drywell is ruptured, so the suppression pool is completely bypassed. Furthermore, the containment sprays do operate late in the accident. Thus, the steam generated from the interaction between the hot debris and the water in the cavity will not be condensed and instead will accumulate in the containment. The accumulation of this steam will pressurize the containment to the point that it will eventually fail. Thus, the containment pressure is set equal to the failure pressure of the containment. The quantification for this case is:

Branch 1: LT-Pres - 1.00
Branch 2: nLT-Pres - 0.00

For Branch 1, the value (kPa) assigned to the parameter is the failure pressure of the containment. Based on the mean value of the containment failure distribution, the quantification for this case is:

Parameter 47: ImpLoad - 383

Because Branch 2 is never taken, the value assigned to the parameter for this branch is irrelevant.

Case 4: The vessel fails and the core debris released into the cavity participates in CCI. If the core debris is covered by water, either the containment sprays are operating or the suppression pool is not completely bypassed. Thus, the steam generated from the interaction between the hot debris and the water in the cavity is condensed. The noncondensibles generated during CCI, however, are released to the wetwell. If the core debris is released into a dry cavity, the operation of the sprays and the amount of suppression pool bypass is not particularly important because of the small amount of steam generated by CCI in a dry cavity. Thus, in this case, the long-term pressurization of the containment is dominated by the noncondensibles released during CCI.

A MELCOR simulation of a TBUX PDS (short-term SBO in which ac and dc power are not recovered)[A-5] indicates that the containment pressure will be approximately 250 kPa. In this calculation, not all of the core participated in CCI. However, extrapolation of a BMI calculation for a TB1 accident (long-term SBO)[A-9] resulted in a containment pressure of approximately 550 kPa. Because of the uncertainties associated with the amount of steam in the containment and the amount of noncondensibles released during CCI, containment pressure late in the accident was quantified using a uniform distribution that ranged from 250 kPa to 550 kPa. It was felt that this distribution would adequately cover the containment pressures that are likely to occur during a severe accident. The quantification for this case is:

Branch 1: LT-Pres - 1.00
Branch 2: nLT-Pres - 0.00

For Branch 1, the value (kPa) assigned to the parameter, based on the mean value of the distribution is:

Parameter 47: LT-Pres - 400

Because Branch 2 is never taken, the value assigned to the parameter for this branch is irrelevant.

Question 124. **Does Containment Failure Occur Late due to Noncondensibles or Steam?**
4 Branches, Type 5, 1 Case

The branches for this question are:

1. LPnCL The containment does not fail due to noncondensibles and steam late in the accident.

2. LP-CL2 The containment fails in the leak mode; nominal hole size is 0.1 ft^2.

3. LP-CL3 The containment fails by rupture; nominal hole size is 7 ft^2.

4. LP-CL4 The containment fails by catastrophic rupture. This failure mechanism does not occur in this analysis but has been retained in the tree for completeness.

A module in the user function is used to determine whether the containment fails late in the accident from the accumulation of noncondensibles and steam, and the mode of failure. In the user function, the late containment pressure, Parameter 47, is compared to the containment failure pressure (Parameter 21). The way in which the random number (Parameter 22) is used to determine the mode of containment failure is described in Subsection A.2. [illegible] method differs depending on whether the rate of pressure rise is fast or slow relative to the rate at which a leak depressurizes the containment. The slow pressure rise method is used in this question.

Question 125. **What Is the Long-Term Level of Containment Leakage?**
4 Branches, Type 2, 4 Cases

The branches for this question are:

1. LTnCL The containment does not fail during the accident.

2. LT-CL2 The containment fails in the leak mode; nominal hole size is 0.1 ft^2.

3. LT-CL3 The containment fails by rupture; nominal hole size is 7 ft^2.

4. LT-CL4 The containment fails by catastrophic rupture. This failure mechanism does not occur in this analysis but has been retained in the tree for completeness.

This question is not sampled. The branching at this question depends upon the branch taken at Questions 117, 119, and 124. This question summarizes the level of containment failure at the end of the accident (i.e., essentially 24 hours from initiating event). The containment failures during the late time period are combined with the failures that resulted from accumulation of noncondensibles and steam in the containment.

Case 1: The containment has failed by a catastrophic rupture. The quantification for this case is:

Branch 1: LTnCL - 0.0
Branch 2: LT-CL2 - 0.0
Branch 3: LT-CL3 - 0.0
Branch 4: LT-CL4 - 1.0

Case 2: The containment has either failed by a rupture or was vented late in the accident. A vented containment is treated the same as a ruptured containment in the source term analysis. The quantification for this case is:

Branch 1: LTnCL - 0.0
Branch 2: LT-CL2 - 0.0
Branch 3: LT-CL3 - 1.0
Branch 4: LT-CL4 - 0.0

Case 3: The containment has failed in the leak mode. The quantification for this case is:

Branch 1: LTnCL - 0.0
Branch 2: LT-CL2 - 1.0
Branch 3: LT-CL3 - 0.0
Branch 4: LT-CL4 - 0.0

Case 4: The containment does not fail during the accident. The quantification for this case is:

Branch 1: LTnCL - 1.0
Branch 2: LT-CL2 - 0.0
Branch 3: LT-CL3 - 0.0
Branch 4: LT-CL4 - 0.0

A.1.2 Listing of the APET

This subsection lists the Grand Gulf APET. The 125 questions in the Grand Gulf APET are listed concisely in Table 2.3-1. The event tree itself is too large to be depicted graphically and exists only as the computer input listed here.

The Grand Gulf APET used in the accident progression analyses for NUREG-1150 is in the form a computer input file. This file is designed to be easily understood, with mnemonic abbreviations for each branch of every question. Comments in the APET appear to the right of $s and are ignored by EVNTRE. The structure of the input file is defined in the EVNTRE Reference Manual, NUREG/CR-5174.[A-10]

Listing of APET:

```
  GRAND GULF ACCIDENT PROGRESSION EVENT TREE
  125
   NQ
    1      1.000
             cen
1 What is the initiating event?
    3      TLOSP        T2         TC
    1          1         2          3
           1.000     0.000      0.000
2 Is there a Station Blackout (Diesel Generators fail)?
    2         SB       nSB
    1          1         2
           1.000     0.000
3 Is DC Power not available?
    2      E1fDC     E1-DC
    1          1         2
           0.000     1.000
4 Do one or more S/RVs fail to reclose?
    2     E1SORV   E1nSORV
    1          1         2
           0.020     0.980
5 Does HPCS fail to inject?
    3  E1fHPInj  E1rHPInj  E1-HPInj
    1          1         2          3
           0.000     1.000      0.000
6 Does RCIC fail to inject initially?
    2    E1fRCIC   E1-RCIC
    1          1         2
           1.000     0.000
7 Does the CRD hydraulic system fail to inject?
    3     E1fCRD    E1rCRD     E1-CRD
    1          1         2          3
           1.000     0.000      0.000
8 Does the condensate system fail?
    3    E1fCond   E1rCond    E1aCond
    1          1         2          3
           0.000     1.000      0.000
9 Do the LPCS and LPCI systems fail?
    4     E1fLPC    E1rLPC     E1aLPC     E1-LPC
    1          1         2          3          4
           0.000     1.000      0.000      0.000
10 Does RHR fail (heat exchangers not available)?
    4     E1fRHR    E1rRHR     E1aRHR     E1-RHR
    1          1         2          3          4
           0.000     1.000      0.000      0.000
11 Does the service water system or cross-tie to LPCI fail?
    3     E1fSSW    E1rSSW     E1aSSW
    1          1         2          3
           1.000     0.000      0.000
12 Does the fire protection system cross-tie to LPCI fail?
    3     E1fFWS   E1ofFWS     E1aFWS
    1          1         2          3
           0.000     0.000      1.000
13 Are the containment (wetwell) sprays failed?
    4     E1fCSS    E1rCSS     E1aCSS     E1-CSS
    1          1         2          3          4
           0.000     1.000      0.000      0.000
14 What is the status of vessel depressurization?
    4     E1fDep   E1ofDep     E1nDep     E1-Dep
    1          1         2          3          4
          0.0000    0.0000     1.0000     0.0000
15 When does core damage occur?
    2     CD-Fst    CD-Slw
    1          1         2
```

```
          1.000     0.000
16 What is the level of pre-existing leakage or isolation failure?
     3       ElnL       E1L2       E1L3
     1          1          2          3
         0.9935    0.0065     0.000
17 What is the level of pre-existing suppression pool bypass?
     3     E1nSPB   E1-SPB2   E1-SPB3
     1          1          2          3
         0.9996    0.0004    0.0000
18 What is the structural capacity of the containment?
     1   Contain
     3          1
          1.000
     4
    21    334.00
    22      0.20
    24     19.50
    25      0.50
19 What is the structural capacity of the drywell?
     1   Drywell
     3          1
          1.000
     5
    26    528.00
    30    659.00
    31 !18,1,2,1
    34     32.00
    35 !18,1,4,1
20 What type of sequence is this (summary of plant damage)?
     6     Fst-SB     Slw-SB     Fst-T2     Slw-T2   Fst-TC   Slw-TC
     2          1          2          3          4        5        6
     6
     2          2         15
                1        * 1
               SB     CD-Fst
          1.000      0.000      0.000      0.000    0.000    0.000
     1          2
                1
               SB
          0.000      1.000      0.000      0.000    0.000    0.000
     2          1         15
                2        * 1
               T2     CD-Fst
          0.000      0.000      1.000      0.000    0.000    0.000
     1          1
                2
               T2
          0.000      0.000      0.000      1.000    0.000    0.000
     2          1         15
                3        * 1
               TC     CD-Fst
          0.000      0.000      0.000      0.000    1.000    0.000
      Otherwise
          0.000      0.000      0.000      0.000    0.000    1.000
21 Do the operators turn on the HIS before core degradation?
     2     E2-HIS     E2nHIS
     2          1          2
     2
     1          2
                2
              nSB
          0.840      0.160
      Otherwise   --    Station Blackout
          0.500      0.500
22 Is the containment not vented before core degradation?
     2   E3nVENT    E3VENT
```

```
     2         1         2
     5
     3         1        15        21
               3       * 2       * 2
              TC    CD-Slw    E2nHIS
           1.000     0.000
     2         1        15
               3       * 2
              TC    CD-Slw
           0.805     0.195
     3         1         6        15
               3       * 2       * 1
              TC   E1-RCIC    CD-Fst
           1.000     0.000
     1         2
               2
             nSB
           1.000     0.000
       Otherwise
           1.000     0.000
23 Does (do) any S/RV tailpipe vacuum breaker(s) stick wide open?
     2   oSRVBkr   cSRVBkr
     2         1         2
     5
     1         4
               1
          E1SORV
           0.000     1.000
     3        20        20        14
             ( 1   -    3)        -4
          Fst-SB    Fst-T2   nE1-Dep
           0.250     0.750
     4        20        20        20        14
             ( 2       + 4     +  6)        -4
          Slw-SB    Slw-T2    Slw-TC   nE1-Dep
         !23,2,1  !23,2,2
     1        20
               5
          Fst-TC
           0.055     0.945
       Otherwise
         !23,4,1  !23,4,2
24 Does AC power remain lost during core degradation?
     2     E4fAC     E4-AC
     2         1         2
     4
     1         3
               1
           E1fDC
           1.000     0.000
     2         2        15
               1         2
              SB    CD-Slw
           0.610     0.390
     1         2
               1
              SB
           0.370     0.630
       Otherwise
           0.000     1.000
25 Is DC power available during core degradation?
     2     E4fDC     E4-DC
     2         1         2
     4
     1         3
               1
```

```
           E1fDC
           1.000     0.000
     1        24
               2
           E4-AC
           0.000     1.000
     2         2        15
               1         2
              SB    CD-Slw
           0.200     0.800
       Otherwise
           0.000     1.000
26 What is the RPV pressure during core degradation?
     2    E4-HiP    E4-LoP
     2         1         2
     6
     2        14        25
               4       * 2
          E1-Dep     E4-DC
           0.000     1.000
     1         4
               1
         E1-SORV
           0.000     1.000
     2        14        25
               1       + 1
          E1fDep     E4fDC
           1.000     0.000
     2         2        14
               1         3
              SB    E1nDep
           0.260     0.740
     6        21         1         1        15      22      15
               1     *  (2    +    3     * ( 2    *  2  +  1))
          E2-HIS        T2        TC    CD-Slw  E3VENT  CD-Fst
           0.805     0.195
       Otherwise
           1.000     0.000
27 What is the status of the HIS before vb?
     2    E4-HIS    E4nHIS
     2         1         2
     7
     1        21
               2
          E2nHIS
           0.000     1.000
     1         2
               2
             nSB
           1.000     0.000
     1        24
               1
           E4fAC
           1.000     0.000
     4        20        26        14        25
               1     *   1      *  3      *  2
          Fst-SB    E4-HiP    E1nDep     E4-DC
           0.128     0.872
     2        20        26
               1     *   2
          Fst-SB    E4-LoP
           0.064     0.936
     1        20
               2
          Slw-SB
           0.160     0.840
```

```
       Otherwise
           0.000     1.000
28 Is RPV injection restored during core degradation?
     3    E4nLPI    E4-LPI    E4-HPI
     2         1         2         3
    10
     2         5        24
               2     *   2
        E1rHPInj     E4-AC
           0.000     0.000     1.000
     1        26
               1
          E4-HPI
           1.000     0.000     0.000
     2         9        24
              -1         2
         nE1fLPI     E4-AC
           0.000     1.000     0.000
     4         8        24        20        27
              -1     *   2     *  -1     *   2
       nE1fCond      E4-AC  nFst-SB    E4nHIS
           0.161     0.839     0.000
     3         8        24        20
              -1     *   2     *  -1
       nE1fCond      E4-AC  nFst-SB
           0.322     0.678     0.000
     3         8        24        27
              -1     *   2     *   2
       nE1fCond      E4-AC    E4nHIS
           0.064     0.936     0.000
     2         8        24
              -1     *   2
       nE1fCond      E4-AC
           0.128     0.872     0.000
     5        12        20        24        27      24
               3     *   1   * (   2     *   2  +  1)
          E1aFPS    Fst-SB     E4-AC    E4nHIS   E4fAC
           0.128     0.872     0.000
     2        12        20
               3     *   1
          E1aFPS    Fst-SB
           0.256     0.744     0.000
       Otherwise
           1.000     0.000     0.000
29 Is the core in a critical configuration following injection recovery?
     2  E4-Crit   E4nCrit
     2         1         2
     3
     2         1        28
               3         2
              TC    E4-LPI
           0.100     0.900
     2        28        28
               2     +   3
          E4-LPI    E4-HPI
           0.010     0.990
       Otherwise
           0.000     1.000
30 What is the status of containment sprays?
     4     E4fCS     E4rCS     E4aCS     E4-CS
     2         1         2         3         4
     5
     1        13
               1
          E1fCSS
           1.000     0.000     0.000     0.000
```

```
     2        13        24
               2       * 1
          E1fCSS     E4fAC
           0.000     1.000     0.000     0.000
     2         1        15
               3       * 2
              TC    CD-Slw
           0.000     0.000     0.010     0.990
     2        20        24
               2       * 2
          Slw-SB     E4-AC
           0.000     0.000     0.010     0.990
       Otherwise
           0.000     0.000     1.000     0.000
31 What amount of Oxygen is in the wetwell during core degradation?
     1      O2WW
     3         1
           1.000
     2
     9     316.0
    44    1191.0
32 What amount of Oxygen is in the drywell during core degradation?
     1      O2DW
     3         1
           1.000
     1
    10      61.0
33 What amount of steam is present in the containment at core damage?
     1     H2OWW
     4         1
     6
     2        16        22
               3       + 2
            E1L3    E3VENT
           1.000
     1
     1   1582.00
     2         1        15
               3       * 2
              TC    CD-Slw
           1.000
     1
     1   1582.00
     2        10        13
               4         4
          E1-RHR    E1-CSS
           1.000
     1
     1     75.00
     3         2        14        15
               1       * 1       * 2
              SB    E1fDep    CD-Slw
           1.000
     1
     1   4235.00
     1        20
               2
          Slw-SB
           1.000
     1
     1   2200.00
       Otherwise
           1.000
     1
     1     75.00
```

```
34 What amount of steam is present in the drywell at core damage?
    1     H2ODW
    4         1
    6
    1        23
              1
      oSRVBkr
        1.000
    1
    6    305.00
    2         1        15
              3      *  2
             TC    CD-Slw
        1.000
    1
    6    223.00
    2        10        13
              4         4
       E1-RHR    E1-CSS
        1.000
    1
    6     14.50
    3         2        14        15
              1      *  1      *  2
             SB    ElfDep    CD-Slw
        1.000
    1
    6    817.00
    1        20
              2
       Slw-SB
        1.000
    1
    6     424.00 $ STMDWELL: Amount of steam in drywell (kg-mole) from LTAS
     Otherwise
        1.000
    1
    6     14.50 $ STMDWELL: Amount of steam in drywell (kg-mole) BMI-2139
35 Total amount of hydrogen released in-vessel during core degradation?
    1    In-VsH2
    4         1
    6
    2         1        28
              3         2
             TC    E4-LPI
        1.000
    1
    2      221.7 H2INVES - H2 released in-vessel (Kg-Mole)
    1         1
              3
             TC
        1.000
    1
    2     458.4
    3        14        28        28
             -4      * ( 2     +  3)
       nE1-DeP    E4-LPI    E4-HPI
        1.000
    1
    2     326.1
    2        28        28
            ( 2     +  3)
        E4-LPI    E4-HPI
        1.000
    1
    2     277.1
```

```
    1         26
               1
          E4-HiP
           1.000
    1
    2      442.3
       Otherwise
           1.000
    1
    2      477.0
36 What is the level of In-Vessel zirconium oxidation?
    7     ZrOx75    ZrOx50    ZrOx40    ZrOx30  ZrOx21  ZrOx10 ZrOx<10
    5          1         2         3         4       5       6       7
    1          2
         H2INVES
             AND
        GETHRESH         6    1302.7     868.5   694.8   521.1   364.8   173.7

37 What is the containment pressure during core damage?
    3      E1P>3     E1P>2     E1P>1
    6          1         2         3
    7
    2         16        22
               3     +   2
            E1L3    E3VENT
    5          9        44         1         2       5
            O2WW      N2WW     H2OWW      H2WW  EPBase
      FUN-EBASP1
        GETHRESH         3   9999.00   9999.00    1.00

    2          1        15
               3     *   2
              TC    CD-Slw
    5          9        44         1         2       5
            O2WW      N2WW     H2OWW      H2WW  EPBase
      FUN-EBASP1
        GETHRESH         3   9999.00   9999.00    1.00

    2         10        13
               4         4
          E1-RHR    E1-CSS
    5          9        44         1         2       5
            O2WW      N2WW     H2OWW      H2WW  EPBase
      FUN-EBASP2
        GETHRESH         3     304.0     202.6   101.3

    2         20        30
               2         4
          Slw-SB     E4-CS
    5          9        44         1         2       5
            O2WW      N2WW     H2OWW      H2WW  EPBase
      FUN-EBASP3
        GETHRESH         3     304.0     202.6   101.3

    3          2        14        15
               1     *   1     *   2
              SB    E1fDep    CD-Slw
    5          9        44         1         2       5
            O2WW      N2WW     H2OWW      H2WW  EPBase
      FUN-EBASP4
        GETHRESH         3     304.0     202.6   101.3

    1         20
               2
          Slw-SB
    5          9        44         1         2       5
```

```
            O2WW      N2WW     H2OWW      H2WW  EPBase
       FUN-EBASP5
        GETHRESH         3     304.0     202.6   101.3

       Otherwise
     5         9        44         1         2       5
            O2WW      N2WW     H2OWW      H2WW  EPBase
       FUN-EBASP2
        GETHRESH         3     304.0     202.6   101.3

38 What is the level of containment leakage due to slow pressurization before V
     4    ESPnCL   ESP-CL2   ESP-CL3   ESP-CL4
     6         1         2         3         4
     4
     2        16        22
               3       +  2
            E1L3    E3VENT
     1         5
          EPBase
             AND
        GETHRESH         3   9999.00   9999.00    1.00
                           Dummy -- Already failed by detonation
     2         1        15
               3       *  2
              TC    CD-Slw
     2        21        22
          PCFail     CFRan
       FUN-SLWP1
        GETHRESH         3      3.00      2.00    1.00
                           Dummy -- Already leaking from detonation
     3         2        14        15
               1       *  1      *  2
              SB    ElfDep    CD-Slw
     3         5        21        22
          EPBase    PCFail     CFRan
       FUN-SLWP2
        GETHRESH         3      3.00      2.00    1.00

       Otherwise
     1         5
          EPBase
             AND
        GETHRESH         3     -1.00    999.00  999.00
                           Parameter value triggers particular branch
39 What is the maximum hydrogen concentration in tha wetwell before VB?
     6    HWW>20    HWW>16    HWW>12     HWW>8   HWW>4   NoHWW
     6         1         2         3         4       5       6
     7
     2        23        20
               1       *  6
         oSRVBkr    Slw-TC
     6         2         1         9         3      44      14
         In-VsH2     H2OWW      O2WW      H2WW    N2WW    NTOT
       FUN-H2WW1
       GETHRESH          5      0.20      0.16    0.12    0.08    0.04
                 leakage from tailpipe vacuum breaker and containment hole
     4        23        16        38        38
               1    *  ( 3     +   3     + 4 )
         oSRVBkr      E1L3   ESP-CL3   ESP-CL4
     6         2         1         9         3      44      14
         In-VsH2     H2OWW      O2WW      H2WW    N2WW    NTOT
       FUN-H2WW2
       GETHRESH          5      0.20      0.16    0.12    0.08    0.04
                 leakage from tailpipe vacuum breaker and containment hole
     1        20
               6
```

```
          Slw-TC
     6         2         1         9         3      44      14
         In-VsH2     H2OWW      O2WW      H2WW    N2WW    NTOT
       FUN-H2WW3
       GETHRESH          5      0.20      0.16    0.12    0.08    0.04

     3        16        38        38
            ( 3    +   3   + 4 )
            E1L3   ESP-CL3   ESP-CL4
     6         2         1         9         3      44      14
         In-VsH2     H2OWW      O2WW      H2WW    N2WW    NTOT
       FUN-H2WW4
       GETHRESH          5      0.20      0.16    0.12    0.08    0.04
                 Vessel to pool but large containment hole
     1        23
               1
         oSRVBkr
     6         2         1         9         3      44      14
         In-VsH2     H2OWW      O2WW      H2WW    N2WW    NTOT
       FUN-H2WW5
       GETHRESH          5      0.20      0.16    0.12    0.08    0.04
                 Large leakage from tailpipe vacuum breaker
     1        17
               3
         E1-SPB3
     6         2         1         9         3      44      14
         In-VsH2     H2OWW      O2WW      H2WW    N2WW    NTOT
       FUN-H2WW6
       GETHRESH          5      0.20      0.16    0.12    0.08    0.04
                 Large initial suppression pool bypass
       Otherwise -- Nominal or small leakage into drywell
     6         2         1         9         3      44      14
         In-VsH2     H2OWW      O2WW      H2WW    N2WW    NTOT
       FUN-H2WW7
       GETHRESH          5      0.20      0.16    0.12    0.08    0.04
                 Assume leakage back to drywell & vessel retention independent
40 To what level is the wetwell inert during core degradation?
     3    E4nWIn   E4-WIn2   E4-WIn3
     5         1         2         3
     3         1         3         9
           H2OWW      H2WW      O2WW
        FUN-INRT
        GETHRESH         3      0.65      0.45    0.00
                                 Det   Combust   Inert
41 Do diffusion flames consume the hydrogen released before VB?
     2    E4-Dif    E4nDif
     2         1         2
     6
     2        40        20
               3     +    6
         E4-WIn3    Slw-TC
           0.000     1.000
     2         2        21
               2     *    1
             nSB    E2-HIS
           1.000     0.000
     1         2
               2
             nSB
           0.750     0.250
     3         2        24        27
               1     *    2     *    1
              SB     E4-AC    E4-HIS
           0.120     0.880
     2         2        24
               1     *    2
```

```
               SB     E4-AC
            0.060     0.940
       Otherwise -- Low Pressure station blackout without recovery
            0.000     1.000
42 What is the maximum hydrogen concentration in the drywell before VB?
     6    HDW>20    HDW>16    HDW>12     HDW>8   HDW>4   NoHDW
     6         1         2         3         4       5       6
     6
     2        23        20
               1     *   6
         oSRVBkr    SLW-TC
     5         2         3         6        10       4
         In-VsH2      H2WW     H2ODW      O2DW    H2DW
       FUN-H2DW1
       GETHRESH          5      0.20      0.16    0.12    0.08    0.04
                 Small leakage from tailpipe vacuum breaker
     4        23        16        38        38
               1     * ( 3     +   3     + 4 )
         oSRVBkr      E1L3   ESP-CL3   ESP-CL4
     5         2         3         6        10       4
         In-VsH2      H2WW     H2ODW      O2DW    H2DW
       FUN-H2DW2
       GETHRESH          5      0.20      0.16    0.12    0.08    0.04
                 Small leakage from tailpipe vacuum breaker
     1        23
               1
         oSRVBkr
     5         2         3         6        10       4
         In-VsH2      H2WW     H2ODW      O2DW    H2DW
       FUN-H2DW3
       GETHRESH          5      0.20      0.16    0.12    0.08    0.04
                 Large leakage from tailpipe vacuum breaker
     2        17        41
               3     *   2
         E1-SPB3    E4nDif
     5         2         3         6        10       4
         In-VsH2      H2WW     H2ODW      O2DW    H2DW
       FUN-H2DW4
       GETHRESH          5      0.20      0.16    0.12    0.08    0.04
                 Large initial suppression pool bypass
     2        17        41
               2     *   2
         E1-SPB2    E4nDif
     5         2         3         6        10       4
         In-VsH2      H2WW     H2ODW      O2DW    H2DW
       FUN-H2DW5
       GETHRESH          5      0.20      0.16    0.12    0.08    0.04
                 Small initial suppression pool bypass
       Otherwise -- Nominal leakage into drywell only
     5         2         3         6        10       4
         In-VsH2      H2WW     H2ODW      O2DW    H2DW
       FUN-H2DW6
       GETHRESH          5      0.20      0.16    0.12    0.08    0.04
                 Assume leakage back to drywell & vessel retention independent
43 Do deflagrations occur in the WW prior to vb?
     2   E4-WWDf   E4nWWDf
     2         1         2
    13
     3        41        40        20
               1     +   3     +   6
          E4-Dif    E4-WIn    SLW-TC
           0.000     1.000
     3        26         4        39
             ( 2     *   2)    *   6
          E4-LoP   E1nSORV     NoHWW
           0.000     1.000
```

```
     1        24
               2
           E4-AC
           1.000     0.000
     4        26        14         4        39
             ( 1     +  -4     *  1)      *  6
          E4-HiP   nE1-Dep    E1SORV     NoHWW
           0.180     0.820
     4        26        14         4        39
             ( 1     +  -4     *  1)      *  5
          E4-HiP   nE1-Dep    E1SORV     HWW>4
           0.230     0.770
     1        39
               5
           HWW>4
           0.210     0.790
     4        26        14         4        39
             ( 1     +  -4     *  1)      *  4
          E4-HiP   nE1-Dep    E1SORV     HWW>8
           0.280     0.720
     1        39
               4
           HWW>8
           0.280     0.720
     4        26        14         4        39
             ( 1     +  -4     *  1)      *  3
          E4-HiP   nE1-Dep    E1SORV    HWW>12
           0.390     0.610
     1        39
               3
          HWW>12
           0.380     0.620
     5        26        14         4        39      39
             ( 1     +  -4     *  1)    * ( 2   +  1)
          E4-HiP   nE1-Dep    E1SORV    HWW>16  HWW>20
           0.500     0.500
     2        39        39
             ( 2     +  1)
          HWW>16    HWW>20
           0.490     0.510
       Otherwise
           0.000     1.000
44 Is there a detonation in the wetwell prior to vb?
     2    E4-WWDt  E4nWWDt
     4         1         2
     8
     6        40        30        40        39      39      39
               2     *  -4     +   3     +   4   +   5   +   6
         E4-WIn2    nE4-CS   E4-WIn3     HWW>8   HWW>4   NoHWW
           0.000     1.000
     1
    20      0.00      0.00
     4        43        39        40        30
               1     *   3  *  (  2    *     4)
         E4-WWDf    HWW>12   E4-WIn2     E4-CS
           0.220     0.780
     1
    20      5.80      0.00
     2        43        39
               1     *   3
         E4-WWDf    HWW>12
           0.000     1.000
     1
    20      0.00      0.00
     4        43        39        40        30
               1     *   2  *  (  2    *     4)
```

```
        E4-WWDf    HWW>16   E4-WIn2     E4-CS
          0.250     0.750
    1
   20 !44,2,1,1      0.00
    2         43        39
              1       * 2
        E4-WWDf    HWW>16
          0.260     0.740
    1
   20      12.40      0.00
    4         43        39        40        30
              1       * 1 *  (    2     *  4)
        E4-WWDf    HWW>20   E4-WIn2     E4-CS
      !44,4,1   !44,4,2
    1
   20 !44,2,1,1      0.00
    2         43        39
              1       * 1
        E4-WWDf    HWW>20
          0.450     0.550
    1
   20 !44,5,1,1      0.00
      Otherwise  --  No combustion
          0.000     1.000
    1
   20       0.00      0.00                     S ImpLoad: Impulse loading to dr
45 What is the level of containment impulse load before vb?
    7   E-Ip>60   E-Ip>50   E-Ip>40   E-Ip>30 E-Ip>20 E-Ip>10 E-Ip<10
    5          1         2         3         4       5       6       7
    1         20
        ImpLoad
            AND
       GETHRESH          6     60.00     50.00   40.00   30.00   20.00   10.00

46 With what efficiency is hydrogen burned prior to VB?
    1   H2EfBVB
    4          1
   12
    1         43
              2
        E4nWWDf
          1.000
    2
   18      0.000
   19      0.000
    2         40        39
              2       * 6
        E4-WIn2     NoHWW
          1.000
    2
   18      0.079
   19      0.275
    1         39
              6
          NoHWW
          1.000
    2
   18      0.000
   19 !46,2,2,1
    2         40        39
              2       * 5
        E4-WIn2     HWW>4
          1.000
    2
   18       0.28
   19 !46,2,2,1
```

```
    1        39
              5
          HWW>4
          1.000
    2
   18     0.280
   19 !46,2,2,1
    2        40        39
              2    *    4
        E4-WIn2     HWW>8
          1.000
    2
   18     0.464
   19     0.740
    1        39
              4
          HWW>8
          1.000
    2
   18     0.575
   19 !46,6,2,1
    2        40        39
              2    *    3
        E4-WIn2    HWW>12
          1.000
    2
   18     0.483
   19     0.881
    1        39
              3
         HWW>12
          1.000
    2
   18     0.734
   19 !46,8,2,1
    3        40        39        39
              2    *  ( 2     +  1)
        E4-WIn2    HWW>16    HWW>20
          1.000
    2
   18     0.492
   19     0.935
    2        39        39
            ( 2     +  1)
         HWW>16    HWW>20
          1.000
    2
   18     0.752
   19 !46,10,2,1
      Otherwise
          1.000
    2
   18      0.00
   19      0.00
47 What is the peak pressure in containment from a hydrogen burn?
    6    PBrn>7    PBrn>6    PBrn>5    PBrn>4  PBrn>3  PBrn<3
    6         1         2         3         4       5       6
    4
    2        41        43
              2    *    2
         E4nDif   E4nWWDf
    8         3         1         9         5      11      18      19       44
           H2WW     H2OWW      O2WW    EPBase    PBrn H2EfVB1 H2EfVB2     N2WW
      FUN-EPBRN1
        GETHRESH         5     709.3     608.0   506.6   405.3   304.0
                Parse peak pressure for vurification
```

```
     5        16        22        38        38       41
               3     +   2     +   3     +   4     +  1
            E1L3   E3-Vent   ESP-CL3   ESP-CL4   E4-Dif
     8         3         1         9         5       11      18      19      44
            H2WW     H2OWW      O2WW    EPBase     PBrn H2EfVB1 H2EfVB2    N2WW
       FUN-EPBRN2
        GETHRESH         5     709.3     608.0    506.6   405.3   304.0
                 Parse peak pressure for verification
     1        44
               1
         E4-WWDt
     8         3         1         9         5       11      18      19      44
            H2WW     H2OWW      O2WW    EPBase     PBrn H2EfVB1 H2EfVB2    N2WW
       FUN-EPBRN3
        GETHRESH         5     709.3     608.0    506.6   405.3   304.0
                 Parse peak pressure for verification
       Otherwise
     8         3         1         9         5       11      18      19      44
            H2WW     H2OWW      O2WW    EPBase     PBrn H2EfVB1 H2EfVB2    N2WW
       FUN-EPBRN4
        GETHRESH         5     709.3     608.0    506.6   405.3   304.0
                 Parse peak pressure for verification
48 What is the level of drywell leakage induced by an early detonation in conta
     3    EnDWDt   E-DWDt2   E-DWDt3
     6         1         2         3
     2
     1        44
               1
         E4-WWDt
     3        20        34        35
         ImpLoad    IMPDWF    IMRanD
         FUN-EDI
        GETHRESH         2      2.00      1.00
                 $ Dummy parameter values used to trigger particular branch
       Otherwise
     3        20        34        35
         ImpLoad    IMPDWF    IMRanD
             AND
        GETHRESH         2      0.00     -1.00
                 $  Parameter values force Branch 1
49 What is the level of containment leakage induced by an early detonation?
     3    E4nDtF   E4-DtF2   E4-DtF3
     6         1         2         3
     3
     2        48        48
               2    +    3
         E-DWDt2   E-DWDt3
     5        20        24        25        34       35
         ImpLoad     IMPCF    IMRanC    IMPDWF   IMRanD
        FUN-ECI1
        GETHRESH         2      2.00      1.00

     1        44
               1
         E4-WWDt
     3        20        24        25
         ImpLoad     IMPCF    IMRanC
        FUN-ECI2
        GETHRESH         2      2.00      1.00

       Otherwise
     1        20
         ImpLoad
             AND
        GETHRESH         2     -1.00     -1.00
                 $  Parameter values force Branch 1
```

```
30 What is the level of containment leakage before vb?
     4     E5nCL    E5-CL2    E5-CL3    E5-CL4
     6         1         2         3         4
     4
     5        16        22        38        38      49
               3    +    2      +  3      +  4   +   3
            E1L3    E3VENT   ESP-CL3   ESP-CL4 E4-DtF3
     1         5
          EPBase
       FUN-ECBrn1
        GETHRESH         3   9999.00   9999.00    1.00
                           Dummy -- Already failed by detonation
     3        16        38        43
            (  2    +   2)      *  2
            E1L2   ESP-CL2   E4nWWDf
     1         5
          EPBase
             AND
        GETHRESH         3   9999.00      0.00   -1.00
                           Dummy -- Already leaking from detonation
     3        16        49        38
               2    +    2      +  2
            E1L2   E4-DtF2   ESP-CL2
     4         5        11        21        22
          EPBase      PBrn    PCFail     CFRan
       FUN-ECBrn2
        GETHRESH         3   9999.00      2.00    1.00
                           Dummy -- Already leaking from detonation
       Otherwise
     4         5        11        21        22
          EPBase      PBrn    PCFail     CFRan
       FUN-ECBrn2
        GETHRESH         3      3.00      2.00    1.00
                           Parameter value triggers particular branch
51 What is the level of drywell leakage induced by containment pressurization?
     5    EnDWDf   E-DWDf2  E-DWHDf2   E-DWDf3 E-DWHDf3
     6         1         2         3         4       5
     5
     2        17        48
               3    +    3
         E1-SPB3   E-DWDt3
     1         5
          EPBase
             AND
        GETHRESH         4   9999.00   9999.00 9999.00    0.00

     3        17        50        50
               2    (    3    +    4)
         E1-SPB2    E5-CL3    E5-CL4
     4         5        11        30        31
          EPBase      PBrn     EPDWF    DWFRan
       FUN-EDBrn1
        GETHRESH         4   9999.00      3.00    2.00   -1.00

     2        50        50
               3    +    4
          E5-CL3    E5-CL4
     4         5        11        30        31
          EPBase      PBrn     EPDWF    DWFRan
       FUN-EDBrn2
        GETHRESH         4      4.00      3.00    2.00   -1.00

     1        17
               2
         E1-SPB2
     4         5        11        30        31
```

```
          EPBase      PBrn     EPDWF    DWFRan
       FUN-EDBrn3
        GETHRESH         4   9999.00      3.00    2.00   -1.00

       Otherwise
     4         5        11        30        31
          EPBase      PBrn     EPDWF    DWFRan
       FUN-EDBrn4
        GETHRESH         4      4.00      3.00    2.00   -1.00
                $ Dummy parameters select failure mode
52 What is the level of suppression pool bypass following early combustion even
     3    E5nSPB   E5-SPB2   E5-SPB3
     2         1         2         3
     5
     4        17        48        51        51
               3  +      3  +      4  +      5
         E1-SPB3   E-DWDt3   E-DWDf3  E-DWHDf3
           0.000     0.000     1.000
     4        17        24        41        43
               2         2  (      1  +     1)
         E1-SPB2     E4-AC    E4-Dif   E4-WWDf
           0.000     0.950     0.050
     4        17        48        51        51
               2  +      2  +      2  +      3
         E1-SPB2   E-DWDt2   E-DWDf2  E-DWHDf2
           0.000     1.000     0.000
     3        24        41        43
               2  (      1  +     1)
           E4-AC    E4-Dif   E4-WWDf
       !52,2,2       0.000 !52,2,3
       Otherwise
           1.000     0.000     0.000
53 Has the upper pool dumped?
     2     UPDmp   noUPDmp
     2         1         2
     2
     1        24
               2
           E4-AC
           1.000     0.000
       Otherwise
           0.000     1.000
54 Is there water in the reactor cavity?
     3   E5-DFld   E5-DWet   E5-DDry
     2         1         2         3
     9
     1        51
               5
        E-DWHDf3
           1.000     0.000     0.000
     6        16        22        38        38      50      50
              -3     *   1   *  -3   *  -4  * ( 3  +   4)
           nE1L3   E3nVENT   ESP-CL3   ESP-CL4  E5-CL3  E5-CL4
           0.990     0.010     0.000
     5        16        22        43        39      39
              -3         1   *   1   *  -6  *  -5
           nE1L3   E3nVENT   E4-WWDf   nNoHWW  nHWW>4
           0.999     0.001     0.000
     8        16        22        17        41      30      39      39      24
              -3         1        -3         1      -4      -5      -6       1
           nE1L3   E3nVENT  nE1-SPB3    E4-Dif  nE4-CS  nHWW>4  nNoHWW   E4fAC
           0.450     0.450     0.100
     7        16        22        17        53      39      39      39
              -3         1        -3         1  (    1  +   2  +  3 )
           nE1L3   E3nVENT  nE1-SPB3     UPDmp HWW>20  HWW>16  HWW>12
           0.500     0.500     0.000
```

```
     1        20
               2
          Slw-SB
           0.000     1.000     0.000
     1        53
               1
           UPDmp
           0.000     1.000     0.000
     7        16        22        24        17       39       39       39
              -3         1         1        -3  (     1  +    2    +  3)
           nE1L3   E3nVENT     E4nAC nE1-SPB3  HWW>20   HWW>16   HWW>12
           0.000 !54,5,1   !54,5,2
       Otherwise
           0.000     0.000     1.000
55 What is the containment pressure before vb?
     3     E5P>3     E5P>2     E5P>1
     6         1         2         3
     5
     1        50
              -1
           E5-CL
     8         1         9        44         3        6        10        4        5
           H2OWW      O2WW      N2WW      H2WW    H2ODW      O2DW     H2DW   EPBASE
       FUN-IBASP1
        GETHRESH         2     304.0     202.6

     2        52        30
               3       * 4
         E5-SPB3     E4-CS
     8         1         9        44         3        6        10        4        5
           H2OWW      O2WW      N2WW      H2WW    H2ODW      O2DW     H2DW   EPBASE
       FUN-IBASP2
        GETHRESH         2     304.0     202.6

     1        52
               3
         E5-SPB3
     8         1         9        44         3        6        10        4        5
           H2OWW      O2WW      N2WW      H2WW    H2ODW      O2DW     H2DW   EPBASE
       FUN-IBASP3
        GETHRESH         2     304.0     202.6

     1        30
               4
           E4-CS
     8         1         9        44         3        6        10        4        5
           H2OWW      O2WW      N2WW      H2WW    H2ODW      O2DW     H2DW   EPBASE
       FUN-IBASP4
        GETHRESH         2     304.0     202.6

       Otherwise
     8         1         9        44         3        6        10        4        5
           H2OWW      O2WW      N2WW      H2WW    H2ODW      O2DW     H2DW   EPBASE
       FUN-IBASP5
        GETHRESH         2     304.0     202.6

56 To what level is the DW steam inert at vb?
     3    E5nDIn   E5-DIn2   E5-DIn3
     5         1         2         3
     3         4         6        10
         H2DWELL     H2ODW   O2DWELL
       FUN-DWIN1             $ Calculates dry air mole fraction in DW
        GETHRESH         3 !40,1,1   !40,1,2   !40,1,3
                                 Det     Comb.   Inert
57 Is there sufficient H2 for combustion/detonation in the DW before VB?
     3   E5cDWDt   E5cDWDf    E5nDWC
```

```
    5         1         2         3
    3         4         6        10
        H2DWELL     H2ODW   O2DWELL
      FUN-DWCBVB
       GETHRESH         3      0.16      0.06     0.00
                          H2min  -- 16%, 6% or less than 6%
58 Does an Alpha Mode Event fail both the vessel and the containment?
    2     Alpha   noAlpha
    2         1         2
    2
    1        26
              1
         E4-HiP
          0.001     0.999
      Otherwise
          0.010     0.990
59 What fraction of the core participates in core slump?
    3      HiSL     MedSL     LowSL
    2         1         2         3
    7
    1        58
              1
          Alpha
          1.000     0.000     0.000
    2        26        28
              1       * 3
         E4-HiP    E4-HPI
          0.000     0.000     1.000
    3        26         7        24
              1  * (   -1    *   2)
         E4-HiP   nElfCRD     E4-AC
          0.000     0.000     1.000
    1        26
              1
         E4-HiP
          1.000     0.000     0.000
    2        28        28
            ( 2      +  3)
         E4-LPI    E4-HPI
        !59,2,1   !59,2,2   !59,2,3
    2         7        24
           ( -1     *   2)
        nElfCRD     E4-AC
        !59,3,1   !59,3,2   !59,3,3
      Otherwise
        !59,4,1   !59,4,2   !59,4,3
60 Is there a large in-vessel steam explosion?
    2    VesStx   nVesSTx
    2         1         2
    3
    1        58
              1
          Alpha
          1.000     0.000
    1        26
              1
         E4-HiP
          0.100     0.900
      Otherwise
           0.86      0.14
61 What fraction of the core debris would be mobile at vb?
    2   HiLiqVB   LoLiqVB
    4         1         2
    3
    4         7        24        28        28
           ( -1     *   2)   +    2     +   3
```

```
         nE1fCRD     E4-AC    E4-LPI    E4-HPI
           0.025     0.975
     1
    46     0.400     0.100
     1        26
               1
          E4-HiP
           0.100     0.900
     1
    46     0.400     0.100
       Otherwise -- Low pressure with no injection
        !61,2,1  !61,2,2
     1
    46     0.400     0.100
62 Does a large in-vessel steam explosion fail the vessel?
     5  SE-Alpha   SE-BtHd SE-LgBrch SE-SmBrch SE-nFail
     2         1         2         3         4       5
     3
     1        58
               1
           Alpha
          1.0000    0.0000    0.0000    0.0000  0.0000
     1        60
               1
          VesStx
          0.0000    0.2000    0.2000    0.3000  0.3000
       Otherwise
           0.000     0.000     0.000     0.000   1.000
63 What is the mode of vb?
     5    A-Fail   BH-Fail    LgBrch    SmBrch nBreach
     2         1         2         3         4       5
    10
     1        58
               1
           Alpha
          1.0000    0.0000    0.0000    0.0000  0.0000
     1        62
               2
         SE-BtHd
          0.0000    1.0000    0.0000    0.0000  0.0000
     1        62
               3
       SE-LgBrch
          0.0000    0.0000    1.0000    0.0000  0.0000
     1        62
               4
       SE-SmBrch
          0.0000    0.0000    0.0000    1.0000  0.0000
     4        28        28        61        29
      (  2   +    3)       * 1       * 2
          E4-LPI    E4-HPI   HiLiqVB   E4nCrit
          0.0000    0.1240    0.0050    0.3710  0.5000
     2        26        61
               1         1
          E4-HiP   HiLiqVB
          0.0000    0.2490    0.0050    0.7460  0.0000
     1        61
               1
         HiLiqVB
          0.0000    0.2490    0.0050    0.7460  0.0000
     3        28        28        29
      (  2   +    3)       * 2
          E4-LPI    E4-HPI   E4nCrit
          0.0000    0.0620    0.0050    0.1880  0.7450
     1        26
               1
```

```
          E4-HiP
          0.0000    0.2490    0.0050    0.7460  0.0000
       Otherwise -- Low press., no steam explosion, no injection
          0.0000    0.2490    0.0050    0.7460  0.0000
64 Does high pressure melt ejection occur?
     2      HPME     nHPME
     2         1         2
     5
     3        58        63        26
               1       + 5       + 2
           Alpha   nBreach    E4-LoP
           0.000     1.000
     3        63        63        61
             ( 2      + 3)       * 1
         BH-Fail    LgBrch   HiLiqVB
           0.800     0.200
     2        63        63
             ( 2      + 3)
         BH-Fail    LgBrch
       !64,2,1   !64,2,2
     1        61
               1
         HiLiqVB
       !64,2,1   !64,2,2
       Otherwise
       !64,2,1   !64,2,2
65 Does a detonation occur in the DW at vb?
     2    I-DWDt    InDWDt
     4         1         2
     2
     3        56        57        63
               1         1        -5
         E5nDWIn   E5cDWDt    Breach
           1.000     0.000
     1
    36     12.00      0.00                        $ DW-DtILd: Impulse load from de
       Otherwise
           0.000     1.000
     1
    36     12.00      0.00                        $ DW-DtILd: Impulse load from de
66 Does a deflagration occur in the DW at vb?
     2    I-DWDf    InDWDf
     2         1         2
     2
     4        56        57        63        65
              -3        -3        -5         2
       nE5-DwIn3   nE5nDWC    Breach    InDWDt
           1.000     0.000
       Otherwise
           0.000     1.000
67 Does a large ex-vessel steam explosion occur?
     2      ExSE     nExSE
     2         1         2
     3
     4        58        63        54        28
               1       + 5   + (  3      *  1)
           Alpha   nBreach   E5-DDry      nLPI
           0.000     1.000
     1        64
               1
            HPME
           0.800     0.200
       Otherwise
            0.86      0.14
68 What amount of H2 is released at vb?
     1      H2VB
```

```
    4         1
    7
    2        63        63
              1    +    5
         A-Fail   nBreach
          1.000
    1
    7      0.00
    2         1        28
              3         2
             TC    E4-LPI
          1.000
    1
    7      41.0
    1         1
              3
             TC
          1.000
    1
    7      65.0
    3        14        28        28
             -4    * ( 2     +  3)
        nE1-DeP    E4-LPI    E4-HPI
          1.000
    1
    7      41.0
    2        28        28
            ( 2     +  3)
         E4-LPI    E4-HPI
          1.000
    1
    7      15.0
    1        28
              1
         E4-HiP
          1.000
    1
    7     121.0
      Otherwise -- Low Pressure no injection recovery
          1.000
    1
    7      48.0
69 How much hydrogen is released at vb?
    4   H2VB>50   H2VB>25   H2VB>10   H2VB<10
    6         1         2         3         4
    2
    2        64        67
            ( 1     +  1)
           HPME      EXSE
    4         2         7        46         8
       H2INVES       H2VB    FEJECT     FH2VB
      FUN-H2AVB1
       GETHRESH         3     868.5    434.25   17.37

      Otherwise
    4         2         7        46         8
       H2INVES       H2VB    FEJECT     FH2VB
      FUN-H2AVB2
       GETHRESH         3     868.5    434.25   17.37

70 What is the peak drywell/wellwell pressure difference resulting from VB?
    1    DPDWVB
    4         1
   14
    2        63        63
              1    +    5
```

```
      A-Fail   nBreach
       1.000
 1
13      0.00
 6        26        61        63        63        54        54
           1         1   (     2   +     3)  (     1   +     2)
      E4-HiP   HiLiqVB   BH-Fail    LgBrch E5-DFld E5-DWet
       1.000
 1
13    433.00
 4        26        61        54        54
           l         1   (     1   +     2)
      E4-HiP   HiLiqVB   E5-DFld   E5-DWet
       1.000
 1
13    332.00
 4        26        61        63        63
           1         1   (     2   +     3)
      E4-HiP   HiLiqVB   BH-Fail    LgBrch
       1.000
 1
13    392.00
 2        26        61
           1         1
      E4-HiP   HiLiqVB
       1.000
 1
13    242.00
 5        26        63        63        54        54
           1   (     2   +     3)  (     1   +     2)
      E4-HiP   BH-Fail    LgBrch   E5-DFld E5-DWet
       1.000
 1
13    425.00
 3        26        54        54
           1   (     1   +     2)
      E4-HiP   E5-DFld   E5-DWet
       1.000
 1
13    312.00
 3        26        63        63
           1   (     2   +     3)
      E4-HiP   BH-Fail    LgBrch
       1.000
 1
13    337.00
 1        26
           1
      E4-HiP
       1.000
 1
13    222.00
 5        61        63        63        54        54
           1   (     2   +     3)  (     1   +     2)
     HiLiqVB   BH-Fail    LgBrch   E5-DFld E5-DWet
       1.000
 1
13    295.00
```

```
    3        61        54        54
              1    (    1    +    2)
        HiLiqVB   E5-DFld   E5-DWet
          1.000
    1
   13    242.00
    4        63        63        54        54
         (    2    +    3)   (    1    +    2)
        BH-Fail    LgBrch   E5-DFld   E5-DWet
          1.000
    1
   13    290.00
    2        54        54
         (    1    +    2)
        E5-DFld   E5-DWet
          1.000
    1
   13    238.00
      Otherwise
          1.000
    1
   13      0.00
71 What is the peak pedestal pressure at vb?
    1   Ped-VBP
    4         1
   18
    2        63        63
              1    +    5
         A-Fail   nBreach
          1.000
    1
   39      0.00
    6        26        61        63        63       54       54
              1         1    (    2    +    3)  (    1    +    2)
         E4-HiP   HiLiqVB   BH-Fail    LgBrch E5-DFld E5-DWet
          1.000
    1
   39   3575.00
    4        26        61        54        54
              1         1    (    1    +    2)
         E4-HiP   HiLiqVB   E5-DFld   E5-DWet
          1.000
    1
   39   2780.00
    4        26        61        63        63
              1         1    (    2    +    3)
         E4-HiP   HiLiqVB   BH-Fail    LgBrch
          1.000
    1
   39   3080.00
    2        26        61
              1         1
         E4-HiP   HiLiqVB
          1.000
    1
   39   1720.00
    5        26        63        63        54       54
              1    (    2    +    3)   (    1    +    2)
         E4-HiP   BH-Fail    LgBrch   E5-DFld E5-DWet
          1.000
    1
   39   3245.00
    3        26        54        54
              1    (    1    +    2)
         E4-HiP   E5-DFld   E5-DWet
          1.000
```

```
 1
39   2175.00
 3        26        63        63
           1   (     2   +     3)
     E4-HiP   BH-Fail    LgBrch
       1.000
 1
39   2850.00
 1        26
           1
     E4-HiP
       1.000
 1
39   1430.00
 7        36        36        63        63        54        54        61
        ( -6   *   -7)   (     2   +     3)   ( 1   +   2)         1
    nZrOx10  nZrOx<10   BH-Fail    LgBrch E5-DFld E5-DWet HiLiqVB
       1.000
 1
39   1120.00
 5        36        36        54        54        61
        ( -6   *   -7)   (     1   +   2)         1
    nZrOx10  nZrOx<10   E5-DFld   E5-DWet HiLiqVB
       1.000
 1
39    744.00
 5        63        63        54        54        61
     (     2   +     3)  (     1   +   2)         1
    BH-Fail    LgBrch   E5-DFld   E5-DWet HiLiqVB
       1.000
 1
39 !71,10,1,1
 3        54        54        61
     (     1   +   2)          1
    E5-DFld   E5-DWet   HiLiqVB
       1.000
 1
39    557.00
 6        36        36        63        63        54        54
        ( -6   *   -7)   (     2   +     3)   ( 1   +   2)
    nZrOx10  nZrOx<10   BH-Fail    LgBrch E5-DFld E5-DWet
       1.000
 1
39   1000.00
 4        36        36        54        54
        ( -6   *   -7)     ( 1   +   2)
    nZrOx10  nZrOx<10   E5-DFld   E5-DWet
       1.000
 1
39    605.00
 4        63        63        54        54
     (     2   +     3)    ( 1   +   2)
    BH-Fail    LgBrch   E5-DFld   E5-DWet
       1.000
 1
39 !71,15,1,1
 2        54        54
     (     1   +   2)
    E5-DFld   E5-DWet
       1.000
 1
39    435.00
   Otherwise
       1.000
 1
39    100.00
```

```
72 Is the impulse loading to the drywell at VB sufficient to cause failure?
     3    InDWFI   I-DWFI2   I-DWFI3
     6         1         2         3
     2
     1        65
               1
          I-DWDt
     3        36        34        35
        DW-DtILd    IMPDWF    IMRanD
       FUN-IDI1LD
        GETHRESH         2      2.00      1.00

       Otherwise
     1        36
        DW-DtILd
             AND
        GETHRESH         2      0.00     -1.00
                           $ Dummy parameters force no leakage
73 Is drywell pressurization at VB sufficient to cause failure?
     5    InDWOP   I-DWOP2  I-DWHOP2   I-DWOP3 I-DWHOP3
     5         1         2         3         4       5
     3        13        26        31
          DPDWVB     IPDWF    DWFRan
       FUN-DWFAVB          $ Function returns dummy value depending on pressure
        GETHRESH         4      4.00      3.00    2.00   -1.00
                            $ NoFail      Leak Hd. Leak  Rupt.
74 Does the RPV pedestal fail due to pressurization at vb?
     2   I-PedFP   InPedFP
     5         1         2
     1        39
         Ped-VBP
             AND
          THRESH         1   1300.00
                           Pressure required to fail pedestal or lift RPV
75 Does the RPV pedestal fail from an ex-vessel steam explosion (impulse loadin
     2   I-PedFI   InPedFI
     2         1         2
     3
     1        74
               1
         I-PedFP
           0.000     1.000
     1        67
               1
            ExSE
           0.500     0.500
       Otherwise
           0.000     1.000
76 Does the RPV pedestal failure induce drywell failure?
     2  I-DWFPed  InDWFPed
     2         1         2
     3
     5        52        58        72        73      73
               3     +   1     +   3      +  4    +  5
         E5-SPB3     Alpha   I-DWFI3   I-DWOP3 I-DWHOP3
           0.000     1.000
     2        74        75
               1      + 1
         I-PedFP   I-PedFI
           0.175     0.825
       Otherwise
           0.000     1.000
77 What is the pressure in the containment at VB prior to a hydrogen burn?
     1     CP-VB
     4         1
     6
```

```
     4        63        63        50        50
               1   +     5    +    3      +  4
          A-Fail   nBreach    E5-CL3    E5-CL4
           1.000
     1
    40      0.00
     7        52        72        73        73      54      54      26
         (     3  +      3    +    4    +    5)  (   1   +   2)      1
         E5-SPB3  DW-IFVB3   I-DWOP3  I-DWHOP3 E5-DFld E5-DWet  E5-HiP
           1.000
     1
    40     50.00
     5        52        72        73        73      26
         (     3  +      3    +    4    +    5)      1
         E5-SPB3  DW-IFVB3   I-DWOP3  I-DWHOP3  E4-HiP
           1.000
     1
    40     40.00
     6        52        72        73        73      54      54
         (     3  +      3    +    4    +    5)  (   1   +   2)
         E5-SPB3  DW-IFVB3   I-DWOP3  I-DWHOP3 E5-DFld E5-DWet
           1.000
     1
    40     35.00
     4        52        72        73        73
         (     3  +      3    +    4    +    5)
         E5-SPB3  DW-IFVB3   I-DWOP3  I-DWHOP3
           1.000
     1
    40      5.00
     3        64        67        61
             ( 1     + 1)       * 1
            HPME      ExSE   HiLiqVB
           1.000
     1
    40     56.75
     2        64        67
             ( 1     + 1)
            HPME      ExSE
           1.000
     1
    40 177,6,1,1
       Otherwise
           1.000
     1
    40      0.00
78 What is the concentration of hydrogen in containment immediately after VB?
     6   IHWW>20   IHWW>16   IHWW>12    IHWW>8  IHWW>4 I-NoHWW
     6         1         2         3         4       5       6
     7
     2        58        63
               1    +    5
           ALPHA   nBreach
     8         1         3         6         4       7       9      10      44
           H2OWW      H2WW     H2ODW      H2DW    H2VB    O2WW    O2DW    N2WW
       FUN-IH2WW0
       GETHRESH           5      0.20      0.16    0.12    0.08    0.04

     6        64        65        66        67      50      50
             ( 1    +    1    +    1    +    1)  * ( 3   +   4)
            HPME    I-DWDt    I-DWDf      ExSE  E5-CL3  E5-CL4
     8         1         3         6         4       7       9      10      44
           H2OWW      H2WW     H2ODW      H2DW    H2VB    O2WW    O2DW    N2WW
       FUN-IH2WW1
       GETHRESH           5      0.20      0.16    0.12    0.08    0.04
```

```
     4        64        65        66         67
             ( 1    +    1    +    1    +    1)
            HPME    I-DWDt    I-DWDf       ExSE
     8         1         3         6          4        7        9        10        44
           H2OWW      H2WW     H2ODW       H2DW     H2VB     O2WW      O2DW      N2WW
       FUN-IH2WW2
       GETHRESH            5      0.20       0.16     0.12     0.08      0.04

     6        28        28        54         54       50       50
         (     2    +    3    +    1    +     2)  * ( 3   +    4)
          E4-LPI    E4-HPI   E5-DFld    E5-DWet   E5-CL3   E5-CL4
     8         1         3         6          4        7        9        10        44
           H2OWW      H2WW     H2ODW       H2DW     H2VB     O2WW      O2DW      N2WW
       FUN-IH2WW3
       GETHRESH            5      0.20       0.16     0.12     0.08      0.04
                   Drywell purged by steam and pool bypassed
     4        28        28        54         54
         (     2    +    3    +    1    +     2)
          E4-LPI    E4-HPI   E5-DFld    E5-DWet
     8         1         3         6          4        7        9        10        44
           H2OWW      H2WW     H2ODW       H2DW     H2VB     O2WW      O2DW      N2WW
       FUN-IH2WW4
       GETHRESH            5      0.20       0.16     0.12     0.08      0.04

     2        50        50
             ( 3    +    4)
          E5-CL3    E5-CL4
     8         1         3         6          4        7        9        10        44
           H2OWW      H2WW     H2ODW       H2DW     H2VB     O2WW      O2DW      N2WW
       FUN-IH2WW5
       GETHRESH            5      0.20       0.16     0.12     0.08      0.04

       Otherwise
     8         1         3         6          4        7        9        10        44
           H2OWW      H2WW     H2ODW       H2DW     H2VB     O2WW      O2DW      N2WW
       FUN-IH2WW6
       GETHRESH            5      0.20       0.16     0.12     0.08      0.04
                   Assume leakage back to drywell & vessel retention independent
79 Is AC power not recovered following vb?
     2      IfAC      I-AC
     2         1         2
     4
     1        24
               2
           E4-AC
           0.000     1.000
     1        25
               1
           E4fDC
           1.000     0.000
     2         2        15
               1         2
              SB    CD-Slw
           0.670     0.330
       Otherwise -- Short term blackout w/ no recovery before VB
           0.551     0.449
80 Is DC power available following vb?
     2      IfDC      I-DC
     2         1         2
     4
     1        25
               1
           E4fDC
           1.000     0.000
     1        24
               2
```

```
           E4-AC
           0.000     1.000
    2          2        15
               1         2
              SB    CD-Slw
           0.210     0.790
       Otherwise -- Short term blackout w/ no recovery before VB
           0.010     0.990
81 What is the status of containment sprays following vb?
    4       IfCS      IrCS      IaCS      I-CS
    2          1         2         3         4
    8
    1         30
               1
          E1fCSS
           1.000     0.000     0.000     0.000
    6         30        79        50        50      16      22
               2         1   (     4    +    3 * (  -3  +  1))
          E1rCSS      IfAC    E5-CL4    E5-CL3   nE1L3 E3nVENT
           0.500     0.500     0.000     0.000
    2         30        79
               2         1
          E1rCSS      IfAC
           0.000     1.000     0.000     0.000
    5         30        50        50        16      22
               4   (     4    +    3   * (  -3  +  1))
           E4-CS    E5-CL4    E5-CL3     nEiL3 E3nVENT
       !81,2,1       0.000     0.000 !81,2,2
    1         30
               4
           E4-CS
           0.000     0.000     0.000     1.000
    5         79        50        50        16      22
               2   (     4    +    3   * (  -3  +  1))
            I-AC    E5-CL4    E5-CL3     nEiL3 E3nVENT
           0.500     0.000     0.450     0.050
    1         79
               2
            I-AC
           0.000     0.000 !30,4,3   !30,4,4
       Otherwise
           0.000     0.000     1.000     0.000
82 To what level is the wetwell inert after vb?
    3     InWWIn   I-WWIn2   I-WWIn3
    5          1         2         3
    4          1         3         9        44
           H2OWW      H2WW      O2WW      N2WW
       FUN-WWH2O1
        GETHRESH         3 !40,1,1  !40,1,2  !40,1,3

83 Is there sufficient oxygen in the containment to support combustion
    5    O2Det20   O2Det16   O2Det12      WWO2   nWWO2
    5          1         2         3         4       5
    4          1         3         9        44
           H2OWW      H2WW      O2WW      N2WW
        FUN-WWO2
        GETHRESH         4       4.0       3.0     2.0     1.0

84 Does ignition occur in the containment at vb?
    2     I-CIgn    InCIgn
    2          1         2
    8
    3         78        82        83
               6    +    3    +    5
         I-NoHWW   I-WWIn3     nWWO2
           0.000     1.000
```

```
    5        24        52        52        72        73
              2    +    2    +    3    +   -1    +   -1
           I-AC   E5-SPB2   E5-SPB3   DW-IFVB    I-DWLP
          1.000     0.000
    4        26        67        78        78
         (    1    +    1)   (    1    +    2)
         E4-HiP      ExSE   IHWW>20   IHWW>16
          0.600     0.400
    3        26        67        78
         (    1    +    1)        3
         E4-HiP      ExSE   IHWW>12
          0.550     0.450
    3        26        67        78
         (    1    +    1)        4
         E4-HiP      ExSE    IHWW>8
          0.450     0.550
    3        26        67        78
         (    1    +    1)        5
         E4-HiP      ExSE    IHWW>4
          0.300     0.700
    3        26        67        78
         (    1    +    1)        6
         E4-HiP      ExSE   I-NoHWW
          0.005     0.995
      Otherwise
          0.010     0.990
85 Does ignition occur in the containment following vb?
    2    IgnFVB   nIgnFVB
    2         1         2
    6
    5        78        82        81        83        84
              6    +    3    *   -4    +    5    +    1
        I-NoHWW   I-WWIn3     nI-CS     nWWO2    I-CIgn
          0.000     1.000
    1        78
              2
           I-AC
          1.000     0.000
    2        78        78
              1    +    2
        IHWW>20   IHWW>16
       !43,12,1  !43,12,2
    1        78
              3
        IHWW>12
       !43,10,1  !43,10,2
    1        78
              4
         IHWW>8
       !43,8,1   !43,8,2
      Otherwise
       !43,6,1   !43,6,2
86 Is there a detonation in the wetwell following vb?
    2    I-WWDt    InWWDt
    4         1         2
   10
    8        84        85        82        82        81        78        78        78
              2    *    2    +  (  3    +    2)   *   -4    +    4    +    5    +    6
         InCIgn   nIgnFVB    I-WIn3   I-WWIn2     nI-CS    IHWW>8    IHWW>4    INoHWW
          0.000     1.000
    1
   20      0.00      0.00
    5        24        27        83        83        83
              2    *    1    *  (  3    +    2    +    1)
          E4-AC    E4-HIS   O2Det12   O2Det16   O2Det20
           0.01      0.99
```

```
     1
    20 !44,5,1,1      0.00
     8        52        72        73        73      39      39      39      43
           (  -1    +  -1    +  -1    *  -3) * ( -1   *  -2   *  -3   +  1)
          E5-SPB    I-DWFI    I-DWOP   InDWOP2 nH2WW20 nH2WW16 nH2WW12 E4-WWDf
            0.01      0.99
     1
    20 !44,5,1,1      0.00
     6        78        82        82        83      83      83
               3  * (   2  +    3)   * (  3    +  2    +  1)
         IHWW>12   I-WWIn2   I-WWIn3  O2Det12 O2Det16 O2Det20
       !44,2,1   !44,2,2
     1
    20 !44,2,1,1      0.00
     4        78        83        83        83
               3  *  (  3      +  2      +  1)
         IHWW>12  O2Det12   O2Det16   O2Det20
       !44,3,1   !44,3,2
     1
    20 !44,3,1,1      0.00
     5        78        82        82        83      83
               2  *  (  2  +    3)   *  (  2 +    1)
         IHWW>16   I-WWIn2   I-WWIn3  O2Det16 O2Det20
       !44,4,1   !44,4,2
     1
    20 !44,4,1,1      0.00
     3        78        83        83
               2     (  2   +   1)
         IHWW>16  O2Det16   O2Det20
       !44,5,1   !44,5,2
     1
    20 !44,5,1,1      0.00
     4        78        82        82        83
               1  *  (  2  +    3)      *  1
         IHWW>20   I-WWIn2   I-WWIn3  O2Det20
       !44,6,1   !44,6,2
     1
    20 !44,6,1,1      0.00
     2        78        83
               1         1
         IHWW>20  O2Det20
       !44 7,1   !44,7,2
     1
    20 !44,7,1,1      0.00
       Otherwise
           0.000     1.000
     1
    20      0.00      0.00
87 What is the level of containment impulse load following vb?
     7   I-Ip>60   I-Ip>50   I-Ip>40   I-Ip>30 I-Ip>20 I-Ip>10 I-Ip<10
     5         1         2         3         4       5       6       7
     1        20
         ImpLoad
             AND
        GETHRESH         6     60.00     50.00   40.00   30.00   20.00   10.00
                             $ Parse containment impulse load for verification
88 With what efficiency is hydrogen burned following VB?
     1   H2Ef@VB
     4         1
     9
     7        84        85        82        82      81      78      78
           (   1   +    1)   * (  2     +   3   *  4) *  ( 5  +    6)
          I-CIgn    IgnFVB   I-WWIn2   I-WWIn3    I-CS IHWW>4 I-NoHWW
           1.000
     2
    18 !46,4,1,1                          $ Peak pressure from hydrogen combustion
```

```
    19 !46,4,2,1                    $ Combustion efficiency
    4         84        85        78        78
          (    1   +    1)    (    5    +   6)
          I-CIgn    IgnFVB    IHWW>4   I-NoHWW
           1.000
    2
    18 !46,5,1,1                    $ Peak pressure from hydrogen combustion
    19 !46,5,2,1                    $ Combustion efficiency
    6         84        85        82        82      81      78
          (    1   +    1)    * (  2     +   3   *  4)   *   4
          I-CIgn    IgnFVB   I-WWIn2   I-WWIn3    I-CS  IHWW>8
           1.000
    2
    18 !46,6,1,1
    19 !46,6,2,1
    3         84        85        78
          (    1   +    1)         4
          I-CIgn    IgnFVB    IHWW>8
           1.000
    2
    18 !46,7,1,1
    19 !46,7,2,1
    6         84        85        82        82      81      78
          (    1   +    1)    * (  2     +   3   *  4)   *   3
          I-CIgn    IgnFVB   I-WWIn2   I-WWIn3    I-CS IHWW>12
           1.000
    2
    18 !46,8,1,1
    19 !46,8,2,1
    3         84        85        78
          (    1   +    1)         3
          I-CIgn    IgnFVB   IHWW>12
           1.000
    2
    18 !46,9,1,1
    19 !46,9,2,1
    7         84        85        82        82      81      78      78
          (    1   +    1)    * (  2     +   3   *  4)   * ( 1   + 2)
          I-CIgn    IgnFVB   I-WWIn2   I-WWIn3    I-CS IHWW>20 IHWW>16
           1.000
    2
    18 !46,10,1,1
    19 !46,10,2,1
    4         84        85        78        78
          (    1   +    1)    (    1    +   2)
          I-CIgn    IgnFVB   IHWW>20   IHWW>16
           1.000
    2
    18 !46,11,1,1
    19 !46,11,2,1
       Otherwise
           1.000
    2
    18       0.00
    19       0.00
89 What would be the peak pressure in containment from a hydrogen burn at VB?
    6   I-PBrn>7  I-PBrn>6  I-PBrn>5  I-PBrn>4 I-PBrn>3 I-PBrn<3
    6          1         2         3         4       5       6
    4
    2         84        85
               2   *     2
          InCIgn   nIgnFVB
    8          3         1         9         5      11      18      19      44
            H2WW     H2OWW      O2WW    EPBase    PBrn H2EfVB1 H2EfVB2    N2WW
      FUN-IPBRN1
        GETHRESH         5     709.3     608.0   506.6   405.3   304.0
```

```
                 Parse peak pressure for verification
     3        50        50        58
            (  3      +  4      +  1)
          E5-CL3    E5-CL4     Alpha
     8         3         1         9         5        11      18      19        44
            H2WW     H2OWW      O2WW    EPBase      PBrn H2EfVB1 H2EfVB2      N2WW
      FUN-IPBRN2
        GETHRESH         5     709.3     608.0    506.6   405.3   304.0
                 Parse peak pressure for verification
     1        86
               1
          I-WWDt
     8         3         1         9         5        11      18      19        44
            H2WW     H2OWW      O2WW    EPBase      PBrn H2EfVB1 H2EfVB2      N2WW
      FUN-IPBRN3
        GETHRESH         5     709.3     608.0    506.6   405.3   304.0
                 Parse peak pressure for verification
      Otherwise
     8         3         1         9         5        11      18      19        44
            H2WW     H2OWW      O2WW    EPBase      PBrn H2EfVB1 H2EfVB2      N2WW
      FUN-IPBRN4
        GETHRESH         5     709.3     608.0    506.6   405.3   304.0
                 Parse peak pressure for verification
90 What is the level of containment pressurization at vb?
     6    I-CP>7    I-CP>6    I-CP>5    I-CP>4  I-CP>3  I-CP<3
     6         1         2         3         4       5       6
     4
     3        50        50        58
               3   +     4   +     1
          E5-CL3    E5-CL4     Alpna
     3         5        11        41
          EPBase      PBrn  CP-VBTot
      FUN-CPCLOW
        GETHRESH         5     709.3     608.0    506.6   405.3   304.0

     1        84
               1
          I-CIgn
     4         5        11        40        41
          EPBase      PBrn     CP-VB  CP-VBTot
        FUN-CPC1
        GETHRESH         5     709.3     608.0    506.6   405.3   304.0

     1        85
               1
          IgnFVB
     4         5        11        40        41
          EPBase      PBrn     CP-VB  CP-VBTot
        FUN-CPC2
        GETHRESH         5     709.3     608.0    506.6   405.3   304.0

       Otherwise
     4         5        11        40        41
          EPBase      PBrn     CP-VB  CP-VBTot
        FUN-CPC3
        GETHRESH         5     709.3     608.0    506.6   405.3   304.0
                 $ Parse containment pressure
91 What is the level of drywell leakage induced by a detonation in containment
     3    InDWDt   I-DWDt2   I-DWDt3
     6         1         2         3
     2
     1        86
               1
          I-WWDt
     3        20        34        35
         ImpLoad    IMPDWF    IMRanD
```

```
         FUN-EDI
        GETHRESH         2      2.00      1.00
                 $ Dummy parameter values used to trigger particular branch
       Otherwise -- No detonation and thus no failure
     3        20        34        35
         ImpLoad    IMPDWF    IMRanD
             MAX
        GETHRESH         2      0.00     -1.00
                 $  Parameter values force Branch 1
92 What is the level of containment leakage induced by a detonation at VB?
     3     InDtF    I-DtF2    I-DtF3
     6         1         2         3
     3
     2        91        91
                2   +     3
         I-DWDt2   I-DWDt3
     5        20        24        25        34      35
         ImpLoad     IMPCF    IMRanC    IMPDWF  IMRanD
        FUN-ECI1
        GETHRESH         2      2.00      1.00

     1        66
                1
          I-WWDt
     3        20        24        25
         ImpLoad     IMPCF    IMRanC
        FUN-ECI2
        GETHRESH         2      2.00      1.00

       Otherwise
     3        20        24        25
         ImpLoad     IMPCF    IMRanC
             MAX
        GETHRESH         2      0.00     -1.00
                 $  Parameter values force Branch 1
93 What is the level of containment leakage following vb?
     4      InCL     I-CL2     I-CL3     I-CL4
     6         1         2         3         4
     4
     2        50        58
                4   +     1
          E5-CL4     Alpha
     1         5
          EPBase
             AND
        GETHRESH         3   9999.00   9999.00 9999.00
                           Dummy -- Already ruptured
     2        50        92
                3   +     3
          E5-CL3    I-DtF3
     1         5
          EPBase
             AND
        GETHRESH         3   9999.00   9999.00      1.00
                           Dummy -- Already failed by detonation
     2        50        92
                2   +     2
          E5-CL2    I-DtF2
     4         5        41        21        22
          EPBase  CP-VBTot    PCFail     CFRan
       FUN-ECBrn2
        GETHRESH         3   9999.00      2.00      1.00
                           Dummy -- Already leaking from detonation
       Otherwise
     4         5        41        21        22
          EPBase  CP-VBTot    PCFail     CFRan
```

```
       FUN-ECBrn2
        GETHRESH         3      3.00      2.00    1.00
                           Parameter value triggers particular branch
94 What is the level of drywell leakage induced by containment pressurization?
     5    InDWDf   I-DWDf2  I-DWHDf2   I-DWDf3 I-DWHDf3
     6         1         2         3         4       5
    10
     5        51        72        73        76      91
               4   +     3   +     4      +  1  +    3
         E-DWDf3   I-DWFI3   I-DWOP3  I-DWFPed I-DWDt3
     1         5
          EPBase
             AND
        GETHRESH         4   9999.00   9999.00 9999.00    0.00

     1        51
               5
        E-DWHDf3
     1         5
          EPBase
             AND
        GETHRESH         4   9999.00   9999.00 9999.00 9999.00

     7        85        51        72        73      91      93      93
               1  * (    2   +     2   +     2  +   2)   (  3  +    4)
          IgnFVB   E-DWDf2   I-DWFI2   I-DWOP2 I-DWDt2   I-CL3   I-CL4
     5         5        41        30        31      40
          EPBase  CP-VBTot     EPDWF    DWFRan   CP-VB
       FUN-IDBrn1
        GETHRESH         4   9999.00      3.00    2.00   -1.00

     5        85        51        72        73      91
               1  * (    2   +     2   +     2  +   2)
          IgnFVB   E-DWDf2   I-DWFI2   I-DWOP2 I-DWDt2
     5         5        41        30        31      40
          EPBase  CP-VBTot     EPDWF    DWFRan   CP-VB
       FUN-IDBrn2
        GETHRESH         4   9999.00      3.00    2.00   -1.00

     4        85        51        93        93
               1      *  3   * (   3    +    4)
          IgnFVB  E-DWHDf2     I-CL3     I-CL4
     5         5        41        30        31      40
          EPBase  CP-VBTot     EPDWF    DWFRan   CP-VB
       FUN-IDBrn3
        GETHRESH         4   9999.00      3.00    2.00   -1.00

     2        85        51
               1      *  3
          IgnFVB  E-DWHDf2
     5         5        41        30        31      40
          EPBase  CP-VBTot     EPDWF    DWFRan   CP-VB
       FUN-IDBrn4
        GETHRESH         4   9999.00      3.00    2.00   -1.00
                 $ Dummy parameters select failure mode
     1        85
               1
          IgnFVB
     5         5        41        30        31      40
          EPBase  CP-VBTot     EPDWF    DWFRan   CP-VB
       FUN-IDBrn5
        GETHRESH         4      4.00      3.00    2.00   -1.00
                 $ Dummy parameters select failure mode
     4        51        72        73        91
           (   2  +      2   +     2    +   2)
         E-DWDf2   I-DWFI2   I-DWOP2   I-DWDt2
```

```
     1         5
          EPBase
             AND
        GETHRESH         4   9999.00      0.00   -1.00   -1.00
                 $ Dummy parameters select failure mode
     1        51
               3
        E-DWHDf2
     1         5
          EPBase
             AND
        GETHRESH         4   9999.00   9999.00    0.00   -1.00
                 $ Dummy parameters select failure mode
       Otherwise
     1         5
          EPRase
             AND
        GETHRESH         4      0.00     -1.00   -1.00   -1.00
                 $ Dummy parameters select failure mode
95 What is the level of suppression pool bypass following VB?
     3     InSPB    I-SPB2    I-SPB3
     2         1         2         3
     5
     4        52        94        94        58
               3    +    4    +    5    +    1
         E5-SPB3   I-DWDf3  I-DWHDf3     Alpha
           0.000     0.000     1.000
     6        52        94        94        79      84      85
           (   2    +    2    +    3)        2    (  1   +   1)
         E5-SPB2   I-DWDf2  I-DWHDf2      I-AC  I-CIgn  IgnFVB
           0.000 !52,2,2   !52,2,3
     3        52        94        94
               2    +    2    +    3
         E5-SPB2   I-DWDf2  I-DWHDf2
           0.000     1.000     0.000
     3        79        84        85
               2     (   1    +    1)
            I-AC    I-CIgn    IgnFVB
       !52,2,2       0.000 !52,2,3
       Otherwise
           1.000     0.000     0.000
96 What is the containment pressure after vb?
     4      IP>4      IP>3      IP>2      IP>1
     6         1         2         3         4
     3
     1        93
              -1
            I-CL
     8         1         9        44         3       6      10       4       5
           H2OWW      O2WW      N2WW      H2WW   H2ODW    O2DW    H2DW  EPBASE
       FUN-LBASP1
        GETHRESH         3     405.3     304.0   202.6

     1        81
               4
            I-CS
     8         1         9        44         3       6      10       4       5
           H2OWW      O2WW      N2WW      H2WW   H2ODW    O2DW    H2DW  EPBASE
       FUN-LBASP2
        GETHRESH         3     405.3     304.0   202.6

       Otherwise
     8         1         9        44         3       6      10       4       5
           H2OWW      O2WW      N2WW      H2WW   H2ODW    O2DW    H2DW  EPBASE
       FUN-LBASP3
        GETHRESH         3     405.3     304.0   202.6
```

```
97 Is water not supplied to the debris late?
     3   nLDBWat  S-LDBWat  L-LDBWat
     2         1         2         3
     6
     1        63
               5
         nBreach
           0.000     0.000     1.000
     2        79        12
               1         3
            IfAC    ElaFPS
           0.500     0.250     0.250
     1        79
               1
            IfAC
           1.000     0.000     0.000
     2        28        28
           (   2    +  3)
          E4-LPI    E4-HPI
           0.333     0.333     0.334
     5         5         7         8         9      11
             ( 2    +   -1   +   -1    +  -1 +  -1)
        ElrHPInj   nElfCRD   nElfCon   nElfLPC nElfSSW
           0.333     0.333     0.334
       Otherwise
           1.000     0.000     0.000
98 Is there water in the reactor cavity after VB?
     3    LDWFld    LRCWet    LRCDry
     2         1         2         3
     7
     2        54        94
               1    +    5
         E5-DFld  I-DWHDf3
           1.000     0.000     0.000
     7        54        64        67        65      66      95      79
               2  (      1   +     1   +     1 +     1)     -3       1
         E5-DWet      HPME      ExSE    I-DWDt  I-DWDf nI-SPB3    LfAC
           1.000     0.000     0.000
     3        84        85        95
           (   1    +   1)        -3
          I-CIgn    IgnFVB   nI-SPB3
           1.000     0.000     0.000
     3        84        85        95
           (   1    +   1)         3
          I-CIgn    IgnFVB    I-SPB3
           0.900     0.100     0.000
     6        64        67        65      66      95      79
          (    1   +     1   +     1  +    1)     -3       1
            HPME      ExSE    I-DWDt  I-DWDf nI-SPB3    LfAC
           0.900     0.100     0.000
     1        54
               2
         E5-DWet
           0.000     1.000     0.000
       Otherwise
           0.000     0.000     1.000
99 What is the nature of the core-concrete interaction?
     5       CCI    WetCCI    FldCCI    DlyCCI   noCCI
     2         1         2         3         4       5
    11
     1        63
               5
         nBreach
           0.000     0.000     0.000     0.000   1.000
     2        97        98
```

```
               1    *    3
        nLDBWat    LRCDry
          1.000     0.000     0.000     0.000   0.000
     5       98        26        28         9      24
              3    *    1  * ( -1    +    -1 *    2)
         LRCDry    E4-HiP    E4-LPI   nElfLPC   E4-AC
          0.000     0.000     0.200     0.000   0.800
     3       98        26        28
              3    *    2    *  -1
         LRCDry    E4-LoP    E4-LPI
          0.000     0.000     0.840     0.000   0.160
     1       98
              3
         LRCDry
          0.500     0.000     0.500     0.000   0.000
     4       98        98        97        26
            ( 1  +      2    *  -1)    *    1
         LDWFld    LRCWet    LDBWat    E4-HiP
          0.000     0.000     0.200     0.000   0.800
     4       98        98        97        61
            ( 1  +      2    *  -1)    *    1
         LDWFld    LRCWet    LDBWat   HiLiqVB
          0.000     0.000     0.840     0.000   0.160
     3       98        98        97
            ( 1  +      2    *  -1)
         LDWFld    LRCWet    LDBWat
          0.000     0.000     0.600     0.000   0.400
     1       26
              1
         E4-HiP
          0.000     0.200     0.000     0.800   0.000
     1       61
              1
        HiLiqVB
          0.000     0.840     0.000     0.160   0.000
      Otherwise
          0.000     0.600     0.000     0.400   0.000
100 What fraction of core not participating in HPME participates in CCI?
     2   HiFCCI    LoFCCI
     4        1         2
     4
     2       63        63
              1    +    5
         A-Fail   nBreach
          0.000     1.000
     1
    45    0.000     0.000
     2       67        61
              1         1
           ExSE   HiLiqVB
          0.000     1.000
     1
    45    0.900     0.600
     2       67        61
              1         2
           ExSE   LoLiqVB
          1.000     0.000
     1
    45    0.900     0.600
      Otherwise
          1.000     0.000
     1
    45    1.000     0.000
101 How much H2 (& equivalent CO) and CO2 are produced during CCI?
     4   H2CCI4    H2CCI3    H2CCI2    H2CCI1
     6        1         2         3         4
```

```
      3
      3        63        63        99
                1    +    5    +    5
           A-Fail   nBreach     noCCI
      7         2        46         8        45      16       42      17
          H2INVES    FEJECT     FH2VB      FCCI   LH2CC     LCO2   FZROX
         FUN-CCI1
        GETHRESH 3    868.50    434.22     17.37

      1        64
                1
             HPME
      7         2        46         8        45      16       42      17
          H2INVES    FEJECT     FH2VB      FCCI   LH2CC     LCO2   FZROX
         FUN-CCI2
        GETHRESH 3    868.50    434.22     17.37

        Otherwise
      7         2        46         8        45      16       42      17
          H2INVES    FEJECT     FH2VB      FCCI   LH2CC     LCO2   FZROX
         FUN-CCI3
        GETHRESH 3    868.50    434.22     17.37

102 What is the level of zirconium oxidation in the pedestal before CCI?
      7    ZrOx75    ZrOx50    ZrOx40    ZrOx30  ZrOx21   ZrOx10 ZrOx<10
      5         1         2         3         4       5        6       7
      1        17
            FZROX
              AND
         GETHRESH         6      0.75      0.50    0.40     0.30    0.21    0.10

103 Is the containment not vented following VB?
      2    InVENT    I-VENT
      2         1         2
      3
      3        79        93        93
                1    +    3    +    4
             LfAC     I-CL3     I-CL4
            1.000     0.000
      4        99        63        81        95
                4    (    5    +    2    +   -3)
            noCCI   nBreach      I-CS   nI-SPB3
            1.000     0.000
        Otherwise
            0.900     0.100
104 Is AC power not recovered late in the accident?
      2      LfAC      L-AC
      2         1         2
      4
      1        79
                2
             I-AC
            0.000     1.000
      1        80
                1
            E1fDC
            1.000     0.000
      2         2        15
                1         2
               SB    CD-Slw
            0.910     0.090
        Otherwise
            0.230     0.770
105 Is DC power available late in the accident?
      2      LfDC      L-DC
      2         1         2
```

```
      4
      1         80
                 1
             F1fDC
             1.000     0.000
      1         79
                 2
              I-AC
             0.000     1.000
      2          2        15
                 1         2
                SB    CD-Slw
             0.330     0.670
        Otherwise
             0.060     0.940
106 What is the late status of containment sprays?
      4       LfCS      LrCS      LaCS      L-CS
      2          1         2         3         4
      8
      1         81
                 1
              IfCS
             1.000     0.000     0.000     0.000
      6         81       104        50        50      93      93
                 2   *     1 * (     1    +   2) *  (  3  +   4)
              IrCS      LfAC     E5nCL    E5-CL2   I-CL3   I-CL4
           !81,2,1   !81,2,2     0.000     0.000
      2         81       104
                 2         1
              IrCS      LfAC
             0.000     1.000     0.000     0.000
      5         81        50        50        93      93
                 4 *  (    1    +   2)    *  ( 3   +  4)
              I-CS     E5nCL    E5-CL2     I-CL3   I-CL4
           !81,4,1     0.000 !81,4,3   !81,4,4
      1         81
                 4
              I-CS
             0.000     0.000     0.000     1.000
      5        104        50        50        93      93
                 2 *  (    1    +   2)    *  ( 3   +  4)
              L-AC     E5nCL    E5-CL2     I-CL3   I-CL4
           !81,6,1   !81,6,2   !81,6,3   !81,6,4
      1        104
                 2
              L-AC
             0.000     0.000 !30,4,3   !30,4,4
        Otherwise -- This case should not be used
             0.000     0.000     1.000     0.000
107 What is the late concentration of combustible gases in the containment?
      6    LGWW>20   LGWW>16   LGWW>12    LGWW>8  LGWW>4 L-NoGWW
      6          1         2         3         4       5       6
      4
      5         63        95        97        98     106
                -5   *    -1   * (  -1    +  -3)   *  -4
            Breach     I-SPB    LDBWat   nLRCDry   nL-CS
      8          1         3         9        16      42      44      4       10
             H2OWW      H2WW      O2WW     LH2CC    LCO2    N2WW   H2DW     O2DW
        FUN-LGWW1
        GETHRESH           5      0.20      0.16    0.12    0.08   0.04

      2         93       103
                -1   +     2
              I-CL    I-VENT
      8          1         3         9        16      42      44      4       10
             H2OWW      H2WW      O2WW     LH2CC    LCO2    N2WW   H2DW     O2DW
```

```
        FUN-LGWW2
        GETHRESH          5      0.20      0.16    0.12    0.08    0.04

      1       106
                4
             L-CS
      8         1         3         9        16      42      44       4       10
            H2OWW      H2WW      O2WW     LH2CC    LCO2    N2WW    H2DW     O2DW
        FUN-LGWW3
        GETHRESH          5      0.20      0.16    0.12    0.08    0.04

        Otherwise
      8         1         3         9        16      42      44       4       10
            H2OWW      H2WW      O2WW     LH2CC    LCO2    N2WW    H2DW     O2DW
        FUN-LGWW4
        GETHRESH          5      0.20      0.16    0.12    0.08    0.04
                  Parse the combustible gas concentration
108 To what level is the wetwell inert after vb?
      3    LnWWIn   L-WWIn2   L-WWIn3
      5         1         2         3
      4         1         3         9        44
            H2OWW      H2WW      O2WW      N2WW
        FUN-WWH2O1
         GETHRESH         3 !40,1,1   !40,1,2   !40,1,3

109 Is there sufficient oxygen in the containment to support late combustion?
      5  LO2Det20  LO2Det16  LO2Det12     LWWO2  LnWWO2
      5         1         2         3         4       5
      4         1         3         9        44
            H2OWW      H2WW      O2WW      N2WW
        FUN-WWO2
        GETHRESH          4       4.0       3.0     2.0     1.0

110 Does ignition occur late in the containment?
      2    L-CIgn    LnCIgn
      2         1         2
      7
      4       107       108       106       109
                6    +    3    *   -4    +    5
          L-NoGWW   I-WWIn3     nL-CS    LnWWO2
            0.000     1.000
      5        82        83        84        85     104
               -3        -5    (    2     *  2)       1
         nI-WWIn3      WWO2    InCIgn    IgnFVB    LfAC
            0.000     1.000
      1       104
                2
             L-AC
            1.000     0.000
      2       107       107
                1    +    2
          LGWW>20   LGWW>16
            0.510     0.490
      1       107
                3
          LGWW>12
            0.420     0.580
      1       107
                4
           LGWW>8
            0.330     0.670
        Otherwise
            0.280     0.720
111 Is there a detonation in the wetwell following vb?
      2    L-WWDt    LnWWDt
      4         1         2
```

```
  9
  8       110       108       108       106       108       107       107       107
            2   +  ( 2    +    3)    *  -4    +  3    +   4    +  5    +   6
       LnCIgn   L-WWIn2   L-WWIn3     nL-CS  L-WWIn  LGWW>8  LGWW>4 L-NoGWW
        0.000     1.000
  1
 20      0.00      0.00
  2        27        79
            1     *   2
       E4-HIS      I-AC
        0.000     1.000
  1
 20      0.00      0.00
  6       107       108       108       109       109       109
            3  * (    2   +    3)   *  (  3   +  2    +  1)
     LGWW>12    L-WWIn2   L-WWIn3  LO2Det12 LO2Dt16 LO2Dt20
        0.220     0.730
  1
 20       5.8      0.00
  4       107       109       109       109
            3     (   3   +  2       +  1)
     LGWW>12   LO2Det12   LO2Dt16   LO2Dt20
        0.000     1.000
  1
 20      0.00      0.00
  5       107       108       108       109       109
            2  * (    2   +    3)   *  (  2  +   1)
     LGWW>16    L-WWIn2   L-WWIn3   LO2Dt16 LO2Dt20
        0.250     0.750
  1
 20       5.8      0.00
  3       107       109       109
            2     (   2   +    1)
     LGWW>16    LO2Dt16   LO2Dt20
        0.260     0.740
  1
 20      12.4      0.00
  4       107       108       108       109
            1  * (    2   +    3)     *   1
     LGWW>20    L-WWIn2   L-WWIn3  LO2Det20
        0.250     0.750
  1
 20       5.8      0.00
  2       107       109
            1         1
     LGWW>20   LO2Det20
        0.450     0.550
  1
 20      12.4      0.00
    Otherwise
        0.000     1.000
  1
 20      0.00      0.00
112 What is the late level of containment impulse load?
  7   L-Ip>60   L-Ip>50   L-Ip>40   L-Ip>30 L-Ip>20 L-Ip>10 L-Ip<10
  5         1         2         3         4       5       6       7
  1        20
      ImpLoad
          AND
     GETHRESH         6     60.00     50.00   40.00   30.00   20.00   10.00
                        $ Parse containment impulse load for verification
113 What is the late gas combustion efficiency?
  1  H2EffCVB
  4         1
  9
  6       110       108       108       106     107     107
```

```
            1   *   ( 2     +   3)   *     4   (   5 +    6)
       L-CIgn   L-WWIn2   L-WWIn3       L-CS  LGWW>4 L-NoGWW
        1.000
  2
 18     0.280                       $ Peak pressure from hydrogen combustion
 19     0.275                       $ Combustion efficiency
  3       110       107       107
            1    (     5    +    6)
       L-CIgn    LGWW>4   L-NoGWW
        1.000
  2
 18     0.280                       $ Peak pressure from hydrogen combustion
 19     0.275                       $ Combustion efficiency
  5       110       108       108       106      107
            1   *   ( 2     +   3)   *     4     * 4
       L-CIgn   L-WWIn2   L-WWIn3       L-CS  LGWW>8
        1.000
  2
 18     0.464
 19     0.740
  2       110       107
            1         4
       L-CIgn    LGWW>8
        1.000
  2
 18     0.575
 19     0.740
  5       110       108       108       106      107
            1   *   ( 2     +   3)   *     4     * 3
       L-CIgn   L-WWIn2   L-WWIn3       L-CS LGWW>12
        1.000
  2
 18     0.483
 19     0.881
  2       110       107
            1         3
       L-CIgn   LGWW>12
        1.000
  2
 18     0.734
 19     0.881
  6       110       108       108       106      107      107
            1   *   ( 2     +   3)   *     4   * (  1 +    2)
       L-CIgn   L-WWIn2   L-WWIn3       L-CS LGWW>20 LGWW>16
        1.000
  2
 18     0.482
 19     0.935
  3       110       107       107
            1    (     1    +    2)
       L-CIgn   LGWW>20   LGWW>16
        1.000
  2
 18     0.752
 19     0.935
    Otherwise
        1.000
  2
 18      0.00
 19      0.00
114 What is be the peak pressure in containment from a late hydrogen burn?
  6  L-PBrn>7  L-PBrn>6  L-PBrn>5  L-PBrn>4 L-PRrn>3 L-PBrn>2
  6         1         2         3         4        5        6
  4
  1       110
            2
```

```
          LnCIgn
     8         3         1         9         5        11        18        19        44
            H2WW    H2OWW      O2WW    EPBase      PBrn H2EfVB1 H2EfVB2      N2WW
      FUN-1PBRN1
       GETHRESH         5     709.3     608.0     506.6   405.3   304.0
                  Parse peak pressure for verification
     4        93        93        27        79
               3     +   4     +   1     *   2
            I-CL3     I-CL4    E4-HIS      I-AC
     8         3         1         9         5        11        18        19        44
            H2WW    H2OWW      O2WW    EPBase      PBrn H2EfVB1 H2EfVB2      N2WW
      FUN-IPBRN2
       GETHRESH         5     709.3     608.0     506.6   405.3   304.0
                  Parse peak pressure for verification
     1       111
               1
          L-WWDt
     8         3         1         9         5        11        18        19        44
            H2WW    H2OWW      O2WW    EPBase      PBrn H2EfVB1 H2EfVB2      N2WW
      FUN-IPBRN3
       GETHRESH         5     709.3     608.0     506.6   405.3   304.0
                  Parse peak pressure for verification
      Otherwise
     8         3         1         9         5        11        18        19        44
            H2WW    H2OWW      O2WW    EPBase      PBrn H2EfVB1 H2EfVB2      N2WW
      FUN-IPBRN4
       GETHRESH         5     709.3     608.0     506.6   405.3   304.0
                  Parse peak pressure for verification
115 What is the level of drywell leakage induced by a late detonation in contain
     3    LnDWDt   L-DWDt2   L-DWDt3
     6         1         2         3
     2
     1       111
               1
          L-WWDt
     3        20        34        35
         ImpLoad    IMPDWF    IMRanD
         FUN-EDI
       GETHRESH         2      2.00      1.00
                  $ Dummy parameter values used to trigger particular branch
      Otherwise -- No detonation and thus no failure
     3        20        34        35
         ImpLoad    IMPDWF    IMRanD
             MAX
       GETHRESH         2      0.00     -1.00
                  $  Parameter values force Branch 1
116 What is the level of containment leakage induced by a late detonation?
     3     LnDtF    L-DtF2    L-DtF3
     6         1         2         3
     3
     2       115       115
               2    +    3
         L-DWDt2   L-DWDt3
     5        20        24        25        34        35
         ImpLoad     IMPCF    IMRanC    IMPDWF    IMRanD
        FUN-ECI1
       GETHRESH         2      2.00      1.00

     1       111
               1
          L-WWDt
     3        20        24        25
         ImpLoad     IMPCF    IMRanC
        FUN-ECI2
       GETHRESH         2      2.00      1.00
```

```
        Otherwise
      3        20        24        25
          ImpLoad     IMPCF    IMRanC
              MAX
         GETHRESH         2      0.00     -1.00
                  $  Parameter values force Branch 1
117 What is the level of containment leakage induced by late combustion events?
      4      LnCL     L-CL2     L-CL3     L-CL4
      6         1         2         3         4
      4
      1        93
                4
            I-CL4
      2         5        11
           EPBase      PBrn
        FUN-LCPLOW
         GETHRESH         3   9999.00   9999.00 9999.00
                            Dummy -- Already ruptured
      3        93       103       116
                3    +    2    +    3
            I-CL3    I-VENT    L-DtF3
      2         5        11
           EPBase      PBrn
        FUN-LCPLOW
         GETHRESH         3   9999.00   9999.00    1.00
                            Dummy -- Already failed
      2        93       116
                2    +    2
            I-CL2    L-DtF2
      4         5        11        21        22
           EPBase      PBrn    PCFail     CFRan
        FUN-ECBrn2
         GETHRESH         3   9999.00      2.00    1.00
                            Dummy -- Already leaking from detonation
        Otherwise
      4         5        11        21        22
           EPBase      PBrn    PCFail     CFRan
        FUN-ECBrn2
         GETHRESH         3      3.00      2.00    1.00
                            Parameter value triggers particular branch
118 What is the level of drywell leakage induced by late combustion?
      5    LnDWDf   L-DWDf2  L-DWHDf2   L-DWDf3 L-DWHDf3
      6         1         2         3         4       5
      7
      2        94       115
                4    +    3
          I-DWDf3   L-DWDt3
      1         5
           EPBase
              AND
         GETHRESH         4   9999.00   9999.00 9999.00    0.00

      1        94
                5
         I-DWHDf3
      1         5
           EPBase
              AND
         GETHRESH         4   9999.00   9999.00 9999.00 9999.00
                  $ Dummy case, head rupture is retained
      4        94       115       117       117
           (    2    +    2)   (    3    +    4)
          I-DWDf2  LI-DWDt2     L-CL3     L-CL4
      4         5        11        30        31
           EPBase      PBrn     EPDWF    DWFRan
        FUN-LDBrn1
```

```
        GETHRESH         4   9999.00      3.00    2.00   -1.00

     2        94       115
               2   +     2
         I-DWDf2  LI-DWDt2
     4         5        11        30        31
          EPBase      PBrn     EPDWF    DWFRan
       FUN-LDBrn2
        GETHRESH         4   9999.00      3.00    2.00   -1.00

     3        94       117       117
               3     (    3  +      4)
         I-DWHDf2     L-CL3     L-CL4
     4         5        11        30        31
          EPBase      PBrn     EPDWF    DWFRan
       FUN-LDBrn3
        GETHRESH         4   9999.00      3.00    2.00   -1.00

     1        94
               3
         I-DWHDf2
     4         5        11        30        31
          EPBase      PBrn     EPDWF    DWFRan
       FUN-LDBrn4
        GETHRESH         4   9999.00      3.00    2.00   -1.00
                 $ Dummy parameters select failure moos
       Otherwise
     4         5        11        30        31
          EPBase      PBrn     EPDWF    DWFRan
       FUN-LDBrn5
        GETHRESH         4      4.00      3.00    2.00   -1.00
                 $ Dummy parameters select failure mode
119 Is the containment not vented late?
     2    LnVENT    L-VENT
     2         1         2
     4
     3       104       117       117
               1  +  (    3  +      4)
            LfAC     L-CL3     L-CL4
           1.000     0.000
     4        99        63        81        95
               4     (   5   +     2    +  -3)
           noCCI   nBreach      I-CS   nI-SPB3
           1.000     0.000
     5        99        63       106       118     118
               4     (   5   +     4    + ( -4     -5))
           noCCI   nBreach      L-CS nL-DWDf3 nL-DWHDf3
        !103,2,1  !103,2,2
       Otherwise
        !103,3,1  !103.3,2
120 How much concrete must be eroded to cause pedestal failure?
     1  ConErPed
     3         1
           1.000
     1
    43      0.40           $ ConErPed: Depth of concrete eroded radially to fai
121 At what time does pedestal failure occur?
     6   PedF@VB   PedF@10    PedF@6    PefF@3  PedF@1  NoPedF
     6         1         2         3         4       5       6
     9
     4        63        63        99        99
               1       + 5         4       + 5
          A-Fail   nBreach    DlyCCI     noCCI
     1        43
        ConErPed
             AND
```

```
         GETHRESH         5   9999.0    9999.0  9999.0  9999.0  9999.0
                            $ Dummy parameters force Branch 0
      2        75        74
                1       + 1
          I-PedFI   I-PedFP
      1        43
         ConErPed
              AND
         GETHRESH         5      0.00     -1.00   -1.00   -1.00   -1.00
                            $ Dummy parameters force Branch 1
      4       102       102        61        99
               -1      * -2       * 1      *  2
          nZrOx75   nZrOx50   HiLiqVB    WetCCI
      1        43
         ConErPed
              AND
         GETHRESH         5   9999.00      0.83     0.55    0.32     0.19

      4       102       102        61        99
               -1      * -2       * 2      *  2
          nZrOx75   nZrOx50   LoLiqVB    WetCCI
      1        43
         ConErPed
              AND
         GETHRESH         5   9999.00      0.79     0.52    0.29     0.16

      1        99
                2
           WetCCI
      1        43
         ConErPed
              AND
         GETHRESH         5   9999.00      0.74     0.49    0.26     0.14

      5       102       102        61        63       63
               -1      * -2       * 1  * (   2    +   3)
          nZrOx75   nZrOx50   HiLiqVB   BH-Fail  LgBrch
      1        43
         ConErPed
              AND
         GETHRESH         5   9999.00      0.83     0.66    0.40     0.20

      3        61        63        63
                1 *  (    2    +   3)
          HiLiqVB   BH-Fail    LgBrch
      1        43
         ConErPed
              AND
         GETHRESH         5   9999.00      0.92     0.73    0.47     0.26

      4       102       102        63        63
               -1      * -2 *  (   2    +   3)
          nZrOx75   nZrOx50   BH-Fail    LgBrch
      1        43
         ConErPed
              AND
         GETHRESH         5   9999.00      0.92     0.71    0.47     0.26

        Otherwise -- Group 4 for MCCI experts
      1        43
         ConErPed
              AND
         GETHRESH         5   9999.00      0.82     0.62    0.40     0.20

122 What is the level of late suppression pool bypass?
      3     LnSPB    L-SPB2    L-SPB3
```

```
      2         1         2         3
      7
      3        95       118       118
                3    +    4    +    5
           I-SPB3   L-DWDf3  L-DWHDf3
            0.000     0.000     1.000
      5        95       118       118       121       121
           (    2    +    2    +    3)       -1        -6
           L-SPB2   L-DWDf2  L-DWHDf2  nPedF@VB    L-PedF
            0.000 !76,2,2   !76,2,1
      5        95       118       118       104       110
           (    2    +    2    +    3)        2         1
           L-SPB2   L-DWDf2  L-DWHDf2      L-AC    L-CIgn
            0.000 !52,2,2   !52,2,3
      3        95       118       118
                2    +    2    +    3
           L-SPB2   L-DWDf2  L-DWHDf2
            0.000     1.000     0.000
      2       121       121
               -1        -6
         nPedF@VB    L-PedF
        !76,2,2       0.000 !76,2,1
      2       104       110
                2         1
             L-AC    L-CIgn
        !52,2,2       0.000 !52,2,3
        Otherwise
            1.000     0.000     0.000
123 What is the late containment pressure due to non-condensibles or steam?
      2   LT-Pres  nLT-Pres
      4         1         2
      4
      2       117       119
               -1    +    2
             L-CL    L-VENT
            0.000     1.000
      1
     47     0.000     0.000
      5        99        63       106       118       118
                4    (    5    +    4    +  ( -4      -5))
            noCCI   nBreach      L-CS nL-DWDf3 nL-DWHDf3
            0.000     1.000
      1
     47     400.0     0.000
      5        63        95        97        98       106
               -5    *    3    * ( -1    +  1)    *   -4
           Breach    I-SPB3    LDBWat    LDWFld     nL-CS
            1.000     0.000
      1
     47 !18,1,1,1     0.000
        Otherwise
            1.000     0.000
      1
     47 !123,2,1,1    0.000
124 Does containment failure occur late due to non-condensibles or steam?
      4     LPnCL    LP-CL2    LP-CL3    LP-CL4
      5         1         2         3         4
      4         5        47        21        22
           EPBASE   LT-PRES    PCFail     CFRan
    FUN-LTPRES
    GETHRESH                3      3.00      2.00      1.00

125 What is the long-term level of containment leakage?
      4     LTnCL    LT-CL2    LT-CL3    LT-CL4
      2         1         2         3         4
      4
```

```
2        117       124
           4     +   4
        L-CL4    LP-CL4
        0.000    0.000     0.000     1.000
3        117       124       110
           3     +   3   +     2
        L-CL3    LP-CL3    L-VENT
        0.000    0.000     1.000     0.000
2        117       124
           2     +   2
        L-CL2    LP-CL2
        0.000    1.000     0.000     0.000
   Otherwise
        1.000    0.000     0.000     0.000
```

A.1.3 Description of the APET Binner

The binner is the computer input file that instructs EVNTRE how to group the APET pathways. There are too many outcomes for all to be saved for analysis afterwards, so as each unique path through the event tree is evaluated, the probability of that path is added to the probability for the appropriate accident progression bin. The term "binner" refers to the computer input file that defines these bins.

Section 2.4 of this volume generally describes the accident progression bins and defines each attribute of each characteristic, so that material is not repeated here. The binner itself, a computer input file read by EVNTRE, defines the accident progression bins and is listed in Subsection A.1.4. This subsection of Appendix A contains a case-by-case description of the binner.

Characteristic 1. ASeq (Plant Damage State Type)
6 Attributes, 6 Cases

The attributes for this characteristic are:

A. Fst-SB The PDS is a short-term SBO. Core damage occurs approximately 1 hour after the initiating event. None of the emergency coolant injection systems provide water to the RPV before core damage.

B. Slw-SB The PDS is a long-term SBO. Core damage occurs approximately 12 hours after the initiating event. Emergency coolant injection systems initially provide water to the core; however, the systems subsequently fail, and the accident proceeds to core damage.

C. Fst-T2 The PDS is a short-term T2 transient. Core damage occurs approximately 1 hour after the initiating event. None of the emergency coolant injection systems provide water to the RPV before core damage. The RPV is at high pressure before core damage.

D. Slw-T2 The PDS is a long-term T2 transient. Core damage occurs approximately 12 hours after the initiating event. Emergency coolant injection systems initially provide water to the core; however, the systems subsequently fail, and the accident proceeds to core damage. The RPV is at high pressure before core damage.

E. Fst-TC The PDS is a short-term ATWS. The standby liquid control system is not initiated, and core damage occurs approximately 1 hour after the initiating event. None of the emergency coolant injection systems provide water to the RPV before core damage. The RPV is at high pressure before core damage.

F. Slw-TC The PDS is a long-term ATWS. The standby liquid control system is not initiated, and core damage occurs approximately 12 hours after the initiating event. Emergency coolant injection systems initially provide water to the core; however, the systems subsequently fail, and the accident proceeds to core damage. The RPV is at high pressure before core damage.

This characteristic represents the type of accident (i.e., SBO, ATWS, or T2) and the time at which core damage occurs.

Case 1: This case defines the conditions for Attribute A, Fst-SB. The conditions for this case are that the PDS must be an SBO and core damage must occur in 1 hour.

Case 2: This case defines the conditions for Attribute B, Slw-SB. The conditions for this case are that the PDS must be an SBO and core damage must occur in 12 hours.

Case 3: This case defines the conditions for Attribute C, Fst-T2. The conditions for this case are that the PDS must be a T2 transient and core damage must occur in 1 hour.

Case 4: This case defines the conditions for Attribute D, Slw-T2. The conditions for this case are that the PDS must be a T2 transient and core damage must occur in 12 hours.

Case 5: This case defines the conditions for Attribute E, Fst-TC. The conditions for this case are that the PDS must be an ATWS and core damage must occur in 1 hour.

Case 6: This case defines the conditions for Attribute F, Slw-TC. The conditions for this case are that the PDS must be an ATWS and core damage must occur in 12 hours.

Characteristic 2. ZrOxid (Fraction of Zirconium Oxidized In-Vessel)
2 Attributes, 2 Cases

The attributes for this characteristic are:

A. HiZrOx A large amount of zirconium was oxidized before VB. This attribute represents pathways in which more than 21% of the zirconium in the core was oxidized.

B. LoZrOx A small amount of zirconium was oxidized in-vessel before VB. This attribute represents pathways in which less than 21% of the zirconium in the core was oxidized.

This characteristic represents fraction of zirconium that is oxidized in the vessel before core damage.

Case 1: This case defines the conditions for Attribute A, HiZrOx. The condition for this case is that the fraction of zirconium oxidized before VB must be greater than 21% of the total inventory of zirconium in the vessel.

Case 2: This case defines the conditions for Attribute B, LoZrOx. The condition for this case is that the fraction of zirconium oxidized before VB must be less than 21% of the total inventory of zirconium in the vessel.

Characteristic 3. VB (Vessel Condition at VB)
5 Attributes, 5 Cases

The attributes for this characteristic are:

A. HiP-nLPI The RPV fails at high pressure and coolant injection is not provided to the RPV after VB.

B. LoP-nLPI The RPV fails at low pressure and coolant injection is not provided to the RPV after VB.

C. HiP-LPI The RPV fails at high pressure and water is being injected into the RPV after VB.

D. LoP-LPI The RPV fails at low pressure and water is being injected into the RPV after VB.

E. nVB The RPV does not fail (i.e., core damage was arrested).

This characteristic represents the RPV pressure just before VB and the availability of coolant injection after VB.

Case 1: This case defines the conditions for Attribute E, nVB. Coolant injection is restored to the RPV during core damage and VB is averted.

Case 2: This case defines the conditions for Attribute A, HiP-nLPI. The conditions for this case are that the RPV must be at high pressure during core damage and water is not supplied to the vessel shortly after VB. Accidents that have partial flow from an injection source after VB or late recovery of an injection system are included in this case.

Case 3: This case defines the conditions for Attribute B, LoP-nLPI. The conditions for this case are that the RPV must be at low pressure (less than 200 psia) during core damage and water is not supplied to the vessel shortly after VB. Accidents that have partial flow from an injection source after VB or late recovery of an injection system are included in this case.

Case 4: This case defines the conditions for Attribute C, HiP-LPI. The conditions for this case are that the RPV must be at high pressure during core damage and water must be supplied to the vessel after VB. The water can be supplied to the RPV either during VB or shortly after

VB Recovery of injection systems late in the accident is not considered in this case.

Case 5: This case defines the conditions for Attribute D, LoP-LPI. The conditions for this case are that the RPV must be at low pressure (less than 200 psia) during core damage and water must be supplied to the vessel after VB. The water can be supplied to the RPV either during VB or shortly after VB. Recovery of injection systems late in the accident is not considered in this case.

Characteristic 4. DCH-SE (Fraction of Core Participating in DCH or Ex-Vessel Steam Explosion)
5 Attributes, 5 Cases

The attributes for this characteristic are:

A. HiDCH A large fraction of the core (40%) participates in an (HPME/DCH) event.

B. LoDCH A small fraction of the core (10%) participates in an HPME/DCH event.

C. HiEXSE A large fraction of the core (20%) participates in an ex-vessel steam explosion.

D. LoEXSE A small fraction of the core (5%) participates in an ex-vessel steam explosion.

E. nDCH-SE Neither an HPME/DCH event nor an ex-vessel steam explosion occurs at VB.

This characteristic represents whether a HPME/DCH event or an ex-vessel steam explosion occurs at VB. This characteristic also indicates the amount of material that is involved in the energetic event.

Case 1: This case defines the conditions for Attribute A, HiDCH. A HPME/DCH event that involves a large amount of molten core debris occurs at VB.

Case 2: This case defines the conditions for Attribute B, LoDCH. A HPME/DCH event that involves a small amount of molten core debris occurs at VB.

Case 3: This case defines the conditions for Attribute C, HiEXSE. An ex-vessel steam explosion that involves a large amount of molten core debris occurs at VB.

Case 4: This case defines the conditions for Attribute D, LoEXSE. An ex-vessel steam explosion that involves a small amount of molten core debris occurs at VB.

Case 5: This case defines the conditions for Attribute E, nDCH-SE. Neither an HPME/DCH event nor an ex-vessel steam explosion occurs at VB.

Characteristic 5. SPB-L (Mode and Timing of Suppression Pool Bypass)
8 Attributes, 8 Cases

The attributes for this characteristic are:

A. SPBE0L0 The suppression pool is not bypassed during the accident.

B. SPBE0I3 The drywell is intact during core damage; however, it is ruptured at VB or shortly after VB.

C. SPBE0L2 The drywell develops a leak late in the accident.

D. SPBE0L3 The drywell is intact early in the accident but is ruptured late in the accident.

E. SPBE2L2 The drywell develops a leak during core damage. The size of the failure does not increase later in the accident.

F. SPBE2I3 The drywell develops a leak during core damage that increases into a rupture at VB or shortly after VB.

G. SPBE2L3 The drywell develops a leak during core damage. The leak increases into a rupture during the late time period.

H. SPBE3L3 The drywell is ruptured during core damage.

The mode and timing of drywell failure are represented by this characteristic. Failure of the drywell establishes a pathway from the drywell to wetwell that bypasses the suppression pool. A leak in the drywell allows some radionuclides in the drywell to bypass the suppression pool, whereas a rupture allows all the radionuclides in the drywell to bypass the pool.

Case 1: This case defines the conditions for Attribute A, SPBE0L0. The condition for this case is that the drywell does not fail during the accident.

Case 2: This case defines the conditions for Attribute B, SPBE0I3. The condition for this case is that the drywell is intact during core damage and then is ruptured shortly after VB.

Case 3: This case defines the conditions for Attribute C, SPBE0L2. The condition for this case is that the drywell is intact during core damage and shortly after VB and then develops a leak during the late time period.

Case 4: This case defines the conditions for Attribute D, SPBE0L3. The condition for this case is that the drywell is intact during core damage and shortly after VB and then is ruptured during the late time period.

Case 5: This case defines the conditions for Attribute E, SPBE2L2. The condition for this case is that the drywell develops a leak either during core damage or shortly after VB. The size of the failure does not increase during the later stages of the accident.

Case 6: This case defines the conditions for Attribute F, SPBE2I3. The condition for this case is that the drywell develops a leak during core damage that increases into a rupture shortly after VB.

Case 7: This case defines the conditions for Attribute G, SPBE2L3. The condition for this case is that the drywell develops a leak either during core damage or shortly after VB. The leak increases into a rupture during the late time period.

Case 8: This case defines the conditions for Attribute H, SPBE3L3. The condition for this case is that the drywell develops a rupture during core damage.

Characteristic 6. CLEAK-L (Mode and Timing of Containment Failure)
9 Attributes, 9 Cases

The attributes for this characteristic are:

A.	CE-Lk	The containment develops a leak during core damage.
B.	CE-Rpt	The containment is ruptured early during core damage.
C.	CE-VENT	The operators vent the containment before core damage.
D.	CVB-Lk	The containment develops a leak shortly after VB.
E.	CVB-Rpt	The containment is ruptured shortly after VB.
F.	CL-Lk	The containment develops a leak late in the accident.
G.	CL-Rpt	The containment is ruptured late in the accident.
H.	CL-VENT	The containment is vented late in the accident.
I.	CnFail	The containment does not fail during the accident.

The mode and timing of containment failure are represented by this characteristic. In a vented containment, the operators knowingly open the vent and release radionuclides to the environment, but in a failed containment, the operators cannot control the event. In the source term analysis a vented containment is treated the same as a ruptured containment.

Case 1: This case defines the conditions for Attribute A, CE-LK. The condition for this case is that the containment develops a leak during core damage, and it does not increase to a rupture during VB. During the late time period, the failure can either remain as a leak or increase into a rupture.

Case 2: This case defines the conditions for Attribute C, CE-VENT. The condition for this case is that the operators vent the containment during core damage.

Case 3: This case defines the conditions for Attribute B, CE-Rpt. The condition for this case is that the containment is ruptured during core damage.

Case 4: This case defines the conditions for Attribute D, CVB-LK. The condition for this case is that the containment is intact during core damage and then develops a leak at VB. During the late time period, the failure can either remain as a leak or increase into a rupture.

Case 5: This case defines the conditions for Attribute E, CVB-Rpt. The condition for this case is that the containment is ruptured at VB. The containment was either intact or leaking during core damage.

Case 6: This case defines the conditions for Attribute F, CL-LK. The condition for this case is that the containment is intact at VB and then develops a leak late in the accident.

Case 7: This case defines the conditions for Attribute H, CL-VENT. The condition for this case is that the containment is intact at VB, and then the operators vent the containment late in the accident.

Case 8: This case defines the conditions for Attribute G, CL-Rpt. The condition for this case is that the containment is intact at VB, and then is ruptured late in the accident.

Case 9: This case defines the conditions for Attribute I, CnFail. The condition for this case is that the containment does not fail during the accident.

Characteristic 7. Sprays (Time Period in Which Containment Sprays Operate)

4 Attributes, 4 Cases

The attributes for this characteristic are:

A.	noCS	The containment sprays do not operate during the accident.
B.	ECSnoL	The containment sprays operate early in the accident but are not available after VB.
C.	LCS	Although the containment sprays do not operate early in the accident, they do operate after VB.
D.	ECS	The containment sprays operate both before and after VB.

The status of the containment spray system during the various time regimes considered in this analysis is represented by this characteristic. The operation of the containment sprays is important in the source term analysis because the water droplets sprayed into the containment atmosphere will remove a fraction of the airborne radionuclides.

Case 1: This case defines the conditions for Attribute A, noCS. The condition for this case is that the sprays do not operate during core damage or shortly after VB. The operation of the sprays during the late time period will not significantly affect the release of radionuclides from the containment. If the containment fails before the late period, most of the radionuclides will have been released before the sprays are recovered. When the containment fails in the late time period, the failure is usually caused either by a hydrogen burn or by the accumulation of noncondensibles or steam. Although hydrogen burns in the late time period are generally ignited when ac power is recovered, the sprays will not be initiated immediately, and most of the releases will not be affected by the sprays. Similarly, the sprays are generally not available when the containment fails from the accumulation of noncondensibles or steam.

Case 2: This case defines the conditions for Attribute B, ECSnoL. The condition for this case is that the sprays operate during core damage but do not operate after VB.

Case 3: This case defines the conditions for Attribute C, LCS. The condition for this case is that the sprays do not operate during core damage but do operate shortly after VB. As mentioned in Case 1, the operation of the sprays during the late time period will not significantly affect the release of radionuclides from the containment.

Case 4: This case defines the conditions for Attribute D, ECS. The condition for this case is that the sprays operate during core damage and shortly after VB. As mentioned in Case 1, the operation of the sprays during the late time period will not significantly affect the release of radionuclides from the containment.

Characteristic 8. MCCI (Type of Core-Concrete Interactions)

5 Attributes, 5 Cases

The attributes for this characteristic are:

A.	DryCCI	Core-concrete interactions occur in a dry cavity.
B.	WetCCI	Core-concrete interactions are initiated in a wet cavity. However, the cavity eventually boils dry.
C.	FLDCCI	Core-concrete interactions occur in a flooded cavity. The core debris is always covered by a pool of water.
D.	DlyCCI	The onset of core-concrete interactions is delayed by several hours.

E. noCCI The core debris in the reactor cavity is cooled by a replenishable source of water. Thus, CCIs do not occur.

This characteristic summarizes the coolability of the core debris in the reactor cavity and the amount of water covering this core debris. If the core debris is coolable, there are no CCIs.

Case 1: This case defines the conditions for Attribute A, DryCCI. The condition for this case is that the core debris in the reactor cavity is not coolable and CCI occurs in a dry cavity.

Case 2: This case defines the conditions for Attribute B, WetCCI. The condition for this case is that the core debris in the reactor cavity is not coolable and CCI occurs in a wet cavity. The water in the cavity is not replenished, so the cavity eventually boils dry.

Case 3: This case defines the conditions for Attribute C, FLDCCI. The condition for this case is that the core debris in the reactor cavity is not coolable and CCI occurs in a flooded cavity. Because of the amount of water in the drywell, the core debris in the cavity will be covered with water throughout the accident.

Case 4: This case defines the conditions for Attribute D, DlyCCI. The condition for this case is that the core debris in the reactor cavity is coolable and the cavity is wet. However, because the water in the cavity is not replenished, the core debris will eventually boil dry. Once the cavity is dry, CCI will be initiated.

Case 5: This case defines the conditions for Attribute E, noCCI. The condition for this case is that the core debris in the reactor cavity is coolable and the cavity is either flooded, or the cavity is wet and there is a replenishable supply of water. Thus, there are no core-concrete interactions.

Characteristic 9. SRVBkr (Occurrence of a Stuck-Open SRV Tailpipe Vacuum Breaker)
2 Attributes, 2 Cases

The attributes for this characteristic are:

A. oSRVBkr An SRV tailpipe vacuum breaker sticks open during core damage.

B. cSRVBkr There are no tailpipe vacuum breakers stuck open.

This characteristic summarizes the performance of the SRV tailpipe vacuum breakers. A tailpipe vacuum breaker sticking open is important because a fraction of the in-vessel releases are discharged into the drywell rather than into the suppression pool. If the drywell fails during core damage, the radionuclides released to the drywell can enter the wetwell without going through the suppression pool. If the drywell is intact during core damage, these releases will enter the wetwell through the horizontal vents in the suppression pool. However, the decontamination factor (DF) associated with releases that pass through the horizontal vents is less than the DF associated with releases that pass through the T quencher at the end of the SRV tailpipe.

Case 1: This case defines the conditions for Attribute A, oSRVBkr. The condition for this case is that an SRV tailpipe vacuum breaker failed to reclose during core damage.

Case 2: This case defines the conditions for Attribute B, cSRVBkr. The condition for this case is that there are no SRV tailpipe vacuum breakers stuck open.

Characteristic 10. CF-BVB (Modes and Events That Cause Containment Failure Before VB)
8 Attributes, 8 Cases

The attributes for this characteristic are:

A.	E-VENT	The operators vent the containment during core damage.
B.	CR-SP	The containment is ruptured during core damage by steam generated from the saturated suppression pool.
C.	CR-DET	A detonation in the wetwell ruptures the containment during core damage.
D.	CR-DEF	A deflagration in the wetwell ruptures the containment during core damage.
E.	CL-SP	Steam generated from a saturated suppression pool fails the containment during core damage. The failure mode is a leak.
F.	CL-DET	A detonation in the wetwell fails the containment during core damage. The failure mode is a leak.
G.	CL-DEF	A deflagration in the wetwell fails the containment during core damage. The failure mode is a leak.
H.	nCFail	The containment does not fail during core damage.

This characteristic summarizes the events that cause containment failure and the mode of containment failure during core damage. This information is not passed on to the source term analysis.

Case 1: This case defines the conditions for Attribute A, E-VENT. The condition for this case is that the operators vent the containment during core damage.

Case 2: This case defines the conditions for Attribute B, CR-SP. The condition for this case is that the containment fails either before or during core damage as a result of the accumulation of steam in the containment. The mode of failure is a rupture. The source of the steam is the saturated suppression pool.

Case 3: This case defines the conditions for Attribute C, CR-DET. The condition for this case is that a detonation in the wetwell ruptures the containment during core damage.

Case 4: This case defines the conditions for Attribute D, CR-DEF. The condition for this case is that a deflagration in the wetwell ruptures the containment during core damage.

Case 5: This case defines the conditions for Attribute E, CL-SP. The condition for this case is that the containment fails either before or during core damage as a result of the accumulation of steam in the containment. The mode of failure is a leak. The source of the steam is the saturated suppression pool.

Case 6: This case defines the conditions for Attribute F, CL-DET. The condition for this case is that a detonation in the wetwell fails the containment during core damage. The mode of failure is a leak.

Case 7: This case defines the conditions for Attribute G, CL-DEF. The condition for this case is that a deflagration in the wetwell fails the containment during core damage. The mode of failure is a leak.

Case 8: This case defines the conditions for Attribute H, nCFail. The condition for this case is that the containment does not fail before VB.

Characteristic 11. CF-VB (Modes and Events That Cause Containment Failure at VB)
8 Attributes, 8 Cases

The attributes for this characteristic are:

A.	ERupt	The containment is ruptured during core damage.
B.	ALPHA	An Alpha Mode event fails the containment.
C.	IR-Det	A detonation in the wetwell ruptures the containment shortly after VB.
D.	IR-Def	A deflagration in the wetwell ruptures the containment shortly after VB.
E.	E-Leak	The containment fails in the leak mode during core damage.
F.	IL-Det	A detonation in the wetwell fails the containment shortly after VB. The mode of failure is a leak.
G.	IL-Def	A deflagration in the wetwell fails the containment shortly after VB. The mode of failure is a leak.

H. nICFail The containment does not fail shortly after VB.

This characteristic summarizes the events that cause containment failure and the mode of containment failure shortly after VB. This information is not passed on to the source term analysis.

Case 1: This case defines the conditions for Attribute A, ERupt. The condition for this case is that the containment is ruptured during core damage.

Case 2: This case defines the conditions for Attribute B, ALPHA. The condition for this case is that a large in-vessel steam explosion results in an Alpha Mode event. The Alpha Mode event ruptures both the drywell and the containment.

Case 3: This case defines the conditions for Attribute C, IR-Det. The condition for this case is that a detonation in the wetwell ruptures the containment shortly after VB.

Case 4: This case defines the conditions for Attribute D, IR-Def. The condition for this case is that a deflagration in the wetwell ruptures the containment shortly after VB.

Case 5: This case defines the conditions for Attribute E, E-Leak. The condition for this case is that the containment fails during core damage. The mode of failure is a leak.

Case 6: This case defines the conditions for Attribute F, IL-Det. The condition for this case is that a detonation in the wetwell fails the containment shortly after VB. The mode of failure is a leak.

Case 7: This case defines the conditions for Attribute G, IL-Def. The condition for this case is that a deflagration in the wetwell fails the containment shortly after VB. The mode of failure is a leak.

Case 8: This case defines the conditions for Attribute H, nICFail. The condition for this case is that the containment does not fail shortly after VB.

Characteristic 12. DF-BVB (Modes and Events That Cause Drywell Failure During Core Damage)
5 Attributes, 5 Cases

The attributes for this characteristic are.

A. DR-Det A detonation in the wetwell ruptures the drywell during core damage.

B. DR-Def A deflagration in the wetwell ruptures the drywell during core damage.

C. DL-Det A detonation in the wetwell fails the drywell in the leak mode during core damage.

D. DL-Def A deflagration in the wetwell fails the drywell in the leak mode during core damage.

E. nDFail The drywell does not fail during core damage.

This characteristic summarizes the events that cause drywell failure and the mode of drywell failure during core damage. Before VB, the only events that can fail the drywell are detonations and severe deflagrations. It is also possible for the drywell to have a pre-existing leak. Because the probability of pre-existing leaks is small, these leaks are grouped with leaks caused by deflagrations. This information is not passed on to the source term analysis.

Case 1: This case defines the conditions for Attribute A, DR-Det. The condition for this case is that a detonation in the wetwell ruptures the drywell during core damage.

Case 2: This case defines the conditions for Attribute B, DR-Def. The condition for this case is that a deflagration in the wetwell ruptures the drywell during core damage.

Case 3: This case defines the conditions for Attribute C, DL-Det. The condition for this case is that a detonation in the wetwell fails the drywell during core damage. The mode of failure is a leak.

Case 4: This case defines the conditions for Attribute D, DL-Def. The condition for this case is that a deflagration in the wetwell fails the drywell during core damage. The mode of failure is a leak.

Case 5: This case defines the conditions for Attribute E, nDFail. The condition for this case is that the drywell does not fail during core damage.

Characteristic 13. DF-VB (Modes and Events That Cause Drywell Failure at VB)
12 Attributes, 12 Cases

The attributes for this characteristic are:

A. EDWRpt The drywell is ruptured during core damage.

B. ALPHA An Alpha Mode event fails the drywell.

C. R-DWOP The drywell is ruptured by quasi-static loads accompanying VB.

D. DR-Det A detonation in the wetwell ruptures the drywell shortly after VB.

E.	DR-Def	A deflagration in the wetwell ruptures the drywell shortly after VB.
F.	R-PedP	The failure of the reactor pedestal at VB ruptures the drywell. Quasi-static loads accompanying VB fail the pedestal.
G.	R-PedSE	The failure of the reactor pedestal at VB ruptures the drywell. Dynamic loads associated with an ex-vessel steam explosion fail the pedestal at VB.
H.	EDWLK	The drywell fails in the leak mode during core damage.
I.	L-DWOP	Quasi-static loads accompanying VB fail the drywell in the leak mode.
J.	DL-Det	A detonation in the wetwell fails the drywell shortly after VB. The mode of failure is a leak.
K.	DL-Def	A deflagration in the wetwell fails the drywell shortly after VB. The mode of failure is a leak.
L.	nIDWF	The drywell does not fail shortly after VB.

This characteristic summarizes the events that cause drywell failure and the mode of drywell failure shortly after VB. This information is not passed on to the source term analysis.

Case 1: This case defines the conditions for Attribute A, EDWRpt. The condition for this case is that the drywell is ruptured during core damage.

Case 2: This case defines the conditions for Attribute B, ALPHA. The condition for this case is that a large in-vessel steam explosion results in an Alpha Mode event that ruptures both the drywell and the containment

Case 3: This case defines the conditions for Attribute C, R-DWOP. The condition for this case is that the drywell is ruptured at VB by the quasi-static loads accompanying VB. These loads include contributions from DCH, ex-vessel steam explosions, and RPV blowdown.

Case 4: This case defines the conditions for Attribute D, DR-Det. The condition for this case is that a detonation in the wetwell ruptures the drywell shortly after VB.

Case 5: This case defines the conditions for Attribute E, DR-Def. The condition for this case is that a deflagration in the wetwell ruptures the drywell shortly after VB.

Case 6: This case defines the conditions for Attribute F, R-PedP. The condition for this case is that failure of the reactor pedestal at VB ruptures the drywell. Quasi-static loads accompanying VB fail the pedestal.

Case 7: This case defines the conditions for Attribute G, R-PedSE. The condition for this case is that failure of the reactor pedestal at VB ruptures the drywell. Dynamic loads associated with an ex-vessel steam explosion failed the pedestal at VB.

Case 8: This case defines the conditions for Attribute H, EDWLK. The condition for this case is that the drywell fails during core damage. The mode of failure was a leak.

Case 9: This case defines the conditions for Attribute I, L-DWOP. The condition for this case is that the drywell fails in the leak mode at VB by the quasi-static loads accompanying VB. These loads include contributions from DCH, ex-vessel steam explosions, and RPV blowdown.

Case 10: This case defines the conditions for Attribute J, DL-Det. The condition for this case is that a detonation in the wetwell fails the drywell shortly after VB. The mode of failure is a leak.

Case 11: This case defines the conditions for Attribute K, DL-Def. The condition for this case is that a deflagration in the wetwell fails the drywell shortly after VB. The mode of failure is a leak.

Case 12: This case defines the conditions for Attribute L, nIDWF. The condition for this case is that the drywell does not fail shortly after VB.

A.1.4 Listing of the APET Binner

Section 2.4 of this volume generally describes the accident progression bins and defines each attribute of each characteristic, so that material is not repeated here. Subsection A.1.3 is a detailed case-by-case description of the binner. The binner, a computer input file read by EVNTRE, is listed here.

The binner file uses a format similar to that used in the APET, with the same mnemonic abbreviations for each branch of every question. The structure of the binner file is explained in the EVNTRE reference manual, NUREG/CR-5174.[A-10] The binner is listed below.

```
GRAND GULF BINNING INPUT  ** Version 7 **
13     ASeq      ZrOxid    VB        DCH-SE    SPB-L   CLEAK-L SPRAYS
       MCCI      SRVBKr    CF-BVB    CF-VB     DF-BVB  DF-VB
 6   6 Fst-SB      Slw-SB    Fst-T2    Slw-T2  Fst-TC  Slw-TC
 1   1        20
               1
          Fst-SB
 1   2        20
               2
          Slw-SB
 1   3        20
               3
          Fst-T2
 1   4        20
               4
          Slw-T2
 1   5        20
               5
          Fst-TC
 1   6        20
               6
          Slw-TC
 2   2    HiZrOx    LoZrOx
 2   1        36        36
              -6    *    -7
         nZrOx10  nZrOx<10
 2   2        36        36
               6     +   7
          ZrOx10   ZrOx<10
 5   5  HiP-nLPI  LoP-nLPI   HiP-LPI   LoP-LPI       nVB
 1   5        63
               5
         nBreach
 3   1        26        97        97
               1      (  1     +  2)
          E4-HiP   nLDBWat  S-LDBWat
 2   2        97        97
            (  1     +  2)
         nLDBWat  S-LDBWat
 1   3        26
               1
          E4-HiP
 1   4        26
               2
          E4-LoP
 5   5     HiDCH     LoDCH    HiEXSE    LoEXSE nDCH-SE
 2   1        64        61
               1         1
            HPME   HiLiqVB
 1   2        64
               1
            HPME
 2   3        67        61
               1         1
            ExSE   HiLiqVB
 1   4        67
               1
            ExSE
 2   5        64        67
               2         2
           nHPME     nExSE
 8   8   SPBE0L0   SPBE0I3   SPBE0L2   SPBE0L3 SPBE2L2 SPBE2I3 SPBE2L3 SPBE3L3
 1   1       122
               1
           LnSPB
```

```
2   2       52        95
             1         3
        E5nSPB    I-SPB3
3   3       52        95       122
             1         1         2
        E5nSPB     InSPB    L-SPB2
3   4       52        95       122
             1         1         3
        E5nSPB     InSPB    L-SPB3
5   5       95       122        52        95     122
           ( 2      * 2)      + (1       * 2    * 2)
        I-SPB2    L-SPB2    E5nSPB    I-SPB2  L-SPB2
2   6       52        95
             2     *   3
       E5-SPB2    I-SPB3
2   7       95       122
             2     *   3
        I-SPB2    L-SPB3
1   8       52
             3
       E5-SPB3
9   9    CE-Lk    CE-Rpt   CE-VENT    CVB-Lk CVB-Rpt   CL-Lk  CL-Rpt
       CL-VENT    CnFail
2   1       50        93
             2       * 2
        E5-CL2     I-CL2
1   3       22
             2
       E3-VENT
2   2       50        50
             3       + 4
        E5-CL3    E5-CL4
1   4       93
             2
         I-CL2
2   5       93        93
             3       + 4
         I-CL3     I-CL4
1   6      125
             2
        LT-CL2
2   8      103       119
             2     +   2
        I-Vent    L-Vent
2   7      125       125
             3       + 4
        LT-CL3    LT-CL4
1   9      125
             1
         LTnCL
4   4     noCS    ECSnoL       LCS       ECS
6   1       30        81       106        30      81     106
          (  -4    *   -4    *  -4)   + (  -4  *   -4  *  4)
        nE4-CS     nI-CS     nL-CS    nE4-CS   nI-CS    L-CS
3   2       30        81       106
             4        -4        -4
         E4-CS     nI-CS     nL-CS
6   3       30        81       106        30      81     106
          (  -4    *    4    *  -4)   + (  -4  *    4  *  4)
        nE4-CS      I-CS     nL-CS    nE4-CS    I-CS    L-CS
6   4       30        81       106        30      81     106
          (   4    *    4    *  -4)   + (   4  *    4  *  4)
         E4-CS      I-CS     nL-CS     E4-CS    I-CS    L-CS
5   5   DryCCI    WetCCI    FLDCCI    DlyCCI   noCCI
1   1       99
             1
```

```
                CCI
1   2            99
                  2
             WetCCI
1   3            99
                  3
             FldCCI
1   4            99
                  4
             DlyCCI
1   5            99
                  5
              noCCI
2   2       oSRVBkr   cSRVBkr
1   1            23
                  1
            oSRVBkr
1   2            23
                  2
            cSRVBkr
8   8        E-VENT     CR-SP    CR-DET    CR-DEF   CL-SP  CL-DET  CL-DEF  nCFail
1   1            22
                  2
             E3VENT
3   2            16        38        38
                  3    +    3    +    4
              E1-L3   ESP-CL3   ESP-CL4
1   3            49
                  3
            E4-DtF3
2   4            50        50
                  3    +    4
               -CL3    E5-CL4
2   5            16        38
                  2    +    2
              E1-L2   ESP-CL2
1   6            49
                  2
            E4-DtF2
1   7            50
                  2
             E5-CL2
1   8            50
                  1
              E5nCL
8   8         ERupt     ALPHA    IR-Det    IR-Def  E-Leak  IL-Det  IL-Def nICFail
2   1            50        50
                  3    +    4
             E5-CL3    E5-CL4
1   2            58
                  1
              ALPHA
1   3            92
                  3
             I-DtF3
2   4            93        93
                  3    +    4
              I-CL3     I-CL4
1   5            50
                  2
             E5-CL2
1   6            92
                  2
             I-DtF2
```

```
 1  7        93
              2
          I-CL2
 1  8        93
              1
           InCL
 5  5    DR-Det    DR-Def    DL-Det    DL-Def  nDFail
 1  1        48
              3
        E-DWDt3
 1  2        52
              3
        E5-SPB3
 2  3        48        17
              2     *  -2
        E-DWDt2   E1-SPB2
 1  4        52
              2
        E5-SPB2
 1  5        52
              1
        E5-SPB1
12 12    EDWRpt     ALPHA    R-DWOP    R-PedP R-PedSE   DR-Det  DR-Def
          EDWLk    L-DWOP    DL-Det    DL-Def   nIDWF
 1  1        52
              3
        E5-SPB3
 1  2        58
              1
          ALPHA
 2  3        73        73
              4     +   5
        I-DWOP3  I-DWHOP3
 2  4        76        74
              1     *   1
       I-DWFPed   I-PedFP
 1  5        76
              1
       I-DWFPed
 2  6        91        72
              3     +   3
        I-DWDt3   I-DWFI3
 1  7        95
              3
          I-SPB3
 1  8        52
              2
        E5-SPB2
 2  9        73        73
              2     +   3
        I-DWOP2  I-DWHOP2
 2 10        91        72
              2     +   2
        I-DWDt2   I-DWFI2
 1 11        95
              2
         I-SPB2
 1 12        95
              1
          InSPB
```

A.1.5 Description of the APET Rebinner

Section 2.4 of this volume generally describes the accident progression bins and defines each attribute of each characteristic, so that material is not repeated here. The binning scheme utilized for the evaluation of the APET does not exactly match the input information required by GGSOR. The additional information in the initial binning is kept because it provides a better record of the outcomes of the APET evaluation. Therefore, there is a step between the evaluation of the APET and the evaluation of GGSOR known as "rebinning." In rebinning, a few attributes in some characteristics are combined because there are no significant differences between them for calculating the fission product releases.

In the rebinning for Grand Gulf, there are no changes for Characteristics 1 through 9. That is, for these nine characteristics, the information produced by the APET is exactly that used by GGSOR. Characteristics 10, 11, 12, and 13, provide additional information on the types of events that caused containment and drywell failure. This additional information is not used by GGSOR and has therefore been deleted in the rebinning process.

A.1.6 Listing of the APET Rebinner

Section 2.4 of this volume generally describes rebinning and defines each attribute of each characteristic of the accident progression bins, so that material is not repeated here. Subsection A.1.5 describes the function of the rebinner. The rebinner, a computer input file read by the EVNTRE postprocessing code, PSTEVNT, is listed here.

The rebinner file uses a format similar to that used in the APET binner. It uses mnemonic abbreviations for each attribute of each characteristic in a manner similar to the way in which the binner itself uses the mnemonic question and branch mnemonic indicators of the APET. The structure of the rebinner file is explained in the PSTEVNT Reference Manual, NUREG/CR-5380.[A-11] The rebinner is listed below.

```
ACCIDENT PATHWAY BINNING FOR GGSOR
9 ASeq   ZrOxid        VB    DCH-SE       SPB       CF  SPRAYS
  MCCI   SRVBkr
6   6    Fst-SB    Slw-SB    Fst-T2    Slw-T2  Fst-TC  Slw-TC
1   1         1
              1
         Fst-SB
1   2         1
              2
         Slw-SB
1   3         1
              3
         Fst-T2
1   4         1
              4
         Slw-T2
1   5         1
              5
         Fst-TC
1   6         1
              6
         Slw-TC
2   2    HiZrOx    LoZrOx
1   1         2
              1
         HiZrOx
1   2         2
              2
         LoZrOx
5   5  HiP-nLPI  LoP-nLPI   HiP-LPI   LoP-LPI      nVB
1   1         3
              1
       HiP-nLPI
1   2         3
              2
       LoP-nLPI
1   3         3
              3
        HiP-LPI
1   4         3
              4
        LoP-LPI
1   5         3
              5
            nVB
5   5     HiDCH     LoDCH    HiEXSE    LoEXSE nDCH-SE
1   1         4
              1
          HiDCH
1   2         4
              2
          LoDCH
1   3         4
              3
         HiEXSE
1   4         4
              4
         LoEXSE
1   5         4
              5
        nDCH-SE
8   8   SPBE0L0   SPBE0I3   SPBE0L2   SPBE0L3  SPBE2L2 SPBE2I3 SPBE2L3 SPBE3L3
1   1         5
              1
        SPBE0L0
```

```
 1   2          5
                2
          SPBE0I3
 1   3          5
                3
          SPBE0L2
 1   4          5
                4
          SPBE0L3
 1   5          5
                5
          SPBE2L2
 1   6          5
                6
          SPBE2I3
 1   7          5
                7
          SPBE2L3
 1   8          5
                8
          SPBE3L3
 9   9      CE-Lk     CE-Rpt   CE-VENT    CVB-Lk CVB-Rpt   CL-Lk  CL-Rpt
          CL-VENT     CnFail
 1   1          6
                1
            CE-Lk
 1   2          6
                2
           CE-Rpt
 1   3          6
                3
          CE-VENT
 1   4          6
                4
           CVB-Lk
 1   5          6
                5
          CVB-Rpt
 1   6          6
                6
            CL-Lk
 1   7          6
                7
           CL-Rpt
 1   8          6
                8
          CL-VENT
 1   9          6
                9
           CnFail
 4   4       noCS     ECSnoL       LCS        ECS
 1   1          7
                1
             noCS
 1   2          7
                2
           ECSnoL
 1   3          7
                3
              LCS
 1   4          7
                4
              ECS
 5   5     DryCCI     WetCCI    FLDCCI    DlyCCI   noCCI
 1   1          8
                1
```

```
          DryCCI
1   2          8
               2
          WetCCI
1   3          8
               3
          FLDCCI
1   4          8
               4
          DlyCCI
1   5          8
               5
           noCCI
2   2   oSRVBkr    cSRVBkr
1   1          9
               1
         oSRVBkr
1   2          9
               2
         cSRVBkr
```

A.2 DESCRIPTION AND LISTING OF THE USER FUNCTION

A.2.1 Description of the User Function for the Grand Gulf APET

The user function is a FORTRAN function subprogram linked with EVNTRE after compilation. Without the user function, EVNTRE is applicable to any event tree evaluation problem. Once linked with the user function for the Grand Gulf APET, however, an executable module of EVNTRE specific for Grand Gulf is created. The user function allows calculations and manipulations to be performed as the event tree is evaluated that are too complicated to be treated in the tree itself.

The general types of calculations performed in the user function in support of the Grand Gulf APET are those that:

- Determine the containment baseline pressure during the various time periods;
- Compute the amount of hydrogen released to the containment at VB and during CCI;
- Compute the concentration and the flammability of the atmosphere in the containment and drywell during the various time periods;
- Calculate the pressure rise due to hydrogen burns;
- Determine whether the containment fails and the mode of failure;
- Determine whether the drywell fails and the mode of failure.

The Grand Gulf user function consists of a series of computational modules, each identified by a six character name. The APET accesses the computational modules through these names. APET question types 6 through 8 are used to access the user function. The command in the APET used to access the user function is FUN-######, where # represents an alphanumeric character. For example, the command FUN-EBASP1 in Question 37 accesses the computational module EBASP1 in the user function. The various computational modules in the Grand Gulf user function are listed in Table A.2-1. In addition to the name of the module, the APET question number from which the module is called and a brief description of the calculation performed in the module are included in this table.

The Grand Gulf user function utilizes four other FORTRAN functions: PSLOW, PFAST, H2BURN, and XINTRP. The functions PSLOW and PFAST determine whether the containment (or drywell) fails, and the mode of failure for the slow and fast pressure rise methods, respectively. The logic coded in these two functions is explained in more detail in the following paragraphs. The function H2BURN calculates the overpressure that results from the combustion of hydrogen in an air/steam mixture based on the adiabatic isochoric complete combustion (AICC) model. This function is used with information provided by the Containment Loads Expert Panel to determine the peak pressure in the containment following a hydrogen burn. The function H2BURN calls the function UENERG, which is used to calculate the change in internal energy of the gaseous constituents as a result of the burn. The function XINTRP is a utility function used to interpolate linearly between points in a distribution.

The method of determining containment (or drywell) failure and the mode of failure warrants additional discussion. This discussion will refer to the containment structure, but the methods are also applicable to the drywell structure. Furthermore, the method as explained below considers three modes of failure: leak, rupture, and catastrophic rupture. However, the probability that the Grand Gulf containment will fail as a catastrophic rupture (CR) is negligible. Thus, in the numerical examples discussed below, the probability of a CR is zero. These methods can also be extended to more than three modes of failure. In fact, the routines coded in the functions PSLOW and PFAST can handle five locations with up to five failure modes at each location.

The method is straightforward for determining the mode of containment failure for a pressure rise that is slow compared to the leak rate, but the method is more complex for determining the mode of containment failure for a pressure rise that is fast compared to the leak rate. For each observation in the sample, the LHS code selects a containment failure pressure from containment failure pressure distribution (see Volume 2, Part 6) and a random number between zero and one to be used to determine the mode of failure. The load pressure depends on the progression of the accident, and it either can be a fixed value or can be sampled from a distribution. The load pressure is considered a known quantity in the following discussion.

The load pressure and the containment failure pressure are compared in either function PSLOW or function PFAST, depending on whether the pressure rise is slow or fast. If the load pressure is less than the containment failure pressure, the containment does not fail. If the load pressure is greater than or equal to the containment failure pressure, the containment fails. If the containment fails, the random number is used to determine the failure mode.

If the pressure rise is slow compared to the time it takes a leak to depressurize the containment, the conditional failure probabilities (contained in the array PCONC) for the load pressure are used directly. If the random number is less than the leak conditional probability, the failure mode is leak. If the random number is greater than the leak conditional probability but less than the sum of the leak conditional probability and the rupture conditional probability, the failure mode is rupture. If the random number is greater than the sum of the leak conditional probability and the rupture conditional probability, the failure mode is catastrophic rupture. Consider an example in which the failure pressure is 335 kPa and the load pressure is greater than 335 kPa. The data statements in the user function show that the conditional probability for leak at 335 kPa is 0.69, so if the random number is less than 0.69, the failure mode is leak. The interval conditional probability for rupture is 0.31 (conditional probability of CR is 0.0), so if the random number is between 0.69 and 1.0, the failure mode is rupture.

If the pressure rise is fast compared to the time it takes a leak to depressurize the containment, the determination of the failure mode is more complicated. Development of a leak will not arrest the pressure rise in the containment, and a rupture or catastrophic rupture may occur at a higher pressure. The pressure will keep on rising until the load pressure is reached, or until a rupture or catastrophic rupture occurs and terminates the pressure rise. Figure A.2-1 illustrates the process for discrete steps. At the failure pressure, there is some probability of rupture and CR. Most of the failures are shown as leaks in this illustration, and for them, the pressure rises to the next step, where again a fraction is converted to rupture and CR. The process stops at the load pressure. The leak fraction remaining at that pressure is the total leak probability. The rupture probability is the total of all the rupture fractions at all the steps, and similarly for CR.

Function PFAST performs an analogous calculation for mode of containment failure considering all the pressures between the failure pressure and the load pressure. It calculates the probability of rupture or catastrophic rupture (CR) at all these intermediate pressures and then sums them to obtain total conditional probabilities for each failure mode. These probabilities are specific to the pair of failure and load pressures considered. Once the total conditional probabilities for failure mode are computed, the random number is used to choose the failure mode as in the slow pressure rise case.

Consider an example in which the failure pressure is 335 kPa and the load pressure is 363 kPa. If the containment fails by rupture or CR at 335 kPa, the failure is so large that the pressure rises no further. However, if a leak develops at 335 kPa, the pressure will keep on rising, and a rupture or CR may develop between 335 and 363 kPa. The probability of an additional failure between 335 and 363 kPa is proportional to the failure probability density (FPD) for this pressure interval. The portion of the cumulative failure probability (CFP) distribution below 335 kPa is discounted because failure has occurred at 335 kPa. Thus, the probability used to determine whether an additional failure will occur between 335 and 363 kPa is not FPD(335) = 0.108 [i.e., CFP(363) - CFP(335)], but FPD(335)/[1 - CFP(335)] = 0.108/(1 - 0.33) = 0.16. The conditional probability of additional ruptures forming between 335 and 363 kPa is the conditional leak probability at 335 kPa times the conditional rupture probability for the 363 kPa interval times the failure probability for the interval. For the conditional rupture probability, C_{rp}, for the interval between 335 and 363 kPa, the average of the values for 335 and 363 kPa is used: (0.31 + 0.43)/2 = 0.37. Thus, the total conditional probability of rupture, for rapid pressure rise with a failure pressure of 335 kPa and a load pressure of 363 kPa, is:

$$0.31 + 0.69 * 0.37 * 0.16 = 0.35.$$

In general terms, this is:

$$R_{rp}(i) = R_{rp}(i-1) + R_{lk}(i-1) * 0.5 * [(C_{rp}(i) + C_{rp}(i-1)] * FPD(i)/[1 - CFP(i-1)]$$

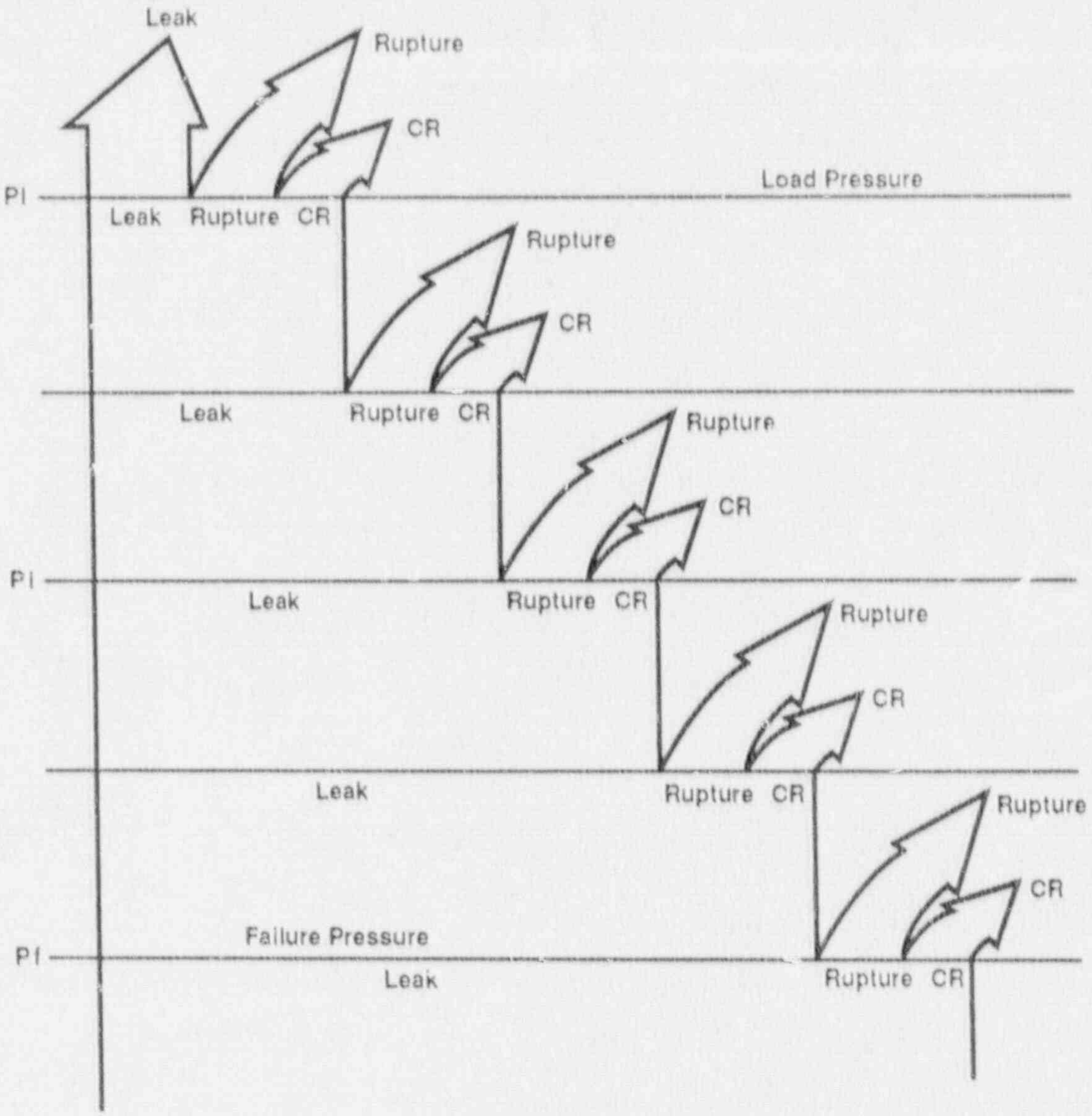

Figure A.2-1. Process Used to Determine the Mode of Containment Failure for Fast Pressure Rise.

where C_{rp}, FPD, and CFP have been defined above and R_{rp} and R_{lk} are the conditional probabilities of rupture and leak for fast pressure rise. There is an analogous equation for R_{cr}, the conditional probability of catastrophic rupture for fast pressure rise. After R_{rp} and R_{cr} have been found, the remaining leak fraction is found from:

$$R_{lk}(i) = 1 - R_{rp}(i) - R_{cr}(i).$$

For a rapid pressure rise, a failure pressure of 335 kPa, and a load pressure of 363 kPa, the conditional probabilities of leak and rupture may be shown to be 0.65 and 0.35, respectively. To determine the mode of containment failure for fast pressure rise, the random number is used as it is for slow pressure rise. In this example, if the random number is less than 0.65, the failure mode is leak. If the random number is greater than 0.65, the failure mode is rupture.

To find the conditional failure mode probabilities for fast pressure rise, function PFAST integrates from the failure pressure to the load pressure in 28-kPa increments (for the drywell, the increments are 37 kPa), incrementing the rupture (and CR if there were any) conditional probabilities at each step and decreasing the leak conditional probability. Partial intervals are used at the beginning and the end of this process.

Table A.2-1
Grand Gulf User Function Description

UFUN Name	Question Number	Description
EBASP#	37	The containment pressure before VB is computed (# = 1-5).
SLWP#	38	Computes whether the containment fails and the mode of failure caused by slow pressurization events before VB (# = 1-2).
H2WW#	39	Computes the hydrogen concentration (mole %) in the wetwell for the time regime before VB (# = 1-7).
INRT	40	Determines whether the wetwell is inert to hydrogen detonations or deflagrations for the time regime before VB.
H2DW#	42	Computes the hydrogen concentration (mole %) in the drywell for the time regime before VB (# = 1-6).
EPBRN#	47	Computes the peak pressure in the wetwell and the peak drywell/wetwell pressure differential associated with a hydrogen burn in the wetwell (# = 1-4).
EDI	48,91,115	Determines whether the drywell fails and the mode of failure from detonations in the wetwell.
ECI#	49,92,116	Determines whether the containment fails and the mode of failure from detonations in the wetwell (# = 1,2).
ECBrn#	50,93,117	Determines whether the containment fails and the mode of failure from quasi-static pressurization events caused by hydrogen burns in the wetwell (# = 1,2).
EDBrn#	51	Determines whether the drywell fails and the mode of failure from quasi-static pressurization events caused by hydrogen burns in the wetwell (# = 1-4).
IBASP#	55	Computes the containment pressure for the time period immediately before VB (# = 1-5).

Table A.2-1 (Continued)

UFUN Name	Question Number	Description
DWIN1	56	Determines whether the drywell is inert to hydrogen detonations or deflagrations.
DWCBVB	57	Determines whether there is sufficient hydrogen for a combustion or detonation in the drywell before VB.
H2AVB#	69	Computes the amount of hydrogen that is released at VB (released from RPV, DCH, and ex-vessel steam explosion), (# = 1,2).
IDI1LD	72	Determines whether the drywell fails and the mode of failure from hydrogen detonations in the drywell at VB.
DWFAVB	73	Determines whether the drywell fails and the mode of failure from quasi-static pressurization events in the drywell associated with VB.
IH2WW#	78	Computes the hydrogen concentration (mole %) in the wetwell for the time period associated with VB (# = 1-7).
WWH2O1	82,108	Determines whether the wetwell is inert to hydrogen detonations or deflagrations.
WWO2	83,109	Determines whether there is sufficient oxygen in the containment to support a hydrogen deflagration or detonation.
IPBRN#	89,114	Computes the peak pressure in the wetwell and the peak drywell/wetwell pressure differential associated with a hydrogen burn in the wetwell immediately following VB (# = 1-4).
CPC#	90	Computes the peak containment pressure for the time regime associated with VB (# = LOW,1,2,3).
IDBrn#	94	Determines whether the drywell fails and the mode of failure from quasi-static pressurization events in the wetwell that are associated with VB (# = 1-5).

Table A.2-1 (Continued)

UFUN Name	Question Number	Description
LBASP#	96	Computes the baseline containment pressure for the time period following VB (# = 1-3).
CCI#	101	Computes the amount of hydrogen, carbon monoxide, and carbon dioxide that are produced during CCI (# = 1-3).
LCWW#	107	Computes the hydrogen concentration (mole %) in the wetwell for the late time regime (# = 1-4).
LCPLOW	117	Sets the containment pressure to atmospheric pressure for those cases that have a ruptured containment
LDBrn#	118	Determines whether the drywell fails and the mode of failure from quasi-static pressurization events caused by hydrogen burns in the wetwell (# = 1-5).
LTPRES	124	Computes whether the containment fails and the mode of failure caused by slow pressurization events in the late time regime.

A.2.2 Listing of the Grand Gulf APET User Function

This section contains a listing of the FORTRAN function subprogram GGUFUN.FOR.

```
C
C
C  GRAND GULF CET USER FUNCTION SUBROUTINE - REV 7
C
C  THE FUNCTION UFUN MANIPULATES THE PARAMETERS THAT ARE ASSIGNED IN THE
C  CET.  THE LOGIC FOR CALLING THE UFUN IS CONTAINED IN THE CET, UFUN
C  ONLY MANIPULATES THE PARAMETER VALUES.  THE PARAMETER NUMBERS ARE
C  CONTAINED IN THE ARRAY IDARG (e.g. IDARG(1) CONTAINS THE FIRST PARAMETER
C  NUMBER LISTED FOR A GIVEN FUNCTION CALL).  THE ARRAY ARG CONTAINS THE
C  VARIOUS PARAMETER VALUES.  NARG IS THE NUMBER OF PARAMETERS LISTED FOR
C  A GIVEN FUNCTION CALL.  NAME CONTAINS THE NAME (6 CHARACTERS) OF THE
C  MODULE IN UFUN TO BE ACCESSED.  THIS CHARACTER STRING CORRESPONDS TO
C  THE NAME ASSIGNED IN THE CET (e.g. FUN_H2WW1)
C
      FUNCTION UFUN(NAME,NARG,IDARG,ARG)
C
      DIMENSION ARG(*),IDARG(*),PTABLE(5,5),PX(5),PY(5),
     +  PC(21),   PTC(21),   PCONC(21,3,1),  MPC(5),
     +  PED(21),  PTED(21),  PCONED(21,2,2), MPED(5),
     +  PID(21),  PTID(21),  PCONID(21,2,2), MPID(5),
     +  DC(41),   DTC(41),   DCONC(41,2,1),  MDC(5),
     +  DD(50),   DTD(50),   DCOND(50,2,1),  MDD(5),
     +  PDIF6(6,2), PDIF10(6,2), PDIF14(6,2), PDIF18(6,2),
     +  PDIF25(6,2)
      CHARACTER*6 NAME, FRATE
      REAL INERTS, NTOT, NTOTI, NTOTWW, NTOTDW, NLEAK,
     +     N2WW, H2, NATM, NATMDW
C
C  INPUT DATA
C
      DATA O2FRAC, FPRED, FH2DET, FH2COM/0.21, 0.8, 0.16, 0.06/
      DATA FO2COM, FH2LK/0.05, 1.43/
      DATA FH2LK2, FH2LK3, FO2BRN, FDWVB/ 0.01, 0.05, 0.05, 0.16/
      DATA FH2DCH,FCCIWW/0.9, 0.95/
      DATA ZRWT, CZRH2, CVCOH2/ 79240.0, 0.0219, 1.17/
      DATA VOLWW, VOLDW/ 39650.0, 7640.0/
      DATA PATM, NATM, NATMDW, H2SRVV/ 101.324, 1582.0, 305.0, 10.0/
      DATA STMHI, STMMED, STMLOW/ 4235.0, 2200.0, 75.0/
      DATA DWSTM1, DWSTM2/ 392.0, 183.0/
      DATA C11H2, C12H2, C21H2, C22H2    / 1400.,  .0, 839.0, 140.0/
      DATA C11CO, C12CO, C21CO, C22CO    / 2000., 0.0, 959.0, 260.0/
      DATA C11CO2, C12CO2, C21CO2, C22CO2/ 160.,  0.0, 120.0, 10.0/
C
C  STRUCTURAL CAPACITY INPUT FOR THE CONTAINMENT AND DRYWELL
C
C  **** CONTAINMENT FAILURE FROM QUASI-STATIC LOADS ***
C
C     PC     = PRESSURE (kPa)
C     PTC    = TOTAL CUMULATIVE FAILURE PROBABILITY CORRESPONDING TO PC
C     PCONC  = CONDITIONAL FAILURE FOR EACH MODE AT EACH LOCATION
C     NPLC   = NUMBER OF FAILURE LOCATIONS
C     NPPC   = NUMBER OF POINTS IN PC & PTC
C     MPC(K) = TOTAL NUMBER OF MODES AT LOCATION K
C
      DATA PC/195.0, 223.0, 251.0, 279.0, 307.0, 335.0, 363.0, 391.0,
     +       419.0, 447.0, 475.0, 503.0, 531.0, 559.0, 587.0, 615.0,
     +       643.0, 671.0, 699.0, 727.0, 755.0/
C
      DATA PTC/0.000, 0.022, 0.042, 0.115, 0.223, 0.330, 0.438,0.545,
     +        0.653, 0.760, 0.868, 0.952, 0.958, 0.965, 0.971,0.978,
     +        0.984, 0.990, 0.994, 0.997, 1.000/
C
      DATA PCONC/1.000, 1.000, 1.000, 0.927, 0.808,0.689,0.569,0.450,
     +          0.330, 0.211, 0.091, 0.001, 0.001,0.001,0.001,0.001,
     +          0.001, 0.001, 0.001, 0.001, 0.001,
     +          0.000, 0.000, 0.000, 0.073, 0.192,0.311,0.431,0.550,
```

```
     +          0.670, 0.789, 0.909, 0.999, 0.999,0.999,0.999,0.999,
     +          0.999, 0.999, 0.999, 0.999, 0.999,
     +          21*0.00/
C
      DATA NPLC, NPPC, MPC/1, 21, 3, 4*0/
C
C  **** DRYWELL FAILURE INTERNAL FROM QUASI-STATIC LOADS ***
C
C     PID     = PRESSURE (kPa)
C     PTID    = TOTAL CUMULATIVE FAILURE PROBABILITY CORRESPONDING TO PC
C     PCONID  = CONDITIONAL FAILURE FOR EACH MODE AT EACH LOCATION
C     NPLID   = NUMBER OF FAILURE LOCATIONS
C     NPPID   = NUMBER OF POINTS IN PC & PTC
C     MPID(K) = TOTAL NUMBER OF MODES AT LOCATION K
C
      DATA PID/260.0, 297.0, 334.0, 371.0, 408.0, 445.0, 482.0,519.0,
     +         556.0, 593.0, 630.0, 667.0, 704.0, 741.0, 778.0,815.0,
     +         852.0, 889.0, 926.0, 963.0, 1000.0/
C
      DATA PTID/0.000, 0.022, 0.044, 0.099, 0.168, 0.237,0.306,0.375,
     +          0.444, 0.513, 0.582, 0.651, 0.720, 0.789,0.858,0.927,
     +          0.957, 0.968, 0.979, 0.989, 1.000/
C
      DATA PCONID/1.000, 1.000, 1.000, 0.946,0.869,0.792,0.716,0.639,
     +            0.562, 0.486, 0.409, 0.332,0.256,0.179,0.102,0.026,
     +            0.001, 0.001, 0.001, 0.001,0.001,
     +            0.000, 0.000, 0.000, 0.054,0.131,0.208,0.284,0.361,
     +            0.438, 0.514, 0.591, 0.668,0.744,0.821,0.898,0.974,
     +            0.999, 0.999, 0.999, 0.999,0.999,
     +            21*0.000, 21*0.000/
C
      DATA NPLID, NPPID, MPID/2, 21, 2, 2, 3*0/
C
C  **** DRYWELL FAILURE EXTERNAL FROM QUASI-STATIC LOADS ***
C
C     PED     = PRESSURE (kPa)
C     PTED    = TOTAL CUMULATIVE FAILURE PROBABILITY CORRESPONDING TO PC
C     PCONED  = CONDITIONAL FAILURE FOR EACH MODE AT EACH LOCATION
C     NPLED   = NUMBER OF FAILURE LOCATIONS
C     NPPED   = NUMBER OF POINTS IN PC & PTC
C     MPED(K) = TOTAL NUMBER OF MODES AT LOCATION K
C
      DATA PED/260.0, 297.0, 334.0, 371.0, 408.0, 445.0, 482.0,519.0,
     +         556.0, 593.0, 630.0, 667.0, 704.0, 741.0, 778.0,815.0,
     +         852.0, 889.0, 926.0, 963.0, 1000.0/
C
      DATA PTED/0.000, 0.022, 0.044, 0.099, 0.168, 0.237,0.306,0.375,
     +          0.444, 0.513, 0.582, 0.651, 0.720, 0.789,0.858,0.927,
     +          0.957, 0.968, 0.979, 0.989, 1.000/
C
      DATA PCONED/1.000, 1.000, 1.000, 0.946,0.869,0.792,0.716,0.639,
     +            0.562, 0.486, 0.409, 0.332,0.256,0.179,0.102,0.026,
     +            0.001, 0.001, 0.001, 0.001,0.001,
     +            0.000, 0.000, 0.000, 0.054,0.131,0.208,0.284,0.361,
     +            0.438, 0.514, 0.591, 0.668,0.744,0.821,0.898,0.974,
     +            0.999, 0.999, 0.999, 0.999,0.999,
     +            21*0.000, 21*0.000/
C
      DATA NPLED, NPPED, MPED/2, 21, 2, 2, 3*0/
C
C  **** CONTAINMENT FAILURE IMPULSIVE LOADS ***
C
C     DC      = IMPULSE (kPa-Sec)
C     DTC     = TOTAL CUMULATIVE FAILURE PROBABILITY CORRESPONDING TO PC
C     DCONC   = CONDITIONAL FAILURE FOR EACH MODE AT EACH LOCATION
C     NDLC    = NUMBER OF FAILURE LOCATIONS
```

```
C     NDPC   = NUMBER OF POINTS IN PC & PTC
C     MDC(K) = TOTAL NUMBER OF MODES AT LOCATION K
C
      DATA DC/2.5,    5.0,   7.5,  10.0,  12.5,  15.0,  17.5,  20.0,
     +        22.5,  25.0,  27.5,  30.0,  32.5,  35.0,  37.5,  40.0,
     +        42.5,  45.0,  47.5,  50.0,  52.5,  55.0,  57.5,  60.0,
     +        62.5,  65.0,  67.5,  70.0,  72.5,  75.0,  77.5,  80.0,
     +        82.5,  85.0,  87.5,  90.0,  92.5,  95.0,  97.5,  100.0,
     +        102.5/
C
      DATA DTC/0.026, 0.130, 0.273, 0.360, 0.445, 0.525, 0.590, 0.652,
     +         0.709, 0.747, 0.771, 0.795, 0.818, 0.836, 0.852, 0.869,
     +         0.885, 0.902, 0.916, 0.929, 0.939, 0.950, 0.957, 0.965,
     +         0.971, 0.977, 0.980, 0.983, 0.986, 0.989, 0.991, 0.993,
     +         0.994, 0.996, 0.997, 0.998, 0.998, 0.999, 0.999, 0.999,
     +         1.000/
C
      DATA DCONC/0.877, 0.856, 0.829, 0.782, 0.650, 0.507,0.309,0.266,
     +           0.226, 0.211, 0.211, 0.211, 0.211, 0.211,0.211,0.211,
     +           0.211, 0.211, 0.211, 0.211, 0.211, 0.211,0.211,0.211,
     +           0.211, 0.211, 0.211, 0.211, 0.211, 0.211,0.211,0.211,
     +    0.211, 0.211, 0.211, 0.211, 0.211, 0.211, 0.211,0.211,0.211,
     +           0.123, 0.144, 0.171, 0.218, 0.350, 0.493,0.692,0.734,
     +           0.774, 0.789, 0.789, 0.789, 0.789, 0.789,0.789,0.789,
     +           0.789, 0.789, 0.789, 0.789, 0.789, 0.789,0.789,0.789,
     +           0.789, 0.789, 0.789, 0.789, 0.789, 0.789,0.789,0.789,
     +    0.789, 0.789, 0.789, 0.789, 0.789, 0.789, 0.789,0.789,0.789/
C
      DATA NDLC, NDPC, MDC/1, 41, 2, 4*0/
C
C  **** DRYWELL FAILURE IMPULSIVE LOADS ***
C
C     DD     = IMPULSE (kPa-Sec)
C     DTD    = TOTAL CUMULATIVE FAILURE PROBABILITY CORRESPONDING TO PC
C     DCOND  = CONDITIONAL FAILURE FOR EACH MODE AT EACH LOCATION
C     NDLD   = NUMBER OF FAILURE LOCATIONS
C     NDPD   = NUMBER OF POINTS IN PC & PTC
C     MDD(K) = TOTAL NUMBER OF MODES AT LOCATION K
C
      DATA DD/2.5,   5.0,   7.5,   10.0,  12.5,  15.0,  17.5,  20.0,
     +        22.5,  25.0,  27.5,  30.0,  32.5,  35.0,  37.5,  40.0,
     +        42.5,  45.0,  47.5,  50.0,  52.5,  55.0,  57.5,  60.0,
     +        62.5,  65.0,  67.5,  70.0,  72.5,  75.0,  77.5,  80.0,
     +        82.5,  85.0,  87.5,  90.0,  92.5,  95.0,  97.5,  100.0,
     +        102.5, 105.0, 107.5, 110.0, 112.5, 115.0, 117.5, 120.0,
     +        122.5, 125.0/
C
      DATA DTD/0.000, 0.020, 0.055, 0.104, 0.165, 0.234, 0.313, 0.385,
     +         0.450, 0.506, 0.551, 0.595, 0.637, 0.670, 0.698, 0.723,
     +         0.747, 0.770, 0.791, 0.811, 0.828, 0.844, 0.855, 0.867,
     +         0.877, 0.887, 0.895, 0.902, 0.909, 0.916, 0.922, 0.928,
     +         0.934, 0.939, 0.945, 0.950, 0.954, 0.959, 0.963, 0.968,
     +         0.972, 0.977, 0.981, 0.982, 0.984, 0.986, 0.987, 0.989,
     +         0.991, 0.993/
C
      DATA DCOND/0.877, 0.870, 0.861, 0.846, 0.836, 0.827,0.818,0.750,
     +           0.706, 0.619, 0.463, 0.459, 0.456, 0.452,0.446,0.440,
     +           0.434, 0.428, 0.421, 0.416, 0.409, 0.403,0.397,0.391,
     +           0.385, 0.379, 0.373, 0.366, 0.359, 0.352,0.345,0.338,
     +           0.332, 0.324, 0.318, 0.311, 0.304, 0.297,0.290,0.283,
     +           0.276, 0.269, 0.263, 0.258, 0.254, 0.249,0.244,0.240,
     +           0.235, 0.230,
     +           0.123, 0.130, 0.139, 0.154, 0.164, 0.173,0.183,0.250,
     +           0.294, 0.381, 0.537, 0.540, 0.544, 0.548,0.554,0.560,
     +           0.566, 0.572, 0.578, 0.585, 0.591, 0.597,0.603,0.609,
     +           0.615, 0.622, 0.627, 0.634, 0.641, 0.648,0.655,0.662,
```

```
     +          0.669, 0.675, 0.683, 0.689, 0.696, 0.703,0.710,0.717,
     +          0.724, 0.731, 0.738, 0.742, 0.747, 0.751,0.756,0.761,
     +          0.765, 0.770/
C
      DATA NDLD, NDPD, MDD/1, 50, 2, 4*0/
C
C  WETWELL/DRYWELL PRESSURE DIFFERENTIAL  DATA
C
C  H2 CONCENTRATION = 6%
C
      DATA PDIF6/ 156.0, 196.0, 213.0, 248.0, 278.0, 284.0,
     +             0.0  , 0.38 , 0.54 , 0.75 , 0.96 , 1.0/
C
C  H2 CONCENTRATION = 10%
C
      DATA PDIF10/ 198.0, 258.0, 291.0, 357.0, 431.0, 440.0,
     +              0.0  , 0.38 , 0.59 , 0.77 , 0.97 , 1.0/
C
C  H2 CONCENTRATION = 14%
C
      DATA PDIF14/ 185.0, 294.0, 344.0, 423.0, 562.0, 583.0,
     +              0.0  , 0.44 , 0.63 , 0.81 , 0.97 , 1.0/
C
C  H2 CONCENTRATION = 18%
C
      DATA PDIF18/ 173.0, 318.0, 375.0, 480.0, 669.0, 701.0,
     +              0.0  , 0.49 , 0.69 , 0.83 , 0.98 , 1.0/
C
C  H2 CONCENTRATION = 25%
C
      DATA PDIF25/ 152.0, 353.0, 418.0, 575.0, 842.0, 893.0,
     +              0.0  , 0.59 , 0.79 , 0.86 , 0.98 , 1.0/
C
C  THE 2-DIMENSTIONAL ARRAY PTABLE IS AN EXAMPLE MATRIX OF PRESSURE
C  RISE FROM HYDROGEN BURNS AS A FUNCTION OF PERCENT HYDROGEN AND
C  PERCENT STEAM.  THE ONE DIMENSTIONAL ARRAYS PX AND PY CONTAIN THE
C  TWO INDEPENDENT VARIABLES, %H2 AND %STEAM, RESPECTIVELY.
C
      DATA PTABLE/5.1,5.2,5.3,5.4,5.5,4.1,4.2,4.3,4.4,4.5,
     + 3.1,3.2,3.3,3.4,3.5,2.1,2.2,2.3,2.4,2.5,1.1,1.2,1.3,1.4,1.5/
      DATA PX,PY/5,10,15,20,60,0,5,10,20,40/
C
C======================================================================
C  INITIAL CONTAINMENT PRESSURE (AND STEAM CONCENTRATION CORRECTIONS)
C
      IF(NAME(:5).EQ.'EBASP')THEN
       O2WW  = ARG(IDARG(1))
       N2WW  = ARG(IDARG(2))
       H2OWW = ARG(IDARG(3))
       H2WW  = ARG(IDARG(4))
C
C  O2WW  = AMOUNT OF O2 IN WETWELL BEFORE H2 BURN (Kg-Mols)
C  N2WW  = AMOUNT OF N2 IN WETWELL BEFORE H2 BURN (Kg-Mols)
C  H2OWW = AMOUNT OF H2O IN WETWELL BEFORE H2 BURN (Kg-Mols)
C  H2WW  = AMOUNT OF H2 IN WETWELL BEFORE H2 BURN (Kg-Mols)
C
C  PRE-EXISTING RUPTURE OR CONTAINMENT VENTED
C  (OR LONG TERM ATWS)
C
       IF(NAME(6:6).EQ.'1')THEN
         PWW = PATM
C
C  CONTAINMENT SPRAYS ARE WORKING - WETWELL NOT PRESSURIZED BY STEAM
C
       ELSEIF(NAME(6:6).EQ.'2')THEN
         PWW = PATM*(O2WW+N2WW+H2OWW+H2WW)/(O2WW+N2WW+H2OWW)
```

```
C
C  LONG-TERM STATION BLACKOUT WITH SPRAYS RECOVERED
C
      ELSEIF(NAME(6:6).EQ.'3')THEN
        PWW = 303.0
        PCTH2O = H2OWW/( O2WW + N2WW + H2OWW + H2WW )
C
C  IF STEAM CONCENTRATION GREATER THAN 55%, REDUCE TO 55% TO ACCOUNT
C  FOR SPRAYS (H2 BURNS WILL BE CONSIDERED AT 55% H2O FOR THIS CASE)
C
        IF(PCTH2O.GT.0.55)THEN
          H2OWWF = 0.55*(O2WW+N2WW+H2WW)/0.45
          PWW = PWW*(H2OWWF+H2WW+O2WW+N2WW)/(H2OWW+O2WW+N2WW)
          H2OWW = H2OWWF
        ENDIF
C
C  VERY LONG-TERM STATION BLACKOUT - NO AC OR DC POWER
C  VERY HIGH STEAM CONCENTRAION
C
      ELSEIF(NAME(6:6).EQ.'4')THEN
        PWW = 498.0*(H2OWW+H2WW+O2WW+N2WW)/(H2OWW+O2WW+N2WW)
C
C  LONG-TERM STATION BLACKOUT WITHOUT SPRAYS
C
      ELSEIF(NAME(6:6).EQ.'5')THEN
        PWW = 303.0*(H2OWW+H2WW+O2WW+N2WW)/(H2OWW+O2WW+N2WW)
      ENDIF
      ARG(IDARG(3)) = H2OWW
      ARG(IDARG(5)) = PWW
      UFUN = PWW
      RETURN
C
C=======================================================================
C  DOES THE CONTAINMENT FAIL FROM SLOW PRESSURIZATION DURING CORE DAMAGE
C
C  LONG TERM ATWS (HPCS > 5 HR.S)
C  PRESSURE WILL CONTINUE TO RISE UNTIL FAILURE, THUS, PL = PF
C
      ELSEIF(NAME(:5).EQ.'SLWP1')THEN
       PL = ARG(IDARG(1))
       PF = ARG(IDARG(1))
       RN = ARG(IDARG(2))
       UFUN = PSLOW(PL,PF,RN,PC,PTC,PCONC,NPLC,MPC,NPPC)
       RETURN
C
C  VERY LONG TERM STATION BLACKOUT (CD AT APPROX. 18 HR.S)
C
      ELSEIF(NAME(:5).EQ.'SLWP2')THEN
       PL = ARG(IDARG(1)) - PATM
       PF = ARG(IDARG(2))
       RN = ARG(IDARG(3))
       UFUN = PSLOW(PL,PF,RN,PC,PTC,PCONC,NPLC,MPC,NPPC)
       RETURN
C
C=======================================================================
C  MAXIMUM HYDROGEN CONCENTRATION IN WETWELL BEFORE VB?
C
      ELSEIF(NAME(:4).EQ.'H2WW')THEN
C
C  H2VES = AMOUNT OF H2 RELEASED IN-VESSEL (KG-MOLS)
C  H2OWW = AMOUNT OF STEAM IN WETWELL (KG-MOLS)
C  O2WW  = AMOUNT OF OXYGEN IN WETWELL (KG-MOLS)
C  N2WW  = AMOUNT OF NITROGEN IN WETWELL (KG-MOLS)
C  H2WW  = AMOUNT OF HYDROGEN IN WETWELL BEFORE A BURN (KG-MOLS)
C  NTOT  = TOTAL NUMBER OF MOLES IN WETWELL BEFORE A BURN
C
```

```
      H2VES = ARG(IDARG(1))
      H2OWW = ARG(IDARG(2))
      O2WW  = ARG(IDARG(3))
      N2WW  = ARG(IDARG(5))
C
C  STUCK OPEN SRV TAILPIPE VACUUM BREAKER AND A LONG-TERM ATWS
C  (CONTAINMENT FAILED, AIR PURGED OUT BY STEAM)
C
      IF(NAME(5:6).EQ.'1 ')THEN
        H2WW   = H2VES - H2SRVV
        IF( H2VES .LE. H2SRVV) H2WW = 0.0
        H2WW   = NATM*( 1.0 -EXP( -H2WW/NATM ))
        H2OWW  = NATM - H2WW
        O2WW   = 0.0
        N2WW   = 0.0
        NTOT   = H2WW + H2OWW + O2WW + N2WW
        UFUN   = H2WW/NTOT
        ARG(IDARG(2)) = H2OWW
        ARG(IDARG(3)) = O2WW
        ARG(IDARG(4)) = H2WW
        ARG(IDARG(5)) = N2WW
        ARG(IDARG(6)) = NTOT
        RETURN
C
C  STUCK OPEN SRV TAILPIPE VACUUM BREAKER AND A LARGE CONTAINMENT FAILURE
C  (MOLE FRACTIONS OF CONSTITUENTS ASSUMED TO BE THE SAME BEFORE AND AFTER
C  CONTAINMENT FAILURE - ONLY THE TOTAL NUMBER OF MOLES HAS CHANGED)
C
      ELSEIF(NAME(5:6).EQ.'2 ')THEN
        H2WW   = H2VES - H2SRVV
        IF( H2VES .LE. H2SRVV) H2WW = 0.0
        NTOT   = H2OWW + O2WW + N2WW + H2WW
        YO2    = O2WW/NTOT
        YN2    = N2WW/NTOT
        YH2O   = H2OWW/NTOT
        YH2    = H2WW/NTOT
        H2OWW  = NATM*YH2O
        H2WW   = NATM*YH2
        O2WW   = NATM*YO2
        N2WW   = NATM*YN2
        NTOT   = H2WW + O2WW + N2WW + H2OWW
        UFUN   = H2WW/NTOT
        ARG(IDARG(2)) = H2OWW
        ARG(IDARG(3)) = O2WW
        ARG(IDARG(4)) = H2WW
        ARG(IDARG(5)) = N2WW
        ARG(IDARG(6)) = NTOT
        RETURN
C
C  LONG-TERM ATWS (CONTAINMENT FAILED, AIR PURGED OUT BY STEAM.  AS H2
C  IS INJECTED INTO CONTAINMENT STEAM AND H2 IS PURGED OUT)
C
      ELSEIF(NAME(5:6).EQ.'3 ')THEN
        H2WW   = H2VES
        H2WW   = NATM*( 1.0 -EXP( -H2WW/NATM ))
        H2OWW  = NATM - H2WW
        O2WW   = 0.0
        N2WW   = 0.0
        NTOT   = H2WW + O2WW + N2WW + H2OWW
        UFUN   = H2WW/NTOT
        ARG(IDARG(2)) = H2OWW
        ARG(IDARG(3)) = O2WW
        ARG(IDARG(4)) = H2WW
        ARG(IDARG(5)) = N2WW
        ARG(IDARG(6)) = NTOT
        RETURN
```

```
C
C  LARGE CONTAINMENT FAILURE (MOLE FRACTIONS OF CONSTITUENTS ASSUMED
C  TO BE THE SAME BEFORE AND AFTER CONTAINMENT FAILURE - ONLY THE TOTAL
C  NUMBER OF MOLES HAS CHANGED)
C
      ELSEIF(NAME(5:6).EQ.'4 ')THEN
        H2WW   = H2VES
        NTOT   = H2OWW + O2WW + N2WW + H2WW
        YO2    = O2WW/NTOT
        YN2    = N2WW/NTOT
        YH2O   = H2OWW/NTOT
        YH2    = H2WW/NTOT
        H2OWW  = NATM*YH2O
        H2WW   = NATM*YH2
        O2WW   = NATM*YO2
        N2WW   = NATM*YN2
        NTOT   = H2WW + O2WW + N2WW + H2WW
        UFUN   = H2WW/NTOT
        ARG(IDARG(2)) = H2OWW
        ARG(IDARG(3)) = O2WW
        ARG(IDARG(4)) = H2WW
        ARG(IDARG(5)) = N2WW
        ARG(IDARG(6)) = NTOT
        RETURN
C
C  WHEN A SRV TAILPIPE VACUUM BREAKER STICK OPEN IT IS ESTIMATED THAT
C  THE H2 CONCENTRATION IN THE DRYWELL WILL BE APPROXIMATELY 2.5% OR
C  10.0 Kg-Mols [H2SRVV] (BASED ON MELCOR CALCULATIONS). IF THE AMOUNT
C  OF H2 RELEASED BEFORE VB IS LESS THAN 10 Kg-Mole, IT IS
C  ASSUMED THAT ALL OF THE H2 REMAINS IN THE DRYWELL.
C
C  STUCK OPEN SRV TAILPIPE VACUUM BREAKER (NO LARGE CONTAINMENT FAILURE)
C
      ELSEIF(NAME(5:6).EQ.'5 ')THEN
        H2WW = H2VES - H2SRVV
        IF( H2VES .LE. H2SRVV ) H2WW = 0.0
        NTOT = H2WW + O2WW + N2WW + H2OWW
        UFUN = H2WW/NTOT
        ARG(IDARG(4)) = H2WW
        ARG(IDARG(6)) = NTOT
        RETURN
C
C  LARGE SUPPRESSION POOL BYPASS - A FRACTION OF THE H2 LEAKS INTO THE
C  DRYWELL
C
      ELSEIF(NAME(5:6).EQ.'6 ')THEN
        H2WW = H2VES*(1.0 - FH2LK3)
        NTOT = H2WW + O2WW + N2WW + H2OWW
        UFUN = H2WW/NTOT
        ARG(IDARG(4)) = H2WW
        ARG(IDARG(6)) = NTOT
        RETURN
C
C  ONLY NOMINAL LEAKAGE BETWEEN THE DRYWELL AND WETWELL
C  (NEGLIGIBLE AMOUNT OF H2 IS REMOVED FROM THE WETWELL)
C
      ELSEIF(NAME(5:6).EQ.'7 ')THEN
        H2WW = H2VES
        NTOT = H2WW + O2WW + N2WW + H2OWW
        UFUN = H2WW/NTOT
        ARG(IDARG(4)) = H2WW
        ARG(IDARG(6)) = NTOT
        RETURN
      ENDIF
C
C=======================================================================
```

```
C  INERT LEVEL OF WETWELL DURING CORE DEGRADATION
C  THIS MODULE DETERMINES BOTH THE CONCENTRATION OF STEAM AND OXYGEN
C  IN THE WETWELL.  IF OXYGEN CONCENTRATION IS LESS THAN 5% IT IS ASSUMED
C  THAT THERE IS INSUFFICIENT OXYGEN FOR COMBUSTION AND THE VALUE RETURNED
C  BY UFUN IS 0.0.  IF THE OXYGEN CONCENTRATION IS GREATER THAN 5%,
C  (1 - STEAM CONCENTRATION) IN THE WETWELL IS RETURNED BY UFUN.
C
      ELSEIF(NAME.EQ.'INRT  ')THEN
        H2OWW = ARG(IDARG(1))
        H2WW  = ARG(IDARG(2))
        O2WW  = ARG(IDARG(3))
        PCTH2O =  H2OWW/( H2OWW + H2WW + O2WW/O2FRAC)
        PCTO2  =  O2WW/( H2OWW + H2WW + O2WW/O2FRAC)
        UFUN = 1.0 - PCTH2O
        IF( PCTO2 .LT. FO2COM) UFUN = 0.0
        RETURN
C
C============================================================================
C  MAXIMUM H2 CONCENTRATION IN THE DRYWELL DURING CORE DEGRADATION
C
      ELSEIF(NAME(:4).EQ.'H2DW')THEN
       H2VES = ARG(IDARG(1))
       H2WW  = ARG(IDARG(2))
       H2ODW = ARG(IDARG(3))
       O2DW  = ARG(IDARG(4))
C
C  H2VES = AMOUNT OF H2 RELEASED IN-VESSEL (KG-MOLS)
C  H2ODW = AMOUNT OF STEAM IN DRYWELL (KG-MOLS)
C  O2DW  = AMOUNT OF OXYGEN IN DRYWELL (KG-MOLS)
C  H2DW  = ANOUNT OF HYDROGEN IN DRYWELL BEFORE A BURN (KG-MOLS)
C
C  STUCK OPEN SRV TAILPIPE VACUUM BREAKER AND A LONG-TERM ATWS
C  (CONTAINMENT FAILED, AIR PURGED OUT BY STEAM)
C
       IF(NAME(5:6).EQ.'1 ')THEN
         H2DW = H2SRVV
         IF( H2VES .LT. H2SRVV ) H2DW = H2VES
         H2ODW = NATMDW - H2DW
         O2DW  = 0.0
         UFUN = H2DW/( H2DW + H2ODW + O2DW/O2FRAC )
         ARG(IDARG(3)) = H2ODW
         ARG(IDARG(4)) = O2DW
         ARG(IDARG(5)) = H2DW
         RETURN
C
C  STUCK OPEN SRV TAILPIPE VACUUM BREAKER AND A LARGE CONTAINMENT FAILURE
C  (MOLE FRACTIONS OF CONSTITUENTS ASSUMED TO BE THE SAME BEFORE AND AFTER
C  CONTAINMENT FAILURE - ONLY THE TOTAL NUMBER OF MOLES HAS CHANGED)
C
       ELSEIF(NAME(5:6).EQ.'2 ')THEN
         H2DW   = H2SRVV
         IF( H2VES .LE. H2SRVV) H2DW = H2VES
         NTOT   = H2ODW + O2DW/O2FRAC + H2DW
         YO2    = O2DW/NTOT
         YH2O   = H2ODW/NTOT
         YH2    = H2DW/NTOT
         H2ODW  = NATMDW*YH2O
         H2DW   = NATMDW*YH2
         O2DW   = NATMDW*YO2
         UFUN   = H2DW/(H2DW + O2DW/O2FRAC + H2ODW)
         ARG(IDARG(3)) = H2ODW
         ARG(IDARG(4)) = O2DW
         ARG(IDARG(5)) = H2DW
         RETURN
C
C  STUCK OPEN SRV TAILPIPE VACUUM BREAKER - NO LARGE CONTAINMENT FAILURE
```

```
C
      ELSEIF(NAME(5:6).EQ.'3 ')THEN
        H2DW = H2SRVV
        IF( H2VES .LT. H2SRVV ) H2DW = H2VES
        UFUN  = H2DW/(H2DW + H2ODW + O2DW/O2FRAC)
        ARG(IDARG(5)) = H2DW
        RETURN
C
C  LARGE SUPPRESSION POOL BYPASS WITH NO DIFFUSION FLAME (FRACTION OF THE
C  WETWELL HYDROGEN ENTERS THE DRYWELL (NOTE: WETWELL H2 HAS ALREADY BEEN
C  REDUCED TO ACCOUNT FOR THE LEAKAGE INTO THE DRYWELL FOR THIS CASE)
C
      ELSEIF(NAME(5:6).EQ.'4 ')THEN
        H2DW = H2WW*FH2LK3/(1.0 - FH2LK3)
        UFUN = H2DW/( H2DW + H2ODW + O2DW/O2FRAC)
        ARG(IDARG(5)) = H2DW
        RETURN
C
C  SMALL SUPPRESSION POOL BYPASS WITH NO DIFFUSION FLAME (FRACTION OF THE
C  WETWELL HYDROGEN ENTERS THE DRYWELL (NOTE: WETWELL H2 HAS NOT BEEN
C  REDUCED TO ACCOUNT FOR THE LEAKAGE INTO THE DRYWELL FOR THIS CASE)
C
      ELSEIF(NAME(5:6).EQ.'5 ')THEN
        H2DW = H2WW*FH2LK2
        UFUN = H2DW/( H2DW + H2ODW + O2DW/O2FRAC)
        ARG(IDARG(5)) = H2DW
        ARG(IDARG(2)) = H2WW*(1 - FH2LK2)
        RETURN
C
C  NOMINAL LEAKAGE - NEGLIGIBLE H2 ENTERS THE DRYWELL
C
      ELSEIF(NAME(5:6).EQ.'6 ')THEN
        H2DW = 0.0
        UFUN = H2DW/( H2DW + H2ODW + O2DW/O2FRAC)
        ARG(IDARG(5)) = H2DW
        RETURN
      ENDIF
C
C=======================================================================
C  PEAK PRESSURE FROM H2 BURN BVB
C
      ELSEIF(NAME(:5).EQ.'EPBRN'.OR. NAME(:5).EQ.'IPBRN')THEN
        H2MAX  = ARG(IDARG(1))
        H2O    = ARG(IDARG(2))
        O2     = ARG(IDARG(3))
        PBASE  = ARG(IDARG(4))
        EFFBC  = ARG(IDARG(6))
        ACTBC  = ARG(IDARG(7))
        N2     = ARG(IDARG(8))
        TI     = 350.0
        NTOT   = ARG(14)
C
C  ARG(12) = PEAK WETWELL/DRYWELL PRESSURE DIFFERENCE
C  ARG(14) = TOTAL NUMBER OF MOLES IN WETWELL
C
C  THE BASE PRESSURE, PBASE, FOR IPBRN NEEDS TO BE AJUSTED TO ACCOUNT
C  FOR THE ADDITION OF H2 (THIS WAS DONE IN A PREVIOUS QUESTION FOR EPBRN
C
        IF(NAME(:5).EQ.'IPBRN')THEN
          PBASE = PBASE*( H2MAX + H2O + O2 + N2 )/NTOT
          ARG(IDARG(4)) = PBASE
        ENDIF
C
C  NO H2 BURN
C
        IF(NAME(6:6).EQ.'1')THEN
```

```
          ARG(IDARG(5)) = 0.0
          ARG(12) = 0.0
          UFUN = ARG(IDARG(5))
          RETURN
C
C  H2 BURNED AS DIFFUSION FLAME OR CONTAINMENT ALREADY FAILED
C  (NEGLIGIBLE PRESSURE RISE)
C
        ELSEIF(NAME(6:6).EQ.'2')THEN
          ARG(IDARG(5)) = 0.0
          ARG(12) = 0.0
          UFUN = ARG(IDARG(5))
C
C  H2 BURNED AS A DEFLAGRATION OR DETONATION - PRESSURE RISE BASED ON
C  MAXIMUM CONCENTRATION IN THE WETWELL BEFORE VB
C
        ELSE
          H2BRN = H2MAX
C
C  DETERMINE WHETHER H2 OR O2 IS THE LIMITING CONSTITUENT
C
          IF( H2BRN .GT. 2.0*O2 ) H2BRN = 2.0*O2
C
C  CALCULATED THE ADIABATIC ISOCHORIC COMPLETE COMBUSTION PRESSURE
C  BASED ON THE COMPOSTION IN THE WETWELL BEFORE VB
C
          AICC = H2BURN( H2BRN, H2O, O2, N2, 1.0, PBASE, TI )
C
C  EFFBC < 0.0 INDICATES THAT THE PRESSURE RISE WILL BE CALCULATED
C  IN THE USER FUNCTION (i.e., NO EXPERT DISTRIBUTION)
C
          IF( EFFBC .LT. 0.0 )THEN
            ARG(IDARG(5)) = AICC*FPRED - PBASE
          ELSE
C
C  CORRECT DISTRIBUTION BASED ON THE ACTUAL AMOUNT OF H2 IN THE
C  WETWELL AT THE TIME OF IGNITION
C
            ARG(IDARG(5)) = EFFBC*(AICC - PBASE)
          ENDIF
C
C  H2 BURNED AS A DETONATION - VERY FAST PRESSURE RISE
C
            IF(NAME(6:6) .EQ. '3' ) THEN
              ARG(12) = ARG(IDARG(5))
C
C  H2 BURNED AS A DEFLAGRATION
C  WETWELL/DRYWELL PRESSURE DIFFERENTIAL IS CALCULATED BASED ON WETWELL
C  PEAK OVERPRESSURE AND CONCENTRATION OF H2 THAT IS BURNED
C
            ELSEIF(NAME(6:6) .EQ. '4' ) THEN
              PCTH2 = H2BRN/( H2MAX + H2O + O2 + N2 )
              PWW   = ARG(IDARG(5))
              IF( PCTH2 .LE. 0.08 ) THEN
                ARG(12) = XINTRP( PWW, PDIF6, 6 )*PWW
              ELSEIF( PCTH2 .LE. 0.12 ) THEN
                ARG(12) = XINTRP( PWW, PDIF10, 6 )*PWW
              ELSEIF( PCTH2 .LE. 0.16 ) THEN
                ARG(12) = XINTRP( PWW, PDIF14, 6 )*PWW
              ELSEIF( PCTH2 .LE. 0.20 ) THEN
                ARG(12) = XINTRP( PWW, PDIF18, 6 )*PWW
              ELSE
                ARG(12) = XINTRP( PWW, PDIF25, 6 )*PWW
              ENDIF
            ENDIF
          ENDIF
```

```
C
C  CORRECT MOLAR COMPOSITION OF H2, O2, AND H2O AFTER THE BURN
C
          IF( H2MAX*ACTBC .GT. 2.0*O2 ) ACTBC = 2.0*O2/H2MAX
          ARG(IDARG(1)) = H2MAX - H2MAX*ACTBC
          ARG(IDARG(2)) = H2O + H2MAX*ACTBC
          ARG(IDARG(3)) = O2 - H2MAX*ACTBC/2.0
          UFUN = ARG(IDARG(5))
          RETURN
C
C===========================================================================
C  DRYWELL FAILURE LEVEL FROM EARLY DETONATION IN CONTAINMENT
C
      ELSEIF(NAME.EQ.'EDI   ')THEN
        PL = ARG(IDARG(1))
        PF = ARG(IDARG(2))
        RN = ARG(IDARG(3))
        UFUN   = PFAST(PL,PF,RN,DD,DTD,DCOND,NDLD,MDD,NDPD)
        RETURN
C
C===========================================================================
C  CONTAINMENT FAILURE LEVEL FROM DETONATION
C
C  DETONATION FAILED THE DRYWELL
C
      ELSEIF(NAME.EQ.'ECI1  ')THEN
       PL    = ARG(IDARG(1))
       PCF   = ARG(IDARG(2))
       RN    = ARG(IDARG(3))
       PDF   = ARG(IDARG(4))
       RNPED = ARG(IDARG(5))
       UFUN   = PFAST(PL,PCF,RN,DC,DTC,DCONC,NDLC,MDC,NDPC)
       RETURN
C
C  DRYWELL SURVIVED DETONATION
C
      ELSEIF(NAME.EQ.'ECI2  ')THEN
       PL  = ARG(IDARG(1))
       PF  = ARG(IDARG(2))
       RN  = ARG(IDARG(3))
       UFUN   = PFAST(PL,PF,RN,DC,DTC,DCONC,NDLC,MDC,NDPC)
       RETURN
C
C===========================================================================
C  LEVEL OF CONTAINMENT FAILURE FROM H2 BURN BVB
C
C  L3 OR VENT OR DtF3
      ELSEIF(NAME.EQ.'ECBrn1')THEN
        PL = ARG(IDARG(1))
        UFUN  = 1.5
        RETURN
C  L2 OR DtF2
      ELSEIF(NAME.EQ.'ECBrn2')THEN
        PL = ARG(IDARG(1)) + ARG(IDARG(2)) - PATM
        PF = ARG(IDARG(3))
        RN = ARG(IDARG(4))
        UFUN = PFAST(PL,PF,RN,PC,PTC,PCONC,NPLC,MPC,NPPC)
        RETURN
C
C===========================================================================
C  DRYWELL LEAKAGE INDUCED BY CONTAINMENT PRESSURIZATION
C
      ELSEIF(NAME(:5).EQ.'EDBrn')THEN
        PBASE = ARG(IDARG(1))
        PL    = ARG(IDARG(2))
        PF    = ARG(IDARG(3))
```

```
       RN     = ARG(IDARG(4))
C  SPB2( DfF3 OR DfF4)
       IF(NAME(6:6).EQ.'1')THEN
         UFUN  = PFAST(PL,PF,RN,PED,PTED,PCONED,NPLED,MPED,NPPED)
         IF( UFUN .EQ. 2.5 ) UFUN = 3.5
C  DfF3 OR DfF4
       ELSEIF(NAME(6:6).EQ.'2')THEN
         UFUN  = PFAST(PL,PF,RN,PED,PTED,PCONED,NPLED,MPED,NPPED)
C  SPB2
       ELSEIF(NAME(6:6).EQ.'3')THEN
         UFUN  = PFAST(PL,PF,RN,PED,PTED,PCONED,NPLED,MPED,NPPED)
         IF( UFUN .EQ. 2.5 ) UFUN = 3.5
C  OTHERWISE : BURN OR NO BURN WITH NO PRIOR RUPTURES
       ELSEIF(NAME(6:6).EQ.'4')THEN
         UFUN  = PFAST(PL,PF,RN,PED,PTED,PCONED,NPLED,MPED,NPPED)
       ENDIF
       RETURN
C
C==========================================================================
C  CONTAINMENT PRESSURE BEFORE VB
C
      ELSEIF(NAME(:5).EQ.'IBASP')THEN
C
C  H2OWW = AMOUNT OF H2O IN THE WETWELL JUST PRIOR TO VB (Kg-Mols)
C  O2WW  = AMOUNT OF O2 IN THE WETWELL JUST PRIOR TO VB (Kg-Mols)
C  N2WW  = AMOUNT OF N2 IN THE WETWELL JUST PRIOR TO VB (Kg-Mols)
C  H2WW  = AMOUNT OF H2 IN THE WETWELL JUST PRIOR TO VB (Kg-Mols)
C  NTOT  = TOTAL NUMBER OF MOLES IN WETWELL JUST PRIOR TO VB (Kg-Mols)
C  H2ODW = AMOUNT OF H2O IN THE DRYWELL JUST PRIOR TO VB (Kg-Mols)
C  O2DW  = AMOUNT OF O2 IN THE DRYWELL JUST PRIOR TO VB (Kg-Mols)
C  H2DW  = AMOUNT OF H2 IN THE DRYWELL JUST PRIOR TO VB (Kg-Mols)
C  PBASE = CONTAINMENT BASE PRESSURE
C
       H2OWW = ARG(IDARG(1))
       O2WW  = ARG(IDARG(2))
       N2WW  = ARG(IDARG(3))
       H2WW  = ARG(IDARG(4))
       H2ODW = ARG(IDARG(5))
       O2DW  = ARG(IDARG(6))
       H2DW  = ARG(IDARG(7))
       PBASE = ARG(IDARG(8))
       NTOTI = ARG(14)
C
C  CONTAINMENT HAS FAILED - REDUCED TO ATMOSPHERIC PRESSURE AND
C  REDUCE NUMBER OF MOLES IN CONTAINMENT
C
       IF(NAME(6:6).EQ.'1')THEN
         PBASE  = PATM
C
C  ADJUST MOLES IN WETWELL - ASSUME MOLE FRACTION BEFORE AND AFTER DOES
C  NOT CHANGE
C
         NTOTWW = H2OWW + O2WW + N2WW + H2WW
C
C  WETWELL PRESSURE ABOVE ATMOSPHERIC PRESSURE - REDUCE NUMBER OF MOLES
C
         IF(NTOTWW .GT. NATM) THEN
           YO2    = O2WW/NTOTWW
           YN2    = N2WW/NTOTWW
           YH2O   = H2OWW/NTOTWW
           YH2    = H2WW/NTOTWW
           H2OWW  = NATM*YH2O
           H2WW   = NATM*YH2
           O2WW   = NATM*YO2
           N2WW   = NATM*YN2
         ELSE
```

```
C
C  WETWELL PRESSURE BELOW ATMOSPHERIC PRESSURE - ADD MOLES OF H2O
C  TO BRING PRESSURE UP TO ATMOSPHERIC
C
            H2OWW = NATM - NTOTWW + H2OWW
          ENDIF
          NTOTI  = H2WW + O2WW + N2WW + H2OWW
C
C  ADJUST MOLES IN DRYWELL - ASSUME MOLE FRACTION BEFORE AND AFTER
C  DOES NOT CHANGE
C
          NTOTDW = H2ODW + O2DW/O2FRAC + H2DW
C
C  WETWELL PRESSURE ABOVE ATMOSPHERIC PRESSURE - REDUCE NUMBER OF MOLES
C
          IF( NTOTDW .GT. NATMDW ) THEN
            YO2    = O2DW/NTOTDW
            YH2O   = H2ODW/NTOTDW
            YH2    = H2DW/NTOTDW
            H2ODW  = NATMDW*YH2O
            H2DW   = NATMDW*YH2
            O2DW   = NATMDW*YO2
          ELSE
C
C  WETWELL PRESSURE BELOW ATMOSPHERIC PRESSURE - ADD MOLES OF H2O
C  TO BRING PRESSURE UP TO ATMOSPHERIC
C
            H2ODW = NATMDW - NTOTDW + H2ODW
          ENDIF
C
C  LARGE SUPPRESSION POOL BYPASS ASSUME DRYWELL AND WETWELL WELL MIXED
C
        ELSEIF(NAME(6:6).EQ.'2'.OR. NAME(6:6).EQ.'3')THEN
          IF(NAME(6:6) .EQ. '2')THEN
C
C  CONTAINMENT SPRAYS ARE WORKING - REDUCE STEAM TO NOMINAL LEVEL
C
            H2OWW = STMLOW
            H2ODW = STMLOW*VOLDW/VOLWW
          ENDIF
          NTOT  = H2OWW + O2WW + N2WW + H2WW +
     +            H2ODW + O2DW/O2FRAC + H2DW
C
C  IF PRESSURE BELOW ATMOSPHERIC - ADD MOLES OF H2O TO BRING PRESSURE
C  UP TO ATMOSPHERIC
C
          IF( NTOT .LT. (NATM + NATMDW) ) THEN
            H2OWW = (NATM + NATMDW) - NTOT + H2OWW
            NTOT  = NATM + NATMDW
          ENDIF
C
C  ADJUST MOLES IN WETWELL - THE RATIO OF THE WETWELL VOLUME TO THE
C  DRYWELL VOLUME IS USED TO CALCULATE THE MOLES IN THE WETWELL FROM
C  THE TOTAL NUMBER OF MOLES
C
C  FRACTION OF WETWELL VOLUME TO TOTAL VOLUME
C
          FVOLWW = VOLWW/(VOLWW + VOLDW)
C
          O2WW   = (O2WW + O2DW)*FVOLWW
          H2OWW  = (H2OWW + H2ODW)*FVOLWW
          N2WW   = (N2WW+O2DW/O2FRAC*(1.0-O2FRAC))*FVOLWW
          H2WW   = (H2WW + H2DW)*FVOLWW
          NTOTWW = O2WW + H2OWW + N2WW + H2WW
C
C  ADJUST MOLES IN DRYWELL
```

```
C
          O2DW   = O2WW*VOLDW/VOLWW
          H2ODW  = H2OWW*VOLDW/VOLWW
          H2DW   = H2WW*VOLDW/VOLWW
C
C  ADJUST THE BASE PRESSURE
C
          PBASE = PBASE*NTOTWW/NTOTI
          NTOTI = NTOTWW
C
C  CONTAINMENT INTACT AND NO LARGE SUPPRESSION POOL BYPASS
C
        ELSEIF(NAME(6:6).EQ.'4'.OR. NAME(6:6).EQ.'5')THEN
          IF(NAME(6:6) .EQ. '4')THEN
C
C  CONTAINMENT SPRAYS ARE WORKING - REDUCE STEAM TO NOMINAL LEVEL
C
            H2OWW = STMLOW
          ENDIF
C
C  TOTAL NUMBER OF MOLES IN THE WETWELL
C
          NTOTWW = H2OWW + O2WW + N2WW + H2WW
C
C  IF PRESSURE BELOW ATMOSPHERIC - ADD MOLES OF H2O TO BRING PRESSURE
C  UP TO ATMOSPHERIC
C
          IF( NTOTWW .LT. NATM ) THEN
            H2OWW  = NATM - NTOTWW + H2OWW
            NTOTWW = NATM
          ENDIF
C
C  ADJUST THE BASE PRESSURE
C
          PBASE = PBASE*NTOTWW/NTOTI
          NTOTI = NTOTWW
C
C  ADJUST MOLES OF STEAM IN DRYWELL BASED ON PRESSURE CHANGE IN WETWELL
C
          H2ODW  = PBASE/PATM*NATMDW - (O2DW/O2FRAC + H2DW)
          IF( H2ODW .LT. 0.0 ) H2ODW = 0.0
        ENDIF
          ARG(IDARG(1)) = H2OWW
          ARG(IDARG(2)) = O2WW
          ARG(IDARG(3)) = N2WW
          ARG(IDARG(4)) = H2WW
          ARG(IDARG(5)) = H2ODW
          ARG(IDARG(6)) = O2DW
          ARG(IDARG(7)) = H2DW
          ARG(IDARG(8)) = PBASE
          ARG(14)       = NTOTI
          UFUN = PBASE
          RETURN
C
C========================================================================
C  INERT LEVEL OF DRYWELL AT VB
C
       ELSEIF(NAME(:5).EQ.'DWIN1')THEN
         H2DW  = ARG(IDARG(1))
         H2ODW = ARG(IDARG(2))
         O2DW  = ARG(IDARG(3))
C
         UFUN = 1. - H2ODW/(H2DW + H2ODW + O2DW/O2FRAC)
         RETURN
C
C========================================================================
```

```
C  SUFFICIENT H2 FOR COMBUST/DETON IN DW BEFORE VB
C
      ELSEIF(NAME.EQ.'DWCBVB')THEN
        H2DW  = ARG(IDARG(1))
        H2ODW = ARG(IDARG(2))
        O2DW  = ARG(IDARG(3))
        NTOT  = H2DW + H2ODW + O2DW/O2FRAC
        PCTH2 = H2DW/NTOT
        PCTO2 = O2DW/NTOT
        O2DET = FH2DET*NTOT/2.
        O2COM = FH2COM*NTOT/2.
C
        IF(PCTH2.GE.FH2DET.AND.O2DW.GE.O2DET)THEN
          UFUN = FH2DET
        ELSEIF(PCTH2.GE.FH2COM.AND.O2DW.GE.O2COM)THEN
          UFUN = FH2COM
        ELSE
          UFUN = 0.0
        ENDIF
        RETURN
C
C======================================================================
C  DRYWELL FAILURE FROM IMPULSE LOADING AT VB
C
      ELSEIF(NAME.EQ.'IDI1LD')THEN
        PL = ARG(IDARG(1))
        PF = ARG(IDARG(2))
        RN = ARG(IDARG(3))
        UFUN  = PFAST(PL,PF,RN,DD,DTD,DCOND,NDLD,MDD,NDPD)
        RETURN
      ELSEIF(NAME.EQ.'IDI2LD')THEN
        PL = AMAX1( ARG(IDARG(1)), ARG(IDARG(2)) )
        PL = 0.0
        PF = ARG(IDARG(3))
        RN = ARG(IDARG(4))
        UFUN  = PFAST(PL,PF,RN,DD,DTD,DCOND,NDLD,MDD,NDPD)
        RETURN
C
C======================================================================
C  DRYWELL FAILURE FROM OVERPRESSURIZATION AT VB
C
      ELSEIF(NAME.EQ.'DWFAVB')THEN
        PL = ARG(IDARG(1))
        PF = ARG(IDARG(2))
        RN = ARG(IDARG(3))
        UFUN  = PFAST(PL,PF,RN,PID,PTID,PCONID,NPLID,MPID,NPPID)
        RETURN
C
C======================================================================
C  AMOUNT OF HYDROGEN GENERATED AT VB
C
C    ZRWT  = INITIAL MASS OF ZIRCONUIM IN THE VESSEL
C    CZRH2 = CONVERSION FACTOR USED TO CONVERT FROM KG OF Zr TO Kg-Mols
C            OF H2
C    H2VES   = AMOUNT OF H2 PRODUCED IN-VESSEL DURING CORE DEGRADATION
C    H2BLWDN = AMOUNT OF H2 RELEASED AT VB DURING THE BLOW DOWN
C    EJECT   = FRACTION OF CORE EJECTED AT VB
C    FH2VB = FRACTION OF OXIDIZABLE Zr IN EJECTED MATERIAL THAT IS OXIDIZED
C
      ELSEIF(NAME(:5).EQ.'H2AVB')THEN
        H2VES  = ARG(IDARG(1))
        H2BLWDN= ARG(IDARG(2))
        FEJECT = ARG(IDARG(3))
C
        IF( NAME(6:6) .EQ. '1' ) THEN
C
```

```
C  HPME OR EX-VESSEL STEAM EXPLOSION OCCURE AT VB - ADDITIONAL
C  H2 IS GENERATED BY THESE EVENTS
C
C  FH2DCH = FRACTION OF OXIDIZABLE Zr IN EJECTED MATERIAL THAT IS OXIDIZED
C           BY HPME OR EvSE
C  H2DCH  = H2 GENERATED BY HPME OR EvSE
C
         H2DCH = FEJECT*( ZRWT*CZRH2 - H2VES )*FH2DCH
C
         IF( H2DCH .GT. H2BLWDN ) THEN
C
C  IF THE AMOUNT OF H2 GENERATED BY THE  HPME OR EvSE IS GREATER THAN THE
C  THE AMOUNT PRODUCED BY THE BLOW DOWN, USE THE H2 ASSOCIATED WITH THE
C  HPME OR EvSE
C
           H2VB = H2DCH
         ELSE
C
C  THE AMOUNT OF H2 RELEASED DURING THE BLOW DOWN IS GREATER THAN THE HPME
C  OR EvSE RELEASE - ONLY USE THE SLOW DOWN AMOUNT
C
           H2VB = H2BLWDN
         ENDIF
C
        ELSEIF( NAME(6:6) .EQ. '2') THEN
C
C  NO HPME OR EvSE - H2 IS ASSOCIATED WITH THE BLOW DOWN
C
          H2VB = H2BLWDN
        ENDIF
C
C  H2AEJEC = MAXIMUM AMOUNT OF H2 THAT CAN BE GENERATED BY THE MATERIAL
C             EJECTED AT VB
C
        H2AEJEC = (ZRWT*CZRH2 - H2VES)*FEJECT
C
        IF( H2VB .LT. H2AEJEC )THEN
C
C  THE AMOUNT OF H2 RELEASED AT VB (CONSIDERING BOTH THE BLOW
C  DOWN AND THE HPME OR EvSE) CAN BE ASSOCIATED WITH THE MATERIAL EJECTED
C  AT VB
C
          FH2VB = H2VB/H2AEJEC
        ELSE
C
C  THE AMOUNT OF H2 RELEASED AT VB IS GREATER THAN THE AMOUNT
C  OF H2 THAT CAN BE GENERATED BY THE MATERIAL EJECTED AT VB.
C  THUS, OXIDIZED ALL OF THE Zr IN THE EJECTED MATERIAL AND THE APPROPRIATE
C  AMOUNT OF Zr THAT IS STILL IN THE VESSEL
C
          FH2VB = 1.0
          H2VES = H2VES + (H2VB - H2AEJEC)
        ENDIF
C
C  REINITIALIZE THE INPUT VARIABLES
C
        ARG(IDARG(1)) = H2VES
        ARG(IDARG(2)) = H2VB
        ARG(IDARG(4)) = FH2VB
        UFUN = H2VB
        RETURN
C
C===========================================================================
C  H2 CONCENTRATION IN CONTAINMENT IMMEDIATELY AFTER VB
C
      ELSEIF(NAME(:5).EQ.'IH2WW')THEN
```

```
C
C  INPUT VARIABLES
C
      H2OWW = ARG(IDARG(1))
      H2WW  = ARG(IDARG(2))
      H2ODW = ARG(IDARG(3))
      H2DW  = ARG(IDARG(4))
      H2AVB = ARG(IDARG(5))
      O2WW  = ARG(IDARG(6))
      O2DW  = ARG(IDARG(7))
      N2WW  = ARG(IDARG(8))
C
C  EITHER NO VB OR ALPHA MODE FAILURE
C  - NO VB, THUS, NO CHANGE IN H2
C  - ALPHA MODE FAILURE, THUS, H2 CONCENTRATION NOT IMPORTANT - DRYWELL
C    AND CONTAINMENT ALREADY FAILED
C
      IF( NAME(6:6) .EQ. '0' ) THEN
        H2WW = H2WW
C
C  ENERGETIC EVENT IN DRYWELL AT VB
C
C  ALL OF THE PRE-EXISTING H2 (IF THERE IS ENOUGH O2) AND A FRACTION
C  (O2DW*FO2BRN*2.0) OF THE H2 GENERATED AT VB (H2AVB) IS BURNED
C  IN THE DRYWELL AT VB. ALL OF THE REMAINING CONSTITUENTS ARE
C  PUSHED INTO THE WETWELL
C
      ELSEIF(NAME(6:6).EQ.'1' .OR. NAME(6:6).EQ.'2')THEN
        N2WW = N2WW + (O2DW/O2FRAC)*(1.0 - O2FRAC)
        IF( H2DW .GT. 2.0*O2DW )THEN
C
C  ALL OF THE DRYWELL O2 IS CONSUMED BURNING THE PRE-EXISTING DRYWELL H2
C
          H2DW = H2DW - 2.0*O2DW
          O2DW = 0.0
        ELSE
C
C  ENOUGH OXYGEN TO CONSUME ALL OF THE PRE-EXISTING HYDROGEN
C
C  PRE-EXISTING H2 IS BURNED: SET H2DW = 0.0 AND REDUCE O2DW ACCORDINGLY
C
          O2DW  = O2DW - H2DW/2.0
          H2DW  = 0.0
C
C  A FRACTION OF THE REMAINING O2 IS USED TO BURN H2 THAT IS GENERATED AT
C  VB.
C
C  DETERMINE IF H2AVB OR O2DW IS THE LIMITING CONSTITUENT
C
          IF( H2AVB .LT. 2.0*O2DW*FO2BRN )THEN
C
C  H2AVB IS THE LIMITING CONSTITUENT
C
            H2AVB = 0.0
            O2DW = O2DW - H2AVB/2.0
          ELSE
C
C  O2DW*FO2BRN IS THE LIMITING CONSTITUENT
C
            H2AVB = H2AVB - 2.0*O2DW*FO2BRN
            O2DW  = O2DW - O2DW*FO2BRN
          ENDIF
        ENDIF
C
C  SUM THE WETWELL H2 AND O2
C
```

```
         H2WW  = H2WW + H2DW + H2AVB
         O2WW  = O2WW + O2DW
         H2OWW = H2OWW
         H2DW  = 0.0
         O2DW  = 0.0
C
       ELSEIF(NAME(6:6).EQ.'3' .OR. NAME(6:6).EQ.'4')THEN
C
C  WATER IS IN THE DRYWELL AT VB WITH SUPPRESSION POOL BYPASS
C   - STEAM GENERATED AT VB PURGES THE GASES FROM THE DRYWELL INTO THE
C     WETWELL. ALL OF THE DRYWELL CONSTITUENTS ( H2DW, O2DW, N2DW) ARE
C     ADDED TO THE WETWELL CONSTITUENTS
C
         H2WW  = H2WW + H2DW + H2AVB
         O2WW  = O2WW + O2DW
         N2WW  = N2WW + (O2DW/O2FRAC)*(1.0 - O2FRAC)
         H2OWW = H2OWW
         H2DW  = 0.0
         O2DW  = 0.0
C
       ELSEIF(NAME(6:6).EQ.'5' .OR. NAME(6:6).EQ.'6')THEN
C
C  NO MAJOR ENERGTIC EVENTS A VB AND THE DRYWELL IS DRY
C  - DRYWELL RETAINS SOME FRACTION (FDWVB) OF THE H2 AND O2
C    THE FRACTION FDWVB IS APPLIED TO THE MOLE FRACTIONS OF H2 (YH2)
C    AND AIR (YAIR)
C
C  NTOT  = TOTAL NUMBER OF MOLES IN THE DRYWELL AT VB
C  YH2   = MOLE FRACTION OF H2 IN THE DRYWELL AT VB
C  YAIR  = MOLE FRACTION OF AIR IN THE DRYWELL AT VB
C  FDWVB = FRACTION OF DRYWELL CONSTITUENTS THAT REMAIN IN THE DRYWELL
C
         H2WW  = H2WW + (H2DW + H2AVB)*(1.0 - FDWVB)
         O2WW  = O2WW + O2DW*(1-FDWVB)
         N2WW  = N2WW + O2DW/O2FRAC*(1.0-O2FRAC)*(1.0-FDWVB)
         H2DW  = (H2DW + H2VB)*FDWVB
         O2DW  = O2DW*FDWVB
       ENDIF
C
C  IF CONTAINMENT FAILED - REDUCE NUMBER OF MOLES IN THE WETWELL ASSUMING
C  THE WETWELL WAS WELL MIXED
C
       IF( NAME(6:6).EQ.'1' .OR. NAME(6:6).EQ.'3' .OR.
     +       NAME(6:6) .EQ. '5' ) THEN
C
C  CALCULATE MOLE FRACTIONS ASSUMING ALL GASES STAY IN WETWELL
C
         NTOT = H2OWW + H2WW + O2WW + N2WW
         YH2O = H2OWW/NTOT
         YH2  = H2WW/NTOT
         YO2  = O2WW/NTOT
         YN2  = N2WW/NTOT
C
C  ADJUST MOLES OF EACH CONSTITUENT BASED ON MOLE FRACTIONS AND THE
C   OTAL NUMBER OF MOLES IN THE CONTAINMENT AT ATMOSPHERIC PRESSURE
C
         H2OWW= YH2O*NATM
         H2WW = YH2*NATM
         O2WW = YO2*NATM
         N2WW = YN2*NATM
       ENDIF
C
C  CALCULATE MOLE FRACTION OF H2 IN WETWELL AT VB
C
       UFUN = H2WW/( H2WW + H2OWW + O2WW + N2WW)
C
```

```
C  REINITIALIZE INPUT VARIABLES
C
        ARG(IDARG(1)) = H2OWW
        ARG(IDARG(2)) = H2WW
        ARG(IDARG(3)) = H2ODW
        ARG(IDARG(4)) = H2DW
        ARG(IDARG(6)) = O2WW
        ARG(IDARG(7)) = O2DW
        ARG(IDARG(8)) = N2WW
        RETURN
C
C=========================================================================
C  WETWELL INERT LEVEL AFTER VB
C
      ELSEIF(NAME(:6).EQ.'WWH2O ')THEN
        H2OWW = ARG(IDARG(1))
        H2WW  = ARG(IDARG(2))
        O2WW  = ARG(IDARG(3))
        N2WW  = ARG(IDARG(4))
C
C  MOLE FRACTION OF H2O IN WETWELL
C
        PCTH2O = H2OWW/(H2OWW + H2WW + O2WW + N2WW)
C
C  UFUN RETURNS 1 - FRACTION OF H2O IN WETWELL
C
        UFUN   = 1.0 - PCTH2O
        RETURN
C
C=========================================================================
C  SUFFICIENT O2 IN CONTAINMENT TO SUPPORT COMBUSTION
C
      ELSEIF(NAME(:4).EQ.'WWO2')THEN
C
C  INITIALIZE H2O, H2, O2, AND N2
C
        H2OWW = ARG(IDARG(1))
        H2WW  = ARG(IDARG(2))
        O2WW  = ARG(IDARG(3))
        N2WW  = ARG(IDARG(4))

C
C    O2PCT = PERCENTAGE OF O2 IN CONTAINMENT
C    O2BRN1 = KG-MOLES OF O2 REQUIRED TO BURN A MIXTURE OF 12% H2
C    O2BRN2 = KG-MOLES OF O2 REQUIRED TO BURN A MIXTURE OF 16% H2
C    O2BRN3 = KG-MOLES OF O2 REQUIRED TO BURN A MIXTURE OF 20% H2
C
C    UFUN = 0.5 : NOT ENOUGH O2 FOR COMBUSTION
C    UFUN = 1.5 : ENOUGH O2 FOR COMBUSTION BUT NOT FOR A DETONATION
C    UFUN = 2.5 : ENOUGH O2 FOR A DETONATION WITH 12% H2
C    UFUN = 3.5 : ENOUGH O2 FOR A DETONATION WITH 16% H2
C    UFUN = 4.5 : ENOUGH O2 FOR A DETONATION WITH 20% H2
C
        O2PCT = O2WW/( H2OWW + H2WW + O2WW + N2WW)
        O2BRN1 = 0.5*(0.12/(1.-0.12))*(H2OWW + O2WW + N2WW)
        O2BRN2 = 0.5*(0.16/(1.-0.16))*(H2OWW + O2WW + N2WW)
        O2BRN3 = 0.5*(0.20/(1.-0.20))*(H2OWW + O2WW + N2WW)
C
C    DETERMINE WHAT LEVEL OF COMBUSTION IS POSSIBLE
C
        IF( O2PCT .LT. FO2COM)THEN
          UFUN = 0.5
        ELSEIF( O2WW .GE. O2BRN3 )THEN
          UFUN = 4.5
        ELSEIF( O2WW .GE. O2BRN2 )THEN
          UFUN = 3.5
```

```
        ELSEIF( O2WW .GE. O2BRN1 ) THEN
          UFUN = 2.5
        ELSE
          UFUN = 1.5
        ENDIF
        RETURN
C
C=======================================================================
C  LEVEL OF CONTAINMENT PRESSURIZATION AT VB
C
C  THE CONTAINMENT HAS ALREADY FAILED (RUPTURE OR CAT. RUPTURE).
C  OVERPRESSURE IS REDUCED
C
      ELSEIF(NAME.EQ.'CPCLOW')THEN
        PBASE = PATM
        PBRN  = ARG(IDARG(2))
        PTOT  = 0.0
        UFUN  = PBASE
        ARG(IDARG(1)) = PBASE
        ARG(IDARG(3)) = PTOT
        RETURN
      ELSEIF(NAME.EQ.'CPC1  ')THEN
        PTOT = ARG(IDARG(2)) + ARG(IDARG(3))
        UFUN = PTOT
        ARG(IDARG(4)) = PTOT
        RETURN
      ELSEIF(NAME.EQ.'CPC2  ')THEN
        P1   = ARG(IDARG(2))
        P2   = ARG(IDARG(3))
        PTOT = AMAX1( P1, P2 )
        UFUN = PTOT
        ARG(IDARG(4)) = PTOT
        RETURN
      ELSEIF(NAME.EQ.'CPC3  ')THEN
        PTOT = ARG(IDARG(3))
        UFUN = PTOT
        ARG(IDARG(4)) = PTOT
        RETURN
C
C=======================================================================
C  LEVEL OF DRYWELL LEAKAGE INDUCED BY CONTAINMENT PRESSURIZATION
C
      ELSEIF(NAME(:5).EQ.'IDBrn')THEN
        PBASE = ARG(IDARG(1))
        PL    = ARG(IDARG(2))
        PF    = ARG(IDARG(3))
        RN    = ARG(IDARG(4))
        PDWVB = ARG(IDARG(5))
        PL    = AMAX1(PL - PDWVB, 0.0)
        IF(NAME(6:6).EQ.'1')THEN
          UFUN  = PFAST(PL,PF,RN,PED,PTED,PCONED,NPLED,MPED,NPPED)
          IF( UFUN .EQ. 2.5 ) UFUN = 3.5
        ELSEIF(NAME(6:6).EQ.'2')THEN
          UFUN  = PFAST(PL,PF,RN,PED,PTED,PCONED,NPLED,MPED,NPPED)
          IF( UFUN .EQ. 2.5 ) UFUN = 3.5
        ELSEIF(NAME(6:6).EQ.'3')THEN
          UFUN  = PFAST(PL,PF,RN,PED,PTED,PCONED,NPLED,MPED,NPPED)
        ELSEIF(NAME(6:6).EQ.'4')THEN
          UFUN  = PFAST(PL,PF,RN,PED,PTED,PCONED,NPLED,MPED,NPPED)
        ELSEIF(NAME(6:6).EQ.'5')THEN
          UFUN  = PFAST(PL,PF,RN,PED,PTED,PCONED,NPLED,MPED,NPPED)
        ENDIF
        RETURN
C
C=======================================================================
C  CONTAINMENT PRESSURE AFTER VB
```

```
C
      ELSEIF(NAME(:5).EQ.'LBASP')THEN
C
C  H2OWW = AMOUNT OF H2O IN THE WETWELL JUST PRIOR TO VB (Kg-Mols)
C  O2WW  = AMOUNT OF O2 IN THE WETWELL JUST PRIOR TO VB (Kg-Mols)
C  N2WW  = AMOUNT OF N2 IN THE WETWELL JUST PRIOR TO VB (Kg-Mols)
C  H2WW  = AMOUNT OF H2 IN THE WETWELL JUST PRIOR TO VB (Kg-Mols)
C  NTOT  = TOTAL NUMBER OF MOLES IN WETWELL JUST PRIOR TO VB (Kg-Mols)
C  H2ODW = AMOUNT OF H2O IN THE DRYWELL JUST PRIOR TO VB (Kg-Mols)
C  O2DW  = AMOUNT OF O2 IN THE DRYWELL JUST PRIOR TO VB (Kg-Mols)
C  H2DW  = AMOUNT OF H2 IN THE DRYWELL JUST PRIOR TO VB (Kg-Mols)
C  PBASE = CONTAINMENT BASE PRESSURE
C
        H2OWW = ARG(IDARG(1))
        O2WW  = ARG(IDARG(2))
        N2WW  = ARG(IDARG(3))
        H2WW  = ARG(IDARG(4))
        H2ODW = ARG(IDARG(5))
        O2DW  = ARG(IDARG(6))
        H2DW  = ARG(IDARG(7))
        PBASE = ARG(IDARG(8))
        NTOTI = ARG(14)
C
C  CONTAINMENT HAS FAILED - REDUCED TO ATMOSPHERIC PRESSURE AND
C  REDUCE NUMBER OF MOLES IN CONTAINMENT
C
        IF(NAME(6:6).EQ.'1')THEN
          PBASE  = PATM
C
C  ADJUST MOLES IN WETWELL - ASSUME MOLE FRACTION BEFORE AND AFTER DOES
C  NOT CHANGE
C
          NTOTWW = H2OWW + O2WW + N2WW + H2WW
C
C  WETWELL PRESSURE ABOVE ATMOSPHERIC PRESSURE - REDUCE NUMBER OF MOLES
C
          IF(NTOTWW .GT. NATM) THEN
            YO2    = O2WW/NTOTWW
            YN2    = N2WW/NTOTWW
            YH2O   = H2OWW/NTOTWW
            YH2    = H2WW/NTOTWW
            H2OWW  = NATM*YH2O
            H2WW   = NATM*YH2
            O2WW   = NATM*YO2
            N2WW   = NATM*YN2
          ELSE
C
C  WETWELL PRESSURE BELOW ATMOSPHERIC PRESSURE - ADD MOLES OF H2O
C  TO BRING PRESSURE UP TO ATMOSPHERIC
C
            H2OWW = NATM - NTOTWW + H2OWW
          ENDIF
          NTOTI  = H2WW + O2WW + N2WW + H2OWW
C
C  ADJUST MOLES IN DRYWELL - ASSUME MOLE FRACTION BEFORE AND AFTER
C  DOES NOT CHANGE
C
          NTOTDW = H2ODW + O2DW/O2FRAC + H2DW
C
C  WETWELL PRESSURE ABOVE ATMOSPHERIC PRESSURE - REDUCE NUMBER OF MOLES
C
          IF( NTOTDW .GT. NATMDW ) THEN
            YO2    = O2DW/NTOTDW
            YH2O   = H2ODW/NTOTDW
            YH2    = H2DW/NTOTDW
            H2ODW  = NATMDW*YH2O
```

```
            H2DW   = NATMDW*YH2
            O2DW   = NATMDW*YO2
          ELSE
C
C  WETWELL PRESSURE BELOW ATMOSPHERIC PRESSURE - ADD MOLES OF H2O
C  TO BRING PRESSURE UP TO ATMOSPHERIC
C
            H2ODW = NATMDW - NTOTDW + H2ODW
          ENDIF
C
C  CONTAINMENT INTACT
C
        ELSEIF(NAME(6:6).EQ.'2'.OR. NAME(6:6).EQ.'3')THEN
          IF(NAME(6:6) .EQ. '2')THEN
C
C  CONTAINMENT SPRAYS ARE WORKING - REDUCE STEAM TO NOMINAL LEVEL
C
            H2OWW = STMLOW
          ENDIF
C
C  TOTAL NUMBER OF MOLES IN THE WETWELL
C
          NTOTWW = H2OWW + O2WW + N2WW + H2WW
C
C  IF PRESSURE BELOW ATMOSPHERIC - ADD MOLES OF H2O TO BRING PRESSURE
C  UP TO ATMOSPHERIC
C
          IF( NTOTWW .LT. NATM ) THEN
            H2OWW   = NATM - NTOTWW + H2OWW
            NTOTWW  = NATM
          ENDIF
C
C  ADJUST THE BASE PRESSURE
C
          PBASE = PBASE*NTOTWW/NTOTI
          NTOTI = NTOTWW
C
C  ADJUST MOLES OF STEAM IN DRYWELL BASED ON PRESSURE CHANGE IN WETWELL
C
          H2ODW  = PBASE/PATM*NATMDW - (O2DW/O2FRAC - H2DW)
          IF( H2ODW .LT. 0.0 ) H2ODW = 0.0
        ENDIF
          ARG(IDARG(1)) = H2OWW
          ARG(IDARG(2)) = O2WW
          ARG(IDARG(3)) = N2WW
          ARG(IDARG(4)) = H2WW
          ARG(IDARG(5)) = H2ODW
          ARG(IDARG(6)) = O2DW
          ARG(IDARG(7)) = H2DW
          ARG(IDARG(8)) = PBASE
          ARG(14)       = NTOTI
          UFUN = PBASE
          RETURN
C
C=====================================================================
C  GASES RELEASED DURING CCI
C
C  H2VES  = AMOUNT OF H2 GENERATED IN-VESSEL DURING CORE DEGRADATION
C  FEJECT = FRACTION OF THE CORE EJECTED AT VB - IT IS
C           ASSUMED THAT THE CORE DEBRIS EJECTED AT VB HAS
C           THE SAME COMPOSITION AT THE DEBRIS THAT REMAINS IN THE VESSEL
C  FH2VB  = FRACTION OF OXIDIZABLE DEBRIS THAT IS OXIDIZED AT VB
C  FCCI   = FRACTION OF CORE THAT PARTICIPATES IN CCI. IF A HPME OCCURS, I.
C           IS ASSUMED THAT THE MATERIAL THAT IS MOBILE AT VB IS
C           BLOWN OUT OF THE CAVITY (HPME INCLUDES EX-VESSEL STEAM EXPLOSIONS
C           THAT ARE COINCIDENT WITH THE HPME EVENT). IF AN EX-VESSEL STEAM
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```
C           EXPLOSION OCCURS (WITHOUT HPME), 1 - FCCI REPRESENTS THE FRACTION
C           OF MATERIAL BLOWN OUT OF THE CAVITY BY THE STEAM EXPLOSION. IF
C           THERE IS NO HPME OR STEAM EXPLOSION, THEN ALL OF THE CORE CAN
C           PARTICIPATE IN CCI.
C
      ELSEIF(NAME(:3).EQ.'CCI')THEN
        H2VES  = ARG(IDARG(1))
        FEJECT = ARG(IDARG(2))
        FH2VB  = ARG(IDARG(3))
        FCCI   = ARG(IDARG(4))
C
C       H2EQV  = ARG(IDARG(5))
C       CO2CCI = ARG(IDARG(6))
C       FZROX  = ARG(IDARG(7))
C       FZROX  = AMOUNT OF OXIDIZED ZR IN PEDESTAL BEFORE CCI BEGINS
C
C  IF ALPHA MODE FAILURE OCCURS OR THERE IS NO VB OR NO CCI,
C  THEN SET H2CCI, COCCI, AND CO2CCI TO ZERO
C
       IF(NAME(4:4).EQ.'1')THEN
         ARG(IDARG(5)) = 0.0
         ARG(IDARG(6)) = 0.0
         ARG(IDARG(7)) = 0.0
         UFUN = ARG(IDARG(5))
         RETURN
       ENDIF
C
C  ZRVES  = MASS OF IN-VESSEL Zr THAT IS AVAILABLE FOR OXIDATION
C  ZRLATE = MASS OF Zr THAT IS RELEASED AFTER VB
C  ZRFAST = MASS OF Zr THAT IS RELEASED AT VB
C
         ZRVES = ZRWT - H2VES/CZRH2
         ZRLATE = ZRVES*(1.0 - FEJECT)
         ZRFAST = ZRVES*FEJECT
C
C  FOR HPME CASES ALL OF THE MATERIAL RELEASED AT VB IS
C  ASSUMED TO BE BLOWN OUT OF THE CAVITY
C
       IF(NAME(4:4).EQ.'2')FCCI = 1.0 - FEJECT
C
C  FOR CASES IN WHICH THE AMOUNT OF MATERIAL REMOVED FROM THE CAVITY IS
C  LESS THAN OR EQUAL TO THE AMOUNT EJECTED AT VB, THE AMOUNT OF Zr
C  OXIDIZED AT VB MUST BE ACCOUNTED FOR
C
       IF( (1.0 - FCCI) .LE. FEJECT )THEN
C
C  ZREXIT = AMOUNT OF Zr BLOWN OUT OF THE CAVITY AT VB
C  ZRFAST = AMOUNT OF Zr THAT IS EJECTED AT VB THAT REMAINS IN THE CAVITY
C  ZRCCI  = AMOUNT OF Zr THAT CAN BE OXIDIZED DURING CCI
C
         ZREXIT = ZRVES*( 1.0 - FCCI )
         ZRFAST = ( ZRFAST - ZREXIT )*( 1.0 - FH2VB )
         ZRCCI  = ZRLATE + ZRFAST
       ELSE
         ZRFAST = ZRFAST*( 1.0 - FH2VB)
         ZRCCI  = (ZRLATE + ZRFAST)*FCCI
       ENDIF
C
C  FZR = FRACTION OF UNOXIDIZED Zr IN PEDESTAL CAVITY
C
       FZR = ZRCCI/(ZRWT*FCCI)
C
C  H2CCI  = HYDROGEN PRODUCED DURING CCI (Kg-Mol)
C  COCCI  = CARBON MONOXIDE PRODUCED DURING CCI (Kg-Mol)
C  CO2CCI = CARBON DIOXIDE PRODUCED DURING CCI (Kg-Mol)
C  H2EQV  = HYDROGEN EQUIVALENT - MOLES OF CO ARE CONVERTED TO
```

```
C          EQUIVALENT MOLES OF H2 BASED ON THE ENERGY RELEASED
C          DURING COMBUSTION
C
      IF( FZR .LE. 0.25 )THEN
        H2CCI  = ( C11H2*FZR  + C12H2  )*FCCI
        COCCI  = ( C11CO*FZR  + C12CO  )*FCCI
        CO2CCI = ( C11CO2*FZR + C12CO2 )*FCCI
      ELSE
        H2CCI  = ( C21H2*FZR  + C22H2  )*FCCI
        COCCI  = ( C21CO*FZR  + C22CO  )*FCCI
        CO2CCI = ( C21CO2*FZR + C22CO2 )*FCCI
      ENDIF
        H2EQV  = H2CCI + COCCI*CVCOH2
C
      ARG(IDARG(5)) = H2EQV
      ARG(IDARG(6)) = CO2CCI
      ARG(IDARG(7)) = 1.0 - FZR
      UFUN = H2EQV
      RETURN
C
C==========================================================================
C  LATE CONCENTRATION OF COMBUSTIBLE GASES IN THE CONTAINMENT
C
      ELSEIF(NAME(:4).EQ.'LGWW')THEN
C
C  H2OWW = AMOUNT OF STEAM IN WETWELL LATE (Kg-Mols)
C  H2WW  = AMOUNT OF HYDROGEN IN WETWELL LATE (BEFORE CCI) (Kg-Mols)
C  O2WW  = AMOUNT OF OXYGEN IN WETWELL LATE (Kg-Mols)
C  H2CC  = AMOUNT OF EQUIVALENT H2 (INCLUDES CO) RELEASED BY CCI (Kg-Mols)
C  CO2   = AMOUNT OF CARBON DIOXIDE RELEASED BY CCI (Kg-Mols)
C  N2WW  = AMOUNT OF NITROGEN IN WETWELL LATE (Kg-Mols)
C  H2DW  = AMOUNT OF H2 IN DRYWELL LATE (Kg-Mols)
C  O2DW  = AMOUNT OF O2 IN DRYWELL LATE (Kg-Mols)
C
        H2OWW = ARG(IDARG(1))
        H2WW  = ARG(IDARG(2))
        O2WW  = ARG(IDARG(3))
        H2CC  = ARG(IDARG(4))
        CO2   = ARG(IDARG(5))
        N2WW  = ARG(IDARG(6))
        H2DW  = ARG(IDARG(7))
        O2DW  = ARG(IDARG(8))
C
C  SUPPRESSION POOL BYPASS WITH LARGE AMOUNT OF STEAM GENERATED BY CCI
C  CONTAINMENT INERT TO H2 BURNS
C
        IF(NAME(5:6).EQ.'1 ')THEN
C
C  SET H2O CONCENTRATION TO 60% (ASSURES WETWELL IS INERT)
C
          H2OWW = 0.6/.4*(H2WW + H2CC + O2WW + N2WW + CO2
     +                    + H2DW + O2DW/O2FRAC)
          IF( H2OWW .LE. 0.0) H2OWW = NATM
C
        ELSEIF(NAME(5:6).EQ.'2 ')THEN
C
C  CONTAINMENT HAS FAILED - REDUCE NUMBER OF MOLES IN THE WETWELL TO
C  CORRESPOND TO ATMOSPHERIC PRESSURE ASSUMING THE WETWELL WAS WELL MIXED
C
C  CALCULATE THE MOLE FRACTIONS ASSUMING ALL GASES STAY IN THE WETWELL
C
          NTOT  = H2OWW + H2WW + H2CC + O2WW + N2WW + CO2
     +            + H2DW + O2DW/O2FRAC
          YH2O  = (H2OWW + CO2)/NTOT
          YH2   = (H2WW + H2CC + H2DW)/NTOT
          YO2   = (O2WW + O2DW)/NTOT
```

```
          YN2   = (N2WW + O2DW/O2FRAC*(1.0 - O2FRAC))/NTOT
C
C  ADJUST MOLES OF EACH CONSTITUENT BASED ON MOLE FRACTIONS AND THE TOTAL
C  NUMBER OF MOLES IN THE CONTAINMENT AT ATMOSPHERIC PRESSURE
C
          H2OWW = NATM*YH2O
          H2WW  = NATM*YH2
          O2WW  = NATM*YO2
          N2WW  = NATM*YN2
C
        ELSEIF(NAME(5:6).EQ.'3 '.OR. NAME(5:6).EQ.'4 ')THEN
C
C  CONTAINMENT INTACT - CCI RELEASES ENTER CONTAINMENT
C
          IF( NAME(5:6) .EQ. '3 ')THEN
C
C  CONTAINMENT SPRAYS ARE WORKING - REDUCE STEAM CONCENTRATION
C
            H2OWW = STMLOW
          ENDIF
          H2WW  = H2WW + H2CC*FCCIWW + H2DW
          H2OWW = H2OWW + CO2*FCCIWW
          O2WW  = O2WW + O2DW
          N2WW  = N2WW + O2DW/O2FRAC*(1.0 - O2FRAC)
        ENDIF
C
C  CALCULATE THE MOLE FRACTION OF H2 IN THE WETWELL
C
          UFUN  = H2WW/(H2OWW + H2WW + O2WW + N2WW)
C
C  REINITIALIZE PARAMETERS
C
          ARG(IDARG(1)) = H2OWW
          ARG(IDARG(2)) = H2WW
          ARG(IDARG(3)) = O2WW
          ARG(IDARG(6)) = N2WW
          ARG(IDARG(7)) = 0.0
          ARG(IDARG(8)) = 0.0
          RETURN
C
C======================================================================
C  THIS MODULE REDUCES THE LATE BURN OVERPRESSURE IS THE CONTAINMENT HAS
C  ALREADY FAILED (RUPTURE OR CAT. RUPTURE).
C
      ELSEIF(NAME.EQ.'LCPLOW')THEN
        PBASE = ARG(IDARG(1))
        PBRN  = 0.0
        UFUN  = PBASE
        ARG(IDARG(2)) = PBRN
        RETURN
C
C======================================================================
C  THIS MODULE DETERMINES THE LEVEL OF DRYWELL LEAKAGE INDUCED
C  BY A LATE COMBUSTION
C
      ELSEIF(NAME(:5).EQ.'LDBrn')THEN
        PBASE = ARG(IDARG(1))
        PL    = ARG(IDARG(2))
        PF    = ARG(IDARG(3))
        RN    = ARG(IDARG(4))
        IF(NAME(6:6).EQ.'1')THEN
          UFUN  = PFAST(PL,PF,RN,PED,PTED,PCONED,NPLED,MPED,NPPED)
          IF(UFUN .EQ. 2.5)UFUN = 3.5
        ELSEIF(NAME(6:6).EQ.'2')THEN
          UFUN  = PFAST(PL,PF,RN,PED,PTED,PCONED,NPLED,MPED,NPPED)
          IF(UFUN .EQ. 2.5)UFUN = 3.5
```

```
        ELSEIF(NAME(6:6).EQ.'3')THEN
          UFUN  = PFAST(PL,PF,RN,PED,PTED,PCONED,NPLED,MPED,NPPED)
        ELSEIF(NAME(6:6).EQ.'4')THEN
          UFUN  = PFAST(PL,PF,RN,PED,PTED,PCONED,NPLED,MPED,NPPED)
        ELSEIF(NAME(6:6).EQ.'5')THEN
          UFUN  = PFAST(PL,PF,RN,PED,PTED,PCONED,NPLED,MPED,NPPED)
        ENDIF
        RETURN
C
C=========================================================================
C  CONTAINMENT FAILURE FROM LATE PRESSURE (NON-CONDENSIBLES/STEAM)
C
      ELSEIF(NAME( :6).EQ.'LTPRES')THEN
        PL = ARG(IDARG(1)) + ARG(IDARG(2)) - PATM
        PF = ARG(IDARG(3))
        RN = ARG(IDARG(4))
        UFUN = PSLOW(PL,PF,RN,PC,PTC,PCONC,NPLC,MPC,NPPC)
        RETURN
      ENDIF
C
C=========================================================================
C  IF USER FUNCTION NOT FOUND - WRITE ERROR MESSAGE
C
      WRITE(6,10)NAME
  10  FORMAT(1X,'USER FUNCTION NAME ',A6,' NOT FOUND')
      STOP
      END
C=========================================================================
C
C                   PSLOW
C
C=========================================================================
      FUNCTION PSLOW(PL,PF,RN,P,PT,COND,NLOC,M,NP)
      DIMENSION P(NP), PT(NP), COND(NP,5,NLOC), M(NLOC), SFR(10),
     +          FRX(5,5)
C
C  PL = LOAD PRESSURE
C  PF = FAILURE PRESSURE
C  RN = RANDOM NUMBER USED TO DETERMINE FAILURE MODE
C  P  = PRESSURE
C  PT = TOTAL CUMULATIVE FAILURE DISTRIBUTION
C  COND = CONDITIONAL FAILURE FOR EACH MODE AT EACH LOCATION
C  NLOC = NUMBER OF LOCATIONS
C  M(K) = NUMBER OF FAILURE MODES AT LOCATION K
C  DP   = PRESSURE INCREMENT OF P
C  NP   = TOTAL NUMBER OF PRESSURE INCREMENTS
C  SFR  = FAILURE FRACTION (RN IS COMPARED TO THIS NUMBER)
C
C  IF PL IS LESS THAN PF, NO FAILURE.
C  SET PSLOW = TOTAL # OF LOCATION/MODE COMBINATIONS + 0.5
C
       IF (PL .LT. PF ) THEN
C
C  DETERMINE THE TOTAL NUMBER OF LOCATION/MODE COMBINATIONS
C
         ISUM = 0.0
         DO 60 K = 1, NLOC
           DO 70 IM = 1, M(K)
             ISUM = ISUM + 1
 70        CONTINUE
 60      CONTINUE
         PSLOW = ISUM + 0.5
       ELSE
C  CALCULATE TABLE SPACING
C
       DP = ( P(NP) - P(1) )/( NP - 1)
```

```
C
C  IF PL IS GREATER THAN PF THEN CALCULATE FAILURE MODE AT PF.
C  FIND PRESSURE INTERVAL CORRESPONDING TO THE SAMPLED FAILURE
C  PRESSURE PF.  IFO = LOWER VALUE OF INTERVAL, IF1 = UPPER VALUE
C
      IFO = (( PF - P(1) )/DP) + 1
      IF1 = IFO + 1
C
C  INTERPOLATE TO GET THE CONDITIONAL FAILURE MODE PROBABILITIES AT
C  PF. FRINT = FRACTION OF INTERVAL TO EXTRAPOLATE FOR SAMPLED VALUE
C
      FRINT = ( PF - P(IFO) )/DP
C
C  !!! NOTE - THIS METHOD OF SUMMING ASSUMES THAT EACH LOCATION HAS THE
C             SAME NUMBER OF MODES !!!
C
C  THE INPUT ARRAY FOR THE CONDITIONALS IS IN THE ORDER LEAK, RUPTURE FOR
C  LOCATION 1; LEAK, RUPTURE FOR LOCATION 2 ETC. THE VALUES RETURN BY PFAST
C  ARE IN A DIFFERENT ORDER:  LEAK LOCATION 1, LEAK LOCATION 2, RUPTURE
C  LOCATION 1, RUPTURE LOCATION 2 ETC.
C
C  ISUM = TOTAL NUMBER OF MODES
C
      ISUM = 0
      DO 10 IM = 1, M(1)
        DO 20 K = 1, NLOC
           ISUM = ISUM + 1
           C1 = COND(IFO,IM,K)
           C2 = COND(IF1,IM,K)
           FRX(IM,K) = C1 + FRINT*( C2 - C1)
           IF(ISUM .EQ. 1) THEN
             SFR(ISUM) = FRX(IM,K)
           ELSE
             SFR(ISUM) = SFR(ISUM -1) + FRX(IM,K)
           ENDIF
 20     CONTINUE
 10   CONTINUE
      PSLOW = 0.5
      DO 30 I = 1, ISUM - 1
         IF( I .EQ. 1)THEN
           IF(RN .LT. SFR(I)) PSLOW = ISUM - I + 0.5
         ELSE
           IF(RN.LT.SFR(I) .AND. RN.GE.SFR(I-1))PSLOW=ISUM-I+0.5
         ENDIF
 30   CONTINUE
      ENDIF
      RETURN
      END
C========================================================================
C
C                     PFAST
C
C========================================================================
      FUNCTION PFAST(PL,PF,RN,P,PT,COND,NLOC,M,NP)
      DIMENSION P(NP), PT(NP), COND(NP,2,NLOC), M(NLOC), SFR(10),
     +          FR(5,5), C0(5,5), CL(5,5)
C
C  PL = LOAD PRESSURE
C  PF = FAILURE PRESSURE
C  RN = RANDOM NUMBER USED TO DETERMINE FAILURE MODE
C  P  = PRESSURE
C  PT = TOTAL CUMULATIVE FAILURE DISTRIBUTION
C  COND = CONDITIONAL FAILURE FOR EACH MODE AT EACH LOCATION
C  NLOC = NUMBER OF LOCATIONS
C  M(K) = NUMBER OF FAILURE MODES AT LOCATION K (MAX IS 2)
C  NP   = TOTAL NUMBER OF PRESSURE INCREMENTS
```

```
C  SFR  = FAILURE FRACTION (RN IS COMPARED TO THIS NUMBER
C
C  IF PL IS LESS THAN PF, NO FAILURE.
C  SET PFAST = TOTAL # LOCATION/MODE COMBINATIONS + 0.5
C
      IF (PL .LT. PF ) THEN
C
C  DETERMINE THE TOTAL NUMBER OF LOCATION/MODE COMBINATIONS
C
        ISUM = 0.0
        DO 60 K = 1, NLOC
          DO 70 IM = 1, M(K)
            ISUM = ISUM + 1
 70       CONTINUE
 60     CONTINUE
        PFAST = ISUM + 0.5
      ELSE
C
C  IF PL IS GREATER THAN PF THEN CALCULATE FAILURE MODE AT PF.
C  FIND PRESSURE INTERVAL CORRESPONDING TO THE SAMPLED FAILURE
C  PRESSURE PF.  IFO = LOWER VALUE OF INTERVAL, IF1 = UPPER VALUE
C
      DP = (P(NP)-P(1))/(NP-1)
      IFO = (( PF - P(1) )/DP) + 1
      IF1 = IFO + 1
C
C  INTERPOLATE TO GET THE CONDITIONAL FAILURE MODE PROBABILITIES AT
C  PF. FRINT = FRACTION OF INTERVAL TO EXTRAPOLATE FOR SAMPLED VALUE
C
      FRINT = ( PF - P(IFO) )/DP
C
      DO 40 K = 1, NLOC
        DO 50 IM = 1, M(K)
           C1 = COND(IFO,IM,K)
           C2 = COND(IF1,IM,K)
           FR(IM,K) = C1 + FRINT*( C2 - C1)
 50     CONTINUE
 40   CONTINUE

C       A subroutine to calculate fraction of failures in each of
C    several modes and locations, for rapidly rising pressures.
C    Arguments are PF (failure pressure),PL (Load),the total
C        cumulative failure distribution (PT), and conditional failures
C        in each mode and location, given that failure occurs within
C        the stated pressure interval.
C        P(I) = PRESSURE (EQUALLY SPACED POINTS)
C    COND(I,J,K) = CONDITIONAL FAILURE FOR EACH MODE AT EACH LOCATION,
C    I.E., PROBABILITY THAT A FAILURE OCCURRING IN THE INTERVAL
C    P(I-1) TO P(I) IS MODE J AT LOCATION K IS COND(I,J,K)
C    M(K)=TOTAL NUMBER OF MODES AT LOCATION K (MAX = 5)
C    NLOC=NUMBER OF LOCATIONS (MAX = 5)
C    NP=NUMBER OF POINTS IN P,PT ARRAYS (MAX = 200)
C    PF=SAMPLED FAILURE PRESSURE
C    PL=SAMPLED LOAD PRESSURE
C    FR=FRACTION OF FAILURES IN EACH MODE (VALUES CALCULATED BY
C    SUBROUTINE)
C    ***********************************************************
C    XF=PROBABILITY OF FAILURE CORRESPONDING TO PF
     IF(PF.LE.P(1))THEN
       XF=0.
     ELSE IF(PF.GE.P(NP))THEN
       XF=1.0
     ELSE
       DO 5 I=2,NP
         IF(P(I).LT.PF)GOTO 5
```

```
          II=I
          GOTO 7
5      CONTINUE
       II=NP
7      XF=PT(II-1)+(PF-P(II-1))*(PT(II)-PT(II-1))/(P(II)-P(II-1))
       XF=AMIN1(XF,1.0)
       XF=AMAX1(XF,0.0)
     END IF
C    SPACING OF PRESSURE TABLE
     DP=(P(NP)-P(1))/(NP-1)
C    FIND POINT CORRESPONDING TO PF
     IF(PF.LE.P(1))THEN
       IF0=1
     ELSE
       IF0=(PF-P(1))/DP+1
     END IF
C    FIND POINT CORRESPONDING TO PL
     IF(PL.GE.P(NP))THEN
       IFL=NP-1
     ELSE
       IFL=(PL-P(1))/DP+1
     END IF
C    FIND UPPER AND LOWER PARTIAL INTERVAL SIZES
     FRINT0=1.-(PF-P(IF0))/DP
     FRINTL=(PL-P(IFL))/DP
     IF1=IF0+1
     IFL1=IFL+1
     SUMLK=0.
     DO 10 K=1, NLOC
       DO 11 IM=1,M(K)
C    FIND CONDITIONALS FOR LOWER PARTIAL INTERVAL
           C1=COND(IF0,IM,K)
           C2=COND(IF1,IM,K)
                IF(IF1.EQ.IFL1)THEN
                  C0(IM,K) = (C2+3.0*C1+(C2-C1)*(FRINTL+(1-FRINT0)))/4.
                ELSE
              C0(IM,K)= (C2 + (C1+(C2-C1)*(1-FRINT0)))*0.5
                ENDIF
C    FIND CONDITIONALS FOR UPPER PARTIAL INTERVAL
           C1=COND(IFL,IM,K)
           C2=COND(IFL1,IM,K)
           CL(IM,K)=( C1 + (C1+(C2-C1)*FRINTL) )*0.5
11       CONTINUE
         SUMLK=SUMLK+FR(1,K)
10   CONTINUE
C    NOW WORK UP FROM PF TO PL, DETERMINING PROBABILITY OF NEW RUPTURES
     DO 31 IP=IF1, IFL1
       SUML=0.0
       SUMR=0.0
       DO 32 K=1,NLOC
         DO 34 IM=2,M(K)
            IF(IP.EQ.IF1)THEN
C    LOWER PARTIAL INTERVAL
                   IF(IF1.EQ.IFL1) THEN
                     FX=FRINTL - (1.0 - FRINT0)
                   ELSE
                 FX=FRINT0
                   ENDIF
               CX=C0(IM,K)
               DIV=AMAX1(1.-XF,1.E-6)
            ELSE IF(IP.EQ.IFL1)THEN
C    UPPER PARTIAL INTERVAL
               FX=FRINTL
               CX=CL(IM,K)
       DIV=AMAX1(1.-PT(IP-1),1.E-6)
            ELSE
```

```
C   WHOLE INTERVALS
          FX=1.
          CX=( COND(IP,IM,K) + COND(IP-1,IM,K) )/2
     DIV=AMAX1(1.-PT(IP-1),1.E-6)
         END IF
C   RUPTURES IN THIS INTERVAL AND SUMMED RUPTURES
         DFR=(PT(IP)-PT(IP-1))*CX*FX*SUMLK/DIV
         SUMR=SUMR+DFR
         FR(IM,K)=FR(IM,K)+DFR
34      CONTINUE
32    CONTINUE
      SUMNU=0.0
      DO 321 K=1,NLOC
        FR(1,K)=FR(1,K)-SUMR*FR(1,K)/SUMLK
        SUMNU=SUMNU+FR(1,K)
321   CONTINUE
      SUMLK=SUMNU
31  CONTINUE
C
C   SET UF TO CORRECT VALUES
C
C
C  ISUM = TOTAL NUMBER OF MODES
C
C  !!! NOTE - THIS METHOD OF SUMMING ASSUMES THAT EACH LOCATION HAS THE
C            SAME NUMBER OF MODES !!!
C
C  THE INPUT ARRAY FOR THE CONDITIONALS IS IN THE ORDER LEAK, RUPTURE FOR
C  LOCATION 1; LEAK, RUPTURE FOR LOCATION 2 ETC. THE VALUES RETURN BY PFAST
C  ARE IN A DIFFERENT ORDER:  LEAK LOCATION 1, LEAK LOCATION 2, RUPTURE
C  LOCATION 1, RUPTURE LOCATION 2 ETC.
C
      ISUM = 0
      DO 15 IM = 1, M(1)
        DO 20 K = 1, NLOC
           ISUM = ISUM + 1
           IF(ISUM .EQ. 1) THEN
             SFR(ISUM) = FR(IM,K)
           ELSE
             SFR(ISUM) = SFR(ISUM -1) + FR(IM,K)
           ENDIF
 20     CONTINUE
 15   CONTINUE
      PFAST = 0.5
      DO 30 I = 1, ISUM - 1
         IF( I .EQ. 1)THEN
           IF(RN .LT. SFR(I)) PFAST = ISUM - I + 0.5
         ELSE
           IF(RN.LT.SFR(I) .AND. RN.GE.SFR(I-1))PFAST=ISUM-I+0.5
         ENDIF
 30   CONTINUE
      ENDIF
      RETURN
     END
C=============================================================================
C
C                     H2BURN
C
C=============================================================================
C  THIS FUNCTION CALCULATES THE FINAL PRESSURE ASSOCIATED
C  WITH THE ADIABATIC COMBUSTION OF H2 IN AN AIR/STEAM MIXTURE AT
C  CONSTANT VOLUME.  IT IS ASSUMED THAT ALL COMPONENTS ARE IDEAL GASES.
C
      FUNCTION H2BURN( H2, H2O, O2, N2, CONV, PBASE, TI )
      REAL N2,N2P
C
```

```
C  H2BRN IS THE AMOUNT OF H2 (Kg-mols) THAT BURNS.
C
      H2BRN=H2*CONV
C
C  TI = INITIAL GAS TEMPERATURE
C  TREF = THE REFERENCE TEMPERATURE, CORRESPONDS TO THE TEMPERATURE
C      AT WHICH THE HEATS OF FORMATION ARE EVALUATED.
C
      TI   = TI - 273.15
      TREF = 25.0
C
C  INTERNAL ENERGY OF REACTANTS
C
      UR=UENERG(TI,TREF,H2,H2O,O2,N2)
C
C  HEAT OF REACTION
C
      UREACT=-2.406E5*H2BRN
C
C  MOLES OF PRODUCT
C
      H2P =H2-H2BRN
      H2OP=H2O+H2BRN
      O2P =O2-H2BRN/2.
      N2P =N2
C
C  TPLOW AND TPHI CORRESPOND TO THE RANGE THAT THE FINAL GAS TEMPERATURE
C  IS EXPECTE TO FALL WITHIN.
C
      TPLOW=TI
      TPHI=2000.
C
C  THE GAS TEMPERATURE OF THE PRODUCTS IS DETERMINED BY SOLVING THE ENERGY
C  EQUATION FOR A CONSTANT VOLUME ADIABATIC COMBUSTION.  BECAUSE THE
C  INTERNAL ENERGY OF THE PRODUCTS IS CALCULATED FROM HEAT CAPACITY DATA
C  WHICH IS IN THE FORM OF A FOURTH ORDER POLYNOMIAL, THE TEMPERATURE OF
C  THE PRODUCTS IS CALULATED USING A TRIAL AND ERROR METHOD (BI-SECTION
C  METHOD).
C
C  INTERNAL ENERGY OF PRODUCTS (BASED ON TPLOW)
C
      UPLOW=UENERG(TPLOW,TREF,H2P,H2OP,O2P,N2P)
C
C  ENERGY BALANCE
C
      DULOW=UPLOW+UREACT-UR
C
C  INTERNAL ENERGY OF PRODUCTS (BASED ON TPHI)
C
      UPHI=UENERG(TPHI,TREF,H2P,H2OP,O2P,N2P)
C
C  ENERGY BALANCE
C
      DUHI=UPHI+UREACT-UR
C
C  MAKE SURE PRODUCT TEMPERATURE IS IN THE ASSUMED TEMPERATURE
C  RANGE
C
  5   IF(DUHI*DULOW.GT.0.0)THEN
C
C  IF THE AMOUNT OF H2 IS TO HIGH (PREDICTING ADIABATIC BURN TEMPERATURES
C  GREATER THAN 3000 C), THEN AUTOMATICALLY SET PRESSURE RISE TO 10.
C
        IF(TPHI.GT.3000)THEN
          H2BURN=10.0
          RETURN
```

```
          ENDIF
          TPHI=TPHI*1.5
          UPHI=UENERG(TPHI,TREF,H2P,H2OP,O2P,N2P)
          DUHI=UPHI+UREACT-UR
          GO TO 5
        ENDIF
C
C  MIDPOINT IN TEMPERATURE RANGE
C
  10  TPMED=(TPHI+TPLOW)/2.
C
C  INTERNAL ENERGY OF PRODUCTS (BASED ON MIDPOINT TEMP.)
C
        UPMED=UENERG(TPMED,TREF,H2P,H2OP,O2P,N2P)
C
C  ENERGY BALANCE
C
        DUMED=UPMED+UREACT-UR
C
C  DETERMINE WHICH SIDE OF MIDPOINT THE SOLUTION LIES
C
        IF(DULOW*DUMED.GT.0.0)THEN
          TPLOW=TPMED
          DULOW=DUMED
        ELSE
          TPHI=TPMED
          DUHI=DUMED
        ENDIF
C
C  SUCCESS CRITERION IS 1 C.
C
        IF(ABS(TPLOW-TPHI).GT.1.0)GO TO 10
        TF=(TPLOW+TPHI)/2.
C
C   FINAL PRESSURE BASE ON IDEAL GAS LAW
C
        PRATIO=(H2P+H2OP+O2P+N2P)/(H2+H2O+O2+N2)*(TF+273.15)/(TI+273.15)
        H2BURN=PRATIO*PBASE
        RETURN
        END
C=========================================================================
C
C                            UENERG
C
C=========================================================================
C  THIS FUNCTION CALCULATES THE CHANGE IN INTERNAL ENERGY ASSOCIATED
C  WITH A CHANGE IN TEMPERATURE (FROM TREF TO TI) OF GASEOUS H2,H2O,O2
C  AND N2.  THE INTERNAL ENERGY IS IN JOULES.
C
        FUNCTION UENERG(TI,TREF,H2,H2O,O2,N2)
        REAL N2
C
C  INTERNAL ENERGY OF HYDROGEN
C
        UH2=(20.53*(TI-TREF)+3.825E-5*(TI**2-TREF**2)+1.096E-6*(
      +          TI**3-TREF**3)-2.175E-10*(TI**4-TREF**4))
C
C  INTERNAL ENERGY OF STEAM
C
        UH2O=(25.15*(TI-TREF)+3.44E-3*(TI**2-TREF**2)+2.535E-6*(
      +          TI**3-TREF**3)-8.983E-10*(TI**4-TREF**4))
C
C  INTERNAL ENERGY OF OXYGEN
C
        UO2=(20.79*(TI-TREF)+5.70E-3*(TI**2-TREF**2)-2.025E-6*(
      +          TI**3-TREF**3)+3.278E-10*(TI**4-TREF**4))
```

```
C
C  INTERNAL ENERGY OF NITROGEN
C
      UN2=(20.69*(TI-TREF)+1.1E-3*(TI**2-TREF**2)+1.908E-6*(
     +         TI**3-TREF**3)-7.178E-10*(TI**4-TREF**4))
      UENERG=UH2*H2+UH2O*H2O+UO2*O2+UN2*N2
      RETURN
      END
C==========================================================================
C
C                      TLOOK
C
C==========================================================================
C  TABLE LOOKUP SUBROUTINE : 2-DIMINSIONAL TABLE
C
C  THIS FUNCTION DETERMINES THE VALUE IN THE MATRIX TABLE FOR A GIVEN
C  X AND Y PAIR.  THE ARRAYS XRANG AND YRANG CONTAIN THE INDEPENDENT
C  VARIABLES FOR THE MATRIX.  THE VARIABLES NUMX AND NUMY ARE THE
C  NUMBER OF ELEMENTS IN THE ARRAYS XRANG AND YRANG RESPECTIVELY.
C
      FUNCTION TLOOK(X,Y,XRANG,NUMX,YRANG,NUMY,TABLE,NAME)
C
      DIMENSION TABLE(NUMX,NUMY),XRANG(NUMX),YRANG(NUMY),
     +          XBOUND(3),YBOUND(3),TBOUND(4)
      CHARACTER*6 NAME
C
C  CHECK TO MAKE SURE THE X AND Y VALUES ARE WITHIN THE RANGE OF THE
C  MATRIX.  IF THE X AND Y VARLUES FALL OUTSIDE THE RANGE, AN ERROR
C  MESSAGE IS RETURNED.
C
      IF(X.LT.XRANG(1).OR.X.GT.XRANG(NUMX))THEN
        WRITE(6,100)NAME
 100    FORMAT(1X,'ERROR IN FUN_',A6,' IN SUBROUTINE TLOOK, X RANGE')
        STOP
      ENDIF
      IF(Y.LT.YRANG(1).OR.Y.GT.YRANG(NUMY))THEN
        WRITE(6,101)NAME
 101    FORMAT(1X,'ERROR IN FUN_',A6,' IN SUBROUTINE TLOOK, Y RANGE')
        STOP
      ENDIF
C
C  FIND THE 2 VALUES IN XRANG THAT SURROUND X
C
      I=1
  10  IF(X.GT.XRANG(I))THEN
        I=I+1
        GO TO 10
      ELSE
        IF(I.EQ.1)I=2
        XBOUND(1)=XRANG(I-1)
        XBOUND(2)=X
        XBOUND(3)=XRANG(I)
      ENDIF
C
C  FIND THE 2 VALUES IN YRANG THAT SURROUND Y
C
      J=1
  20  IF(Y.GT.YRANG(J))THEN
        J=J+1
        GO TO 20
      ELSE
        IF(J.EQ.1)J=2
        YBOUND(1)=YRANG(J-1)
        YBOUND(2)=Y
        YBOUND(3)=YRANG(J)
      ENDIF
```

```
C
C  FOUR VALUES IN THE MATRIX TABLE THAT CORRESPOND TO THE XRANG AND
C  YRANG VALUES THAT SURROUND X AND Y.
C
      TBOUND(1)=TABLE(I-1,J-1)
      TBOUND(2)=TABLE(I,J-1)
      TBOUND(3)=TABLE(I-1,J)
      TBOUND(4)=TABLE(I,J)
C
C  INTERPOLATE TO FIND DEPENDENT VARIABLE THAT CORRESPONDS TO X AND Y.
C
      TLOOK=TINTRP(XBOUND,YBOUND,TBOUND)
      PRINT*,XBOUND
      PRINT*,YBOUND
      PRINT*,TBOUND
      PRINT*,TLOOK
      RETURN
      END
C========================================================================
C
C                       TINTRP
C
C========================================================================
C  THIS FUNCTION PERFORMS A LINEAR INTERPOLATION OF A 2-DIMENSIONAL TABLE
C  X = ARRAY CONTAINS 3 ELEMENTS
C       X(1)= X VALUE CORRESPONDING TO T(1,1) AND T(1,2)
C       X(2)= X VALUE FOR WHICH AN INTERPOLATED VALUE OF T WILL BE OBTAINED.
C       X(3)= X VALUE CORRESPONDING TO T(2,1) AND T(2,2)
C  Y = ARRAY CONTAINS 3 ELEMENTS
C       Y(1)= Y VALUE CORRESPONDING TO T(1,1) AND T(2,1)
C       Y(2)= Y VALUE FOR WHICH AN INTERPOLATED VALUE OF T WILL BE OBTAINED.
C       Y(3)= Y VALUE CORRESPONDING TO T(1,2) AND T(2,2)
C
      FUNCTION TINTRP(X,Y,T)
C
      DIMENSION X(3),Y(3),T(4)
      XRATIO=(X(2)-X(3))/(X(1)-X(3))
      YRATIO=(Y(2)-Y(3))/(Y(1)-Y(3))
      T1=(T(1)-T(2))*XRATIO + T(2)
      T2=(T(3)-T(4))*XRATIO + T(4)
      TINTRP=(T1-T2)*YRATIO + T2
      RETURN
      END
C========================================================================
C
C                       XINTRP
C
C========================================================================
C  THIS FUNCTION PERFORMS A LINEAR INTERPOLATION
C
C  T(IMAX,2) = 2 DIMENSIONAL ARRAY
C     T(I,1)  = X DATA
C     T(I,2)  = Y DATA
C     IMAX    = TOTAL NUMBER OF X VALUES (AND ALSO Y VALUES)
C  X          = X VALUE FOR WHICH A Y VALUE WILL BE CALCULATED
C
      FUNCTION XINTRP( X, T, IMAX)
      DIMENSION T(IMAX,2)
C
C  IF THE VALUE X IS GREATER THAN THE LAST VALUE IN T, SET Y TO THE LAST
C  VALUE IN T
C
      IF( X .GT. T(IMAX,1) ) THEN
         XINTRP = T(IMAX,2)
      ELSEIF( X .LT. T(1,1) ) THEN
         XINTRP = T(1,2)
```

```
      ELSE
        I = 1
10      IF( X .GT. T(I,1) ) THEN
          I = I + 1
          GOTO 10
        ELSE
          IF( I .EQ. 1 ) I = 2
            XLO = T(I-1, 1)
            YLO = T(I-1, 2)
            XHI = T(I, 1)
            YHI = T(I, 2)
            XINTRP = (X - XLO)/(XHI - XLO)*(YHI - YLO) + YLO
        ENDIF
      ENDIF
      RETURN
      END
```

A.3 ADDITIONAL INFORMATION CONCERNING THE ACCIDENT PROGRESSION ANALYSIS

A summary of basic plant parameters is presented in Subsection A.3.1. The quantification of the initial questions in the APET, which are used to distinguish among the various PDSs, is presented in Subsection A.3.2. Presented in Subsection A.3.3 is additional information that was used in the development of the APET.

A.3.1 Summary of Plant Information

Type of Reactor	BWR-6 Boiling Water Reactor	
Manufacturer	General Electric	
Date of Commercial Operation	1985	
Reactor Core		
Nominal Power	3833 MWt	13,082 E6 Btu/h
Number of Fuel Assemblies	800	
Fuel Rods Per Assembly	62	
Core Weight, Total	259,249 kg	571,550 lbm
Uranium Dioxide	166,195 kg	366,400 lbm
Zircaloy	79,242 kg	174,700 lbm
Miscellaneous	13,812 kg	30,450 lbm
Reactor Vessel		
Inside Diameter	6.37 m	251 in
Inside Height	22.2 m	73 ft
Design Pressure	8.7 MPa	1250 psig
Design Temperature	301.7°C	575°F
Steam Pressure in Core	7.3 MPa	1040 psig
Primary System Oper. Temperature	290.6°C	555°F
Reactor Coolant System Liquid Mass	3.17 E5 kg	6.99 E5 lbm
Reactor Coolant System Steam Mass	10,736 kg	23,667 lbm
Primary Containment		
Type	Mark III	
Constructed by	Bechtel Corporation	
Design Pressure	0.21 MPa	15 psig
Free Volume	39,650 m^3	1.4 E6 ft^3
Inside Diameter	37.8 m	124 ft
Maximum Inside Height	63 m	206.75 ft
Height of Spring Line Above Grade	32 m	105.25 ft
Construction	Reinforced Concrete	
Wall Thickness	1.07 m	3.5 ft
Dome Thickness	0.76 m	2.5 ft
Basemat Thickness:		
Pedestal Cavity Floor	3.35 m	11.0 ft
Cavity Sump Floor	2.44 m	8.0 ft
Pressure Boundary	Welded Steel Liner	
Liner Thickness	0.63 cm	0.25 in

Drywell		
Internal Design Pressure (Dif.)	0.207 MPa	30 psid
Design Temperature	165.6°C	330°F
Free Volume	7649 m^3	270,100 ft^3
Inside Diameter	22.2 m	73 ft
Construction	Reinforced Concrete	
Wall Thickness	1.52 m	5 ft
Roof Thickness	1.29 m	4.25 ft
Drywell Head	Steel 2:1 Ellipsoidal Head	
Reactor Cavity		
Annular Cavity	3.2 m Radius	10.58 ft Radius
Wall Thickness (Below CRD Opening)	1.75 m	5.75 ft
Height from Bottom RPV to Floor	8.6 m	28.3 ft
Height from Floor to Access Door	2.9 m	9.6 ft
Concrete Type	Limestone Common Sand	
Suppression Pool		
Nominal Water Volume	3,851 m^3	136,000 ft^3
Horizontal Vents		
Number	135	
Internal Diameter	0.71m	2.33 ft

Sources of Information:
BMI-2104[A-12]
Grand Gulf FSAR

A.3.2 Initialization Questions

The first fifteen questions of the Grand Gulf APET determine the initial conditions for the accident progression analysis; that is, the state of the plant at the time that core degradation starts. This time has been taken to be when the collapsed water level in the RPV is 2 feet above the BAF, although it is realized that actual core damage will not start until a short time later. The first 15 questions are used to distinguish between the different PDS groups. The branch probabilities and parameter values are the same for the remaining 110 questions in the APET, but the branch probabilities for the first 15 questions depend on the PDS group to be analyzed. This group of APET questions is often referred to as the "tree top." A listing of the "tree tops" for the 12 PDSs used in this analysis follows.

PDS 1 Tree Top:

```
  GRAND GULF ACCIDENT PROGRESSION EVENT TREE
  125
   NQ
    1     1.000
            cen
 1 What is the initiating event?
    3     TLOSP        T2        TC
    1         1         2         3
          1.000     0.000     0.000
 2 Is there a Station Blackout (Diesel Generators fail)?
    2        SB       nSB
    1         1         2
          1.000     0.000
 3 Is DC Power not available?
    2     E1fDC     E1-DC
    1         1         2
          0.000     1.000
 4 Do one or more S/RVs fail to reclose?
    2    E1SORV   E1nSORV
    1         1         2
          0.020     0.980
 5 Does HPCS fail to inject?
    3  E1fHPInj  E1rHPInj  E1-HPInj
    1         1         2         3
          0.000     1.000     0.000
 6 Does RCIC fail to inject initially?
    2   E1fRCIC   E1-RCIC
    1         1         2
          1.000     0.000
 7 Does the CRD hydraulic system fail to inject?
    3    E1fCRD    E1rCRD    E1-CRD
    1         1         2         3
          1.000     0.000     0.000
 8 Does the condensate system fail?
    3   E1fCond   E1rCond   E1aCond
    1         1         2         3
          0.000     1.000     0.000
 9 Do the LPCS and LPCI systems fail?
    4    E1fLPC    E1rLPC    E1aLPC    E1-LPC
    1         1         2         3         4
          0.000     1.000     0.000     0.000
10 Does RHR fail (heat exchangers not available)?
    4    E1fRHR    E1rRHR    E1aRHR    E1-RHR
    1         1         2         3         4
          0.000     1.000     0.000     0.000
11 Does the service water system or cross-tie to LPCI fail?
    3    E1fSSW    E1rSSW    E1aSSW
    1         1         2         3
          1.000     0.000     0.000
12 Does the fire protection system cross-tie to LPCI fail?
    3    E1fFWS   E1ofFWS    E1aFWS
    1         1         2         3
          0.000     0.000     1.000
13 Are the containment (wetwell) sprays failed?
    4    E1fCSS    E1rCSS    E1aCSS    E1-CSS
    1         1         2         3         4
          0.000     1.000     0.000     0.000
14 What is the status of vessel depressurization?
    4    E1fDep   E1ofDep    E1nDep    E1-Dep
    1         1         2         3         4
         0.0000    0.0000    1.0000    0.0000
15 When does core damage occur?
    2    CD-Fst    CD-Slw
    1         1         2
          1.000     0.000
```

PDS 2 Tree Top:

```
  GRAND GULF ACCIDENT PROGRESSION EVENT TREE
  125
   NQ
    1     1.000
            cen
1 What is the initiating event?
    3     TLOSP         T2         TC
    1         1          2          3
          1.000      0.000      0.000
2 Is there a Station Blackout (Diesel Generators fail)?
    2        SB        nSB
    1         1          2
          1.000      0.000
3 Is DC Power not available?
    2     E1fDC      E1-DC
    1         1          2
          0.000      1.000
4 Do one or more S/RVs fail to reclose?
    2    E1SORV    E1nSORV
    1         1          2
          0.020      0.980
5 Does HPCS fail to inject?
    3  E1fHPInj   E1rHPInj   E1-HPInj
    1         1          2          3
          0.000      1.000      0.000
6 Does RCIC fail to inject initially?
    2   E1fRCIC    E1-RCIC
    1         1          2
          1.000      0.000
7 Does the CRD hydraulic system fail to inject?
    3    E1fCRD     E1rCRD     E1-CRD
    1         1          2          3
          1.000      0.000      0.000
8 Does the condensate system fail?
    3   E1fCond    E1rCond    E1aCond
    1         1          2          3
          0.000      1.000      0.000
9 Do the LPCS and LPCI systems fail?
    4    E1fLPC     E1rLPC     E1aLPC     E1-LPC
    1         1          2          3          4
          1.000      0.000      0.000      0.000
10 Does RHR fail (heat exchangers not available)?
    4    E1fRHR     E1rRHR     E1aRHR     E1-RHR
    1         1          2          3          4
          1.000      0.000      0.000      0.000
11 Does the service water system or cross-tie to LPCI fail?
    3    E1fSSW     E1rSSW     E1aSSW
    1         1          2          3
          1.000      0.000      0.000
12 Does the fire protection system cross-tie to LPCI fail?
    3    E1fFWS    E1ofFWS     E1aFWS
    1         1          2          3
          0.000      0.000      1.000
13 Are the containment (wetwell) sprays failed?
    4    E1fCSS     E1rCSS     E1aCSS     E1-CSS
    1         1          2          3          4
          1.000      0.000      0.000      0.000
14 What is the status of vessel depressurization?
    4    E1fDep    E1ofDep     E1nDep     E1-Dep
    1         1          2          3          4
         0.0000     0.0000     1.0000     0.0000
15 When does core damage occur?
    2    CD-Fst     CD-Slw
    1         1          2
          1.000      0.000
```

PDS 3 Tree Top:

```
  GRAND GULF ACCIDENT PROGRESSION EVENT TREE
  125
   NQ
    1     1.000
            cen
1 What is the initiating event?
    3     TLOSP         T2         TC
    1         1          2          3
          1.000      0.000      0.000
2 Is there a Station Blackout (Diesel Generators fail)?
    2        SB        nSB
    1         1          2
          1.000      0.000
3 Is DC Power not available?
    2     E1fDC      E1-DC
    1         1          2
          0.000      1.000
4 Do one or more S/RVs fail to reclose?
    2    E1SORV    E1nSORV
    1         1          2
          0.040      0.980
5 Does HPCS fail to inject?
    3  E1fHPInj   E1rHPInj   E1-HPInj
    1         1          2          3
          1.000      0.000      0.000
6 Does RCIC fail to inject initially?
    2   E1fRCIC    E1-RCIC
    1         1          2
          1.000      0.000
7 Does the CRD hydraulic system fail to inject?
    3    E1fCRD     E1rCRD     E1-CRD
    1         1          2          3
          1.000      0.000      0.000
8 Does the condensate system fail?
    3   E1fCond    E1rCond    E1aCond
    1         1          2          3
          0.000      1.000      0.000
9 Do the LPCS and LPCI systems fail?
    4    E1fLPC     E1rLPC     E1aLPC     E1-LPC
    1         1          2          3          4
          1.000      0.000      0.000      0.000
10 Does RHR fail (heat exchangers not available)?
    4    E1fRHR     E1rRHR     E1aRHR     E1-RHR
    1         1          2          3          4
          1.000      0.000      0.000      0.000
11 Does the service water system or cross-tie to LPCI fail?
    3    E1fSSW     E1rSSW     E1aSSW
    1         1          2          3
          1.000      0.000      0.000
12 Does the fire protection system cross-tie to LPCI fail?
    3    E1fFWS    E1ofFWS     E1aFWS
    1         1          2          3
          0.000      0.000      1.000
13 Are the containment (wetwell) sprays failed?
    4    E1fCSS     E1rCSS     E1aCSS     E1-CSS
    1         1          2          3          4
          1.000      0.000      0.000      0.000
14 What is the status of vessel depressurization?
    4    E1fDep    E1ofDep     E1nDep     E1-Dep
    1         1          2          3          4
         0.0000     0.0000     1.0000     0.0000
15 When does core damage occur?
    2    CD-Fst     CD-Slw
    1         1          2
          1.000      0.000
```

PDS 4 Tree Top:

```
     GRAND GULF ACCIDENT PROGRESSION EVENT TREE
     125
      NQ
       1     1.000
               cen
   1 What is the initiating event?
       3      TLOSP        T2         TC
       1          1         2          3
              1.000     0.000      0.000
   2 Is there a Station Blackout (Diesel Generators fail)?
       2         SB       nSB
       1          1         2
              1.000     0.000
   3 Is DC Power not available?
       2      E1fDC     E1-DC
       1          1         2
              0.000     1.000
   4 Do one or more S/RVs fail to reclose?
       2     E1SORV   E1nSORV
       1          1         2
              0.000     1.000
   5 Does HPCS fail to inject?
       3  E1fHPInj  E1rHPInj  E1-HPInj
       1          1         2          3
              0.000     1.000      0.000
   6 Does RCIC fail to inject initially?
       2    E1fRCIC   E1-RCIC
       1          1         2
              1.000     0.000
   7 Does the CRD hydraulic system fail to inject?
       3     E1fCRD    E1rCRD     E1-CRD
       1          1         2          3
              1.000     0.000      0.000
   8 Does the condensate system fail?
       3    E1fCond   E1rCond    E1aCond
       1          1         2          3
              0.000     1.000      0.000
   9 Do the LPCS and LPCI systems fail?
       4     E1fLPC    E1rLPC     E1aLPC     E1-LPC
       1          1         2          3          4
              0.000     1.000      0.000      0.000
  10 Does RHR fail (heat exchangers not available)?
       4     E1fRHR    E1rRHR     E1aRHR     E1-RHR
       1          1         2          3          4
              0.000     1.000      0.000      0.000
  11 Does the service water system or cross-tie to LPCI fail?
       3     E1fSSW    E1rSSW     E1aSSW
       1          1         2          3
              1.000     0.000      0.000
  12 Does the fire protection system cross-tie to LPCI fail?
       3     E1fFWS   E1ofFWS     E1aFWS
       1          1         2          3
              0.000     1.000      0.000
  13 Are the containment (wetwell) sprays failed?
       4     E1fCSS    E1rCSS     E1aCSS     E1-CSS
       1          1         2          3          4
              0.000     1.000      0.000      0.000
  14 What is the status of vessel depressurization?
       4     E1fDep   E1ofDep     E1nDep     E1-Dep
       1          1         2          3          4
             0.0000    0.0000     0.0000     1.0000
  15 When does core damage occur?
       2     CD-Fst    CD-Slw
       1          1         2
              0.000     1.000
```

PDS 5 Tree Top:

```
  GRAND GULF ACCIDENT PROGRESSION EVENT TREE
  125
   NQ
    1     1.000
            cen
1 What is the initiating event?
    3     TLOSP        T2         TC
    1         1         2          3
          1.000     0.000      0.000
2 Is there a Station Blackout (Diesel Generators fail)?
    2        SB       nSB
    1         1         2
          1.000     0.000
3 Is DC Power not available?
    2     E1fDC     E1-DC
    1         1         2
          0.000     1.000
4 Do one or more S/RVs fail to reclose?
    2    E1SORV   E1nSORV
    1         1         2
          0.000     1.000
5 Does HPCS fail to inject?
    3  E1fHPInj  E1rHPInj  E1-HPInj
    1         1         2         3
          0.000     1.000     0.000
6 Does RCIC fail to inject initially?
    2   E1fRCIC   E1-RCIC
    1         1         2
          1.000     0.000
7 Does the CRD hydraulic system fail to inject?
    3    E1fCRD    E1rCRD    E1-CRD
    1         1         2         3
          1.000     0.000     0.000
8 Does the condensate system fail?
    3   E1fCond   E1rCond   E1aCond
    1         1         2         3
          0.000     1.000     0.000
9 Do the LPCS and LPCI systems fail?
    4    E1fLPC    E1rLPC    E1aLPC    E1-LPC
    1         1         2         3         4
          0.000     1.000     0.000     0.000
10 Does RHR fail (heat exchangers not available)?
    4    E1fRHR    E1rRHR    E1aRHR    E1-RHR
    1         1         2         3         4
          1.000     0.000     0.000     0.000
11 Does the service water system or cross-tie to LPCI fail?
    3    E1fSSW    E1rSSW    E1aSSW
    1         1         2         3
          1.000     0.000     0.000
12 Does the fire protection system cross-tie to LPCI fail?
    3    E1fFWS   E1ofFWS    E1aFWS
    1         1         2         3
          0.000     1.000     0.000
13 Are the containment (wetwell) sprays failed?
    4    E1fCSS    E1rCSS    E1aCSS    E1-CLS
    1         1         2         3         4
          1.000     0.000     0.000     0.000
14 What is the status of vessel depressurization?
    4    E1fDep   E1ofDep    E1nDep    E1-Dep
    1         1         2         3         4
         0.0000    0.0000    0.0000    1.0000
15 When does core damage occur?
    2    CD-Fst    CD-Slw
    1         1         2
          0.000     1.000
```

PDS 6 Tree Top:

```
  GRAND GULF ACCIDENT PROGRESSION EVENT TREE
  125
   NQ
    1     1.000
            cen
1 What is the initiating event?
    3      TLOSP         T2         TC
    1          1          2          3
          1.000      0.000      0.000
2 Is there a Station Blackout (Diesel Generators fail)?
    2         SB        nSB
    1          1          2
          1.000      0.000
3 Is DC Power not available?
    2      E1fDC      E1-DC
    1          1          2
          0.000      1.000
4 Do one or more S/RVs fail to reclose?
    2     E1SORV    E1nSORV
    1          1          2
          0.000      1.000
5 Does HPCS fail to inject?
    3  E1fHPInj   E1rHPInj   E1-HPInj
    1          1          2          3
          1.000      0.000      0.000
6 Does RCIC fail to inject initially?
    2    E1fRCIC    E1-RCIC
    1          1          2
          1.000      0.000
7 Does the CRD hydraulic system fail to inject?
    3     E1fCRD     E1rCRD     E1-CRD
    1          1          2          3
          1.000      0.000      0.000
8 Does the condensate system fail?
    3    E1fCond    E1rCond    E1aCond
    1          1          2          3
          1.000      0.000      0.000
9 Do the LPCS and LPCI systems fail?
    4     E1fLPC     E1rLPC     E1aLPC     E1-LPC
    1          1          2          3          4
          1.000      0.000      0.000      0.000
10 Does RHR fail (heat exchangers not available)?
    4     E1fRHR     E1rRHR     E1aRHR     E1-RHR
    1          1          2          3          4
          1.000      0.000      0.000      0.000
11 Does the service water system or cross-tie to LPCI fail?
    3     E1fSSW     E1rSSW     E1aSSW
    1          1          2          3
          1.000      0.000      0.000
12 Does the fire protection system cross-tie to LPCI fail?
    3     E1fFWS    E1ofFWS     E1aFWS
    1          1          2          3
          0.000      1.000      0.000
13 Are the containment (wetwell) sprays failed?
    4     E1fCSS     E1rCSS     E1aCSS     E1-CSS
    1          1          2          3          4
          1.000      0.000      0.000      0.000
14 What is the status of vessel depressurization?
    4     E1fDep    E1ofDep     E1nDep     E1-Dep
    1          1          2          3          4
         0.0000     0.0000     0.0000     1.0000
15 When does core damage occur?
    2     CD-Fst     CD-Slw
    1          1          2
          0.000      1.000
```

PDS 7 Tree Top:

```
   GRAND GULF ACCIDENT PROGRESSION EVENT TREE
   125
    NQ
     1     1.000
             cen
 1 What is the initiating event?
     3      TLOSP        T2         TC
     1          1         2          3
            1.000     0.000      0.000
 2 Is there a Station Blackout (Diesel Generators fail)?
     2         SB       nSB
     1          1         2
            1.000     0.000
 3 Is DC Power not available?
     2      E1fDC     E1-DC
     1          1         2
            1.000     0.000
 4 Do one or more S/RVs fail to reclose?
     2     E1SORV   E1nSORV
     1          1         2
            0.040     0.960
 5 Does HPCS fail to inject?
     3  E1fHPInj  E1rHPInj  E1-HPInj
     1          1         2          3
            1.000     0.000      0.000
 6 Does RCIC fail to inject initially?
     2    E1fRCIC   E1-RCIC
     1          1         2
            1.000     0.000
 7 Does the CRD hydraulic system fail to inject?
     3     E1fCRD    E1rCRD     E1-CRD
     1          1         2          3
            1.000     0.000      0.000
 8 Does the condensate system fail?
     3    E1fCond   E1rCond    E1aCond
     1          1         2          3
            1.000     0.000      0.000
 9 Do the LPCS and LPCI systems fail?
     4     E1fLPC    E1rLPC     E1aLPC     E1-LPC
     1          1         2          3          4
            1.000     0.000      0.000      0.000
10 Does RHR fail (heat exchangers not available)?
     4     E1fRHR    E1rRHR     E1aRHR     E1-RHR
     1          1         2          3          4
            1.000     0.000      0.000      0.000
11 Does the service water system or cross-tie to LPCI fail?
     3     E1fSSW    E1rSSW     E1aSSW
     1          1         2          3
            1.000     0.000      0.000
12 Does the fire protection system cross-tie to LPCI fail?
     3     E1fFWS   E1ofFWS     E1aFWS
     1          1         2          3
            0.000     0.000      1.000
13 Are the containment (wetwell) sprays failed?
     4     E1fCSS    E1rCSS     E1aCSS     E1-CSS
     1          1         2          3          4
            1.000     0.000      0.000      0.000
14 What is the status of vessel depressurization?
     4     E1fDep   E1ofDep     E1nDep     E1-Dep
     1          1         2          3          4
           1.0000    0.0000     0.0000     0.0000
15 When does core damage occur?
     2     CD-Fst    CD-Slw
     1          1         2
            1.000     0.000
```

PDS 8 Tree Top:

```
    GRAND GULF ACCIDENT PROGRESSION EVENT TREE
    125
     NQ
      1      1.000
               cen
 1 What is the initiating event?
      3      TLOSP          T2          TC
      1          1           2           3
             1.000       0.000       0.000
 2 Is there a Station Blackout (Diesel Generators fail)?
      2         SB         nSB
      1          1           2
             1.000       0.000
 3 Is DC Power not available?
      2      E1fDC       E1-DC
      1          1           2
             1.000       0.000
 4 Do one or more S/RVs fail to reclose?
      2     E1SORV     E1nSORV
      1          1           2
             0.000       1.000
 5 Does HPCS fail to inject?
      3  E1fHPInj   E1rHPInj   E1-HPInj
      1          1           2           3
             1.000       0.000       0.000
 6 Does RCIC fail to inject initially?
      2    E1fRCIC     E1-RCIC
      1          1           2
             1.000       0.000
 7 Does the CRD hydraulic system fail to inject?
      3     E1fCRD      E1rCRD      E1-CRD
      1          1           2           3
             1.000       0.000       0.000
 8 Does the condensate system fail?
      3    E1fCond     E1rCond     E1aCond
      1          1           2           3
             1.000       0.000       0.000
 9 Do the LPCS and LPCI systems fail?
      4     E1fLPC      E1rLPC      E1aLPC      E1-LPC
      1          1           2           3           4
             1.000       0.000       0.000       0.000
10 Does RHR fail (heat exchangers not available)?
      4     E1fRHR      E1rRHR      E1aRHR      E1-RHR
      1          1           2           3           4
             1.000       0.000       0.000       0.000
11 Does the service water system or cross-tie to LPCI fail?
      3     E1fSSW      E1rSSW      E1aSSW
      1          1           2           3
             1.000       0.000       0.000
12 Does the fire protection system cross-tie to LPCI fail?
      3     E1fFWS     E1ofFWS      E1aFWS
      1          1           2           3
             0.000       0.000       1.000
13 Are the containment (wetwell) sprays failed?
      4     E1fCSS      E1rCSS      E1aCSS      E1-CSS
      1          1           2           3           4
             1.000       0.000       0.000       0.000
14 What is the status of vessel depressurization?
      4     E1fDep     E1ofDep      E1nDep      E1-Dep
      1          1           2           3           4
            1.0000      0.0000      0.0000      0.0000
15 When does core damage occur?
      2     CD-Fst      CD-Slw
      1          1           2
             0.000       1.000
```

PDS 9 Tree Top:

```
 GRAND GULF ACCIDENT PROGRESSION EVENT TREE
 125
  NQ
   1     1.000
           cen
1 What is the initiating event?
    3      TLOSP          T2          TC
    1          1           2           3
           0.000       0.000       1.000
2 Is there a Station Blackout (Diesel Generators fail)?
    2         SB         nSB
    1          1           2
           0.000       1.000
3 Is DC Power not available?
    2      E1fDC       E1-DC
    1          1           2
           0.000       1.000
4 Do one or more S/RVs fail to reclose?
    2     E1SORV     E1nSORV
    1          1           2
           0.000       1.000
5 Does HPCS fail to inject?
    3  E1fHPInj   E1rHPInj   E1-HPInj
    1          1           2          3
           1.000       0.000      0.000
6 Does RCIC fail to inject initially?
    2    E1fRCIC     E1-RCIC
    1          1           2
           0.000       1.000
7 Does the CRD hydraulic system fail to inject?
    3     E1fCRD      E1rCRD      E1-CRD
    1          1           2           3
           1.000       0.000       0.000
8 Does the condensate system fail?
    3    E1fCond     E1rCond     E1aCond
    1          1           2           3
           0.000       0.000       1.000
9 Do the LPCS and LPCI systems fail?
    4     E1fLPC      E1rLPC      E1aLPC      E1-LPC
    1          1           2           3           4
           0.000       0.000       1.000       0.000
10 Does RHR fail (heat exchangers not available)?
    4     E1fRHR      E1rRHR      E1aRHR      E1-RHR
    1          1           2           3           4
           0.000       0.000       1.000       0.000
11 Does the service water system or cross-tie to LPCI fail?
    3     E1fSSW      E1rSSW      E1aSSW
    1          1           2           3
           1.000       0.000       0.000
12 Does the fire protection system cross-tie to LPCI fail?
    3     E1fFWS     E1ofFWS      E1aFWS
    1          1           2           3
           0.000       0.000       1.000
13 Are the containment (wetwell) sprays failed?
    4     E1fCSS      E1rCSS      E1aCSS      E1-CSS
    1          1           2           3           4
           0.000       0.000       1.000       0.000
14 What is the status of vessel depressurization?
    4     E1fDep     E1ofDep     E1nDep      E1-Dep
    1          1           2           3           4
          0.0000      1.0000      0.0000      0.0000
15 When does core damage occur?
    2     CD-Fst      CD-Slw
    1          1           2
           1.000       0.000
```

PDS 10 Tree Top:

```
  GRAND GULF ACCIDENT PROGRESSION EVENT TREE
  125
   NQ
    1     1.000
            cen
1 What is the initiating event?
    3      TLOSP         T2         TC
    1          1          2          3
           0.000      0.000      1.000
2 Is there a Station Blackout (Diesel Generators fail)?
    2         SB        nSB
    1          1          2
           0.000      1.000
3 Is DC Power not available?
    2      E1fDC      E1-DC
    1          1          2
           0.000      1.000
4 Do one or more S/RVs fail to reclose?
    2     E1SORV    E1nSORV
    1          1          2
           0.000      1.000
5 Does HPCS fail to inject?
    3  E1fHPInj  E1rHPInj  E1-HPInj
    1          1          2          3
           1.000      0.000      0.000
6 Does RCIC fail to inject initially?
    2   E1fRCIC    E1-RCIC
    1          1          2
           1.000      0.000
7 Does the CRD hydraulic system fail to inject?
    3     E1fCRD     E1rCRD     E1-CRD
    1          1          2          3
           1.000      0.000      0.000
8 Does the condensate system fail?
    3    E1fCond    E1rCond    E1aCond
    1          1          2          3
           0.000      0.000      1.000
9 Do the LPCS and LPCI systems fail?
    4     E1fLPC     E1rLPC     E1aLPC     E1-LPC
    1          1          2          3          4
           0.000      0.000      1.000      0.000
10 Does RHR fail (heat exchangers not available)?
    4     E1fRHR     E1rRHR     E1aRHR     E1-RHR
    1          1          2          3          4
           0.000      0.000      1.000      0.000
11 Does the service water system or cross-tie to LPCI fail?
    3     E1fSSW     E1rSSW     E1aSSW
    1          1          2          3
           1.000      0.000      0.000
12 Does the fire protection system cross-tie to LPCI fail?
    3     E1fFWS     E1rFWS     E1aFWS
    1          1          2          3
           0.000      0.000      1.000
13 Are the containment (wetwell) sprays failed?
    4     E1fCSS     E1rCSS     E1aCSS     E1-CSS
    1          1          2          3          4
           0.000      0.000      0.000      1.000
14 What is the status of vessel depressurization?
    4     E1fDep    E1ofDep     E1nDep     E1-Dep
    1          1          2          3          4
          0.0000     1.0000     0.0000     0.0000
15 When does core damage occur?
    2     CD-Fst     CD-Slw
    1          1          2
           0.000      1.000
```

PDS 11 Tree Top:

```
   GRAND GULF ACCIDENT PROGRESSION EVENT TREE
   125
    NQ
     1     1.000
             cen
 1 What is the initiating event?
     3     TLOSP        T2          TC
     1         1         2           3
           0.000     1.000       0.000
 2 Is there a Station Blackout (Diesel Generators fail)?
     2        SB       nSB
     1         1         2
           0.000     1.000
 3 Is DC Power not available?
     2     E1fDC     E1-DC
     1         1         2
           0.000     1.000
 4 Do one or more S/RVs fail to reclose?
     2    E1SORV   E1nSORV
     1         1         2
           0.000     1.000
 5 Does HPCS fail to inject?
     3  E1fHPInj  E1rHPInj  E1-HPInj
     1         1         2         3
           1.000     0.000     0.000
 6 Does RCIC fail to inject initially?
     2   E1fRCIC   E1-RCIC
     1         1         2
           1.000     0.000
 7 Does the CRD hydraulic system fail to inject?
     3    E1fCRD    E1rCRD    E1-CRD
     1         1         2         3
           1.000     0.000     0.000
 8 Does the condensate system fail?
     3   E1fCond   E1rCond   E1aCond
     1         1         2         3
           0.000     0.000     1.000
 9 Do the LPCS and LPCI systems fail?
     4    E1fLPC    E1rLPC    E1aLPC    E1-LPC
     1         1         2         3         4
           0.000     0.000     1.000     0.000
10 Does RHR fail (heat exchangers not available)?
     4    E1fRHR    E1rRHR    E1aRHR    E1-RHR
     1         1         2         3         4
           0.000     0.000     1.000     0.000
11 Does the service water system or cross-tie to LPCI fail?
     3    E1fSSW    E1rSSW    E1aSSW
     1         1         2         3
           1.000     0.000     0.000
12 Does the fire protection system cross-tie to LPCI fail?
     3    E1fFWS   E1ofFWS    E1aFWS
     1         1         2         3
           0.000     0.000     1.000
13 Are the containment (wetwell) sprays failed?
     4    E1fCSS    E1rCSS    E1aCSS    E1-CSS
     1         1         2         3         4
           0.000     0.000     1.000     0.000
14 What is the status of vessel depressurization?
     4    E1fDep   E1ofDep    E1nDep    E1-Dep
     1         1         2         3         4
          0.0000    1.0000    0.0000    0.0000
15 When does core damage occur?
     2    CD-Fst    CD-Slw
     1         1         2
           1.000     0.000
```

PDS 12 Tree Top:

```
    GRAND GULF ACCIDENT PROGRESSION EVENT TREE
    125
     NO
      1      1.000
               cen
  1 What is the initiating event?
      3      TLOSP           T2          TC
      1          1            2           3
             0.000        1.000       0.000
  2 Is there a Station Blackout (Diesel Generators fail)?
      2         SB          nSB
      1          1            2
             0.000        1.000
  3 Is DC Power not available?
      2      E1fDC        E1-DC
      1          1            2
             0.000        1.000
  4 Do one or more S/RVs fail to reclose?
      2     E1SORV      E1nSORV
      1          1            2
             0.000        1.000
  5 Does HPCS fail to inject?
      3   E1fHPInj     E1rHPInj    E1-HPInj
      1          1            2           3
             1.000        0.000       0.000
  6 Does RCIC fail to inject initially?
      2    E1fRCIC      E1-RCIC
      1          1            2
             1.000        0.000
  7 Does the CRD hydraulic system fail to inject?
      3     E1fCRD       E1rCRD      E1-CRD
      1          1            2           3
             1.000        0.000       0.000
  8 Does the condensate system fail?
      3    E1fCond      E1rCond     E1aCond
      1          1            2           3
             0.000        0.000       1.000
  9 Do the LPCS and LPCI systems fail?
      4     E1fLPC       E1rLPC      E1aLPC      E1-LPC
      1          1            2           3           4
             0.000        0.000       1.000       0.000
 10 Does RHR fail (heat exchangers not available)?
      4     E1fRHR       E1rRHR      E1aRHR      E1-RHR
      1          1            2           3           4
             0.000        0.000       1.000       0.000
 11 Does the service water system or cross-tie to LPCI fail?
      3     E1fSSW       E1rSSW      E1aSSW
      1          1            2           3
             1.000        0.000       0.000
 12 Does the fire protection system cross-tie to LPCI fail?
      3     E1fFWS      E1ofFWS      E1aFWS
      1          1            2           3
             0.000        0.000       1.000
 13 Are the containment (wetwell) sprays failed?
      4     E1fCSS       E1rCSS      E1aCSS      E1-CSS
      1          1            2           3           4
             0.000        0.000       1.000       0.000
 14 What is the status of vessel depressurization?
      4     E1fDep      E1ofDep      E1nDep      E1-Dep
      1          1            2           3           4
            0.0000       1.0000      0.0000      0.0000
 15 When does core damage occur?
      2     CD-Fst       CD-Slw
      1          1            2
             0.000        1.000
```

A.3.3 Additional APET Information

A.3.3.1 Description of Human Reliability Analysis Used in the APET. In the APET, there is a series of questions that considers actions the operator may take to mitigate the accident. The APET questions that involve operator actions are Questions 21, 22, 26, 27, and 29. The reliability of the operator to perform various tasks depends on his previous performance. The likelihood that an operator will perform a task correctly decreases as the number of previous errors increases. Therefore, it is necessary to keep track of the number of operator errors when quantifying these types of questions. In addition, the performance of the operator before core damage is also important because it indicates whether the operator is susceptible to these types of errors. For example, core damage occurs in the T2, ATWS, and long-term SBO PDS because the operator failed to perform some task correctly. Therefore, operator errors are more likely in accidents associated with these PDSs than in accidents associated with a short-term SBO, which did not occur because of operator error.

The questions considered in this section were quantified by the system analyst with input from the personnel at SERI. The system analyst used the ASEP HRA Methodology$^{A\text{-}13}$ to estimate the HEP. The HEPs are based on the assumption that for a task to fail, the operator must fail to perform the task correctly and the supervisor must fail to correct the operator's error. Furthermore, the HEP for a particular task is doubled if the operator has previously committed an error. For example, the HEP associated with the operator turning off the HIS during core damage is doubled if the operator has previously failed to depressurize the RPV.

Short-Term SBO PDSs

The APET question considered in the HRA analysis for the short-term SBO PDSs are Questions 21, 26, 27, and 28. The relationships between these questions are shown in Figure A.3-1 In these PDSs, core damage occurs because of random failures and not because of operator errors. In the following four paragraphs, a description of the task performed by the operator and the estimated HEP is presented for each question.

In Question 21, the operator must decide whether to turn on the HIS. The EOPs instruct the operator to turn on the HIS when the RPV level drops below the TAF. Discussions with SERI personnel, however, indicate that operators are trained not to actuate equipment that they know to be inoperable (HIS requires ac power). Furthermore, because there is no ac power (SBO), the operator will not know the containment hydrogen concentration. Personnel at SERI indicated that during an SBO it would take at least 30 minutes to take a sample of the containment atmosphere and determine its hydrogen concentration. It is highly uncertain what the operator will do in this situation. Thus, the probability that the operator will turn the HIS on is 0.5. Because, on the one hand, the EOPs instruct the operators to turn on the HIS and, on the other hand, the operators are trained not to actuate equipment that is inoperable, either action by the operator could be seen as appropriate. Thus, the performance

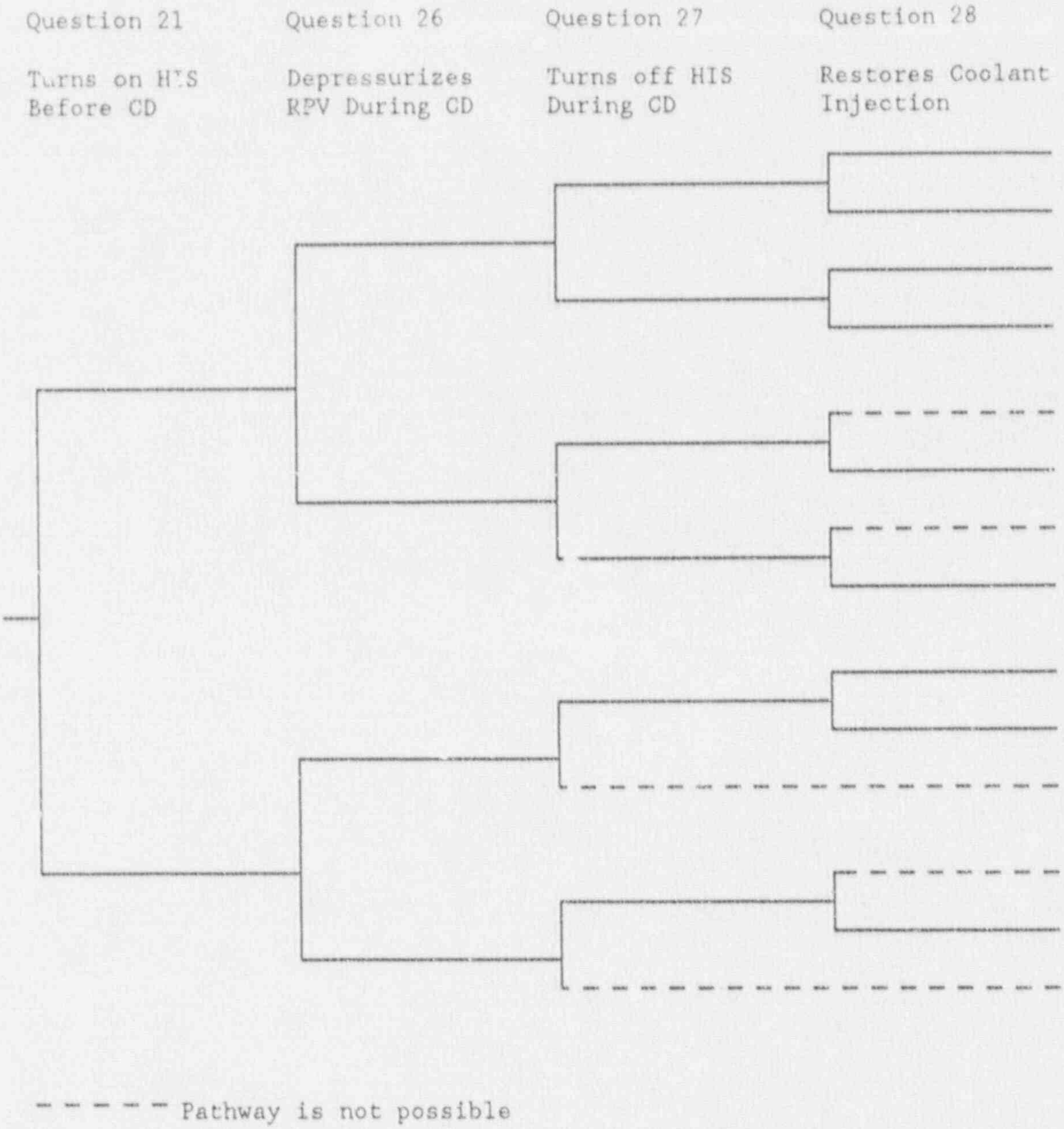

Figure A.3-1. HRA APET Question Dependencies, Short-Term SBO of the operator in subsequent questions is not affected by the action taken in this question.

Question 26 considers depressurization of the RPV. The EOPs instruct the operator to depressurize the RPV before core damage. Thus, failure of the operator to depressurize the RPV is considered an error. If the operator failed to depressurize the RPV before core damage, he can still depressurize the RPV during core damage. However, it is unlikely that the RPV is depressurized during core damage because the operator has already committed an error by not depressurizing the RPV before core damage. To calculate the human error probability (HEP), it is assumed that the operator is under extremely high stress and that the interaction is dynamic. The individual HEPs for the operator and the supervisor are doubled for the quantification of RPV depressurization during core damage because of their previous errors (i.e., did not depressurize the RPV before core damage). The probability that the operator will fail to depressurize the RPV is estimated to be 0.26.

Question 27 considers whether the operator turns the HIS off during core damage. During core damage, the operator will not know how much hydrogen is in the containment. If a large amount of hydrogen has accumulated in the containment and ac power is recovered with the HIS on, the resulting hydrogen burn could be severe. Thus, if the operator turns the HIS on before the core is damaged and ac power is recovered, the operator should turn the HIS off. The HEP is calculated assuming that the operator is under extremely high stress and that the interaction is step by step. Assuming there were no previous operator errors, the probability that the operator will fail to turn the HIS off is estimated to be 0.064. If the HIS is off before core damage and the operator turns it on during core damage, it is considered an error of commission. Errors of commission are not in the scope of this analysis.

Question 28 considers whether the operator successfully aligns an alternate low pressure injection system. If HPCS, LPCS, or LPCI is available when ac power is recovered, it is assumed that coolant injection is supplied to the RPV. If all of these systems have failed, the operator must manually actuate the condensate system or align the FWS and then actuate it. If the operator has previously failed to depressurize the RPV, these systems cannot be used (both are low pressure injection systems). The HEPs are calculated assuming that the operator is under extremely high stress and that the interaction is step by step. Assuming there were no previous operator errors, the probability that the operator will fail to actuate the condensate system is estimated to be 0.064. Similarly, the probability that the operator will fail to align and actuate the FWS is 0.128.

Long-Term SBO PDSs

The APET question considered in the HRA analysis for both the short-term ATWS PDS and the T2 PDSs are Questions 21, 27, and 28. The relationships between these questions are shown in Figure A.3-2. In these PDSs, core damage occurs because the operator has failed to perform various tasks correctly. To reflect the operator's susceptibility to these types of errors, the individual HEPs for the operator and the supervisor are

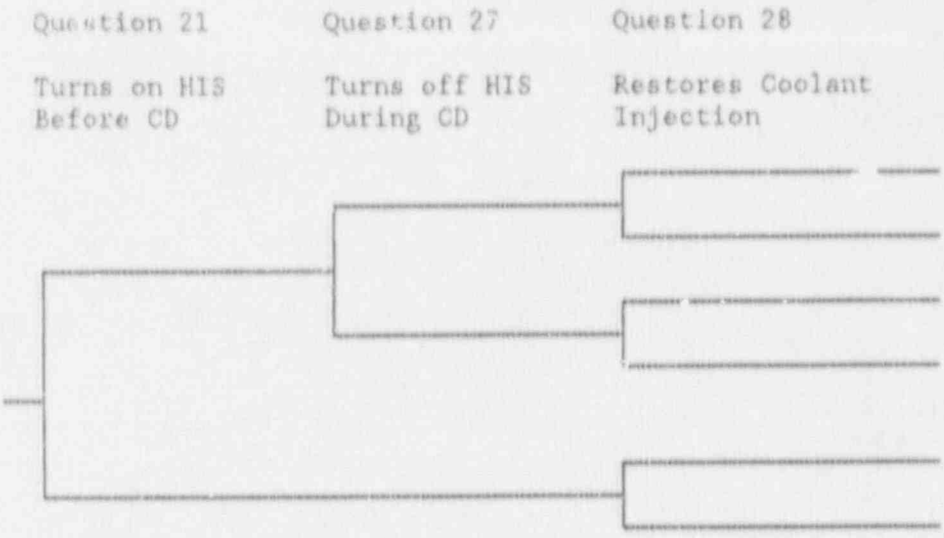

Figure A.3-2. HRA APET Question Dependencies, Long-Term SBO

doubled. In all but one of the long-term SBO PDSs, the RPV is depressurized before core damage. In the one PDS that the RPV is not depressurized, the loss of dc power precludes depressurization. Thus, RPV depressurization is not considered in these PDSs. A description follows of the task performed by the operator and the estimated HEP is presented for each question.

In Question 21, the operator must decide whether to turn on the HIS before core damage. As explained in the section on the short-term SBOs, when ac power is not available it is not certain whether the operator will follow the EOPs and turn on the HIS or follow his training and not actuate a system that is unavailable. Thus, the probability that the operator will turn the HIS on is 0.5.

Question 27 considers whether the operator turns the HIS off during core damage. This issue is discussed in the section on short-term SBOs. The HEP is calculated assuming that the operator is under extremely high stress and that the interaction is step by step. The probability that the operator will fail to turn the HIS off is estimated to be 0.16.

Question 28 considers whether the operator successfully aligns alternate low pressure injection systems. As with the short-term SBO PDSs, if HPCS, LPCS, or LPCI is available when ac power is recovered, it is assumed that coolant injection is supplied to the RPV. If all of these systems have failed, the operator can still manually actuate the condensate system. In the long-term SBO PDS, the failure of the operators to use the FWS resulted in core damage. Because they failed to use this system before core damage, it is assumed that they will not use it during core damage when they have much less time to assess the situation. The HEPs are calculated assuming that the operator is under extremely high stress and that the interaction is step-by-step. The probability that the operator will actuate the condensate system is estimated to be 0.16.

Long-Term ATWS PDS

The APET question considered in the HRA analysis for both the short-term ATWS PDS and the T2 PDSs are Question 21, 22, and 26. The relationships between these question are shown in Figure A.3-3. In this PDS, core damage occurs because the operator has failed to depressurize the RPV and initiate the standby liquid control system before core damage. To reflect the operator's susceptibility to these types of errors, the individual HEPs for the operator and the supervisor are doubled. Although the emergency low pressure injection systems (i.e., LPCS or LPCI) are available, the operator failed to depressurize the RPV before core damage, so these systems are not operating. If the operator depressurizes the RPV during core damage, it is assumed that one of these systems will provide coolant to the core. Thus, coolant injection is not considered in the HRA analysis for this PDS. In the following paragraphs, a description of the task performed by the operator and the estimated HEP is presented for each question.

In Question 21, the operator must decide whether to turn on the HIS before core damage. In this PDS, ac power is available during the accident. Thus, according to the EOPs and the training, the operator should actuate the HIS. The HEP is calculated assuming that the operator is under extremely high stress and that the interaction is step by step. The probability that the operator will fail to turn the HIS on is estimated to be 0.16.

In Question 22 the operator must decide whether to vent the containment before core damage. The venting procedures instruct the operator to vent the containment when its pressure exceeds 17.25 psig. The containment pressure will exceed the venting pressure before core damage during a long-term ATWS PDS. Thus, the operator should vent the containment. The HEP is calculated assuming that the operator is under extremely high stress and that the interaction is dynamic. The probability that the operator will fail to vent the containment before core damage is estimated to be 0.8.

Question 26 considers the possibility that the operator will depressurize the RPV during core damage. If he does depressurize the RPV, the low pressure injection systems can provide coolant to the core and potentially arrest core damage. Therefore, the operator should depressurize the RPV during core damage if he failed to do so before core damage. To calculate the HEP it is assumed that the operator is under extremely high stress and that the interaction is dynamic. The probability that the operator will fail to depressurize the RPV during core damage is estimated to be 0.8.

Short-Term ATWS and T2 PDSs

The APET question considered in the HRA analysis for both the short-term ATWS PDS and the T2 PDSs are Question 21 and 26. The relationship between these questions is shown in Figure A.3-4. In these PDSs, core damage occurs because the operator has failed to perform various tasks correctly.

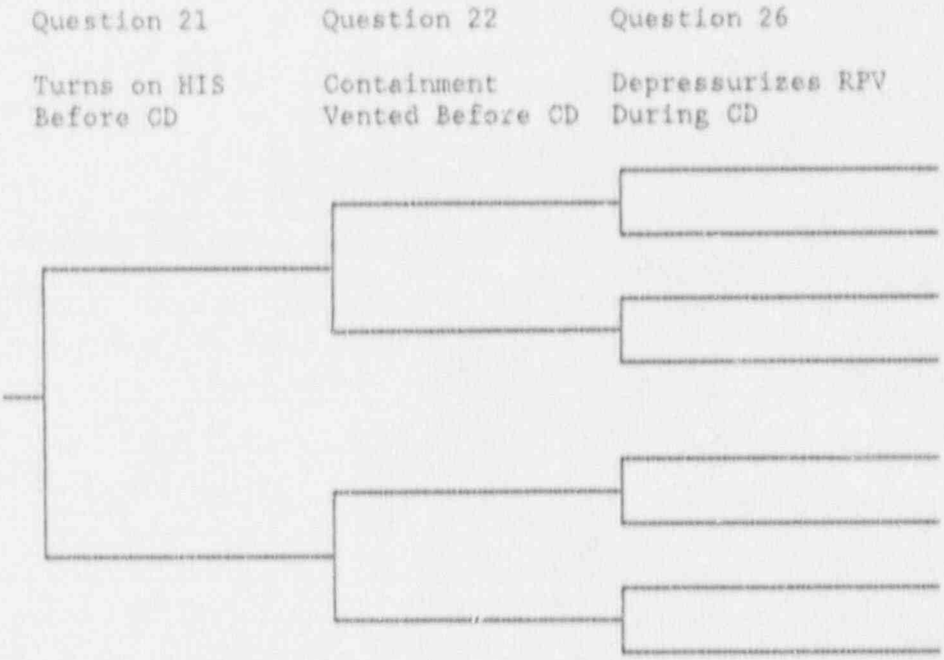

Figure A.3-3. HRA APET Question Dependencies, Long-Term ATWS

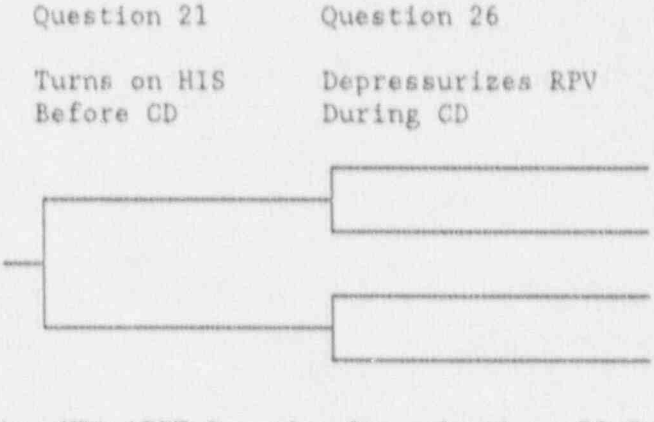

Figure A.3-4. HRA APET Question Dependencies, T2 Transients and Short-Term ATWS

Although the emergency low pressure injection systems (i.e., LPCS or LPCI) are available, the operator failed to depressurize the RPV before core damage, so these systems are not operating. If the operator depressurizes the RPV during core damage, it is assumed that one of these systems will provide coolant to the core. Furthermore, in the short-term ATWS PDS and the T2 PDSs, the containment does not pressurize sufficiently before core damage to require venting. Therefore, neither coolant injection nor venting is considered in the HRA analysis for these PDSs. Thus, except for venting, the HEPs for these PDSs are identical to the HEPs estimated for the long-term ATWS. That is, the HEPs for turning on the HIS before core damage (Question 21) and depressurizing the RPV during core damage (Question 26) are 0.16 and 0.8, respectively.

A.3.3.2 APET Time Intervals. The Grand Gulf APET is divided into four time regimes. The time regimes are used to represent various segments of the accident. Four time regimes are considered in the Grand Gulf APET: before core degradation, during core degradation, following VB, and late. The time intervals defined in this section are used to quantify the probability of recovering ac power during the accident. In this analysis, the probability of power recovery is defined as the probability that offsite electrical power is recovered in the period in question given that power was not recovered prior to the period. A discussion of the power recovery curves used in this analysis is presented in Subsection A.3.3.3 of this report. A description of each time regime is presented below.

Before Core Damage. This time regime ranges from the accident initiation to core damage. This time regime was analyzed in the accident frequency analysis and is reported in NUREG/CR 4550, Volume 6. During this time interval it is determined in the APET whether the operators turned on the hydrogen ignition system or vented the containment. The end of this time interval is the beginning of the next time period. For consistency, the time used in the accident frequency analysis is also used in the APET. Core damage occurs roughly when the collapsed water level in the RPV reaches 2 feet above the BAF. The time that this level is reached was estimated from BWRLTAS code calculations for both a short-term SBO and a long-term SBO. For a short-term SBO core damage occurs approximately 1 hour after the initiation of the accident. For a long-term SBO core damage occurs approximately 12 hours after the initiation of the accident.

During Core Damage. This time regime covers the period from core damage to significant core collapse. Core collapse is chosen to end this time regime because it is assumed that after core collapse, recovery of coolant injection will not significantly alter the accident progression before VB (and it will not avert VB). BWRSAR code calculations for a Peach Bottom short-term low-pressure meltdown and a Peach Bottom long-term meltdown were used to estimate the time of core collapse. (See Volume 2, Part 1, of this report).

For a short-term SBO, core collapse occurs 3.35 hours after the initiation of the accident. Core damage begins 60 minutes after the initiation of the accident. Thus, the length of this time regime is 2.35 hours. VB occurs approximately 15 minutes after core collapse.

For a long-term SBO, core collapse occurs 14.73 hours after the initiation of the accident. Core damage begins 12 hours after the initiation of the accident. For a long-term SBO the length of this time regime is 2.73 hours. VB occurs approximately 15 minutes after core collapse.

Following VB. This time regime ranges from core collapse to 2 hours after VB. In this time interval, events associated with the failure of the vessel are addressed. The end point for this time period was selected for two reasons. First, although containment failure during this time period is most likely to occur at VB, it is possible that the hydrogen will not be ignited at VB. Thus, the containment can fail shortly after VB if this hydrogen is ignited. The hydrogen can be ignited by ac sources associated with the recovery of ac power or by random ignition sources. It was felt that containment failures within two hours of VB could be grouped together. The second reason for selecting this end point is that the peak in CCI occurs more than two hours after VB. Adding water to the debris after the peak has occurred will not significantly alter the source term. Thus, the amount of water in the reactor cavity during the first two hours after VB is important. Furthermore, by selecting this end point, most of the CCI releases (including hydrogen) will be released near the beginning of the late time period. Therefore, the hydrogen generated during CCI is available to be burned during the late time interval and is not addressed in this time interval.

Late. This time interval ranges from the peak in CCI to the end of the accident analysis. In this time regime, the events associated with CCI are addressed. The end of the accident analysis is arbitrarily set at 24 hours after the initiation of the accident because, except for very unusual accidents, almost all of the fission products that are going to be released from the containment will have been released.

A.3.3.3 Conditional Probability of AC Power Recovery. Whether offsite electrical power is recovered during a specified period following the onset of core degradation is determined by sampling from a set of distributions for power recovery.[A-14] These distributions reflect the type of electrical switchyard at Grand Gulf, as explained in NUREG-1032.[A-15] To get ac power to the safety systems, not only does ac power have to be restored to the site, but dc power must be available as well. DC power is required for circuit breaker control power; once the station batteries have failed, it is very difficult to get ac power back to the safety systems. Although the circuit breakers can be moved manually, this procedure is very complicated and slow. Thus, for the timeframe considered in this analysis, it is assumed that once dc power is lost, ac power cannot be recovered. The station battery depletion time was internally quantified during the accident frequency analysis. A distribution was developed for Grand Gulf to model the failure probability of the station batteries versus time for SBO sequences.[A-16] This distribution was convolved with the ac power recovery distributions for the time intervals of interest. The result is the probability of recovering ac power in a given time interval conditional on ac power not being available at the start of the time interval and conditional on dc power not being lost before ac power is restored. Figure A.3-5 shows the conditional probabilities of power recovery for the time intervals used in this analysis (see previous sections). The programs used to generate these distributions are presented in Appendix E.

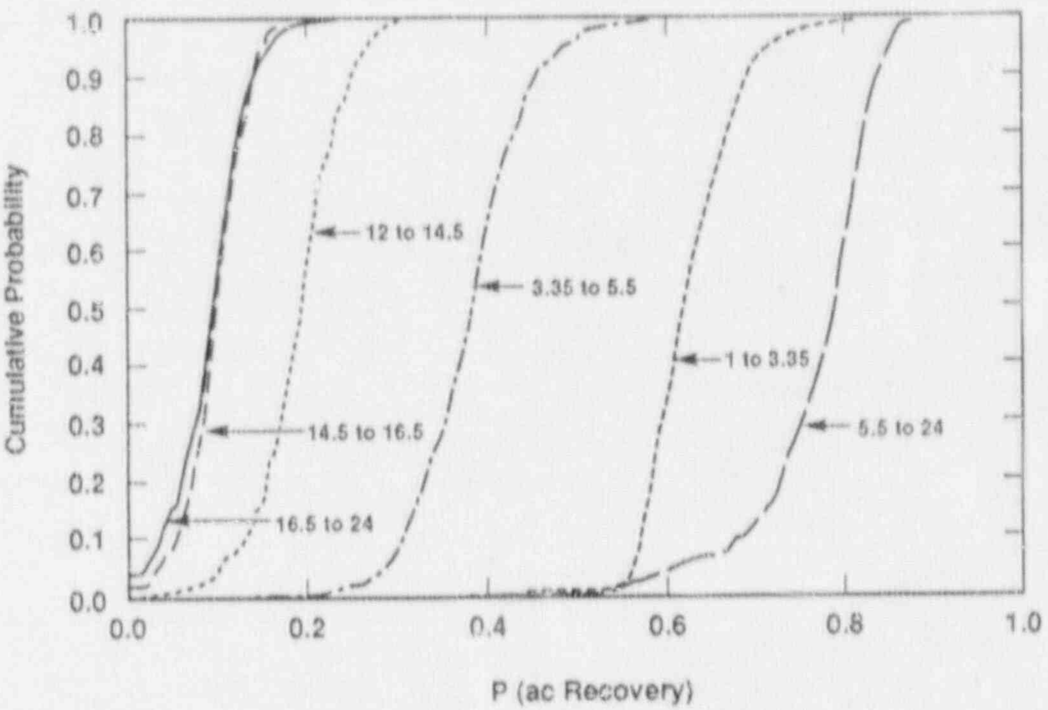

Figure A.3-5. Grand Gulf, Probability of ac Recovery Before dc Loss

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APPENDIX B
SUPPORTING INFORMATION FOR THE SOURCE TERM ANALYSIS

CONTENTS

FIGURES

TABLES

B.1 LISTING OF GGSOR

This section contains a listing of the FORTRAN program GGSOR.FOR.

```
      PROGRAM GGSOR
C*****ADAPTATION OF RELTRAC INPUT PROCESSOR FOR USE IN GGSOR
      PARAMETER (MAXBD=20, MAXBIN=10000, MAXSMP=300, MAXCAS=8,
     1           MAXISS=20, MAXLEV=10, MAXVAR=100, MAXVAL=12000,
     2           MAXSPC=10, MAXTIM=10)
      LOGICAL NOCALC, SAMPLE, REPRTB, BINNED, BYRUN, CONSFL, DIAG,
     1   EXPERT, PRTINP, NOCF, SUBCL, CDB, TMPCDB, BRKOPN, VB, ECF, ICF
      COMMON /KEYS/ NOCALC, SAMPLE, REPRTB, BINNED, BYRUN, CONSFL, DIAG,
     1   EXPERT, PRTINP, NOCF, SUBCL, CDB, TMPCDB, BRKOPN, VB, ECF, ICF
      COMMON /CONTRL/ NLHS, NOBS, NSTART, NBIN, NDM, NTOT
C
C
C*****READ KEYWORDS AND RELATED INFORMATION FROM UNIT 5.
C*****KEYWORDS DETERMINE OPERATION OF RELCLC:
C*****(1) BINNED INPUT WITH SAMPLING
C*****(2) BINNED INPUT WITHOUT SAMPLING
C*****(3) DIRECT INPUT WITH SAMPLING
C*****(4) DIRECT INPUT WITHOUT SAMPLING
      CALL INPUT
C*****CHECK FOR BINNED EXECUTION
      IF (BINNED) THEN
C********CHECK FOR SAMPLING EXECUTION
         IF (SAMPLE) THEN
C************BINNED INPUT WITH SAMPLING
            CALL BINSMP
         ELSE
C************BINNED INPUT WITHOUT SAMPLING
            CALL BIN
         ENDIF
      ELSE
C********CHECK FOR SAMPLING EXECUTION
         IF (SAMPLE) THEN
C************DIRECT INPUT WITH SAMPLING
            CALL DIRSMP
         ELSE
C************DIRECT INPUT WITHOUT SAMPLING
            CALL DIR
         ENDIF
      ENDIF
      STOP
      END
      SUBROUTINE INPUT
C*****PROCESS KEYWORD INPUT ON UNIT 5
      PARAMETER (MAXLEN=101)
      PARAMETER (MAXBD=20, MAXBIN=10000, MAXSMP=300, MAXCAS=8,
     1           MAXISS=20, MAXLEV=10, MAXVAR=100, MAXVAL=12000,
     2           MAXSPC=10, MAXTIM=10)
      COMMON /CONTRL/ NLHS. NOBS, NSTART, NBIN, NDM, NTOT
      LOGICAL NOCALC, SAMPLE, REPRTB, BINNED, BYRUN, CONSFL, DIAG,
     1   EXPERT, PRTINP, NOCF, SUBCL, CDB, TMPCDB, BRKOPN, VB, ECF, ICF
      COMMON /KEYS/ NOCALC, SAMPLE, REPRTB, BINNED, BYRUN, CONSFL, DIAG,
     1   EXPERT, PRTINP, NOCF, SUBCL, CDB, TMPCDB, BRKOPN, VB, ECF, ICF
      CHARACTER BINARR*(MAXBD), BTITLE*80, TITLE*80
      COMMON /BINS/ BINARR(MAXBIN), BTITLE, TITLE
      CHARACTER*80 FILNAM
      CHARACTER*80 DEFFIL, SAMFIL, VECFIL
      COMMON /FILBLK/ DEFFIL, SAMFIL, VECFIL
      CHARACTER CARD*(MAXLEN), CVAL*(MAXLEN), KEYWRD*20
C*****SET LOGICAL TYPES FOR FREE FORMAT SUBROUTINE RDSTRG
      LOGICAL EOR, LVAL, TYPE(4)
C
C
C*****INITIALLIZE COLUMN POINTER FOR CURRENT RECORD
      IC=1
C*****READ RECORD
      READ(5,1001) CARD
```

```
C*****READ MODE SWITCH
      CALL RDSTRG (CARD, IC, KEYWRD, LVAL, IVAL, RVAL, KLNGTH, TYPE,
     1             EOR)
C*****CHECK FOR BINNED OR DIRECT EXECUTION
      IF (KEYWRD(1:KLNGTH) .EQ. 'BINNED') THEN
C*********SET BINNED EXECUTION TYPE
         BINNED=.TRUE.
      ELSE IF (KEYWRD(1:KLNGTH) .EQ. 'DIRECT') THEN
C*********SET DIRECT EXECUTION TYPE
         BINNED=.FALSE.
      ELSE
C*********MODE SWITCH WAS NEITHER BINNED NOR DIRECT SO PRINT ERROR MESSAGE
         WRITE(6,5030)
         STOP
      ENDIF
C*****SET DEFAULT VALUES
      SAMPLE=.FALSE.
      NOCALC=.FALSE.
      PRTINP=.FALSE.
      NOBS=1
      REPRTB=.FALSE.
      BYRUN=.FALSE.
      CONSFL=.FALSE.
      DIAG=.FALSE.
      EXPERT=.FALSE.
C*****INITIALLIZE NUMBER OF BINS
      NBIN=0
C*****READ TITLE
      READ(5,1001) TITLE
C*****PRINT MESSAGE FOR EXECUTION TYPE AND TITLE
      WRITE(6,1003) KEYWRD(1:KLNGTH), TITLE
      WRITE(6,1002) CARD
      WRITE(6,1002) TITLE
C*****PROCESS KEYWORDS
  666 CONTINUE
C*****READ RECORD
      READ(5,1001,END=6000) CARD
      WRITE(6,1002) CARD
C*****INITIALLIZE COLUMN POINTER FOR CURRENT RECORD
      IC=1
 500  CONTINUE
C*****READ CHARACTER STRING FOR COMPARISON AGAINST KEYWORDS
      CALL RDSTRG (CARD, IC, KEYWRD, LVAL, IVAL, RVAL, KLNGTH, TYPE,
     1             EOR)
C*****CHECK FOR END-OF-RECORD
      IF (EOR) GO TO 666
C*****CHECK CHARACTER STRING AGAINST KEYWORDS
      IF (KEYWRD(1:KLNGTH) .EQ. 'SAMPLE') THEN
C*********SET SAMPLE TYPE TO .TRUE.
         SAMPLE=.TRUE.
C*********OBTAIN SAMPLE INFORMATION
C*********OBTAIN NUMBER OF SAMPLE VECTORS TO BE EXECUTED
         CALL RDSTRG (CARD, IC, CVAL, LVAL, NOBS, RVAL, LENGTH, TYPE,
     1                EOR)
C*********CHECK FOR INTEGER VALUE
         IF (TYPE(3)) THEN
C************OBTAIN SAMPLE VECTOR NUMBER TO BEGIN EXECUTION
            CALL RDSTRG (CARD, IC, CVAL, LVAL, NSTART, RVAL, LENGTH,
     1                   TYPE, EOR)
C************CHECK FOR INTEGER VALUE
            IF (TYPE(3)) THEN
C***************OBTAIN NAME OF FILE CONTAINING SAMPLE VECTORS
               CALL RDSTRG (CARD, IC, FILNAM, LVAL, IVAL, RVAL, LENGTH,
     1                      TYPE, EOR)
C***************CHECK FOR CHARACTER VALUE
               IF (TYPE(1)) THEN
```

```
C*****************CHARACTER VALUE FOUND, OPEN SAMPLE VECTOR FILE
                  OPEN(3, FILE=FILNAM, STATUS='OLD', ERR=8000, READONLY)
               ELSE
C*****************PRINT ERROR MESSAGE
                  GO TO 9200
               ENDIF
            ELSE
C**************PRINT ERROR MESSAGE
               GO TO 9100
            ENDIF
         ELSE
C***********PRINT ERROR MESSAGE
            GO TO 9100
         ENDIF
      ELSE IF (KEYWRD(1:KLNGTH) .EQ. 'NORUN') THEN
C********SET TYPE FOR VALIDATION OF INPUT ONLY, NO EXECUTION
         NOCALC=.TRUE.
      ELSE IF (KEYWRD(1:KLNGTH) .EQ. 'DEFAULT') THEN
C********READ NAME OF FILE CONTAINING DEFAULT VALUES
         CALL RDSTRG (CARD, IC, DEFFIL, LVAL, IVAL, RVAL, LENGTH, TYPE,
     1                EOR)
C********CHECK FOR CHARACTER VALUE
         IF (.NOT. TYPE(1)) GO TO 9100
      ELSE IF (KEYWRD(1:KLNGTH) .EQ. 'VECPOS') THEN
C********READ NAME OF FILE CONTAINING SAMPLE VECTOR POSTION INFORMATION
         CALL RDSTRG (CARD, IC, SAMFIL, LVAL, IVAL, RVAL, LENGTH, TYPE,
     1                EOR)
C********CHECK FOR CHARACTER VALUE
         IF (.NOT. TYPE(1)) GO TO 9100
      ELSE IF (KEYWRD(1:KLNGTH) .EQ. 'BINFILE') THEN
C********READ A BIN ARRAY FILE
C********CHECK FOR BINNED EXECUTION
         IF (BINNED) THEN
C***********READ NAME OF FILE CONTAINING BIN INFORMATION
            CALL RDSTRG (CARD, IC, FILNAM, LVAL, IVAL, RVAL, LENGTH,
     1                   TYPE, EOR)
C***********CHECK FOR CHARACTER VALUE
            IF (TYPE(1)) THEN
C**************CHARACTER VALUE FOUND SO OPEN BIN FILE
               OPEN(4, FILE=FILNAM, STATUS='OLD', ERR=8000, READONLY)
            ELSE
C**************PRINT ERROR MESSAGE
               GO TO 9200
            ENDIF
         ELSE
C***********NO BINS USED FOR DIRECT EXECUTION, PRINT ERROR MESSAGE
            GO TO 9300
         ENDIF
      ELSE IF (KEYWRD(1:KLNGTH) .EQ. 'PRTINP') THEN
C********SET CONTROL FLAG PRTINP
         PRTINP=.TRUE.
      ELSE IF (KEYWRD(1:KLNGTH) .EQ. 'REPORTB') THEN
C********SET CONTROL FLAG REPORTB
         REPRTB=.TRUE.
      ELSE IF (KEYWRD(1:KLNGTH) .EQ. 'KPBYRUN') THEN
C********SET CONTROL FLAG KPBYRUN
         BYRUN=.TRUE.
      ELSE IF (KEYWRD(1:KLNGTH) .EQ. 'CONSFL') THEN
C********SET CONTROL FLAG CONSFL
         CONSFL=.TRUE.
      ELSE IF (KEYWRD(1:KLNGTH) .EQ. 'DIAG') THEN
C********SET DIAGNOSTIC PRINT CONTROL FLAG DIAG
         DIAG=.TRUE.
      ELSE IF (KEYWRD(1:KLNGTH) .EQ. 'EXPERT') THEN
C********SET EXPERT OPINION CONTROL FLAG EXPERT
         EXPERT=.TRUE.
```

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      ELSE
C********INVALID KEYWORD, PRINT ERROR MESSAGE
         WRITE(6,5020) KEYWRD(1:KLNGTH)
         NOCALC=.TRUE.
      ENDIF
      GO TO 500
 6000 CONTINUE
C*****VALIDATE COMBINATION OF FLAGS
      IF (EXPERT .AND. ((.NOT. BINNED) .OR. (.NOT. SAMPLE))) THEN
         WRITE(6,6001)
         STOP
      ENDIF
      IF (NOCALC) STOP
C*****PRINT CONTROL INFORMATION
      IF (SAMPLE) WRITE(6,5025) NOBS, NSTART
C*****CALCULATE TOTAL NUMBER OF SOURCE TERMS FOR BINNED/SAMPLED EXECUTION
      IF (BINNED .AND. BYRUN) THEN
C********READ BIN FILE TO DETERMINE TOTAL NUMBER OF SOURCE TERMS
         NTOT=0
         NSAMPL=NSTART + NOBS - 1
         DO 7000 IOBS=1,NSAMPL
            READ(4,1001) BTITLE
            READ(4,*) NDM, NBIN
            IF (IOBS .GE. NSTART) NTOT=NTOT + NBIN
            IF (NBIN .GT. 0) READ(4,1001) (BINARR(1)(1:NDM),I=1,NBIN)
 7000    CONTINUE
         REWIND 4
      ENDIF
      RETURN
C*****FILE OPEN ERROR
 8000 WRITE(6,5022) FILNAM, KEYWRD(1:KLNGTH)
      NOCALC=.TRUE.
      GO TO 500
 9100 CONTINUE
C*****PRINT ERROR MESSAGE FOR WRONG TYPE OF VARIABLE
      WRITE(6,9101) KEYWRD(1:KLNGTH)
      NOCALC=.TRUE.
      GO TO 500
 9200 CONTINUE
C*****PRINT ERROR MESSAGE FOR NO FILE NAME
      WRITE(6,9201) KEYWRD(1:KLNGTH)
      NOCALC=.TRUE.
      GO TO 500
 9300 CONTINUE
C*****PRINT ERROR MESSAGE FOR BINNED KEYWORD USED FOR DIRECT EXECUTION
      WRITE(6,9301) KEYWRD(1:KLNGTH)
      NOCALC=.TRUE.
      GO TO 500
 9500 CONTINUE
C*****PRINT ERROR MESSAGE FOR INVALID EVENT NAME FOR OFFSET CONTROL
      WRITE(6,9501) KEYWRD(1:KLNGTH), CVAL(1:LENGTH)
      NOCALC=.TRUE
      GO TO 500
C*****FORMAT STATEMENTS
 1001 FORMAT(A)
 1002 FORMAT(11X,A)
 1003 FORMAT(/1X,130('*'),
     1       /1X,48('*'),5X,'GGSOR ',A,' EXECUTION',5X,48('*'),
     2       /1X,20('*'),5X,A,5X,20('*'),
     3       /1X,130('*'),/)
 1004 FORMAT(1X,A)
 5020 FORMAT(1X,'>>>>>UNRECOGNIZED KEYWORD (',A,')',/)
 5022 FORMAT(1X,'>>>>>OPEN ERROR ON FILE ',A,' FOR KEYWORD ',A,/)
 5025 FORMAT(//1X,'THE INPUT WILL BE SAMPLED WITH ',I4,
     1       ' SAMPLE VECTOR(S) STARTING WITH SAMPLE VECTOR ',I4,//)
 5030 FORMAT(1X,'>>>>>UNRECOGNIZED MODE SWITCH',/)
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 8001 FORMAT(1X,'>>>>>BINNED AND SAMPLE FLAGS MUST BE SPECIFIED ',
     1       'TO USE EXPERT OPINION TABLES')
 9101 FORMAT(1X,'>>>>>VALUE(S) FOLLOWING KEYWORD ',A,' INVALID',/)
 9201 FORMAT(1X,'>>>>>NO FILE NAME FOUND FOLLOWING KEYWORD ',A,/)
 9301 FORMAT(1X,'>>>>>INVALID KEYWORD (',A,') SPECIFIED FOR DIRECT ',
     1       'EXECUTION',/)
 9501 FORMAT(1X,'>>>>>UNABLE TO LOCATE EVENT NAME ',A,' DURING ',
     1        'PROCESSING OF KEYWORD ',A,/)
      END
      SUBROUTINE DIR
C*****IMPLEMENTS GOSOR RUNS WHICH INVOLVE DIRECT INPUT WITHOUT
C*****SAMPLING
      PARAMETER (MAXBD=20, MAXBIN=10000, MAXSMP=300, MAXCAS=8,
     1           MAXISS=20, MAXLEV=10, MAXVAR=100, MAXVAL=12000,
     2           MAXSPC=10, MAXTIM=10)
      CHARACTER BINARR*(MAXBD), BTITLE*80, TITLE*80
      COMMON /BINS/ BINARR(MAXBIN), BTITLE, TITLE
      COMMON /CONTRL/ NLHS, NOBS, NSTART, NBIN, NDM, NTOT
      CHARACTER*7 NAME
      LOGICAL LDEFLT, LREAL
      COMMON /DEFLT1/ NAME(MAXVAR)
      COMMON /DEFLT2/ NVAR, NVAL, NVCB1, NVCB2, NVCB3, NVCB4,
     1                NVCB5, IDIMEN(3,MAXVAR), ISPOS(MAXVAR),
     2                ISMPPS(MAXVAL), IPNT(MAXVAR), LDEFLT(MAXVAL),
     3                LREAL(MAXVAL)
      LOGICAL NOCALC, SAMPLE, REPRTB, BINNED, BYRUN, CONSFL, DIAG,
     1   EXPERT, PRTINP, NOCF, SUBCL, CDB, TMPCDB, BRKOPN, VB, ECF, ICF
      COMMON /KEYS/ NOCALC, SAMPLE, REPRTB, BINNED, BYRUN, CONSFL, DIAG,
     1   EXPERT, PRTINP, NOCF, SUBCL, CDB, TMPCDB, BRKOPN, VB, ECF, ICF
      COMMON /SRCTRM/ ST(MAXSPC), STE(MAXSPC), STCCI(MAXSPC),
     1                STL(MAXSPC), STIL, STRVOL(MAXSPC),
     2                ST1(MAXSPC), ST2(MAXSPC), RV(MAXSPC)
      COMMON /BASVAL/ FCOR(MAXSPC), FVES(MAXSPC), DFVPA(MAXSPC),
     1                DFCPA(MAXSPC), FEVSE(MAXSPC), FDCH(MAXSPC),
     2                FCCI(MAXSPC), DFCAV(MAXSPC), VBPUF(MAXSPC),
     3                FCONV(MAXSPC), FCONC(MAXSPC), DFSPRV(MAXSPC),
     4                DFSPRC(MAXSPC), FREVO(MAXSPC), VALISS(MAXISS),
     5                FLTI1, FLTI2, NSPEC, FLV, FHPE, EVSE, WFAC, PFAC,
     6                FPLBYE, FPLBYP, FPLBYD, FPLBYC, FTLPH, FTLPL,
     7                FTLP, TC11, TC12, TB11, TB12, TB21, TB22, TBS1,
     8                TBS2, TBR1, TBR2, TW, T1, T2, DT1, DT2, DTCDB,
     9                ELEV, PUFF
      COMMON /BINNED/ FCOR0(MAXSPC,MAXCAS), FVES0(MAXSPC,MAXCAS),
     1                DFVPA0(MAXSPC,MAXCAS), DFCPA0(MAXSPC,MAXCAS),
     2                FDCH0(MAXSPC,MAXCAS), FEVSE0(MAXSPC,MAXCAS),
     3                FCCI0(MAXSPC,MAXCAS), DFCAV0(MAXSPC,MAXCAS),
     4                VBPUF0(MAXSPC,MAXCAS), FCONV0(MAXSPC,MAXCAS),
     5                FCONC0(MAXSPC,MAXCAS), DFSPRV0(MAXSPC,MAXCAS),
     6                DFSPRC0(MAXSPC,MAXCAS), FREVO0(MAXSPC,MAXCAS),
     7                FLTI10(MAXCAS), FLTI20(MAXCAS), FHPE0(MAXCAS),
     8                EVSE0(MAXCAS), FPLBY0(3), TW0(MAXTIM),
     9                T10(MAXTIM), DT10(MAXTIM), DT20(MAXTIM),
     A                PUFF0(MAXTIM)
      COMMON /EXPERT/ FCORL(MAXSPC,MAXLEV,MAXCAS),
     1                FVESL(MAXSPC,MAXLEV,MAXCAS),
     2                FREVOL(MAXSPC,MAXLEV,MAXCAS),
     3                FCCIL(MAXSPC,MAXLEV,MAXCAS),
     4                FCONVL(MAXSPC,MAXLEV,MAXCAS),
     5                FCONCL(MAXSPC,MAXLEV,MAXCAS),
     6                FLTI1L(MAXLEV,MAXCAS), FLTI2L(MAXLEV,MAXCAS),
     7                FDCHL(MAXSPC,MAXLEV,MAXCAS),
     8                FEVSEL(MAXSPC,MAXLEV,MAXCAS),
     9                DFVPAL(MAXSPC,MAXLEV,MAXCAS),
     A                DFCPAL(MAXSPC,MAXLEV,MAXCAS),
     B                DFCAVL(MAXSPC,MAXLEV,MAXCAS),
     C                DFSPRVL(MAXSPC,MAXLEV,MAXCAS),
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     D                 DFSPRCL(MAXSPC,MAXLEV,MAXCAS),
     E                 PRBLEV(MAXLEV)
      COMMON /LHSBLK/ XLHS(MAXSMP)
      DATA IOBS / 1 /, IBIN / 1 /
C
C
C*****SET NUMBER OF SAMPLE VALUES
      NVART=1
      XLHS(1)=0.0
C*****DEFINE VARIABLE NAMES FOR DEFAULT INPUT
      CALL DEFINE
C*****SET DEFAULT VALUE ARRAY BY READING DEFAULT INPUT FROM FILE DEFFIL
      CALL SETDEF
C*****PRINT DEFAULT VALUE INFORMATION
      IF (PRTINP) CALL WRTPAR
C*****TERMINATE EXECUTION IF ONLY VALIDATING INPUT OR ERROR ENCOUNTERED
C*****DURING READING OF INPUT DATA
      IF (NOCALC) THEN
C********PRINT MESSAGE
         WRITE(6,1010)
         STOP
      ENDIF
C*****TRANSFER DEFAULT VALUE ARRAY TO COMMON BLOCK VALUES
      CALL TRANS (FCOR(1), FCOR0(1,1), FCORL(1,1,1))
C*****PRINT CONTENTS OF COMMON BLOCKS
      IF (REPRTB) CALL WRREL
C*****SET TOTAL NUMBER OF SOURCE TERMS
      NTOT=1
C*****WRITE HEADER TO CONSEQUENCE DATA FILE
      IF (CONSFL) WRITE(9,1006) TITLE, NDM, NSPEC, NTOT, NOBS
C*****PERFORM SOURCE TERM CALCULATIONS
      CALL GGSORC (IOBS, IBIN)
C*****PRINT PROCESSING SUMMARY
      WRITE(6,2003)
      RETURN
C*****FORMAT STATEMENTS
 1006 FORMAT(1X,A,/1X,4I10)
 1010 FORMAT(/1X,'EXECUTION TERMINATED FOLLOWING VALIDATION OF INPUT')
 2003 FORMAT(/1X,'SINGLE DIRECT EXECUTION PROCESSED')
      END
      SUBROUTINE DIRSMP
C*****IMPLEMENTS GGSOR RUNS WHICH INVOLVE DIRECT INPUT WITH
C*****SAMPLING
      PARAMETER (MAXBD=20, MAXBIN=10000, MAXSMP=300, MAXCAS=8,
     1           MAXISS=20, MAXLEV=10, MAXVAR=100, MAXVAL=12000,
     2           MAXSPC=10, MAXTIM=10)
      CHARACTER BINARR*(MAXBD), BTITLE*80, TITLE*80
      COMMON /BINS/ BINARR(MAXBIN), BTITLE, TITLE
      COMMON /CONTRL/ NLHS, NOBS, NSTART, NBIN, NDM, NTOT
      CHARACTER*7 NAME
      LOGICAL LDEFLT, LREAL
      COMMON /DEFLT1/ NAME(MAXVAR)
      COMMON /DEFLT2/ NVAR, NVAL, NVCB1, NVCB2, NVCB3, NVCB4,
     1                NVCB5, IDIMEN(3,MAXVAR), ISPOS(MAXVAR),
     2                ISMPPS(MAXVAL), IPNT(MAXVAR), LDEFLT(MAXVAL),
     3                LREAL(MAXVAL)
      LOGICAL NOCALC, SAMPLE, REPRTB, BINNED, BYRUN, CONSFL, DIAG,
     1   EXPERT, PRTINP, NOCF, SUBCL, CDB, TMPCDB, BRKOPN, VB, ECF, ICF
      COMMON /KEYS/ NOCALC, SAMPLE, REPRTB, BINNED, BYRUN, CONSFL, DIAG,
     1   EXPERT, PRTINP, NOCF, SUBCL, CDB, TMPCDB, BRKOPN, VB, ECF, ICF
      COMMON /SRCTRM/ ST(MAXSPC), STE(MAXSPC), STCCI(MAXSPC),
     1                STL(MAXSPC), STIL, STRVOL(MAXSPC),
     2                ST1(MAXSPC), ST2(MAXSPC), RV(MAXSPC)
      COMMON /BASVAL/ FCOR(MAXSPC), FVES(MAXSPC), DFVPA(MAXSPC),
     1                DFCPA(MAXSPC), FEVSE(MAXSPC), FDCH(MAXSPC),
     2                FCCI(MAXSPC), DFCAV(MAXSPC), VBPUF(MAXSPC),
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     3                FCONV(MAXSPC), FCONC(MAXSPC), DFSPRV(MAXSPC),
     4                DFSPRC(MAXSPC), FREVO(MAXSPC), VALISS(MAXISS),
     5                FLTI1, FLTI2, NSPEC, FLV, FHPE, EVSE, WFAC, PFAC,
     6                FPLBYE, FPLBYP, FPLBYD, FPLBYC, FTLPH, FTLPL,
     7                FTLP, TC11, TC12, TB11, TB12, TB21, TB22, TBS1,
     8                TBS2, TBR1, TBR2, TW, T1, T2, DT1, DT2, DTCDB,
     9                ELEV, PUFF
      COMMON /BINNED/ FCOR0(MAXSPC,MAXCAS), FVES0(MAXSPC,MAXCAS),
     1                DFVPA0(MAXSPC,MAXCAS), DFCPA0(MAXSPC,MAXCAS),
     2                FDCH0(MAXSPC,MAXCAS), FEVSE0(MAXSPC,MAXCAS),
     3                FCCI0(MAXSPC,MAXCAS), DFCAV0(MAXSPC,MAXCAS),
     4                VBPUF0(MAXSPC,MAXCAS), FCONV0(MAXSPC,MAXCAS),
     5                FCONC0(MAXSPC,MAXCAS), DFSPRV0(MAXSPC,MAXCAS),
     6                DFSPRC0(MAXSPC,MAXCAS), FREVO0(MAXSPC,MAXCAS),
     7                FLTI10(MAXCAS), FLTI20(MAXCAS), FHPE0(MAXCAS),
     8                EVSE0(MAXCAS), FPLBY0(3), TW0(MAXTIM),
     9                T10(MAXTIM), DT10(MAXTIM), DT20(MAXTIM),
     A                PUFF0(MAXTIM)
      COMMON /EXPERT/ FCORL(MAXSPC,MAXLEV,MAXCAS),
     1                FVESL(MAXSPC,MAXLEV,MAXCAS),
     2                FREVOL(MAXSPC,MAXLEV,MAXCAS),
     3                FCCIL(MAXSPC,MAXLEV,MAXCAS),
     4                FCONVL(MAXSPC,MAXLEV,MAXCAS),
     5                FCONCL(MAXSPC,MAXLEV,MAXCAS),
     6                FLTI1L(MAXLEV,MAXCAS), FLTI2L(MAXLEV,MAXCAS),
     7                FDCHL(MAXSPC,MAXLEV,MAXCAS),
     8                FEVSEL(MAXSPC,MAXLEV,MAXCAS),
     9                DFVPAL(MAXSPC,MAXLEV,MAXCAS),
     A                DFCPAL(MAXSPC,MAXLEV,MAXCAS),
     B                DFCAVL(MAXSPC,MAXLEV,MAXCAS),
     C                DFSPRVL(MAXSPC,MAXLEV,MAXCAS),
     D                DFSPRCL(MAXSPC,MAXLEV,MAXCAS),
     E                PRBLEV(MAXLEV)
      COMMON /LHSBLK/ XLHS(MAXSMP)
C
C
C*****DEFINE VARIABLE NAMES AND POSITION INFORMATION FOR DEFAULT
C*****INPUT AND SAMPLE VECTOR SUBSTITUTION
      CALL DEFINE
C*****SET DEFAULT VALUE ARRAY BY READING DEFAULT INPUT FROM FILE DEFFIL
      CALL SETDEF
C*****SET SAMPLE VECTOR POSITIONS
      CALL VECPOS
C*****PRINT DEFAULT VALUE AND SAMPLE VECTOR POSITION INFORMATION
      IF (PRTINP) CALL WRTPAR
C*****TERMINATE EXECUTION IF ONLY VALIDATING INPUT OR ERROR ENCOUNTERED
C*****DURING READING OF INPUT DATA
      IF (NOCALC) THEN
C********PRINT MESSAGE
         WRITE(6,1010)
         STOP
      ENDIF
C*****SKIP TO STARTING SAMPLE VECTOR
      IF (NSTART .NE. 1) THEN
         DO 1000 ISKIP=1,NSTART-1
            READ(3,*) IOBSD, NLHS, (XLHS(I),I=1,NLHS)
 1000    CONTINUE
      ENDIF
C*****SET TOTAL NUMBER OF SOURCE TERMS
      NTOT=NOBS
C*****PROCESS SAMPLE VECTORS
      DO 2000 IOBS=1,NOBS
C********READ CURRENT SAMPLE VECTOR
         READ(3,*) IOBSD, NLHS, (XLHS(I),I=1,NLHS)
C********SET NUMBER OF SAMPLE VALUES
         NVART=NLHS
```

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C*********TRANSFER SAMPLE VECTOR VALUES TO DEFAULT ARRAY
         CALL SUBVEC
C*********TRANSFER DEFAULT VALUE ARRAY TO COMMON BLOCK VALUES
         CALL TRANS (FCOR(1), FCOR0(1,1), FCORL(1,1,1))
C*********PRINT CONTENTS OF COMMON BLOCKS
         IF (REPRTB) CALL WRREL
C*********WRITE HEADER TO CONSEQUENCE DATA FILE
         IF (CONSFL .AND. (IOBS .EQ. 1))
     1        WRITE(9.1006) TITLE, NDM, NSPEC, NTOT, NOBS
C*********PERFORM SOURCE TERM CALCULATIONS
         CALL GGSORC (IOBS+NSTART-1, IBIN)
 2000 CONTINUE
C*****PRINT PROCESSING SUMMARY
      IF (NOBS .EQ. 1) THEN
         WRITE(6,2003) NOBS
      ELSE
         WRITE(6,2004) NSTART, NSTART+NOBS-1, NOBS
      ENDIF
      RETURN
C*****FORMAT STATEMENTS
 1006 FORMAT(1X,A,/1X,4I10)
 1010 FORMAT(/1X,'EXECUTION TERMINATED FOLLOWING VALIDATION OF INPUT')
 2003 FORMAT(/1X,I5,' SAMPLE VECTOR PROCESSED')
 2004 FORMAT(/1X,'SAMPLE VECTORS ',I4,' THRU ',I5,
     1        ' WERE PROCESSED (TOTAL OF ',I5,')')
      END
      SUBROUTINE BIN
C*****IMPLEMENTS GGSOR RUNS WHICH INVOLVE BINNED INPUT WITHOUT
C*****SAMPLING
      PARAMETER (MAXBD=20, MAXBIN=10000, MAXSMP=300, MAXCAS=8,
     1           MAXISS=20, MAXLEV=10, MAXVAR=100, MAXVAL=12000,
     2           MAXSPC=10, MAXTIM=10)
      CHARACTER BINARR*(MAXBD), BTITLE*80, TITLE*80
      COMMON /BINS/ BINARR(MAXBIN), BTITLE, TITLE
      COMMON /CONTRL/ NLHS, NOBS, NSTART, NBIN, NDM, NTOT
      CHARACTER*7 NAME
      LOGICAL LDEFLT, LREAL
      COMMON /DEFLT1/ NAME(MAXVAR)
      COMMON /DEFLT2/ NVAR, NVAL, NVCB1, NVCB2, NVCB3, NVCB4,
     1                NVCB5, IDIMEN(3,MAXVAR), ISPOS(MAXVAR),
     2                ISMPPS(MAXVAL), IPNT(MAXVAR), LDEFLT(MAXVAL),
     3                LREAL(MAXVAL)
      LOGICAL NOCALC, SAMPLE, REPRTB, BINNED, BYRUN, CONSFL, DIAG,
     1   EXPERT, PRTINP, NOCF, SUBCL, CDB, TMPCDB, BRKOPN, VB, ECF, ICF
      COMMON /KEYS/ NOCALC, SAMPLE, REPRTB, BINNED, BYRUN, CONSFL, DIAG,
     1   EXPERT, PRTINP, NOCF, SUBCL, CDB, TMPCDB, BRKOPN, VB, ECF, ICF
      COMMON /SRCTRM/ ST(MAXSPC), STE(MAXSPC), STCCI(MAXSPC),
     1                STL(MAXSPC), STIL, STRVOL(MAXSPC),
     2                ST1(MAXSPC), ST2(MAXSPC), RV(MAXSPC)
      COMMON /BASVAL/ FCOR(MAXSPC), FVES(MAXSPC), DFVPA(MAXSPC),
     1                DFCPA(MAXSPC), FEVSE(MAXSPC), FDCH(MAXSPC),
     2                FCCI(MAXSPC), DFCAV(MAXSPC), VBPUF(MAXSPC),
     3                FCONV(MAXSPC), FCONC(MAXSPC), DFSPRV(MAXSPC),
     4                DFSPRC(MAXSPC), FREVO(MAXSPC), VALISS(MAXISS),
     5                FLTI1, FLTI2, NSPEC, FLV, FHPE, EVSE, WFAC, PFAC,
     6                FPLBYE, FPLBYP, FPLBYD, FPLBYC, FTLPH, FTLPL,
     7                FTLP, TC11, TC12, TB11, TB12, TB21, TB22, TBS1,
     8                TBS2, TBR1, TBR2, TW, T1, T2, DT1, DT2, DTCDB,
     9                ELEV, PUFF
      COMMON /BINNED/ FCOR0(MAXSPC,MAXCAS), FVES0(MAXSPC,MAXCAS),
     1                DFVPA0(MAXSPC,MAXCAS), DFCPA0(MAXSPC,MAXCAS),
     2                FDCH0(MAXSPC,MAXCAS), FEVSE0(MAXSPC,MAXCAS),
     3                FCCI0(MAXSPC,MAXCAS), DFCAV0(MAXSPC,MAXCAS),
     4                VBPUF0(MAXSPC,MAXCAS), FCONV0(MAXSPC,MAXCAS),
     5                FCONC0(MAXSPC,MAXCAS), DFSPRV0(MAXSPC,MAXCAS),
     6                DFSPRC0(MAXSPC,MAXCAS), FREVO0(MAXSPC,MAXCAS),
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     7                FLTI10(MAXCAS), FLTI20(MAXCAS), FHPE0(MAXCAS),
     8                EVSE0(MAXCAS), FPLBY0(3), TW0(MAXTIM),
     9                T10(MAXTIM), DT10(MAXTIM), DT20(MAXTIM),
     A                PUFF0(MAXTIM)
      COMMON /EXPERT/ FCORL(MAXSPC,MAXLEV,MAXCAS),
     1                FVESL(MAXSPC,MAXLEV,MAXCAS),
     2                FREVOL(MAXSPC,MAXLEV,MAXCAS),
     3                FCCIL(MAXSPC,MAXLEV,MAXCAS),
     4                FCONVL(MAXSPC,MAXLEV,MAXCAS),
     5                FCONCL(MAXSPC,MAXLEV,MAXCAS),
     6                FLTI1L(MAXLEV,MAXCAS), FLTI2L(MAXLEV,MAXCAS),
     7                FDCHL(MAXSPC,MAXLEV,MAXCAS),
     8                FEVSEL(MAXSPC,MAXLEV,MAXCAS),
     9                DFVPAL(MAXSPC,MAXLEV,MAXCAS),
     A                DFCPAL(MAXSPC,MAXLEV,MAXCAS),
     B                DFCAVL(MAXSPC,MAXLEV,MAXCAS),
     C                DFSPRVL(MAXSPC,MAXLEV,MAXCAS),
     D                DFSPRCL(MAXSPC,MAXLEV,MAXCAS),
     E                PRBLEV(MAXLEV)
      COMMON /LHSBLK/ XLHS(MAXSMP)
      DATA IOBS / 1 /
C
C
C*****DEFINE VARIABLE NAMES FOR DEFAULT INPUT
      CALL DEFINE
C*****SET DEFAULT VALUE ARRAY BY READING DEFAULT INPUT FROM FILE DEFFIL
      CALL SETDEF
C*****PRINT DEFAULT VALUE INFORMATION
      IF (PRTINP) CALL WRTPAR
C*****TERMINATE EXECUTION IF ONLY VALIDATING INPUT OR ERROR ENCOUNTERED
C*****DURING READING OF INPUT DATA
      IF (NOCALC) THEN
C********PRINT MESSAGE
         WRITE(6,1010)
         STOP
      ENDIF
C*****TRANSFER DEFAULT VALUE ARRAY TO COMMON BLOCK VALUES
      CALL TRANS (FCOR(1), FCOR0(1,1), FCORL(1,1,1))
C*****ONE SET OF BIN DEFINITIONS IS USED
      READ(4,1001) BTITLE
      READ(4,*) NDM, NBIN
C*****SET NUMBER OF SAMPLE VALUES EQUAL TO VALUE OF BIN DIMENSION
      NVART=NDM
      IF (NBIN .GT. MAXBIN) THEN
C********PRINT ERROR MESSAGE
         WRITE(6,1011) NBIN, MAXBIN, NBIN
         STOP
      ENDIF
      IF (NBIN .GT. 0) READ(4,1002) (BINARR(I)(1:NDM),I=1,NBIN)
      WRITE(6,1003) BTITLE, NBIN, (I, BINARR(I)(1:NDM),I=1,NBIN)
      WRITE(6,1004)
C*****SET TOTAL NUMBER OF SOURCE TERMS
      NTOT=NBIN
C*****WRITE HEADER TO CONSEQUENCE DATA FILE
      IF (CONSFL) WRITE(9,1006) TITLE, NDM, NSPEC, NTOT, NOBS
C*****LOOP OVER INDIVIDUAL BINS
      DO 1000 IBIN=1,NBIN
C********TRANSLATE CURRENT BIN ID TO PARAMETERS FOR USE IN RELCLC
         CALL BINTRN (IBIN)
C********PRINT CONTENTS OF COMMON BLOCKS
         IF (REPRTB) CALL WRREL
C********PERFORM SOURCE TERM CALCULATIONS
         CALL GGSORC (IOBS, IBIN)
 1000 CONTINUE
C*****PRINT NUMBER OF BINS PROCESSED
      WRITE(6,2003) NBIN
```

```
      RETURN
C*****FORMAT STATEMENTS
 1001 FORMAT(A)
 1002 FORMAT(1X,A)
 1003 FORMAT(//1X,130('='),
     1       //1X,'BINNING INFORMATION',
     2       /1X,A,
     3       //1X,'THE FOLLOWING ',I7,' BIN(S) ARE TO BE PROCESSED:',
     4       //(1X,I7,'=',A))
 1004 FORMAT(/1X,130('='),//)
 1006 FORMAT(1X,A,/1X,4I10)
 1010 FORMAT(/1X,'EXECUTION TERMINATED FOLLOWING VALIDATION OF INPUT')
 1011 FORMAT(/1X,'>>>>>NUMBER OF BINS (',I7,') READ FROM FILE IS ',
     1        'LARGER THAN ALLOWED DIMENSION (',I7,')',
     2       /1X,'>>>>>INCREASE PARAMETER MAXBIN TO AT LEAST ',I7,
     3       /1X,'>>>>>EXECUTION TERMINATED')
 2003 FORMAT(/1X,I7,' BIN(S) PROCESSED')
      END
      SUBROUTINE BINSMP
C*****IMPLEMENTS GGSOR RUNS WHICH INVOLVE BINNED INPUT WITH SAMPLING
      PARAMETER (MAXBD=20, MAXBIN=10000, MAXSMP=300, MAXCAS=8,
     1           MAXISS=20, MAXLEV=10, MAXVAR=100, MAXVAL=12000,
     2           MAXSPC=10, MAXTIM=10)
      CHARACTER BINARR*(MAXBD), BTITLE*80, TITLE*80
      COMMON /BINS/ BINARR(MAXBIN), BTITLE, TITLE
      COMMON /CONTRL/ NLHS, NOBS, NSTART, NBIN, NDM, NTOT
      CHARACTER*7 NAME
      LOGICAL LDEFLT, LREAL
      COMMON /DEFLT1/ NAME(MAXVAR)
      COMMON /DEFLT2/ NVAR, NVAL, NVCB1, NVCB2, NVCB3, NVCB4,
     1                NVCB5, IDIMEN(3,MAXVAR), ISPOS(MAXVAR),
     2                ISMPPS(MAXVAL), IPNT(MAXVAR), LDEFLT(MAXVAL),
     3                LREAL(MAXVAL)
      LOGICAL NOCALC, SAMPLE, REPRTB, BINNED, BYRUN, CONSFL, DIAG,
     1   EXPERT, PRTINP, NOCF, SUBCL, CDB, TMPCDB, BRKOPN, VB, ECF, ICF
      COMMON /KEYS/ NOCALC, SAMPLE, REPRTB, BINNED, BYRUN, CONSFL, DIAG,
     1   EXPERT, PRTINP, NOCF, SUBCL, CDB, TMPCDB, BRKOPN, VB, ECF, ICF
      COMMON /SRCTRM/ ST(MAXSPC), STE(MAXSPC), STCCI(MAXSPC),
     1                STL(MAXSPC), STIL, STRVOL(MAXSPC),
     2                ST1(MAXSPC), ST2(MAXSPC), RV(MAXSPC)
      COMMON /BASVAL/ FCOR(MAXSPC), FVES(MAXSPC), DFVPA(MAXSPC),
     1                DFCPA(MAXSPC), FEVSE(MAXSPC), FDCH(MAXSPC),
     2                FCCI(MAXSPC), DFCAV(MAXSPC), VBPUF(MAXSPC),
     3                FCONV(MAXSPC), FCONC(MAXSPC), DFSPRV(MAXSPC),
     4                DFSPRC(MAXSPC), FREVO(MAXSPC), VALISS(MAXISS),
     5                FLTI1, FLTI2, NSPEC, FLV, FHPE, EVSE, WFAC, PFAC,
     6                FPLBYE, FPLBYP, FPLBYD, FPLBYC, FTLPH, FTLPL,
     7                FTLP, TC11, TC12, TB11, TB12, TB21, TB22, TBS1,
     8                TBS2, TBR1, TBR2, TW, T1, T2, DT1, DT2, DTCDB,
     9                ELEV, PUFF
      COMMON /BINNED/ FCOR0(MAXSPC,MAXCAS), FVES0(MAXSPC,MAXCAS),
     1                DFVPA0(MAXSPC,MAXCAS), DFCPA0(MAXSPC,MAXCAS),
     2                FDCH0(MAXSPC,MAXCAS), FEVSE0(MAXSPC,MAXCAS),
     3                FCCI0(MAXSPC,MAXCAS), DFCAV0(MAXSPC,MAXCAS),
     4                VBPUF0(MAXSPC,MAXCAS), FCONV0(MAXSPC,MAXCAS),
     5                FCONC0(MAXSPC,MAXCAS), DFSPRV0(MAXSPC,MAXCAS),
     6                DFSPRC0(MAXSPC,MAXCAS), FREVO0(MAXSPC,MAXCAS),
     7                FLTI10(MAXCAS), FLTI20(MAXCAS), FHPE0(MAXCAS),
     8                EVSE0(MAXCAS), FPLBY0(3), TW0(MAXTIM),
     9                T10(MAXTIM), DT10(MAXTIM), DT20(MAXTIM),
     A                PUFF0(MAXTIM)
      COMMON /EXPERT/ FCORL(MAXSPC,MAXLEV,MAXCAS),
     1                FVESL(MAXSPC,MAXLEV,MAXCAS),
     2                FREVOL(MAXSPC,MAXLEV,MAXCAS),
     3                FCCIL(MAXSPC,MAXLEV,MAXCAS),
     4                FCONVL(MAXSPC,MAXLEV,MAXCAS),
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     5               FCONCL(MAXSPC,MAXLEV,MAXCAS),
     6               FLTI1L(MAXLEV,MAXCAS), FLTI2L(MAXLEV,MAXCAS),
     7               FDCHL(MAXSPC,MAXLEV,MAXCAS),
     8               FEVSEL(MAXSPC,MAXLEV,MAXCAS),
     9               DFVPAL(MAXSPC,MAXLEV,MAXCAS),
     A               DFCPAL(MAXSPC,MAXLEV,MAXCAS),
     B               DFCAVL(MAXSPC,MAXLEV,MAXCAS),
     C               DFSPRVL(MAXSPC,MAXLEV,MAXCAS),
     D               DFSPRCL(MAXSPC,MAXLEV,MAXCAS),
     E               PRBLEV(MAXLEV)
      COMMON /LHSBLK/ XLHS(MAXSMP)
C
C
C*****DEFINE VARIABLE NAMES AND POSITION INFORMATION FOR DEFAULT
C*****INPUT AND SAMPLE VECTOR SUBSTITUTION
      CALL DEFINE
C*****SET DEFAULT VALUE ARRAY BY READING DEFAULT INPUT FROM FILE DEFFIL
      CALL SETDEF
C*****SET SAMPLE VECTOR POSITIONS
      CALL VECPOS
C*****PRINT DEFAULT VALUE AND SAMPLE VECTOR POSITION INFORMATION
      IF (PRTINP) CALL WRTPAR
C*****TERMINATE EXECUTION IF ONLY VALIDATING INPUT OR ERROR ENCOUNTERED
C*****DURING READING OF INPUT DATA
      IF (NOCALC) THEN
C********PRINT MESSAGE
         WRITE(6,1010)
         STOP
      ENDIF
      IF (.NOT. BYRUN) THEN
C********READ SET OF BINS WHICH WILL BE USED FOR ALL SAMPLES
         READ(4,1001) BTITLE
         READ(4,*) NDM, NBIN
         IF (NBIN .GT. MAXBIN) THEN
C***********PRINT ERROR MESSAGE
            WRITE(6,1011) NBIN, MAXBIN, NBIN
            STOP
         ENDIF
         IF (NBIN .GT. 0) READ(4,1002) (BINARR(I)(1:NDM),I=1,NBIN)
         WRITE(6,1003) IOBS, BTITLE, NBIN,
     1                 (I, BINARR(I)(1:NDM),I=1,NBIN)
         WRITE(6,1004)
C********SET TOTAL NUMBER OF SOURCE TERMS
         NTOT=NBIN * NOBS
      ENDIF
C*****CHECK FOR STARTING SAMPLE VECTOR
      IF (NSTART .NE. 1) THEN
C********SKIP TO STARTING SAMPLE VECTOR
         DO 1000 ISKIP=1,NSTART-1
C***********READ SAMPLE VECTOR VALUES
            READ(3,*) IOBSD, NLHS, (XLHS(I),I=1,NLHS)
            IF (BYRUN) THEN
C**************READ BIN DEFINITIONS FOR CURRENT SAMPLE VECTOR
               READ(4,1001) BTITLE
               READ(4,*) NDM, NBIN
               IF (NBIN .GT. MAXBIN) THEN
C*****************PRINT ERROR MESSAGE
                  WRITE(6,1011) NBIN, ISKIP, MAXBIN, NBIN
                  STOP
               ENDIF
               IF (NBIN .GT. 0) READ(4,1002)
     1                                (BINARR(I)(1:NDM),I=1,NBIN)
            ENDIF
 1000    CONTINUE
      ENDIF
C*****PROCESS SAMPLE VECTOR
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      DO 3000 IOBS=1,NOBS
C*********READ CURRENT SAMPLE VECTOR VALUES
         READ(3,*) IOBSD, NLHS, (XLHS(I),I=1,NLHS)
C*********VALIDATE NUMBER OF SAMPLE VECTOR VALUES
         IF (NLHS .GT. MAXSMP) THEN
            WRITE(6,1005) NLHS, MAXSMP
            STOP
         ENDIF
C*********TRANSFER SAMPLE VECTOR VALUES
         CALL SUBVEC
C*********TRANSFER DEFAULT VALUE ARRAY TO COMMON BLOCK VALUES
         CALL TRANS (FCOR(1), FCORO(1,1), FCORL(1,1,1))
C*********WRITE HEADER TO CONSEQUENCE DATA FILE
         IF (CONSFL .AND. (IOBS .EQ. 1))
     1        WRITE(9,1006) TITLE, NDM, NSPEC, NTOT, NOBS
C*********USE EXPERT OPINION TABLES
         IF (EXPERT) CALL EXPTAB
C*********CHECK FOR SEPARATE BIN DEFINITIONS FOR EACH SAMPLE
         IF (BYRUN) THEN
C************READ SET OF BINS FOR CURRENT SAMPLE
            READ(4,1001) BTITLE
            READ(4,*) NDM, NBIN
            IF (NBIN .GT. MAXBIN) THEN
C***************PRINT ERROR MESSAGE
               WRITE(6,1011) NBIN, NSTART+IOBS-1, MAXBIN, NBIN
               STOP
            ENDIF
            IF (NBIN .GT. 0) READ(4,1002) (BINARR(I)(1:NDM),I=1,NBIN)
            WRITE(6,1003) IOBS, BTITLE, NBIN,
     1                    (I, BINARR(I)(1:NDM),I=1,NBIN)
            WRITE(6,1004)
         ENDIF
C*********SET NUMBER OF LHS VARIABLES PLUS NUMBER OF BIN DEFINITIONS
         NVART=NLHS + NDM
C*********LOOP OVER INDIVIDUAL BINS
         DO 2000 IBIN=1,NBIN
C************TRANSLATE CURRENT BIN ID TO PAR'METERS FOR USE IN RELCLC
            CALL BINTRN (IBIN)
C************PRINT CONTENTS OF COMMON BLOCKS
            IF (REPRTB) CALL WRREL
C************PERFORM SOURCE TERM CALCULATIONS
            CALL GGSORC (IOBS+NSTART-1, IBIN)
 2000    CONTINUE
C*********PRINT NUMBER OF BINS PROCESSED FOR CURRENT SAMPLE VECTOR
         WRITE(6,2003) NBIN, IOBS+NSTART-1
 3000 CONTINUE
      RETURN
C*****FORMAT STATEMENTS
 1001 FORMAT(A)
 1002 FORMAT(1X,A)
 1003 FORMAT(//1X,130('='),
     1       //1X,'BINNING INFORMATION FOR SAMPLE VECTOR ',I4,
     2       /1X,A,
     3       //1X,'THE FOLLOWING ',I7,' BIN(S) ARE TO BE PROCESSED:',
     4       //(1X,I7,'-',A))
 1004 FORMAT(/1X,130('='),//)
 1005 FORMAT(/1X,'>>>>>NUMBER OF SAMPLE VECTOR VALUES (',I4,
     1        ') READ FROM UNIT 3 EXCEEDS ',
     2       /1X,'>>>>>MAXIMUM NUMBER ALLOWED (MAXSMP=',I4,')',
     3       /1X,'>>>>>EXECUTION TERMINATED')
 1006 FORMAT(1X,A,/1X,4I10)
 1010 FORMAT(/1X,'EXECUTION TERMINATED FOLLOWING VALIDATION OF INPUT')
 1011 FORMAT(/1X,'>>>>>NUMBER OF BINS (',I7,') READ FROM UNIT 4, ',
     1        'SAMPLE VECTOR ',I4,
     2        ', IS LARGER THAN ALLOWED DIMENSION (',I7,')',
     3       /1X,'>>>>>INCREASE PARAMETER MAXBIN TO AT LEAST ',I7,
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     4       /1X,'>>>>>EXECUTION TERMINATED')
 2003 FORMAT(/1X,I7,' BIN(S) PROCESSED FOR SAMPLE VECTOR ',I4)
      END
      SUBROUTINE DEFINE
C*****DEFINE NAMES AND DIMENSIONS OF VARIABLES TO BE SET THROUGH
C*****DEFAULT INPUT AND SAMPLE VECTOR SUBSTITUTION
      PARAMETER (MAXBD=20, MAXBIN=10000, MAXSMP=300, MAXCAS=8,
     1           MAXISS=20, MAXLEV=10, MAXVAR=100, MAXVAL=12000,
     2           MAXSPC=10, MAXTIM=10)
      CHARACTER*7 NAME
      LOGICAL LDEFLT, LREAL
      COMMON /DEFLT1/ NAME(MAXVAR)
      COMMON /DEFLT2/ NVAR, NVAL, NVCB1, NVCB2, NVCB3, NVCB4,
     1                NVCB5, IDIMEN(3,MAXVAR), ISPOS(MAXVAR),
     2                ISMPPS(MAXVAL), IPNT(MAXVAR), LDEFLT(MAXVAL),
     3                LREAL(MAXVAL)
      LOGICAL NOCALC, SAMPLE, REPRTB, BINNED, BYRUN, CONSFL, DIAG,
     1   EXPERT, PRTINP, NOCF, SUBCL, CDB, TMPCDB, BRKOPN, VB, ECF, ICF
      COMMON /KEYS/ NOCALC, SAMPLE, REPRTB, BINNED, BYRUN, CONSFL, DIAG,
     1   EXPERT, PRTINP, NOCF, SUBCL, CDB, TMPCDB, BRKOPN, VB, ECF, ICF
C*****DEFINE VARIABLE NAMES AND CORRESPONDING DIMENSIONS TO BE SET
C*****THROUGH DEFAULT AND SAMPLE VECTOR SUBSTITUTION FOR BINNED
C*****EXECUTION.  VARIABLE NAMES AND DIMENSIONS CORRESPOND EXACTLY
C*****TO ORDER OF VARIABLES IN COMMON BLOCKS:
C*****(1) BASVAL, (2) BINNED, AND (3) EXPERT
C*****AS IF THESE COMMON BLOCKS ARE CONCATENTATED.
      DATA NAME /
     1  'FCOR', 'FVES', 'DFVPA', 'DFCPA',
     2  'FEVSE', 'FDCH', 'FCCI', 'DFCAV',
     3  'VBPUF', 'FCONV', 'FCONC',
     4  'DFSPRV', 'DFSPRC', 'FREVO', 'VALISS',
     5  'FLTI1', 'FLTI2', 'NSPEC', 'FLV', 'FHPE', 'EVSE', 'WFAC',
     6  'PFAC', 'FPLBYE', 'FPLBYP', 'FPLBYD', 'FPLBYC', 'FTLPH',
     7  'FTLPL', 'FTLP', 'TC11', 'TC12', 'TB11', 'TB12', 'TB21',
     8  'TB22', 'TBS1', 'TBS2', 'TBR1', 'TBR2',
     9  'TW', 'T1', 'T2', 'DT1', 'DT2', 'DTCDB', 'ELEV', 'PUFF',
     A  'FCOR0', 'FVES0', 'DFVPA0',
     B  'DFCPA0', 'FDCH0', 'FEVSE0',
     C  'FCCI0', 'DFCAV0', 'VBPUF0',
     D  'FCONV0', 'FCONC0',
     E  'DFSPRV0', 'DFSPRC0', 'FREVO0', 'FLTI10',
     F  'FLTI20', 'FHPE0', 'EVSE0', 'FPLPY0',
     G  'TW0', 'T10', 'DT10', 'DT20', 'PUFF0',
     H  'FCORL', 'FVESL',
     I  'FREVOL', 'FCCIL',
     J  'FCONVL', 'FCONCL',
     K  'FLTI1L', 'FLTI2L',
     L  'FDCHL', 'FEVSEL',
     M  'DFVPAL', 'DFCPAL',
     N  'DFCAVL', 'DFSPRVL',
     O  'DFSPRCL', 'PRBLEV',
     P  12*' ' /
C*****DEFINE 3 DIMENSIONS FOR EACH OF THE VARIABLES
      DATA IDIMEN /
     1  MAXSPC,1,1, MAXSPC,1,1, MAXSPC,1,1, MAXSPC,1,1,
     2  MAXSPC,1,1, MAXSPC,1,1, MAXSPC,1,1, MAXSPC,1,1,
     3  MAXSPC,1,1, MAXSPC,1,1, MAXSPC,1,1,
     4  MAXSPC,1,1, MAXSPC,1,1, MAXSPC,1,1, MAXISS,1,1,
     5  1,1,1, 1,1,1, 1,1,1, 1,1,1, 1,1,1, 1,1,1, 1,1,1,
     6  1,1,1, 1,1,1, 1,1,1, 1,1,1, 1,1,1, 1,1,1,
     7  1,1,1, 1,1,1, 1,1,1, 1,1,1, 1,1,1, 1,1,1, 1,1,1,
     8  1,1,1, 1,1,1, 1,1,1, 1,1,1, 1,1,1,
     9  1,1,1, 1,1,1, 1,1,1, 1,1,1, 1,1,1, 1,1,1, 1,1,1, 1,1,1,
     A  MAXSPC,MAXCAS,1, MAXSPC,MAXCAS,1, MAXSPC,MAXCAS,1,
     B  MAXSPC,MAXCAS,1, MAXSPC,MAXCAS,1, MAXSPC,MAXCAS,1,
     C  MAXSPC,MAXCAS,1, MAXSPC,MAXCAS,1, MAXSPC,MAXCAS,1,
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     D   MAXSPC,MAXCAS,1, MAXSPC,MAXCAS,1,
     E   MAXSPC,MAXCAS,1, MAXSPC,MAXCAS,1, MAXSPC,MAXCAS,1, MAXCAS,1,1,
     F   MAXCAS,1,1, MAXCAS,1,1, MAXCAS,1,1, 3,1,1,
     G   MAXTIM,1,1, MAXTIM,1,1, MAXTIM,1,1, MAXTIM,1,1, MAXTIM,1,1,
     H   MAXSPC,MAXLEV,MAXCAS, MAXSPC,MAXLEV,MAXCAS,
     I   MAXSPC,MAXLEV,MAXCAS, MAXSPC,MAXLEV,MAXCAS,
     J   MAXSPC,MAXLEV,MAXCAS, MAXSPC,MAXLEV,MAXCAS,
     K   MAXLEV,MAXCAS,1, MAXLEV,MAXCAS,1,
     L   MAXSPC,MAXLEV,MAXCAS, MAXSPC,MAXLEV,MAXCAS,
     M   MAXSPC,MAXLEV,MAXCAS, MAXSPC,MAXLEV,MAXCAS,
     N   MAXSPC,MAXLEV,MAXCAS, MAXSPC,MAXLEV,MAXCAS,
     O   MAXSPC,MAXLEV,MAXCAS, MAXLEV,1,1,
     P   36*0 /
C*****DEFINE NUMBERS OF VALUES IN COMMON BLOCKS:
C*****(1) BASVAL, (2) BINNED, AND (3) EXPERT
      DATA NVCB1 / 193 /, NVCB2 / 1205 /, NVCB3 / 10570 /, NVCB4 / 0 /,
     1     NVCB5 / 0 /
C
C
C*****INITIALLIZE MAXIMUM LENGTH OF VARIABLE NAMES
      NCHAR=7
C*****SET DEFAULT TYPES TO .FALSE.
      DO 1000 I=1,MAXVAL
         LDEFLT(I)=.FALSE.
 1000 CONTINUE
C*****INITIALLIZE NUMBER OF VARIABLES
      NVAR=0
C*****INITIALLIZE TOTAL NUMBER OF VALUES
      NVAL=1
C*****SET POSITION INFORMATION
      DO 2000 IVAR=1,MAXVAR
C********CHECK FOR BLANK VARIABLE NAME
         IF (NAME(IVAR) .EQ. ' ') GO TO 3000
C********INCREMENT NUMBER OF VARIABLES
         NVAR=NVAR + 1
C********SAVE STARTING POSITION OF CURRENT VARIABLE
         ISPOS(NVAR)=NVAL
C********CHECK FOR NON-ZERO DIMENSIONS
         IF ((IDIMEN(1,NVAR) .LE. 0) .OR. (IDIMEN(2,NVAR) .LE. 0) .OR.
     1       (IDIMEN(3,NVAR) .LE. 0)) THEN
C***********PRINT ERROR MESSAGE
            WRITE(6,1001) NAME(IVAR), (IDIMEN(I,NVAR),I=1,3)
            NOCALC=.TRUE.
         ENDIF
C********INCREMENT TOTAL NUMBER OF VALUES
         NVAL=NVAL + IDIMEN(1,NVAR)*IDIMEN(2,NVAR)*IDIMEN(3,NVAR)
 2000 CONTINUE
 3000 CONTINUE
C*****SET TOTAL NUMBER OF VALUES
      NVAL=NVAL - 1
C*****VALIDATE TOTAL NUMBER OF VALUES AGAINST MAXIMUM DIMENSION
      IF (NVAL .GT. MAXVAL) THEN
C********PRINT ERROR MESSAGE
         WRITE(6,3001) NVAL, MAXVAL, NVAL
         NOCALC=.TRUE.
      ENDIF
C*****VALIDATE TOTAL NUMBER OF VALUES AGAINST SUM OF VALUES IN
C*****DEFAULTED COMMON BLOCKS
      IF (NVAL .NE. NVCB1+NVCB2+NVCB3+NVCB4+NVCB5) THEN
C********PRINT ERROR MESSAGE
         WRITE(6,3002) NVAL, NVCB1+NVCB2+NVCB3+NVCB4+NVCB5
         NOCALC=.TRUE.
      ENDIF
C*****SET ASCII CODE FOR CHARACTERS I AND N
      ICI=ICHAR('I')
      ICN=ICHAR('N')
```

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C*****INITIALLIZE VALUE POINTER
      IVAL=1
C*****SET VARIABLE TYPES
      DO 5000 IVAR=1,NVAR
C*********INITIALLIZE POINTER ARRAY
         IPNT(IVAR)=IVAR
C*********SET ASCII CODE FOR FIRST CHARACTER OF VARIABLE NAME
         IC=ICHAR(NAME(IVAR)(1:1))
C*********COMPARE ASCII CODE TO I THRU N RANGE (INTEGER VARIABLE)
         IF ((IC .GE. ICI) .AND. (IC .LE. ICN)) THEN
C************SET REAL VARIABLE FLAG TO .FALSE. (INTEGER VARIABLE)
            LREAL(IVAL)=.FALSE.
         ELSE
C************SET REAL VARIABLE FLAG TO .TRUE. (REAL VARIABLE)
            LREAL(IVAL)=.TRUE.
         ENDIF
C*********SET ALL TYPES FOR CURRENT VARIABLE
         IFIRST=IVAL
         ILAST=IVAL - 1 + IDIMEN(1,IVAR)*IDIMEN(2,IVAR)*IDIMEN(3,IVAR)
         DO 4000 I=IFIRST,ILAST
            LREAL(I)=LREAL(IVAL)
 4000    CONTINUE
C*********RESET VALUE POINTER
         IVAL=ILAST + 1
 5000 CONTINUE
C*****ALL INFORMATION FOR VARIABLES THAT MAY BE SET THROUGH DEFAULT
C*****AND VECTOR POSITION HAS BEEN SAVED
C*****SORT LIST OF VARIABLE NAMES USING POINTER IPNT TO FACILITAYE
C*****SEARCHING
      CALL CSORT (NVAR, NAME, IPNT)
      RETURN
C*****FORMAT STATEMENTS
 1001 FORMAT(1X,'>>>>>DIMENSIONS FOR VARIABLE ',A,' MUST BE GREATER ',
     1        'THAN 0',
     2     /1X,'>>>>>DIMENSION 1 =',I5,', DIMENSION 2 =',I5,
     3      ', DIMENSION 3 =',I5,
     4     /1X,'>>>>>CHECK VARIABLE DEFINITIONS IN SUBROUTINE DEFINE',/)
 3001 FORMAT(1X,'>>>>>NUMBER OF VARIABLES (NVAR=',I5,') EXCEEDS ',
     1        'DIMENSION (MAXVAR=',I5,')',
     2       /1X,'>>>>>CHECK VARIABLE DEFINITIONS IN SUBROUTINE DEFINE ',
     3        'AND/OR',
     4       /1X,'>>>>>RESET PARAMETER MAXVAR TO AT LEAST ',I5,/)
 3002 FORMAT(1X,'>>>>>NUMBER OF VALUES WHICH CAN BE SET THROUGH ',
     1        'DEFAULT AND VECTOR SUBSTITUTION (',I5,')',
     2       /1X,'>>>>>SHOULD BE EQUAL TO THE TOTAL NUMBER OF VALUES ',
     3        'IN THE COMMON BLOCKS TO BE SET ',
     4       /1X,'>>>>>(NVCB1+NVCB2+NVCB3+NVCB4+NVCB5=',I5,') ',
     5        '-- SUBROUTINE DEFINE',/)
      END
      SUBROUTINE SETDEF
C*****SET DEFAULT VALUES BY READING VARIABLE NAMES AND CORRESPONDING
C*****VALUES FROM FILE DESIGNATED FOR DEFAULT VALUES (DEFFIL)
      PARAMETER (MAXLEN=101, MAXVLN=20)
      PARAMETER (MAXBD=20, MAXBIN=10000, MAXSMP=300, MAXCAS=8,
     1           MAXISS=20, MAXLEV=10, MAXVAR=100, MAXVAL=12000,
     2           MAXSPC=10, MAXTIM=10)
      CHARACTER*7 NAME
      LOGICAL LDEFLT, LREAL
      COMMON /DEFLT1/ NAME(MAXVAR)
      COMMON /DEFLT2/ NVAR, NVAL, NVCB1, NVCB2, NVCB3, NVCB4,
     1                NVCB5, IDIMEN(3,MAXVAR), ISPOS(MAXVAR),
     2                ISMPPS(MAXVAL), IPNT(MAXVAR), LDEFLT(MAXVAL),
     3                LREAL(MAXVAL)
      LOGICAL NOCALC, SAMPLE, REPRTB, BINNED, BYRUN, CONSFL, DIAG,
     1   EXPERT, PRTINP, NOCF, SUBCL, CDB, TMPCDB, BRKOPN, VB, ECF, TCF
      COMMON /KEYS/ NOCALC, SAMPLE, REPRTB, BINNED, BYRUN, CONSFL, DIAG,
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     1    EXPERT, PRTINP, NOCF, SUBCL, CDB, TMPCDB, BRKOPN, VB, ECF, ICF
      CHARACTER*80 DEFFIL, SAMFIL, VECFIL
      COMMON /FILBLK/ DEFFIL, SAMFIL, VECFIL
      CHARACTER*(MAXLEN) CARD
      CHARACTER*(MAXVLN) CVAL, TMPVAL
      DIMENSION INDX(3)
      LOGICAL EOR, TYPE(4), LVAL
      CHARACTER*10 IFRMT
      COMMON /VALUES/ RVL(MAXVAL)
      DIMENSION IVL(MAXVAL)
      EQUIVALENCE (IVL, RVL)
C
C
C*****PRINT HEADER MESSAGE
      IF (PRTINP) WRITE(6,1003) DEFFIL
C*****WRITE INTEGER FORMAT FOR READING VARIABLE ARRAY INDICES
      WRITE(IFRMT,1004) MAXVLN
C*****INITIALLIZE CURRENT VALUE POSITION
      IVPOS=-1
C*****OPEN DEFAULT FILE
      OPEN(1, FILE=DEFFIL, STATUS='OLD', READONLY, ERR=9100)
 1000 CONTINUE
C*****READ RECORD
      READ(1,1001,END=8000) CARD
C*****PRINT RECORD
      IF (PRTINP) WRITE(6,1002) CARD
C*****INITIALLIZE COLUMN POINTER FOR CURRENT RECORD
      IC=1
 2000 CONTINUE
C*****READ NEXT VALUE ON RECORD
      CALL RDSTRG (CARD, IC, CVAL, LVAL, IVAL, RVAL, LENGTH, TYPE, EOR)
C*****CHECK FOR END-OF-RECORD
      IF (EOR) GO TO 1000
C*****CHECK FOR CHARACTER VALUE (VARIABLE NAME)
      IF (TYPE(1)) THEN
C********INITIALLIZE ARRAY SPECIFICATIONS
         INDX(1)=1
         INDX(2)=1
         INDX(3)=1
C********CHARACTER VALUE (VARIABLE NAME) FOUND
C********CHECK FOR LEFT PARENTHESIS IN VARIABLE NAME
         ILPAR=INDEX(CVAL, '(')
         IF (ILPAR .NE. 0) THEN
C***********FOUND LEFT PARENTHESIS, CHECK FOR RIGHT PARENTHESIS
            IRPAR=INDEX(CVAL, ')')
            IF (IRPAR .NE. 0) THEN
C**************FOUND RIGHT PARENTHESIS, CHECK FOR COMMA
               ICOMMA=INDEX(CVAL, ',')
               IF (ICOMMA .NE. 0) THEN
C*****************FOUND COMMA, DETERMINE FIRST ARRAY INDEX
                  IS=ILPAR + 1
                  IE=ICOMMA
                  IND=1
 3000             CONTINUE
                  IE=IE - 1
                  IF (CVAL(IE:IE) .EQ. ' ') GO TO 3000
                  IF (IE .GE. IS) THEN
C********************SET CURRENT ARRAY INDEX
                     TMPVAL=' '
                     TMPVAL(MAXVLN+IS-IE:MAXVLN)=CVAL(IS:IE)
                     READ(TMPVAL,IFRMT,ERR=9200) INDX(IND)
                  ELSE
C********************INVALID ARRAY INDEX
                     WRITE(6,3001) IND, CVAL(1:LENGTH)
                     NOCALC=.TRUE.
                  ENDIF
```

```
C******************CHECK FOR FINAL ARRAY INDEX FOUND
                   IF (ICOMMA .GT. 0) THEN
                      IS=ICOMMA + 1
C*********************LOCATE NEXT COMMA
                      ICOMMA=INDEX(CVAL(IS:LENGTH), ',')
                      IF (ICOMMA .GT. 0) THEN
                         ICOMMA=IS + ICOMMA - 1
                         IE=ICOMMA
                      ELSE
                         IE=IRPAR
                      ENDIF
C*********************INCREMENT COUNTER FOR CURRENT ARRAY INDEX
                      IND=IND + 1
                      IF (IND .GT. 3) THEN
C************************MORE THAN 3 ARRAY INDICES
                         WRITE(6,3002) CVAL(1:LENGTH)
                         IVPOS=-1
                         NOCALC=.TRUE.
                         GO TO 2000
                      ENDIF
                      GO TO 3000
                   ENDIF
                ELSE
C******************NO COMMA FOUND, ONLY ONE ARRAY INDEX
                   IS=ILPAR + 1
                   IE=IRPAR
                   IND=1
 4000              CONTINUE
                   IE=IE - 1
                   IF (CVAL(IE:IE) .EQ. ' ') GO TO 4000
                   IF (IE .GE. IS) THEN
C*********************SET SINGLE ARRAY INDEX
                      TMPVAL=' '
                      TMPVAL(MAXVLN+IS-IE:MAXVLN)=CVAL(IS:IE)
                      READ(TMPVAL,IFRMT,ERR=9200) INDX(IND)
                   ELSE
C*********************INVALID ARRAY INDEX
                      WRITE(6,4001) CVAL(1:LENGTH)
                      NOCALC=.TRUE.
                   ENDIF
                ENDIF
C***************BLANK OUT ARRAY INDEX PORTION OF VARIABLE NAME
                CVAL(ILPAR:MAXVLN)=' '
             ELSE
C***************ERROR IN ARRAY INDEX SPECIFICATION
                WRITE(6,4001) CVAL(1:LENGTH)
                NOCALC=.TRUE.
             ENDIF
          ENDIF
C*********SEARCH FOR VARIABLE NAME
          CALL SEARCH (NVAR, CVAL(1:LENGTH), NAME, IPNT, IPOINT)
C*********CHECK FOR VARIABLE NAME FOUND
          IF (IPOINT .GT. 0) THEN
C************VARIABLE NAME FOUND, VALIDATE ARRAY INDICES
             IF ((INDX(1) .GE. 1) .AND. (INDX(2) .GE. 1) .AND.
     1           (INDX(3) .GE. 1) .AND.
     2           (INDX(1) .LE. IDIMEN(1,IPNT(IPOINT))) .AND.
     3           (INDX(2) .LE. IDIMEN(2,IPNT(IPOINT))) .AND.
     4           (INDX(3) .LE. IDIMEN(3,IPNT(IPOINT)))) THEN
C***************VALID ARRAY INDICES, SET CURRENT VALUE POSITION
                IVPOS=ISPOS(IPNT(IPOINT)) + INDX(1) +
     1                (INDX(2)-1)*IDIMEN(1,IPNT(IPOINT)) +
     2                (INDX(3)-1)*IDIMEN(1,IPNT(IPOINT))*
     3                 IDIMEN(2,IPNT(IPOINT)) - 1
             ELSE
C***************INVALID ARRAY INDICES
```

```
               WRITE(6,4002) NAME(IPNT(IPOINT)),
     1                            (1, INDX(I), IDIMEN(I,IPNT(IPOINT)),I=1,3)
C**************SET INVALID VALUE POSITION
               IVPOS=-1
               NOCALC=.TRUE.
            ENDIF
         ELSE
C***********VARIABLE NAME NOT FOUND
            WRITE(6,4003) CVAL(1:LENGTH)
C***********SET INVALID VALUE POSITION
            IVPOS=-1
            NOCALC=.TRUE.
         ENDIF
      ELSE IF (TYPE(3)) THEN
C********CHECK FOR VALID VALUE POSITION
         IF (IVPOS .GE. 0) THEN
C***********SET STARTING POSITION OF VARIABLE FOLLOWING CURRENT VARIABLE
            IP=IPNT(IPOINT)
            IPNXTV=ISPOS(IP) + IDIMEN(1,IP)*IDIMEN(2,IP)*IDIMEN(3,IP)
C***********CHECK FOR VALID ARRAY POSITION
            IF (IVPOS .LT. IPNXTV) THEN
C**************INTEGER VALUE FOUND SO CHECK FOR INTEGER VARIABLE TYPE
               IF (.NOT. LREAL(IVPOS)) THEN
C*****************INTEGER VARIABLE SO TRANSFER INTEGER VALUE
                  IVL(IVPOS)=IVAL
C*****************SET DEFAULT FLAG
                  LDEFLT(IVPOS)=.TRUE.
               ELSE
C*****************REAL VARIABLE, PRINT ERROR MESSAGE
                  WRITE(6,4004) NAME(IPNT(IPOINT)), IVAL
                  NOCALC=.TRUE.
               ENDIF
            ELSE
C**************INVALID ARRAY POSITION, PRINT ERROR MESSAGE
               WRITE(6,4006) NAME(IPNT(IPOINT)),
     1                            (IDIMEN(I,IPNT(IPOINT)),I=1,3)
               NOCALC=.TRUE.
            ENDIF
C***********INCREMENT VALUE POSITION
            IVPOS=IVPOS + 1
         ENDIF
      ELSE IF (TYPE(4)) THEN
C********CHECK FOR VALID VALUE POSITION
         IF (IVPOS .GE. 0) THEN
C***********SET STARTING POSITION OF VARIABLE FOLLOWING CURRENT VARIABLE
            IP=IPNT(IPOINT)
            IPNXTV=ISPOS(IP) + IDIMEN(1,IP)*IDIMEN(2,IP)*IDIMEN(3,IP)
C***********CHECK FOR VALID ARRAY POSITION
            IF (IVPOS .LT. IPNXTV) THEN
C**************REAL VALUE FOUND SO CHECK FOR REAL VARIABLE TYPE
               IF (LREAL(IVPOS)) THEN
C*****************REAL VARIABLE SO TRANSFER REAL VALUE
                  RVL(IVPOS)=RVAL
C*****************SET DEFAULT FLAG
                  LDEFLT(IVPOS)=.TRUE.
               ELSE
C*****************INTEGER VARIABLE, PRINT ERROR MESSAGE
                  WRITE(6,4005) NAME(IPNT(IPOINT)), RVAL
                  NOCALC=.TRUE.
               ENDIF
            ELSE
C**************INVALID ARRAY POSITION, PRINT ERROR MESSAGE
               WRITE(6,4006) NAME(IPNT(IPOINT)),
     1                            (IDIMEN(I,IPNT(IPOINT)),I=1,3)
               NOCALC=.TRUE.
            ENDIF
```

```
C***********INCREMENT VALUE POSITION
            IVPOS=IVPOS + 1
          ENDIF
      ENDIF
      GO TO 2000
 8000 CONTINUE
C*****CLOSE DEFAULT FILE
      CLOSE (1)
      RETURN
 9100 CONTINUE
C*****ERROR IN OPENING DEFAULT FILE
      WRITE(6,9101) DEFFIL
      STOP
 9200 CONTINUE
C*****ERROR IN READING ARRAY INDEX
      WRITE(6,9201)
      NOCALC=.TRUE.
      GO TO 1000
C*****FORMAT STATEMENTS
 1001 FORMAT(A)
 1002 FORMAT(11X,A)
 1003 FORMAT('1',/1X,130('*'),
     1       /1X,53('*'),5X,'DEFAULT INPUT',5X,54('*'),
     2       /1X,17('*'),5X,'FILE =',A,5X,17('*'),
     3       /1X,130('*'),/)
 1004 FORMAT('(I',I2,')')
 3001 FORMAT(1X,'>>>>>DEFAULT VARIABLE ARRAY INDEX ',I1,' FOR ',
     1        'VARIABLE ',A,' IS INVALID',/)
 3002 FORMAT(1X,'>>>>>MORE THAN 3 ARRAY INDICES GIVEN FOR VARIABLE ',A,
     1        'ON DEFAULT FILE')
 4001 FORMAT(1X,'>>>>>DEFAULT VARIABLE ARRAY INDEX FOR ',
     1        'VARIABLE ',A,' IS INVALID',/)
 4002 FORMAT(1X,'>>>>>ARRAY INDICES FOR DEFAULT VARIABLE ',A,
     1        ' ARE OUT OF RANGE:'
     2   /(1X,'>>>>>  INDEX',I2,' =',I5,', VALID RANGE = 1 TO ',I5,/:))
 4003 FORMAT(1X,'>>>>>DEFAULT VARIABLE NAME ',A,
     1        ' NOT FOUND IN DEFAULT VARIABLE LIST',/)
 4004 FORMAT(1X,'>>>>>ATTEMPT TO DEFAULT REAL VARIABLE (',A,
     1        ') TO INTEGER VALUE (',I10,')',/)
 4005 FORMAT(1X,'>>>>>ATTEMPT TO DEFAULT INTEGER VARIABLE (',A,
     1        ') TO REAL VALUE (',1PE10.3,')',/)
 4006 FORMAT(1X,'>>>>>INVALID ARRAY POSITION ENCOUNTERED WHILE ',
     1        'SETTING DEFAULT VALUES FOR VARIABLE--',
     2        A,'(',I2,',',I2,',',I2,')')
 8001 FORMAT('1')
 9101 FORMAT(1X,'>>>>>ERROR OPENING DEFAULT FILE ',A,/)
 9201 FORMAT(1X,'>>>>>ERROR IN READING PREVIOUS ARRAY INDEX')
      END
      SUBROUTINE VECPOS
C*****SET SAMPLE VECTOR POSITIONS BY READING VARIABLE NAMES AND
C*****CORRESPONDING SAMPLE VECTOR POSITIONS FROM FILE DESIGNATED
C*****FOR SAMPLE VECTOR POSITIONS (SAMFIL)
      PARAMETER (MAXBD=20, MAXBIN=10000, MAXSMP=300, MAXCA[illegible]8,
     1           MAXISS=20, MAXLEV=10, MAXVAR=100, MAX[illegible]00,
     2           MAXSPC=10, MAXTIM=10)
      PARAMETER (MAXLEN=101, MAXVLN=20)
      CHARACTER*7 NAME
      LOGICAL LDEFLT, LREAL
      COMMON /DEFLT1/ NAME(MAXVAR)
      COMMON /DEFLT2/ NVAR, NVAL, NVCB1, NVCB2, NVCB3, NVCB4,
     1                NVCB5, IDIMEN(3,MAXVAR), ISPOS(MAXVAR),
     2                ISMPPS(MAXVAL), IPNT(MAXVAR), LDEFLT(MAXVAL),
     3                LREAL(MAXVAL)
      LOGICAL NOCALC, SAMPLE, REPRTB, BINNED, BYRUN, CONSFL, DIAG,
     1   EXPERT, PRTINP, NOCF, SUBCL, CDB, TMPCDB, BRKOPN, VB, ECF, ICF
      COMMON /KEYS/ NOCALC, SAMPLE, REPRTB, BINNED, BYRUN, CONSFL, DIAG,
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```
     1    EXPERT, PRTINP, NOCF, SUBCL, CDB, TMPCDB, BRKOPN, VB, ECF, ICF
      CHARACTER*80 DEFFIL, SAMFIL, VECFIL
      COMMON /FILBLK/ DEFFIL, SAMFIL, VECFIL
      CHARACTER*(MAXLEN) CARD
      CHARACTER*(MAXVLN) CVAL, TMPVAL
      CHARACTER*10 IFRMT
      DIMENSION INDX(3)
      LOGICAL EOR, TYPE(4), LVAL
C
C
C*****PRINT HEADER MESSAGE
      IF (PRTINP) WRITE(6,1003) SAMFIL
C*****WRITE INTEGER FORMAT FOR READING VARIABLE ARRAY INDICES
      WRITE(IFRMT,1004) MAXVLN
C*****INITIALLIZE CURRENT VALUE POSITION
      IVPOS=-1
C*****OPEN SAMPLE VECTOR POSITION FILE
      OPEN(1, FILE=SAMFIL, STATUS='OLD', READONLY, ERR=9100)
 1000 CONTINUE
C*****READ RECORD
      READ(1,1001,END=9000) CARD
C*****PRINT RECORD
      IF (PRTINP) WRITE(6,1002) CARD
C*****INITIALLIZE COLUMN POINTER FOR CURRENT RECORD
      IC=1
 2000 CONTINUE
C*****READ NEXT VALUE ON RECORD
      CALL RDSTRG (CARD, IC, CVAL, LVAL, IVAL, RVAL, LENGTH, TYPE, EOR)
C*****CHECK FOR END-OF-RECORD
      IF (EOR) GO TO 1000
C*****CHECK FOR CHARACTER VALUE (VARIABLE NAME)
      IF (TYPE(1)) THEN
C********INITIALLIZE ARRAY SPECIFICATIONS
         INDX(1)=1
         INDX(2)=1
         INDX(3)=1
C********CHARACTER VALUE (VARIABLE NAME) FOUND
C********CHECK FOR LEFT PARENTHESIS IN VARIABLE NAME
         ILPAR=INDEX(CVAL, '(')
         IF (ILPAR .NE. 0) THEN
C***********FOUND LEFT PARENTHESIS, CHECK FOR RIGHT PARENTHESIS
            IRPAR=INDEX(CVAL, ')')
            IF (IRPAR .NE. 0) THEN
C**************FOUND RIGHT PARENTHESIS, CHECK FOR COMMA
               ICOMMA=INDEX(CVAL, ',')
               IF (ICOMMA .NE. 0) THEN
C*****************FOUND COMMA, DETERMINE FIRST ARRAY INDEX
                  IS=ILPAR + 1
                  IE=ICOMMA
                  IND=1
 3000             CONTINUE
                  IE=IE - 1
                  IF (CVAL(IE:IE) .EQ. ' ') GO TO 3000
                  IF (IE .GE. IS) THEN
C********************SET CURRENT ARRAY INDEX
                     TMPVAL=' '
                     TMPVAL(MAXVLN+IS-IE:MAXVLN)=CVAL(IS:IE)
                     READ(TMPVAL,IFRMT,ERR=9200) INDX(IND)
                  ELSE
C********************INVALID ARRAY INDEX
                     WRITE(6,3001) IND, CVAL(1:LENGTH)
                     NOCALC=.TRUE.
                  ENDIF
C*****************CHECK FOR FINAL ARRAY INDEX FOUND
                  IF (ICOMMA .GT. 0) THEN
                     IS=ICOMMA + 1
```

```
C********************LOCATE NEXT COMMA
                     ICOMMA=INDEX(CVAL(IS:LENGTH), ',')
                     IF (ICOMMA .GT. 0) THEN
                        ICOMMA=IS + ICOMMA - 1
                        IE=ICOMMA
                     ELSE
                        IE=IRPAR
                     ENDIF
C********************INCREMENT COUNTER FOR CURRENT ARRAY INDEX
                     IND=IND + 1
                     IF (IND .GT. 3) THEN
C***********************MORE THAN 3 ARRAY INDICES
                        WRITE(6,3002) CVAL(1:LENGTH)
                        IVPOS=-1
                        NOCALC=.TRUE.
                        GO TO 2000
                     ENDIF
                     GO TO 3000
                  ENDIF
               ELSE
C*****************NO COMMA FOUND, ONLY ONE ARRAY INDEX
                  IS=ILPAR + 1
                  IE=IRPAR
                  IND=1
 4000             CONTINUE
                  IE=IE - 1
                  IF (CVAL(IE:IE) .EQ. ' ') GO TO 4000
                  IF (IE .GE. IS) THEN
C********************SET SINGLE ARRAY INDEX
                     TMPVAL=' '
                     TMPVAL(MAXVLN+IS-IE:MAXVLN)=CVAL(IS:IE)
                     READ(TMPVAL,IFRMT,ERR=9200) INDX(IND)
                  ELSE
C********************INVALID ARRAY INDEX
                     WRITE(6,4001) CVAL(1:LENGTH)
                     NOCALC=.TRUE.
                  ENDIF
               ENDIF
C**************BLANK OUT ARRAY INDEX PORTION OF VARIABLE NAME
               CVAL(ILPAR:MAXVLN)=' '
            ELSE
C**************ERROR IN ARRAY INDEX SPECIFICATION
               WRITE(6,4001) CVAL(1:LENGTH)
               NOCALC=.TRUE.
            ENDIF
         ENDIF
C********SEARCH FOR VARIABLE NAME
         CALL SEARCH (NVAR  CVAL(1:LENGTH), NAME, IPNT, IPOINT)
C********CHECK FOR VARIABLE NAME FOUND
         IF (IPOINT .GT. 0) THEN
C***********VARIABLE NAME FOUND, VALIDATE ARRAY INDICES
            IF ((INDX(1) .GE. 1) .AND  (INDX(2) .GE. 1) .AND.
     1           (INDX(2) .GE. 1) .AND.
     2           (INDX(1) .LE. IDIMEN(1,IPNT(IPOINT))) .AND.
     3           (INDX(2) .LE. IDIMEN(2,IPNT(IPOINT))) .AND.
     4           (INDX(3) .LE. IDIMEN(3,IPNT(IPOINT)))) THEN
C**************VALID ARRAY INDICES, SET CURRENT VALUE POSITION
               IVPOS=ISPOS(IPNT(IPOINT)) + INDX(1) +
     1                (INDX(2)-1)*IDIMEN(1,IPNT(IPOINT)) +
     2                (INDX(3)-1)*IDIMEN(1,IPNT(IPOINT))*
     3                 IDIMEN(2,IPNT(IPOINT)) - 1
            ELSE
C**************INVALID ARRAY INDICES
               WRITE(6,4002) CVAL(1:LENGTH),
     1                       (I, INDX(I), IDIMEN(I,IPNT(IPOINT)),I=1,3)
C**************SET INVALID VALUE POSITION
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```
               IVPOS=-1
               NOCALC=.TRUE.
            ENDIF
         ELSE
C************VARIABLE NAME NOT FOUND
            WRITE(6,4003) CVAL(1:LENGTH)
            NOCALC=.TRUE.
         ENDIF
      ELSE IF (TYPE(3)) THEN
C*********CHECK FOR VALID VALUE POSITION
         IF (IVPOS .GE. 0) THEN
C************SET STARTING POSITION OF VARIABLE FOLLOWING CURRENT VARIABLE
            IP=IPNT(IPOINT)
            IPNXTV=ISPOS(IP) + IDIMEN(1,IP)*IDIMEN(2,IP)*IDIMEN(3,IP)
C************CHECK FOR VALID ARRAY POSITION
            IF (IVPOS .LT. IPNXTV) THEN
C***************TRANSFER INTEGER VALUE TO SAMPLE VECTOR POSITION
               ISMPPS(IVPOS)=IVAL
            ELSE
C***************INVALID ARRAY POSITION, PRINT ERROR MESSAGE
               WRITE(6,4006) NAME(IPNT(IPOINT)),
     1                             (IDIMEN(I,IPNT(IPOINT)),I=1,2)
               NOCALC=.TRUE.
            ENDIF
C************INCREMENT VALUE POSITION
            IVPOS=IVPOS + 1
         ENDIF
      ELSE IF (TYPE(4)) THEN
C*********REAL VALUE TYPE, INVALID FOR SAMPLE VECTOR POSITION
         WRITE(6,4004) RVAL, NAME(IPNT(IPOINT))
         NOCALC=.TRUE.
      ENDIF
      GO TO 2000
 9000 CONTINUE
C*****CLOSE SAMPLE VECTOR POSITION FILE
      CLOSE (1)
      RETURN
 9100 CONTINUE
C*****ERROR IN OPENING SAMPLE VECTOR POSITION FILE
      WRITE(6,9101) SAMFIL
      STOP
 9200 CONTINUE
C*****ERROR IN READING ARRAY INDEX
      WRITE(6,9201)
      NOCALC=.TPUE.
      GO TO 1000
C*****FORMAT STATEMENTS
 1001 FORMAT(A)
 1002 FORMAT(11X,A)
 1003 FORMAT('1',/1X,130('*'),
     1      /1X,46('*'),5X,'SAMPLE VECTOR POSITION INPUT',5X,46('*'),
     2      /1X,17('*'),5X,'FILE =',A,5X,17('*'),
     3      /1X,130('*'),/)
 1004 FORMAT('(I',I2,')')
 3001 FORMAT(1X,'>>>>>SAMPLE VECTOR POSITION VARIABLE ARRAY INDEX ',
     1       I1,' FOR VARIABLE ',A,' IS INVALID',/)
 3002 FORMAT(1X,'>>>>>MORE THAN 3 ARRAY INDICES GIVEN FOR VARIABLE ',A,
     1       'ON SAMPLE VECTOR POSITION FILE')
 4001 FORMAT(1X,'>>>>>SAMPLE VECTOR POSITION VARIABLE ARRAY INDEX ',
     1       'FOR VARIABLE ',A,' IS INVALID',/)
 4002 FORMAT(1X,'>>>>>ARRAY INDICES FOR SAMPLE VECTOR POSITION ',
     1       'VARIABLE ',A,' ARE OUT OF RANGE:'
     2  /(1X,'>>>>>  INDEX',I2,' =',I5,', VALID RANGE = 1 TO ',I5,/:))
 4003 FORMAT(1X,'>>>>>SAMPLE VECTOR POSITION VARIABLE NAME ',A,
     1        ' NOT FOUND IN DEFAULT VARIABLE LIST',/)
 4004 FORMAT(1X,'>>>>>ATTEMPT TO USE REAL VALUE (',1PE10.2,') TO ',
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     1         'SPECIFY SAMPLE VECTOR POSITION FOR VARIABLE ',A,/)
4006 FORMAT(1X,'>>>>>INVALID ARRAY POSITION ENCOUNTERED WHILE ',
     1         'SETTING DEFAULT VALUES FOR VARIABLE--',
     2         A,'(',I2,',',I2,',',I2,')')
9101 FORMAT(1X,'>>>>>ERROR OPENING SAMPLE VECTOR POSITION FILE ',A,/)
9201 FORMAT(1X,'>>>>>ERROR IN READING PREVIOUS ARRAY INDEX')
      END
      SUBROUTINE RDSTRG (CARD, IC, CVAL, LVAL, IVAL, RVAL,
     1                   LENGTH, TYPE, EOR)
C*****CONVERTS A RECORD STRING TO A CHARACTER VALUE, A LOGICAL VALUE,
C*****A REAL VALUE, AND AN INTEGER VALUE
      PARAMETER (IL=100)
      CHARACTER*(*) CARD, CVAL
      CHARACTER*(IL) TMPCRD
      CHARACTER*8 IFRMT, LFRMT, RFRMT
      LOGICAL EOR, FIRST, LVAL, TYPE(4)
      DATA FIRST / .TRUE. /
C
C
C*****CHECK FOR FIRST TIME INTO ROUTINE
      IF (FIRST) THEN
C********WRITE INTEGER AND REAL FORMATS
         WRITE(IFRMT,1001) IL
         WRITE(RFRMT,1002) IL
         WRITE(LFRMT,1003) IL
C********RESET INITIALLIZATION TYPE
         FIRST=.FALSE.
      ENDIF
C*****SET LENGTH OF INCOMING RECORD
      ILMAX=LEN(CARD)
C*****SET LENGTH OF CHARACTER VARIABLE
      LENCVAL=LEN(CVAL)
C*****INITIALLIZE VARIABLE FLAG TYPES (1=CHAR, 2=LOGIC, 3=INTEG, 4=REAL)
      DO 1000 I=1,4
         TYPE(I)=.FALSE.
 1000 CONTINUE
C*****INTIALLIZE END-OF-RECORD TYPE
      EOR=.FALSE.
C*****RESET STARTING POSITION FOR CHARACTER POINTER
      IC=IC - 1
C*****SEARCH FOR FIRST NON-BLANK CHARACTER
 2000 CONTINUE
C*****INCREMENT CHARACTER POINTER
      IC=IC + 1
C*****CHECK FOR END OF RECORD
      IF (IC .GT. ILMAX) GO TO 9100
C*****CHECK FOR BLANK CHARACTER (STRING DELIMITER)
      IF (CARD(IC:IC) .EQ. ' ') GO TO 2000
C*****CHECK FOR BEGINNING OF COMMENT
      IF (CARD(IC:IC) .EQ. '$') GO TO 9100
C*****CHECK FOR COMMA CHARACTER (STRING DELIMITER)
      IF (CARD(IC:IC) .EQ. ',') GO TO 2000
C*****CHECK FOR QUOTE CHARACTER (CHARACTER STRING DELIMITER)
      IF (CARD(IC:IC) .EQ. '''') THEN
C********SAVE STARTING POSITION OF CHARACTER STRING
         IS=IC + 1
C********SEARCH FOR ANOTHER QUOTE
         IC=INDEX(CARD(IS:ILMAX), '''')
         IF (IC .EQ. 0) THEN
C***********QUOTE NOT FOUND SO CONTINUE SEARCH FOR BLANK TO TERMINATE
C***********CHARACTER STRING
            IC=IS - 1
         ELSE
C***********QUOTE FOUND
            IC=IS + IC - 1
            GO TO 3100
```

```
      ENDIF
C*********SEARCH FOR END OF CHARACTER STRING (' SIGNIFIES BEGINNING AND
C*********END OF CHARACTER STRING)
 3000   CONTINUE
C*********INCREMENT CHARACTER POINTER
        IC=IC + 1
C*********CHECK FOR END OF RECORD
        IF (IC .GT. ILMAX) GO TO 9100
C*********CHECK FOR BEGINNING OF COMMENT
        IF (CARD(IC:IC) .EQ. '$') GO TO 3100
C*********CHECK FOR BLANK TO TERMINATE CHARACTER STRING
        IF (CARD(IC:IC) .NE. ' ') GO TO 3000
 3100   CONTINUE
C*********END OF CHARACTER STRING FOUND
C*********COMPARE STRING LENGTH TO CHARACTER VARIABLE LENGTH
        IE=IC - 1
        IF (IE-IS+1 .GT. LENCVAL) GO TO 9300
C*********TRANSFER CHARACTER STRING
        CVAL=CARD(IS:IE)
C*********SET LENGTH OF CHARACTER STRING
        LENGTH=IE - IS + 1
C*********SET VARIABLE FLAG TYPE FOR CHARACTER VARIABLE FOUND
        TYPE(1)=.TRUE.
      ELSE
C*********SAVE STARTING POSITION FOR STRING
        IS=IC
C*********SEARCH FOR END OF STRING (BLANK OR , SIGNIFY END OF STRING)
 4000   CONTINUE
C*********INCREMENT CHARACTER POINTER
        IC=IC + 1
C*********CHECK FOR END OF RECORD
        IF (IC .GT. ILMAX) GO TO 9100
C*********CHECK FOR BEGINNING OF COMMENT
        IF (CARD(IC:IC) .EQ. '$') GO TO 4100
C*********CHECK FOR COMMA CHARACTER
        IF (CARD(IC:IC) .EQ. ',') GO TO 4000
C*********CHECK FOR BLANK CHARACTER
        IF (CARD(IC:IC) .NE. ' ') GO TO 4000
 4100   CONTINUE
C*********END OF STRING FOUND
C*********COMPARE STRING LENGTH TO FORMAT LENGTH
        IE=IC - 1
        IF (IE-IS+1 .GT. IL) GO TO 9200
C*********RIGHT JUSTIFY STRING FOR INTERNAL FORMATTED READS
        TMPCRD=' '
        TMPCRD(IL+IS-IE:IL)=CARD(IS:IE)
C*********READ STRING WITH LOGICAL FORMAT (NOT USED IN GGSOR)
C        READ(TMPCRD,LFRMT,ERR=5000) LVAL
C        TYPE(2)=.TRUE.
C 5000   CONTINUE
C*********READ STRING WITH INTEGER FORMAT
C        READ(TMPCRD,IFRMT,ERR=6000) IVAL
C        TYPE(3)=.TRUE.
C 6000   CONTINUE
C*********READ STRING WITH REAL FORMAT
        READ(TMPCRD,RFRMT,ERR=7000) RVAL
        TYPE(4)=.TRUE.
C*********CHECK FOR DECIMAL POINT IN VALUE AND MAGNITUDE OF VALUE
        IF ((INDEX(TMPCRD, '.') .EQ. 0) .AND.
     1      (ABS(RVAL) .LE. 1.0E10)) THEN
          IVAL=NINT (RVAL)
          TYPE(3)=.TRUE.
        ENDIF
        GO TO 8000
 7000   CONTINUE
C*********STRING IS NOT LOGICAL, INTEGER, OR REAL SO ASSUMED TO BE CHAR
```

```
C********COMPARE STRING LENGTH TO CHARACTER VARIABLE LENGTH
        IF (IE-IS+1 .GT. LENCVAL) GO TO 9300
C********TRANSFER CHARACTER STRING
        CVAL=CARD(IS:IE)
C********SET LENGTH OF CHARACTER STRING
        LENGTH=IE - IS + 1
C********SET VARIABLE FLAG TYPE FOR CHARACTER VARIABLE FOUND
        TYPE(1)=.TRUE.
 8000   CONTINUE
      ENDIF
C*****CHECK FOR BEGINNING OF COMMENT
      IF (CARD(IC:IC) .NE. '$') IC=IC + 1
      RETURN
 9100 CONTINUE
C*****END OF RECORD ENCOUNTERED SEARCHING FOR VALUE POSITION
C*****SET END-OF-RECORD TYPE
      EOR=.TRUE.
      RETURN
 9200 CONTINUE
C*****LENGTH OF STRING TOO LONG FOR EITHER CHARACTER STORAGE OR INTERNAL
C*****FORMATTED READ
      WRITE(6,9201) CARD, IL
      RETURN
 9300 CONTINUE
C*****LENGTH OF STRING TOO LONG FOR CHARACTER VARIABLE
      WRITE(6,9301) CARD(IS:IE), LENCVAL
      RETURN
C*****FORMAT STATEMENTS
 1001 FORMAT('(I',I3,')')
 1002 FORMAT('(E',I3,'.0)')
 1003 FORMAT('(L',I3,')')
 9201 FORMAT(1X,'>>>>>LENGTH OF STRING TOO LONG FOR EITHER CHARACTER ',
     1        'STORAGE OR INTERNAL FORMATTED READ',
     2       /1X,'>>>>>',A,
     3       /1X,'>>>>>RESET PARAMETER IL IN RDSTRG TO A VALUE ',
     4        'GREATER THAN ',I3,' TO ACCOUNT FOR ',
     5       /1X,'>>>>>LARGER STRING SIZE FOR VALUES ON INPUT FILE',/)
 9301 FORMAT(1X,'>>>>>LENGTH OF STRING TOO LONG FOR CHARACTER ',
     1        'VARIABLE STORAGE ',
     2       /1X,'>>>>>',A,
     3       /1X,'>>>>>RESET CORRESPONDING CHARACTER VARIABLE LENGTH ',
     4        ' IN RDSTRG TO A VALUE ',
     4       /1X,'>>>>>GREATER THAN ',I3,' TO ACCOUNT FOR ',
     5        'LARGER STRING SIZE FOR VALUES ON INPUT FILE',/)
      END
      SUBROUTINE SEARCH (NVAR, CVAL, NAME, IPNT, IPOINT)
C*****LOCATE VARIABLE NAME CVAL USING BINARY SEARCH RETURNING IPOINT
C*****AS POSITION IN IPNT OF NAME (IPOINT=0 IF NOT LOCATED)
      CHARACTER*(*) CVAL, NAME(NVAR)
      DIMENSION IPNT(NVAR)
C
C
C*****SET LOWER LIMIT POINTER FOR SEARCH RANGE
      IL=1
C*****SET UPPER LIMIT POINTER FOR SEARCH RANGE
      IH=NVAR
C*****SET MIDPOINT POINTER FOR SEARCH RANGE
      IM=IH / 2
C*****BEGINNING OF BINARY SEARCH LOOP
 1000 CONTINUE
C*****COMPARE SEARCH ID TO CURRENT MIDPOINT ID
      IF (CVAL .EQ. NAME(IPNT(IM))) GO TO 2000
C*****CHECK TO SEE IF MIDPOINT ID IS GREATER THAN SEARCH ID
      IF (CVAL .GT. NAME(IPNT(IM))) THEN
C********SEARCH ID IS IN UPPER HALF OF SEARCH RANGE
C********RESET LOWER LIMIT POINTER TO FORMER MIDPOINT
```

```
            IL=IM
C*********RESET MIDPOINT TO CURRENT INTERVAL
            IM=(IL+IH+1) / 2
         ELSE
C*********SEARCH ID IS IN LOWER HALF OF SEARCH RANGE
C*********RESET UPPER LIMIT POINTER TO FORMER MIDPOINT
            IH=IM
C*********RESET MIDPOINT TO CURRENT INTERVAL
            IM=(IL+IH) / 2
         ENDIF
         IF (IL+1 .EQ. IH) THEN
            IF ((CVAL .NE. NAME(IPNT(IL))) .AND.
     1          (CVAL .NE. NAME(IPNT(IH)))) THEN
C************VALUE NOT FOUND SO RETURN 0 FOR POINTER
               IPOINT=0
               RETURN
            ENDIF
         ENDIF
         GO TO 1000
 2000 CONTINUE
C*****VALUE FOUND SO RETURN MIDPOINT FOR POINTER
      IPOINT=IM
      RETURN
      END
      SUBROUTINE CSORT (NVAR, NAME, IPNT)
C*****SORT NVAR VALUES OF CHARACTER ARRAY NAME IN INCREASING ORDER
C*****USING POINTER ARRAY IPNT
      CHARACTER*(*) NAME(NVAR)
      DIMENSION IPNT(NVAR)
C
C
      N=NVAR
      L=N/2+1
      IR=N
  100 CONTINUE
      IF (L.LE.1) GO TO 700
      L=L-1
      LHOLD=IPNT(L)
  200 CONTINUE
      J=L
  300 CONTINUE
      I=J
      J=2*J
      IF (J-IR) 400, 500, 600
  400 CONTINUE
      IF (NAME(IPNT(J)) .LT. NAME(IPNT(J+1))) J=J+1
  500 CONTINUE
      IF (NAME(LHOLD) .GE. NAME(IPNT(J))) GO TO 600
      IPNT(I)=IPNT(J)
      GO TO 300
  600 CONTINUE
      IPNT(I)=LHOLD
      GO TO 100
  700 CONTINUE
      LHOLD=IPNT(IR)
      IPNT(IR)=IPNT(1)
      IR=IR - 1
      IF (IR .GT. 1) GO TO 200
      IPNT(1)=LHOLD
      RETURN
      END
      SUBROUTINE SUBVEC
C*****SUBSTITUTE SAMPLE VECTOR VALUES INTO DEFAULT VALUE ARRAY
      PARAMETER (MAXBD=20, MAXBIN=10000, MAXSMP=300, MAXCAS=8,
     1           MAXISS=20, MAXLEV=10, MAXVAR=100, MAXVAL=12000,
     2           MAXSPC=10, MAXTIM=10)
```

```
      COMMON /LHSBLK/ XLHS(MAXSMP)
      CHARACTER*7 NAME
      LOGICAL LDEFLT, LREAL
      COMMON /DEFLT1/ NAME(MAXVAR)
      COMMON /DEFLT2/ NVAR, NVAL, NVCB1, NVCB2, NVCB3, NVCB4,
     1                NVCB5, IDIMEN(3,MAXVAR), ISPOS(MAXVAR),
     2                ISMPPS(MAXVAL), IPNT(MAXVAR), LDEFLT(MAXVAL),
     3                LREAL(MAXVAL)
      COMMON /VALUES/ RVL(MAXVAL)
      DIMENSION IVL(MAXVAL)
      EQUIVALENCE (IVL, RVL)
C
C
C*****MAKE SAMPLE VECTOR SUBSTITUTIONS
      DO 1000 IVAL=1,NVAL
C********CHECK FOR POSITIVE SAMPLE VECTOR SUBSTITUTION POSITION
         IF (ISMPPS(IVAL) .GT. 0) THEN
C***********CHECK FOR REAL VALUE
            IF (LREAL(IVAL)) THEN
C**************TRANSFER REAL VALUE
               RVL(IVAL)=XLHS(ISMPPS(IVAL))
            ELSE
C**************TRANSFER INTEGER VALUE
               IVL(IVAL)=NINT(XLHS(ISMPPS(IVAL)))
            ENDIF
         ENDIF
 1000 CONTINUE
      RETURN
      END
      SUBROUTINE WRTPAR
C*****PRINT DEFAULT AND SAMPLE VECTOR SUBSTITUTION INFORMATION FOR
C*****BINNED AND DIRECT EXECUTIONS
      PARAMETER (MAXBD=20, MAXBIN=10000, MAXSMP=300, MAXCAS=8,
     1           MAXISS=20, MAXLEV=10, MAXVAR=100, MAXVAL=12000,
     2           MAXSPC=10, MAXTIM=10)
      PARAMETER (MAXPR=132)
      CHARACTER*(MAXPR) RECOUT
      CHARACTER*7 NAME
      LOGICAL LDEFLT, LREAL
      COMMON /DEFLT1/ NAME(MAXVAR)
      COMMON /DEFLT2/ NVAR, NVAL, NVCB1, NVCB2, NVCB3, NVCB4,
     1                NVCB5, IDIMEN(3,MAXVAR), ISPOS(MAXVAR),
     2                ISMPPS(MAXVAL), IPNT(MAXVAR), LDEFLT(MAXVAL),
     3                LREAL(MAXVAL)
      COMMON /VALUES/ RVL(MAXVAL)
      DIMENSION IVL(MAXVAL)
      EQUIVALENCE (IVL, RVL)
C
C
C*****PRINT HEADER RECORD
      WRITE(6,1001)
C*****LOAD OUTPUT RECORD BEFORE PRINTING (10 OR FEWER VALUES PER RECORD)
      IVAL=0
C*****LOOP OVER VARIABLES, PRINTING IN SORTED ORDER
      DO 4000 IVR=1,NVAR
         IVAR=IPNT(IVR)
C********START NEW RECORD FOR EACH VARIABLE
         WRITE(RECOUT,2001) NAME(IVAR)
C********INITIALLIZE VALUE POSITION FOR CURRENT VARIABLE
         IVAL=ISPOS(IVAR) - 1
C********SET COLUMN POINTER
         IC=1
C********LOOP OVER VALUES FOR CURRENT VARIABLE (3RD DIMENSION)
         DO 3000 IDM3=1,IDIMEN(3,IVAR)
C***********LOOP OVER VALUES FOR CURRENT VARIABLE (2ND DIMENSION)
            DO 2000 IDM2=1,IDIMEN(2,IVAR)
```

```
C**************LOOP OVER VALUES FOR CURRENT VARIABLE (1ST DIMENSION)
               DO 1000 IDM1=1,IDIMEN(1,IVAR)
C*****************INCREMENT VALUE POINTER
                  IVAL=IVAL + 1
C*****************INCREMENT COLUMN
                  IC=IC + 11
C*****************CHECK FOR DEFAULT AND SAMPLE VECTOR SUBSTITUTION
                  IF (ISMPPS(IVAL) .GT. 0) THEN
C********************TRANSFER SAMPLE VECTOR POSITION TO OUTPUT RECORD
                     WRITE(RECOUT(IC:IC+10),2002) ISMPPS(IVAL)
                  ELSE IF (LDEFLT(IVAL)) THEN
C********************CHECK FOR REAL DEFAULT VALUE
                     IF (LREAL(IVAL)) THEN
C***********************TRANSFER REAL VALUE TO OUTPUT RECORD
                        WRITE(RECOUT(IC:IC+10),2003) RVL(IVAL)
                     ELSE
C***********************TRANSFER INTEGER VALUE TO OUTPUT RECORD
                        WRITE(RECOUT(IC:IC+10),2004) IVL(IVAL)
                     ENDIF
                  ELSE
C********************NO DEFAULT OR SAMPLE VECTOR SUBSTITUTION
                     WRITE(RECOUT(IC:IC+10),2005)
                  ENDIF
C*****************CHECK FOR OUTPUT RECORD WITH MORE THAN 104 COLUMNS
                  IF (IC .GT. 104) THEN
C********************PRINT OUTPUT RECORD
                     WRITE(6,2010) RECOUT
C********************INITIALLIZE OUTPUT RECORD
                     RECOUT=' '
C********************RESET COLUMN POINTER
                     IC=1
                  ENDIF
 1000          CONTINUE
 2000       CONTINUE
 3000    CONTINUE
C********IF INFORMATION IS STORED ON OUTPUT RECORD, PRINT OUTPUT RECORD
         IF (IC .GT. 1) WRITE(6,2010) RECOUT
 4000 CONTINUE
C*****START NEW PAGE
      WRITE(6,3001)
      RETURN
C*****FORMAT STATEMENTS
 1001 FORMAT('1',/1X,130('*'),
     1       /1X,30('*'),5X,'DEFAULT INPUT AND SAMPLE VECTOR ',
     2        'SUBSTITUTION INFORMATION',5X,34('*'),
     3       /1X,130('*'),/)
 2001 FORMAT(1X,A9)
 2002 FORMAT('  V-POS-',I3.3)
 2003 FORMAT(1PE11.3)
 2004 FORMAT(I11)
 2005 FORMAT('   NO VALUE')
 2010 FORMAT(A)
 3001 FORMAT('1')
      END
      SUBROUTINE TRANS (CB1, CB2, CB3)
C*****TRANSFER VALUES FROM ARRAY RVAL TO COMMON BLOCKS CB1 AND CB2
C*****IN THIS ORDER
      PARAMETER (MAXBD=20, MAXBIN=10000, MAXSMP=300, MAXCAS=8,
     1           MAXISS=20, MAXLEV=10, MAXVAR=100, MAXVAL=12000,
     2           MAXSPC=10, MAXTIM=10)
      CHARACTER*7 NAME
      LOGICAL LDEFLT, LREAL
      COMMON /DEFLT1/ NAME(MAXVAR)
      COMMON /DEFLT2/ NVAR, NVAL, NVCB1, NVCB2, NVCB3, NVCB4,
     1                NVCB5, IDIMEN(3,MAXVAR), ISPOS(MAXVAR),
     2                ISMPPS(MAXVAL), IPNT(MAXVAR), LDEFLT(MAXVAL),
```

```
     3               LREAL(MAXVAL)
      COMMON /VALUES/ RVL(MAXVAL)
      DIMENSION IVL(MAXVAL)
      EQUIVALENCE (IVL, RVL)
      DIMENSION CB1(NVCB1), CB2(NVCB2), CB3(NVCB3)
C
C
C*****INITIALLIZE VALUE COUNTER
      IVAL=0
C*****CHECK NUMBER OF VALUES ASSIGNED TO COMMON BLOCK 1
      IF (NVCB1 .GT. 0) THEN
C********TRANSFER VALUES FOR COMMON BLOCK 1
         DO 1000 I=1,NVCB1
C***********INCREMENT VALUE COUNTER
            IVAL=IVAL + 1
            CB1(I)=RVL(IVAL)
 1000    CONTINUE
      ENDIF
C*****CHECK NUMBER OF VALUES ASSIGNED TO COMMON BLOCK 2
      IF (NVCB2 .GT. 0) THEN
C********TRANSFER VALUES FOR COMMON BLOCK 2
         DO 2000 I=1,NVCB2
C***********INCREMENT VALUE COUNTER
            IVAL=IVAL + 1
            CB2(I)=RVL(IVAL)
 2000    CONTINUE
      ENDIF
C*****CHECK NUMBER OF VALUES ASSIGNED TO COMMON BLOCK 3
      IF (NVCB3 .GT. 0) THEN
C********TRANSFER VALUES FOR COMMON BLOCK 3
         DO 3000 I=1,NVCB3
C***********INCREMENT VALUE COUNTER
            IVAL=IVAL + 1
            CB3(I)=RVL(IVAL)
 3000    CONTINUE
      ENDIF
      RETURN
      END
      SUBROUTINE WRREL
C*****PRINT CONTENTS OF COMMON BLOCKS
      PARAMETER (MAXBD=20, MAXBIN=10000, MAXSMP=300, MAXCAS=8,
     1           MAXISS=20, MAXLEV=10, MAXVAR=100, MAXVAL=12000,
     2           MAXSPC=10, MAXTIM=10)
      COMMON /BASVAL/ FCOR(MAXSPC), FVES(MAXSPC), DFVPA(MAXSPC),
     1                DFCPA(MAXSPC), FEVSE(MAXSPC), FDCH(MAXSPC),
     2                FCCI(MAXSPC), DFCAV(MAXSPC), VBPUF(MAXSPC),
     3                FCONV(MAXSPC), FCONC(MAXSPC), DFSPRV(MAXSPC),
     4                DFSPRC(MAXSPC), FREVO(MAXSPC), VALISS(MAXISS),
     5                FLTI1, FLTI2, NSPEC, FLV, FHPE, EVSE, WFAC, PFAC,
     6                FPLBYE, FPLBYP, FPLBYD, FPLBYC, FTLPH, FTLPL,
     7                FTLP, TC11, TC12, TB11, TB12, TB21, TB22, TBS1,
     8                TBS2, TBR1, TBR2, TW, T1, T2, DT1, DT2, DTCDB,
     9                ELEV, PUFF
C
C
      WRITE(6,1001)
C*****PRINT COMMON BLOCK BASVAL ARRAY VARIABLES
      WRITE(6,1002) 'BASVAL', 'BASE VALUES FOR GGSOR'
      WRITE(6,1003) 'FCOR  ', 'FVES  ', 'DFVPA ', 'DFCPA ',
     1              'FEVSE ', 'FDCH  ', 'FCCI  ', 'DFCAV ',
     2              'VBPUF ', 'FCONV '
      DO 1000 K=1,NSPEC
         WRITE(6,1004) FCOR(K), FVES(K), DFVPA(K), DFCPA(K),
     1                 FEVSE(K), FDCH(K), FCCI(K), DFCAV(K),
     2                 VBPUF(K), FCONV(K)
 1000 CONTINUE
```

```
      WRITE(6,1003) 'FCONC  ', 'DFSPRV ', 'DFSPRC ', 'FREVO  '
      DO 2000 K=1,NSPEC
         WRITE(6,1004) FCONC(K), DFSPRV(K), DFSPRC(K), FREVO(K
 2000 CONTINUE
      WRITE(6,1003) 'VALISS '
      DO 3000 IISS=1,MAXISS
         WRITE(6,1004) VALISS(IISS)
 3000 CONTINUE
C*****PRINT COMMON BLOCK BASVAL SINGLE VARIABLES
      WRITE(6,1003) 'FLTI1  ', 'FLTI2  ', 'NSPEC  ', 'FLV    ',
     1              'FHPE   ', 'EVSE   ', 'WFAC   ', 'PFAC   ',
     2              'FPLBYE ', 'FPLBYP '
      WRITE(6,1004) FLTI1, FLTI2, FLOAT(NSPEC), FLV,
     1              FHPE, EVSE, WFAC, PFAC,
     2              FPLBYE, FPLBYP
      WRITE(6,1003) 'FPLBYD ', 'FPLBYC ', 'FTLPH  ', 'FTLPL  ',
     1              'FTLP   ', 'TC11   ', 'TC12   ', 'TB11   ',
     2              'TB12   ', 'TB21   '
      WRITE(6,1004) FPLBYD, FPLBYC, FTLPH, FTLPL,
     1              FTLP, TC11, TC12, TB11,
     2              TB12, TB21
      WRITE(6,1003) 'TB22   ', 'TBS1   ', 'TBS2   ', 'TBR1   ',
     1              'TBR2   ', 'TW     ', 'T1     ', 'T2     ',
     2              'DT1    ', 'DT2    '
      WRITE(6,1004) TB22, TBS1, TBS2, TBR1,
     1              TBR2, TW, T1, T2,
     2              DT1, DT2
      WRITE(6,1003) 'DTCDB  ', 'ELEV   ', 'PUFF   '
      WRITE(6,1004) DTCDB, ELEV, PUFF
      RETURN
C*****FORMAT STATEMENTS
 1001 FORMAT('1')
 1002 FORMAT(//1X,130('='),
     1       /1X,5('*'),' CONTENTS OF COMMON BLOCK ',A,' ',5('*'),
     2       /7X,A,
     3       /1X,130('='))
 1003 FORMAT(/3X,10(A7,4X))
 1004 FORMAT(1X,1P,10E11.3)
      END
      SUBROUTINE BINTRN (IBIN)
C*****PERFORM BIN TRANSLATION
C
C=====BIN DIMENSIONS
C
C-----------------------------------------------------------------
C===== INDX(1): ACCIDENT SEQUENCES
C          1: FAST STATION BLACKOUT
C          2: SLOW STATION BLACKOUT
C          3: FAST TRANSIENT
C          4: SLOW TRANSIENT
C          5: FAST TC
C          6: SLOW TC
C===== INDX(2): ZR OXIDATION
C          1: HIGH
C          2: LOW
C===== INDX(3): VESSEL CONDITION AT VESSEL BREACH
C          1: HIGH PRESSURE, NO LOW PRESSURE INJECTION AFTER VB
C          2: LOW PRESSURE, NO LOW PRESSURE INJECTION AFTER VB
C          3: HIGH PRESSURE, LPI RECOVERY AFTER VB
C          4: LOW PRESSURE, LPI RECOVERY AFTER VB
C          5: NO VESSEL BREACH
C===== INDX(4): FRACTION OF CORE PARTICIPATING IN DCH OR STEAM EXPLOSION
C          1: HIGH DCH, NO STEAM EXPLOSION
C          2: LOW DCH, NO STEAM EXPLOSION
C          3: NO DCH, HIGH STEAM EXPLOSION
C          4: NO DCH, LOW STEAM EXPLOSION
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C         5: NO DCH, NO STEAM EXPLOSION
C===== INDX(5): POOL BYPASS
C         1: NOMINAL (860 CFM)
C         2: EARLY NOMINAL, INTERMEDIATE LARGE (COMLPETE BYPASS)
C         3: EARLY NOMINAL, LATE SMALL (8600 CFM)
C         4: EARLY NOMINAL, LATE LARGE
C         5: EARLY SMALL, LATE SMALL
C         6: EARLY SMALL, INTERMEDIATE LARGE
C         7: EARLY SMALL, LATE LARGE
C         8: EARLY LARGE, LATE LARGE
C===== INDX(6): CONTAINMENT FAILURE
C         1: EARLY LEAK BEFORE VB
C         2: EARLY RUPTURE BEFORE VB
C         3: EARLY VENT
C         4: LEAK AT VB
C         5: RUPTURE AT VB
C         6: LATE LEAK
C         7: LATE RUPTURE
C         8: LATE VENT
C         9: NO CF
C===== INDX(7): CONTAINMENT SPRAY
C         1: NO SPRAY
C         2: EARLY SPRAY ONLY
C         3: LATE SPRAY ONLY
C         4: EARLY AND LATE SPRAY
C===== INDX(8): MOLTEN CORE CONCRETE INTERACTION
C         1: DRY CAVITY
C         2: WET CAVITY (WATER ALMOST DRYOUT AFTER 10 HOURS)
C         3: FLOODED CAVITY
C         4: DELAY CCI RELEASE
C         5: NO CCI RELEASE (I.E., COOLABLE DEBRIS BED)
C===== INDX(9): TAIL PIPE VACUUM BREAKER STUCK OPEN
C         1: YES (SOME POOL BYPASS DURING IN-VESSEL RELEASE)
C         2: NO
C
C --------------------------------------------------------------------------
C
C   SPECIES INDEX = ISP, 1 TO NSPEC; ORDER IS NG,I,CS,TE,SR,RU,LA,CE,BA
C
C ==========================================================================
      PARAMETER (MAXBD=20, MAXBIN=10000, MAXSMP=300, MAXCAS=8,
     1           MAXISS=20, MAXLEV=10, MAXVAR=100, MAXVAL=12000,
     2           MAXSPC=10, MAXTIM=10)
      CHARACTER BINARR*(MAXBD), BTITLE*80, TITLE*80
      COMMON /BINS/ BINARR(MAXBIN), BTITLE, TITLE
      LOGICAL NOCALC, SAMPLE, REPRTB, BINNED, BYRUN, CONSFL, DIAG,
     1    EXPERT, PRTINP, NOCF, SUBCL, CDB, TMPCDB, BRKOPN, VB, ECF, ICF
      COMMON /KEYS/ NOCALC, SAMPLE, REPRTB, BINNED, BYRUN, CONSFL, DIAG,
     1    EXPERT, PRTINP, NOCF, SUBCL, CDB, TMPCDB, BRKOPN, VB, ECF, ICF
      COMMON /SRCTRM/ ST(MAXSPC), STE(MAXSPC), STCCI(MAXSPC),
     1                STL(MAXSPC), STIL, STRVOL(MAXSPC),
     2                ST1(MAXSPC), ST2(MAXSPC), RV(MAXSPC)
      COMMON /BASVAL/ FCOR(MAXSPC), FVES(MAXSPC), DFVPA(MAXSPC),
     1                DFCPA(MAXSPC), FEVSE(MAXSPC), FDCH(MAXSPC),
     2                FCCI(MAXSPC), DFCAV(MAXSPC), VBPUF(MAXSPC),
     3                FCONV(MAXSPC), FCONC(MAXSPC), DFSPRV(MAXSPC),
     4                DFSPRC(MAXSPC), FREVO(MAXSPC), VALISS(MAXISS),
     5                FLTI1, FLTI2, NSPEC, FLV, FHPE, EVSE, WFAC, PFAC,
     6                FPLBYE, FPLBYP, FPLBYD, FPLBYC, FTLPH, FTLPL,
     7                FTLP, TC11, TC12, TB11, TB12, TB21, TB22, TBS1,
     8                TBS2, TBR1, TBR2, TW, T1, T2, DT1, DT2, DTCDB,
     9                ELEV, PUFF
      COMMON /BINNED/ FCOR0(MAXSPC,MAXCAS), FVES0(MAXSPC,MAXCAS),
     1                DFVPA0(MAXSPC,MAXCAS), DFCPA0(MAXSPC,MAXCAS),
     2                FDCH0(MAXSPC,MAXCAS), FEVSE0(MAXSPC,MAXCAS),
     3                FCCI0(MAXSPC,MAXCAS), DFCAV0(MAXSPC,MAXCAS),
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    4                VBPUF0(MAXSPC,MAXCAS), FCONV0(MAXSPC,MAXCAS),
    5                FCONC0(MAXSPC,MAXCAS), DFSPRV0(MAXSPC,MAXCAS),
    6                DFSPRC0(MAXSPC,MAXCAS), FREVO0(MAXSPC,MAXCAS),
    7                FLTI10(MAXCAS), FLTI20(MAXCAS), FHPE0(MAXCAS),
    8                EVSE0(MAXCAS), FPLBY0(3), TW0(MAXTIM),
    9                T10(MAXTIM), DT10(MAXTIM), DT20(MAXTIM),
    A                PUFF0(MAXTIM)
     COMMON /BININD/ INDX(MAXBD)
C
C
      ICAM1=ICHAR('A') - 1
C*****ACCIDENT SEQUENCE
      INDX(1) = ICHAR(BINARR(IBIN)(1:1)) - ICAM1
C*****ZR OXIDATION
      INDX(2) = ICHAR(BINARR(IBIN)(2:2)) - ICAM1
C*****REACTOR PRESSURE AT VESSEL BREACH
      INDX(3) = ICHAR(BINARR(IBIN)(3:3)) - ICAM1
C*****FRACTION OF CORE PARTICIPATING IN DCH OR STEAM EXPLOSION
      INDX(4) = ICHAR(BINARR(IBIN)(4:4)) - ICAM1
C*****POOL BYPASS
      INDX(5) = ICHAR(BINARR(IBIN)(5:5)) - ICAM1
C*****CONTAINMENT FAILURE TIME AND MODE
      INDX(6) = ICHAR(BINARR(IBIN)(6:6)) - ICAM1
C*****CONTAINMENT SPRAYS
      INDX(7) = ICHAR(BINARR(IBIN)(7:7)) - ICAM1
C*****MOLTEN CORE CONCRETE INTERACTION
      INDX(8) = ICHAR(BINARR(IBIN)(8:8)) - ICAM1
C*****TAIL PIPE VACUUM BREAKER STUCK OPEN
      INDX(9) = ICHAR(BINARR(IBIN)(9:9)) - ICAM1
C*****SET LOGICAL FLAGS TO BE PASSED INTO GGSORC
C*****TEMPORARY COOLABLE DEBRIS BED OR COOLABLE DEBRIS BED
      TMPCDB=(INDX(8) .EQ. 4)
      CDB=(INDX(8) .EQ. 5)
C*****VESSEL BREACH
      VB=(INDX(3) .NE. 5)
C*****SUPPRESSION POOL TEMPERATURE
      SUBCL=(INDX(1) .EQ. 1) .OR. (INDX(1) .EQ. 3) .OR.
     1      (INDX(1) .EQ. 4) .OR. (INDX(1) .EQ. 5)
C*****NO CONTAINMENT FAILURE FLAG
      NOCF=(INDX(6) .EQ. 9)
C*****EARLY CF BEFORE VB
      ECF=(INDX(6) .LE. 3)
C*****INTERMEDIATE CF AT VB
      ICF=(INDX(6) .EQ. 4) .OR. (INDX(6) .EQ. 5)
C*****TAIL PIPE VACUUM BREAKER STUCK OPEN FLAG
      BRKOPN=(INDX(9) .EQ. 1)
C*****LOOP OVER SPECIES
      DO 500 ISP=1,NSPEC
C********FCOR ******************
         IF (INDX(2) .EQ. 1) THEN
            FCOR(ISP)=FCOR0(ISP,1)
         ELSE
            FCOR(ISP)=FCOR0(ISP,2)
         ENDIF
C********FVES * **************
         IF (INDX(1) .LE. 2) THEN
C***********STATION BLACKOUT
            IF ((INDX(3) .EQ. 1) .OR. (INDX(3, .EQ. 3)) THEN
C**************HIGH PRESSURE AT VB
               FVES(ISP)=FVES0(ISP,1)
            ELSE
C**************LOW PRESSURE AT VB
               FVES(ISP)=FVES0(ISP,2)
            ENDIF
         ELSE
C***********TRANSIENTS, TC:  CRD FLOW
```

```
            IF ((INDX(3) .EQ. 1) .OR. (INDX(3) .EQ. 3)) THEN
C**************HIGH PRESSURE AT VB
               FVES(ISP)=FVES0(ISP,3)
            ELSE
C**************LOW PRESSURE AT VB
               FVES(ISP)=FVES0(ISP,2)
            ENDIF
         ENDIF
C********REVOLATILIZATION AFTER VESSEL BREACH
         IF (INDX(3) .EQ. 5) THEN
C***********NO VESSEL BREACH, NO REVOLATILIZATION
            FREVO(ISP)=0.0
         ELSE IF ((INDX(3) .EQ. 3) .OR. (INDX(3) .EQ. 4)) THEN
C***********LPI RECOVERY, AFTER VB
            FREVO(ISP)=FREVO0(ISP,3)
         ELSE
C***********NO LPI RECOVERY AFTER VB
            FREVO(ISP)=FREVO0(ISP,1)
         ENDIF
C********FCCI  ************
         IF (CDB) THEN
C***********COOLABLE DEBRIS BED: NO CCI RELEASE
            FCCI(ISP)=0.0
         ELSE IF ((INDX(8) .EQ. 1) .OR. TMPCDB) THEN
C***********DRY CAVITY OR CCI RELEASE AFTER WATER DRYOUT
            IF (INDX(2) .EQ. 1) THEN
C**************HIGH ZR OXIDATION .IE., LOW ZR CONTENT IN MCCI
               FCCI(ISP)=FCCI0(ISP,1)
            ELSE
C**************LOW ZR OXIDATION IE., HIGH ZR CONTENT IN MCCI
               FCCI(ISP)=FCCI0(ISP,3)
            ENDIF
         ELSE
C***********WATER OVER DEBRIS DURING CCI RELEASE
            IF (INDX(2) .EQ. 1) THEN
C**************HIGH ZR OXIDATION .IE., LOW ZR CONTENT IN MCCI
               FCCI(ISP)=FCCI0(ISP,4)
            ELSE
C**************LOW ZR OXIDATION IE., HIGH ZR CONTENT IN MCCI
               FCCI(ISP)=FCCI0(ISP,2)
            ENDIF
         ENDIF
C********FCONV: CONTAINMENT RETENTION FOR IN-VESSEL RELEASE, OUTER
C********        CONTAINMENT ONLY
C********FCONC: CONTAINMENT RETENTION FOR EX-VESSEL RELEASE, INCLUDING
C********        DRYWELL AND OUTER CONTAINMENT
C********THIS IS RETENTION WITHOUT CONSIDERING OTHER EFFECTS SUCH AS:
C********POOL BYPASS, CONTAINMENT SPRAYS, ETC.
         IF (INDX(6) .EQ. 9) THEN
C***********NO CONTAINMENT FAILURE
            FCONV(ISP)=FCONV0(ISP,7)
            FCONC(ISP)=FCONC0(ISP,7)
         ELSE IF ((INDX(6) .EQ. 1) .OR. (INDX(6) .EQ. 4)) THEN
C***********EARLY LEAK
            IF (SUBCL) THEN
C**************SUPPRESSION POOL IS SUBCOOLED
               FCONV(ISP)=FCONV0(ISP,1)
               FCONC(ISP)=FCONV0(ISP,1)
            ELSE
               FCONV(ISP)=FCONV0(ISP,2)
               FCONC(ISP)=FCONC0(ISP,2)
            ENDIF
         ELSE IF ((INDX(6) .EQ. 2) .OR. (INDX(6) .EQ. 3) .OR.
     1            (INDX(6) .EQ. 5)) THEN
C***********EARLY RUPTURE
            IF (SUBCL) THEN
```

```
C**************SUPPRESSION POOL SUBCOOLED
               FCONV(ISP)=FCONV0(ISP,3)
               FCONC(ISP)=FCONC0(ISP,3)
            ELSE
C**************SUPPRESSION POOL SATURATED
               FCONV(ISP)=FCONV0(ISP,4)
               FCONC(ISP)=FCONC0(ISP,4)
            ENDIF
         ELSE IF (INDX(6) .EQ. 6) THEN
C***********LATE LEAK
            FCONV(ISP)=FCONV0(ISP,5)
            FCONC(ISP)=FCONC0(ISP,5)
         ELSE
C***********LATE RUPTURE OR LATE VENTING
            FCONV(ISP)=FCONV0(ISP,6)
            FCONC(ISP)=FCONC0(ISP,6)
         ENDIF
C********FDCH OR EX-VESSEL STEAM EXPLOSION ************
         IF (INDX(4) .EQ. 5) THEN
C***********NO DCH, NO STEAM EXPLOSION
            FHPE=0.0
            EVSE=0.0
            FDCH(ISP)=0.0
            FEVSE(ISP)=0.0
         ELSE IF (INDX(4) .LE. 2) THEN
C***********DCH, NO STEAM EXPLOSION
            EVSE=0.
            FEVSE(ISP)=0.
            FDCH(ISP)=FDCH0(ISP,1)
            IF (INDX(4) .EQ. 1) THEN
               FHPE=FHPE0(1)
            ELSE
               FHPE=FHPE0(2)
            ENDIF
         ELSE
C***********NO DCH, BUT EX-VESSEL STEAM EXPLOSION
            FHPE=0.0
            FDCH(ISP)=0.0
            FEVSE(ISP)=FEVSE0(ISP,1)
            IF (INDX(4) .EQ. 3) THEN
               EVSE=EVSE0(1)
            ELSE
               EVSE=EVSE0(2)
            ENDIF
         ENDIF
C********POOL BYPASS
C********FPLBYE, FPLBYI, AND FPLBYL:
C********FOR EARLY PHASE, ASSUME VACUUM BREAKER STICKS OPEN FOR ASSIGNING
C********FPLBYE.  IF BRKOPEN IS FALSE, SET FPLBYE TO 0.0 LATER
         IF (INDX(5) .LE. 4) THEN
C***********ALL EARLY NOMINAL CASES:  TAIL PIPE VACUUM BREAKER STAYS CLOSED
            FPLBYE=FPLBY0(1)
            IF (INDX(5) .EQ. 1) THEN
C**************NOMINAL BYPASS FOR ALL STAGES
               FPLBYI=FPLBY0(1)
               FPLBYL=FPLBY0(1)
            ELSE IF (INDX(5) .EQ. 2) THEN
C**************EARLY NOMINAL, INTERMEDIATE LARGE
               FPLBYI=FPLBY0(3)
               FPLBYL=FPLBY0(3)
            ELSE IF (INDX(5) .EQ. 3) THEN
C**************EARLY NOMINAL, LATE SMALL
               FPLBYI=FPLBY0(1)
               FPLBYL=FPLBY0(2)
            ELSE
C**************EARLY NOMINAL, LATE LARGE
```

```
                FPLBYI=FPLBYO(1)
                FPLBYL=FPLBYO(3)
             ENDIF
          ELSE IF (INDX(5) .EQ. 5) THEN
C************EARLY SMALL OR LATE SMALL
             FPLBYE=FPLBYO(2)
             FPLBYI=FPLBYO(2)
             FPLBYL=FPLBYO(2)
          ELSE IF (INDX(5) .EQ. 6) THEN
C************EARLY SMALL, INTERMEDIATE LARGE
             FPLBYE=FPLBYO(2)
             FPLBYI=FPLBYO(3)
             FPLBYL=FPLBYO(3)
          ELSE IF (INDX(5) .EQ. 7) THEN
C************EARLY SMALL, LATE LARGE
             FPLBYE=FPLBYO(2)
             FPLBYI=FPLBYO(2)
             FPLBYL=FPLBYO(3)
          ELSE IF (INDX(5) .EQ. 8) THEN
C************EARLY LARGE AND LATE LARGE
             FPLBYE=FPLBYO(3)
             FPLBYI=FPLBYO(3)
             FPLBYL=FPLBYO(3)
          ENDIF
C*********IF BRKOPN IS FALSE, THEN FPLBYE=0.0 IRREGARDLESS OF DRYWELL
C*********LEAKAGE SINCE EVERYTHING GOES THROUGH POOL
          IF (.NOT. BRKOPN) FPLBYE=0.0
          IF (BRKOPN) THEN
C************FOR VACUUM BREAKER STUCK OPEN CASES, ASSIGN TAIL PIPE FLOW
C************FRACTION FOR HIGH PRESSURE VERSUS LOW PRESSURE SEQUENCES
             IF ((INDX(3) .EQ. 1) .OR. (INDX(3) .EQ. 3)) THEN
C***************VESSEL AT HIGH PRESSURE
                FTLP=FTLPH
             ELSE
C***************VESSEL AT LOW PRESSURE
                FTLP=FTLPL
             ENDIF
          ELSE
C************VACUUM BREAKER STAYS CLOSED, NO POOL BYPASS
             FTLP=0.0
          ENDIF
C*********THE THREE POOL BYPASS FRACTIONS ARE FOR A "DRY CAVITY" AND
C*********"FAILED CONTAINMENT". IT IS MULTIPLIED BY 'PFAC' IF CONTAINMENT
C*********HAS NOT FAILED AND DIVIDED BY 'WFAC' IF THE CAVITY IS FLOODED.
C*********
C*********ESTIMATE BYPASS FRACTION FOR THE VESSEL BREACH PUFF (FPLBYP),
C*********DCH (FPLBYD) AND CCI RELEASES (FPLBYC)
C*********
C*********FOR IN-VESSEL RELEASE PHASE, ASSUMES NO PRESSURE FACTOR (PFAC)
C*********APPLIES BUT STEAMING FACTOR (WFAC) ALWAYS APPLIES
          FPLBYE=FPLBYE / WFAC
C*********FOR THE PUFF CASE, IT IS ASSUMED VALUES WITH STEAM ALWAYS APPLY
C*********ROUGHLY CONSISTENT WITH TB2
C*********FOR DCH, POOL BYPASS IS TREATED LIKE PUFF RELEASE
          FPLBYP=FPLBYI / WFAC
          FPLBYD=FPLBYI / WFAC
C*********LATE CONTAINMENT FAILURE CASES, APPLY PRESSURE CORRECTION
          IF (INDX(6) .GE. 6) THEN
             FPLBYP=FPLBYP * PFAC
             FPLBYD=FPLBYD * PFAC
          ENDIF
C*********CCI RELEASE
          FPLBYC=FPLBYL
C*********FOR WET OR FLOODED CAVITY CASES, STEAMING FACTOR APPLIES
          IF ((INDX(8) .EQ. 2) .OR. (INDX(8) .EQ. 3))
     1         FPLBYC=FPLBYC / WFAC
```

```
      IF (INDX(6) .GE. 6) FPLBYC=FPLBYC * FFAC
      FPLBYE=MIN (FPLBYE, 1.0)
      FPLBYP=MIN (FPLBYP, 1.0)
      FPLBYD=MIN (FPLBYD, 1.0)
      FPLBYC=MIN (FPLBYC, 1.0)
C*********LATE IODINE RELEASE FROM POOL
      IF (SUBCL) THEN
         FLTI1=FLTI10(1)
      ELSE
         FLTI1=FLTI10(2)
      ENDIF
C*********LATE IODINE RELEASE FROM CAVITY WATER
      IF ((INDX(8) .EQ. 1) .OR. TMPCDB) THEN
C************DRY CAVITY CASES
         FLTI2=1.0
      ELSE IF (INDX(8) .EQ. 2) THEN
C************WET CAVITY CASE LIKE TBS
         FLTI2=FLTI20(1)
      ELSE IF (INDX(8) .EQ. 3) THEN
C************FLOODED CAVITY CASE LIKE TC
         FLTI2=FLTI20(2)
      ELSE
C************NO CCI RELEASE CASE
         FLTI2=0.0
      ENDIF
C*********IN-VESSEL RELEASE POOL SCRUBBING
      DFVPA(ISP)=DFVPA0(ISP,1)
C*********EX-VESSEL RELEASE POOL SCRUBBING
      DFCPA(ISP) = DFCPA0(ISP,1)
C*********CONTAINMENT (WETWELL) SPRAY DF
      IF (INDX(7) .EQ. 1) THEN
C************NO SPRAYS
         DFSPRV(ISP)=1.0
         DFSPRC(ISP)=1.0
      ELSE IF (INDX(7) .EQ. 2) THEN
C************EARLY SPRAYS ONLY
         DFSPRV(ISP)=DFSPRV0(ISP,1)
         DFSPRC(ISP)=1.0
      ELSE IF (INDX(7) .EQ. 3) THEN
C************LATE SPRAYS ONLY
         DFSPRV(ISP)=1.0
         DFSPRC(ISP)=DFSPRC0(ISP,1)
      ELSE
C************EARLY SPRAYS AND LATE SPRAYS
         DFSPRV(ISP)=DFSPRV0(ISP,1)
         DFSPRC(ISP)=DFSPRC0(ISP,1)
      ENDIF
C*********REACTOR CAVITY WATER SCRUBBING OF FISSION PRODUCTS
      IF ((INDX(8) .EQ. 1) .OR. TMPCDB) THEN
C************DRY CAVITY OR DELAYED CCI RELEASE CASE
         DFCAV(ISP)=1.0
      ELSE IF (INDX(8) .EQ. 2) THEN
C************WET CAVITY LIKE BMI-2139 TBS/TBR
         DFCAV(ISP)=DFCAV0(ISP,1)
      ELSE
C************FLOODED CAVITY  CDB: LIKE BMI-2139 TC
         DFCAV(ISP)=DFCAV0(ISP,2)
      ENDIF
C*********OTHER VARIABLES NOT SAMPLED IN LHS
C*********ASSUMES ALL CORE ULTIMATELY LEAVE VESSEL AFTER VESSEL BREACH
      FLV=1.0
      IF (.NOT. VB) FLV=0.0
C*********VESSEL BREACH PUFF RELEASE
      VBPUF(ISP)=VBPUF0(ISP,1)
  500 CONTINUE
```

```
C*****WARNING TIME
      IF ((INDX(1) .EQ. 1) .OR. (INDX(1) .EQ. 3) .OR.
     1    (INDX(1) .EQ. 5)) THEN
C*********FAST STATION BLACKOUT, FAST TRANSIENT, FAST TC
         TW=TW0(1)
      ELSE IF ((INDX(1) .EQ. 2) .OR. (INDX(1) .EQ. 4)) THEN
C*********SLOW STATION BLACKOUT, SLOW TRANSIENT
         TW=TW0(2)
      ELSE
C*********SLOW TC
         TW=TW0(3)
      ENDIF
C*****CONTAINMENT FAILURE TIME OR START OF FIRST RELEASE
C*****WARNING TIME, CONTAINMENT FAILURE TIME, OR FIRST RELEASE TIME
      IF ((INDX(1) .EQ. 1) .OR. (INDX(1) .EQ. 3) .OR.
     1    (INDX(1) .EQ. 5)) THEN
C*********FAST SBO, FAST TRANSIENTS, FAST TC
         TW=TW0(1)
         IF (INDX(6) .LE. 3) THEN
C************CF BEFORE VB
            T1=T10(1)
         ELSE IF (INDX(6) .GE. 6) THEN
C************LATE CF OR NO CF
            T1=T10(3)
         ELSE
C************CF AT VB
            T1=T10(2)
         ENDIF
      ELSE IF ((INDX(1) .EQ. 2) .OR. (INDX(1) .EQ. 4)) THEN
C*********SLOW SBO, SLOW TRANSIENTS
         TW=TW0(2)
         IF (INDX(6) .LE. 3) THEN
C************CF BEFORE VB
            T1=T10(4)
         ELSE IF (INDX(6) .GE. 6) THEN
C************LATE CF OR NO CF
            T1=T10(6)
         ELSE
C************CF AT VB
            T1=T10(5)
         ENDIF
      ELSE
C*********SLOW TC
         TW=TW0(3)
         IF (INDX(6) .LE. 3) THEN
C************CF BEFORE VB
            T1=T10(7)
         ELSE IF (INDX(6) .GE. 6) THEN
C************LATE CF OR NO CF
            T1=T10(9)
         ELSE
C************CF AT VB
            T1=T10(8)
         ENDIF
      ENDIF
C*****RELEASE DURATIONS DT1 AND DT2
C
      IF (INDX(6).EQ.9) THEN
C*****NO C.F.
            DT1 = DT10(4)
            DT2 = DT20(3)
      ELSE IF (INDX(6).LE.3) THEN
C*****C.F. LEAK, RUPTURE, OR VENT BEFORE V.B.
            DT1 = DT10(1)
         IF (INDX(4).LE.4) THEN
C*****DCH, OR EVSE OCCURS
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           DT2 = DT20(1)
         ELSE
C*****NO DCH, NO EVSE
           DT2 = DT20(2)
         ENDIF
C*****IF THE EARLY C.F. IS LEAK THEN USE LEAKAGE DT2
           IF (INDX(6).EQ.1) DT2 = DT20(3)
      ELSE IF ((INDX(6).EQ.4).OR.(INDX(6).EQ.6)) THEN
C*****LEAK AT V.B. OR LEAK LATE
           DT1 = DT10(4)
           DT2 = DT20(3)
      ELSE
C*****C.F. RUPTURE AT V.B. OR LATE OR VENT LATE
        IF (SUBCL) THEN
           DT1 = DT10(2)
        ELSE
           DT1 = DT10(3)
        ENDIF
           DT2 = DT20(2)
      ENDIF
C*****START OF SECOND RELEASE
C*****NO TEMPORARY COOLABLE DEBRIS BED
      T2=T1 + DT1
C*****TEMPORARY COOLABLE DEBRIS BED
      IF (TMPCDB) T2=T2 + DTCDB
C*****FOR LATE CONTAINMENT FAILURE CASES, ASSIGN FRACTION
C*****OF TOTAL RELEASE TO THE FIRST RELEASE SEGMENT
C*****SET DEFAULT OF PUFF TO 1.0
         PUFF = 1.0
      IF ((INDX(6) .EQ. 7) .OR. (INDX(6) .EQ. 8)) THEN
C********LATE RUPTURE OR LATE VENT
         PUFF=PUFF0(1)
      ELSE IF ((INDX(6).EQ.6).OR.(INDX(6).EQ.9)) THEN
C********LATE LEAK OR NO CONTAINMENT FAILURE
         PUFF=PUFF0(2)
      ENDIF
      RETURN
      END
      SUBROUTINE EXPTAB
C*****SET VARIABLES IN COMMON BLOCK BINNED BY INTERPOLATION OF
C*****EXPERT OPINION TABLES
      PARAMETER (MAXBD=20, MAXBIN=10000, MAXSMP=300, MAXCAS=8,
     1           MAXISS=20, MAXLEV=10, MAXVAR=100, MAXVAL=12000,
     2           MAXSPC=10, MAXTIM=10)
      COMMON /BASVAL/ FCOR(MAXSPC), FVES(MAXSPC), DFVPA(MAXSPC),
     1                DFCPA(MAXSPC), FEVSE(MAXSPC), FDCH(MAXSPC),
     2                FCCI(MAXSPC), DFCAV(MAXSPC), VBPUF(MAXSPC),
     3                FCONV(MAXSPC), FCONC(MAXSPC), DFSPRV(MAXSPC),
     4                DFSPRC(MAXSPC), FREVO(MAXSPC), VALISS(MAXISS),
     5                FLTI1, FLTI2, NSPEC, FLV, FHPE, EVSE, WFAC, PFAC,
     6                FPLBYE, FPLBYP, FPLBYD, FPLBYC, FTLPH, FTLPL,
     7                FTLP, TC11, TC12, TB11, TB12, TB21, TB22, TBS1,
     8                TBS2, TBR1, TBR2, TW, T1, T2, DT1, DT2, DTCDB,
     9                ELEV, PUFF
      COMMON /BINNED/ FCOR0(MAXSPC,MAXCAS), FVES0(MAXSPC,MAXCAS),
     1                DFVPA0(MAXSPC,MAXCAS), DFCPA0(MAXSPC,MAXCAS),
     2                FDCH0(MAXSPC,MAXCAS), FEVSE0(MAXSPC,MAXCAS),
     3                FCCI0(MAXSPC,MAXCAS), DFCAV0(MAXSPC,MAXCAS),
     4                VBPUF0(MAXSPC,MAXCAS), FCONV0(MAXSPC,MAXCAS),
     5                FCONC0(MAXSPC,MAXCAS), DFSPRV0(MAXSPC,MAXCAS),
     6                DFSPRC0(MAXSPC,MAXCAS), FREVO0(MAXSPC,MAXCAS),
     7                FLTI10(MAXCAS), FLTI20(MAXCAS), FHPE0(MAXCAS),
     8                EVSE0(MAXCAS), FPLBY0(3), TW0(MAXTIM),
     9                T10(MAXTIM), DT10(MAXTIM), DT20(MAXTIM),
     A                PUFF0(MAXTIM)
      COMMON /EXPERT/ FCORL(MAXSPC,MAXLEV,MAXCAS),
```

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     1                 FVESL(MAXSPC,MAXLEV,MAXCAS),
     2                 FREVOL(MAXSPC,MAXLEV,MAXCAS),
     3                 FCCIL(MAXSPC,MAXLEV,MAXCAS),
     4                 FCONVL(MAXSPC,MAXLEV,MAXCAS),
     5                 FCONCL(MAXSPC,MAXLEV,MAXCAS),
     6                 FLTI1L(MAXLEV,MAXCAS), FLTI2L(MAXLEV,MAXCAS),
     7                 FDCHL(MAXSPC,MAXLEV,MAXCAS),
     8                 FEVSEL(MAXSPC,MAXLEV,MAXCAS),
     9                 DFVPAL(MAXSPC,MAXLEV,MAXCAS),
     A                 DFCPAL(MAXSPC,MAXLEV,MAXCAS),
     B                 DFCAVL(MAXSPC,MAXLEV,MAXCAS),
     C                 DFSPRVL(MAXSPC,MAXLEV,MAXCAS),
     D                 DFSPRCL(MAXSPC,MAXLEV,MAXCAS),
     E                 PRBLEV(MAXLEV)
      DATA I1 / 1 /
C
C
C*****SET VALUES FOR RELEASE FRACTIONS DURING IN-VESSEL RELEASE
      CALL INTERP (MAXSPC, MAXLEV, MAXCAS, VALISS(1), FCORL, FCOR0,
     1             PRBLEV)
C*****SET VALUES FOR RELEASE FRACTIONS FROM VESSEL
      CALL INTERP (MAXSPC, MAXLEV, MAXCAS, VALISS(2), FVESL, FVES0,
     1             PRBLEV)
C*****SET VALUES FOR REVOLATILIZATION RELEASE AFTER VESSEL BREACH
      CALL INTERP (MAXSPC, MAXLEV, MAXCAS, VALISS(3), FREVOL, FREVO0,
     1             PRBLEV)
C*****SET VALUES FOR RELEASE FRACTIONS DURING CCI RELEASE
      CALL INTERP (MAXSPC, MAXLEV, MAXCAS, VALISS(4), FCCIL, FCCI0,
     1             PRBLEV)
C*****SET VALUES FOR RELEASE FRACTIONS FROM CONTAINMENT TO ENVIRONMENT
C*****FOR IN-VESSEL RELEASE SOURCE TERMS
      CALL INTERP (MAXSPC, MAXLEV, MAXCAS, VALISS(5), FCONVL, FCONV0,
     1             PRBLEV)
C*****SET VALUES FOR RELEASE FRACTIONS FROM CONTAINMENT TO ENVIRONMENT
C*****FOR EX-VESSEL RELEASE SOURCE TERMS
      CALL INTERP (MAXSPC, MAXLEV, MAXCAS, VALISS(6), FCONCL, FCONC0,
     1             PRBLEV)
C*****SET VALUES FOR RELEASE FRACTIONS FOR LATE IODINE RELEASE FROM
C*****SUPPRESSION POOL
      CALL INTERP (I1, MAXLEV, MAXCAS, VALISS(7), FLTI1L, FLTI10,
     1             PRBLEV)
C*****SET VALUES FOR RELEASE FRACTIONS FOR LATE IODINE RELEASE FROM
C*****CAVITY WATER
      CALL INTERP (I1, MAXLEV, MAXCAS, VALISS(8), FLTI2L, FLTI20,
     1             PRBLEV)
C*****SET VALUES FOR RELEASE FRACTIONS DUE TO DIRECT CONTAINMENT HEATING
      CALL INTERP (MAXSPC, MAXLEV, MAXCAS, VALISS(9), FDCHL, FDCH0,
     1             PRBLEV)
C*****SET VALUES FOR SUPPRESSION POOL DF FOR IN-VESSEL RELEASE
      CALL INTERP (MAXSPC, MAXLEV, MAXCAS, VALISS(10), DFVPAL, DFVPA0,
     1             PRBLEV)
C*****SET VALUES FOR SUPPRESSION POOL DF AFTER VESSEL BREACH
      CALL INTERP (MAXSPC, MAXLEV, MAXCAS, VALISS(11), DFCPAL, DFCPA0,
     1             PRBLEV)
C*****SET VALUES FOR CAVITY WATER DF FOR CCI RELEASE
      CALL INTERP (MAXSPC, MAXLEV, MAXCAS, VALISS(12), DFCAVL, DFCAV0,
     1             PRBLEV)
C*****SET VALUES FOR CONTAINMENT SPRAYS DF FOR IN-VESSEL RELEASE
      CALL INTERP (MAXSPC, MAXLEV, MAXCAS, VALISS(13), DFSPRVL, DFSPRV0,
     1             PRBLEV)
C*****SET VALUES FOR CONTAINMENT SPRAYS DF FOR EX-VESSEL RELEASE
      CALL INTERP (MAXSPC, MAXLEV, MAXCAS, VALISS(14), DFSPRCL, DFSPRC0,
     1             PRBLEV)
C*****SET VALUES FOR EX-VESSEL STEAM EXPLOSION RELEASE
      CALL INTERP (MAXSPC, MAXLEV, MAXCAS, VALISS(15), FEVSEL, FEVSE0,
     1             PRBLEV)
```

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      RETURN
      END
      SUBROUTINE INTERP (MAXSPC, MAXLEV, MAXCAS, PROB, RL, R0, PRBLEV)
C*****PERFORM INTERPOLATION IN SPECIFIED EXPERT OPINION TABLE
      DIMENSION RL(MAXSPC,MAXLEV,MAXCAS), R0(MAXSPC,MAXCAS),
     1          PRBLEV(MAXLEV)
      LOGICAL FIRST
      DATA FIRST / .TRUE. /
C
C
      IF (FIRST) THEN
C********DETERMINE NUMBER OF LEVELS
         DO 100 ILEV=2,MAXLEV
            IF (PRBLEV(ILEV) .LE. 0.0) THEN
               NLEV=ILEV - 1
               GO TO 200
            ENDIF
  100    CONTINUE
         NLEV=MAXLEV
  200    CONTINUE
         IF (NLEV .LE. 1) THEN
            WRITE(6,1002)
            STOP
         ENDIF
         FIRST=.FALSE.
      ENDIF
C*****VALIDATE PROBABILITY
      IF (PROB .LT. PRBLEV(1)) THEN
         WRITE(6,1001) PROB, (PRBLEV(I),I=1,NLEV)
         STOP
      ENDIF
C*****LOCATE PROBABILITY LEVELS TO INTERPOLATE BETWEEN
      DO 1000 ILEV=2,NLEV
         IF (PROB .LE. PRBLEV(ILEV)) THEN
           JLEV=ILEV
           GO TO 2000
         ENDIF
 1000 CONTINUE
C*****PROBABILITY VALUE OUTSIDE OF TABLE RANGE
      WRITE(6,1001) PROB, (PRBLEV(I),I=1,NLEV)
      STOP
 2000 CONTINUE
C*****LOOP OVER CASES
      DO 4000 ICAS=1,MAXCAS
C********LOOP OVER SPECIES
         DO 3000 ISPEC=1,MAXSPC
C***********PERFORM INTERPOLATION FOR CURRENT SPECIES AND CASE
            IF ((RL(ISPEC,1,ICAS) .GT. 0.0) .AND.
     1          (RL(ISPEC,NLEV,ICAS)/RL(ISPEC,1,ICAS) .GT. 10.)) THEN
C**************PERFORM LOGARITHMIC INTERPOLATION
               R0(ISPEC,ICAS)=10.**(LOG10(RL(ISPEC,JLEV-1,ICAS)) +
     1                         (PROB-PRBLEV(JLEV-1)) *
     2   (LOG10(RL(ISPEC,JLEV,ICAS))-LOG10(RL(ISPEC,JLEV-1,ICAS))) /
     3                      (PRBLEV(JLEV)-PRBLEV(JLEV-1)))
            ELSE
C**************PERFORM LINEAR INTERPOLATION
               R0(ISPEC,ICAS)=RL(ISPEC,JLEV-1,ICAS) +
     1                         (PROB-PRBLEV(JLEV-1)) *
     2             (RL(ISPEC,JLEV,ICAS)-RL(ISPEC,JLEV-1,ICAS)) /
     3                     (PRBLEV(JLEV)-PRBLEV(JLEV-1))
            ENDIF
 3000    CONTINUE
 4000 CONTINUE
      RETURN
C*****FORMAT STATEMENTS
 1001 FORMAT(/1X,'>>>>>PROBABILITY VALUE (',F5.2,') OUT OF RANGE FOR ',
```

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     1          'INTERPOLATION OF LEVELS',
     2          /1X,'>>>>>PRBLEV(I)=',20F6.3)
 1002 FORMAT(/1X,'>>>>>FEWER THAN 2 PROBABILITY LEVELS (PRBLEV) ',
     1          'SPECIFIED')
      END
      SUBROUTINE GGSORC (IOBS, IBIN)
C*****CALCULATE XXSOR TYPE OF SOURCE TERMS FOR THE GRAND GULF
C---------------------------------------------------------------
C
C                          - - - - OUTPUT - - -
C
C  ST(ISP)     == TOTAL ENVIRONMENTAL RELEASE FRACTIONS FOR SPECIES 'ISP'
C                 (EARLY + LATE)
C  STE(ISP)    == RELEASES UP THROUGH VESSEL BREACH. THE DEFINING TIME
C                 IS RELEASE TO THE CONTAINMENT; ACTUAL RELEASE TO THE
C                 ENVIRONMENT WILL BE LATER IF CONTAINMENT FAILURE IS LATER
C  STCCI(ISP) == CCI RELEASE SOURCE TERMS
C  STL(ISP)    == LATE RELEASE SOURCE TERMS (CCI+STIL+STRVOL)
C  STIL        == "LATE" IODINE COMPONENT, TREATED AS GASEOUS (E.G., ORGANIC)
C                 IODINE RELEASED FROM POOL AND FLOODED CAVITY;
C                 NO DF'S OR CONTAINMENT RETENTION FACTORS APPLY
C  STRVOL(ISP)== I, CS AND TE COMPONENT REVOLATILIZED FROM PRIMARY SYSTEM:
C                 TREATED AS AEROSOL; DF'S FOR SPRAYS, SUPPRESSION POOL
C                 SCRUBBING, AND CONTAINMENT RETENTION APPLY
C=========================================================================
C
C   SPECIES INDEX=ISP, 1 TO NSPEC; ORDER IS NG,I,CS,TE,SR,RU,LA,CE,BA
C
C  FCOR  == RELEASE FRACTION OF EACH ELEMENT GROUP FROM THE FUEL DURING
C           DURING IN-VESSEL RELEASE
C  FVES  == RELEASE FRACTION FROM THE VESSEL (FRACTION OF FCOR)
C  DFVPA == POOL DF'S DURING IN-VESSEL RELEASE
C  DFCPA == POOL DF'S DURING CCI RELEASE
C  VBPUF == PUFF RELEASE FRACTION OF THE TOTAL CORE AT VESSEL BREACH
C                - - - POOL BYPASS PARAMETERS - - -
C  FPLBYE, FPLBYP, FPLBYD, FPLBYC  ==
C           FRACTION OF POOL BYPASS AT IFFERENT TIME STEPS:
C           EARLY (BEFORE VB), PUFF SOURCE TERMS,
C           DCH SOURCE TERMS, AND CCI SOURCE TERMS.
C           THIS FRACTION DO NOT GO THROUGH SUPPRESSION POOL
C  FCONV == FRACTIONS OF AEROSOL SPECIES RELEASED FROM THE RCS TO THE
C           CONTAINMENT AND THEN TO THE ENVIRONMENT
C  FCONC == FRACTIONS OF AEROSOL SPECIES RELEASED TO FROM CCI TO THE
C           CONTAINMENT AND THEN TO THE ENVIRONMENT (INCLUDES DRYWELL
C           RETENTION AND OUTER CONTAINMENT RETENTION)
C  DFSPRV== DF'S FOR SPRAYS (ESTIMATED FROM CALCULATED CS AND I RELEASES)
C  DFSPRC== DF'S FOR SPRAYS (ESTIMATED FROM CALCULATED SR AND CE RELEASES)
C  FLTI1 == LATE IODINE RELEASE FROM SUPPRESSION POOL
C  FLTI2 == LATE IODINE RELEASE FROM CAVITY WATER
C
      PARAMETER (MAXBD=20, MAXBIN=10000, MAXSMP=300, MAXCAS=8,
     1           MAXISS=20, MAXLEV=10, MAXVAR=100, MAXVAL=12000,
     2           MAXSPC=10, MAXTIM=10)
      CHARACTER BINARR*(MAXBD), BTITLE*80, TITLE*80
      COMMON /BINS/ BINARR(MAXBIN), BTITLE, TITLE
      LOGICAL NOCALC, SAMPLE, REPRTB, BINNED, BYRUN, CONSFL, DIAG,
     1    EXPERT, PRTINP, NOCF, SUBCL, CDB, TMPCDB, BRKOPN, VB, ECF, ICF
      COMMON /KEYS/ NOCALC, SAMPLE, REPRTB, BINNED, BYRUN, CONSFL, DIAG,
     1    EXPERT, PRTINP, NOCF, SUBCL, CDB, TMPCDB, BRKOPN, VB, ECF, ICF
      COMMON /SRCTRM/ ST(MAXSPC), STE(MAXSPC), STCCI(MAXSPC),
     1                STL(MAXSPC), STIL, STRVOL(MAXSPC),
     2                ST1(MAXSPC), ST2(MAXSPC), RV(MAXSPC)
      COMMON /BASVAL/ FCOR(MAXSPC), FVES(MAXSPC), DFVPA(MAXSPC),
     1                DFCPA(MAXSPC), FEVSE(MAXSPC), FDCH(MAXSPC),
     2                FCCI(MAXSPC), DFCAV(MAXSPC), VBPUF(MAXSPC),
     3                FCONV(MAXSPC), FCONC(MAXSPC), DFSPRV(MAXSPC),
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     4               DFSPRC(MAXSPC), FREVO(MAXSPC), VALISS(MAXISS),
     5               FLTI1, FLTI2, NSPEC, FLV, FHPE, EVSE, WFAC, PFAC,
     6               FPLBYE, FPLBYP, FPLBYD, FPLBYC, FTLPH, FTLPL,
     7               FTLP, TC11, TC12, TB11, TB12, TB21, TB22, TBS1,
     8               TBS2, TBR1, TBR2, TW, T1, T2, DT1, DT2, DTCDB,
     9               ELEV, PUFF
      COMMON /BININD/ INDX(MAXBD)
      COMMON /CONTRL/ NLHS, NOBS, NSTART, NBIN, NDM, NTOT
      DIMENSION RFDCH(MAXSPC), RFCCI(MAXSPC), RFBVB(MAXSPC),
     1          RFEVSE(MAXSPC)
C
C
C*****ZERO OUT THE SOURCE TERM ARRAYS
      DO 1000 ISP=1,NSPEC
         RFBVB(ISP)=0.0
         RFEVSE(ISP)=0.0
         RFDCH(ISP)=0.0
         RFCCI(ISP)=0.0
         ST(ISP)=0.0
         STE(ISP)=0.0
         STCCI(ISP)=0.0
         STL(ISP)=0.0
         STRVOL(ISP)=0.0
 1000 CONTINUE
      POOLI=0.0
      CAVWI=0.0
      STIL=0.0
C*****SAVE I, CS, AND TE IN VESSEL FOR REVOLATILIZATION IN LATE RELEASES
      DO 1200 ISP=2,4
         RV(ISP)=FCOR(ISP) * (1.0-FVES(ISP))
 1200 CONTINUE
C*****RELEASE FROM VESSEL PRIOR TO VESSEL BREACH
      DO 2000 ISP=1,NSPEC
C*********RELEASE FRACTION THRU TAIL PIPE THAT BYPASSES POOL
         RELF1=FTLP * FPLBYE / DFSPRV(ISP)
C*********RELEASE FRACTION THRU TAIL PIPE THAT GOES THRU POOL
         RELF2=FTLP * (1.0-FPLBYE) / MAX (DFCPA(ISP), DFSPRV(ISP))
C*********RELEASE FRACTION THRU T-QUENCHER
         RELF3=(1.0-FTLP) / MAX (DFVPA(ISP), DFSPRV(ISP))
C*********EARLY RELEASE FRACTION
         STE(ISP)=FCOR(ISP) * FVES(ISP) * (RELF1+RELF2+RELF3) *
     1            FCONV(ISP)
         RFBVB(ISP)=STE(ISP)
C*********SAVE IODINE IN POOL
         IF (ISP .EQ. 2) THEN
            POOLI=FCOR(ISP) * FVES(ISP) *
     1            MAX (0.0, (1.0-RELF1-RELF2-RELF3))
         ENDIF
 2000 CONTINUE
      IF (DIAG) THEN
C*********DIAGNOSTIC PRINT
         WRITE(6,2001)
         WRITE(6,4202) (STE(ISP),ISP=1,NSPEC)
         WRITE(6,4203) (STL(ISP),ISP=1,NSPEC)
         WRITE(6,4204) (ST(ISP),ISP=1,NSPEC)
         WRITE(6,4205) (RFBVB(ISP),ISP=1,NSPEC)
         WRITE(6,4206) (RFEVSE(ISP),ISP=1,NSPEC)
         WRITE(6,4207) (RFDCH(ISP),ISP=1,NSPEC)
         WRITE(6,4208) (RFCCI(ISP),ISP=1,NSPEC)
         WRITE(6,4209) (STCCI(ISP),ISP=1,NSPEC)
         WRITE(6,4210) (RV(I),I=2,4), (STRVOL(I),I=2,4), POOLI,
     1                 CAVWI, STIL
      ENDIF
C*****IF NO VB, THEN NO PUFF, NO CCI, NO DCH SOURCE TERMS
      IF (.NOT. VB) GO TO 7500
C*****ADD VESSEL BREACH PUFF RELEASE TO EARLY SOURCE TERM
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      DO 3000 ISP=1,NSPEC
C*********RELEASE FRACTION DUE TO VESSEL BREACH PUFF THAT BYPASSES POOL
         RELF1=FPLBYP / DFSPRC(ISP)
C*********RELEASE FRACTION DUE TO VESSEL BREACH PUFF THAT GOES THRU POOL
         RELF2=(1.0-FPLBYP) / MAX (DFCPA(ISP), DFSPRC(ISP))
C*********EARLY RELEASE FRACTION
         STE(ISP)=STE(ISP) + VBPUF(ISP)*(RELF1+RELF2)*FCONC(ISP)
         STE(ISP)=MIN (STE(ISP), 1.0)
C*********SAVE IODINE IN POOL
         IF (ISP .EQ. 2) THEN
            POOLI=POOLI + VBPUF(ISP)*MAX (0.0, (1.0-RELF1-RELF2))
         ENDIF
 3000 CONTINUE
      IF (DIAG) THEN
C*********DIAGNOSTIC PRINT
         WRITE(6,3001)
         WRITE(6,4202) (STE(ISP),ISP=1,NSPEC)
         WRITE(6,4203) (STL(ISP),ISP=1,NSPEC)
         WRITE(6,4204) (ST(ISP),ISP=1,NSPEC)
         WRITE(6,4205) (RFBVB(ISP),ISP=1,NSPEC)
         WRITE(6,4206) (RFEVSE(ISP),ISP=1,NSPEC)
         WRITE(6,4207) (RFDCH(ISP),ISP=1,NSPEC)
         WRITE(6,4208) (RFCCI(ISP),ISP=1,NSPEC)
         WRITE(6,4209) (STCCI(ISP),ISP=1,NSPEC)
         WRITE(6,4210) (RV(I),I=2,4), (STRVOL(I),I=2,4), POOLI,
     1                 CAVWI, STIL
      ENDIF
C*****ADD DIRECT CONTAINMENT HEATING RELEASE TO EARLY SOURCE TERM
      DO 4000 ISP=1,NSPEC
C*********RELEASE FRACTION DUE TO DIRECT CONTAINMENT HEATING
         RFDCH(ISP)=MAX (0.0, (1.0-FCOR(ISP)-VBPUF(ISP))) * FLV *
     1              FHPE * FDCH(ISP)
         IF (RFDCH(ISP) .GT. 0.0) THEN
C************RELEASE FRACTION DUE TO DIRECT CONTAINMENT HEATING THAT
C************BYPASSES POOL
            RELF1=FPLBYD / DFSPRC(ISP)
C************RELEASE FRACTION DUE TO DIRECT CONTAINMENT HEATING THAT
C************GOES THRU POOL
            RELF2=(1.0-FPLBYD) / MAX (DFCPA(ISP), DFSPRC(ISP))
C************EARLY RELEASE FRACTION
            STE(ISP)=STE(ISP) + RFDCH(ISP) * (RELF1+RELF2) * FCONC(ISP)
            STE(ISP)=MIN (STE(ISP), 1.0)
C************SAVE IODINE IN POOL
            IF (ISP .EQ. 2) THEN
               POOLI=POOLI + RFDCH(ISP)*MAX (0.0, (1.0-RELF1-RELF2))
            ENDIF
         ENDIF
 4000 CONTINUE
      IF (DIAG) THEN
C*********DIAGNOSTIC PRINT
         WRITE(6,4201)
         WRITE(6,4202) (STE(ISP),ISP=1,NSPEC)
         WRITE(6,4203) (STL(ISP),ISP=1,NSPEC)
         WRITE(6,4204) (ST(ISP),ISP=1,NSPEC)
         WRITE(6,4205) (RFBVB(ISP),ISP=1,NSPEC)
         WRITE(6,4206) (RFEVSE(ISP),ISP=1,NSPEC)
         WRITE(6,4207) (RFDCH(ISP),ISP=1,NSPEC)
         WRITE(6,4208) (RFCCI(ISP),ISP=1,NSPEC)
         WRITE(6,4209) (STCCI(ISP),ISP=1,NSPEC)
         WRITE(6,4210) (RV(I),I=2,4), (STRVOL(I),I=2,4), POOLI,
     1                 CAVWI, STIL
      ENDIF
C*****ADD EX-VESSEL STEAM EXPLOSION (DCH TAKES PRECEDENT OVER EVSE)
      DO 4500 ISP=1,NSPEC
C*********RELEASE FRACTION DUE TO EX-VESSEL STEAM EXPLOSION
         RFEVSE(ISP)=MAX (0.0, (1.0-FCOR(ISP)-VBPUF(ISP))) * FLV *
```

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     1              EVSE * FEVSE(ISP)
         IF (RFEVSE(ISP) .GT. 0.0) THEN
C************RELEASE FRACTION DUE TO EX-VEFSEL STEAM EXPLOSION, THAT
C************BYPASSES POOL
            RELF1=FPLBYD / DFSPRC(ISP)
C************RELEASE FRACTION DUE TO EX-VESSEL STEAM EXPLOSION THAT
C************GOES THRU POOL
            RELF2=(1.0-FPLBYD) / MAX (DFCPA(ISP), DFSPRC(ISP))
C************EARLY RELEASE FRACTION
            STE(ISP)=STE(ISP) + RFEVSE(ISP)*(RELF1+RELF2)*FCONC(ISP)
            STE(ISP)=MIN (STE(ISP), 1.0)
C************SAVE IODINE IN POOL
            IF (ISP .EQ. 2, THEN
               POOLI=POOLI + RFEVSE(ISP)*MAX (0.0, (1.0-RELF1-RELF2))
            ENDIF
         ENDIF
 4500 CONTINUE
      IF (DIAG) THEN
C*********DIAGNOSTIC PRINT
         WRITE(6,4501)
         WRITE(6,4202) (STE(ISP),ISP=1,NSPEC)
         WRITE(6,4203) (STL(ISP),ISP=1,NSPEC)
         WRITE(6,4204) (ST(ISP),ISP=1,NSPEC)
         WRITE(6,4205) (RFBVB(ISP),ISP=1,NSPEC)
         WRITE(6,4206) (RFEVSE(ISP) ISP=1,NSPEC)
         WRITE(6,4207) (RFDCH(ISP),ISP=1,NSPEC)
         WRITE(6,4208) (RFCCI(ISP),ISP=1,NSPEC)
         WRITE(6,4209) (STCCI(ISP),ISP=1,NSPEC)
         WRITE(6,4210) (RV(I),I=2,4), (STRVOL(I),I=2,4), POOLI,
     1                 CAVWI, STIL
      ENDIF
      IF (EVSE .GT. 0.0) THEN
         XCCI=1.0 - EVSE
      ELSE IF (FHPE .GT. 0.0) THEN
         XCCI=1.0 - FHPE
      ELSE
         XCCI=1.0
      ENDIF
      IF (.NOT. CDB) THEN
C*********CORE-CONCRETE INTERACTION RELEASES AND CAVITY SCRUBBING
         DO 5000 ISP=1,NSPEC
C************RELEASE FRACTION DUE TO CORE-CONCRETE INTERACTIONS
            RFCCI(ISP)=MAX (0.0, (1.0-FCOR(ISP)-VBPUF(ISP))) * FLV *
     1                 XCCI * FCCI(ISP)
C************RELEASE FRACTION DUE TO CORE-CONCRETE INTERACTIONS THAT
C************BYPASSES POOL
            RELF1=FPLBYC / MAX (DFCAV(ISP), DFSPRC(ISP))
C************RELEASE FRACTION DUE TO CORE-CONCRETE INTERACTIONS THAT
C************GOES THRU POOL
            RELF2=(1.0-FPLBYC) /
     1           MAX (DFCAV(ISP), DFCPA(ISP), DFSPRC(ISP))
C************CORE-CONCRETE RELEASE FRACTION
            STCCI(ISP)=RFCCI(ISP) * (RELF1+RELF2) * FCONC(ISP)
C************SAVF IODINE IN CAVITY WATER AND IN POOL
            IF (ISP .EQ. 2) THEN
               CAVWI=1.0 - 1.0/DFCAV(ISP)
               POOLI=POOLI + RFCCI(ISP) *
     1               MAX (0.0, (1.0-RELF1-RELF2-CAVWI))
               CAVWI=RFCCI(ISP) * CAVWI
            ENDIF
 5000    CONTINUE
      ENDIF
C*****REVOLATIZATION RELEASE OF I, CS, AND TE
C*****(SIMILAR TO VESSEL BREACH PUFF RELEASE)
      DO 6000 ISP=2,4
C*********RELEASE FRACTION DUE TO REVOLATILIZATION THAT BYPASSES POOL
```

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         RELF1=FPLBYC / DFSPRC(ISP)
C*********RELEASE FRACTION DUE TO REVOLATILIZATION THAT GOES THRU POOL
         RELF2=(1.0-FPLBYC) / MAX (DFCPA(ISP), DFSPRC(ISP))
C*********REVOLATILIZATION RELEASE FRACTION
         STRVOL(ISP)=FREVO(ISP) * RV(ISP) * (RELF1+RELF2) * FCONC(ISP)
C*********SAVE IODINE IN POOL
         IF (ISP .EQ. 2) THEN
            POOLI=POOLI + FREVO(ISP)*RV(ISP)*
     1            MAX (0.0, (1.0-RELF1-RELF2))
         ENDIF
 6000 CONTINUE
C*****CCI, RCS REVOLATILIZATION WERE SKIPPED IF VESSEL BREACH WAS PREVENTED,
C*****BUT LATE IODINE RELEASE FROM THE POOL CAN STILL OCCUR.
 7500 CONTINUE
C*****NOW WE CALCULATE THE IODINE REVOLATILIZED FROM THE POOL,
C*****WHICH IS NOT SUBJECT TO ANY DF'S OR CONTAINMENT RETENTION IF
C*****CONTAINMENT FAILS. HOWEVER, IF NO CONTAINMENT FAILURE, ASSUME
C*****ONLY SMALL FRACTION RELEASED TO ENVIRONMENT.
C*****FOR LATE IODINE RELEASE FROM CAVITY WATER, POOL BYPASS FRACTION
C*****APPLIES. POOL DF OF IODINE APPLIES TO FRACTION GO THROUGH POOL
      STIL1=FLTI1 * POOLI
      STIL2=FLTI2 * CAVWI * (FPLBYC+(1.0-FPLBYC)/DFCPA(2))
      STIL=STIL1 + STIL2
C*****IF NO CONTAINMENT FAILURE, LATE IODINE RELEASE IS TREATED SIMILAR
C*****TO NOBLE GASES SINCE IODINE IS VOLATILE
      IF (NOCF) STIL=STIL * FCONC(1)
C*****ADD ALL SOURCE TERMS UP TO GET TOTAL SOURCE TERMS
      DO 8000 ISP=1,NSPEC
         STL(ISP)=STCCI(ISP) + STRVOL(ISP)
         ST(ISP)=STE(ISP) + STL(ISP)
 8000  CONTINUE
      ST(2)=ST(2) + STIL
      STL(2)=STL(2) + STIL
C*****REALLOCATE RELEASE FRACTIONS
      DO 9000 ISP=1,NSPEC
         IF (ECF) THEN
C************CF BEFORE VB
            ST1(ISP)=RFBVB(ISP)
            ST2(ISP)=ST(ISP) - ST1(ISP)
         ELSE IF (ICF) THEN
C************CF AT VB
            ST1(ISP)=STE(ISP)
            ST2(ISP)=STL(ISP)
         ELSE
C************LATE LEAK OR RUPTURE OR NO CONTAINMENT FAILURE
            STE(ISP)=0.0
            STL(IP)=ST(ISP)
            ST1(ISP)=PUFF * ST(ISP)
            ST2(ISP)=(1.0-PUFF) * ST(ISP)
         ENDIF
 9000 CONTINUE
C*****CALCULATE ENERGY RELEASES
      CALL ENERGY (E1, E2)
C*****CALCULATE ENERGY RELEASE RATES
      ER1=E1 / DT1
      ER2=E2 / DT2
      IF (DIAG) THEN
         WRITE(6,8001)
         WRITE(6,4202) (STE(ISP),ISP=1,NSPEC)
         WRITE(6,4203) (STL(ISP),ISP=1,NSPEC)
         WRITE(6,4204) (ST(ISP),ISP=1,NSPEC)
         WRITE(6,4205) (RFBVB(ISP),ISP=1,NSPEC)
         WRITE(6,4206) (RFEVSE(ISP),ISP=1,NSPEC)
         WRITE(6,4207) (RFDCH(ISP),ISP=1,NSPEC)
         WRITE(6,4208) (RFCCI(ISP),ISP=1,NSPEC)
         WRITE(6,4209) (STCCI(ISP),ISP=1,NSPEC)
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            WRITE(6,4210) (RV(I),I=2,4), (STRVOL(I),I=2,4), POOLI,
     1                    CAVWI, STIL
            WRITE(6,4211) TW, T1, DT1, T2, DT2, ELEV, ER1, ER2
            WRITE(6,4212) (ST1(ISP),ISP=1,NSPEC)
            WRITE(6,4213) (ST2(ISP),ISP=1,NSPEC)
         ENDIF
         IF (CON FL) THEN
C********WRITE SOURCE TERM TO FILE
            WRITE(9,1003) IOBS, BINARR(IBIN)(1:NDM)
            WRITE(9,1004) TW, T1, DT1, T2, DT2, ELEV
            WRITE(9,1004) ER1, (ST1(ISP),ISP=1,NSPEC)
            WRITE(9,1004) ER2, (ST2(ISP),ISP=1,NSPEC)
         ENDIF
         RETURN
C*****FORMAT STATEMENTS
 1003 FORMAT(I4,2X,A)
 1004 FORMAT(1P10E12.4)
 2001 FORMAT(//5X,'***** DIAGNOSTIC PRINT *****',
     1       /10X,'===== PARAMETER VALUES UP TO VESSEL BREACH =====')
 3001 FORMAT(//5X,'***** DIAGNOSTIC PRINT *****',
     1       /10X,'===== PARAMETER VALUES AFTER VESSEL BREACH =====')
 4201 FORMAT(//5X,'***** DIAGNOSTIC PRINT *****',
     1       /10X,'===== PARAMETER VALUES AFTER DCH =====')
 4202 FORMAT(/5X,'STE:',1P,/(5X,10E10.2))
 4203 FORMAT(5X,'STL:',1P,/(5X,10E10.2))
 4204 FORMAT(5X,'ST :',1P,/(5X,10E10.2))
 4205 FORMAT(5X,'RFBVB:',1P,/(5X,10E10.2))
 4206 FORMAT(5X,'RFEVSE:',1P,/(5X,10E10.2))
 4207 FORMAT(5X,'RFDCH:',1P,/(5X,10E10.2))
 4208 FORMAT(5X,'RFCCI:',1P,/(5X,10E10.2))
 4209 FORMAT(5X,'STCCI:',1P,/(5X,10E10.2))
 4210 FORMAT(5X,1P,'RVI = ',E10.2,5X,'RVCS = ',E10.2,5X,'RVTE = ',E10.2,
     1       /5X,'STRVOL(2) = ',E10.2,5X,'STRVOL(3) = ',E10.2,
     2        5X,'STRVOL(4) = ',E10.2,
     3       /5X,'POOLI = ',E10.2,5X,'CAVWI = ',E10.2,
     4        5X,'STIL = ',E10.2)
 4211 FORMAT(/5X,'SOURCE TERM INFORMATION:',
     1       /5X,1P,'TW =',E10.2,5X,'T1 =',E10.2,5X,'DT1 =',E10.2,5X,
     2        'T2 =',E10.2,5X,'DT2 =',E10.2,
     3       /5X,'ELEV =',E10.2,5X,'ER1 =',E10.2,5X,'ER2 =',E10.2)
 4212 FORMAT(5X,'ST1:',1P,/(5X,10E10.2))
 4213 FORMAT(5X,'ST2:',1P,/(5X,10E10.2))
 4501 FORMAT(//5X,'***** DIAGNOSTIC PRINT *****',
     1       /10X,'===== PARAMETER VALUES AFTER EVSE =====')
 6001 FORMAT(//5X,'***** DIAGNOSTIC PRINT *****',
     1       /10X,'===== PARAMETER VALUES AT END OF GGSORC =====')
      END
      SUBROUTINE ENERGY (EARLY, TAIL)
C*****ESTIMATE ENERGY RELEASES FOR BOTH EARLY PUFF AND LATE
C*****TAIL. DATA BASE ARE TAKEN FROM RESULTS OF STCP CALCULATIONS
C*****FOR GRAND GULF: TC, TB1, TB2, AND TBS.
C*****TC11: 15 MINUTE PUFF ENERGY RELEASE (BTU) FOR TC
C*****TC12: TOTAL ENERGY RELEASE (BTU) FOR TC
C*****EARLY: CALCULATED 15 MINUTE PUFF ENERGY RELEASE (JOULES)
C*****TAIL: CALCULATED ENERGY RELEASE AFTER 15 MINUTES (JOULES)
C*****RLATCF: COORECTION FACTOR FOR LATE CONTAINMENT FAILURE,
C*****            AND IS EQUAL TO RATIO OF TB22/TB12.
C*****SPRFAC: CONTAINMENT SPRAY FACTOR FOR [illegible] EARLY AND TAIL
C*****ENERGY RELEASE, AND IS EQUAL TO RATIO OF TBS2/TBR2.
      PARAMETER (MAXBD=20, MAXBIN=10000, MAXSMP=300, MAXCAS=8,
     1           MAXISS=20, MAXLEV=10, MAXVAR=100, MAXVAL=12000,
     2           MAXSPC=10, MAXTIM=10)
      COMMON /BASVAL/ FCOR(MAXSPC), FVES(MAXSPC), DFVPA(MAXSPC),
     1                DFCPA(MAXSPC), FEVSE(MAXSPC), FDCH(MAXSPC),
     2                FCCI(MAXSPC), DFCAV(MAXSPC), VBPUF(MAXSPC),
     3                FCONV(MAXSPC), FCONC(MAXSPC), DFSPRV(MAXSPC),
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```
     4                  DFSPRC(MAXSPC), FREVO(MAXSPC), VALISS(MAXISS),
     5                  FLT11, FLT12, NSPEC, FLV, FHPE, EVSE, WFAC, PFAC,
     6                  FPLBYE, FPLBYP, FPLBYD, FPLBYC, FTLPH, FTLPL,
     7                  FTLP, TC11, TC12, TB11, TB12, TB21, TB22, TBS1,
     8                  TBS2, TBR1, TBR2, TW, T1, T2, DT1, DT2, DTCDB,
     9                  ELEV, PUFF
      COMMON /BININD/ INDX(MAXBD)
C
C
      RLATCF=TB22 / TB12
      SPRFAC=TBS2 / TBR2
C*****IF CONTAINMENT DOES NOT FAIL, BYPASS CALCULATION
      IF (INDX(6) .NE. 5) THEN
C*********CONTAINMENT FAILS EARLY OR LATE
C*********ASSIGN SPRAY FACTORS
         IF (INDX(7) .EQ. 1) THEN
            SPRAYV=1.0
            SPRAYC=1.0
         ELSE IF (INDX(7) .EQ.2 ) THEN
            SPRAYV=SPRFAC
            SPRAYC=1.0
         ELSE IF (INDX(7) .EQ. 3) THEN
            SPRAYV=1.0
            SPRAYC=SPRFAC
         ELSE IF (INDX(7) .EQ. 4) THEN
            SPRAYV=SPRFAC
            SPRAYC=SPRFAC
         END IF
         IF (INDX(3) .EQ. 5) THEN
C************NO VESSEL BREACH
            EARLY=TC11 / SPRAYV
            TAIL=0.0
         ELSE
C************VESSEL BREACH
            IF (INDX(1) .GE. 5) THEN
C***************LIKE TC SEQUENCE
               EARLY=TC11 / SPRAYV
               TAIL=(TC12-TC11) / SPRAYC
            ELSE IF ((INDX(1) .EQ. 1) .OR. (INDX(1) .EQ. 3)) THEN
C***************LIKE TBS/TBR SEQUENCES
               EARLY=TBS1 / SPRAYV
               TAIL=(TBS2-TBS1) / SPRAYC
            ELSE
C***************SLOW TRANSIENT AND SLOW SBO:  LIKE TB1/TB2 SEQUENCES
               EARLY=TB21 / SPRAYV
               TAIL=(TB22-TB21) / SPRAYC
            ENDIF
            IF (INDX(6) .GE. 6) THEN
C***************CORRECT FOR LATE CF
               TAIL=TAIL / RLATCF
            ENDIF
         ENDIF
      ELSE
C*********NO CONTAINMENT FAILURE
         EARLY=0.0
         TAIL=0.0
      ENDIF
C*****CONVERT BTU TO JOULES
      EARLY=1055. * EARLY
      TAIL=1055. * TAIL
      RETURN
      END
```

B.2 GGSOR DATA FILE

This section contains the data file read by GGSOR when it begins execution.

Listing of GGSOR Data File

```
$ GGSOR DATA BASE : FEBRUARY 17, 1989
$********************************************************************
$  ENERGY RELEASE PARAMETERS BASED ON STCP VALUES (BTU) (BMI-2139)
TC11  5.45E+7        $ 15 MIN. ENERGY RELEASE (TC)
TC12  1.44E+8        $ TOTAL ENERGY RELEASE (TC)
TB11  1.91E+7        $ 15 MIN. ENERGY RELEASE (TB1)
TB12  1.95E+7        $ TOTAL ENERGY RELEASE (TB1)
TB21  1.96E+7        $ 15 MIN. ENERGY RELEASE (TB2)
TB22  4.67E+7        $ TOTAL ENERGY RELEASE (TB2)
TBS1  5.10E+6        $ 15 MIN. ENERGY RELEASE (TBS)
TBS2  2.80E+7        $ TOTAL ENERGY RELEASE (TBS)
TBR1  3.57E+6        $ 15 MIN. ENERGY RELEASE (TBR)
TBR2  5.45E+6        $ TOTAL ENERGY RELEASE (TBR)
$   WARNING TIME (S)  CORE DAMAGE (2 FT ABOVE BOTTOM OF ACTIVE FUEL)
TW0(1)   3600. $ FAST STATION BLACKOUT
TW0(2)  43200. $ SLOW STATION BLACKOUT
TW0(3)  28800. $ SLOW TC
$   CONTAINMENT FAILURE TIME OR FIRST RELEASE TIME (S)
T10(1)   8280. $ FAST SEQUENCES, CF BEFORE VB
T10(2)  12960. $ FAST SEQUENCES, CF AT VB
T10(3)  50400. $ FAST SEQUENCES, CF LATE OR NO CF
T10(4)  48800. $ SLOW SBO, CF BEFORE VB
T10(5)  54000. $ SLOW SBO, CF AT VB
T10(6)  72000. $ SLOW SBO, CF LATE OR NO CF
T10(7)  32400. $ SLOW TC, CF BEFORE VB
T10(8)  36000. $ SLOW TC, CF AT VB
T10(9)  72000. $ SLOW TC, CF LATE OR NO CF
$   RELEASE DURATION FOR FIRST RELEASE (S)
DT10(1)  4680. $ CF RUPTURE, VENTING OR LEAK BEFORE VB
DT10(2)   180. $ CF RUPTURE AT VB OR LATE, SUBCOOLED
DT10(3)   900. $ CF RUPTURE AT VB OR LATE, SATURATED
DT10(4)  7200. $ LEAK
$   RELEASE DURATION FOR SECOND RELEASE (S)
DT20(1)  3600. $ CF RUPTURE BEFORE VB AND DCH OR EVSE AT VB
DT20(2) 14400. $ CF RUPTURE AT VB OR LATE
DT20(3) 21600. $ CF LEAK
$   DELAY TIME FOR SECOND RELEASE (S) FOR TEMPORARY COOLABLE DEBRIS BED
DTCDB  10800.
$  FIRST RELEASE (PUFF) FRACTION FOR LATE CONTAINMENT FAILURE
PUFF0(1) 0.90  $ LATE CONTAINMENT FAILURE
PUFF0(2) 0.50  $ LATE LEAK OR NO CONTAINMENT FAILURE
$   RELEASE ELEVATION (M)
ELEV  32.
$ *****************************************************************
$ FPLBY0: FRACTION OF POOL BYPASS HAS THREE CASES
FPLBY0(1)  0.0564  1.32  1.E+06
$ DRY CAVITY AND CONTAINMENT FAILURE CASES DERIVED FROM BMI-2139 GG STCP CALC
$   IF CAVITY IS WET, DIVIDED BY WFAC
$   IF LATE CF, MULTIPLIED BY PFAC
$ STEAMING CORRECTION FACTOR FOR FPLBY0 IF CAVITY IS NOT DRY
WFAC  3.1
$ PRESSURE CORRECTION FACTOR FOR FPLBY0 IF LATE CONTAINMENT FAILURE
PFAC  3.9
$ SPLIT FRACTION BETWEEN TAIL PIPE VACUUM BREAKER OPENING AND T-QUENCHER
$   HIGH PRESSURE SEQUENCES
FTLPH  0.39
$   LOW PRESSURE SEQUENCES
FTLPL  1.0
$************************************************************
$  FHPE: FRACTION OF CORE PARTICIPATING IN DCH OR STEAM EXPLOSION
$      TWO CASES:  (1) HIGH, (2) LOW
FHPE0(1)  0.4  0.1
$ ************************************************************************
$  EVSE:  FRACTION OF CORE PARTICIPATING IN EX-VESSEL STEAM EXPLOSION
```

```
EVSE0(1)  0.2  0.05
$ *************************************************************************
$    PUFF RELEASE AT VESSEL BREACH: ONE SET FOR ALL => USE GG TB1/TB2
VBPUF0(1,1) 7.55E-5  5.92E-5  6.83E-5  5.30E-5  1.87E-7  2.31E-10  7.64E-12
           0.0      5.63E-6
$ ***********************************************************************
$  THE FOLLOWING DATA BLOCKS WHICH HAVE VARIABLES ENDING WITH "0"
$  ARE TAKEN FROM MEDIAN VALUES FROM EXPERT OPINION VALUES FOR GRAND GULF
$  UNLESS OTHERWISE NOTED.
$         (1) FIRST DIMENSION IS CHEMICAL SPECIES
$         (2) SECOND DIMENSION IS CASE
$  *********************************************************************
$   NUMBER OF CHEMICAL SPECIES (NG, I, CS, TE, SR, RU, LA, CE, BA)
NSPEC   9
$ ***********************************************************************
$ FCOR0 : IN-VESSEL RELEASE FRACTION FROM CORE TO RPV ATMOS.
$    BWR CASE 1: HIGH ZR OXIDATION
FCOR0(1,1)  .9    .74    .59   .15  6.4E-3  4.6E-3  1.0E-4  1.5E-4  8.6E-3
$     BWR CASE 2: LOW ZR OXIDATION
FCOR0(1,2)  .90   .69   .50   .14  4.0E-3  2.0E-3  1.0E-4  1.5E-4  6.5E-3
$     BWR CASE 2: LOW ZR OXIDATION
$ ************************************************************************
$ FVES0:  FRACTION OF RADIONUCLIDE LEAVING VESSEL DUIRNG IN-VESSEL
$         RELEASE PHASE
$     FVES BWR CASE 1: TBUX (FAST, HIGH PRESSURE)
FVES0(1,1)  1.   .086  .033  .033  .033  .033  .033  .033  .033
$     FVES BWR CASE 2: TBU (FAST, LOW PRESSURE)
FVES0(1,2)  1.   .41   .30   .27   .26   .26   .26   .26   .26
$     FVES BWR CASE 3: TCUX (SLOW, HIGH PRESSURE, CRD)
FVES0(1,3)  1.   .28   .25   .10   .078  .078  .078  .078  .078
$ ****************************************************************************
$ FCCI0: RELEASE FRACTIONS FROM MOLTEN CORE CONCRETE INTERACTION
$      FCCI BWR CASE 1:  LOW ZR CONTENTS AND DRY CAVITY
FCCI0(1,1)  1.  1.  1.  .66  .052  5.6E-9  2.2E-3  2.9E-3  .061
$      FCCI BWR CASE 2: LOW ZR CONTENTS AND WATER OVER DEBRIS
FCCI0(1,2)  1.  1.  1.  .64  .036  1.7E-9  2.1E-3  2.5E-3  .032
$     FCCI BWR CASE 3:  HIGH ZR CONTENTS AND DRY CAVITY
FCCI0(1,3)  1.  1.  1.  .67  .052  5.6E-9  2.2E-3  2.9E-3  .061
$     FCCI BWR CASE 4:  HIGH ZR CONTENTS AND WATER OVER DEBRIS
FCCI0(1,4)  1.  1.  1.  .64  .036  1.7E-9  2.1E-3  2.5E-3  .032
$**********************************************************
$ FDCH: DIRECT CONTAINMENT HEATING RELEASE
$ FDCH: BWR ONE CASE ONLY: FOR HIGH PRESSURE SEQUENCES
FDCH0(1,1)  1.0  1.0  1.0   .043  .012  .020  .011  .011  .012
$*************************************************************************
$ FEVSE:  EX-VESSEL STEAM EXPLOSION RELEASE
FEVSE0(1,1) 1.   1.   1.    .043  .012  .020  .011  .011  .012
$***********************************************************
$ FLTI1: LATE IODINE RELEASE FROM SUPPRESSION POOL: IODINE ONLY
$     FLTI1 CASE 1: SUBCOOLED SUPPRESSION POOL
FLTI10(1)  1.55E-3
$     FLTI1 CASE 2: SATURATED SUPPRESSION POOL
FLTI10(2)  4.63E-3
$*************************************************************************************
$ FLTI2: LATE IODINE RELEASE FROM CAVITY WATER: IODINE ONLY
$     FLTI2 CASE 1: WET CAVITY (LIKE TBS)
FLTI20(1)  .847
$     FLTI2 CASE 2: FLOODED CAVITY LIKE TC (REPLENISHABLE WATER SUPPLY)
FLTI20(2)  .435
$*******************************************************************
$ FREVO0: REVOLATILIZATION RELEASE AFTER VESSEL BREACH: I,CS AND TE
$ SET ALL OTHER NUCLIDE GROUPS TO ZERO
$    BWR CASE 1: STATION BLACKOUT AND HIGH DRYWELL TEMPERATURE
FREVO0(1,1)  1.   .115  .051  0.    0.     0.   0.    0.    0.
$     BWR CASE 2: STATION BLACKOUT AND LOW DRYWELL TEMPERATURE
$     (NOT APPLICABLE TO GRAND GULF SINCE GRAND GULF CONTAINMENT SPRAY
```

```
$      IS IN OUTER CONTAINMENT, NOT DRYWELL)
FREVO0(1,2)  1.    .114  .050  0.    0.     0.   0.    0.    0.
$     BWR CASE 3: ATWS HIGH PRESSURE (TCUX) AND LOW PRESS. SYSTEMS
$                 AVAILABLE FOR INJECTION AFTER VESSEL BREACH
FREVO0(1,3)  1.    .03   .001  0.    0.     0.   0.    0.    0.
$*******************************************************************
$ FCONV: CONTAINMENT RELEASE FRACTION BEFORE VESSEL BREACH
$   FCONV GG CASE 1: EARLY LEAK SUBCOOLED POOL
FCONV0(1,1)  1.  .233  .233  .233  .233  .233  .233  .233  .233
$   FCONV GG CASE 2: EARLY LEAK SATUARATED POOL
FCONV0(1,2)  1.  .245  .245  .245  .245  .245  .245  .245  .245
$   FCONV GG CASE 3: EARLY RUPTURE SUBCOOLED POOL
FCONV0(1,3)  1.  .639  .639  .639  .639  .639  .639  .639  .639
$   FCONV GG CASE 4: EARLY RUPTURE SATURATED POOL
FCONV0(1,4)  1.  .639  .639  .639  .639  .639  .639  .639  .639
$   FCONV GG CASE 5: LATE LEAK
FCONV0(1,5)  1.  .052  .052  .052  .052  .052  .052  .052  .052
$   FCONV GG CASE 6: LATE RUPTURE
FCONV0(1,6)  1.  .084  .084  .084  .084  .084  .084  .084  .084
$   NO CONTAINMENT FAILURE CASE
FCONV0(1,7)  0.005 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6
$***************************************************************
$ FCONC: CONTAINMENT RELEASE FRACTION AFTER VESSEL BREACH
$     FCONC GG CASE 1: EARLY LEAK SUBCOOLED POOL
FCONC0(1,1)  1    .280  .280  .251  .251  .251  .251  .251  .251
$     FCONC GG CASE 2: EARLY LEAK SATURATED POOL
FCONC0(1,2)  1.   .251  .251  .231  .231  .231  .231  .231  .231
$     FCONC GG CASE 3: EARLY RUPTURE SUBCOOLED POOL
FCONC0(1,3)  1.   .743  .743  .720  .720  .720  .720  .720  .720
$     FCONC GG CASE 4: EARLY RUPTURE SATURATED POOL
FCONC0(1,4)  1.   .719  .719  .675  .675  .675  .675  .675  .675
$     FCONC GG CASE 5: LATE LEAK
FCONC0(1,5)  1.   .052  .052  .062  .063  .062  .063  .072  .072
$     FCONC GG CASE 6: LATE RUPTURE
FCONC0(1,6)  1.   .084  .084  .107  .094  .107  .094  .094  .094
$     NO CONTAINMENT FAILURE CASE
FCONC0(1,7)  0.005 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6
$ ********************************************************************
$ SUPPRESSION POOL DF VALUES BASED ON VALUES FROM DRAFT NUREG/CR-4551
$ EXPERT MEDIAN VALUES
$     SUPPRESSION POOL DF THROUGH SRV T-QUENCHERS
DFVPA0(1,1)     1.0  56.    56.    56.    56.    56.    56.    56.    56.
$     SUPPRESSION POOL DF THROUGH DOWNCOMERS
DFCPA0(1,1)     1.0  6.8    6.8    6.8    6.8    6.8    6.8    6.8    6.8
$ ********************************************************************
$ CONTAINMENT SPRAYS DF BASED ON VALUES FROM DRAFT NUREG/CR-4551
DFSPRV0(1,1)    1.0  11.    11.    11.    11.    11.    11.    11.    11.
DFSPRC0(1,1)    1.0  17.    17.    17.    17.    17.    17.    17.    17.
$ *******************************************************************
$ CAVITY WATER DF VALUES BASED ON VALUES FROM DRAFT NUREG/CR-4551
$     EXPERT MEDIAN VALUES
$               CASE 1: WET CAVITY LIKE GRAND GULF TBS CASE
DFCAV0(1,1)     1.0  4.4    4.4    4.4    4.4    4.4    4.4    4.4    4.4
$               CASE 2: FLOODED CAVITY LIKE GRAND GULF TC CASE
DFCAV0(1,2)     1.0  6.0    6.0    6.0    6.0    6.0    6.0    6.0    6.0
$ **************************************************************
$ ==============================================================
$ **************************************************************
$ GRAND GULF LATIN HYPERCUBE SAMPLE INTERPOLATION DATA BASE
$ ALL VARIABLE ARRAYS END WITH "L" TO REPRESENT LHS VARIABLES
$ STANDARD ARRAYS HAVE THREE DIMENSIONS:
$ FIRST DIMENSION  = RADIONUCLIDE GROUP 1 THROUGH 9
$ SECOND DIMENSION = CUMULATIVE PROBABILITY POINTS
$ THIRD DIMENSION  = DIFFERENT CASES
$ NINE NUCLIDE GROUPS GOING ACROSS: NG,I,CS,TE,SR,RU,LA,CE,BA
$ NINE CUMULATIVE PROBABILITY POINTS GOING DOWN:
```

```
$ 0.,0.01,0.05,0.25,0.5,0.75,0.95,0.99,1.0
PRBLEV  0.0  0.01  0.05  0.25  0.50  0.75  0.95  0.99  1.00
$ EACH CASE CONSISTS OF A BLOCK OF DATA OF 9 BY 9
$ ************************************************************
$ FCORL : IN-VESSEL RELEASE FRACTION FROM CORE TO RPV ATMOS.
$     BWR CASE 1: HIGH ZR OXIDATION
FCORL(1,1,1)  .05     .03     .02     0.      0.      0.      0.      0.      0.
FCORL(1,2,1)  .073    .049    .033    3.0E-3  3.0E-5  0.      0.      0.      2.2E-4
FCORL(1,3,1)  .17     .13     .07     .018    2.5E-4  0.      0.      0.      1.2E-3
FCORL(1,4,1)  .56     .34     .26     .071    2.1E-3  5.0E-5  2.0E-5  2.0E-5  4.2E-3
FCORL(1,5,1)  .9      .74     .59     .15     6.4E-3  4.6E-3  1.0E-4  1.5E-4  8.6E-3
FCORL(1,6,1)  1.      .96     .89     .59     .018    .02     1.2E-3  3.0E-3  .03
FCORL(1,7,1)  1.      1.      1.      .91     .52     .081    .021    .085    .52
FCORL(1,8,1)  1.      1.      1.      .99     1.      .14     .1      .51     1.
FCORL(1,9,1)  1.      1.      1.      1.      1.      .27     .11     1.      1.
$     BWR CASE 2: LOW ZR OXIDATION
FCORL(1,1,2)  .02     6.0E-3  5.0E-3  0.      0       0.      0.      0.      0.
FCORL(1,2,2)  .033    6.6E-3  5.8E-3  2.9E-3  3.0E-5  0.      0.      0.      1.1E-4
FCORL(1,3,2)  .084    9.2E-3  9.0E-3  7.3E-3  1.5E-4  0.      0.      0.      2.2E-4
FCORL(1,4,2)  .41     .16     .088    .049    7.6E-4  5.0E-5  2.0E-5  2.0E-5  1.7E-3
FCORL(1,5,2)  .90     .69     .50     .14     4.0E-3  2.0E-3  1.0E-4  1.5E-4  6.5E-3
FCORL(1,6,2)  1.      .91     .83     .46     .013    .012    6.5E-4  2.5E-3  .027
FCORL(1,7,2)  1.      1.      1.      .89     .52     .058    .021    .085    .52
FCORL(1,8,2)  1.      1.      1.      .98     1       .14     .10     .51     1.
FCORL(1,9,2)  1.      1.      1.      1.      1.      .27     .11     1.      1.
$*****************************************************************
$ FVESL:  FRACTION OF RADIONUCLIDE LEAVING VESSEL DURING IN-VESSEL
$         RELEASE PHASE
$     FVESL BWR CASE 1: TBUX (FAST, HIGH PRESSURE)
FVESL(1,1,1)  1.      0.      0.      0.      0.      0.      0.      0.      0.
FVESL(1,2,1)  1.      2.0E-5  2.0E-5  1.0E-5  1.0E-5  1.0E-5  1.0E-5  1.0E-5  1.0E-5
FVESL(1,3,1)  1.      8.0E-5  8.0E-5  5.0E-5  5.0E-5  5.0E-5  5.0E-5  5.0E-5  5.0E-5
FVESL(1,4,1)  1.      9.6E-3  5.1E-3  1.9E-3  1.9E-3  1.9E-3  1.9E-3  1.9E-3  1.9E-3
FVESL(1,5,1)  1.      .086    .033    .033    .033    .033    .033    .033    .033
FVESL(1,6,1)  1.      .33     .32     .31     .25     .25     .25     .25     .25
FVESL(1,7,1)  1.      .79     .79     .78     .77     .77     .77     .77     .77
FVESL(1,8,1)  1.      .96     .96     96      .95     .95     .95     .95     .95
FVESL(1,9,1)  1.      1.      1.              1.      1.      1.      1.      1.
$     FVESL BWR CASE 2: TBU (FAST, L W PRESSURE)
FVESL(1,1,2)  1.      0.      0.      0.      0.      0.      0.      0.      0.
FVESL(1,2,2)  1.      5.9E-3  3.3E-3  3.3E-3  3.3E-3  3.3E-3  3.3E-3  3.3E-3  3.3E-3
FVESL(1,3,2)  1.      .041    .023    .023    .023    .023    .023    .023    .023
FVESL(1,4,2)  1.      .23     .14     .14     .13     .13     .13     .13     .13
FVESL(1,5,2)  1.      .41     .30     .27     .26     .26     .25     .26     .26
FVESL(1,6,2)  1.      .63     .60     .59     .58     .58     .58     .58     .58
FVESL(1,7,2)  1.      .99     .99     .99     .99     .99     .99     .99     .99
FVESL(1,8,2)  1.      1.      1.      1.      1.      1.      1.      1.      1.
FVESL(1,9,2)  1.      1.      1.      1.      1.      1.      1.      1.      1.
$     FVESL BWR CASE 3: TCUX (SLOW, HIGH PRESSURE, CRD)
FVESL(1,1,3)  1.      0.      1.0E-5  0.      0.      0.      0.      0.      0.
FVESL(1,2,3)  1.      8.0E-5  8.0E-5  2.0E-5  2.0E-5  2.0E-5  2.0E-5  2.0E-5  2.0E-5
FVESL(1,3,3)  1.      .018    7.6E-3  1.0E-4  1.0E-4  1.0E-4  1.0E-4  1.0E-4  1.0E-4
FVESL(1,4,3)  1.      .089    .052    4.9E-3  4.8E-3  4.8E-3  4.8E-3  4.8E-3  4.8E-3
FVESL(1,5,3)  1.      .28     .25     .10     .078    .078    .078    .078    .078
FVESL(1,6,3)  1.      .75     .63     .39     .29     .29     .29     .29     .29
FVESL(1,7,3)  1.      .95     .9      .7      .7      .7      .7      .7      .7
FVESL(1,8,3)  1.      .99     .99     .88     .88     .88     .88     .88     .88
FVESL(1,9,3)  1.      1.      1.      .98     .98     .98     .98     .98     .98
$*****************************************************************
$ FCCIL: RELEASE FRACTIONS FROM MOLTEN CORE CONCRETE INTERACTION
$      FCCI GG CASE 1:  LOW ZR CONTENTS AND DRY CAVITY
FCCIL(1,1,1)  1.      1.      1.      4.4E-3  0.      1.0E-9  0.      0.      3.0E-5
FCCIL(1,2,1)  1.      1.      1.      .012    5.0E-5  1.0E-9  0.      0.      1.2E-4
FCCIL(1,3,1)  1.      1.      1.      .069    3.1E-4  1.2E-9  1.0E-5  3.0E-5  4.9E-4
FCCIL(1,4,1)  1.      1.      1.      .32     2.6E-3  2.4E-9  2.1E-4  3.2E-4  3.2E-3
FCCIL(1,5,1)  1.      1.      1.      .66     .052    5.6E-9  2.2E-3  2.9E-3  .061
```

```
FCCIL(1,6,1)  1.    1.    1.     .76    .62    5.0E-6 .013   .026   .45
FCCIL(1,7,1)  1.    1.    1.     .94    .95    7.3E-3 .086   .016   .88
FCCIL(1,8,1)  1.    1.    1.     .99    .99    9.7E-2 .1     .2     .98
FCCIL(1,9,1)  1.    1.    1.    1.     1.      .25    .1     .2    1.
$     FCCI GO CASE 2: LOW ZR CONTENTS AND WET CAVITY
FCCIL(1,1,2)  1.    1.    1.    1.2E-3 0.     1.0E-9 0.     0.     1.0E-5
FCCIL(1,2,2)  1.    1.    1.    4.8E-3 2.0E-5 1.0E-9 0.     0.     8.0E-5
FCCIL(1,3,2)  1.    1.    1.     .032  2.7E-4 1.1E-9 0.     1.0E-5 3.6E-4
FCCIL(1,4,2)  1.    1.    1.     .26   2.0E-3 1.3E-9 1.9E-4 2.6E-4 2.3E-3
FCCIL(1,5,2)  1.    1.    1.     .64    .036  1.7E-9 2.1E-3 2.5E-3 .032
FCCIL(1,6,2)  1.    1.    1.     .74    .59   1.0E-6 .012   .02    .41
FCCIL(1,7,2)  1.    1.    1.     .93    .94   2.5E-3 .084   .17    .87
FCCIL(1,8,2)  1.    1.    1.     .99    .99   5.8E-2 .099   .2     .98
FCCIL(1,9,2)  1.    1.    1.    1.     1.      .15    .1     .2    1.
$     FCCI GO CASE 3:  HIGH ZR CONTENTS AND DRY CAVITY
FCCIL(1,1,3)  1.    1.    1.    4.4E-3 0.     1.0E-9 0.     0.     3.0E-5
FCCIL(1,2,3)  1.    1.    1.     .012  5.0E-5 1.0E-9 0.     0.     1.2E-4
FCCIL(1,3,3)  1.    1.    1.     .069  3.1E-4 1.2E-9 1.0E-5 3.0E-5 4.9E-4
FCCIL(1,4,3)  1.    1.    1.     .40   2.6E-3 2.4E-9 2.1E-4 3.2E-4 3.2E-3
FCCIL(1,5,3)  1.    1.    1.     .67    .052  5.6E-9 2.2E-3 2.9E-3 .061
FCCIL(1,6,3)  1.    1.    1.     .79    .65   5.0E-6 .02    .031   .51
FCCIL(1,7,3)  1.    1.    1.     .96    .97   7.3E-3 .11    .18    .9
FCCIL(1,8,3)  1.    1.    1.     .99   1.     9.7E-2 .15    .2     .98
FCCIL(1,9,3)  1.    1.    1.    1.     1.      .25    .16    .2    1.
$     FCCI GO CASE 4:  HIGH ZR CONTENTS AND WATER OVER DEBRIS
FCCIL(1,1,4)  1.    1.    1.    1.2E-3 0.     1.0E-9 0.     0.     1.0E-5
FCCIL(1,2,4)  1.    1.    1.    4.8E-3 2.0E-5 1.0E-9 0.     0.     8.0E-5
FCCIL(1,3,4)  1.    1.    1.     .032  2.7E-4 1.1E-9 0.     1.0E-5 3.6E-4
FCCIL(1,4,4)  1.    1.    1.     .26   2.0E-3 1.3E-9 1.9E-4 2.6E-4 2.3E-3
FCCIL(1,5,4)  1.    1.    1.     .64    .036  1.7E-9 2.1E-3 2.5E-3 .032
FCCIL(1,6,4)  1.    1.    1.     .74    .59   1.0E-6 .012   .02    .41
FCCIL(1,7,4)  1.    1.    1.     .93    .94   2.5E-3 .084   .17    .87
FCCIL(1,8,4)  1.    1.    1.     .99    .99   5.8E-2 .099   .2     .98
FCCIL(1,9,4)  1.    1.    1.    1.     1.      .15    .1     .2    1.
$*********************************************************************
$ FDCH: BWR ONE CASE ONLY: FOR HIGH PRESSURE SEQUENCES
$       FISRT DIMENSION  = RADIONUCLIDE GROUP
$       SECOND DIMENSION = PROBABILITY POINTS
FDCHL(1,1,1)  1.     .063   .063  0.     0.     0.     0.     0.     0.
FDCHL(1,2,1)  1.     .15    .15   0.     0.     0.     0.     0.     0.
FDCHL(1,3,1)  1.     .50    .50    .001   .001   .001   .001   .001   .001
FDCHL(1,4,1)  1.    1.     1.      .008   .002   .007   .002   .002   .004
FDCHL(1,5,1)  1.    1.     1.      .043   .012   .020   .011   .011   .012
FDCHL(1,6,1)  1.    1.     1.      .600   .030   .063   .040   .040   .067
FDCHL(1,7,1)  1.    1.     1.      .975   .751   .700   .087   .087   .863
FDCHL(1,8,1)  1.    1.     1.     1.      .980   .900   .200   .280   .980
FDCHL(1,9,1)  1.    1.     1.     1.     1.      .950   .230   .330  1.
$**********************************************************************
$ FEVSE:  EX-VESSEL STEAM EXPLOSION RELEASE
FEVSEL(1,1,1) 1.     .063   .063  0.     0.     0.     0.     0.     0.
FEVSEL(1,2,1) 1.     .15    .15   0.     0.     0.     0.     0.     0.
FEVSEL(1,3,1) 1.     .50    .50    .001   .001   .001   .001   .001   .001
FEVSEL(1,4,1) 1.    1.     1.      .008   .002   .007   .002   .002   .004
FEVSEL(1,5,1) 1.    1.     1.      .043   .012   .020   .011   .011   .012
FEVSEL(1,6,1) 1.    1.     1.      .600   .030   .063   .040   .040   .067
FEVSEL(1,7,1) 1.    1.     1.      .975   .751   .700   .087   .087   .863
FEVSEL(1,8,1) 1.    1.     1.     1.      .980   .900   .200   .280   .980
FEVSEL(1,9,1) 1.    1.     1.     1.     1.      .950   .230   .330  1.
$***********************************************************************
$ FLTI1: LATE IODINE RELEASE FROM SUPPRESSION POOL: IODINE ONLY
$          THEREFORE, PROBABILITY GOING ACROSS
$          FIRST DIMENSION  = PROBABILITY POINTS
$          SECOND DIMENSION = CASES
$     FLTI1 CASE 1: SUBCOOLED SUPPRESSION POOL
FLTI1L(1,1)  0.  0.     0.       5.00E-4  1.55E-3  .0278  .085  .097  .10
$     FLTI1 CASE 2: SATURATED SUPPRESSION POOL
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FLTI1L(1,2)  0.  1.E-6  4.06E-5  9.36E-4  4.63E-3  .173   .750  .93   1.
$*****************************************************************************
$ FLTI2: LATE IODINE RELEASE FROM CAVITY WATER: IODINE ONLY
$     FLTI2 CASE 1: WET CAVITY (LIKE TBS)
FLTI2L(1,1)  .080  .109 .153  .365  .847  .957  1.    1.    1.
$     FLTI2 CASE 2: FLOODED CAVITY LIKE TC (REPLENISHABLE WATER SUPPLY)
FLTI2L(1,2)  .004  .04  .109  .247  .435  .670  .936  .985  1.
$***************************************************************************
$ FREVOL: REVOLATILIZATION RELEASE AFTER VESSEL BREACH: I,CS AND TE
$ SET ALL OTHER NUCLIDE GROUPS TO ZERO
$    BWR CASE 1: STATION BLACKOUT AND HIGH DRYWELL TEMPERATURE
FREVOL(1,1,1)  1.   0.     0.     0.     0.     0.     0.     0.     0.
FREVOL(1,2,1)  1.   0.     0.     0.     0.     0.     0.     0.     0.
FREVOL(1,3,1)  1.   0.     0.     0.     0.     0.     0.     0.     0.
FREVOL(1,4,1)  1.    .03   .001   0.     0.     0.     0.     0.     0.
FREVOL(1,5,1)  1.    .115  .051   0.     0.     0.     0.     0.     0.
FREVOL(1,6,1)  1.    .306  .132   .024   0.     0.     0.     0.     0.
FREVOL(1,7,1)  1.    .557  .284   .224   0.     0.     0.     0.     0.
FREVOL(1,8,1)  1.    .800  .535   .413   0.     0.     0.     0.     0.
FREVOL(1,9,1)  1.   1.     .750   .800   0.     0.     0.     0.     0.
$     BWR CASE 2: STATION BLACKOUT AND LOW DRYWELL TEMPERATURE
$     (NOT APPLICABLE TO GRAND GULF SINCE GRAND GULF CONTAINMENT SPRAY
$      IS IN OUTER CONTAINMENT, NOT DRYWELL)
FREVOL(1,1,2)  1.   0.     0.     0.     0.     0.     0.     0.     0.
FREVOL(1,2,2)  1.   0.     0.     0.     0.     0.     0.     0.     0.
FREVOL(1,3,2)  1.   0.     0.     0.     0.     0.     0.     0.     0.
FREVOL(1,4,2)  1.    .03   .001   0.     0.     0.     0.     0.     0.
FREVOL(1,5,2)  1.    .114  .050   0.     0.     0.     0.     0.     0.
FREVOL(1,6,2)  1.    .261  .122   .024   0.     0.     0.     0.     0.
FREVOL(1,7,2)  1.    .486  .236   .209   0.     0.     0.     0.     0.
FREVOL(1,8,2)  1.    .800  .438   .413   0.     0.     0.     0.     0.
FREVOL(1,9,2)  1.   1.     .750   .800   0.     0.     0.     0.     0.
$     BWR CASE 3: ATWS HIGH PRESSURE (TCUX) AND LOW PRESS. SYSTEMS
$                 AVAILABLE FOR INJECTION AFTER VESSEL BREACH
FREVOL(1,1,3)  1.   0.     0.     0.     0.     0.     0.     0.     0.
FREVOL(1,2,3)  1.   0.     0.     0.     0.     0.     0.     0.     0.
FREVOL(1,3,3)  1.   0.     0.     0.     0.     0.     0.     0.     0.
FREVOL(1,4,3)  1.   0.     0.     0.     0.     0.     0.     0.     0.
FREVOL(1,5,3)  1.    .03   .001   0.     0.     0.     0.     0.     0.
FREVOL(1,6,3)  1.    .117  .061   .024   0.     0.     0.     0.     0.
FREVOL(1,7,3)  1.    .439  .200   .209   0.     0.     0.     0.     0.
FREVOL(1,8,3)  1.    .600  .287   .413   0.     0.     0.     0.     0.
FREVOL(1,9,3)  1.   1.00   .750   .800   0.     0.     0.     0.     0.
$**********************************************************************
$ FCONV: CONTAINMENT RELEASE FRACTION BEFORE VESSEL BREACH: ALL NINE GROUPS
$   FCONVL GG CASE 1: EARLY LEAK, SUBCOOLED POOL
FCONVL(1,1,1)  1.  .001  .001  .001  .001  .001  .001  .001  .001
FCONVL(1,2,1)  1.  .003  .003  .003  .003  .003  .003  .003  .003
FCONVL(1,3,1)  1.  .012  .012  .012  .012  .012  .012  .012  .012
FCONVL(1,4,1)  1.  .117  .117  .117  .117  .117  .117  .117  .117
FCONVL(1,5,1)  1.  .233  .233  .233  .233  .233  .233  .233  .233
FCONVL(1,6,1)  1.  .417  .417  .417  .417  .417  .417  .417  .417
FCONVL(1,7,1)  1.  .676  .676  .676  .676  .676  .676  .676  .676
FCONVL(1,8,1)  1.  .784  .784  .784  .784  .784  .784  .784  .784
FCONVL(1,9,1)  1.  .949  .949  .949  .949  .949  .949  .949  .949
$   FCONVL GG CASE 2: EARLY LEAK, SATURATED POOL
FCONVL(1,1,2)  1.  .002  .002  .002  .002  .002  .002  .002  .002
FCONVL(1,2,2)  1.  .008  .008  .008  .008  .008  .008  .008  .008
FCONVL(1,3,2)  1.  .030  .030  .030  .030  .030  .030  .030  .030
FCONVL(1,4,2)  1.  .151  .151  .151  .151  .151  .151  .151  .151
FCONVL(1,5,2)  1.  .245  .245  .245  .245  .245  .245  .245  .245
FCONVL(1,6,2)  1.  .447  .447  .447  .447  .447  .447  .447  .447
FCONVL(1,7,2)  1.  .695  .695  .695  .695  .695  .695  .695  .695
FCONVL(1,8,2)  1.  .792  .792  .792  .792  .792  .792  .792  .792
FCONVL(1,9,2)  1.  .953  .953  .953  .953  .953  .953  .953  .953
$   FCONVL GG CASE 3: EARLY RUPTURE, SUBCOOLED POOL
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FCONVL(1,1,3)  1.  .021  .021  .021  .021  .021  .021  .021  .021
FCONVL(1,2,3)  1.  .090  .090  .090  .090  .090  .090  .090  .090
FCONVL(1,3,3)  1.  .197  .197  .197  .197  .197  .197  .197  .197
FCONVL(1,4,3)  1.  .437  .437  .437  .437  .437  .437  .437  .437
FCONVL(1,5,3)  1.  .639  .639  .639  .639  .639  .639  .639  .639
FCONVL(1,6,3)  1.  .790  .790  .770  .770  .770  .770  .770  .770
FCONVL(1,7,3)  1.  .915  .915  .892  .892  .892  .892  .892  .892
FCONVL(1,8,3)  1.  .966  .966  .966  .966  .966  .966  .966  .966
FCONVL(1,9,3)  1.  .996  .996  .996  .996  .996  .996  .996  .996
$   FCONVL GG CASE 4: EARLY RUPTURE, SATURATED POOL
FCONVL(1,1,4)  1.  .021  .021  .021  .021  .021  .021  .021  .021
FCONVL(1,2,4)  1.  .090  .090  .090  .090  .090  .090  .090  .090
FCONVL(1,3,4)  1.  .197  .197  .197  .197  .197  .197  .197  .197
FCONVL(1,4,4)  1.  .437  .437  .437  .437  .437  .437  .437  .437
FCONVL(1,5,4)  1.  .639  .639  .639  .639  .639  .639  .639  .639
FCONVL(1,6,4)  1.  .790  .790  .770  .770  .770  .770  .770  .770
FCONVL(1,7,4)  1.  .915  .915  .892  .892  .892  .892  .892  .892
FCONVL(1,8,4)  1.  .966  .966  .966  .966  .966  .966  .966  .966
FCONVL(1,9,4)  1.  .996  .996  .996  .996  .996  .996  .996  .996
$    FCONVL GG CASE 5: LATE LEAK
FCONVL(1,1,5)  1.  0.    0.    0.    0.    0.    0.    0.    0.
FCONVL(1,2,5)  1.  0.    0.    0.    0.    0.    0.    0.    0.
FCONVL(1,3,5)  1.  .001  .001  .001  .001  .001  .001  .001  .001
FCONVL(1,4,5)  1.  .008  .008  .008  .008  .008  .008  .008  .008
FCONVL(1,5,5)  1.  .052  .052  .052  .052  .052  .052  .052  .052
FCONVL(1,6,5)  1.  .125  .128  .128  .128  .128  .128  .128  .128
FCONVL(1,7,5)  1.  .330  .330  .330  .330  .330  .330  .330  .330
FCONVL(1,8,5)  1.  .510  .510  .510  .510  .510  .510  .510  .510
FCONVL(1,9,5)  1.  .814  .814  .814  .814  .814  .814  .814  .814
$     FCONVL GG CASE 6: LATE RUPTURE
FCONVL(1,1,6)  1.  0.    0.    0.    0.    0.    0.    0.    0.
FCONVL(1,2,6)  1.  0.    0.    0.    0.    0.    0.    0.    0.
FCONVL(1,3,6)  1.  .002  .002  .002  .002  .002  .002  .002  .002
FCONVL(1,4,6)  1.  .017  .017  .017  .017  .017  .017  .017  .017
FCONVL(1,5,6)  1.  .084  .084  .084  .084  .084  .084  .084  .084
FCONVL(1,6,6)  1.  .186  .186  .186  .186  .186  .186  .186  .186
FCONVL(1,7,6)  1.  .338  .338  .338  .338  .338  .338  .338  .338
FCONVL(1,8,6)  1.  .540  .540  .540  .540  .540  .540  .540  .540
FCONVL(1,9,6)  1.  .969  .969  .969  .969  .969  .969  .969  .969
$     FCONVL: NO CONTAINMENT FAILURE CASE
FCONVL(1,1,7)  0.005 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6
FCONVL(1,2,7)  0.005 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6
FCONVL(1,3,7)  0.005 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6
FCONVL(1,4,7)  0.005 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6
FCONVL(1,5,7)  0.005 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6
FCONVL(1,6,7)  0.005 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6
FCONVL(1,7,7)  0.005 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6
FCONVL(1,8,7)  0.005 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6
FCONVL(1,9,7)  0.005 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6
$*********************************************************************
$ FCONC: CONTAINMENT RELEASE FRACTION AFTER VESSEL BREACH: ALL NINE GROUPS
$    FCONC GG CASE 1: EARLY LEAK, SUBCOOLED POOL
FCONCL(1,1,1)  1.  .001  .001  .001  .001  .001  .001  .001  .001
FCONCL(1,2,1)  1.  .003  .003  .003  .003  .003  .003  .003  .003
FCONCL(1,3,1)  1.  .012  .012  .012  .012  .012  .012  .012  .012
FCONCL(1,4,1)  1.  .115  .115  .088  .088  .088  .088  .088  .088
FCONCL(1,5,1)  1.  .280  .280  .251  .251  .251  .251  .251  .251
FCONCL(1,6,1)  1.  .461  .461  .428  .428  .428  .428  .428  .428
FCONCL(1,7,1)  1.  .672  .672  .672  .672  .672  .672  .672  .672
FCONCL(1,8,1)  1.  .779  .779  .779  .779  .779  .779  .779  .779
FCONCL(1,9,1)  1.  .876  .876  .876  .876  .876  .876  .876  .876
$    FCONC GG CASE 2: EARLY LEAK, SATURATED POOL
FCONCL(1,1,2)  1.  .002  .002  .002  .002  .002  .002  .002  .002
FCONCL(1,2,2)  1.  .008  .008  .008  .008  .008  .008  .008  .008
FCONCL(1,3,2)  1.  .030  .030  .024  .024  .024  .024  .024  .024
FCONCL(1,4,2)  1.  .141  .141  .115  .115  .115  .115  .115  .115
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FCONCL(1,5,2)  1.  .251  .251  .231  .231  .231  .231  .231  .231
FCONCL(1,6,2)  1.  .449  .449  .405  .405  .405  .405  .405  .405
FCONCL(1,7,2)  1.  .689  .689  .689  .689  .689  .689  .689  .689
FCONCL(1,8,2)  1.  .789  .789  .789  .789  .789  .789  .789  .789
FCONCL(1,9,2)  1.  .892  .892  .892  .892  .892  .892  .892  .892
$    FCONC GG CASE 3: EARLY RUPTURE, SUBCOOLED POOL
FCONCL(1,1,3)  1.  .038  .038  .015  .015  .015  .015  .015  .015
FCONCL(1,2,3)  1.  .148  .148  .054  .054  .054  .054  .054  .054
FCONCL(1,3,3)  1.  .218  .218  .169  .169  .169  .169  .169  .169
FCONCL(1,4,3)  1.  .512  .512  .451  .451  .451  .451  .451  .451
FCONCL(1,5,3)  1.  .743  .743  .720  .720  .720  .720  .720  .720
FCONCL(1,6,3)  1.  .882  .882  .855  .855  .855  .855  .855  .855
FCONCL(1,7,3)  1.  .985  .985  .985  .985  .985  .985  .985  .985
FCONCL(1,8,3)  1.  .990  .990  .990  .990  .990  .990  .990  .990
FCONCL(1,9,3)  1.  1.    1.    1.    1.    1.    1.    1.    1.
$    FCONC GG CASE 4: EARLY RUPTURE, SATURATED POOL
FCONCL(1,1,4)  1.  .038  .038  .013  .013  .013  .013  .013  .013
FCONCL(1,2,4)  1.  .148  .148  .042  .042  .042  .042  .042  .042
FCONCL(1,3,4)  1.  .218  .218  .153  .153  .153  .153  .153  .153
FCONCL(1,4,4)  1.  .491  .491  .435  .435  .435  .435  .435  .435
FCONCL(1,5,4)  1.  .719  .719  .675  .675  .675  .675  .675  .675
FCONCL(1,6,4)  1.  .859  .859  .828  .828  .828  .828  .828  .828
FCONCL(1,7,4)  1.  .940  .940  .936  .936  .936  .936  .936  .936
FCONCL(1,8,4)  1.  .974  .974  .974  .974  .974  .974  .974  .974
FCONCL(1,9,4)  1.  .994  .994  .994  .994  .994  .994  .994  .994
$    FCONC GG CASE 5: LATE LEAK
FCONCL(1,1,5)  1.  0.    0.    0.    0.    0.    0.    0.    0.
FCONCL(1,2,5)  1.  0.    0.    .001  .001  .001  .001  001   .001
FCONCL(1,3,5)  1.  .001  .001  .002  .002  .002  .002  .002  .002
FCONCL(1,4,5)  1.  .008  .008  .023  .014  .023  .014  .014  .014
FCONCL(1,5,5)  1.  .052  .052  .082  .063  .082  .063  .072  .072
FCONCL(1,6,5)  1.  .128  .128  .183  .149  .183  .149  .164  .164
FCONCL(1,7,5)  1.  .330  .330  .423  .392  .423  .392  .404  .404
FCONCL(1,8,5)  1.  .510  .510  595   .510  .595  .510  .510  .510
FCONCL(1,9,5)  1.  .814  .814  .820  .814  .820  .814  .814  .814
$    FCONC GG CASE 6: LATE RUPTURE
FCONCL(1,1,6)  1.  0.    0.    0.    0.    0.    0.    0.    0.
FCONCL(1,2,6)  1.  0.    0.    .001  .001  .001  .001  .001  .001
FCONCL(1,3,6)  1.  .002  .002  .003  .003  .003  .003  .003  .003
FCONCL(1,4,6)  1.  .017  .017  .037  .020  .037  .020  .020  .020
FCONCL(1,5,6)  1.  .084  .084  .107  .094  .107  .094  .094  .094
FCONCL(1,6,6)  1.  .186  .186  .256  .226  .256  .226  .226  .226
FCONCL(1,7,6)  1.  .338  .338  .775  .771  .775  .771  .771  .771
FCONCL(1,8,6)  1.  .540  .540  .920  .920  .920  .920  .920  .920
FCONCL(1,9,6)  1.  .969  .969  .973  .973  .973  .973  .973  .973
$     FCONCL: NO CONTAINMENT FAILURE CASE
FCONCL(1,1,7)  0.005 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6
FCONCL(1,2,7)  0.005 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6
FCONCL(1,3,7)  0.005 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6
FCONCL(1,4,7)  0.005 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6
FCONCL(1,5,7)  0.005 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6
FCONCL(1,6,7)  0.005 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6
FCONCL(1,7,7)  0.005 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6
FCONCL(1,8,7)  0.005 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6
FCONCL(1,9,7)  0.005 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6 1.0E-6
$*****************************************************************************
$  DFVPA:  SUPPRESSION POOL DF DURING IN-VESSEL RELEASE PHASE
$          (THROUGH T-QUENCHER)
$      DFVPA GG CASE 1:  DRAFT NUREG/CR-4551
DFVPAL(1,1,1)  1.0  1.0    1.0    1.0    1.0    1.0    1.0    1.0    1.0
DFVPAL(1,2,1)  1.0  1.1    1.1    1.1    1.1    1.1    1.1    1.1    1.1
DFVPAL(1,3,1)  1.0  1.8    1.8    1.8    1.8    1.8    1.8    1.8    1.8
DFVPAL(1,4,1)  1.0  16.    16.    16.    16.    16.    16.    16.    16.
DFVPAL(1,5,1)  1.0  56.    56.    56.    56.    56.    56.    56.    56.
DFVPAL(1,6,1)  1.0  180.   180.   180.   180.   180.   180.   180.   180.
DFVPAL(1,7,1)  1.0  2500.  2500.  2500.  2500.  2500.  2500.  2500.  2500.
```

```
DFVPAL(1,8,1)  1.0  4300.  4300.  4300.  4300.  4300.  4300.  4300.  4300.
DFVPAL(1,9,1)  1.0  5000.  5000.  5000.  5000.  5000.  5000.  5000.  5000.
$**********************************************************************
$  DFCPA:  SUPPRESSION POOL DF THRU VENT PIPES
$      DFCPA GG CASE 1:  DRAFT NUREG/CR-4551
DFCPAL(1,1,1)  1.0  1.0    1.0    1.0    1.0    1.0    1.0    1.0    1.0
DFCPAL(1,2,1)  1.0  1.0    1.0    1.0    1.0    1.0    1.0    1.0    1.0
DFCPAL(1,3,1)  1.0  1.2    1.2    1.2    1.2    1.2    1.2    1.2    1.2
DFCPAL(1,4,1)  1.0  2.6    2.6    2.6    2.6    2.6    2.6    2.6    2.6
DFCPAL(1,5,1)  1.0  6.8    6.8    6.8    6.8    6.8    6.8    6.8    6.8
DFCPAL(1,6,1)  1.0  20.    20.    20.    20.    20.    20.    20.    20.
DFCPAL(1,7,1)  1.0  72.    72.    72.    72.    72.    72.    72.    72.
DFCPAL(1,8,1)  1.0  94.    94.    94.    94.    94.    94.    94.    94.
DFCPAL(1,9,1)  1.0  100.   100.   100.   100.   100.   100.   100.   100.
$**********************************************************************
$  DFCAV:  CAVITY WATER DF FOR CCI RELEASE
$      DFCAV GG CASE 1:  WET CAVITY SIMILAR TO BMI-2139 GG TBS
$                        (DRAFT NUREG/CR-4551)
DFCAVL(1,1,1)  1.0  1.0    1.0    1.0    1.0    1.0    1.0    1.0    1.0
DFCAVL(1,2,1)  1.0  1.0    1.0    1.0    1.0    1.0    1.0    1.0    1.0
DFCAVL(1,3,1)  1.0  1.1    1.1    1.1    1.1    1.1    1.1    1.1    1.1
DFCAVL(1,4,1)  1.0  2.0    2.0    2.0    2.0    2.0    2.0    2.0    2.0
DFCAVL(1,5,1)  1.0  4.4    4.4    4.4    4.4    4.4    4.4    4.4    4.4
DFCAVL(1,6,1)  1.0  11.    11.    11.    11.    11.    11.    11.    11.
DFCAVL(1,7,1)  1.0  41.    41.    41.    41.    41.    41.    41.    41.
DFCAVL(1,8,1)  1.0  65.    65.    65.    65.    65.    65.    65.    65.
DFCAVL(1,9,1)  1.0  73.    73.    73.    73.    73.    73.    73.    73.
$      DFCAV GG CASE 2:  FLOODED CAVITY SIMILAR TO BMI-2139 GG TC
DFCAVL(1,1,2)  1.0  1.0    1.0    1.0    1.0    1.0    1.0    1.0    1.0
DFCAVL(1,2,2)  1.0  1.0    1.0    1.0    1.0    1.0    1.0    1.0    1.0
DFCAVL(1,3,2)  1.0  1.2    1.2    1.2    1.2    1.2    1.2    1.2    1.2
DFCAVL(1,4,2)  1.0  2.8    2.8    2.8    2.8    2.8    2.8    2.8    2.8
DFCAVL(1,5,2)  1.0  6.0    6.0    6.0    6.0    6.0    6.0    6.0    6.0
DFCAVL(1,6,2)  1.0  15.    15.    15.    15.    15.    15.    15.    15.
DFCAVL(1,7,2)  1.0  56.    56.    56.    56.    56.    56.    56.    56.
DFCAVL(1,8,2)  1.0  89.    89.    89.    89.    89.    89.    89.    89.
DFCAVL(1,9,2)  1.0  100.   100.   100.   100.   100.   100.   100.   100.
$**********************************************************************
$  DFSPRV:  SPRAY DF FOR IN-VESSEL RELEASES
$      DFSPRV GG CASE 1 DRAFT NUREG/CR-4551 (SURRY)
DFSPRVL(1,1,1)  1.0  1.0   1.0    1.0    1.0    1.0    1.0    1.0    1.0
DFSPRVL(1,2,1)  1.0  1.1   1.1    1.1    1.1    1.1    1.1    1.1    1.1
DFSPRVL(1,3,1)  1.0  1.3   1.3    1.3    1.3    1.3    1.3    1.3    1.3
DFSPRVL(1,4,1)  1.0  4.2   4.2    4.2    4.2    4.2    4.2    4.2    4.2
DFSPRVL(1,5,1)  1.0  11.   11.    11.    11.    11.    11.    11.    11.
DFSPRVL(1,6,1)  1.0  29.   29.    29.    29.    29.    29.    29.    29.
DFSPRVL(1,7,1)  1.0  78.   78.    78.    78.    78.    78.    78.    78.
DFSPRVL(1,8,1)  1.0  95.   95.    95.    95.    95.    95.    95.    95.
DFSPRVL(1,9,1)  1.0  100.  100.   100.   100.   100.   100.   100.   100.
$**********************************************************************
$  DFSPRC:  SPRAY DF FOR CCI RELEASES
$      DFSPRC GG CASE 1 DRAFT NUREG/CR-4551 (SURRY)
DFSPRCL(1,1,1)  1.0  1.0   1.0    1.0    1.0    1.0    1.0    1.0    1.0
DFSPRCL(1,2,1)  1.0  1.1   1.1    1.1    1.1    1.1    1.1    1.1    1.1
DFSPRCL(1,3,1)  1.0  1.5   1.5    1.5    1.5    1.5    1.5    1.5    1.5
DFSPRCL(1,4,1)  1.0  7.8   7.8    7.8    7.8    7.8    7.8    7.8    7.8
DFSPRCL(1,5,1)  1.0  17.   17.    17.    17.    17.    17.    17.    17.
DFSPRCL(1,6,1)  1.0  29.   29.    29.    29.    29.    29.    29.    29.
DFSPRCL(1,7,1)  1.0  480.  480.   480.   480.   480.   480.   480.   480.
DFSPRCL(1,8,1)  1.0  860.  860.   860.   860.   860.   860.   860.   860.
DFSPRCL(1,9,1)  1.0  1000. 1000.  1000.  1000.  1000.  1000.  1000.  1000.
```

B.3 SOURCE TERM RESULTS

This section contains examples of additional source term results for internal initiators. Figure B.3-1 presents the complementary cumulative distribution function (CCDF) for release fractions for the iodine, cesium, strontium, and lanthanum radionuclide classes. The CCDFs for noble gases are not particularly interesting, since almost all the noble gases that escape from the fuel are eventually released to the environment. If the containment fails, the noble gases are released within a day or less. If the containment does not fail, the xenon and krypton fission products are released from the containment over many days due to design-level leakage. The CCDFs for the other four radionuclide classes are not shown because they are similar to the CCDFs that are displayed. Figure B.3-1 shows the relationship of exceedance frequency to release fraction for each of the 250 observations in the sample for Grand Gulf.

Figure B.3-2 illustrates another way to present the results of the source term analysis. This figure shows the range of release fractions for accidents in which both the containment and drywell fail early and the containment sprays are not available (summary APB 1). Figure B.3-3 presents the same type of information for accidents in which both the containment and drywell also fail early; however, in these accidents the containment sprays are operating (summary ABP 2). These plots were constructed by considering all the source terms computed for each radionuclide class without regard for their frequency. To obtain the mean value for iodine for the accidents that involve early failure of the containment, drywell, and containment sprays. For example, all the iodine release fractions for source terms resulting from these accidents are simply averaged. That is, the total release fractions for all of these types of accidents are treated equally even though one may be more likely than another by several orders of magnitude. Thus, it is not possible to give a probabilistic interpretation to the means or the quantiles shown in Figures B.3-2 and B.3-3.

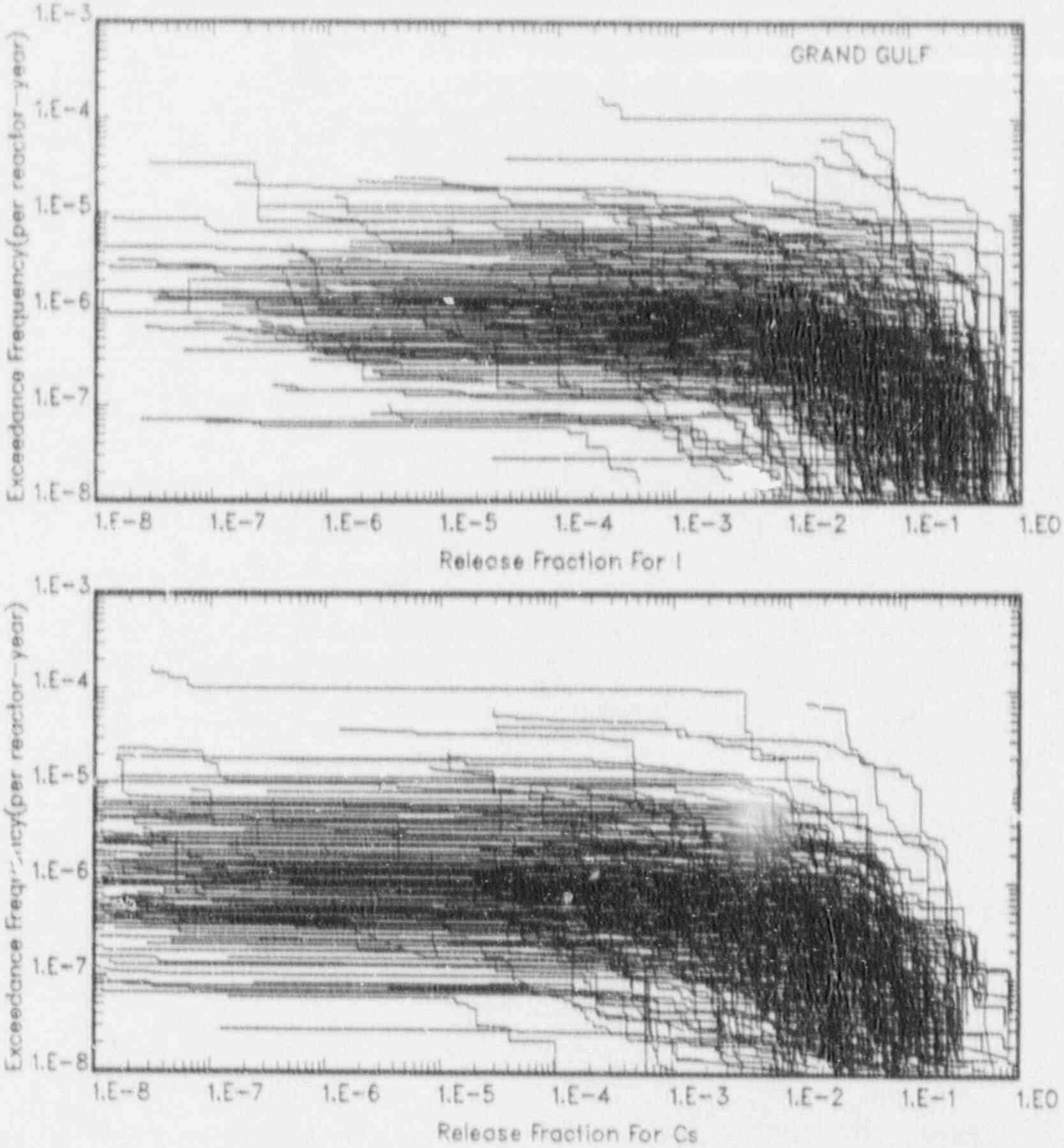
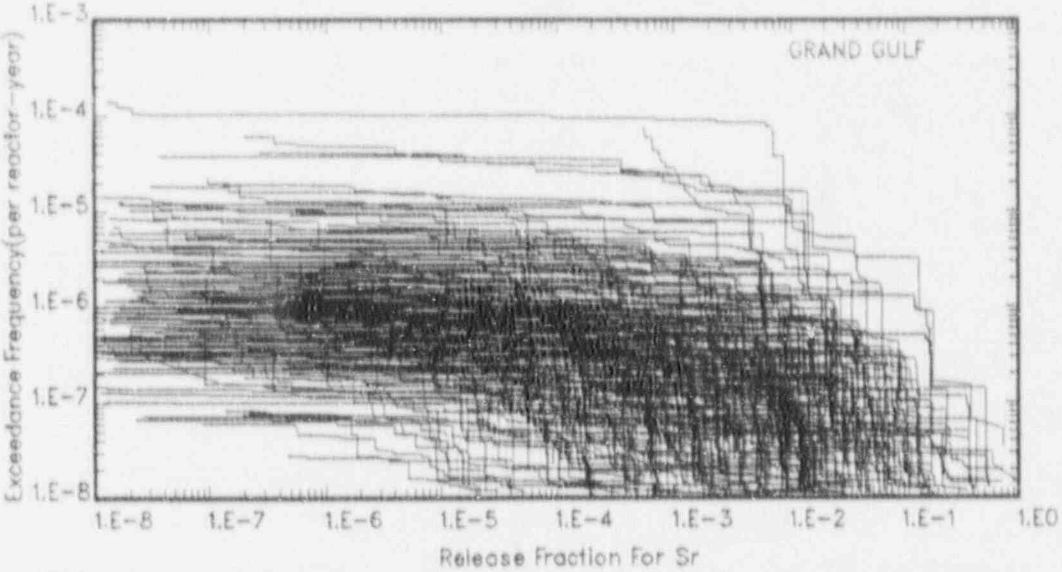


Figure B.3-1. Exceedance Frequencies for Release Fractions (Iodine, Cesium, Strontium, Lanthanum)



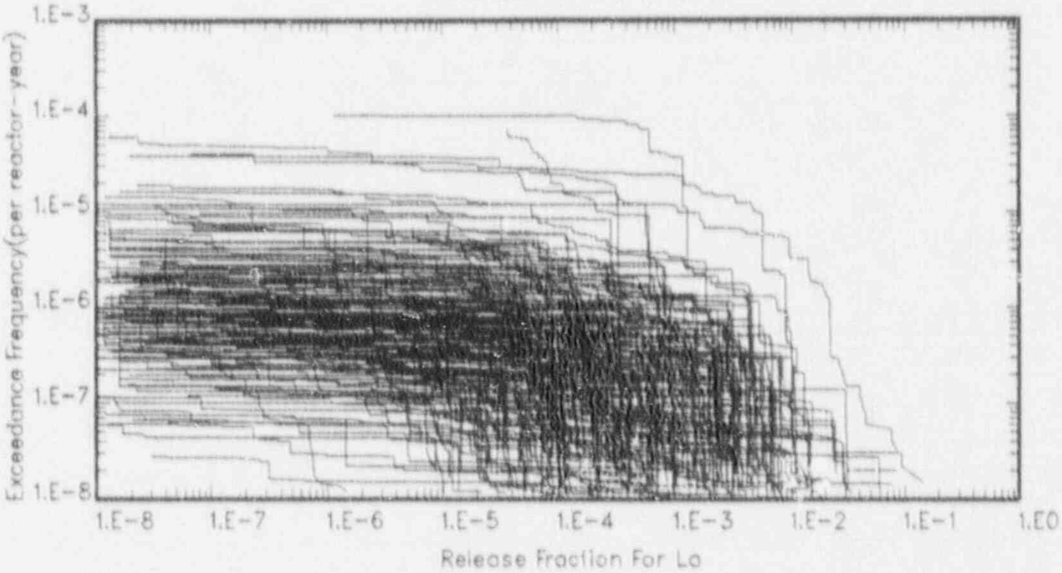


Figure B.3-1. (continued)

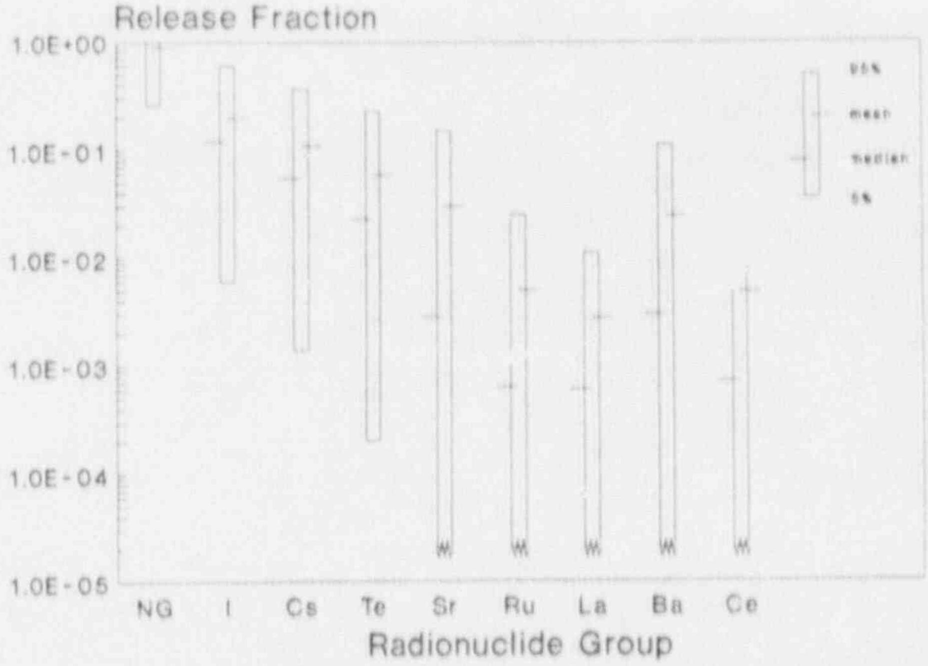


Figure B.3-2. Total Release Fractions for Summary APB 1: Early Containment Failure, Early Suppression Pool Bypass, and Containment Sprays Not Available

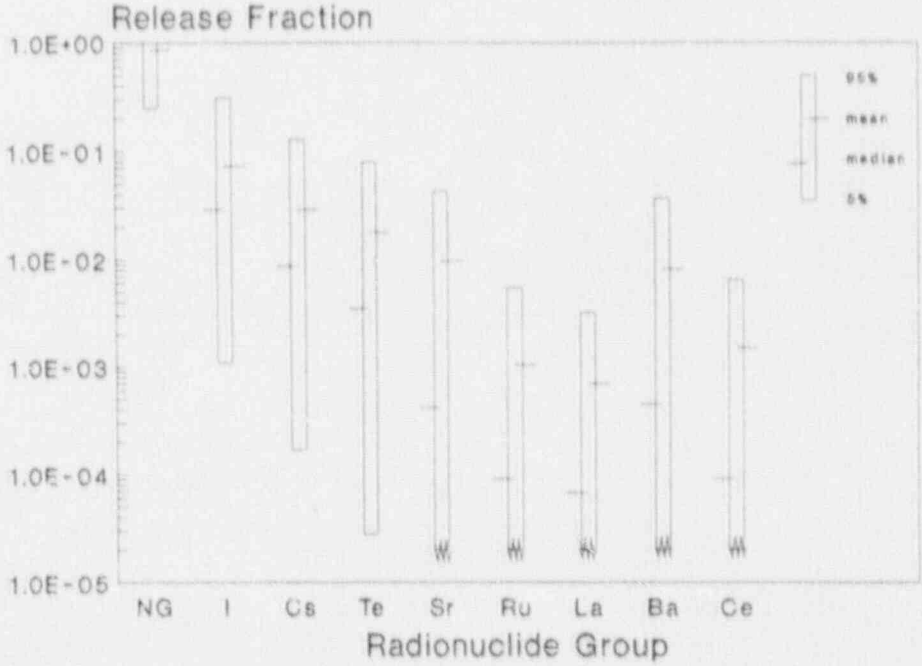


Figure B.3-3. Total Release Fractions for Summary APB 2: Early Containment Failure, Early Suppression Pool Bypass, and Containment Sprays Available

B.4 INFORMATION USED IN SOURCE TERM PARTITIONING

This section contains one figure and two tables that present information used in source term partitioning for Grand Gulf. Specifically, Figure B.4-1 and Table B.4-1 present the results of site-specific MACCS calculations for Grand Gulf used in the definition of early and chronic health effect weights, respectively. The generation of these results is discussed in the methodology volume of this report (Volume 1) and in NUREG/CR-5353[B-1]. Table B.4-2 lists the PARTITION input file for the Grand Gulf analysis. It contains dose factors, reactor inventory, summaries of the results in Figure B.4-1 and Table B.4-1, and other information needed to define the early and chronic health effect weights.

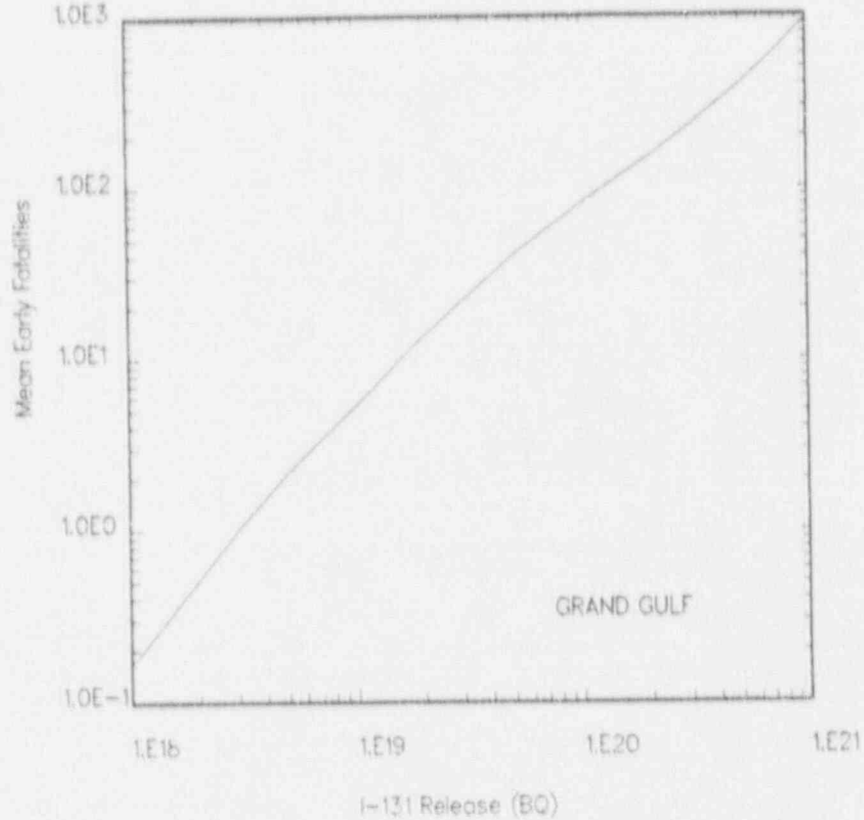


Figure B.4-1. Total Release Fractions for Summary APB 2: Early Containment Failure, Early Suppression Pool Bypass, and Containment Sprays Available

The curve relates released activity (Bq) for I-131 to a corresponding mean number of early fatalities predicted by a full MACCS calculation. This calculation assumed an instantaneous ground-level release, no plume rise, and no evacuation or other mitigating actions. The assumptions/data used in the calculation are the same as those described in Volume 2, Part 7, of this report.

Table B.4-1 presents the results of a full MACCS calculation for each isotope. Each calculation assumes that the indicated quantity of the isotope under consideration is released. Additional computational assumptions are the same as those indicated in conjunction with Figure B.4-1.

Table B.4-1
Selected MACCS Mean Results for Single Isotope Releases for Grand Gulf

Release[1] Class	Element[2]	Isotope	Half-life (Days)	Release (bq)	Early[3] Fatalities	Early[4] Injuries	E.L.C.F.[5]	C.L.C.F.[6]
1					0.00E+00	1.50E-02	2.93E-01	0.00E+00
	KR				0.00E+00	1.50E-02	1.63E-01	0.00E+00
		KR-85	3.919E+03	3.317E+15	0.00E+00	0.00E+00	1.27E-04	0.00E+00
		KR-85M	1.867E-01	1.206E+17	0.00E+00	0.00E+00	4.37E-03	0.00E+00
		KR-87	5.278E-02	2.193E+17	0.00E+00	0.00E+00	1.44E-02	0.00E+00
		KR-88	1.167E-01	2.960E+17	0.00E+00	1.50E-02	1.44E-01	0.00E+00
	XE				0.00E+00	0.00E+00	1.30E-01	0.00E+00
		XE-133	5.291E+00	7.182E+17	0.00E+00	0.00E+00	1.12E-01	0.00E+00
		XE-135	3.821E-01	1.707E+17	0.00E+00	0.00E+00	1.80E-02	0.00E+00
2					6.21E-01	2.55E+00	9.10E+00	2.18E+02
	I				6.21E-01	2.55E+00	9.10E+00	2.18E+02
		I-131	8.041E+00	3.417E+17	6.76E-03	8.78E-02	5.30E+00	2.18E+02
		I-132	9.521E-02	5.020E+17	9.80E-02	4.32E-01	3.21E-01	0.00E+00
		I-133	8.667E-01	7.172E+17	1.43E-01	5.73E-01	2.15E+00	3.86E-04
		I-134	3.653E-02	7.850E+17	4.42E-02	2.94E-01	1.84E-01	0.00E+00
		I-135	2.744E-01	6.751E+17	3.29E-01	1.16E+00	1.14E+00	3.37E-16
3					4.53E-03	4.15E-02	6.67E+00	1.28E+04
	RB				0.00E+00	0.00E+00	1.23E-03	1.24E-03
		RB-86	1.865E+01	1.856E+14	0.00E+00	0.00E+00	1.23E-03	1.24E-03
	CS				4.53E-03	4.15E-02	6.67E+00	1.28E+04
		CS-134	7.524E+02	5.596E+16	4.53E-03	4.00E-02	4.45E+00	8.11E+03
		CS-136	1.300E+01	1.501E+16	0.00E+00	1.11E-03	8.43E-01	1.24E+00
		CS-137	1.099E+04	3.350E+16	0.00E+00	3.61E-04	1.38E+00	4.66E+03
4					6.02E-01	1.97E+00	1.89E+01	7.33E+00
	SB				8.66E-05	2.07E-02	7.39E-01	3.64E-02
		SB-127	3.800E+00	3.077E+16	0.00E+00	3.70E-04	6.33E-01	3.64E-02
		SB-129	1.808E-01	1.066E+17	.66E-05	2.03E-02	1.06E-01	2.96E-25
	TE				6.02E-01	1.95E+00	1.81E+01	7.29E+00
		TE-127	3.896E-01	2.970E+16	0.00E+00	0.00E+00	5.10E-03	3.03E-15
		TE-127M	1.090E+02	4.010E+15	0.00E+00	0.00E+00	7.50E-02	6.36E-02
		TE-129	4.861E-02	1.002E+17	0.00E+00	0.00E+00	1.25E-03	0.00E+00
		TE-129M	3.340E+01	2.634E+16	0.00E+00	0.00E+00	8.14E-01	3.01E-01
		TE-131M	1.250E+00	5.058E+16	8.05E-05	1.67E-02	7.27E-01	5.75E+00
		TE-132	3.250E+00	4.944E+17	6.02E-01	1.93E+00	1.65E+01	1.18E+00
5					2.60E-01	7.90E-01	7.13E+00	6.48E+03
	SR				2.60E-01	7.90E-01	7.13E+00	6.48E+03
		SR-89	5.200E+01	3.373E+17	9.20E-02	1.34E-02	2.83E+00	1.48E+03
		SR-90	1.026E+04	2.599E+16	0.00E+00	0.00E+00	2.87E+00	5.00E+03
		SR-91	3.950E-01	4.771E+17	1.19E-01	4.93E-01	1.03E+00	6.25E-02
		SR-92	1.129E-01	4.984E+17	4.86E-02	2.84E-01	3.97E-01	2.94E-30

Table B.4-1 (continued)

Release[1] Class	Element[2]	Isotope	Half-life (Days)	Release (bq)	Early[3] Fatalities	Early[4] Injuries	E.L.C.F.[5]	C.L.C.F.[6]
6					1.56E+00	6.91E-01	8.83E+01	1.90E+02
	CO				0.00E+00	0.00E+00	6.06E-01	3.88E+01
		CO-58	7.130E+01	2.024E+15	0.00E+00	0.00E+00	7.92E-02	7.28E-01
		CO-60	1.921E+03	2.423E+15	0.00E+00	0.00E+00	5.27E-01	3.81E+01
	MO				2.05E-01	2.32E-01	7.25E+00	9.51E-02
		MO-99	2.751E+00	6.436E+17	2.05E-01	2.32E-01	7.25E+00	9.51E-02
	TC				0.00E+00	3.37E-03	6.52E-02	8.03E-19
		TC-99M	2.508E-01	5.554E+17	0.00E+00	3.37E-03	6.52E-02	8.03E-19
	RU				1.35E+00	4.55E-01	7.99E+01	1.51E+02
		RU-103	3.959E+01	4.877E+17	1.09E-01	3.17E-01	1.12E+01	4.73E+01
		RU-105	1.850E-01	3.254E+17	3.26E-03	8.25E-02	2.75E-01	4.04E-05
		RU-106	3.690E+02	1.327E+17	1.24E+00	5.51E-02	6.84E+01	1.04E+02
	RH				0.00E+00	7.43E-04	5.08E-01	2.11E-04
		RH-105	1.479E+00	2.429E+17	0.00E+00	7.43E-04	5.08E-01	2.11E-04
7					5.21E+00	7.84E+00	1.84E+02	4.73E+02
	Y				1.03E+00	2.61E-01	2.95E+01	8.68E+00
		Y-90	2.670E+00	2.783E+16	0.00E+00	0.00E+00	4.47E-01	3.03E-04
		Y-91	5.880E+01	4.482E+17	8.21E-01	6.09E-02	2.77E+01	8.68E+00
		Y-92	1.475E-01	5.004E+17	3.40E-02	5.91E-02	1.64E-01	9.04E-31
		Y-93	4.208E-01	5.690E+17	1.77E-01	1.41E-01	1.15E+00	6.50E-12
	ZR				9.34E-01	2.75E+00	2.62E+01	3.15E+02
		ZR-95	6.550E+01	5.899E+17	3.14E-01	8.04E-01	2.06E+01	3.15E+02
		ZR-97	7.000E-01	6.073E+17	6.20E-01	1.95E+00	5.60E+00	2.38E-06
	NB				2.14E-01	7.37E-01	1.37E+01	7.14E+01
		NB-95	3.510E+01	5.581E+17	2.14E-01	7.37E-01	1.37E+01	7.14E+01
	LA				1.29E+00	4.06E+00	1.41E+01	8.38E-02
		LA-140	1.676E+00	6.655E+17	1.18E+00	[illegible].65E+00	1.37E+01	3.61E-02
		LA-141	1.641E-01	6.145E+17	1.84E-02	[illegible]14E-02	1.48E-01	4.77E-02
		LA-142	6.625E-02	5.917E+17	9.21E-02	4.[illegible]E-01	2.92E-01	0.00E+00
	PR				1.90E-01	1.94E-02	8.34E+00	4.31E-01
		PR-143	1.358E+01	5.643E+17	1.90E-01	1.94E-02	8.34E+00	4.31E-01
	ND				2.28E-02	1.19E-02	3.79E+00	1.16E+00
		ND-147	1.099E+01	2.522E+17	2.28E-02	1.19E-02	3.79E+00	1.16E+00
	AM				0.00E+00	0.00E+00	2.40E+00	3.79E+00
		AM-241	1.581E+05	2.903E+13	0.00E+00	0.00E+00	2.40E+00	3.79E+00
	CM				1.53E+00	0.00E+00	8.61E+01	7.22E+01
		CM-242	1.630E+02	7.667E+15	1.53E+00	0.00E+00	6.33E+01	4.29E+01
		CM-244	6.611E+03	4.137E+14	6.80E-04	0.00E+00	2.28E+01	2.93E+01
8					8.29E+00	5.41E+00	4.18E+02	4.36E+02
	CE				4.54E+00	4.92E-01	1.67E+02	1.54E+02
		CE-141	3.253E+01	5.922E+17	1.18E-01	3.32E-02	8.71E+00	9.07E+00
		CE-143	1.375E+00	5.765E+17	1.37E-01	2.19E-01	4.42E+00	5.06E-02
		CE-144	2.844E+02	3.841E+17	4.28E+00	2.40E-01	1.54E+02	1.45E+02
	NP				3.69E+00	4.92E+00	4.38E+01	7.83E-01
		NP-239	2.350E+00	7.516E+18	3.69E+00	4.92E+00	4.38E+01	7.83E-01

Table B.4-1 (continued)

Release[1] Class	Element[2]	Isotope	Half-life (Days)	Release (bq)	Early[3] Fatalities	Early[4] Injuries	E.L.C.F.[5]	C.L.C.F.[6]
	PU				6.09E-02	0.00E+00	2.07E+02	2.81E+02
		PU-238	3.251E+04	5.226E+14	6.08E-02	0.00E+00	9.36E+01	1.21E+02
		PU-239	8.912E+06	1.325E+14	0.00E+00	0.00E+00	2.25E+01	3.20E+01
		PU-240	2.469E+06	1.659E+14	1.39E-04	0.00E+00	2.86E+01	4.01E+01
		PU-241	5.333E+03	2.856E+16	0.00E+00	0.00E+00	6.20E+01	8.79E+01
9					2.39E-01	3.75E-01	2.97E+01	6.55E+01
	BA				2.39E-01	3.75E-01	2.97E+01	6.55E+01
		BA-139	5.771E-02	6.612E+17	0.00E+00	5.15E-03	1.61E-02	0.00E+00
		BA-140	1.279E+01	6.522E+17	2.39E-01	3.70E-01	2.97E+01	6.55E+01

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[1] The Release Class row contains the sum of the results for all isotopes in the release class.

[2] The Element row contains the sum of the results for all isotopes of the element.

[3] Mean number of early fatalities.

[4] Mean number of prodromal vomiting cases.

[5] Mean number of latent cancer fatalities due to early exposure (i.e., within 7 days of the accident).

[6] Mean number of latent cancer fatalities due to chronic exposure.

Table B.4-2
PARTITION Input File for Grand Gulf Analysis Containing Dose Factors, Reactor Inventory, Site-Specific MACCS Results, and Other Information Needed to Define the Early and Chronic Health Effect Weights

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GRAND GULF:  (1) B RATE, (2) CLD SF, (3) INH SF, (4) GRD SF, (5) DEP VEL
                2.66E-4        0.75          0.41          0.33         0.01
MACCS DOSE CONVERSION FILE:  MOD SER #32,  1-NOV-88, 10:20:02  (RED MARROW ONLY)
           CLOUDSHINE  GROUND    GROUND     GROUND     INHALED   INHALED   INGESTION
                       SHINE 8H  SHINE 7DAY SHINE RATE ACUTE     CHRONIC
60
CO-58      3.869E-14 2.179E-11 4.430E-10 7.579E-16 1.577E-10 8.226E-10 2.601E-10
CO-60      9.957E-14 5.032E-11 1.055E-09 1.747E-15 3.986E-10 1.718E-08 1.311E-09
KR-85      8.562E-17 0.000E+00 0.000E+00 0.000E+00 6.808E-14 7.007E-14 0.000E+00
KR-85M     5.549E-15 0.000E+00 0.000E+00 0.000E+00 6.369E-14 6.372E-14 0.000E+00
KR-87      3.456E-14 0.000E+00 0.000E+00 0.000E+00 2.179E-13 2.179E-13 0.000E+00
KR-88      1.156E-13 0.000E+00 0.000E+00 0.000E+00 3.666E-13 3.666E-13 0.000E+00
RB-86      3.805E-15 1.979E-12 3.662E-11 6.913E-17 8.076E-10 2.362E-09 3.789E-09
SR-89      5.518E-18 2.998E-15 6.017E-14 1.043E-19 9.360E-10 5.651E-09 3.261E-09
SR-90      0.000E+00 0.000E+00 0.000E+00 0.000E+00 1.725E-09 3.051E-07 1.752E-07
SR-91      3.936E-14 1.599E-11 3.760E-11 7.620E-16 7.944E-11 1.446E-10 1.233E-10
SR-92      5.327E-14 1.266E-11 1.556E-11 9.196E-16 4.114E-11 4.213E-11 4.225E-11
Y-90       0.000E+00 0.000E+00 0.000E+00 0.000E+00 8.668E-12 1.507E-11 3.664E-13
Y-91       1.436E-16 7.310E-14 1.476E-12 2.543E-18 2.798E-11 3.174E-10 5.562E-12
Y-92       1.012E-14 2.708E-12 3.423E-12 1.861E-16 2.061E-12 2.079E-12 4.930E-12
Y-93       3.712E-15 1.443E-12 3.427E-12 6.532E-17 3.495E-12 4.018E-12 4.936E-12
ZR-95      2.924E-14 1.656E-11 3.575E-10 5.740E-16 2.845E-10 3.207E-09 2.135E-10
ZR-97      5.084E-14 2.673E-11 1.044E-10 1.191E-15 1.079E-10 1.396E-10 1.297E-10
NB-95      3.051E-14 1.711E-11 3.367E-10 5.961E-16 1.212E-10 4.425E-10 1.993E-10
MO-99      6.057E-15 4.111E-12 5.687E-11 1.202E-16 3.098E-11 5.074E-11 7.872E-11
TC-99M     4.217E-15 1.755E-12 2.915E-12 9.323E-17 2.296E-12 2.369E-12 6.273E-12
RU-103     1.849E-14 1.093E-11 2.166E-10 3.606E-16 8.176E-11 3.183E-10 1.666E-10
RU-105     3.076E-14 1.021E-11 1.558E-11 6.152E-16 7.221E-12 7.686E-12 2.340E-11
RU-106     8.054E-15 4.622E-12 9.660E-11 1.608E-16 8.744E-11 1.770E-09 1.483E-09
RH-105     2.936E-15 1.682E-12 1.116E-11 6.310E-17 5.365E-12 7.746E-12 1.463E-11
SB-127     2.584E-14 1.456E-11 1.739E-10 5.200E-16 9.334E-11 1.547E-10 1.317E-10
SB-129     5.771E-14 1.811E-11 2.540E-11 1.078E-15 1.608E-11 1.654E-11 3.661E-11
TE-127     1.836E-16 8.405E-14 1.879E-13 3.869E-18 3.342E-12 3.986E-12 6.413E-12
TE-127M    2.632E-17 5.643E-14 2.669E-12 1.034E-18 2.769E-10 5.309E-09 5.373E-09
TE-129     2.042E-15 2.501E-13 2.522E-13 4.186E-17 6.131E-13 6.131E-13 7.610E-13
TE-129M    1.259E-15 1.344E-12 2.940E-11 2.524E-17 4.854E-10 3.038E-09 3.432E-09
TE-131M    6.028E-14 3.011E-11 1.918E-10 1.145E-15 9.441E-11 1.386E-10 2.393E-10
TE-132     7.642E-15 3.531E-11 6.006E-10 1.681E-16 2.300E-10 3.951E-10 4.064E-10
I-131      1.449E-14 8.678E-12 1.388E-10 3.057E-16 3.518E-11 6.260E-11 9.444E-11
I-132      9.132E-14 1.910E-11 2.099E-11 1.757E-15 1.401E-11 1.401E-11 2.450E-11
I-133      2.350E-14 1.196E-11 5.196E-11 4.725E-16 2.454E-11 2.717E-11 4.313E-11
I-134      1.059E-13 9.008E-12 9.025E-12 1.982E-15 6.067E-12 6.067E-12 1.090E-11
I-135      6.656E-14 2.377E-11 4.682E-11 1.165E-15 2.104E-11 2.231E-11 3.636E-11
XE-133     7.293E-16 0.000E+00 0.000E+00 0.000E+00 1.558E-13 1.686E-13 0.000E+00
XE-135     9.228E-15 0.000E+00 0.000E+00 0.000E+00 2.532E-13 2.554E-13 0.000E+00
CS-134     6.152E-14 3.488E-11 7.303E-10 1.211E-15 9.057E-10 1.178E-08 1.868E-08
CS-136     8.593E-14 4.655E-11 8.245E-10 1.630E-15 7.018E-10 1.855E-09 2.952E-09
CS-137     2.217E-14 1.260E-11 2.666E-10 4.410E-16 5.625E-10 8.295E-09 1.316E-08
BA-139     1.227E-15 1.841E-13 1.875E-13 2.607E-17 4.351E-12 4.351E-12 9.610E-13
BA-140     7.071E-15 7.296E-12 8.525E-10 1.471E-16 4.739E-10 1.221E-09 4.219E-10
LA-140     9.481E-14 4.419E-11 3.242E-10 1.643E-15 1.440E-10 2.124E-10 2.616E-10
LA-141     1.712E-15 4.545E-13 7.461E-13 2.917E-17 5.104E-12 6.845E-12 1.073E-12
LA-142     1.221E-13 1.521E-11 1.560E-11 1.899E-15 6.799E-12 6.799E-12 1.930E-11
CE-141     2.419E-15 1.556E-12 3.047E-11 5.422E-17 2.434E-11 8.891E-11 3.396E-11
CE-143     9.545E-15 5.330E-12 3.345E-11 2.010E-16 2.039E-11 2.953E-11 5.074E-11
CE-144     1.882E-15 9.613E-13 2.070E-11 3.457E-17 4.025E-11 2.786E-09 8.660E-11
PR-143     3.552E-22 1.963E-19 3.551E-18 6.644E-24 4.864E-12 1.497E-11 1.039E-12
ND-147     4.471E-15 2.729E-12 4.682E-11 9.576E-17 3.426E-11 9.219E-11 5.042E-11
NP-239     5.454E-15 3.314E-12 3.095E-11 1.208E-16 7.943E-11 2.075E-10 4.660E-11
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Table B.4-2 (continued)

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PU-238       4.535E 19 1.113E-15 2.040E-14 3.869E-20 2.552E-09 5.785E-05 1.266E-08
PU-239       1.671E-18 1.379E-15 2.665E-14 4.768E-20 2.400E-09 6.568E-05 1.405E-08
PU-240       4.681E-19 1.095E-15 2.301E-14 3.805E-20 2.400E-09 6.562E-05 1.405E-08
PU-241       0.000E+00 6.539E-19 3.146E-16 0.000E+00 4.411E-13 1.426E-06 2.780E-10
AM-241       3.203E-16 2.657E-13 5.580E-12 9.228E-18 4.847E-08 1.738E-04 1.448E-06
CM-242       4.915E-19 1.296E-15 2.684E-14 4.503E-20 5.125E-08 3.908E-06 3.581E-08
CM-244       3.583E-19 1.097E-15 2.301E-14 3.805E-20 5.102E-08 9.330E-05 7.760E-07
I-131 EARLY FATALITIES VS INVENTORY RELEASED
RELEASE      # EARLY FATALITIES
  (BQ)
16
 1.000E+18   1.65E-01
 2.000E+18   5.21E-01
 3.000E+18   1.02E+00
 5.000E+18   2.15E+00
 7.000E+18   3.40E+00
 1.000E+19   5.36E+00
 2.000E+19   1.36E+01
 3.000E+19   2.19E+01
 5.000E+19   4.01E+01
 7.000E+19   5.70E+01
 1.000E+20   8.03E+01
 2.000E+20   1.51E+02
 3.000E+20   2.25E+02
 5.000E+20   3.91E+02
 7.000E+20   5.87E+02
 1.000E+21   9.57E+02
ISOTOPE     HALF-LIFE   RELEASE      EARLY      EARLY     E.L.C.F.  C.L.C.F.
             (DAYS)      (BQ)     FATALITIES INJURIES
CO-58       7.130E+01  2.024E+15   0.00E+00   0.00E+00   7.92E-02  7.28E-01
CO-60       1.921E+03  2.423E+15   0.00E+00   0.00E+00   5.27E-01  3.81E+01
KR-85       3.919E+03  3.317E+15   0.00E+00   0.00E+00   1.27E-04  0.00E+00
KR-85M      1.867E-01  1.206E+17   0.00E+00   0.00E+00   [illegible].37E-03  0.00E+00
KR-87       5.278E-02  2.163E+17   0.00E+00   0.00E+00   1.44E-02  0.00E+00
KR-88       1.167E-01  2.960E+17   0.00E+00   1.50E-02   1.44E-01  0.00E+00
RB-86       1.865E+01  1.856E+14   0.00E+00   0.00E+00   1.23E-03  1.24E-03
SR-89       5.200E+01  3.673E+17   9.20E-02   1.34E-02   2.83E+00  1.48E+03
SR-90       1.026E+04  2.599E+16   0.00E+00   0.00E+00   2.87E+00  5.00E+03
SR-91       3.950E-01  4.771E+17   1.19E-01   4.93E-01   1.03E+00  6.25E-02
SR-92       1.129E-01  4.984E+17   4.86E-02   2.84E-01   3.97E-01  2.94E-30
Y-90        2.670E+00  2.783E+16   0.00E+00   0.00E+00   4.47E-01  3.03E-04
Y-91        5.880E+01  4.482E+17   8.21E-01   6.09E-02   2.[illegible]E-01  8.68E+00
Y-92        1.475E-01  5.004E+17   3.40E-02   5.91E-02   1.64E-01  9.04E-31
Y-93        4.208E-01  5.690E+17   1.77E-01   1.41E-01   1.15E+00  6.50E-12
ZR-95       6.550E+01  5.899E+17   3.14E-01   8.04E-01   2.06E+01  3.15E+02
ZR-97       7.000E-01  6.073E+17   6.20E-01   1.95E+00   5.60E+00  2.38E-06
NB-95       3.510E+01  5.581E+17   2.14E-01   7.37E-01   1.37E+01  7.14E+01
MO-99       2.751E+00  6.436E+17   2.05E-01   2.32E-01   7.25E+00  9.51E-02
TC-99M      2.508E-01  5.554E+17   0.00E+00   3.37E-03   6.52E-02  8.03E-19
RU-103      3.959E+01  4.877E+17   1.09E-01   3.17E-01   1.12E+01  4.73E+01
RU-105      1.850E-01  3.254E+17   3.26E-03   8.25E-02   2.75E-01  4.04E-05
RU-106      3.690E+02  1.327E+17   1.24E+00   5.51E-02   6.84E+01  1.04E+02
RH-105      1.479E+00  2.429E+17   0.00E+00   7.43E-04   5.08E-01  2.11E-04
SB-127      3.800E+00  3.077E+16   0.00E+00   3.70E-04   6.33E-01  3.64E-02
SB-129      1.808E-01  1.068E+17   8.66E-05   2.03E-02   1.06E-01  2.96E-25
TE-127      3.896E-01  2.979E+16   0.00E+00   0.00E+00   5.10E-03  3.03E-15
TE-127M     1.090E+02  4.010E+15   0.00E+00   0.00E+00   7.50E-02  6.36E-02
TE-129      4.861E-02  1.002E+17   0.00E+00   0.00E+00   1.25E-03  0.00E+00
TE-129M     3.340E+01  2.634E+16   0.00E+00   0.00E+00   8.14E-01  3.01E-01
TE-131M     1.250E+00  5.058E+16   8.05E-05   1.67E-02   7.27E-01  5.75E+00
TE-132      3.250E+00  4.944E+17   6.02E-01   1.93E+00   1.65E+01  1.18E+00
I-131       8.041E+00  3.417E+17   6.76E-03   8.78E-02   5.30E+00  2.18E+02
I-132       9.521E-02  5.020E+17   9.80E-02   4.32E-01   3.21E-01  0.00E+00
I-133       8.667E-01  7.172E+17   1.43E-01   5.73E-01   2.15E+00  3.86E-04
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Table B.4-2 (continued)

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I-134      3.653E-02   7.850E+17   4.42E-02  2.94E-01  1.84E-01  0.00E+00
I-135      2.744E-01   6.751E+17   3.29E-01  1.16E+00  1.14E+00  3.37E-16
XE-133     5.291E+00   7.182E+17   0.00E+00  0.00E+00  1.12E-01  0.00E+00
XE-135     3.821E-01   1.707E+17   0.00E+00  0.00E+00  1.80E-02  0.00E+00
CS-134     7.524E+02   5.596E+16   4.53E-03  4.00E-02  4.45E+00  8.11E+03
CS-136     1.300E+01   1.501E+16   0.00E+00  1.11E-03  8.43E-01  1.24E+00
CS-137     1.099E+04   3.350E+16   0.00E+00  3.61E-04  1.38E+00  4.66E+03
BA-139     5.771E-02   6.612E+17   0.00E+00  5.15E-03  1.61E-02  0.00E+00
BA-140     1.279E+01   6.522E+17   2.39E-01  3.70E-01  2.87E+01  6.55E+01
LA-140     1.676E+00   6.655E+17   1.18E+00  3.65E+00  1.27E+01  3.61E-02
LA-141     1.641E-01   6.145E+17   1.84E-02  1.14E-02  1.48E-01  4.77E-02
LA-142     6.625E-02   5.912E+17   9.21E-02  4.00E-01  2.92E-01  0.00E+00
CE-141     3.253E+01   5.922E+17   1.18E-01  3.32E-02  8.71E+00  9.07E+00
CE-143     1.375E+00   5.765E+17   1.37E-01  2.19E-01  4.42E+00  5.06E-02
CE-144     2.844E+02   3.641E+17   4.28E+00  2.40E-01  1.54E+02  1.45E+02
PR-143     1.358E+01   5.643E+17   1.90E-01  1.94E-02  5.34E+00  4.31E-01
ND-147     1.099E+01   2.522E+17   2.28E-02  1.19E-02  3.79E+00  1.16E+00
NP-239     2.350E+00   7.516E+18   3.69E+00  4.92E+00  4.38E+01  7.83E-01
PU-238     3.251E+04   5.226E+14   6.08E-02  0.00E+00  9.36E+01  1.21E+02
PU-239     8.912E+06   1.325E+14   0.00E+00  0.00E+00  2.25E+01  3.20E+01
PU-240     2.469E+06   1.659E+14   1.39E-04  0.00E+00  2.86E+01  4.01E+01
PU-241     5.333E+03   2.856E+16   0.00E+00  0.00E+00  6.20E+01  8.79E+01
AM-241     1.581E+05   2.903E+13   0.00E+00  0.00E+00  2.40E+00  3.79E+00
CM-242     1.630E+02   7.667E+15   1.53E+00  0.00E+00  6.33E+01  4.29E+01
CM-244     6.611E+03   4.137E+14   6.80E-04  0.00E+00  2.28E+01  2.93E+01
1.071        POWER LEVEL FOR GRAND GULF (BWR INVENTORY)
NUCNAM    IGROUP      HAFLIF      ACTIVITY
                        (S)         (BQ)
CO-58        6      6.160E+06  2.024E+16
CO-60        6      1.660E+08  2.423E+16
KR-85        1      3.386E+08  3.317E+15
KR-85M       1      1.613E+04  1.206E+17
KR-87        1      4.560E+03  2.193E+17
KR-88        1      1.008E+04  2.960E+17
RB-86        3      1.611E+06  1.856E+15
SR-89        5      4.493E+06  3.673E+18
SR-90        5      8.865E+08  2.599E+17
SR-91        5      3.413E+04  4.771E+18
SR-92        5      9.756E+03  4.984E+18
Y-90         7      2.307E+05  2.783E+17
Y-91         7      5.080E+06  4.482E+18
Y-92         7      1.274E+04  5.004E+18
Y-93         7      3.636E+04  5.690E+18
ZR-95        7      5.659E+06  5.899E+18
ZR-97        7      6.048E+04  6.073E+18
NB-95        7      3.033E+06  5.581E+18
MO-99        6      2.377E+05  6.436E+18
TC-99M       6      2.167E+04  5.554E+18
RU-103       6      3.421E+06  4.877E+18
RU-105       6      1.598E+04  3.254E+18
RU-106       6      3.188E+07  1.327E+18
RH-105       6      1.278E+05  2.429E+18
SB-127       4      3.283E+05  3.077E+17
SB-129       4      1.562E+04  1.068E+18
TE-127       4      3.366E+04  2.979E+17
TE-127M      4      9.418E+06  4.010E+16
TE-129       4      4.200E+03  1.002E+18
TE-129M      4      2.886E+06  2.634E+17
TE-131M      4      1.080E+05  5.058E+17
TE-132       4      2.808E+05  4.944E+18
I-131        2      6.947E+05  3.417E+18
I-132        2      8.226E+03  5.020E+18
I-133        2      7.488E+04  7.172E+18
I-134        2      3.156E+03  7.850E+18
```

Table B.4-2 (continued)

I-135	2	2.371E+04	6.751E+18
XE-133	1	4.571E+05	7.182E+17
XE-135	1	3.301E+04	1.707E+17
CS-134	3	6.501E+07	5.596E+17
CS-136	3	1.123E+06	1.501E+17
CS-137	3	9.495E+08	3.350E+17
BA-139	9	4.986E+03	6.612E+18
BA-140	9	1.105E+06	6.522E+18
LA-140	7	1.448E+05	6.655E+18
LA-141	7	1.418E+04	6.145E+18
LA-142	7	5.724E+03	5.912E+18
CE-141	8	2.811E+06	5.922E+18
CE-143	8	1.188E+05	5.765E+18
CE-144	8	2.457E+07	3.841E+18
PR-143	7	1.173E+06	5.643E+18
ND-147	7	9.495E+05	2.522E+18
NP-239	8	2.030E+05	7.516E+19
PU-238	8	2.809E+09	5.226E+15
PU-239	8	7.700E+11	1.325E+15
PU-240	8	2.133E+11	1.659E+15
PU-241	8	4.608E+08	2.856E+17
AM-241	7	1.366E+10	2.903E+14
CM-242	7	1.408E+07	7.667E+16
CM-244	7	5.712E+08	4.137E+15

B.5 REFERENCES

B.1 R. L. Iman, J. C. Helton, and J. D. Johnson, "A User's Guide for PARTITION: A Program for Defining the Source Term/Consequence Analysis Interface in the NUREG-1150 Probabilistic Risk Assessments," NUREG/CR-5253, SAND88-2940, Sandia National Laboratories, Albuquerque, NM, 1989.

APPENDIX C
SUPPORTING INFORMATION FOR THE CONSEQUENCE ANALYSIS

CONTENTS

TABLES

APPENDIX C
SUPPORTING INFORMATION FOR THE CONSEQUENCE ANALYSIS

Table C.1 provides a more detailed representation of the mean consequence analysis results for internal initiators at Grand Gulf than is given in Table 4.3-1. Table C.1 shows mean results for the population within 10 miles of the plant under the assumptions that everyone evacuates, everyone continues normal activity, and everyone takes shelter. Further, divisions of results between within 10 miles and beyond 10 miles and between early exposure (within 7 days) and chronic exposure (beyond 7 days) are also shown. In addition, the mean result for the effects of early exposure (obtained by combining the results for normal activity beyond 10 miles with the results for evacuation, normal activity, and sheltering within 10 miles) is listed. This result is labeled TOTAL EARLY in Table C.1. As indicated in the table, 99.5% of the population is assumed to evacuate, 0.5% is assumed to continue normal activity, and 0% is assumed to take shelter. The mean effects from early exposure are also combined with the mean effects from chronic exposure to produce a mean that includes effects from both early and chronic exposure (labeled TOTAL). The source terms used for the MACCS calculations that produced the results in Table C.1 are given in Table 3.4-4. A more detailed description of the information in each column of Table C.1 follows.

The column labeled EVACUATE, 0-10 MI contains the mean effects incurred by the population within 10 miles of the reactor due to radiation exposure within seven days of the accident under the assumption that everyone within 10 miles evacuates 1.25 hours after the warning time. For the two population dose consequence measures, the results are only for the part of the population initially within 10 miles. (The results for the population initially beyond 10 miles are in the column headed NORMAL ACTIVITY, >10 MI.) The value 0.995 in the row labeled WEIGHT at the top of the column indicates that 99.5% of the population within 10 miles evacuates; the results in this column are multiplied by 0.995 in the generation of the mean results in the columns headed TOTAL EARLY and TOTAL.

The column labeled NORMAL ACTIVITY, 0-10 MI contains the mean effects incurred by the population within 10 miles of the reactor due to radiation exposure within seven days of the accident under the assumption that everyone within 10 miles continues their normal activities after the accident. For the two population dose consequence measures, the results are for only the part of the population initially within 10 miles. (The results for the population initially beyond 10 miles are in the column headed NORMAL ACTIVITY, >10 MI.) The value 0.005 in the row labeled WEIGHT at the top of the column indicates that 0.5% of the population within 10 miles continues normal activities; the results in this column are multiplied by 0.005 in the generation of the mean results in the columns headed TOTAL EARLY and TOTAL.

The column labeled SHELTER, 0-10 MI contains the mean effects incurred by the population within 10 miles of the reactor due to radiation exposure within seven days of the accident under the assumption that everyone within 10 miles takes shelter 45 minutes after the warning time. For the two population dose consequence measures, the results are only for the part of the population initially within 10 miles. (The results for the population initially beyond 10 miles are in the column headed NORMAL ACTIVITY, >10 MI.) The value 0.000 in the row labeled WEIGHT at the top of the column indicates that none of the population within 10 miles takes shelter; the results in this column are ignored in computing the mean results.

The column labeled NORMAL ACTIVITY, >10 MI contains the mean effects incurred by the population further than 10 miles from the reactor due to radiation exposure within seven days of the accident under the assumption that everyone beyond 10 miles continues their normal activities. For the two population dose consequence measures, the results are only for the part of the population initially beyond 10 miles. The value 1.000 in the row labeled WEIGHT at the top of the column indicates that everyone beyond 10 miles continues normal activities; the results in this column are multiplied by 1.000 in the generation of the mean results in the columns headed TOTAL EARLY and TOTAL.

The column labeled TOTAL EARLY contains the total mean effects incurred by the entire population due to radiation exposure within seven days of the accident. The values in this column are weighted sums of the values in the first four columns as explained above.

The column labeled CHRONIC contains the total mean effects incurred by the entire population due to radiation exposure more than seven days after the accident.

The column labeled TOTAL contains the total mean effects incurred by the entire population due to both early (within 7 days) and chronic (after 7 days) radiation exposure. The values in this column are weighted sums of the values in columns 1, 2, 3, 4, and 6. The weights used are contained in the first row, labeled WEIGHT. As column 5 contains the weighted sum of columns 1 through 4, the TOTAL values may equivalently be obtained by summing columns 5 and 6.

Table C-1
Detailed Listing of Mean Consequence Results for Internal Initiators

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```
SOURCE TERM    GG-01-1, MEAN FREQUENCY = 1.51E-08 /YR
  CONSEQUENCE*            EVACUATE  NORMAL    SHELTER   NORMAL    TOTAL     CHRONIC   TOTAL
                                    ACTIVITY            ACTIVITY  EARLY

                          0-10 MI   0-10 MI   0-10 MI   >10 MI
WEIGHT                     0.995     0.005     0.000    1.000     ----      1.000     ----
EARLY FATALITIES          0.00E+00  5.88E-04  3.14E-04  0.00E+00  2.94E-06  ----      2.94E-06
PRODROM VOMITING          0.00E+00  1.25E-01  9.92E-02  0.00E+00  6.23E-04  ----      6.23E-04
EF RISK, 1 MI             0.00E+00  3.90E-06  2.46E-06  ----      1.95E-08  ----      1.95E-08
CANCER FATALITIES         0.00E+00  4.05E-01  3.34E-01  1.26E+00  1.26E+00  5.19E+00  6.46E+00
POP DOSE, 0-50 MI         0.00E+00  1.88E+01  1.48E+01  1.34E+01  1.35E+01  1.11E+02  1.25E+02
POP DOSE, 0-1000 MI       0.00E+00  1.88E+01  1.48E+01  7.62E+01  7.63E+01  3.39E+02  4.15E+02
ECONOMIC COSTS ($)        ----      ----      ----      ----      ----      7.50E+06  7.50E+06
POP EF RISK, 0-1 MI       0.00E+00  7.24E-06  [illegible].37E-06  ----      3.62E-08  ----      3.62E-08
POP CF RISK, 0-10 MI      0.00E+00  3.95E-05  3.26E-05  ----      1.97E-07  1.62E-05  1.64E-05


SOURCE TERM    GG-01-2, MEAN FREQUENCY = 4.34E-08 /YR
  CONSEQUENCE             EVACUATE  NORMAL    SHELTER   NORMAL    TOTAL     CHRONIC   TOTAL
                                    ACTIVITY            ACTIVITY  EARLY
                          0-10 MI   0-10 MI   0-10 MI   >10 MI
WEIGHT                     0.995     0.005     0.000    1.000     ----      1.000     ----
EARLY FATALITIES          0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  ----      0.00E+00
PRODROM VOMITING          0.00E+00  4.19E-02  3.26E-02  0.00E+00  2.10E-04  ----      2.10E-04
EF RISK, 1 MI             0.00E+00  0.00E+00  0.00E+00  ----      0.00E+00  ----      0.00E+00
CANCER FATALITIES         4.46E-04  3.14E-01  2.45E-01  1.19E+00  1.19E+00  6.21E+00  7.39E+00
POP DOSE, 0-50 MI         2.09E-02  1.62E+01  1.20E+01  1.28E+01  1.29E+01  1.27E+02  1.40E+02
POP DOSE, 0-1000 MI       2.09E-02  1.62E+01  1.20E+01  7.25E+01  7.26E+01  4.01E+02  4.74E+02
ECONOMIC COSTS ($)        ----      ----      ----      ----      ----      3.91E+06  3.91E+06
POP EF RISK, 0-1 MI       0.00E+00  0.00E+00  0.00E+00  ----      0.00E+00  ----      0.00E+00
POP CF RISK, 0-10 MI      4.35E-08  3.07E-05  2.39E-05  ----      1.97E-07  1.27E-05  1.29E-05


SOURCE TERM    GG-01-3, MEAN FREQUENCY = 0.00E+00 /YR


SOURCE TERM    GG-02-1, MEAN FREQUENCY = 8.26E-08 /YR
  CONSEQUENCE             EVACUATE  NORMAL    SHELTER   NORMAL    TOTAL     CHRONIC   TOTAL
                                    ACTIVITY            ACTIVITY  EARLY
                          0-10 MI   0-10 MI   0-10 MI   >10 MI
WEIGHT                     0.995     0.005     0.000    1.000     ----      1.000     ----
EARLY FATALITIES          0.00E+00  1.70E-02  9.02E-03  0.00E+00  8.48E-05  ----      8.48E-05
PRODROM VOMITING          0.00E+00  4.32E-01  3.31E-01  0.00E+00  2.16E-03  ----      2.16E-03
EF RISK, 1 MI             0.00E+00  7.33E-05  3.64E-05  ----      3.67E-07  ----      3.67E-07
CANCER FATALITIES         0.00E+00  1.27E+00  8.74E-01  2.95E+00  2.96E+00  2.89E+01  3.19E+01
POP DOSE, 0-50 MI         0.00E+00  7.44E+01  4.98E+01  5.61E+01  5.65E+01  3.62E+02  4.19E+02
POP DOSE, 0-1000 MI       0.00E+00  7.44E+01  4.98E+01  2.05E+02  2.06E+02  1.88E+03  2.09E+03
ECONOMIC COSTS ($)        ----      ----      ----      ----      ----      1.00E+08  1.00E+08
POP EF RISK, 0-1 MI       0.00E+00  2.05E-04  1.10E-04  ----      1.03E-06  ----      1.03E-06
POP CF RISK, 0-10 MI      0.00E+00  1.24E-04  8.52E-05  ----      6.21E-07  5.79E-05  5.85E-05
1

SOURCE TERM    GG-02-2, MEAN FREQUENCY = 8.30E-08 /YR
  CONSEQUENCE             EVACUATE  NORMAL    SHELTER   NORMAL    TOTAL     CHRONIC   TOTAL
                                    ACTIVITY            ACTIVITY  EARLY
                          0-10 MI   0-10 MI   0-10 MI   >10 MI
WEIGHT                     0.995     0.005     0.000    1.000     ----      1.000     ----
EARLY FATALITIES          0.00E+00  2.72E-04  1.29E-04  0.00E+00  1.36E-06  ----      1.36E-06
PRODROM VOMITING          0.00E+00  9.89E-02  7.32E-02  0.00E+00  4.94E-04  ----      4.94E-04
EF RISK, 1 MI             0.00E+00  2.97E-06  1.59E-06  ----      1.48E-08  ----      1.48E-08
```

Table C-1 (continued)

```
CANCER FATALITIES        5.68E-04  8.71E-01  5.64E-01  2.82E+00  2.82E+00  4.00E+01  4.28E+01
POP DOSE, 0-50 MI        2.80E-02  5.57E+01  3.61E+01  5.16E+01  5.19E+01  3.66E+02  4.18E+02
POP DOSE, 0-1000 MI      2.80E-02  5.57E+01  3.61E+01  1.96E+02  1.96E+02  2.52E+03  2.72E+03
ECONOMIC COSTS ($)         ----      ----      ----      ----      ----    1.45E+08  1.45E+08
POP EF RISK, 0-1 MI      0.00E+00  3.44E-06  1.64E-06    ----    1.72E-08    ----    1.72E-08
POP CF RISK, 0-10 MI     5.53E-08  8.49E-05  5.50E-05    ----    4.80E-07  5.11E-05  5.16E-05


SOURCE TERM    GG-02-3, MEAN FREQUENCY = 0.00E+00 /YR


SOURCE TERM    GG-03-1, MEAN FREQUENCY = 1.18E-07 /YR
  CONSEQUENCE            EVACUATE  NORMAL    SHELTER   NORMAL    TOTAL     CHRONIC   TOTAL
                                   ACTIVITY            ACTIVITY  EARLY
                         0-10 MI   0-10 MI   0-10 MI   >10 MI
WEIGHT                    0.995     0.005     0.000     1.000      ----     1.000      ----
EARLY FATALITIES         0.00E+00  2.03E-03  1.51E-05  0.00E+00  1.01E-05    ----    1.01E-05
PRODROM VOMITING         0.00E+00  1.20E-01  1.99E-02  0.00E+00  6.00E-04    ----    6.00E-04
EF RISK, 1 MI            0.00E+00  8.31E-07  0.00E+00    ----    4.16E-09    ----    4.16E-09
CANCER FATALITIES        0.00E+00  2.01E+00  1.09E+00  8.57E+00  8.58E+00  8.52E+01  9.38E+01
POP DOSE, 0-50 MI        0.00E+00  1.34E+02  7.77E+01  1.88E+02  1.88E+02  5.10E+02  6.98E+02
POP DOSE, 0-1000 MI      0.00E+00  1.34E+02  7.77E+01  6.66E+02  6.66E+02  5.56E+03  6.22E+03
ECONOMIC COSTS ($)         ----      ----      ----      ----      ----    6.83E+08  6.83E+08
POP EF RISK, 0-1 MI      0.00E+00  1.90E-05  1.91E-07    ----    9.52E-08    ----    9.52E-08
POP CF RISK, 0-10 MI     0.00E+00  1.96E-04  1.06E-04    ----    9.80E-07  6.60E-05  6.70E-05


SOURCE TERM    GG-03-2, MEAN FREQUENCY = 5.73E-08 /YR
  CONSEQUENCE            EVACUATE  NORMAL    SHELTER   NORMAL    TOTAL     CHRONIC   TOTAL
                                   ACTIVITY            ACTIVITY  EARLY
                         0-10 MI   0-10 MI   0-10 MI   >10 MI
WEIGHT                    0.995     0.005     0.000     1.000      ----     1.000      ----
EARLY FATALITIES         0.00E+00  1.03E-03  4.47E-04  0.00E+00  5.15E-06    ----    5.15E-06
PRODROM VOMITING         0.00E+00  1.42E-01  1.04E-01  0.00E+00  7.11E-04    ----    7.11E-04
EF RISK, 1 MI            0.00E+00  5.19E-06  3.15E-06    ----    2.59E-08    ----    2.59E-08
CANCER FATALITIES        6.27E-04  3.15E+00  2.23E+00  7.76E+00  7.78E+00  9.07E+01  9.85E+01
POP DOSE, 0-50 MI        3.22E-02  1.32E+02  9.40E+01  1.52E+02  1.53E+02  6.47E+02  8.00E+02
POP DOSE, 0-1000 MI      3.22E-02  1.32E+02  9.40E+01  5.41E+02  5.42E+02  5.67E+03  6.21E+03
ECONOMIC COSTS ($)         ----      ----      ----      ----      ----    5.92E+08  5.92E+08
POP EF RISK, 0-1 MI      0.00E+00  1.27E-05  5.66E-06    ----    6.37E-08    ----    6.37E-08
POP CF RISK, 0-10 MI     6.12E-08  3.07E-04  2.17E-04    ----    1.60E-06  7.47E-05  7.63E-05


SOURCE TERM    GG-03-3, MEAN FREQUENCY = 0.00E+00 /YR
1


SOURCE TERM    GG-04-1, MEAN FREQUENCY = 9.16E-08 /YR
  CONSEQUENCE            EVACUATE  NORMAL    SHELTER   NORMAL    TOTAL     CHRONIC   TOTAL
                                   ACTIVITY            ACTIVITY  EARLY
                         0-10 MI   0-10 MI   0-10 MI   >10 MI
WEIGHT                    0.995     0.005     0.000     1.000      ----     1.000      ----
EARLY FATALITIES         0.00E+00  3.59E-05  0.00E+00  0.00E+00  1.80E-07    ----    1.80E-07
PRODROM VOMITING         0.00E+00  9.96E-03  9.03E-05  0.00E+00  4.98E-05    ----    4.98E-05
EF RISK, 1 MI            0.00E+00  0.00E+00  0.00E+00    ----    0.00E+00    ----    0.00E+00
CANCER FATALITIES        0.00E+00  8.92E-01  2.97E-01  5.66E+00  5.66E+00  7.48E+01  8.05E+01
POP DOSE, 0-50 MI        0.00E+00  7.09E+01  2.65E+01  1.21E+02  1.21E+02  4.48E+02  5.68E+02
POP DOSE, 0-1000 MI      0.00E+00  7.09E+01  2.65E+01  4.41E+02  4.41E+02  4.78E+03  5.22E+03
ECONOMIC COSTS ($)         ----      ----      ----      ----      ----    3.47E+08  3.47E+08
```

Table C-1 (continued)

POP EF RISK, 0-1 MI	0.00E+00	3.44E-07	0.00E+00	----	1.72E-09	----	1.72E-09
POP CF RISK, 0-10 MI	0.00E+00	8.70E-05	2.90E-05	----	4.35E-07	5.83E-05	5.87E-05

SOURCE TERM GG-04-2, MEAN FREQUENCY = 2.30E-[illegible] /YR

CONSEQUENCE	EVACUATE	NORMAL ACTIVITY	SHELTER	NORMAL ACTIVITY	TOTAL EARLY	CHRONIC	TOTAL
	0-10 MI	0-10 MI	0-10 MI	>10 MI			
WEIGHT	0.995	0.005	0.000	1.000	----	1.000	----
EARLY FATALITIES	0.00E+00	1.18E-04	1.51E-05	0.00E+00	5.89E-07	----	5.89E-07
PRODROM VOMITING	0.00E+00	6.89E-03	2.48E-03	0.00E+00	3.44E-05	----	3.44E-05
EF RISK, 1 MI	0.00E+00	0.00E+00	0.00E+00	----	0.00E+00	----	0.00E+00
CANCER FATALITIES	4.55E-04	1.01E+00	6.17E-01	4.06E+00	4.07E+00	8.17E+01	8.58E+01
POP DOSE, 0-50 MI	2.48E-02	7.93E+01	5.23E+01	9.87E+01	9.91E+01	7.08E+02	8.07E+02
POP DOSE, 0-1000 MI	2.48E-02	7.93E+01	5.23E+01	3.17E+02	3.17E+02	4.98E+03	5.29E+03
ECONOMIC COSTS ($)	----	----	----	----	----	1.85E+08	1.85E+08
POP EF RISK, 0-1 MI	0.00E+00	1.4[illegible]-06	1.92E-07	----	7.46E-09	----	7.46E-09
POP CF RISK, 0-10 MI	4.44E-08	9.84E-05	6.01E-05	----	5.36E-07	8.16E-05	8.22E-05

SOURCE TERM GG-04-3, MEAN FREQUENCY = 0.00E+00 /YR

SOURCE TERM GG-05-1, MEAN FREQUENCY = 1.07E-07 /YR

CONSEQUENCE	EVACUATE	NORMAL ACTIVITY	SHELTER	NORMAL ACTIVITY	TOTAL EARLY	CHRONIC	TOTAL
	0-10 MI	0-10 MI	0-10 MI	>10 MI			
WEIGHT	0.995	0.005	0.000	1.000	----	1.000	----
EARLY FATALITIES	0.00E+00	4.39E-01	1.17E-03	0.00E+00	2.19E-03	----	2.19E-03
PRODROM VOMITING	0.00E+00	2.91E+00	1.07E-01	2.13E-02	3.58E-02	----	3.58E-02
EF RISK, 1 MI	0.00E+00	1.20E-03	1.01E-07	----	6.00E-06	----	6.00E-06
CANCER FATALITIES	0.00E+00	7.00E+00	1.85E+00	3.85E+01	3.88E+01	1.64E+02	2.02E+02
POP DOSE, 0-50 MI	0.00E+00	5.29E+02	1.64E+02	8.75E+02	8.78E+02	9.41E+02	1.82E+03
POP DOSE, 0-1000 MI	0.00E+00	5.29E+02	1.64E+02	3.21E+03	3.22E+03	1.12E+04	1.44E+04
ECONOMIC COSTS ($)	----	----	----	----	----	1.62E+09	1.62E+09
POP EF RISK, 0-1 MI	0.00E+00	4.04E-03	1.32E-05	----	2.02E-05	----	2.02E-05
POP CF RISK, 0-10 MI	0.00E+00	6.80E-04	1.80E-04	----	3.41E-06	9.21E-05	9.55E-05

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SOURCE TERM GG-05-2, MEAN FREQUENCY = 7.36E-08 /YR

CONSEQUENCE	EVACUATE	NORMAL ACTIVITY	SHELTER	NORMAL ACTIVITY	TOTAL EARLY	CHRONIC	TOTAL
	0-10 MI	0-10 MI	0-10 MI	>10 MI			
WEIGHT	0.995	0.005	0.000	1.000	----	1.000	----
EARLY FATALITIES	0.00E+00	8.37E-02	3.86E-02	0.00E+00	4.19E-04	----	4.19E-04
PRODROM VOMITING	0.00E+00	1.22E+00	6.75E-01	0.00E+00	6.10E-03	----	6.10E-03
EF RISK, 1 MI	0.00E+00	2.92E-04	9.17E-05	----	1.46E-06	----	1.46E-06
CANCER FATALITIES	7.28E-04	1.38E+01	1.03E+01	2.84E+01	2.85E+01	1.55E+02	1.83E+02
POP DOSE, 0-50 MI	3.86E-02	5.00E+02	3.82E+02	5.79E+02	5.82E+02	1.03E+03	1.61E+03
POP DOSE, 0-1000 MI	3.86E-02	5.00E+02	3.82E+02	2.07E+03	2.08E+03	1.05E+04	1.26E+04
ECONOMIC COSTS ($)	----	----	----	----	----	3.05E+09	3.05E+09
POP EF RISK, 0-1 MI	0.00E+00	1.00E-03	4.76E-04	----	5.02E-06	----	5.02E-06
POP CF RISK, 0-10 MI	7.10E-08	1.35E-03	1.01E-03	----	6.60E-06	9.94E-05	1.06E-04

SOURCE TERM GG-05-3, MEAN FREQUENCY = 0.00E+00 /YR

Table C-1 (continued)

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SOURCE TERM    GG-06-1, MEAN FREQUENCY = 1.60E-07 /YR
  CONSEQUENCE              EVACUATE  NORMAL    SHELTER    NORMAL    TOTAL     CHRONIC    TOTAL
                                     ACTIVITY             ACTIVITY  EARLY
                           0-10 MI   0-10 MI   0-10 MI    >10 MI
WEIGHT                      0.995     0.005     0.000     1.000     ----      1.000      ----
EARLY FATALITIES           0.00E+00  7.32E-03  4.07E-05  0.00E+00  3.66E-05    ----     3.66E-05
PRODROM VOMITING           0.00E+00  2.32E-01  3.27E-02  0.00E+00  1.16E-03    ----     1.16E-03
EF RISK, 1 MI              0.00E+00  1.28E-05  0.00E+00    ----    6.40E-08    ----     6.40E-08
CANCER FATALITIES          0.00E+00  2.63E+00  1.33E+00  1.30E+01  1.30E+01  1.93E+02  2.06E+02
POP DOSE, 0-50 MI          0.00E+00  1.71E+02  9.41E+01  2.65E+02  2.66E+02  1.19E+03  1.45E+03
POP DOSE, 0-1000 MI        0.00E+00  1.71E+02  9.41E+01  9.56E+02  9.57E+02  1.19E+04  1.29E+04
ECONOMIC COSTS ($)           ----      ----      ----      ----      ----    2.43E+09  2.43E+09
POP EF RISK, 0-1 MI        0.00E+00  7.36E-05  5.16E-07    ----    3.68E-07    ----     3.68E-07
POP CF RISK, 0-10 MI       0.00E+00  2.57E-04  1.29E-04    ----    1.28E-06  1.35E-04  1.36E-04


SOURCE TERM    GG-06-2, MEAN FREQUENCY = 6.29E-08 /YR
  CONSEQUENCE              EVACUATE  NORMAL    SHELTER    NORMAL    TOTAL     CHRONIC    TOTAL
                                     ACTIVITY             ACTIVITY  EARLY
                           0-10 MI   0-10 MI   0-10 MI    >10 MI
WEIGHT                      0.995    [illegible]05  0.0[illegible]  1.000     ----      1.000      ----
EARLY FATALITIES           0.00E+00  1[illegible]-03  3[illegible]-04  0.00E+00  6.55E-06    ----     6.55E-06
PRODROM VOMITING           0.00E+00  1[illegible]  [illegible]8E-02  0.00E+00  7.50E-04    ----     7.50E-04
EF RISK, 1 MI              0.00E+00  3.33[illegible]  6.13E-07    ----    1.67E-08    ----     1.67E-08
CANCER FATALITIES          6.08E-04  2.36E+00  1.56E+00  8.05E+00  8.06E+00  2.90E+02  2.98E+02
POP DOSE, 0-50 MI          3.65E-02  1.30E+02  8.87E+01  1.71E+02  1.71E+02  1.46E+03  1.63E+03
POP DOSE, 0-1000 MI        3.65E-02  1.30E+02  8.87E+01  5.73E+02  5.74E+02  1.67E+04  1.73E+04
ECONOMIC COSTS ($)           ----      ----      ----      ----      ----    9.89E+08  9.89E+08
POP EF RISK, 0-1 MI        0.00E+00  1.66E-05  4.19E-06    ----    8.29E-08    ----     8.29E-08
POP CF RISK, 0-10 MI       5.93E-08  2.30E-04  1.52E-04    ----    1.21E-06  1.53E-04  1.54E-04


SOURCE TERM    GG-06-3, MEAN FREQUENCY = 0.00E+00 /YR
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SOURCE TERM    GG-07-1, MEAN FREQUENCY = 4.79E-07 /YR
  CONSEQUENCE              EVACUATE  NORMAL    SHELTER    NORMAL    TOTAL     CHRONIC    TOTAL
                                     ACTIVITY             ACTIVITY  EARLY
                           0-10 MI   0-10 MI   0-10 MI    >10 MI
WEIGHT                      0.995     0.005     0.000     1.000     ----      1.000      ----
EARLY FATALITIES           0.00E+00  3.42E-03  0.00E+00  0.00E+00  1.71E-05    ----     1.71E-05
PRODROM VOMITING           0.00E+00  5.94E-02  0.00E+00  0.00E+00  2.97E-04    ----     2.97E-04
EF RISK, 1 MI              0.00E+00  1.23E-06  0.00E+00    ----    6.17E-09    ----     6.17E-09
CANCER FATALITIES          0.00E+00  2.12E+00  4.48E-04  1.78E+01  1.78E+01  1.65E+02  1.83E+02
POP DOSE, 0-50 MI          0.00E+00  1.12E+02  2.68E-02  3.04E+02  3.04E+02  9.73E+02  1.28E+03
POP DOSE, 0-1000 MI        0.00E+00  1.12E+02  2.68E-02  1.27E+03  1.27E+03  1.07E+04  1.19E+04
ECONOMIC COSTS ($)           ----      ----      ----      ----      ----    3.47E+09  3.47E+09
POP EF RISK, 0-1 MI        0.00E+00  2.28E-05  0.00E+00    ----    1.14E-07    ----     1.14E-07
POP CF RISK, 0-10 MI       0.00E+00  2.06E-04  4.37E-08    ----    1.03E-06  9.29E-05  9.40E-05


SOURCE TERM    GG-07-2, MEAN FREQUENCY = 1.06E-08 /YR
  CONSEQUENCE              EVACUATE  NORMAL    SHELTER    NORMAL    TOTAL     CHRONIC    TOTAL
                                     ACTIVITY             ACTIVITY  EARLY
                           0-10 MI   0-10 MI   0-10 MI    >10 MI
WEIGHT                      0.995     0.005     0.000     1.000     ----      1.000      ----
EARLY FATALITIES           0.00E+00  3.48E-05  3.37E-06  0.00E+00  1.74E-07    ----     1.74E-07
PRODROM VOMITING           0.00E+00  9.14E-03  3.26E-03  0.00E+00  4.57E-05    ----     4.57E-05
EF RISK, 1 MI              0.00E+00  0.00E+00  0.00E+00    ----    0.00E+00    ----     0.00E+00
CANCER FATALITIES          1.40E-03  1.91E+00  1.19E+00  8.17E+00  8.18E+00  2.90E+02  2.98E+02
POP DOSE, 0-50 MI          8.86E-02  1.05E+02  6.87E+01  1.62E+02  1.63E+02  1.44E+03  1.60E+03
POP DOSE, 0-1000 MI        8.86E-02  1.05E+02  6.87E+01  5.78E+02  5.79E+02  1.69E+04  1.75E+04
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Table C-1 (continued)

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ECONOMIC COSTS ($)          ----      ----      ----       ----      ----    1.54E+09  1.54E+09
POP EF RISK, 0-1 MI       0.00E+00  4.41E-07  4.27E-08     ----    2.21E-09    ----    2.21E-09
POP CF RISK, 0-10 MI      1.36E-07  1.86E-04  1.16E-04     ----    1.06E-06  1.46E-04  1.47E-04


SOURCE TERM    GG-07-3, MEAN FREQUENCY = 0.00E+00 /YR


SOURCE TERM    GG-08-1, MEAN FREQUENCY = 2.22E-07 /YR
  CONSEQUENCE             EVACUATE   NORMAL   SHELTER    NORMAL    TOTAL    CHRONIC    TOTAL
                                    ACTIVITY            ACTIVITY   EARLY
                          0-10 MI   0-10 MI   0-10 MI    >10 MI
WEIGHT                     0.995     0.005     0.000     1.000      ----     1.000      ----
EARLY FATALITIES          0.00E+00  7.04E-01  1.91E-01  0.00E+00  3.52E-03    ----    3.52E-03
PRODROM VOMITING          0.00E+00  4.21E+00  1.67E+00  0.00E+00  2.11E-02    ----    2.11E-02
EF RISK, 1 MI             0.00E+00  4.15E-03  8.37E-04    ----    2.07E-05    ----    2.07E-05
CANCER FATALITIES         0.00E+00  1.10E+01  7.67E+00  2.94E+01  2.94E+01  3.68E+02  3.97E+02
POP DOSE, 0-50 MI         0.00E+00  5.51E+02  3.92E+02  6.24E+02  6.26E+02  2.[illegible]E+03  2.63E+03
POP DOSE, 0-1000 MI       0.00E+00  5.51E+02  3.92E+02  2.09E+03  2.09E+03  2.26E+04  2.47E+04
ECONOMIC COSTS ($)          ----      ----      ----      ----      ----    4.79E+09  4.79E+09
POP EF RISK, 0-1 MI       0.00E+00  7.62E-03  2.29E-03    ----    3.81E-05    ----    3.81E-05
POP CF RISK, 0-10 MI      0.00E+00  1.08E-03  7.48E-04    ----    5.38E-06  1.62E-04  1.68E-04
1


SOURCE TERM    GG-08-2, MEAN FREQUENCY = 1.40E-07 /YR
  CONSEQUENCE             EVACUATE   NORMAL   SHELTER    NORMAL    TOTAL    CHRONIC    TOTAL
                                    ACTIVITY            ACTIVITY   EARLY
                          0-10 MI   0-10 MI   0-10 MI    >10 MI
WEIGHT                     0.995     0.005     0.000     1.000      ----     1.000      ----
EARLY FATALITIES          0.00E+00  1.85E-01  7.61E-02  0.00E+00  9.24E-04    ----    9.24E-04
PRODROM VOMITING          0.00E+00  2.31E+00  1.14E+00  0.00E+00  1.15E-02    ----    1.15E-02
EF RISK, 1 MI             0.00E+00  5.27E-04  1.55E-04    ----    2.63E-06    ----    2.63E-06
CANCER FATALITIES         5.56E-03  2.06E+01  1.54E+01  5.27E+01  5.29E+01  5.20E+02  5.73E+02
POP DOSE, 0-50 MI         2.67E-01  6.94E+02  5.28E+02  9.79E+02  9.82E+02  2.20E+03  3.18E+03
POP DOSE, 0-1000 MI       2.67E-01  6.94E+02  5.28E+02  3.58E+03  3.58E+03  3.22E+04  3.58E+04
ECONOMIC COSTS ($)          ----      ----      ----      ----      ----    7.13E+09  7.13E+09
POP EF RISK, 0-1 MI       0.00E+00  2.15E-03  9.32E-04    ----    1.07E-05    ----    1.07E-05
POP CF RISK, 0-10 MI      5.42E-07  2.00E-03  1.50E-03    ----    1.06E-05  1.29E-04  1.39E-04


SOURCE TERM    GG-08-3, MEAN FREQUENCY = 0.00E+00 /YR


SOURCE TERM    GG-09-1, MEAN FREQUENCY = 1.59E-07 /YR
  CONSEQUENCE             EVACUATE   NORMAL   SHELTER    NORMAL    TOTAL    CHRONIC    TOTAL
                                    ACTIVITY            ACTIVITY   EARLY
                          0-10 MI   0-10 MI   0-10 MI    >10 MI
WEIGHT                     0.995     0.005     0.000     1.000      ----     1.000      ----
EARLY FATALITIES          0.00E+00  1.29E-02  0.00E+00  0.00E+00  6.45E-05    ----    6.45E-05
PRODROM VOMITING          0.00E+00  1.98E-01  9.08E-04  0.00E+00  9.90E-04    ----    9.90E-04
EF RISK, 1 MI             0.00E+00  4.87E-05  0.00E+00    ----    2.43E-07    ----    2.43E-07
CANCER FATALITIES         0.00E+00  3.21E+00  5.86E-01  2.35E+01  2.35E+01  5.87E+02  6.10E+02
POP DOSE, 0-50 MI         0.00E+00  1.76E+02  3.66E+01  4.05E+02  4.06E+02  2.15E+03  2.56E+03
POP DOSE, 0-1000 MI       0.00E+00  1.76E+02  3.66E+01  1.58E+03  1.58E+03  3.43E+04  3.59E+04
ECONOMIC COSTS ($)          ----      ----      ----      ----      ----    3.96E+09  3.96E+09
POP EF RISK, 0-1 MI       0.00E+00  1.01E-04  0.00E+00    ----    5.05E-07    ----    5.05E-07
POP CF RISK, 0-10 MI      0.00E+00  3.13E-04  5.72E-05    ----    1.57E-06  1.71E-04  1.72E-04


SOURCE TERM    GG-09-2, MEAN FREQUENCY = 3.63E-08 /YR
  CONSEQUENCE             EVACUATE   NORMAL   SHELTER    NORMAL    TOTAL    CHRONIC    TOTAL
                                    ACTIVITY            ACTIVITY   EARLY
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Table C-1 (continued)

	0-10 MI	0-10 MI	0-10 MI	>10 MI			
WEIGHT	0.995	0.005	0.000	1.000	----	1.000	----
EARLY FATALITIES	0.00E+00	1.12E-02	3.96E-03	0.00E+00	5.59E-05	----	5.59E-05
PRODROM VOMITING	0.00E+00	1.89E-01	8.77E-02	0.00E+00	9.47E-04	----	[illegible]
EF RISK, 1 MI	0.00E+00	9.94E-06	9.17E-07	----	4.97E-08		4.97E-08
CANCER FATALITIES	5.05E-04	4.81E+00	3.35E+00	1.64E+01	1.64E+01	4.51E+02	4.67E+02
POP DOSE, 0-50 MI	3.17E-02	2.16E+02	1.55E+02	3.35E+02	3.36E+02	1.85E+03	2.19E+03
POP DOSE, 0-1000 MI	3.17E-02	2.16E+02	1.55E+02	1.13E+03	1.14E+03	2.64E+04	2.75E+04
ECONOMIC COSTS ($)	----	----	----	----	----	2.84E+09	2.84E+09
POP EF RISK, 0-1 MI	0.00E+00	1.40E-04	5.02E-05	----	7.02E-07	----	7.02E-07
POP CF RISK, 0-10 MI	4.93E-08	4.69E-04	3.27E-04	----	2.40E-06	1.26E-04	1.29E-04

SOURCE TERM GG-09-3, MEAN FREQUENCY = 0.00E+00 /YR

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SOURCE TERM GG-10-1, MEAN FREQUENCY = 2.07E-07 /YR

CONSEQUENCE	EVACUATE 0-10 MI	NORMAL ACTIVITY 0-10 MI	SHELTER 0-10 MI	NORMAL ACTIVITY >10 MI	TOTAL EARLY	CHRONIC	TOTAL
WEIGHT	0.995	0.005	0.000	1.000	----	1.000	----
EARLY FATALITIES	0.00E+00	9.82E-04	0.00E+00	0.00E+00	4.91E-06	----	4.91E-06
PRODROM VOMITING	0.00E+00	6.53E-02	0.00E+00	0.00E+00	3.27E-04	----	3.27E-04
EF RISK, 1 MI	0.00E+00	4.52E-07	0.00E+00	----	2.26E-09	----	2.26E-09
CANCER FATALITIES	0.00E+00	2.01E+00	0.00E+00	1.43E+01	1.43E+01	6.13E+02	6.27E+02
POP DOSE, 0-50 MI	0.00E+00	1.22E+02	0.00E+00	2.56E+02	2.57E+02	2.32E+03	2.58E+03
POP DOSE, 0-1000 MI	0.00E+00	1.22E+02	0.00E+00	9.59E+02	9.60E+02	3.49E+04	3.59E+04
ECONOMIC COSTS ($)	----	----	----	----	----	1.96E+09	1.96E+09
POP EF RISK, 0-1 MI	0.00E+00	1.24E-05	0.00E+00	----	6.19E-08	----	6.19E-08
POP CF RISK, 0-10 MI	0.00E+00	1.96E-04	0.00E+00	----	9.82E-07	1.96E-04	1.97E-04

SOURCE TERM GG-10-2, MEAN FREQUENCY = 4.07E-09 /YR

CONSEQUENCE	EVACUATE 0-10 MI	NORMAL ACTIVITY 0-10 MI	SHELTER 0-10 MI	NORMAL ACTIVITY >10 MI	TOTAL EARLY	CHRONIC	TOTAL
WEIGHT	0.995	0.005	0.000	1.000	----	1.000	----
EARLY FATALITIES	0.00E+00	1.41E-03	1.78E-04	0.00E+00	7.03E-06	----	7.03E-06
PRODROM VOMITING	0.00E+00	3.43E-02	1.34E-02	0.00E+00	1.72E-04	----	1.72E-04
EF RISK, 1 MI	0.00E+00	3.44E-09	0.00E+00	----	1.72E-11	----	1.72E-11
CANCER FATALITIES	2.62E-04	3.15E+00	2.05E+00	1.37E+01	1.37E+01	4.88E+02	5.02E+02
POP DOSE, 0-50 MI	1.85E-02	1.57E+02	1.06E+02	2.62E+02	2.63E+02	2.04E+03	2.31E+03
POP DOSE, 0-1000 MI	1.85E-02	1.57E+02	1.06E+02	9.33E+02	9.34E+02	2.84E+04	2.94E+04
ECONOMIC COSTS ($)	----	----	----	----	----	3.12E+09	3.12E+09
POP EF RISK, 0-1 MI	0.00E+00	1.78E-05	2.26E-06	----	8.88E-08	----	8.88E-08
POP CF RISK, 0-10 MI	2.55E-08	3.07E-04	2.00E-04	----	1.56E-06	1.48E-04	1.49E-04

SOURCE TERM GG-10-3, MEAN FREQUENCY = 0.00E+00 /YR

SOURCE TERM GG-11-1, MEAN FREQUENCY = 3.44E-08 /YR

CONSEQUENCE	EVACUATE 0-10 MI	NORMAL ACTIVITY 0-10 MI	SHELTER 0-10 MI	NORMAL ACTIVITY >10 MI	TOTAL EARLY	CHRONIC	TOTAL
WEIGHT	0.995	0.005	0.000	1.000	----	1.000	----
EARLY FATALITIES	0.00E+00	8.05E+00	3.83E+00	0.00E+00	4.02E-02	----	4.02E-02
PRODROM VOMITING	0.00E+00	2.33E+01	1.22E+01	7.65E-04	1.17E-01	----	1.17E-01
EF RISK, 1 MI	0.00E+00	3.10E-02	1.95E-02	----	1.55E-04	----	1.55E-04
CANCER FATALITIES	0.00E+00	3.42E+01	2.72E+01	8.33E+01	8.35E+01	8.58E+02	9.41E+02
POP DOSE, 0-50 MI	0.00E+00	1.61E+03	1.20E+03	1.46E+03	1.47E+03	3.26E+03	4.73E+03
POP DOSE, 0-1000 MI	0.00E+00	1.61E+03	1.20E+03	5.57E+03	5.57E+03	5.18E+04	5.73E+04

Table C-1 (continued)

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ECONOMIC COSTS ($)            ----      ----      ----      ----      ----    8.79E+09  8.79E+09
POP EF RISK, 0-1 MI         0.00E+00  4.11E-02  2.84E-02    ----    2.06E-04    ----    2.06E-04
POP CF RISK, 0-10 MI        0.00E+00  3.34E-03  2.66E-03    ----    1.67E-05  1.24E-04  1.40E-04
1


SOURCE TERM    GG-11-2, MEAN FREQUENCY = 7.30E-08 /YR
  CONSEQUENCE               EVACUATE   NORMAL   SHELTER    NORMAL    TOTAL    CHRONIC    TOTAL
                                      ACTIVITY            ACTIVITY   EARLY
                            0-10 MI   0-10 MI   0-10 MI    >10 MI
WEIGHT                       0.995     0.005     0.000     1.000     ----     1.000      ----
EARLY FATALITIES            0.00E+00  3.79E+00  1.65E+00  0.00E+00  1.90E-02    ----    1.90E-02
PRODROM VOMITING            0.00E+00  2.13E+01  1.07E+01  1.03E-01  2.09E-01    ----    2.09E-01
EF RISK, 1 MI               0.00E+00  1.32E-02  7.26E-03    ----    6.59E-05    ----    6.59E-05
CANCER FATALITIES           2.86E-02  5.62E+01  4.41E+01  1.43E+02  1.44E+02  1.14E+03  1.29E+03
POP DOSE, 0-50 MI           9.93E-01  1.87E+03  1.45E+03  2.35E+03  2.36E+03  3.48E+03  5.84E+03
POP DOSE, 0-1000 MI         9.93E-01  1.87E+03  1.45E+03  9.22E+03  9.23E+03  6.92E+04  7.84E+04
ECONOMIC COSTS ($)            ----      ----      ----      ----      ----    1.11E+10  1.11E+10
POP EF RISK, 0-1 MI         0.00E+00  2.13E-02  1.41E-02    ----    1.07E-04    ----    1.07E-04
POP CF RISK, 0-10 MI        2.79E-06  5.48E-03  4.30E-03    ----    3.02E-05  1.08E-04  1.38E-04


SOURCE TERM    GG-11-3, MEAN FREQUENCY = 0.00E+00 /YR


SOURCE TERM    GG-12-1, MEAN FREQUENCY = 3.62E-08 /YR
  CONSEQUENCE               EVACUATE   NORMAL   SHELTER    NORMAL    TOTAL    CHRONIC    TOTAL
                                      ACTIVITY            ACTIVITY   EARLY
                            0-10 MI   0-10 MI   0-10 MI    >10 MI
WEIGHT                       0.995     0.005     0.000     1.000     ----     1.000      ----
EARLY FATALITIES            0.00E+00  9.98E-01  1.53E-01  0.00E+00  4.99E-03    ----    4.99E-03
PRODROM VOMITING            0.00E+00  5.24E+00  1.03E+00  1.82E-02  4.44E-02    ----    4.44E-02
EF RISK, 1 MI               0.00E+00  5.16E-03  2.73E-04    ----    2.58E-05    ----    2.58E-05
CANCER FATALITIES           0.00E+00  2.00E+01  1.24E+01  7.42E+01  7.43E+01  7.69E+02  8.44E+02
POP DOSE, 0-50 MI           0.00E+00  7.60E+02  4.74E+02  1.16E+03  1.17E+03  2.87E+03  4.04E+03
POP DOSE, 0-1000 MI         0.00E+00  7.60E+02  4.74E+02  4.32E+03  4.83E+03  4.69E+04  5.18E+04
ECONOMIC COSTS ($)            ----      ----      ----      ----      ----    9.86E+09  9.86E+09
POP EF RISK, 0-1 MI         0.00E+00  1.02E-02  1.86E-03    ----    5.10E-05    ----    5.10E-05
POP CF RISK, 0-10 MI        0.00E+00  1.95E-03  1.21E-03    ----    9.74E-06  1.44E-04  1.54E-04


SOURCE TERM    GG-12-2, MEAN FREQUENCY = 5.73E-08 /YR
  CONSEQUENCE               EVACUATE   NORMAL   SHELTER    NORMAL    TOTAL    CHRONIC    TOTAL
                                      ACTIVITY            ACTIVITY   EARLY
                            0-10 MI   0-10 MI   0-10 MI    >10 MI
WEIGHT                       0.995     0.005     0.000     1.000     ----     1.000      ----
EARLY FATALITIES            0.00E+00  2.58E-01  9.78E-02  0.00E+00  1.29E-03    ----    1.29E-03
PRODROM VOMITING            0.00E+00  2.87E+00  1.28E+00  0.00E+00  1.43E-02    ----    1.43E-02
EF RISK, 1 MI               0.00E+00  7.10E-04  2.19E-04    ----    3.55E-06    ----    3.55E-06
CANCER FATALITIES           2.27E-03  1.73E+01  1.26E+01  5.86E+01  5.87E+01  1.01E+03  1.07E+03
POP DOSE, 0-50 MI           1.65E-01  6.43E+02  4.81E+02  1.05E+03  1.06E+03  3.13E+03  4.19E+03
POP DOSE, 0-1000 MI         1.65E-01  6.43E+02  4.81E+02  3.87E+03  3.87E+03  5.97E+04  6.36E+04
ECONOMIC COSTS ($)            ----      ----      ----      ----      ----    8.20E+09  8.20E+09
POP EF RISK, 0-1 MI         0.00E+00  2.84E-03  1.18E-03    ----    1.42E-05    ----    1.42E-05
POP CF RISK, 0-10 MI        2.21E-07  1.68E-03  1.23E-03    ----    8.64E-06  1.27E-04  1.36E-04


SOURCE TERM    GG-12-3, MEAN FREQUENCY = 0.00E+00 /YR
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Table C-1 (continued)

SOURCE TERM GG-13-1, MEAN FREQUENCY = 1.39E-09 /YR

CONSEQUENCE	EVACUATE 0-10 MI	NORMAL ACTIVITY 0-10 MI	SHELTER 0-10 MI	NORMAL ACTIVITY >10 MI	TOTAL EARLY	CHRONIC	TOTAL
WEIGHT	0.995	0.005	0.000	1.000	----	1.000	----
EARLY FATALITIES	0.00E+00	5.38E+01	3.32E+01	1.36E+00	1.63E+00	----	1.63E+00
PRODROM VOMITING	0.00E+00	8.61E+01	4.52E+01	7.36E+00	7.79E+00	----	7.79E+00
EF RISK, 1 MI	0.00E+00	6.93E-02	5.76E-02	----	3.47E-04	----	3.47E-04
CANCER FATALITIES	0.00E+00	1.97E+02	1.80E+02	8.00E+02	8.01E+02	1.58E+03	2.38E+03
POP DOSE, 0-50 MI	0.00E+00	1.01E+04	7.73E+03	8.65E+03	8.70E+03	1.01E+04	1.88E+04
POP DOSE, 0-1000 MI	0.00E+00	1.01E+04	7.73E+03	3.97E+04	3.97E+04	1.02E+05	1.41E+05
ECONOMIC COSTS ($)	----	----	----	----	----	2.67E+10	2.67E+10
POP EF RISK, 0-1 MI	0.00E+00	8.04E-02	6.88E-02	----	4.02E-04	----	4.02E-04
POP CF RISK, 0-10 MI	0.00E+00	1.92E-02	1.75E-02	----	9.58E-05	1.17E-04	2.13E-04

SOURCE TERM GG-13-2, MEAN FREQUENCY = 7.99E-10 /YR

CONSEQUENCE	EVACUATE 0-10 MI	NORMAL ACTIVITY 0-10 MI	SHELTER 0-10 MI	NORMAL ACTIVITY >10 MI	TOTAL EARLY	CHRONIC	TOTAL
WEIGHT	0.995	0.005	0.000	1.000	----	1.000	----
EARLY FATALITIES	1.63E-06	5.82E+01	3.94E+01	1.19E+00	1.48E+00	----	1.48E+00
PRODROM VOMITING	5.89E-06	9.58E+01	5.97E+01	1.04E+01	1.09E+01	----	1.09E+01
EF RISK, 1 MI	0.00E+00	5.04E-02	4.50E-02	----	2.52E-04	----	2.52E-04
CANCER FATALITIES	3.04E-01	2.33E+02	2.12E+02	1.02E+03	1.02E+03	1.71E+03	2.73E+03
POP DOSE, 0-50 MI	7.84E+00	1.19E+04	9.34E+03	1.12E+04	1.13E+04	8.89E+03	2.02E+04
POP DOSE, 0-1000 MI	7.84E+00	1.19E+04	9.34E+03	5.03E+04	5.03E+04	1.10E+05	1.61E+05
ECONOMIC COSTS ($)	----	----	----	----	----	2.85E+10	2.85E+10
POP EF RISK, 0-1 MI	2.07E-08	6.14E-02	5.54E-02	----	3.07E-04	----	3.07E-04
POP CF RISK, 0-10 MI	2.96E-05	2.27E-02	2.07E-02	----	1.43E-04	8.85E-05	2.32E-04

SOURCE TERM GG-13-3, MEAN FREQUENCY = 0.00E+00 /YR

SOURCE TERM GG-14-1, MEAN FREQUENCY = 3.79E-09 /YR

CONSEQUENCE	EVACUATE 0-10 MI	NORMAL ACTIVITY 0-10 MI	SHELTER 0-10 MI	NORMAL ACTIVITY >10 MI	TOTAL EARLY	CHRONIC	TOTAL
WEIGHT	0.995	0.005	0.000	1.000	----	1.000	----
EARLY FATALITIES	0.00E+00	1.04E+01	3.78E+00	4.54E-04	5.26E-02	----	5.26E-02
PRODROM VOMITING	0.00E+00	3.01E+01	1.19E+01	7.17E-01	8.68E-01	----	8.68E-01
EF RISK, 1 MI	0.00E+00	3.31E-02	1.82E-02	----	1.66E-04	----	1.66E-04
CANCER FATALITIES	0.00E+00	5.10E+01	4.00E+01	1.73E+02	1.73E+02	1.50E+03	1.67E+03
POP DOSE, 0-50 MI	0.00E+00	2.04E+03	1.46E+03	2.33E+03	2.34E+03	6.58E+03	8.93E+03
POP DOSE, 0-1000 MI	0.00E+00	2.04E+03	1.46E+03	1.06E+04	1.06E+04	9.08E+04	1.01E+05
ECONOMIC COSTS ($)	----	----	----	----	----	1.73E+10	1.73E+10
POP EF RISK, 0-1 MI	0.00E+00	4.21E-02	2.64E-02	----	2.10E-04	----	2.10E-04
POP CF RISK, 0-10 MI	0.00E+00	4.97E-03	3.90E-03	----	2.49E-05	1.47E-04	1.71E-04

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SOURCE TERM GG-14-2, MEAN FREQUENCY = 6.01E-09 /YR

CONSEQUENCE	EVACUATE 0-10 MI	NORMAL ACTIVITY 0-10 MI	SHELTER 0-10 MI	NORMAL ACTIVITY >10 MI	TOTAL EARLY	CHRONIC	TOTAL
WEIGHT	0.995	0.005	0.000	1.000	----	1.000	----
EARLY FATALITIES	0.00E+00	5.85E+00	2.66E+00	2.59E-04	2.95E-02	----	2.95E-02
PRODROM VOMITING	0.00E+00	2.63E+01	1.28E+01	5.95E-01	7.27E-01	----	7.27E-01
EF RISK, 1 MI	0.00E+00	1.63E-02	9.70E-03	----	8.17E-05	----	8.17E-05
CANCER FATALITIES	5.41E-02	7.09E+01	5.68E+01	2.71E+02	2.72E+02	1.91E+03	2.18E+03
POP DOSE, 0-50 MI	1.81E+00	2.29E+03	1.77E+03	3.42E+03	3.44E+03	5.91E+03	9.35E+03
POP DOSE, 0-1000 MI	1.81E+00	2.29E+03	1.77E+03	1.66E+04	1.67E+04	1.15E+05	1.32E+05
ECONOMIC COSTS ($)	----	----	----	----	----	2.06E+10	2.06E+10

Table C-1 (continued)

POP EF RISK, 0-1 MI	0.00E+00	2.39E-02	1.67E-02	----	1.19E-04	----	1.19E-04
POP CF RISK, 0-10 MI	5.27E-06	6.92E-03	5.54E-03	----	3.96E-05	1.09E-04	1.49E-04

SOURCE TERM GG-14-3, MEAN FREQUENCY = 0.00E+00 /YR

SOURCE TERM GG-15-1, MEAN FREQUENCY = 3.29E-07 /YR

CONSEQUENCE	EVACUATE	NORMAL	SHELTER	NORMAL	TOTAL	CHRONIC	TOTAL
		ACTIVITY		ACTIVITY	EARLY		
	0-10 MI	0-10 MI	0-10 MI	>10 MI			
WEIGHT	0.995	0.005	0.000	1.000	----	1.000	----
EARLY FATALITIES	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	----	0.00E+00
PRODROM VOMITING	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	----	0.00E+00
EF RISK, 1 MI	0.00E+00	0.00E+00	0.00E+00	----	0.00E+00	----	0.00E+00
CANCER FATALITIES	0.00E+00	2.65E-04	0.00E+00	4.83E-03	4.83E-03	5.36E-03	1.02E-02
POP DOSE, 0-50 MI	0.00E+00	1.63E-02	0.00E+00	2.09E-02	2.10E-02	3.26E-01	3.47E-01
POP DOSE, 0-1000 MI	0.00E+00	1.63E-02	0.00E+00	2.93E-01	2.93E-01	4.94E-01	7.87E-01
ECONOMIC COSTS ($)	----	----	----	----	----	1.19E+05	1.19E+05
POP EF RISK, 0-1 MI	0.00E+00	0.00E+00	0.00E+00	----	0.00E+00	----	0.00E+00
POP CF RISK, 0-10 MI	0.00E+00	2.58E-08	0.00E+00	----	1.29E-10	6.25E-09	6.38E-09

SOURCE TERM GG-15-2, MEAN FREQUENCY = 4.20E-10 /YR

CONSEQUENCE	EVACUATE	NORMAL	SHELTER	NORMAL	TOTAL	CHRONIC	TOTAL
		ACTIVITY		ACTIVITY	EARLY		
	0-10 MI	0-10 MI	0-10 MI	>10 MI			
WEIGHT	0.995	0.005	0.000	1.000	----	1.000	----
EARLY FATALITIES	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	----	0.00E+00
PRODROM VOMITING	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	----	0.00E+00
EF RISK, 1 MI	0.00E+00	0.00E+00	0.00E+00	----	0.00E+00	----	0.00E+00
CANCER FATALITIES	4.32E-05	1.98E-02	1.84E-02	1.03E-01	1.03E-01	4.18E-03	1.07E-01
POP DOSE, 0-50 MI	2.04E-03	9.28E-01	8.61E-01	8.38E-01	8.44E-01	3.22E-01	1.17E+00
POP DOSE, 0-1000 MI	2.04E-03	9.28E-01	8.61E-01	5.99E+00	5.99E+00	4.59E-01	6.45E+00
ECONOMIC COSTS ($)	----	----	----	----	----	1.14E+05	1.14E+05
POP EF RISK, 0-1 MI	0.00E+00	0.00E+00	0.00E+00	----	0.00E+00	----	0.00E+00
POP CF RISK, 0-10 MI	4.21E-09	1.93E-06	1.79E-06	----	1.38E-08	2.94E-09	1.68E-08

SOURCE TERM GG-15-3, MEAN FREQUENCY = 0.00E+00 /YR
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SOURCE TERM GG-16-1, MEAN FREQUENCY = 3.82E-07 /YR

CONSEQUENCE	EVACUATE	NORMAL	SHELTER	NORMAL	TOTAL	CHRONIC	TOTAL
		ACTIVITY		ACTIVITY	EARLY		
	0-10 MI	0-10 MI	0-10 MI	>10 MI			
WEIGHT	0.995	0.005	0.000	1.000	----	1.000	----
EARLY FATALITIES	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	----	0.00E+00
PRODROM VOMITING	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	----	0.00E+00
EF RISK, 1 MI	0.00E+00	0.00E+00	0.00E+00	----	0.00E+00	----	0.00E+00
CANCER FATALITIES	0.00E+00	6.52E-03	0.00E+00	5.20E-02	5.20E-02	2.61E-01	3.13E-01
POP DOSE, 0-50 MI	0.00E+00	5.23E-01	0.00E+00	5.90E-01	5.93E-01	1.23E+01	1.29E+01
POP DOSE, 0-1000 MI	0.00E+00	5.23E-01	0.00E+00	3.57E+00	3.58E+00	3.11E+01	3.47E+01
ECONOMIC COSTS ($)	----	----	----	----	----	2.08E+05	2.08E+05
POP EF RISK, 0-1 MI	0.00E+00	0.00E+00	0.00E+00	----	0.00E+00	----	0.00E+00
POP CF RISK, 0-10 MI	0.00E+00	6.36E-07	0.00E+00	----	3.18E-09	1.45E-07	1.48E-07

SOURCE TERM GG-16-2, MEAN FREQUENCY = 3.83E-10 /YR

CONSEQUENCE	EVACUATE	NORMAL	SHELTER	NORMAL	TOTAL	CHRONIC	TOTAL
		ACTIVITY		ACTIVITY	EARLY		
	0-10 MI	0-10 MI	0-10 MI	>10 MI			

Table C-1 (continued)

WEIGHT	0.995	0.005	0.000	1.000	----	1.000	----
EARLY FATALITIES	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	----	0.00E+00
PRODROM VOMITING	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	----	0.00E+00
EF RISK, 1 MI	0.00E+00	0.00E+00	0.00E+00	----	0.00E+00	----	0.00E+00
CANCER FATALITIES	8.10E-05	3.70E-02	3.41E-02	1.97E-01	1.97E-01	2.57E-01	4.54E-01
POP DOSE, 0-50 MI	3.82E-03	1.73E+00	1.59E+00	1.58E+00	1.59E+00	7.81E+00	9.40E+00
POP DOSE, 0-1000 MI	3.82E-03	1.73E+00	1.59E+00	1.15E+01	1.15E+01	1.50E+01	2.65E+01
ECONOMIC COSTS ($)	----	----	----	----	----	1.27E+05	1.27E+05
POP EF RISK, 0-1 MI	0.00E+00	0.00E+00	0.00E+00	----	0.00E+00	----	0.00E+00
POP CF RISK, 0-10 MI	7.90E-09	3.61E-06	3.33E-06	----	2.59E-08	3.43E-07	3.68E-07

SOURCE TERM GG-16-3, MEAN FREQUENCY = 0.00E+00 /YR

SOURCE TERM GG-17-1, MEAN FREQUENCY = 1.80E-07 /YR

CONSEQUENCE	EVACUATE	NORMAL ACTIVITY	SHELTER	NORMAL ACTIVITY	TOTAL EARLY	CHRONIC	TOTAL
	0-10 MI	0-10 MI	0-10 MI	>10 MI			
WEIGHT	0.995	0.005	0.000	1.000	----	1.000	----
EARLY FATALITIES	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	----	0.00E+00
PRODROM VOMITING	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	----	0.00E+00
EF RISK, 1 MI	0.00E+00	0.00E+00	0.00E+00	----	0.00E+00	----	0.00E+00
CANCER FATALITIES	0.00E+00	3.18E-02	0.00E+00	7.30E-01	7.30E-01	3.21E+00	3.94E+00
POP DOSE, 0-50 MI	0.00E+00	2.04E+00	0.00E+00	3.82E+00	3.83E+00	6.91E+01	7.29E+01
POP DOSE, 0-1000 MI	0.00E+00	2.04E+00	0.00E+00	4.52E+01	4.52E+01	2.16E+02	2.61E+02
ECONOMIC COSTS ($)	----	----	----	----	----	1.40E+06	1.40E+06
POP EF RISK, 0-1 MI	0.00E+00	0.00E+00	0.00E+00	----	0.00E+00	----	0.00E+00
POP CF RISK, 0-10 MI	0.00E+00	3.10E-06	0.00E+00	----	1.55E-08	4.49E-06	4.50E-06

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SOURCE TERM GG-17-2, MEAN FREQUENCY = 3.63E-09 /YR

CONSEQUENCE	EVACUATE	NORMAL ACTIVITY	SHELTER	NORMAL ACTIVITY	TOTAL EARLY	CHRONIC	TOTAL
	0-10 MI	0-10 MI	0-10 MI	>10 MI			
WEIGHT	0.995	0.005	0.000	1.000	----	1.000	----
EARLY FATALITIES	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	----	0.00E+00
PRODROM VOMITING	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	----	0.00E+00
EF RISK, 1 MI	0.00E+00	0.00E+00	0.00E+00	----	0.00E+00	----	0.00E+00
CANCER FATALITIES	2.88E-04	7.70E-02	5.98E-02	6.30E-01	6.31E-01	3.42E+00	4.05E+00
POP DOSE, 0-50 MI	1.42E-02	4.28E+00	3.19E+00	4.25E+00	4.29E+00	8.27E+01	8.70E+01
POP DOSE, 0-1000 MI	1.42E-02	4.28E+00	3.19E+00	3.82E+01	3.83E+01	2.09E+02	2.47E+02
ECONOMIC COSTS ($)	----	----	----	----	----	3.05E+06	3.05E+06
POP EF RISK, 0-1 MI	0.00E+00	0.00E+00	0.00E+00	----	0.00E+00	----	0.00E+00
POP CF RISK, 0-10 MI	2.82E-08	7.51E-06	5.83E-06	----	6.56E-08	9.74E-06	9.80E-06

SOURCE TERM GG-17-3, MEAN FREQUENCY = 0.00E+00 /YR

SOURCE TERM GG-18-1, MEAN FREQUENCY = 5.00E-07 /YR

CONSEQUENCE	EVACUATE	NORMAL ACTIVITY	SHELTER	NORMAL ACTIVITY	TOTAL EARLY	CHRONIC	TOTAL
	0-10 MI	0-10 MI	0-10 MI	>10 MI			
WEIGHT	0.995	0.005	0.000	1.000	----	1.000	----
EARLY FATALITIES	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	----	0.00E+00
PRODROM VOMITING	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	----	0.00E+00
EF RISK, 1 MI	0.00E+00	0.00E+00	0.00E+00	----	0.00E+00	----	0.00E+00
CANCER FATALITIES	0.00E+00	2.42E-01	7.90E-06	2.16E+00	2.16E+00	3.43E+01	3.64E+01
POP DOSE, 0-50 MI	0.00E+00	1.88E+01	7.11E-04	3.13E+01	3.14E+01	3.14E+02	3.46E+02
POP DOSE, 0-1000 MI	0.00E+00	1.88E+01	7.11E-04	1.56E+02	1.56E+02	2.20E+03	2.35E+03
ECONOMIC COSTS ($)	----	----	----	----	----	8.55E+07	8.55E+07

Table C-1 (continued)

```
POP EF RISK, 0-1 MI      0.00E+00  0.00E+00  0.00E+00    ----    0.00E+00    ----    0.00E+00
POP CF RISK, 0-10 MI     0.00E+00  2.36E-05  7.71E-10    ----    1.18E-07  4.31E-05  4.32E-05


SOURCE TERM    GG-18-2, MEAN FREQUENCY = 2.45E-08 /YR
  CONSEQUENCE            EVACUATE  NORMAL    SHELTER   NORMAL    TOTAL     CHRONIC    TOTAL
                                   ACTIVITY            ACTIVITY  EARLY
                         0-10 MI   0-10 MI   0-10 MI   >10 MI
WEIGHT                    0.995     0.005     0.000     1.000     ----     1.000      ----
EARLY FATALITIES         0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00    ----    0.00E+00
PRODROM VOMITING         0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00    ----    0.00E+00
EF RISK, 1 MI            0.00E+00  0.00E+00  0.00E+00    ----    0.00E+00    ----    0.00E+00
CANCER FATALITIES        8.62E-05  3.53E-01  1.76E-01  1.54E+00  1.54E+00  2.97E+01  3.13E+01
POP DOSE, 0-50 MI        4.55E-03  2.54E+01  1.37E+01  2.45E+01  2.46E+01  3.46E+02  3.70E+02
POP DOSE, 0-1000 MI      4.55E-03  2.54E+01  1.37E+01  1.07E+02  1.07E+02  1.65E+03  1.95E+03
ECONOMIC COSTS ($)         ----      ----      ----      ----      ----    7.95E+07  7.95E+07
POP EF RISK, 0-1 MI      0.00E+00  0.00E+00  0.00E+00    ----    0.00E+00    ----    0.00E+00
POP CF RISK, 0-10 MI     8.41E-09  3.44E-05  1.72E-05    ----    1.80E-07  4.97E-05  4.99E-05


SOURCE TERM    GG-18-3, MEAN FREQUENCY = 0.00E+00 /YR
1


SOURCE TERM    GG-19-1, MEAN FREQUENCY = 1.6[illegible]-07 /YR
  CONSEQUENCE            EVACUATE  NORMAL    SHELTER   NORMAL    TOTAL     CHRONIC    TOTAL
                                   ACTIVITY            ACTIVITY  EARLY
                         0-10 MI   0-10 MI   0-10 MI   >10 MI
WEIGHT                    0.995     0.005     0 000     1.000     ----     1.000      ----
EARLY FATALITIES         0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00    ----    0.00E+00
PRODROM VOMITING         0.00E+00  7.96E-05  0.00E+00  0.00E+00  3.98E-07    ----    3.98E-07
EF RISK, 1 MI            0.00E+00  0.00E+00  0.00E+00    ----    0.00E+00    ----    0.00E+00
CANCER FATALITIES        0.00E+00  5.76E-01  1.47E-03  5.09E+00  5.10E+00  2.02E+02  2.08E+02
POP DOSE, 0-50 MI        0.00E+00  3.70E+01  1.07E-01  8.01E+01  8.03E+01  1.04E+03  1.12E+03
POP DOSE, 0-1000 MI      0.00E+00  3.70E+01  1.07E-01  3.49E+02  3.49E+02  1.17E+04  1.21E+04
ECONOMIC COSTS ($)         ----      ----      ----      ----      ----    8.60E+08  8.60E+08
POP EF RISK, 0-1 MI      0.00E+00  0.00E+00  0.00E+00    ----    0.00E+00    ----    0.00E+00
POP CF RISK, 0-10 MI     0.00E+00  5.62E-05  1.44E-07    ----    2.81E-07  1.04E-04  1.04E-04


SOURCE TERM    GG-19-2, MEAN FREQUENCY = 1.72E-08 /YR
  CONSEQUENCE            EVACUATE  NORMAL    SHELTER   NORMAL    TOTAL     CHRONIC    TOTAL
                                   ACTIVITY            ACTIVITY  EARLY
                         0-10 MI   0-10 MI   0-10 MI   >10 MI
WEIGHT                    0.995     0.005     0.000     1.000     ----     1.000      ----
EARLY FATALITIES         0.00E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00    ----    0.00E+00
PRODROM VOMITING         0.00E+00  2.72E-05  0.00E+00  0.00E+00  1.36E-07    ----    1.36E-07
EF RISK, 1 MI            0.00E+00  0.00E+00  0.00E+00    ----    0.00E+00    ----    0.00E+00
CANCER FATALITIES        5.09E-05  1.04E+00  5.80E-01  4.10E+00  4.10E+00  1.73E+02  1.77E+02
POP DOSE, 0-50 MI        3.18E-03  5.67E+01  3.28E+01  7.38E+01  7.41E+01  1.04E+03  1.11E+03
POP DOSE, 0-1000 MI      3.18E-03  5.67E+01  3.28E+01  2.77E+02  2.77E+02  9.97E+03  1.02E+04
ECONOMIC COSTS ($)         ----      ----      ----      ----      ----    7.00E+08  7.00E+08
POP EF RISK, 0-1 MI      0.00E+00  0.00E+00  0.00E+00    ----    0.00E+00    ----    0.00E+00
POP CF RISK, 0-10 MI     4.96E-09  1.01E-04  5.65E-05    ----    5.12E-07  1.29E-04  1.29E-04


SOURCE TERM    GG-19-3, MEAN FREQUENCY = 0.00E+00 /YR


SOURCE TERM    GG-20   , MEAN FREQUENCY = 0.00E+00 /YR
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APPENDIX D
RISK RESULTS

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APPENDIX D
RISK RESULTS

This appendix presents detailed risk results for Grand Gulf for internal initiators. Figure D.1 contains the CCDFs for early fatalities, latent cancer fatalities, population dose within 50 miles, population dose within the entire region, individual risk of early fatality within one mile of the site boundary, and individual risk of latent cancer fatality within 10 miles of the plant. Each frame in this figure displays 250 CCDFs; each individual curve results from one observation in the LHS sample for Grand Gulf. These families of curves are the most basic risk results generated in this probabilistic risk assessment.

Table D.1 presents the PRAMIS output for internal initiators in slighlty edited form for Sample 1. The PRAMIS output uses PDS as an abbreviation for plant damage states. The 12 PDSs for internal initiators at Grand Gulf are:

PDS 1-3, 7	Short-Term SBO
PDS 4-6, 8	Long-Term SBO
PDS 9	Short-Term ATWS
PDS 10	Long-Term ATWS
PDS 11	Short-Term T2
PDS 12	Long-Term T2

PRAMIS uses CSQ as an abbreviation for consequence measure. The nine consequence measures for which results are reported are:

1. Early Fatalities
2. Early Injuries
3. Individual Early Fatality Risk at 1 mile
4. Latent Cancer Fatalities
5. Population Dose - 10 miles (Sv)
6. Population Dose - Entire Region (Sv)
7. Economic Cost ($)
8. Individual Early Fatality Risk within 1 mile
9. Individual Latent Cancer Fatality Risk within 10 miles

PRAMIS uses PAR as an abbreviation for source term groups. The source term groups are defined in Section 3.4. PRAMIS uses APB as an abbreviation for accident progression bin; the APB attributes and characteristics are defined in Section 2.4. The two methods of calculating fractional contribution to risk are discussed in Section 5.1.2. The lists of the fractional contributions of individual APBs have been truncated to show only the top 63 contributors.

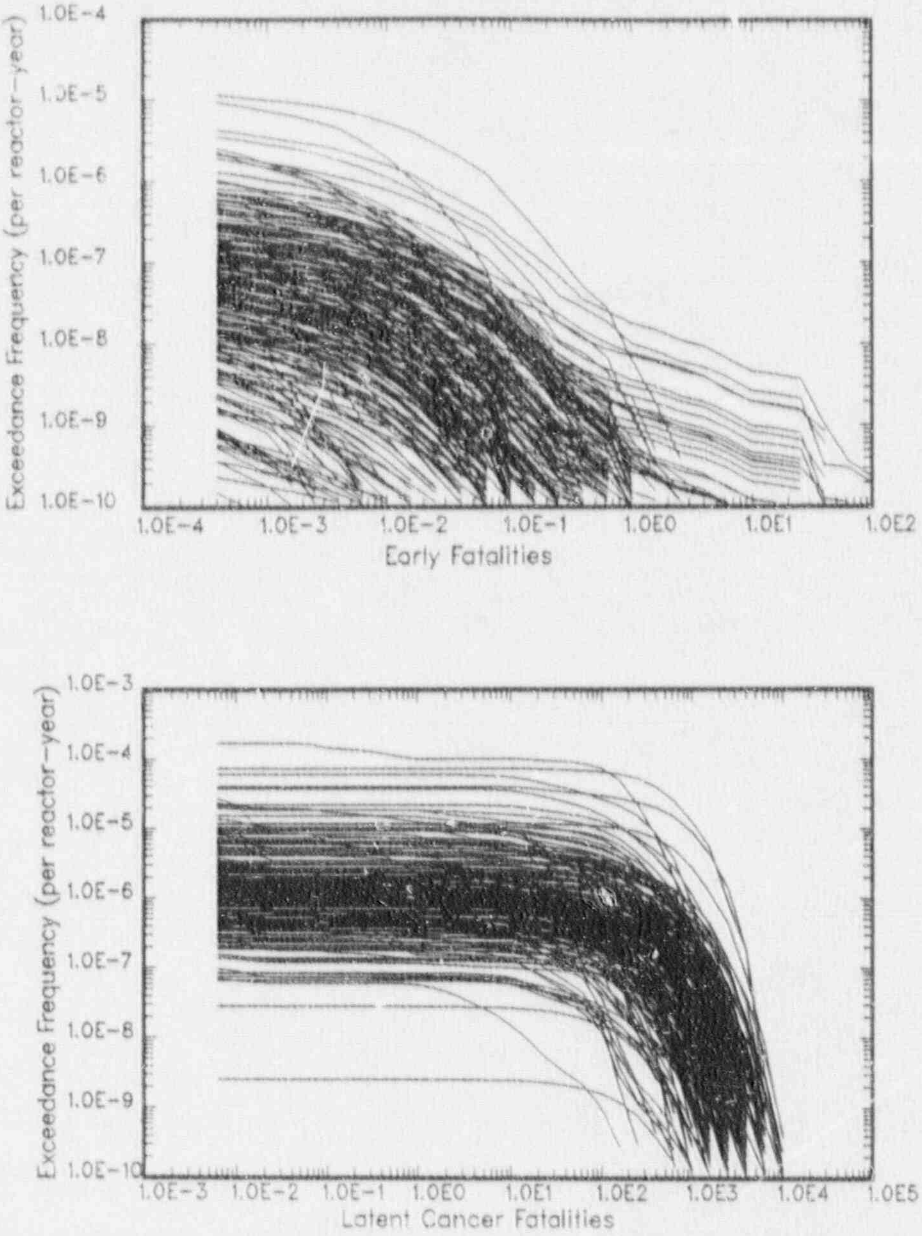
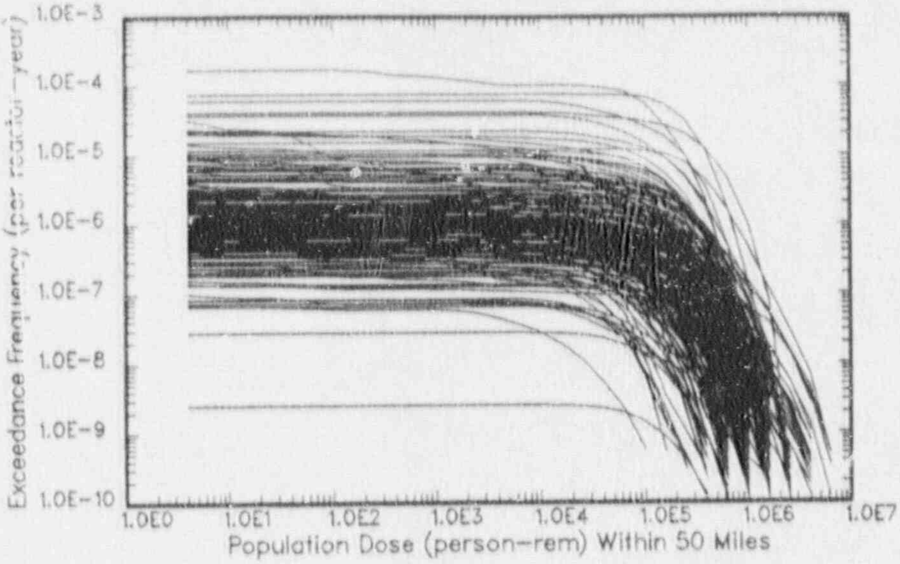


Figure D.1. Exceedance Frequencies for Risk, Grand Gulf: All Internal Initiators



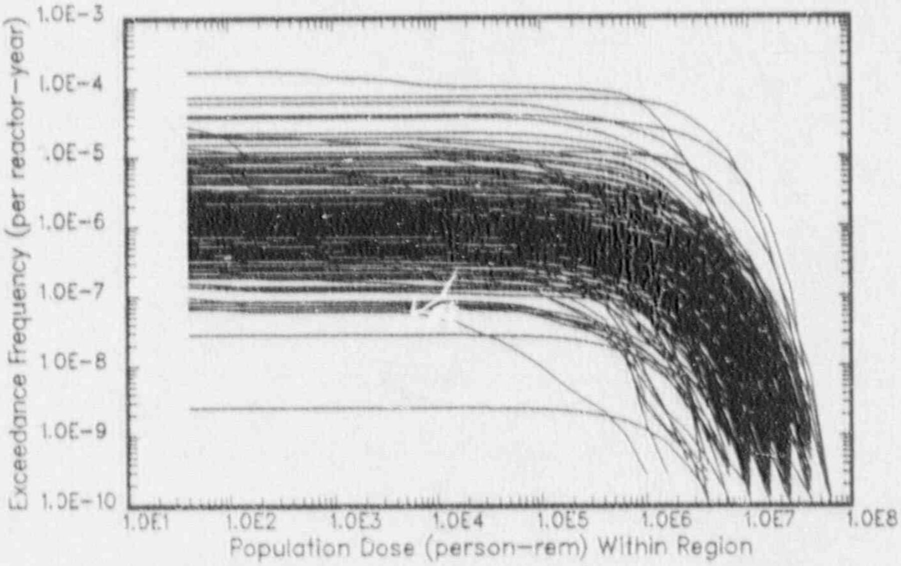
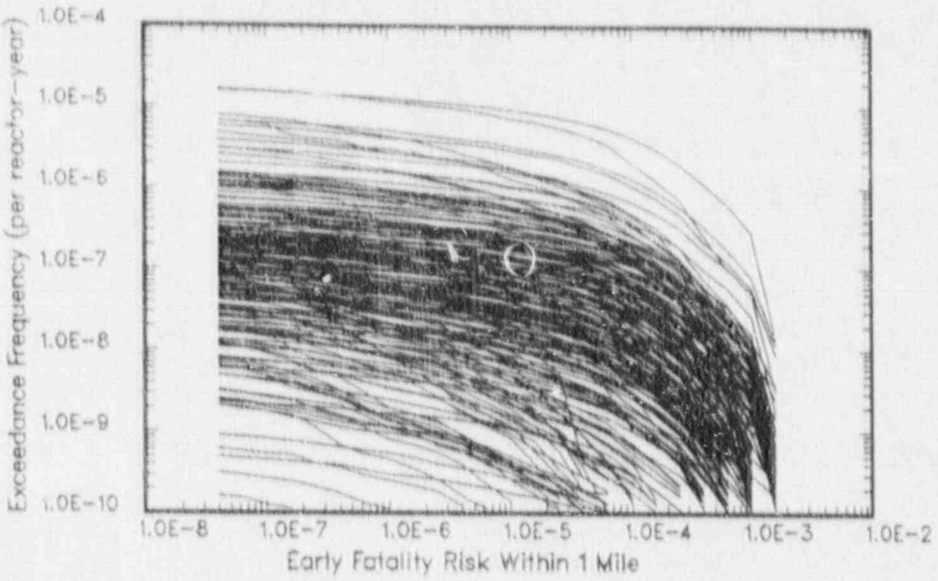


Figure D.1. (continued)



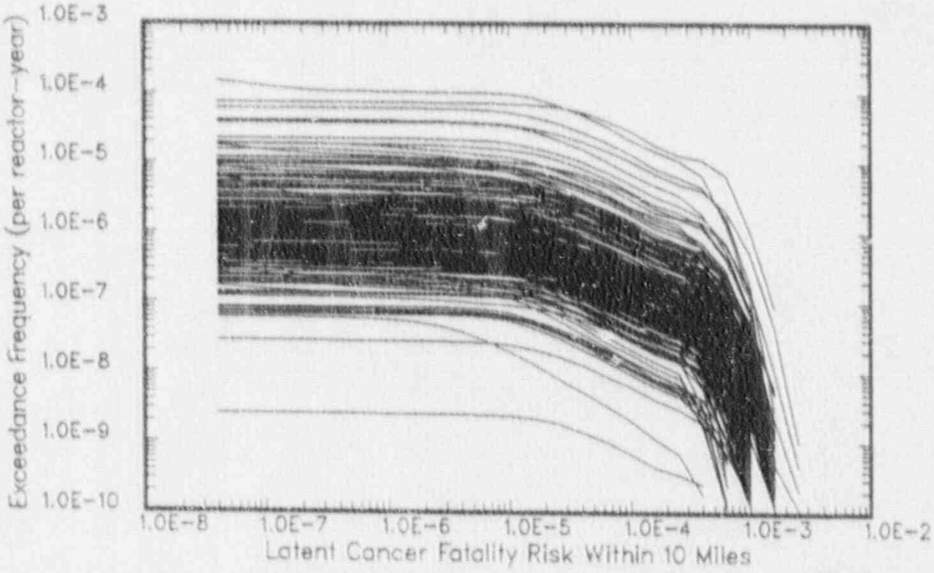


Figure D.1. (continued)

Table D.1
PRAMIS Results for Grand Gulf

	CSQ 1	2	3	4	5	6	7	8	9
MEAN RISK=	8.1E-09	6.0E-08	1.9E-11	9.2E-04	5.1E-03	5.7E-02	8.3E+03	3.3E-11	3.3E-10

MFCR -- FRACTIONAL CONTRIBUTIONS OF PDS TO CSQ, NORMALIZED ON A SAMPLE BASIS

PDS	CSQ 1	2	3	4	5	6	7	8	9
1	0.38190	0.39184	0.37638	0.41780	0.42647	0.41967	0.41273	0.38393	0.43361
2	0.00662	0.00616	0.00660	0.00590	0.00581	0.00590	0.00618	0.00625	0.00550
3	0.09084	0.08968	0.09049	0.08518	0.08351	0.08533	0.09023	0.09042	0.07911
4	0.03662	0.03208	0.03611	0.01598	0.01386	0.01566	0.01707	0.03337	0.01262
5	0.00160	0.00167	0.00147	0.00067	0.00058	0.00066	0.00076	0.00139	0.00046
6	0.00649	0.00545	0.00513	0.00213	0.00172	0.00206	0.00199	0.00459	0.00152
7	0.36143	0.34848	0.36689	0.34427	0.34123	0.34415	0.35246	0.36158	0.33681
8	0.02033	0.02638	0.01921	0.03104	0.02814	0.03004	0.02677	0.01948	0.02630
9	0.04643	0.04454	0.05162	0.02627	0.02922	0.02678	0.02911	0.04884	0.03367
10	0.03276	0.03858	0.03021	0.05612	0.05364	0.05497	0.04869	0.03404	0.05204
11	0.01477	0.01491	0.01553	0.01401	0.01527	0.01417	0.01357	0.01584	0.01774
12	0.00021	0.00022	0.00026	0.00063	0.00055	0.00061	0.00043	0.00027	0.00061

FCMR -- FRACTIONAL CONTRIBUTIONS OF PDS TO CSQ

PDS	CSQ 1	2	3	4	5	6	7	8	9
1	0.61049	0.61678	0.65537	0.70747	0.72117	0.70978	0.72141	0.66768	0.74280
2	0.01010	0.01001	0.01122	0.01920	0.01604	0.01851	0.01270	0.01039	0.01674
3	0.05915	0.05793	0.06785	0.04576	0.04432	0.04575	0.04549	0.06451	0.03902
4	0.01649	0.02366	0.02252	0.01922	0.01694	0.01898	0.01892	0.02228	0.01300
5	0.00226	0.00377	0.00325	0.00221	0.00177	0.00217	0.00220	0.00310	0.00094
6	0.00041	0.00054	0.00049	0.00077	0.00065	0.00075	0.00069	0.00054	0.00054
7	0.25227	0.20927	0.18834	0.14028	0.13786	0.13979	0.13978	0.17923	0.12951
8	0.02741	0.04219	0.01796	0.02600	0.02378	0.02553	0.02403	0.01846	0.02106
9	0.00830	0.00553	0.01553	0.00958	0.01071	0.00969	0.00946	0.01462	0.01262
10	0.01131	0.02798	0.01424	0.02575	0.02323	0.02535	0.02245	0.01596	0.01987
11	0.00181	0.00232	0.00321	0.00370	0.00348	0.00364	0.00282	0.00323	0.00383
12	0.00001	0.00001	0.00001	0.00007	0.00006	0.00006	0.00004	0.00002	0.00007

Table D.1 (continued)

FRACTIONAL CONTRIBUTIONS OF PAR TO CSQ, NORMALIZED ON A SAMPLE BASIS

	CSQ								
PAR	1	2	3	4	5	6	7	8	9
1	0.00103	0.00525	0.00178	0.00096	0.00184	0.00097	0.00032	0.00112	0.00257
2	0.00000	0.00399	0.00000	0.00165	0.00401	0.00169	0.00018	0.00000	0.00463
3	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
4	0.04543	0.04932	0.04829	0.01084	0.01637	0.01110	0.00700	0.04824	0.02268
5	0.00083	0.00943	0.00381	0.00748	0.00996	0.00758	0.00427	0.00099	0.01419
6	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
7	0.01241	0.02784	0.00272	0.04112	0.04168	0.04311	0.04567	0.01180	0.04508
8	0.00197	0.01262	0.00350	0.01679	0.01806	0.01681	0.01416	0.00232	0.02214
9	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
10	0.00036	0.00369	0.00000	0.01797	0.01041	0.01844	0.01219	0.00038	0.02277
11	0.00019	0.00048	0.00000	0.00684	0.00916	0.00675	0.00332	0.00023	0.01152
12	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
13	0.06706	0.09355	0.05521	0.03001	0.03823	0.03313	0.03089	0.07255	0.03013
14	0.02305	0.02409	0.02382	0.01367	0.01746	0.01486	0.02440	0.02679	0.01667
15	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
16	0.02126	0.03257	0.01761	0.06006	0.06632	0.06072	0.08551	0.02206	0.08091
17	0.00386	0.01170	0.00393	0.03872	0.03517	0.03696	0.01885	0.00465	0.04593
18	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
19	0.01921	0.01955	0.00450	0.04532	0.05020	0.04746	0.08366	0.01573	0.05005
20	0.00005	0.00049	0.00000	0.01048	0.00892	0.01002	0.00847	0.00006	0.01116
21	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
22	0.23983	0.17391	0.30619	0.08464	0.09057	0.08502	0.11623	0.27819	0.08702
23	0.06484	0.06768	0.05255	0.07283	0.06872	0.07347	0.09701	0.07618	0.05304
24	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
25	0.01003	0.01101	0.01571	0.08006	0.06249	0.07739	0.06604	0.00929	0.06649
26	0.00803	0.00644	0.00379	0.02375	0.02070	0.02304	0.01914	0.00950	0.02088
27	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
28	0.00102	0.00371	0.00022	0.03124	0.02517	0.02989	0.01480	0.00132	0.02906
29	0.00057	0.00073	0.00000	0.00430	0.00359	0.00415	0.00397	0.00067	0.00376
30	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
31	0.13552	0.06650	0.14873	0.03225	0.02976	0.03210	0.03410	0.12125	0.01763
32	0.09222	0.10995	0.09700	0.05532	0.05029	0.05555	0.05486	0.08978	0.02822
33	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
34	0.08807	0.08813	0.10911	0.05310	0.04724	0.05335	0.06958	0.10884	0.03247
35	0.02880	0.03017	0.02362	0.04268	0.03284	0.04188	0.03970	0.03467	0.02050
36	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
37	0.06501	0.05638	0.02319	0.00568	0.00731	0.00556	0.00701	0.01803	0.00170
38	0.01870	0.01917	0.00572	0.00335	0.00392	0.00323	0.00339	0.00480	0.00138
39	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
40	0.02356	0.03190	0.02274	0.00599	0.00608	0.00594	0.00700	0.01680	0.00254
41	0.02709	0.03962	0.02627	0.01627	0.01442	0.01628	0.01822	0.02376	0.00566
42	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
43	0.00000	0.00000	0.00000	0.00002	0.00008	0.00002	0.00004	0.00000	0.00002
44	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
45	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
46	0.00000	0.00000	0.00000	0.00016	0.00092	0.00029	0.00002	0.00000	0.00013
47	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
48	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
49	0.00000	0.00000	0.00000	0.00393	0.00886	0.00411	0.00031	0.00000	0.00636
50	0.00000	0.00000	0.00000	0.00055	0.00101	0.00052	0.00014	0.00000	0.00111
51	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
52	0.00000	0.00000	0.00000	0.07062	0.08516	0.07221	0.03740	0.00000	0.11252
53	0.00000	0.00000	0.00000	0.00502	0.00728	0.00494	0.00245	0.00000	0.01076
54	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
55	0.00000	0.00012	0.00000	0.09542	0.08588	0.09123	0.06470	0.00000	0.10144
56	0.00000	0.00000	0.00000	0.01092	0.01092	0.01024	0.00600	0.00000	0.01689
57	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
58	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Table D.1 (continued)

FRACTIONAL CONTRIBUTIONS OF PAR TO CSQ

	CSQ								
	1	2	3	4	5	6	7	8	9
N RISK=	8.1E-09	8.0E-08	1.9E-11	9.2E-04	5.1E-03	5.7E-02	8.3E+03	3.3E-11	3.3E-10
PAR									
1	0.00001	0.00016	0.00002	0.00011	0.00037	0.00011	0.00001	0.00002	0.00075
2	0.00000	0.00015	0.00000	0.00035	0.00119	0.00036	0.00002	0.00000	0.00170
3	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
4	0.00087	0.00295	0.00160	0.00285	0.00674	0.00305	0.00100	0.00258	0.01469
5	0.00001	0.00068	0.00007	0.00385	0.00677	0.00399	0.00145	0.00004	0.01303
6	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
7	0.00015	0.00117	0.00003	0.01196	0.01607	0.01298	0.00970	0.00034	0.02400
8	0.00004	0.00067	0.00008	0.00610	0.00894	0.00629	0.00409	0.00011	0.01328
9	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
10	0.00000	0.00008	0.00000	0.00798	0.01017	0.00845	0.00383	0.00000	0.01634
11	0.00000	0.00001	0.00000	0.00221	0.00375	0.00223	0.00053	0.00001	0.00594
12	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
13	0.02917	0.06351	0.03407	0.02358	0.03811	0.02732	0.02085	0.06645	0.03115
14	0.00382	0.00742	0.00568	0.01457	0.02312	0.01639	0.02704	0.01128	0.02371
15	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
16	0.00073	0.00308	0.00054	0.03577	0.04571	0.03659	0.04698	0.00181	0.06633
17	0.00005	0.00078	0.00006	0.02029	0.02001	0.01924	0.00750	0.00016	0.02945
18	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
19	0.00102	0.00235	0.00016	0.09495	0.11974	0.10170	0.20046	0.00168	0.13684
20	0.00000	0.00001	0.00000	0.00341	0.00330	0.00327	0.00196	0.00000	0.00473
21	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
22	0.09684	0.07732	0.24282	0.09524	0.11375	0.09679	0.12794	0.25890	0.11252
23	0.01609	0.02664	0.01950	0.08689	0.08694	0.08858	0.12038	0.04639	0.05963
24	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
25	0.00127	0.00260	0.00204	0.10497	0.07930	0.10074	0.07575	0.00246	0.08348
26	0.00025	0.00057	0.00010	0.01834	0.01551	0.01764	0.01242	0.00078	0.01412
27	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
28	0.00013	0.00112	0.00002	0.14082	0.10448	0.13171	0.04901	0.00039	0.12427
29	0.00000	0.00001	0.00000	0.00221	0.00183	0.00211	0.00153	0.00001	0.00186
30	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
31	0.17186	0.06663	0.28255	0.03508	0.03179	0.03495	0.03648	0.21647	0.01476
32	0.17126	0.25226	0.25501	0.10114	0.08334	0.10119	0.09765	0.23725	0.03063
33	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
34	0.02243	0.02659	0.04946	0.03305	0.02849	0.03311	0.04304	0.05664	0.01696
35	0.00917	0.01354	0.01076	0.06633	0.04672	0.06440	0.05660	0.02493	0.02368
36	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
37	0.28133	0.17910	0.02554	0.00358	0.00510	0.00349	0.00447	0.01714	0.00090
38	0.14680	0.14401	0.01066	0.00236	0.00313	0.00226	0.00274	0.00752	0.00056
39	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
40	0.02472	0.05439	0.03333	0.00686	0.00660	0.00677	0.00791	0.02454	0.00198
41	0.02200	0.07221	0.02591	0.01417	0.01096	0.01402	0.01491	0.02210	0.00272
42	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
43	0.00000	0.00000	0.00000	0.00000	0.00002	0.00000	0.00000	0.00000	0.00001
44	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
45	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
46	0.00000	0.00000	0.00000	0.00013	0.00096	0.00023	0.00001	0.00000	0.00017
47	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
48	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
49	0.00000	0.00000	0.00000	0.00077	0.00256	0.00083	0.00003	0.00000	0.00247
50	0.00000	0.00000	0.00000	0.00002	0.00006	0.00002	0.00000	0.00000	0.00011
51	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
52	0.00000	0.00000	0.00000	0.01974	0.03365	0.02085	0.00515	0.00000	0.06563
53	0.00000	0.00000	0.00000	0.00083	0.00177	0.00085	0.00023	0.00000	0.00371
54	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
55	0.00000	0.00000	0.00000	0.03620	0.03532	0.03428	0.01675	0.00000	0.05109
56	0.00000	0.00000	0.00000	0.00329	0.00372	0.00310	0.00145	0.00000	0.00679
57	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
58	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Table D.1 (continued)

FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ 1, NORMALIZED ON A SAMPLE BASIS
CSQ 1
APB ATTRIBUTES

	1	2	3	4	5	6	7	8	9
A	0.84079	0.54466	0.42465	0.04441	0.31846	0.03673	0.78343	0.02988	0.30117
B	0.06504	0.45533	0.31029	0.39013	0.35919	0.22020	0.02677	0.01252	0.69882
C	0.01477		0.12577	0.02831	0.00478	0.01325	0.18313	0.61531	
D	0.00021		0.11909	0.33132	0.07819	0.05240	0.00667	0.09166	
E	0.04643		0.02020	0.20583	0.12325	0.55401		0.25062	
F	0.03276				0.02327	0.01565			
G					0.00671	0.09835			
H					0.08615	0.00940			
I						0.00000			

FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ 2, NORMALIZED ON A SAMPLE BASIS
CSQ 2
APB ATTRIBUTES

	1	2	3	4	5	6	7	8	9
A	0.83616	0.54709	0.42555	0.04756	0.34989	0.05891	0.76101	0.02812	0.29111
B	0.06559	0.45290	0.29495	0.36854	0.31806	0.26261	0.02866	0.01123	0.70888
C	0.01491		0.12569	0.02821	0.00490	0.01505	0.20005	0.57824	
D	0.00022		0.12424	0.34273	0.08536	0.05152	0.01028	0.09024	
E	0.04454		0.02956	0.19296	0.11647	0.46366		0.29216	
F	0.03858				0.02569	0.02070			
G					0.00669	0.11658			
H					0.09293	0.01096			
I						0.00000			

FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ 3, NORMALIZED ON A SAMPLE BASIS
CSQ 3
APB ATTRIBUTES

	1	2	3	4	5	5	7	8	9
A	0.84035	0.54391	0.43059	0.04469	0.33340	0.03699	0.77915	0.02689	0.29486
B	0.06192	0.45608	0.30081	0.39493	0.35005	0.19521	0.02612	0.01358	0.70513
C	0.01563		0.12783	0.02960	0.00545	0.01180	0.18980	0.63746	
D	0.00026		0.12058	0.32453	0.08176	0.05700	0.00493	0.06412	
E	0.05162		0.02018	0.20625	0.12594	0.58131		0.25794	
F	0.03021				0.02006	0.01356			
G					0.00683	0.09760			
H					0.07651	0.00654			
I						0.00000			

FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ 4, NORMALIZED ON A SAMPLE BASIS
CSQ 4
APB ATTRIBUTES

	1	2	3	4	5	6	7	8	9
A	0.85315	0.54270	0.42084	0.04594	0.47908	0.06266	0.70021	0.01631	0.28541
B	0.04982	0.45729	0.25443	0.41042	0.21826	0.25387	0.02393	0.00883	0.71458
C	0.01401		0.13597	0.02408	0.00472	0.01407	0.24304	0.46097	
D	0.00063		0.11922	0.34931	0.09276	0.03993	0.03281	0.03526	
E	0.02627		0.06953	0.17024	0.10233	0.28701		0.47862	
F	0.05612				0.02385	0.10312			
G					0.00369	0.19715			
H					0.07530	0.04201			
I						0.00018			

Table D.1 (continued)

```
     FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ  5, NORMALIZED ON A SAMPLE BASIS
                                 CSQ  5
                             APB ATTRIBUTES
         1       2       3       4       5       6       7       8       9
A     0.85701 0.53892 0.41331 0.04475 0.49448 0.06567 0.68203 0.01413 0.27342
B     0.04430 0.46107 0.25145 0.40457 0.21334 0.23978 0.02054 0.00813 0.72657
C     0.01527         0.13728 0.02366 0.00487 0.01198 0.26366 0.44967
D     0.00055         0.12076 0.35025 0.09377 0.04201 0.03376 0.03196
E     0.02922         0.07719 0.17676 0.09647 0.28694         0.49610
F     0.05364                         0.02217 0.10668
G                                     0.00367 0.20238
H                                     0.07124 0.04372
I                                             0.00085
```

```
     FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ  6, NORMALIZED ON A SAMPLE BASIS
                                 CSQ  6
                             APB ATTRIBUTES
         1       2       3       4       5       6       7       8       9
A     0.85505 0.54216 0.41848 0.04582 0.47896 0.06212 0.69838 0.01593 0.28385
B     0.04842 0.45783 0.25534 0.40893 0.21801 0.25214 0.02341 0.00876 0.71613
C     0.01417         0.13555 0.02405 0.00474 0.01371 0.24603 0.46411
D     0.00061         0.12036 0.35103 0.09396 0.04048 0.03217 0.03462
E     0.02678         0.06926 0.17016 0.10186 0.28803         0.47657
F     0.05497                         0.02364 0.10276
G                                     0.00375 0.19858
H                                     0.07509 0.04191
I                                             0.00027
```

```
     FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ  7, NORMALIZED ON A SAMPLE BASIS
                                 CSQ  7
                             APB ATTRIBUTES
         1       2       3       4       5       6       7       8       9
A     0.86160 0.54505 0.42860 0.04637 0.45011 0.05566 0.71919 0.01606 0.29145
B     0.04659 0.45494 0.26468 0.41495 0.23636 0.24848 0.02263 0.00931 0.70853
C     0.01357         0.13391 0.02584 0.00516 0.01339 0.23160 0.51378
D     0.00043         0.12436 0.35630 0.09562 0.04620 0.02657 0.03693
E     0.02911         0.04845 0.15654 0.11037 0.33634         0.42391
F     0.04869                         0.02301 0.08115
G                                     0.00409 0.18481
H                                     0.07527 0.03392
I                                             0.00006
```

```
     FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ  8, NORMALIZED ON A SAMPLE BASIS
                                 CSQ  8
                             APB ATTRIBUTES
         1       2       3       4       5       6       7       8       9
A     0.84217 0.54468 0.42894 0.04602 0.34511 0.04133 0.76737 0.02302 0.28952
B     0.05883 0.45531 0.29496 0.39638 0.32536 0.22041 0.02707 0.01321 0.71047
C     0.01584         0.12960 0.02907 0.00572 0.01265 0.19763 0.63441
D     0.00027         0.12563 0.33578 0.08873 0.05680 0.00793 0.05463
E     0.04884         0.02087 0.19275 0.12558 0.53082         0.27472
F     0.03404                         0.02175 0.01720
G                                     0.00643 0.11171
H                                     0.08132 0.00907
I                                             0.00000
```

Table D.1 (continued)

FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ 9, NORMALIZED ON A SAMPLE BASIS
CSQ 9
APB ATTRIBUTES

	1	2	3	4	5	6	7	8	9
A	0.85503	0.53293	0.40718	0.04238	0.53611	0.07132	0.65212	0.01178	0.25908
B	0.04090	0.46706	0.24346	0.40553	0.19725	0.20732	0.01527	0.00663	0.74091
C	0.01774		0.14237	0.02272	0.00459	0.00980	0.29490	0.39507	
D	0.00061		0.11543	0.34427	0.09180	0.04351	0.03770	0.01982	
E	0.03367		0.09156	0.18510	0.08720	0.27932		0.56668	
F	0.05204				0.01894	0.12036			
G					0.00256	0.21685			
H					0.06154	0.05131			
I						0.00022			

FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ, NORMALIZED ON A SAMPLE BASIS
APB ATTRIBUTE 1
CSQ

	1	2	3	4	5	6	7	8	9
A	0.84079	0.83616	0.84035	0.85315	0.85701	0.85505	0.86160	0.84217	0.85503
B	0.06504	0.06559	0.06192	0.04982	0.04430	0.04842	0.04659	0.05883	0.04090
C	0.01477	0.01491	0.01563	0.01401	0.01527	0.01417	0.01357	0.01584	0.01774
D	0.00021	0.00022	0.00026	[illegible]	0.00055	0.00061	0.00043	0.00027	0.00061
E	0.04643	0.04454	0.05162	0.02627	0.02922	0.02678	0.02911	0.04884	0.03367
F	0.03276	0.03858	0.03021	0.05612	0.05364	0.05497	0.04869	0.03404	0.05204

FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ, NORMALIZED ON A SAMPLE BASIS
APB ATTRIBUTE 2
CSQ

	1	2	3	4	5	6	7	8	9
A	0.54466	0.54709	0.54391	0.54270	0.53892	0.54216	0.54505	0.54468	0.53293
B	0.45533	0.45290	0.45608	0.45729	0.46107	0.45783	0.45494	0.45531	0.46706

FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ, NORMALIZED ON A SAMPLE BASIS
APB ATTRIBUTE 3
CSQ

	1	2	3	4	5	6	7	8	9
A	0.42465	0.42555	0.43059	0.42084	0.41331	0.41948	0.42860	0.42894	0.40718
B	0.31029	0.29495	0.30081	0.25443	0.25145	0.25534	0.26468	0.29496	0.24346
C	0.12577	0.12569	0.12783	0.13597	0.13728	0.13555	0.13391	0.12960	0.14237
D	0.11909	0.12424	0.12058	0.11922	0.12076	0.12036	0.12436	0.12563	0.11543
E	0.02020	0.02956	0.02018	0.06953	0.07719	0.06926	0.04845	0.02087	0.09156

FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ, NORMALIZED ON A SAMPLE BASIS
APB ATTRIBUTE 4
CSQ

	1	2	3	4	5	6	7	8	9
A	0.04441	0.04756	0.04469	0.04594	0.04475	0.04582	0.04637	0.04602	0.04238
B	0.39013	0.38854	0.39493	0.41042	0.40457	0.40893	0.41495	0.39638	0.40553
C	0.02831	0.02821	0.02960	0.02408	0.02366	0.02405	0.02584	0.02907	0.02272
D	0.33132	0.34273	0.32453	0.34931	0.35025	0.35103	0.35630	0.33578	0.34427
E	0.20583	0.19296	0.20625	0.17024	0.17676	0.17016	0.15654	0.19275	0.18510

FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ, NORMALIZED ON A SAMPLE BASIS
APB ATTRIBUTE 5
CSQ

	1	2	3	4	5	6	7	8	9
A	0.31846	0.34989	0.33340	0.47908	0.49448	0.47896	0.45011	0.34511	0.53611
B	0.35919	0.31806	0.35005	0.21826	0.21334	0.21801	0.23636	0.32536	0.19725
C	0.00478	0.00490	0.00545	0.00472	0.00487	0.00474	0.00516	0.00572	0.00459
D	0.07819	0.08536	0.08176	0.09276	0.09377	0.09396	0.09562	0.08873	0.09180
E	0.12325	0.11647	0.12594	0.10233	0.09647	0.10186	0.11037	0.12558	0.08720
F	0.02327	0.02569	0.02006	0.02385	0.02217	0.02364	0.02301	0.02175	0.01894
G	0.00671	0.00669	0.00683	0.00369	0.00367	0.00375	0.00409	0.00643	0.00256
H	0.08615	0.09293	0.07651	0.07530	0.07124	0.07509	0.07527	0.08132	0.06154

Table D.1 (continued)

FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ, NORMALIZED ON A SAMPLE BASIS
APB ATTRIBUTE 6

	CSQ								
	1	2	3	4	5	6	7	8	9
A	0.03673	0.05891	0.03699	0.06266	0.06567	0.06212	0.05566	0.04133	0.07132
B	0.22020	0.26261	0.19521	0.25387	0.23978	0 25214	0.24848	0.22041	0.20732
C	0.01325	0.01505	0.01180	0.01407	0.01198	0.01371	0.01339	0.01265	0.00980
D	0.05240	0.05152	0.05700	0.03993	0.04201	0.04048	0.04620	0.05680	0.04351
E	0.55401	0.46366	0.58131	0.28701	0.28694	0.28803	0.33634	0.53082	0.27932
F	0.01565	0.02070	0.01356	0.10312	0.10668	0.10276	0.08115	0.01720	0.12036
G	0.09835	0.11658	0.09760	0.19715	0.20238	0.19858	0.18481	0.11171	0.21685
H	0.00940	0.01096	0.00654	0.04201	0.04372	0.04191	0.03392	0.00907	0.05131
I	0.00000	0.00000	0.00000	0.00018	0.00085	0.00027	0.00006	0.00000	0.00022

FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ, NORMALIZED ON A SAMPLE BASIS
APB ATTRIBUTE 7

	CSQ								
	1	2	3	4	5	6	7	8	9
A	0.78343	0.76101	0.77915	0.70021	0.68203	0.69838	0.71919	0.76737	0.65212
B	0.02677	0.02866	0.02612	0.02393	0.02054	0.02341	0.02263	0.02707	0.01527
C	0.18313	0.20005	0.18980	0.24304	0.26366	0.24603	0.23160	0.19763	0.29490
D	0.00667	0.01028	0.00493	0.03281	0.03376	0.03217	0.02657	0.00793	0.03770

FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ, NORMALIZED ON A SAMPLE BASIS
APB ATTRIBUTE 8

	CSQ								
	1	2	3	4	5	6	7	8	9
A	0.02988	0.02812	0.02689	0.01631	0.01413	0.01593	0.01606	0.02302	0.01178
B	0.01252	0.01123	0.01358	0.00883	0.00813	0.00876	0.00931	0.01321	0.00663
C	0.61531	0.57824	0.63746	0.46097	0.44967	0.46411	0.51378	0.63441	0.39507
D	0.09166	0.06024	0.06412	0.03526	0.03196	0.03462	0.03693	0.05463	0.01982
E	0.25062	0.29216	0.25794	0.47862	0.49610	0.47657	0.42391	0.27472	0.56658

FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ, NORMALIZED ON A SAMPLE BASIS
APB ATTRIBUTE 9

	CSQ								
	1	2	3	4	5	6	7	8	9
A	0.30117	0.29111	0.29486	0.28541	0.27342	0.28385	0.29145	0.28952	0.25908
B	0.69882	0.70888	0.70513	0.71456	0.72657	0.71613	0.70853	0.71047	0.74091

Table D.1 (continued)

FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ 1
CSQ 1 RISK= 8.1E-09
APB ATTRIBUTES

	1	2	3	4	5	6	7	8	9
A	0.93200	0.55398	0.32152	0.01354	0.14432	0.00815	0.83924	0.04868	0.43612
B	0.04657	0.44601	0.47087	0.25490	0.39951	0.35642	0.01017	0.01179	0.56387
C	0.00181		0.05972	0.01979	0.02851	0.00491	0.14920	0.59118	
D	0.00001		0.13312	0.52632	0.06868	0.04042	0.00139	0.16727	
E	0.00830		0.01477	0.18544	0.12280	0.51726		0.18107	
F	0.01131				0.01090	0.00375			
G					0.00295	0.06699			
H					0.22432	0.00210			
I						0.00000			

FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ 2
CSQ 2 RISK= 6.0E-08
APB ATTRIBUTES

	1	2	3	4	5	6	7	8	9
A	0.89399	0.55999	0.30552	0.01935	0.13991	0.01327	0.82570	0.03295	0.43138
B	0.07017	0.44000	0.46852	0.23345	0.34144	0.49236	0.02604	0.01186	0.56860
C	0.00232		0.06150	0.03955	0.02305	0.01334	0.14608	0.60587	
D	0.00001		0.14371	0.53912	0.07039	0.03929	0.00218	0.16076	
E	0.00553		0.02074	0.16853	0.10196	0.34914		0.18855	
F	0.02798				0.01524	0.00684			
G					0.00286	0.08227			
H					0.30515	0.00349			
I						0.00000			

FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ 3
CSQ 3 RISK= 1.9E-11
APB ATTRIBUTES

	1	2	3	4	5	6	7	8	9
A	0.92277	0.43642	0.26813	0.02196	0.15301	0.00800	0.76976	0.01072	0.33784
B	0.04422	0.56357	0.49891	0.24150	0.38490	0.31363	0.01293	0.01570	0.66215
C	0.00321		0.08686	0.03068	0.07122	0.00618	0.21543	0.72314	
D	0.00001		0.12797	0.53977	0.08685	0.09510	0.00187	0.05297	
E	0.01553		0.01813	0.16609	0.08815	0.49675		0.19747	
F	0.01424				0.01308	0.00653			
G					0.00483	0.07050			
H					0.19796	0.00330			
I						0.00000			

FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ 4
CSQ 4 RISK= 9.2E-04
APB ATTRIBUTES

	1	2	3	4	5	6	7	8	9
A	0.91271	0.62828	0.22556	0.03569	0.37739	0.04522	0.60950	0.01799	0.28143
B	0.04819	0.37170	0.38727	0.20426	0.22461	0.29517	0.01540	0.00739	0.71856
C	0.00370		0.08136	0.03421	0.02878	0.00597	0.36272	0.52556	
D	0.00007		0.20679	0.51977	0.09613	0.05467	0.01236	0.02240	
E	0.00958		0.09901	0.20605	0.11028	0.17867		0.42665	
F	0.02575				0.01574	0.18744			
G					0.00193	0.16363			
H					0.14514	0.06904			
I						0.00017			

Table D.1 (continued)

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            FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ  5
                           CSQ  5 RISK= 5.1E-03
                                APB ATTRIBUTES
        1       2       3       4       5       6       7       8       9
A    0.91938 0.60568 0.22467 0.03239 0.36021 0.04829 0.58321 0.01500 0.26725
B    0.04314 0.39431 0.39796 0.20739 0.23346 0.26766 0.01230 0.00707 0.73274
C    0.00348         0.08317 0.02856 0.03439 0.00512 0.39175 0.53714
D    0.00006         0.20074 0.52959 0.11533 0.06825 0.01274 0.02111
E    0.01071         0.09345 0.20207 0.11695 0.18982         0.41967
F    0.02323                         0.01277 0.16024
G                                    0.00172 0.18995
H                                    0.12516 0.06960
I                                            0.00106

            FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ  6
                           CSQ  6 RISK= 5.7E-02
                                APB ATTRIBUTES
        1       2       3       4       5       6       7       8       9
A    0.91382 0.62492 0.22562 0.03535 0.36879 0.04533 0.60763 0.01746 0.27937
B    0.04743 0.37506 0.39185 0.20481 0.22795 0.29482 0.01507 0.00741 0.72062
C    0.00364         0.08145 0.03339 0.02927 0.00588 0.36502 0.53199
D    0.00006         0.20499 0.52274 0.10079 0.05623 0.01226 0.02223
E    0.00969         0.09608 0.20371 0.11152 0.18004         0.42090
F    0.02535                         0.01549 0.17932
G                                    0.00193 0.16939
H                                    0.14426 0.06872
I                                            0.00027

            FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ  7
                           CSQ  7 RISK= 8.3E+03
                                APB ATTRIBUTES
        1       2       3       4       5       6       7       8       9
A    0.91939 0.63371 0.23971 0.03617 0.26499 0.04350 0.60773 0.01510 0.27181
B    0.04584 0.36628 0.44801 0.21718 0.28209 0.30153 0.01352 0.00841 0.72817
C    0.00282         0.08249 0.02967 0.03830 0.00548 0.36805 0.59914
D    0.00004         0.17109 0.54724 0.13317 0.06707 0.01068 0.02517
E    0.00946         0.05869 0.16973 0.12383 0.19875         0.35217
F    0.02245                         0.01439 0.09713
G                                    0.00193 0.21862
H                                    0.14130 0.06790
I                                            0.00002

            FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ  8
                           CSQ  8 RISK= 3.3E-11
                                APB ATTRIBUTES
        1       2       3       4       5       6       7       8       9
A    0.92180 0.43642 0.25610 0.02307 0.15726 0.01579 0.74222 0.00966 0.32831
B    0.04438 0.56357 0.48828 0.23073 0.34889 0.32890 0.01313 0.01422 0.67168
C    0.00323         0.08838 0.03008 0.07619 0.00590 0.24090 0.71590
D    0.00002         0.14525 0.55005 0.10162 0.10586 0.00374 0.04264
E    0.01462         0.02199 0.16606 0.10107 0.43887         0.21757
F    0.01596                         0.01436 0.00897
G                                    0.00446 0.09108
H                                    0.19615 0.00464
I                                            0.00000
```

Table D.1 (continued)

FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ 9
CSQ 9 RISK= 3.3E-10
APB ATTRIBUTES

	1	2	3	4	5	6	7	8	9
A	0.92806	0.60326	0.21329	0.03074	0.43567	0.05199	0.51420	0.01456	0.24362
B	0.03554	0.39673	0.37576	0.20170	0.21083	0.18017	0.00771	0.00533	0.75636
C	0.00383		0.08383	0.02368	0.03423	0.00347	0.46425	0.49246	
D	0.00007		0.21149	0.52420	0.12321	0.07829	0.01383	0.01079	
E	0.01262		0.11563	0.21967	0.11326	0.17856		0.47684	
F	0.01987				0.00787	0.20239			
G					0.00103	0.21783			
H					0.07388	0.08698			
I						0.00031			

FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ
APB ATTRIBUTE 1
CSQ

	1	2	3	4	5	6	7	8	9
A	0.93200	0.89399	0.92277	0.91271	0.91938	0.91382	0.91939	0.92180	0.92806
B	0.04657	0.07017	0.04422	0.04819	0.04314	0.04743	0.04584	0.04438	0.03554
C	0.00181	0.00232	0.00321	0.00370	0.00348	0.00364	0.00282	0.00323	0.00383
D	0.00001	0.00001	0.00001	0.00007	0.00006	0.00006	0.00004	0.00002	0.00007
E	0.00830	0.00553	0.01553	0.00958	0.01071	0.00969	0.00946	0.01462	0.01262
F	0.01131	0.02798	0.01424	0.02575	0.02323	0.02535	0.02245	0.01596	0.01987

FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ
APB ATTRIBUTE 2
CSQ

	1	2	3	4	5	6	7	8	9
A	0.55396	0.55999	0.43642	0.62828	0.60568	0.62492	0.63371	0.43642	0.60326
B	0.44601	0.44000	0.56357	0.37170	0.39431	0.37506	0.36628	0.56357	0.39673

FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ
APB ATTRIBUTE 3
CSQ

	1	2	3	4	5	6	7	8	9
A	0.32152	0.30552	0.26813	0.22556	0.22467	0.22562	0.23871	0.25610	0.21329
B	0.47087	0.46852	0.49891	0.38727	0.39796	0.39185	0.44801	0.48828	0.37576
C	0.05972	0.06150	0.08686	0.08136	0.08317	0.06145	0.08249	0.08838	0.08383
D	0.13312	0.14371	0.12797	0.20679	0.20074	0.20499	0.17109	0.14525	0.21149
E	0.01477	0.02074	0.01813	0.09901	0.09345	0.09608	0.05869	0.02199	0.11563

FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ
APB ATTRIBUTE 4
CSQ

	1	2	3	4	5	6	7	8	9
A	0.01354	0.01935	0.02196	0.03569	0.03239	0.03535	0.03617	0.02307	0.03074
B	0.25490	0.23345	0.24150	0.20426	0.20739	0.20481	0.21718	0.23073	0.20170
C	0.01979	0.03955	0.03068	0.03421	0.02956	0.03339	0.02967	0.03008	0.02368
D	0.52632	0.53912	0.53977	0.51977	0.52959	0.52274	0.54724	0.55005	0.52420
E	0.18544	0.16853	0.16609	0.20605	0.20207	0.20371	0.16973	0.16606	0.21967

FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ
APB ATTRIBUTE 5
CSQ

	1	2	3	4	5	6	7	8	9
A	0.14432	0.13991	0.15301	0.37739	0.36021	0.36879	0.26499	0.15726	0.43567
B	0.39951	0.34144	0.38490	0.22461	0.23346	0.22795	0.28209	0.34889	0.21083
C	0.02851	0.02305	0.07122	0.02878	0.03439	0.02927	0.03830	0.07619	0.03423
D	0.06668	0.07039	0.08685	0.09613	0.11533	0.10079	0.13317	0.10162	0.12321
E	0.10280	0.10196	0.08815	0.11028	0.11695	0.11152	0.12383	0.10107	0.11326
F	0.01090	0.01524	0.01308	0.01574	0.01277	0.01549	0.01439	0.01436	0.00787
G	0.00295	0.00286	0.00483	0.00193	0.00172	0.00193	0.00193	0.00446	0.00103
H	0.22432	0.30515	0.19796	0.14514	0.12516	0.14426	0.14130	0.19615	0.07388

Table D.1 (continued)

FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ
APB ATTRIBUTE 6
CSQ

	1	2	3	4	5	6	7	8	9
A	0.00815	0.01327	0.00800	0.04522	0.04829	0.04533	0.04350	0.01579	0.05199
B	0.35642	0.49236	0.31363	0.28517	0.26766	0.29482	0.30153	0.32890	0.18017
C	0.00491	0.01334	0.00618	0.00597	0.00512	0.00588	0.00548	0.00590	0.00347
D	0.04042	0.03929	0.09510	0.06467	0.06825	0.05623	0.06707	0.10586	0.07829
E	0.51726	0.34914	0.49675	0.17867	0.18982	0.18004	0.19875	0.43887	0.17856
F	0.00375	0.00684	0.00653	0.18746	0.16024	0.17932	0.09713	0.00897	0.20239
G	0.06699	0.08227	0.07050	0.16363	0.19095	0.16939	0.21862	0.09108	0.21783
H	0.00210	0.00349	0.00330	0.06904	0.06960	0.06872	0.06790	0.00464	0.08698
I	0.00000	0.00000	0.00000	0.00017	0.00006	0.00027	0.00002	0.00000	0.00031

FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ
APB ATTRIBUTE 7
CSQ

	1	2	3	4	5	6	7	8	9
A	0.83924	0.82570	0.76976	0.60950	0.58321	0.60763	0.60773	0.74222	0.51420
B	0.01017	0.02604	0.01293	0.01540	0.01230	0.01507	0.01352	0.01313	0.00771
C	0.14920	0.14608	0.21543	0.36272	0.39175	0.36502	0.36805	0.24090	0.46425
D	0.00139	0.00218	0.00187	0.01236	0.01274	0.01226	0.01068	0.00374	0.01383

FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ
APB ATTRIBUTE 8
CSQ

	1	2	3	4	5	6	7	8	9
A	0.04868	0.03295	0.01072	0.01799	0.01500	0.01746	0.01510	0.00966	0.01456
B	0.01179	0.01186	0.01570	0.00739	0.00707	0.00741	0.00841	0.01422	0.00533
C	0.59118	0.60587	0.72314	0.52556	0.53714	0.53199	0.59914	0.71590	0.49246
D	0.16727	0.16076	0.05297	0.02240	0.02111	0.02223	0.02517	0.04254	0.01079
E	0.18107	0.18855	0.19747	0.42665	0.41967	0.42090	0.35217	0.21757	0.47684

FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ
APB ATTRIBUTE 9
CSQ

	1	2	3	4	5	6	7	8	9
A	0.43612	0.43138	0.33784	0.28143	0.26725	0.27937	0.27181	0.32831	0.24362
B	0.56387	0.56860	0.66215	0.71856	0.73274	0.72062	0.72817	0.67168	0.75636

Table D.1 (continued)

FRACTIONAL CONTRIBUTIONS OF AFB TO CSQ, NORMALIZED ON SAMPLE BASIS

	CSQ 1			CSQ 2			CSQ 3	
ABABBEACB	0.018[illegible]	0.01859	ABABBEAEB	0.01407	0.01407	ABABBEACB	0.02056	0.02056
ABABAEACB	0.01469	0.03327	ABABBEACB	0.01374	0.02781	ABABAEACB	0.01790	0.03846
ABABBEAEB	0.01348	0.04675	ABABAEACB	0.01268	0.04049	ABBDDGACB	0.01454	0.05300
ABBEBEAAB	0.01310	0.05985	ABBEBEAAB	0.01175	0.05224	ABABBEAEB	0.01431	0.06731
ABBDDGACB	0.01197	0.07183	ABBDDGACB	0.01172	0.06396	AAABAEACB	0.01245	0.07975
AAABAEACB	0.01108	0.08290	ABABAEAEB	0.00911	0.07307	AABEBEACB	0.00928	0.08904
ABABBEADB	0.01029	0.09319	ABBDDGCCB	0.00890	0.08197	ABCBBEACB	0.00904	0.09808
ABCBBEACB	0.00939	0.10258	AAABAEACB	0.00884	0.09081	AAABBEAEB	0.00831	0.10638
AABEBEACB	0.00925	0.11183	ABABBEADB	0.00798	0.09879	ABBEDGAAB	0.00801	0.11440
AAABEBACB	0.00798	0.11982	AAABEBACB	0.00783	0.10662	ABABEEACB	0.00729	0.12169
ABABEEACB	0.00744	0.12726	ABBEDGAAB	0.00736	0.11399	AABDEBACB	0.00714	0.12883
ABBEDGAAB	0.00743	0.13469	AAABAEAEB	0.00712	0.12111	ABBEBEAAB	0.00685	0.13569
AABDEBACB	0.00738	0.14207	ABCBBEACB	0.00685	0.12795	ABABBEACA	0.00681	0.14250
AAABBEAEB	0.00692	0.14899	AABDEBACB	0.00650	0.13445	AAABEEACB	0.00681	0.14930
ABBDDGCCB	0.00669	0.15568	ABDDDGCCB	0.00646	0.14091	AAABEBACB	0.00676	0.15607
ABABBEACA	0.00655	0.16223	AABDHBACB	0.00603	0.14693	ABABBEADB	0.00661	0.16268
ABAEBEADB	0.00651	0.16874	ABABEEACB	0.00595	0.15288	ABBDDGACA	0.00652	0.16920
AABDHBACA	0.00642	0.17515	AABDHBACA	0.00587	0.15875	AAABBEACB	0.00646	0.17565
[illegible]ABAEAEB	0.00631	0.18146	AAABHBACB	0.00551	0.16426	ABCBAEACB	0.00577	0.18142
AAABAEAEB	0.00558	0.18704	AABEBEACB	0.00548	0.16974	ABDDAEACB	0.00551	0.18693
ABCBBEACA	0.00537	0.19241	ABAEBEADB	0.00532	0.17506	ABAEAEACB	0.00546	0.19238
ABBDDGACA	0.00535	0.19776	ABABBEACA	0.00517	0.18023	ABBDDGCCB	0.00532	0.19771
AABDHBACB	0.00529	0.20305	AAABBEAEB	0.00512	0.18535	AAABAEAEB	0.00531	0.20301
BABDHBACB	0.00523	0.20828	AAABBEADB	0.00504	0.19039	AABDBEACB	0.00507	0.20808
AAABBEACB	0.00521	0.21350	AADDHBACB	0.00504	0.19543	ABBEBEACB	0.00503	0.21312
AAABBEADB	0.00508	0.21858	ABBDDGACA	0.00494	0.20036	BABDBEACB	0.00484	0.21796
AADDHBACB	0.004[illegible]	0.22355	BABDHBACB	0.00483	0.20519	ABABBEAEA	0.00482	0.22278
AAABEEACB	0.00493	0.22848	EAEEAECEB	0.00463	0.20982	ABABAEACA	0.00480	0.22758
ABDDDGCCB	0.00484	0.23332	AAABABACB	0.00442	0.21424	AADDHBACB	0.00479	0.23237
AABDBEACB	0.00477	0.23809	ABCBBEACA	0.00439	0.21863	AABDHBACB	0.00478	0.23715
ABCBAEACB	0.00450	0.24258	ABABAEAEA	0.00437	0.22300	ABCBBEACA	0.00463	0.24177
AAABHBACB	0.00449	0.24708	AACBHBACB	0.00436	0.22736	ABDDDGCCB	0.00458	0.246[illegible]
ABAEAEACB	0.00423	0.25130	AAABEBAEB	0.00435	0.23171	ABABAEAEB	0.00451	0.[illegible]
ABABAEACA	0.00410	0.25540	ABAEAEAEB	0.00425	0.23596	ABBDAEACB	0.00423	0.25510
ABBEBEACB	0.00405	0.25945	ABABAEACA	0.00422	0.24019	EAEEAECEB	0.00415	0.25925
EAEEAECEB	0.00403	0.26349	BAABBBADB	0.00416	0.24435	BABDHBACB	0.00414	0.26339
ABDDAEACB	0.00399	0.26747	ABCBAEAEB	0.00415	0.24850	AAABHBACB	0.00413	0.26752
ABADBEADB	0.00397	0.27144	EBABAECEB	0.00401	0.25251	AAABEEAEA	0.00395	0.27146
ABABBEAEA	0.00393	0.27537	ABABBEAEA	0.00393	0.25644	AAABEEAEB	0.00382	0.27529
ABBDAEACB	0.00382	0.27919	ABBDDGCCA	0.00380	0.26024	ABBDBEACB	0.00368	0.27896
BBBDBEADB	0.00377	0.28296	ABCBAEACB	0.00369	0.26393	ABAEAEAEB	0.00363	0.28259
ABABBEADA	0.00367	0.28662	AADDFBACB	0.00367	0.26760	ABABEEAEB	0.00353	0.28612
ABCBAEAEB	0.00361	0.29024	ABDDAEACB	0.00359	0.27119	AAABAAACB	0.00349	0.28961
ABABAEAEA	0.00357	0.29381	AAABEBAEA	0.00351	0.27470	AAABAEACA	0.00341	0.29302
ABAEAEAEB	0.00352	0.29733	AAABHBAEB	0.00344	0.27814	AACBBEACB	0.00338	0.29641
AAABAAACB	0.00351	0.30084	ABAEAEACB	0.00336	0.28150	AABEBECCB	0.00337	0.29978
BABDBEACB	0.00348	0.30432	ABADBEADB	0.00333	0.28483	AABDFBACB	0.00325	0.30302
AACBHBACB	0.00344	0.30776	AADDABACB	0.00330	0.28813	AADDDGACB	0.00319	0.30621
AABDHBAEA	0.00325	0.31101	AAABAAAEB	0.00326	0.29139	ABABAEAEA	0.00318	0.30940
BAABBBADB	0.00325	0.31426	ABCBBEAEB	0.00317	0.29457	CAABAECEB	0.00314	0.31254
AADDFBACB	0.00319	0.31745	AABDFBACA	0.00317	0.29774	EBABAECEB	0.00312	0.31566
AAABBEAEA	0.00314	0.32059	AACBAAACB	0.00312	0.30086	AACBAEACB	0.00311	0.31878
AABDFBACA	0.00313	0.32372	AABDFBACB	0.00311	0.30397	ABCBBEAEB	0.00311	0.32189
AAABEBAEB	0.00312	0.32684	AAABEEAEB	0.00310	0.30706	AAABBEACA	0.00310	0.32499
AAABEEAEB	0.00311	0.32995	ABBDHBACB	0.00309	0.31015	AABDEEACB	0.00308	0.32807
ABBDBEACB	0.00305	0.33300	AABDHBAEA	0.00308	0.31323	AABEDGAAB	0.00305	0.33113
BABEBEADB	0.00304	0.33604	BBBDBEADB	0.00307	0.31630	AACBAAACB	0.00301	0.33414
ABCBBEAEB	0.00297	0.33901	AAABAAACB	0.00292	0.31922	AABDAEACB	0.00301	0.33714
EBABAECEB	0.00296	0.34197	AAABBEACB	0.00289	0.32211	ABAEBEACB	0.00300	0.34014
CAABAECEB	0.00292	0.34489	ABABBEADA	0.00279	0.32490	AACBHBACB	0.00299	0.34313
[illegible]BBEACB	0.00290	0.34779	ABBEDGACB	0.00275	0.32765	AADDBEACB	0.00295	0.34608
ABABEEAEB	0.00290	0.35068	ABBDAEACB	0.00275	0.33039	BAABBBADB	0.00292	0.34900
AAABHBAEB	0.00283	0.35352	AAABBEADA	0.00274	0.33314	AABDHBACA	0.00286	0.35187

Table D.1 (continued)

FRACTIONAL CONTRIBUTIONS OF APB TO CSQ, NORMALIZED ON SAMPLE BASIS

	CSQ 4			CSQ 5			CSQ 6	
ABABAEAEB	0.01740	0.01740	ABBDDGCCB	0.01798	0.01798	ABABAEAEB	0.01751	0.01751
ABBDDGCCB	0.01674	0.03414	ABABAEAEB	0.01705	0.03504	ABBDDGCCB	0.01709	0.03460
ABABBEAEB	0.01455	0.04869	ABABBEAEB	0.01403	0.04907	ABABBEAEB	0.01467	0.04927
ABBDDGACB	0.01371	0.06240	ABBDDGACB	0.01345	0.06252	ABBDDGACB	0.01382	0.06309
AAABEBAEB	0.01028	0.07268	AAABAEAEB	0.01009	0.07262	AAABEBAEB	0.01017	0.07326
AAABAEAEB	0.00942	0.08210	AAABEBAEB	0.00926	0.08188	AAABAEAEB	0.00966	0.08292
ABBDDGCCA	0.00753	0.08963	ABBDDGCCA	0.00761	0.08949	ABBDDGCCA	0.00765	0.09058
AAABAFAEB	0.00703	0.09666	AAABAFAEB	0.00739	0.09687	AAABAFAEB	0.00708	0.09765
ABABAEACB	0.00687	0.10353	ABDDDGCCB	0.00731	0.10418	ABABAEACB	0.00695	0.10460
ABDDDGCCB	0.00656	0.11010	ABABAEACB	0.00683	0.11101	ABDDDGCCB	0.00686	0.11146
ABABBEACB	0.00625	0.11635	AAABABAEB	0.00649	0.11749	ABABBEACB	0.00622	0.11769
AAABABAEB	0.00611	0.12246	AAABHBAEB	0.00579	0.12329	AAABABAEB	0.00603	0.12371
AAABHBAEB	0.00580	0.12825	ABEEAGCEB	0.00574	0.12902	AAABHBAEB	0.00585	0.12956
ABABAEAEA	0.00535	0.13361	ABABBEACB	0.00563	0.13465	ABABAEAEA	0.00547	0.13503
ABABBEAEA	0.00525	0.13886	ABABAEAEA	0.00557	0.14022	ABBDDGACA	0.00523	0.14026
ABBDDGACA	0.00525	0.14411	ABABBEAEA	0.00483	0.14505	ABABBEAEA	0.00520	0.14545
AABDEBACB	0.00502	0.14913	ABBDDGACA	0.00476	0.14981	AABDEBACB	0.00510	0.15056
AAABAEACB	0.00490	0.15403	AAABAEACB	0.00474	0.15454	AAABAEACB	0.00491	0.15547
ABEEAGCEB	0.00479	0.15881	AABDEBACB	0.00467	0.15922	ABEEAGCEB	0.00481	0.16028
ABABEEAEB	0.00445	0.16327	ABEEAHCEB	0.00462	0.16383	ABABEEAEB	0.00430	0.16458
AAABBEAEB	0.00429	0.16755	AAABBEAEB	0.00438	0.16821	AAABBEAEB	0.00428	0.16886
ABBEDGAAB	0.00429	0.17184	AACBAFAEB	0.00413	0.17234	ABBEDGAAB	0.00418	0.17304
ABCBAEAEB	0.00407	0.17591	ABCBAEAEB	0.00395	0.17629	ABCBAEAEB	0.00406	0.17710
AADDABACB	0.00404	0.17995	AAEEHBAEB	0.00383	0.18011	AADDABACB	0.00399	0.18109
ABEEAHCEB	0.00389	0.18384	AAEEAFCEB	0.00380	0.18392	ABEEAHCEB	0.00390	0.18499
AABDHBACB	0.00386	0.18770	ABABAGAEB	0.00374	0.18766	AABDHBACB	0.00387	0.18886
AAABEBACB	0.00381	0.19152	AACBHBAEB	0.00367	0.19133	AAABEBACB	0.00385	0.19271
ABCBBEAEB	0.00368	0.19519	ABABEEAEB	0.00363	0.19497	ABCBBEAEB	0.00363	0.19634
ABABAGAEB	0.00367	0.19886	AAEEABAEB	0.00357	0.19854	AACBAFAEB	0.00360	0.19994
AACBAFAEB	0.00359	0.20245	AABDHBACB	0.00355	0.20209	ABABAGAEB	0.00358	0.20352
AACBHBAEB	0.00354	0.20599	AAABAEAEA	0.00353	0.20562	ABDDDGACB	0.00353	0.20705
AAEEAHCEA	0.00350	0.20949	ABBEDGAAB	0.00353	0.20915	AACBHBAEB	0.00350	0.21055
ABDDDGACB	0.00347	0.21296	ABBEDGCCB	0.00351	0.21266	AAABEEAEB	0.00343	0.21398
AAABEEAEB	0.00344	0.21640	AAABAGAEB	0.00351	0.21617	AAEEAHCEA	0.00341	0.21739
AAEEHBAEB	0.00339	0.21979	AADDABACB	0.00349	0.21966	AAEEAFCEB	0.00340	0.22079
AAEEEBAEA	0.00338	0.22317	ABDDDGACB	0.00347	0.22314	AAABAEAEA	0.00337	0.22416
AAABAFACB	0.00337	0.22654	AAABEBACB	0.00339	0.22652	AAEEHBAEB	0.00336	0.22753
AAEEAFCEB	0.00335	0.22989	AAABABAEA	0.00325	0.22977	ABBEDGCCB	0.00335	0.23088
AAABAEAEA	0.00333	0.23321	ABCBBEAEB	0.00317	0.23295	AAEEEBAEA	0.00334	0.23422
ABBEDGCCB	0.00328	0.23649	AAEEAHCEA	0.00312	0.23607	AAABAFACB	0.00329	0.23751
AAABABAEA	0.00320	0.23969	AAABEEAEB	0.00310	0.23917	AAABABAEA	0.00320	0.24071
AAABHBAEA	0.00319	0.24287	AAABAGACB	0.00305	0.24222	AAABHBAEA	0.00319	0.24390
AAEEAFCEA	0.00314	0.24602	AAABHBAEA	0.00300	0.24522	AAABAGACB	0.00316	0.24705
AAABAGACB	0.00310	0.24912	AAABAFACB	0.00298	0.24820	AAABAGAEB	0.00306	0.25012
AAEEHBAEA	0.00304	0.25216	AAEEAHCEB	0.00293	0.25114	AAEEAFCEA	0.00305	0.25317
AAABAGAEB	0.00304	0.25520	AAEEEBAEA	0.00293	0.25406	AADDFBACB	0.00302	0.25619
AADDFBACB	0.00304	0.25824	ABEEAFCEB	0.00290	0.25696	AAEEHBAEA	0.00299	0.25918
AAEEABAEB	0.00297	0.26121	AAABABACB	0.00281	0.25977	AAEEABAEB	0.00298	0.26216
AAABABACB	0.00294	0.26415	ABAEAEAEB	0.00279	0.26257	AAABABACB	0.00296	0.26512
AADDHBACB	0.00291	0.26706	AABDABACB	0.00275	0.26531	AADDHBACB	0.00293	0.26805
AAABBBAEB	0.00291	0.26996	AABDAGACB	0.00273	0.26805	AAABBBAEB	0.00289	0.27093
ABEEAHCEA	0.00287	0.27284	AAEEAFCEA	0.00271	0.27075	AABDABACB	0.00288	0.27382
AABDABACB	0.00285	0.27569	EAABAECEB	0.00268	0.27343	ABEEAHCEA	0.00278	0.27660
ABAAAEAEB	0.00274	0.27843	AADDHBACB	0.00267	0.27610	AAABEBAEA	0.00273	0.27932
AAABEBAEA	0.00274	0.28117	AADDFBACB	0.00261	0.27872	ABAAAEAEB	0.00270	0.28203
AAABHBACB	0.00269	0.28386	AAABAFAEA	0.00258	0.28130	AABDAGACB	0.00269	0.28472
AABDAGACB	0.00260	0.28646	ABEEAHCEA	0.00258	0.28388	AAABHBACB	0.00267	0.28739
AABDFBACB	0.00259	0.28905	AAABBBAEB	0.00257	0.28645	AABDBFACB	0.00262	0.29001
AABDBFACB	0.00259	0.29164	ABABAFAEB	0.00253	0.28898	ABBEDGACB	0.00260	0.29261
ABBEDGACB	0.00258	0.29422	AABDBFACB	0.00251	0.29149	AABDFBACB	0.00259	0.29520
AAABAFAEA	0.00254	0.29676	AABDAFACB	0.00250	0.29399	AAABAFAEA	0.00253	0.29774
AABDAFACB	0.00252	0.29927	ABBEDGACB	0.00249	0.29648	AABDAFACB	0.00253	0.30026
AABDBBACB	0.00250	0.30178	AAABEBAEA	0.00248	0.29895	AAEEAHCEB	0.00251	0.30277

Table D.1 (continued)

FRACTIONAL CONTRIBUTIONS OF APB TO CSQ, NORMALIZED ON SAMPLE BASIS

CSQ 7			CSQ 8			CSQ 9		
ABABAEAEB	0.02116	0.02116	ABABBEACB	0.01851	0.01851	ABBDDGCCB	0.01957	0.01957
ABABBEAEB	0.01665	0.03781	ABABAEACB	0.01586	0.03437	ABABAEAEB	0.01847	0.03804
ABBDDGCCB	0.01616	0.05397	ABABBEAEB	0.01564	0.05000	ABABBEAEB	0.01355	0.05159
ABBDDGACB	0.01495	0.06892	ABBDDGACB	0.01462	0.06462	ABBDDGACB	0.01233	0.06392
AAABAEAEB	0.01037	0.07929	AAABAEACB	0.01194	0.07656	AAABAEAEB	0.01175	0.07567
AAABEBAEB	0.00969	0.08898	ABCBBE[illegible]	0.00812	0.08468	AAABEBAEB	0.00836	0.08403
ABABAEACB	0.00908	0.09806	ABDEDGAAB	0.00809	0.09278	AAABAFAEB	0.00819	0.09222
ABBDDGCCA	0.00778	0.10583	AAABEBACB	0.00774	0.10051	AAABABAEB	0.00812	0.10034
ABABBEACB	0.00774	0.11357	AABDEBACB	0.00774	0.10825	ABBDDGCCA	0.00789	0.10823
ABABAEAEA	0.00677	0.12034	AAABBEAEB	0.00758	0.11583	ABEEAGCEB	0.00719	0.11542
ABDDDGCCB	0.00663	0.12697	ABBDDGCCB	0.00752	0.12335	ABDDDGCCB	0.00701	0.12242
AAABAFAEB	0.00663	0.13361	AABEBEACB	0.00719	0.13054	ABABAEAEA	0.00595	0.12837
AAABHBA[illegible]B	0.00658	0.14018	ABABAEAEB	0.00692	0.13746	ABEEAHCEB	0.00586	0.13423
AAABAEACB	0.00648	0.14666	ABBDDGACA	0.00653	0.14399	ABABAEACB	0.00549	0.13972
AABDEBACB	0.00619	0.15286	AAABAEAEB	0.00649	0.15048	ABABAGAEB	0.00528	0.14500
ABABBEAEA	0.00565	0.15851	ABABBEACA	0.00631	0.15679	AAABHBAEB	0.00519	0.15018
ABBDDGACA	0.00555	0.16405	BABDHBACB	0.00584	0.16263	AAEEHBAEB	0.00477	0.15496
AAABBEAEB	0.00537	0.16942	ABABEEACB	0.00583	0.16846	AAEEABAEB	0.00471	0.15967
AAABEBACB	0.00506	0.17448	ABDDDGCCB	0.00567	0.17413	ABABBEAEA	0.00470	0.16437
AAABA[illegible]AEB	0.00493	0.17941	ABCBAEACB	0.00542	0.17955	AAABBEAEB	0.00464	0.16901
ABA[illegible]EAEB	0.00469	0.18410	ABABBEADB	0.00540	0.18495	AACBHBAEB	0.00461	0.17362
ABEEDGAAB	0.00460	0.18870	ABAEAEACB	0.00525	0.19020	AACBAFAEB	0.00454	0.17816
ABCBAEAEB	0.00431	0.19301	AAABBEACB	0.00517	0.19537	AAEEAFCEB	0.00433	0.18249
AABDHBACB	0.00394	0.19695	ABDDAEACB	0.00513	0.20050	ABBDDGACA	0.00419	0.18668
AAABAEAEA	0.00388	0.20083	ABBEBEAAB	0.00507	0.20557	AAABAEAEA	0.00410	0.19078
AADDABACB	0.00388	0.20471	AAABEEACB	0.00486	0.21043	ABCBAEAEB	0.00401	0.19480
AAABEEAEB	0.00384	0.20855	AABDHBACB	0.00484	0.21527	AAABAEACB	0.00399	0.19879
ABCBBEAEB	0.00365	0.21220	ABABAEACA	0.00484	0.22010	ABBEDGCCB	0.00383	0.20261
AABDAGACB	0.00352	0.21572	ABABBEAEA	0.00483	0.22494	ABABBEACB	0.00374	0.20635
AAABABAEA	0.00347	0.21919	AADDHBACB	0.00465	0.22959	AAEEEBAEB	0.00373	0.21008
ABDDDGACB	0.00347	0.22266	EAEEAECEB	0.00413	0.23372	ABABEEAEB	0.00365	0.21373
AAABBBAEB	0.00343	0.22608	ABCBBEACA	0.00409	0.23781	ABAEAEAEB	0.00364	0.21737
AAEEHBAEA	0.00340	0.22948	ABBDAEACB	0.00406	0.24187	ABEEAFCEB	0.00350	0.22087
AAEEAHCEA	0.00338	0.23286	AABDBEACB	0.00404	0.24591	ABDDDGACB	0.00346	0.22433
AABDABACB	0.00335	0.23621	AAABEBAEB	0.00397	0.24988	EAABAECEB	0.00345	0.22778
AAABHBAEA	0.00334	0.23955	AAABHBACB	0.00377	0.25366	AAABAGAEB	0.00343	0.23122
AAABABACB	0.00328	0.24284	ABABAEAEA	0.00372	0.25737	AAEEAHCEB	0.00338	0.23460
ABABAEACA	0.00322	0.24606	ABAEAEAEB	0.00370	0.26107	ABEEAHCEA	0.00330	0.23790
AACBHBAEB	0.00313	0.24919	AAABAAACB	0.00368	0.26475	AAABAGACB	0.00326	0.24116
AAEEAFCEA	0.00311	0.25230	ABABEEAEB	0.00367	0.26842	EBABAECEB	0.00322	0.24438
AAABAGACB	0.00308	0.25538	AAABHBAEB	0.00362	0.27205	ABABAFAEB	0.00322	0.24759
ABBEDGCCB	0.00306	0.25844	BABDBEACB	0.00359	0.27564	AABDEBACB	0.00313	0.25073
AADDFBACB	0.00304	0.26148	AAABBEAE[illegible]	0.00350	0.27914	AAABABAEA	0.00312	0.25385
AAEEEBAEA	0.00299	0.26447	ABBEBEACB	0.00346	0.28260	AAEEAHCEA	0.00310	0.25695
AABDBFACB	0.00299	0.26746	AAABEEAEB	0.00341	0.28602	AAABEEAEB	0.00306	0.26001
AADDHBACB	0.00296	0.27042	ABCBBEAEB	0.00338	0.28940	ABCBBEAEB	0.00303	0.26304
ABDDAEACB	0.00295	0.27337	EBABAECEB	0.00338	0.29277	AAABAFACB	0.00302	0.26605
ABAAAEAEB	0.00295	0.27632	ABCBAEAEB	0.00334	0.29611	AAABAFAEA	0.00286	0.26891
ABCBAEACB	0.00286	0.27917	AABDFBACB	0.00324	0.29935	AABDAGACB	0.00271	0.27162
AACBAFAEB	0.00284	0.28201	ABBDBEACB	0.00316	0.30251	ABEEAGAEB	0.00268	0.27430
AAABAGAFB	0.00274	0.28475	AADDFBACB	0.00311	0.30562	AAEEAFCEA	0.00262	0.27691
AACBHBACB	0.00266	0.28741	AACBHBACB	0.00307	0.30869	AABDHBACB	0.00258	0.27950
BABDHBACB	0.00265	0.29006	ABBDDGCCA	0.00306	0.31175	AACBAEAEB	0.00254	0.28204
AABDFBA[illegible]	0.00263	0.29269	AABEBECCB	0.00301	0.31476	AABDAFACB	0.00253	0.28457
ABBEDGACB	0.00261	0.29530	CAABAECEB	0.00301	0.31777	AAABHBAEA	0.00249	0.287[illegible]7
AAABEBAEA	0.00257	0.29787	AAABAEACA	0.00297	0.32074	AADDABACB	0.00248	0.28955
ABCBAEAEA	0.00253	0.30039	BAABBBADB	0.00295	0.32369	ABBEDGAAB	0.00245	0.29200
AABDBBACB	0.00246	0.30286	ABBEDGACB	0.00286	0.32654	ABADAEAEB	0.00242	0.29442
AADDEBACB	0.00244	0.30530	AAABEBAEA	0.00283	0.32938	ABAAAEAEB	0.00235	0.29678
AAABHBACB	0.00242	0.30773	[illegible]EEEBAEA	0.00282	0.33220	ABDDDGCCA	0.00233	0.29911
ABEEAHCEB	0.00241	0.31013	A[illegible]FACB	0.00281	0.33501	AABDAFCCB	0.00231	0.30141
EAABAECEB	0.00240	0.31254	EAABAECCB	0.00280	0.33781	ABCBAGAEB	0.00230	0.30371
AAEEAFCEB	0.00240	0.31494	AAABABACB	0.00279	0.34060	ABBDAHCCB	0.00229	0.30600

Table D.1 (continued)

FRACTIONAL CONTRIBUTIONS OF APB TO CSQ

CSQ 1			CSQ 2			CSQ 3		
ABBDHBACB	0.05150	0.05150	ABBDHBACB	0.07585	0.07585	ABBDHBACB	0.07666	0.07666
AAABBEADB	0.05096	0.10246	AABDHBACA	0.03977	0.11563	ABBDBEACB	0.03735	0.11401
AABDHBACA	0.04011	0.14256	AAABBEADB	0.03763	0.15326	ABBDCDCCB	0.03650	0.15051
ABBEBEAAB	0.02665	0.16921	ABBDHBACA	0.03108	0.18433	ABBDHBACA	0.03139	0.18190
AABDHBAEA	0.02609	0.19530	AABDHBAEA	0.02573	0.21007	AAABBEACB	0.02589	0.20779
ABBDBEACB	0.02259	0.21789	AAADABACB	0.01884	0.22891	ABBDCDCCA	0.01824	0.22603
ABBDHBACA	0.02108	0.23896	ABBEBEAAB	0.01696	0.24587	ABBDDEACB	0.01708	0.24311
AAABBEADA	0.02079	0.25977	AADDHBACA	0.01568	0.26156	ABBDBEACA	0.01524	0.25835
AAADABACB	0.01920	0.27897	AAABBEADA	0.01540	0.27695	AAABBEACA	0.01249	0.27084
AABDEECCA	0.01730	0.29627	ABDDDGCCB	0.01267	0.28962	ABBEHBACB	0.01236	0.28320
AAABBEACB	0.01574	0.31201	ABBEHBACB	0.01223	0.30185	ABBDDGACB	0.01054	0.29374
AADDEEACA	0.01546	0.32747	ABBDCDCCB	0.01162	0.31347	AABDBBACA	0.00980	0.30354
AADDHBACA	0.01509	0.34256	AAEEABAEA	0.01102	0.32449	AAABBEADB	0.00951	0.31305
ABBDCDCCB	0.01456	0.35712	AABDEECCA	0.01102	0.33551	ABABAEACB	0.00917	0.32223
ABABBEADB	0.01210	0.36921	ABBDBEADB	0.01005	0.34556	ABABBEACB	0.00904	0.33127
ABBDBEADB	0.01192	0.38114	AADDEEACA	0.00984	0.35540	AAABBEAEB	0.00901	0.34028
AABDEECEA	0.01153	0.39267	AABDBBACA	0.00969	0.36509	AAEEABAEA	0.00898	0.34926
AADDEEAEA	0.01030	0.40297	ABBDBEACB	0.00893	0.37402	AABEBEACB	0.00784	0.35710
ABBDDEACB	0.01009	0.41306	AADDHBAEA	0.00866	0.38268	ABBDBECCB	0.00762	0.36472
ABBEDGAAB	0.00998	0.42304	ABBDDGACB	0.00798	0.39066	ABABBEAEB	0.00739	0.37212
AAADAEACB	0.00985	0.43289	ABABBEADB	0.00757	0.39824	AACBHBAEA	0.00733	0.37944
ABBDBEACA	0.00927	0.44216	AACBHBACA	0.00755	0.40578	AADDHBACB	0.00705	0.38649
AADDHBAEA	0.00876	0.45092	AADDHBACB	0.00747	0.41326	ABDDDGCCB	0.00678	0.39327
ABBEHBACB	0.00830	0.45922	AABDEECEA	0.00734	0.42060	ABBDDEACA	0.00664	0.39991
AAEEABAEA	0.00826	0.46747	AACBHBAEA	0.00728	0.42788	AABDBBAEA	0.00631	0.40622
ABABBGADB	0.00774	0.47521	ABBEDGAAB	0.00699	0.43487	AABDHBACB	0.00548	0.41170
AAABBEACA	0.00760	0.48281	AAADABACA	0.00675	0.44162	AAABBEAEA	0.00528	0.41698
ABBDCDCCA	0.00727	0.49008	BAABBBADB	0.00658	0.44820	ABDDCDACB	0.00515	0.42213
AABEEECCA	0.00706	0.49714	AAABBEACB	0.00656	0.45476	ABCBAEAEB	0.00509	0.42722
AAADABACA	0.00688	0.50402	AADDEEAEA	0.00656	0.46131	ABBEHBACA	0.00503	0.43226
AABDBBACA	0.00658	0.51060	BBABBBADB	0.00644	0.46776	AA[illegible]HBACB	0.00482	0.43708
BBABBBADB	0.00652	0.51712	AAADAEACB	0.00631	0.47407	AADEAECCB	0.00438	0.44145
AADEEEACA	0.00630	0.52342	AABDBBAEA	0.00624	0.48031	ABCDEEAEB	0.00414	0.44560
ABBEDGAAA	0.00614	0.52956	AABDHBACB	0.00597	0.48628	AADDBEACB	0.00397	0.44956
ABBDDGACB	0.00601	0.53557	ABBDCDCCA	0.00581	0.49209	AABEBEAEB	0.00395	0.45351
ABDDDGCCB	0.00580	0.54138	AAABHBACB	0.00580	0.49788	ABBDDGACA	0.00394	0.45745
ABCBBEACB	0.00567	0.54704	AACBHBACB	0.00567	0.50355	AAABBEADA	0.00390	0.46135
ABABAEACB	0.00533	0.55237	AADDHBCCA	0.00534	0.50889	AACBHBACB	0.00387	0.46522
ABABBEADA	0.00523	0.55761	FAACBCBDB	0.00517	0.51406	AABDHBACA	0.00381	0.46903
ABABBEACB	0.00513	0.56274	ABBEHBACA	0.00498	0.51904	ABBDBEABB	0.00366	0.47269
ABADBEADB	0.00511	0.56785	ABABBGADB	0.00493	0.52396	ABBDBECCA	0.00364	0.47633
AACBHBAEA	0.00494	0.57279	AABEHBACA	0.00485	0.52881	AADEBECCB	0.00364	0.47997
ABAEBEADB	0.00485	0.57764	ABDDBGCCB	0.00465	0.53346	ABDDCDCCB	0.00362	0.48359
AABEHBACA	0.00481	0.58245	AABEEECCA	0.00447	0.53793	ABBDBDCCB	0.00360	0.48719
AADDHBACB	0.00479	0.58724	AAABHBAEA	0.00432	0.54225	AACDBEACB	0.00358	0.49077
AABEEECEA	0.00463	0.59187	ABBDDEACB	0.00415	0.54639	ABBDABACB	0.00355	0.49432
ABCBBEACA	0.00449	0.59636	ABBEDGAAA	0.00412	0.55051	ABBDDGCCB	0.00352	0.49784
AABEBEACB	0.00441	0.60078	BAABBEADA	0.00400	0.55452	ABBEDGAAB	0.00334	0.50118
ABBDAEACB	0.00424	0.60502	AADEEEACA	0.00399	0.55850	AABEBBACB	0.00328	0.50446
AABDBBAEA	0.00424	0.60925	BBABBBADA	0.00397	0.56248	AAABAEACB	0.00324	0.50770
AADEEEAEA	0.00419	0.61344	BBACBEADB	0.00390	0.56638	ABCBAEAEA	0.00323	0.51093
ABBEBEAAA	0.00418	0.61762	FBAABBBDB	0.00385	0.57023	AADDHBACA	0.00318	0.51411
BBABBBADA	0.00397	0.62160	BABDBGADB	0.00383	0.57406	AADEBEACB	0.00313	0.51724
AAABBEAEB	0.00396	0.62555	ABBDBEACA	0.00359	0.57766	ABBDBEADB	0.00307	0.52031
ABBDDEACA	0.00394	0.62949	ABBDABACB	0.00357	0.58122	ABADEECEB	0.00297	0.52328
ABABBEAEB	0.00381	0.63330	AADDHBCEA	0.00355	0.58478	AACBHBACA	0.00295	0.52623
AABDHBACB	0.00381	0.63711	ABBCBEACB	0.00355	0.58833	EAABBECCB	0.00292	0.52915
AAADAEACA	0.00351	0.64062	ABCBBEACB	0.00347	0.59180	AABDEBACB	0.00289	0.53204
ABBDBECCB	0.00344	0.64406	AADDE[illegible]B	0.00342	0.59522	AADDEBACB	0.00287	0.53491
ABBEHBACA	0.00338	0.64744	AAABHBACA	0.00330	0.59852	AABDBEACB	0.00287	0.53778
AAABHBACB	0.00335	0.65079	AABEBBACB	0.00330	0.60182	AADEAECEB	0.00284	0.54061
AABDABACA	0.00319	0.65398	AABDABACA	0.00328	0.60510	AAABAEAEB	0.00284	0.54345
ABCBAEAEB	0.00309	0.65708	ABADBEADB	0.00326	0.60836	BA[illegible]BBBADB	0.00275	0.54621

Table D.1 (continued)

FRACTIONAL CONTRIBUTIONS OF APB TO CSQ

CSQ 4			CSQ 5			CSQ 6		
ABBDHBACB	0.03041	0.02041	ABBDHBACB	0.02506	0.02506	ABBDHBACB	0.03043	0.03043
AADDAFCCB	0.02617	0.05658	AABDBGCCB	0.02079	0.04585	AADDAFCCB	0.02451	0.05493
AAEEAFCEB	0.02269	0.07927	AADDAFCCB	0.01959	0.06544	AAEEAFCEB	0.02130	0.07623
AADDAFCEB	0.01744	0.09671	AABDDGCCB	0.01935	0.08479	AABDBGCCB	0.01766	0.09389
AABDBGCCB	0.01648	0.11320	AAEEAFCEB	0.01755	0.10234	AABDDGCCB	0.01644	0.11033
AABDDGCCB	0.01535	0.12854	ABBDCDCCB	0.01710	0.11944	AADDAFCEB	0.01633	0.12665
ABBDCDCCB	0.01432	0.14286	AADDAFCEB	0.01304	0.13248	ABBDCDCCB	0.01455	0.14120
ABBDHBACA	0.01245	0.15531	ABBDHBACA	0.01026	0.14274	ABBDHBACA	0.01246	0.15366
AABDAFACB	0.01180	0.16711	AABDAFACB	0.00908	0.15182	AABDAFACB	0.01108	0.16474
ABEEHBAEA	0.01008	0.17719	ABDDDGCCB	0.00876	0.16058	ABEEHBAEA	0.00981	0.17455
AAABBEAEB	0.00778	0.18497	ABBDCDCCA	0.00855	0.16912	AAABBEAEB	0.00766	0.18221
AABDAFAEB	0.00776	0.19273	ABBDDGACB	0.00831	0.17743	ABBDCDCCA	0.00727	0.18948
AAEEAFCEA	0.00748	0.20022	ABBDDGCCB	0.00825	0.18568	AABDAFAEB	0.00727	0.19675
AADDAFCCA	0.00745	0.20767	AADDEBACB	0.00779	0.19347	AAEEAFCEA	0.00717	0.20391
ABBDHBAEB	0.00740	0.21507	ABEEHBAEA	0.00722	0.20069	ABBDDGCCB	0.00716	0.21108
ABBDCDCCA	0.00715	0.22222	AAABBEAEB	0.00718	0.20787	AADDAFCCA	0.00715	0.21822
ABBDDGCCB	0.00698	0.22920	AABDDGACB	0.00695	0.21482	ABBDHBAEB	0.00712	0.22534
ABBDHBAEA	0.00676	0.23596	AABDBGACB	0.00669	0.22152	ABBDDGACB	0.00693	0.23227
ABBDDGACB	0.00655	0.24251	ABBDHBAEB	0.00625	0.22777	ABBDHBAEA	0.00656	0.23883
AADDAHCCB	0.00609	0.24861	AAEEAFCEA	0.00593	0.23370	ABDDDGCCB	0.00640	0.24523
AAEEAFAEB	0.00599	0.25459	AABDAFAEB	0.00588	0.23958	AABDDGACB	0.00594	0.25117
AAEEAHCEB	0.00572	0.26032	AABEDGCCB	0.00585	0.24543	AADDAHCCB	0.00586	0.25703
ABDDDGCCB	0.00562	0.26594	AADDAFCCA	0.00573	0.25116	AADDEBACB	0.00572	0.26275
AABDDGACB	0.00557	0.27151	AAABHBAEB	0.00537	0.25653	AABDBGACB	0.00568	0.26843
AAABHBAEB	0.00551	0.27702	ABABAEAEB	0.00527	0.26180	AAEEAFAEB	0.00563	0.27407
AAABEBAEB	0.00538	0.28240	AACBHBAEB	0.00521	0.26701	AAABHBAEB	0.00558	0.27965
AACBHBAEB	0.00532	0.28772	ABABBEAEB	0.00497	0.27198	AAEEAHCEB	0.00543	0.28508
AABDBGACB	0.00531	0.29303	AAEEAHCEB	0.00486	0.27684	AAABEBAEB	0.00534	0.29041
ABABAEAEB	0.00521	0.29824	AABDBHCCB	0.00484	0.28168	AACBHBAEB	0.00533	0.29574
AADDEBACB	0.00514	0.30338	ABBDHBAEA	0.00478	0.28646	ABABAEAEB	0.00520	0.30093
AADDAFCEA	0.00497	0.30835	AAABBHCEB	0.00476	0.29122	AABEDGCCB	0.00497	0.30590
ABABBEAEB	0.00493	0.31328	AAABEBAEB	0.00474	0.29596	ABABBEAEB	0.00495	0.31085
ABBDBEACB	0.00490	0.31818	AAEEAFAEB	0.00472	0.30068	ABBEHBACB	0.00491	0.31575
ABBEHBACB	0.00490	0.32308	AADDAHCCB	0.00469	0.30538	ABBDBEACB	0.00489	0.32064
AABDHBACB	0.00483	0.32791	AAABBGCCB	0.00460	0.30998	AABDHBACB	0.00486	0.32551
AADDABACB	0.00478	0.33269	ABBDDGCCA	0.00457	0.21455	AADDAFCEA	0.00476	0.33027
AABEDGCCB	0.00464	0.33733	ABBDBEACB	0.00447	0.31901	AADDABACB	0.00467	0.33494
BAABBBADB	0.00454	0.34187	AABDDHCCB	0.00446	0.32348	BAABBBADB	0.00459	0.33953
AABDBBACB	0.00441	0.34628	AABDHBACB	0.00433	0.32781	AABDBBACB	0.00447	0.34400
ABBDDGCCA	0.00428	0.35055	BAABBBADB	0.00428	0.33209	ABBDDGCCA	0.00430	0.34830
AADDAHCEB	0.00408	0.35464	AAEEABAEB	0.00422	0.33631	AABDBHCCB	0.00411	0.35241
AAEEEBAEA	0.00402	0.35865	AABDBBACB	0.00419	0.34050	AAEEEBAEA	0.00408	0.35649
AAEEABAEB	0.00399	0.36264	ABBEHBACB	0.00404	0.34454	AAEEABAEB	0.00406	0.36056
AABDBBACA	0.00390	0.36654	AAEEEBAEA	0.00395	0.34849	AAABBHCEB	0.00404	0.36460
AADEAFCCB	0.00390	0.37044	AAABAEAEB	0.00393	0.35243	AAABBGCCB	0.00391	0.36850
AAABBEAEA	0.00386	0.37430	ABEEAHCEB	0.00391	0.35634	AABDBBACA	0.00390	0.37241
AAEEABAEA	0.00385	0.37815	ABBDADCEA	0.00385	0.36019	AAEEABAEA	0.00385	0.37626
AABDBHCCB	0.00384	0.38199	AADDAFCEA	0.00382	0.36401	AADDAHCEB	0.00382	0.38008
ABBEDGAAB	0.00381	0.38580	AADDEBACA	0.00353	0.36754	AABDDHCCB	0.00379	0.38387
AAABBHCEB	0.00377	0.38957	ABEEAFCEB	0.00353	0.37107	AAABBEAEA	0.00378	0.38765
AAABBGCCB	0.00365	0.39322	AADDABACB	0.00351	0.37458	ABBEDGAAB	0.00372	0.39138
AACBHBAEA	0.00362	0.39684	AAABBEAEA	0.00345	0.37803	AADEAFCCB	0.00365	0.39503
AABDDHCCB	0.00354	0.40038	AAABABAEB	0.00336	0.38140	AADDEBACA	0.00361	0.39864
AADDEBACA	0.00354	0.40392	ABBEDGAAB	0.00326	0.38465	AACBHBAEA	0.00360	0.40224
AABDAFACA	0.00340	0.40732	AAEEABAEA	0.00322	0.38787	AAABAEAEB	0.00342	0.40567
AAABBEACB	0.00337	0.41069	AABDBBACA	0.00322	0.39109	AAABBEACB	0.00337	0.40903
BAAAEAAEB	0.00337	0.41406	AABDBHCEB	0.00316	0.39425	AABDAFACA	0.00327	0.41231
AABCAFACB	0.00333	0.41738	AAAAEFAEB	0.00314	0.39739	BAAAEAAEB	0.00327	0.41558
ABEEAHCEB	0.00328	0.42067	ABDDAGCCB	0.00313	0.40052	ABEEAHCEB	0.00326	0.41883
AAABAEAEB	0.00327	0.42393	AAABBEACB	0.00309	0.40361	AAABHBAEA	0.0032[illegible]	0.42206
ABEEAHCEA	0.00323	0.42715	AADDAHCEB	0.00307	0.40669	AABCAFACB	0.00313	0.42519
AAABHBAEA	0.00322	0.43038	AABDABACB	0.00304	0.40973	AABDABACB	0.00312	0.42831
AAEEAHCEA	0.00321	0.43359	AACBHBAEA	0.00301	0.41273	AADDHBACB	0.00311	0.43141

Table D.1 (continued)

FRACTIONAL CONTRIBUTIONS OF APB TO CSQ

CSQ 7			CSQ 8			CSQ 9		
AABDBGCCB	0.03480	0.03480	ABBDHBACB	0.07134	0.07134	AABDBGCCB	0.02376	0.02376
AABDDGCCB	0.03240	0.06720	ABBDCDCCB	0.03892	0.11026	AADDAFCCB	0.02343	0.04719
ABBDHBACB	0.02936	0.09656	ABBDHBACA	0.02920	0.13946	AABDDGCCB	0.02212	0.06931
ABBDCDCCB	0.01923	0.11579	ABBDBEACB	0.02882	0.16827	AAEEAFCEB	0.02182	0.09113
ABBDHBACA	0.01202	0.12782	AAABBEACB	0.01998	0.18825	ABBDCDCCB	0.01691	0.10804
AABDDGACB	0.01125	0.13906	ABBDCDCCA	0.01945	0.20770	AADDAFCEB	0.01562	0.12367
AABDBGACB	0.01118	0.15025	ABBDDEACB	0.01352	0.22122	AABDAFACB	0.01114	0.13480
AABEDGCCB	0.00979	0.16004	ABBDDGACB	0.01337	0.23459	ABBDDGCCB	0.01052	0.14533
ABBDCDCCA	0.00961	0.16965	ABDDDGCCB	0.01322	0.24781	ABBDHBACB	0.00921	0.15454
AADDAFCCB	0.00933	0.17898	ABBDBEACA	0.01168	0.25949	ABBDCDCCA	0.00845	0.16299
AADDEBACB	0.00912	0.18811	ABBEHBACB	0.01150	0.27099	ABBDDGACB	0.00808	0.17107
ABEEHBAEA	0.00882	0.19693	AAABBEACA	0.00959	0.28058	AABDDGACB	0.00804	0.17911
ABBDDGCCB	0.00809	0.20502	AAABBEAEB	0.00923	0.28981	ABDDDGCCB	0.00797	0.18708
AABDBHCCB	0.00805	0.21307	AABDBBACA	0.00912	0.29893	AADDEBACB	0.00773	0.19482
AAABBHCEB	0.00796	0.22103	AAEEABAEA	0.00837	0.30730	AABDBGACB	0.00765	0.20247
AAEEAFCEB	0.00790	0.22892	ABABBEACB	0.00774	0.31504	AAABBEAEB	0.00714	0.20961
AAABBGCCB	0.00770	0.23663	ABBDBECCB	0.00758	0.32262	AABDAFAEB	0.00709	0.21670
AAABBEAEB	0.00760	0.24423	ABABAEACB	0.00756	0.33018	AAEEAFCEA	0.00671	0.22341
AABDDHCCB	0.00747	0.25170	ABABBEAEB	0.00740	0.33758	AABEDGCCB	0.00669	0.23009
ABBDDGACB	0.00731	0.25901	AACBHBAEA	0.00693	0.34451	ABABAEAEB	0.00662	0.23672
AAABHBAEB	0.00703	0.26603	AAABBEADB	0.00677	0.35128	AAEEAHCEB	0.00652	0.24324
AADDAFCEB	0.00608	0.27211	AABEBEACB	0.00673	0.35801	ABEEAFCEB	0.00646	0.24970
AACBHBAEB	0.00596	0.27807	AADDHBACB	0.00662	0.36463	AADDAFCCA	0.00620	0.25591
BAABBBADB	0.00591	0.28398	AABDHBACB	0.00596	0.37059	AAEEAFAEB	0.00597	0.26187
ABBDHBAEA	0.00575	0.28973	AABDBBAEA	0.00587	0.37646	ABEEAHCEB	0.00585	0.26772
AABDBBACB	0.00564	0.29537	ABDDCDACB	0.00549	0.38195	ABBDHBAEB	0.00571	0.27343
AAABEBAEB	0.00559	0.30096	ABBDDEACA	0.00524	0.38719	ABBDADCEA	0.00561	0.27904
AABDHBACB	0.00557	0.30653	AAABBEAEA	0.00500	0.39220	AABDBHCCB	0.00556	0.28460
AAEEEBAEA	0.00529	0.31182	ABDDBGCCB	0.00486	0.39706	ABBDDGCCA	0.00547	0.29007
AADDAFCCA	0.00528	0.31709	ABBEHBACA	0.00468	0.40174	AAABBHCEB	0.00544	0.29551
AABDBHCEB	0.00527	0.32237	AAABHBACB	0.00462	0.40637	AAABBGCCB	0.00526	0.30077
ABABAEAEB	0.00527	0.32764	AADDEBACB	0.00461	0.41097	ABBDADCEB	0.00521	0.30599
AAAAEFAEB	0.00526	0.33290	ABCDEEAEB	0.00441	0.41539	AABDDHCCB	0.00510	0.31109
ABBDBEACB	0.00519	0.33810	ABBDDGACA	0.00439	0.41978	AADDAHCCB	0.00502	0.31611
ABABBEAEB	0.00514	0.34323	ABBDDGCCB	0.00413	0.42391	ABABBEAEB	0.00494	0.32104
AAEEAFCEA	0.00511	0.34835	AAABAEAEB	0.00405	0.42796	ABDDAGCCB	0.00457	0.32562
ABDDDGCCB	0.00506	0.35340	ABCBAEAEB	0.00394	0.43190	AAABAFAEB	0.00437	0.32998
ABBDHBAEB	0.00502	0.35842	ABDDCDCCB	0.00388	0.43578	AACBHBAEB	0.00437	0.33435
AAEEABAEB	0.00490	0.36332	ABEEHBAEA	0.00385	0.43964	ABEEAGCEB	0.00427	0.33862
AADDEBACA	0.00488	0.36820	AACBHBACB	0.00385	0.44348	AAABAEAEB	0.00424	0.34286
ABBEHBACB	0.00473	0.37294	ABBDBDCCB	0.00384	0.44732	AADDAFCEA	0.00414	0.34700
ABBDDGCCA	0.00453	0.37747	BAABBBADB	0.00353	0.45085	AAEEEBAEB	0.00408	0.35108
AADDAHCCB	0.00450	0.38196	ABBDABACB	0.00350	0.45435	AAABABAEB	0.00395	0.35503
AADDABACB	0.00428	0.38624	AABDBBACB	0.00348	0.45783	AAEEHBAEB	0.00390	0.35892
AABDAFACB	0.00423	0.39047	ABBDBECCA	0.00345	0.46127	ABEEAHCEA	0.00390	0.36282
AABDABACB	0.00411	0.39457	AABEBEAEB	0.00342	0.46469	AAABHBAEB	0.00379	0.36661
AABDEACCA	0.00393	0.39850	AADEAECCB	0.00340	0.46809	ABBDHBACA	0.00377	0.37038
AAABBGAEB	0.00388	0.40239	AABDHBACA	0.00333	0.47142	AADDEBAEB	0.00376	0.37414
ABBDADCEA	0.00383	0.40622	ABBEDGAAB	0.00330	0.47472	ABEEHBAEA	0.00373	0.37787
AABDEBACA	0.00377	0.40999	AABDEBACB	0.00326	0.47799	AADDAHCEB	0.00370	0.38158
AAABHBAEA	0.00375	0.41374	AABEBBACB	0.00326	0.48124	AAEEAHCEA	0.00366	0.38523
AAEEABAEA	0.00367	0.41741	ABBDDDCCB	0.00325	0.48449	AAEEABAEB	0.00362	0.38885
AAABBEAEA	0.00366	0.42108	AAABAEACB	0.00320	0.48769	AABDBHCEB	0.00361	0.39246
ABBEDGAAB	0.00358	0.42466	ABADEECEB	0.00317	0.49086	AAAAEFAEB	0.00359	0.39605
AAABAEAEB	0.00355	0.42821	AADDBEACB	0.00312	0.49398	ABDDAGCCA	0.00359	0.39965
AAABBEACB	0.00355	0.43175	AAABHBAEB	0.00308	0.49706	AADEAFCCB	0.00350	0.40315
AABDBBAEB	0.00354	0.43529	AADDAEACB	0.00287	0.49994	AAABBGAEB	0.00343	0.40658
ABDDBACCB	0.00351	0.43880	AABEBECCB	0.00284	0.50277	AAABEBAEB	0.00341	0.40999
AADDAFCEA	0.00350	0.44230	AADEBECCB	0.00283	0.50560	ABBEDGCCB	0.00334	0.41333
AACBHBAEA	0.00342	0.44572	AAAEBEAEB	0.00282	0.50843	AAABBEAEA	0.00332	0.41665
ABBDBECCB	0.00335	0.44907	ABBDBEABB	0.00280	0.51123	ABEEAFCEA	0.00323	0.41988
AABDEBACB	0.00329	0.45236	AAABBEADA	0.00277	0.51400	AABDAFACA	0.00322	0.42311
AADDEBAEA	0.00323	0.45558	AACDBEACB	0.00274	0.51674	ABEEHBAEB	0.00314	0.42625

APPENDIX E
SAMPLING INFORMATION

CONTENTS

FIGURES

APPENDIX E
SAMPLING INFORMATION

The Grand Gulf analysis uses Latin hypercube sampling[E-1] as implemented by the LHS Program[E-2] in the propagation of uncertainties. The variables sampled in the analysis for Grand Gulf are listed in Tables 2.2-5, 2.3-2 and 3.2-1 of this report. Several input files and programs are used to generate the final LHS sample for Grand Gulf. The relationship between these files and programs is depicted in Figure E-1. These files were used to generate a sample of size 250 for Grand Gulf.

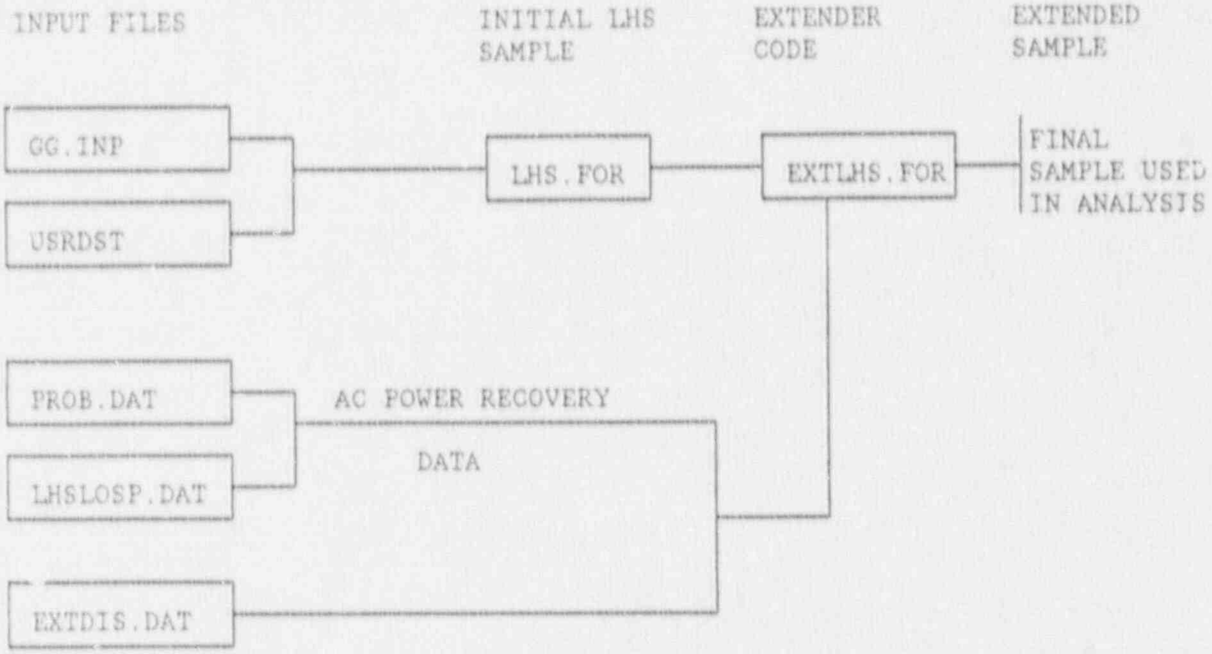

Figure E.1. File Structure Used to Generate Final LHS Sample for Grand Gulf

The input to the LHS program, GG.INP, is listed in Subsection E.1. This file contains the input distributions from the accident frequency analysis, the uncorrelated distributions used in the accident progression analysis, and the random numbers used in the source term analysis (see Subsection 3.2.3). As indicated at the end of the LHS input in Appendix E.1, this file also contains three pairs of variables that were required to have a rank correlation of 0.999.[E-3] There are many other groups of distributions that have a rank correlation of 1 that are handled in the "extender code." For each of these groups of correlated distributions, only a single variable is included in the input file listed in Subsection E.1.

Some of the sampled variables have user-defined distributions. These distributions are implemented by the subroutine USRDST listed in Subsection E.2. The distributions are defined in several ways. The input to LHS for such distributions contains an integer flag that characterizes how the distribution is described as well as the numeric data needed for this description. The nature of these flags is described in comments at the beginning of USRDST.

The LHS input in Subsection E.1 generates a Latin Hypercube sample of size 250 from 90 variables. However, this is not the sample actually used as input to the integrated analysis for Grand Gulf. Rather, certain variables are converted into a format that is easier to use in the integrated analysis, or are expanded into additional variables with the "extender" code EXTLHS, which is shown in Subsection E.3. Four types of conversions occur.

(1) Variables used as indicator variables for events that either always occur or never occur are converted into "0-1" (zero-one) variables. Such variables are identified by an integer flag of 2 in the Latin Hypercube Sampling (LHS) input shown in Subsection E.1. The subroutine USRDST shown in Subsection E.2 recognizes such variables by the integer flag just indicated and outputs a section of FORTRAN code that identifies these variables and the number of "0-1" cases to be generated in the extender code EXTLHS This FORTRAN code is then inserted into the extender code EXTLHS; the inserted code for Grand Gulf can be seen in EXTLHS in Subsection E.3 immediately after the comment line "C READ IN THE NECESSARY NO OF BRANCHES FOR THE 0-1 VARIABLES." A single "0-1" variable is generated for each case associated with an indicator variable in the original sample. These variables are inserted into the extended sample starting at the location of the original indicator variable; an appropriate shift is made when several indicator variables appear in sequence.

(2) The probability of Alpha Mode failure is modified to incorporate a reduced probability of occurrence for conditions involving high pressure in the RPV. The Alpha Mode probability sampled in the original Latin Hypercube sample is assumed to be for events occurring when the RPV is at low pressure. Alpha mode failures are believed to be less likely when the RPV is at high pressure. This is implemented by introducing a second variable into the sample that is 1/10 the original Alpha Mode probability. This new probability for Alpha Mode failure is used when the RPV is at high pressure.

(3) The probability of off-site power recovery is generated from an indicator variable included in the original sample. This variable is identified by the subroutine USRDST by the integer flag 4. This variable is then used in EXTLHS to select 250 sequences of power recovery probabilities from a set of 500 sequences of power recovery probabilities. These recovery probabilities are defined by a model for off-site

power recovery developed by Iman and Hora.[E-4] The actual calculation of power recovery curves is performed by the program MODEL, which is presented in Subsection E.4. In turn, the output of MODEL is used by the program LOSP.FOR to generate conditional probabilities of power recovery for specified time intervals given that power has not been recovered in a previous time interval and given that dc power is available during the time interval of interest; this program is given in Subsection E.5. The result of the operation of the programs in Subsections E.4 and E.5 is the 500 sequences (i.e., rows) of power recovery probabilities given in Subsection E.6. The first set of data presented in Subsection E.6 contains ac power recovery data used in the accident frequency analysis. The first and second columns contain the probability of failure to restore ac power within 1 hour and within 12 hours of the initiating event, respectively. The second set of data presented in Subsection E.6 is the power recovery probabilities used in the accident progression analysis. Each row in Subsection E.6 consists of six conditional probabilities for power recovery defined as follows:

Col. 1	Prob. of Recovery Between	Given No Recovery By
1	1 and 3.35 h	1 h
2	3.35 and 5.6 h	3.35 h
3	5.6 and 24. h	5.6 h
4	12 and 14.7 h	12 h
5	14.7 and 16.7 h	14.7 h
6	16.7 and 24 h	16.7 h

For each observation in the original sample, one row is selected from the table in Subsection E.6 with the indicator variable in the original sample (this is the last variable in the LHS input given in Subsection E.1). Then the value for the indicator variable is dropped from the original sample and the sequence of 8 (2 for accident frequency analysis and 6 for the accident progression analysis) power recovery probabilities from Subsection E.6 is inserted in its place.

(4) In addition, EXTLHS also generates variables for all the correlated variables not handled in LHS. These variables are contained in the file EXTDIS.DAT, which is listed in Subsection E.7. As mentioned previously, a single variable was included in LHS for each group of correlated variables that is handled in EXTLHS. From this single variable, a group of correlated variables is obtained. For example, the containment failure pressure is correlated with the drywell failure pressures (internal and external). In the LHS input, GG.INP, a single variable appears for those distributions. For each observation, the single variable from the original sample is used to obtain values for the containment failure

pressure, the internal drywell failure pressure, and the external drywell failure pressure from the distributions in Subsection E.7. In the extended LHS, the original single variable is dropped, and the three new correlated variables are added.

The original LHS sample that contained 90 variables was extended to include 226 variables that were used in the integrated analysis.

References

E-1. McKay, M. D., W. J. Conover, and R. J. Beckman, "A Comparison of Three Methods for Selecting Values of Input Variables in the Analysis of Output from a Computer Code," Technometrics 21 (1979) 239-45.

E-2. Iman, R. L., and M. J. Shortencarier, "A FORTRAN 77 Program and User's Guide for the Generation of Latin Hypercube and Random Samples for Use with Computer Models," Report No. NUREG/CR-3624, SAND83-2365, Sandia National Laboratories, Albuquerque, NM, 1984.

E-3. Iman, R. L., and W. J. Conover, "A Distribution-Free Approach to Inducing Rank Correlation Among Input Variables," Commun. Stat. Simul. Comput. 11 (1982), 311-334.

E-4. Iman, R. L., and S. C. Hora, "Modeling Time to Recovery and Initiating Event Frequency for Loss of Off-Site Power Incidents at Nuclear Power Plants," NUREG/CR-5032, SAND87-2428, Sandia National Laboratories, Albuquerque, NM (1988).

SUBSECTION E.1

E.1 LHS Input File GG.INP Listing

```
TITLE  NEW VERSION 3/1/89 FOR GRAND GULF
RANDOM SEED 98376433
NOBS 250
LOGNORMAL     MOV-CC MOV FAILS TO OPEN
          0.1490E-04          0.8513E-01
LOGNORMAL     MOV-MA MOV OUT FOR MAINTENANCE
          0.3974E-05          0.2270E-01
LOGNORMAL     MDP-FS MOTOR DRIVEN PUMP FAILS TO START
          0.1490E-04          0.8513E-01
LOGNORMAL     MDP-FR MOTOR DRIVEN PUMP FAILS TO RUN
          0.3576E-05          0.2043E-01
LOGNORMAL     MDP-MA MOTOR DRIVEN PUMP OUT FOR MAINT.
          0.9935E-05          0.5675E-01
LOGNORMAL     TDP-FS TURB. DRIVEN PUMP FAILS TO START
          0.1490E-03          0.8513E+00
USER DISTRIBUTION TDP-FR TURB. DRIVEN PUMP FAILS TO RUN
5  3  0.
          0.1200E-01          0.1200E+00          0.1000E+01
LOGNORMAL     DDP-FR DIESEL DRIVEN PUMP FAILS TO START
          0.9438E-04          0.5392E+00
LOGNORMAL     DGN-FS DIESEL GENERATOR FAILS TO START
          0.3048E-02          0.1890E+00
LOGNORMAL     DGN-FR DIESEL GENERATOR FAILS TO RUN
          0.7948E-04          0.4540E+00
LOGNORMAL     DGN-MA DIESEL GENERATOR OUT FOR MAINTENANCE
          0.2960E-04          0.1703E+00
LOGNORMAL     BAT-LP BATTERY FAILS TO DELIVER POWER
          0.1016E-03          0.6301E-02
LOGNORMAL     SSW-XHE-RE-TAB24 FAIL.TO RESTORE SSW TRAIN AFTER MAINT.
          0.2380E-05          0.7948E-01
USER DISTRIBUTION    RA-RCICDEP-12HR ?????????????
5  3  0.
          0.4100E-02          0.4100E-01          0.4100E+00
LOGNORMAL     CCF-MC-4 CCF OF DRYWELL PRESSURE SENSORS - MISCALIBRATION
          0.3353E-06          0.1915E-02
LOGNORMAL     BETA-2DG BETA FACTOR FOR CCF OF TWO DGN'S
          0.3661E-02          0.2394E+00
LOGNORMAL     BETA-3BAT COMMON CAUSE FACTOR FOR CCF OF THREE BATTERIES
          0.4064E-03          0.2520E-01
LOGNORMAL     BETA-3SSW COMMON CAUSE FACTOR FOR CCF OF THREE SSW PUMPS
          0.1422E-02          0.8821E-01
LOGNORMAL     IE-T2    LOSS OF MAIN FEED WATER SYSTEM
          0.1646E+00          0.1021E+02
LOGNORMAL     RA-INJ-1HR FAILURE TO RESTORE COOLANT INJECTION WITHIN 1H
          0.1739E-05          0.9932E-02
LOGNORMAL     RA-FWSACT-12HR FAILURE TO RESTORE FWS ACTUATION WITHIN 12H
          0.1490E-03          0.8513E+00
USER DISTRIBUTION    RA-PCS-1HR  FAILURE TO RESTORE PCS WITHIN 1H
5  3  0.
          0.1000E-01          0.1000E+00          0.1000E+01
LOGNORMAL     IE-TC   ATWS
          0.7244E+00          0.4492E+02
LOGNORMAL     CM   ??????????????????????????
          0.4967E-07          0.2838E-03
USER DISTRIBUTION    ADS-XHE  ???????????????????
5  3  0.
          0.1250E-01          0.1250E+00          0.1000E+01
USER DISTRIBUTION    IE-T1  LOSP
6  1000  0.
USER DISTRIBUTION  Q18C1P21,Q19C1P26,Q19C1P30-CF PRESSURE
8  3 0.
UNIFORM             Q18CASE1P22-RAN-CF PRESS.
0.0  1.0
USER DISTRIBUTION  Q18CASE1P24,Q19C1P34-CF IMPULSE
8  2   0.
```

```
UNIFORM             Q18CASE1P25 RAN CF IMPULSE
0.0  1.0
UNIFORM             Q23CASE2 SRV Bkr 1
1.0E-2  0.5
UNIFORM             Q23CASE4  SRV Bkr 2
1.0E-2  0.1
USER DISTRIBUTION  Q35[C1-C6]P2 H2-Inverse 1
9  6  0.
UNIFORM             Q41CASE3 Dif nSB
0.5  1.0
USER DISTRIBUTION  Q41CASE4,Q41CASE5 Dif-SB
8 2 0.
USER DISTRIBUTION  Q43[C4-C12] Deflag BVB
8 9 0.
USER DISTRIBUTION  Q44C2,C4,C5,C7 Deton BVB
8 4 0.
USER DISTRIBUTION  Q44CASE2P20,Q44C5P20 Deton Impulse
8 2 0.
USER DISTRIBUTION  Q48[C2,C4-C11]P18 Effect.Brn Press
8 9 0.
USER DISTRIBUTION  Q46[C2,6,8,10]P19 Brn Completeness
8 4 0.
USER DISTRIBUTION  Q52C2 DW Tail- Vac Brk
2  2 0.
1   .95
2   .05
USER DISTRIBUTION  Q54C4 DW Fld - Diff Flm
2  3  0.
1  .45
2  .45
3  .1
USER DISTRIBUTION  Q54C5 DW Fld - H2
2  2 0.
1  .50
2  .50
USER DISTRIBUTION  Q58C1AM Alpha
7  2  0.
USER DISTRIBUTION  Q61C1 Liq. VB - Inject
2  2  0.
1  .025
2  .975
USER DISTRIBUTION  Q61C2 Liq. VB - No Inject
2  2   0.
1  .10
2  .90
USER DISTRIBUTION  Q62C2 RPV Fail - SE
2  4  0.
1  .2
2  .2
3  .3
4  .3
USER DISTRIBUTION  Q63C5 RPV Fail - Inj. & Hi Liq VB
2  4  0.
1   .124
2   .005
3   .371
4   .5
USER DISTRIBUTION  Q63C6 RPV Fail - HiP & Hi Liq VB
2  3   0.
1   .249
2   .005
3   .746
USER DISTRIBUTION  Q63C7 RPV Fail - LoP & Hi Liq VB
2  3   0.
1   .249
2   .005
3   .746
```

```
USER DISTRIBUTION  Q63C8 RPV Fail - Inj. & Lo Liq VB
2  4  0.
1   .062
2   .005
3   .188
4   .745
USER DISTRIBUTION  Q63C9 RPV Fail - HiP & Lo Liq VB
2  3   0.
1   .249
2   .005
3   .746
USER DISTRIBUTION  Q63C10 RPV Fail - LoP & Lo Liq VB
2  3   0.
1   .249
2   .005
3   .746
USER DISTRIBUTION  Q64C2 HPME
2  2  0.
1  .8
2  .2
USER DISTRIBUTION  Q68[C2-C7] H2 - AVB
10 6 0.
USER DISTRIBUTION  Q70[C2,3,6,7]P13,Q77C2P40 DW Press.atVB-HiP&Wet Cav.
8  5  0.
USER DISTRIBUTION  Q70[C4,5,8,9]P13,Q77C3P40 DW Press.atVB-HiP&Dry Cav.
8  5  0.
USER DISTRIBUTION  Q70[10-13]P13,Q77C4P40  DW Press.atVB-LoP&Wet Cav.
8  5  0.
USER DISTRIBUTION  Q71[C2,C3,C6,C7]P39  Pedestal Press.at VB-HiP&Wet Cav.
8  4  0.
USER DISTRIBUTION  Q71[C4,C5,C8,C9]P39 Pedestal Press.at VB-HiP&Dry Cav.
8  4  0.
USER DISTRIBUTION  Q71[C10,11,13-15,17]P39 Pedestal Press.at VB-LoP&Wet Cav.
8  6  0.
UNIFORM            Q74CASE1 Pedestal Fail. Press.
900.   1700.
UNIFORM            Q75 Pedestal Fail. Ex SE
0.  1.
UNIFORM            Q77CASE6P40 WW Pressure at VB
0.0  113.5
USER DISTRIBUTION  Q81CASE2 CS - WW Failed - No AC
2  2  0.
1    .5
2    .5
USER DISTRIBUTION  Q81CASE6 CS - WW Failed - AC
2  3  0.
1    .5
2    .45
3    .05
USER DISTRIBUTION  Q84C3-C7 Ignition at VB
8  5  0.
USER DISTRIBUTION  Q76C2 DW Fail - Pedestal Fail
2  2  0.
1    .175
2    .825
USER DISTRIBUTION  Q97C2 Late Water - No AC
2  3  0.
1  .5
2  .25
3  .25
USER DISTRIBUTION  Q97C4 Late Water - Inject BVB
2  3 0.
1  .333
2  .333
3  .334
USER DISTRIBUTION  Q97C5 Late Water - No Inject BVB
2  3  0.
1  .333
```

```
2  .333
3  .334
UNIFORM       Q100C2 Low Debris - CCI
.6  1.0
UNIFORM       Q100C3 Hi Debris - CCI
.9  1.0
USER DISTRIBUTION  Q110(C4,C5,C6,C7) Ignition Late
8  4  0.
USER DISTRIBUTION  Q120C1P43 Pedestal Fail-Erosion Depth
5  12  3.281
1.0  0.0
1.0  0.090666
2.5  0.342
3.0  0.397333
3.3  0.431
3.5  0.464666
3.7  0.498333
4.0  0.532
4.4  0.565666
4.8  0.599666
5.5  0.966666
7.0  1.00
USER DISTRIBUTION  Q121 Pedestal Erosion Depth - CCI
8  28  0.
UNIFORM            Q123C2 Late Pressure-Noncondensibles
250  550
UNIFORM            GGSOR1 FCOR
0.0  1.0
UNIFORM            GGSOR2 FVES
0.0  1.0
UNIFORM            GGSOR3 FREVO
0.0  1.0
UNIFORM            GGSOR4 FCCI
0.0  1.0
UNIFORM            GGSOR5 FCONV
0.0  1.0
UNIFORM            GGSOR6 FCONC
0.0  1.0
UNIFORM            GGSOR7 FLT1
0.0  1.0
UNIFORM            GGSOR8 FDCH
0.0  1.0
UNIFORM            GGSOR9 DFPOOL
0.0  1.0
UNIFORM            GGSOR10 DFSPRAY
0.0  1.0
UNIFORM            GGSOR11 DFCAV
0.0  1.0
UNIFORM            GGSOR12 FEVSE
0.0  1.0
USER DISTRIBUTION  Q24,Q79,Q104 AC Power Recovery
4 500  0.
CORRELATION MATRIX
3
45  46  .999
65  66  .999
70  71  .999
```

SUBSECTION E.2

E.2 User Distribution Subroutine USRDSTGG.FOR Listing

```
CC***************************************************************
      SUBROUTINE USRDST(J)
C
C  MODIFIED BY AWS 1/25/89 TO TRANSFER SAMPLING OF CORRELATED
C   VARIABLES TO THE EXTENDER CODE.
C  MODIFIED BY AWS 12/23/88
C MODIFIED BY G. WILKINSON (11/17/88) FOR GRAND GULF RUN -
C  VARIABLES FOR SCREENING SENSITIVITY STUDY FOR GRAND GULF
C
C SUBROUTINE USRDST WILL GENERATE VALUES FROM A
C 1) DISCRETE DISTRIBUTION (WITH AND WITHOUT INTERPOLATION);
C     INDICATED WITH IFL = 1 AND IFL = 3.
C 2) DISCRETE DISTRIBUTION FOR LOSP - INDICATED BY IFL = 4
C     AN ARRAY REQUIRED FOR LOSP IS SET IN THE DATA STATEMENT.
C 3) ZERO-ONE CASES INDICATED BY IFL=2. A FILE ASSIGNED TO UNIT 99
C     IS WRITTEN FOR INPUT TO EXTLHS.FOR.
C
C  FOR IFL=5
C   GENERATE A MAXIMUM ENTROPY DISTRIBUTION FUNCTION FOR THE
C   VARIABLE WITH IFL SET TO 5. AN ADDITIONAL LINE OF INPUT IS
C   REQUIRED GIVING THE LOWER END OF THE RANGE, A , THE MEAN, RMU,
C   AND THE UPPER END OF THE RANGE, B .***NOTE*** FOR THIS
C   CASE A LINK TO IMSLIBS/LIB IS REQUIRED.
C
C  FOR IFL=6
C    GENERATE A DISTRIBUTION FUNCTION FOR INITIATING EVENT DATA.
C    AN ADDITIONAL INPUT FILE IS REQUIRED ASSIGNED TO UNIT 29.
C    THE FILE NAME IS 'IE.DAT'.
C
C  FOR IFL=7
C   GENERATE A DISTRIBUTION FUNCTION FOR ALPHA MODE VB. ONLY
C   ONE VARIABLE IS SAMPLED HERE. THE OTHER ONE IS COMPUTED IN
C   THE SUBROUTINE THAT EXTENDS THE LHS MATRIX FOR ZO CASES.
C   AN ADDITIONAL INPUT FILE IS REQUIRED ASSIGNED TO UNIT 28.
C   THE FILE NAME IS 'COMPOSIT.DAT'. A FILE ASSIGNED TO UNIT 99
C    IS WRITTEN FOR INPUT TO EXTLHS.FOR.
C
C  FOR IFL.GT.8
C    ONLY R IS STORED FOR THE SAMPLE SO THAT IT CAN BE COMPUTED
C    IN THE EXTENDER. A FILE ASSIGNED TO UNIT 99
C    IS WRITTEN FOR INPUT TO EXTLHS.FOR
C
C  FOR IFL=9
C    R IS SAVED TO BE STORED FOR THE VARIABLE WITH IFL = 10
C
C THE FOLLOWING SIX LINES OF CODE ARE REQUIRED BY USRDST:
C
C NMAX IS THE MAXIMUM NUMBER OF OBSERVATIONS.
C NVAR IS THE MAXIMUM NUMBER OF VARIABLES.
C LENT IS THE LENGTH OF THE TITLE.
C
      PARAMETER (NMAX=500)
      PARAMETER (NVAR=210)
      PARAMETER (LENT=125)
      COMMON/PARAM/TITLE(LENT),ISEED,N,NV,IRS,ICM,NREP,IDATA,IHIST,
     1            ICORR,IDIST(NVAR),IRP
      COMMON/SAMP/X(NMAX*NVAR)
C
C THE FOLLOWING PARAMETERS ARE REQUIRED FOR THE DISCRETE PROBABILITY FUNCTION
C
      PARAMETER (NCP=100)
      DIMENSION XVAL(NCP), CP(NCP)
C
C THE FOLLOWING PARAMETERS ARE REQUIRED FOR THE LOSP VARIABLES
C
```

```
C NP IS THE NUMBER OF PAIRS OF IVAL AND FREQ
C   IVAL(K) IS THE KTH UNIQUE VALUE OF THE RANDOM VARIABLE
C   FREQ(K) IS THE PROBABILITY ASSOCIATED WITH THE KTH VALUE
C
      PARAMETER(MAXNP=500)
      DIMENSION IVAL(MAXNP),FREQ(MAXNP),CDF(MAXNP+1)
      DATA FREQ/500*.002/
C
C THE FOLLOWING THREE LINES OF CODE ARE NEEDED FOR ****IFL=5****
C XX, F AND WORK ARE USED BY THE MAXIMUM ENTROPY DISTRIBUTION.
C A, RMU AND B ARE THE LOWER, MEAN AND UPPER POINTS FOR THE
C    MAXIMUM ENTROPY DISTRIBUTION.
C FCN IS A SUBROUTINE NEEDED TO GENERATE THE MAXIMUM ENTROPY
C     DISTRIBUTION.
C
      DIMENSION XX(1), F(1), WK(100)
      COMMON /FXIMSL/ A, RMU, B
      EXTERNAL FCN
C
C  THE FOLLOWING STATEMENTS ARE NEEDED FOR ***IFL=6***
C
C  RIEVAL(K) IS THE DISTRIBUTION FOR THE INITIATING EVENT VARIABLE.
      PARAMETER(NPIE=1000)
      DIMENSION RIEVAL(NPIE)
C
C  THE FOLLOWING STATEMENTS ARE NEEDED FOR ****IFL=7****
C
C DVAL(K) IS THE DISTRIBUTION FOR THE ALPHA MODE VB CASE.
C
      PARAMETER(MAXDIS=5500)
      DIMENSION DVAL(MAXDIS)
C
C THE FOLLOWING FUNCTION DEFINITION IS REQUIRED BY USRDST.
C
        LOC(I,J) = (J-1) * N + I
C
C READ FROM LHS INPUT FILES
C
          READ(7,*)IFL,NP,DSR
          IF(IFL.EQ.2)THEN
            WRITE(99,199)J,NP
199         FORMAT(7X,'ID (',I3,') = ',I2)
            DO 200 K=1,NP
200         READ(7,*)XVAL(K),CP(K)
            DO  K= 2 ,NP
            CP(K) = CP(K-1)+CP(K)
            ENDDO
            GO TO 6
          ENDIF
          IF(IFL.EQ.4)GO TO 98
          IF(IFL.EQ.5)GO TO 300
          IF(IFL.EQ.6)GO TO 405
          IF(IFL.EQ.7)THEN
            NAM=2
            WRITE(99,199)J,NAM
            WRITE(99,198)J
198       FORMAT(7X,'JAM = ',I3)
            GO TO 500
          ENDIF
          IF(IFL.GE.8)THEN
            WRITE(99,197)J,NP
197         FORMAT(7X,'IDS(',I3,') = ',I2)
            IF(IFL.EQ.9)THEN
            WRITE(99,297)J
297         FORMAT(7X,'JSAV = ',I3)
            ENDIF
            IF(IFL.EQ.10)THEN
```

```
          WRITE(99,298)J
298       FORMAT(7X,'JGET = ',I3)
          ENDIF
          GO TO 6
        ENDIF
        DO 5 K=1,NP
        READ(7,*) XVAL(K), CP(K)
C DIVIDED BY INPUT VALUE, DSR TO CHANGE VALUES AS REQUIRED
        IF(IFL.EQ.3)XVAL(K)=XVAL(K)/DSR
5       CONTINUE
C  SET THE STARTING POINT (STRTPT) EQUAL TO ZERO AND THE PROBABILITY
C  INCREMENT (PROBINC) EQUAL TO 1/N FOR A LHS WHERE N IS THE SAMPLE SIZE
C
6     STRTPT=0.0
      PROBINC=1.0/FLOAT(N)
      IF(IRS.EQ.1)PROBINC=1.0
C
C  THIS LOOP WILL OBTAIN THE N SAMPLES
C
      DO 4 I=1,N
       R=STRTPT + PROBINC*RAN(ISEED)
C   FOR IFL=8*********NEED ONLY R
       IF(IFL.EQ.8.OR.IFL.EQ.9)THEN
        X(LOC(I,J)) = R
        GO TO 25
       ENDIF
C   FOR IFL=10*********STORE 0.FOR NOW
       IF(IFL.EQ.10)THEN
        X(LOC(I,J)) = 0.
        GO TO 25
       ENDIF
C
C  0-1 VARIABLES   IFL=2
C
      IF (IFL.EQ.2)THEN
        IF (R.LE.CP(1)) X(LOC(I,J)) = XVAL(1)
         DO 2 K=2,NP
          IF ((R.GT.CP(K-1)).AND.(R.LE.CP(K)))
     $            X(LOC(I,J)) = XVAL(K)
    2    CONTINUE
         GO TO 25
      ENDIF
C
C  ALL VARIABLES OTHER THAN 0-1 VARIABLES  IFL=1 AND IFL=3
C
       DO 3 K=1,NP-1
          IF(R.GE.CP(K).AND.R.LT.CP(K+1)) THEN
            IF(XVAL(K).EQ.XVAL(K+1)) THEN
C
C  DISCRETE PROBABILITY
C
              X(LOC(I,J))=XVAL(K)
            ELSE
C
C  INTERPOLATION
C
              X(LOC(I,J)) = ((R-CP(K))/(CP(K+1)-CP(K)))*
     1                    (XVAL(K+1)-XVAL(K))+XVAL(K)
            ENDIF
            GO TO 25
          ENDIF
   3   CONTINUE
       WRITE(99,*)'FELL THRU',J
  25   CONTINUE
       IF(IRS.NE.1)STRTPT=STRTPT + PROBINC
   4  CONTINUE
      GO TO 99
```

```
C
C  LOSP VARIABLES
C
98     NP=MAXNP
       DO 110 K=1,NP
       IVAL(K)=K
  110 CONTINUE
C
C  CONSTRUCT THE CUMULATIVE DISTRIBUTION FUNCTION
C
       CDF(1)=0.0
       DO 120 K=1,NP
  120     CDF(K+1)=CDF(K)+FREQ(K)
C
C SET THE STARTING POINT (STRTPT) EQUAL TO ZERO AND THE PROBABILITY
C   INCREMENT (PROBINC) EQUAL TO 1/N FOR A LHS WHERE N IS THE
C   SAMPLE SIZE.
C
       STRTPT=0.0
       PROBINC=1.0/FLOAT(N)
C
C IF A RANDOM SAMPLE HAS BEEN SPECIFIED IN THE PARAMETER LIST THEN
C   THE ARGUMENT IRS HAS BEEN SET EQUAL TO 1 IN THE MAIN PROGRAM,
C   HENCE THE PROBABILITY INCREMENT IS SET EQUAL TO 1 SO THAT ALL
C   OBSERVATIONS ARE SELECTED BY USING THE INTERVAL (0,1).
C
       IF (IRS.EQ.1) PROBINC = 1.0
C
C THIS LOOP WILL OBTAIN THE N SAMPLE.
C
       DO 150 I=1,N
C
C R IS A RANDOMLY SELECTED POINT IN THE CURRENT SUBINTERVAL OBTAINED
C   BY USING THE RANDOM NUMBER GENERATOR RAN.
C
  125 R = STRTPT + PROBINC * RAN(ISEED)
C
C THIS LOOP WILL SELECT THE SPECIFIC VALUE OF THE RANDOM VARIABLE
C   CORRESPONDING TO R THROUGH THE INVERSE CUMULATIVE FUNCTION.  THESE
C   VALUES ARE STORED BY USE OF THE LOC FUNCTION.
C
       DO 130 K=1,NP
          IF(R.GE.CDF(K).AND.R.LT.CDF(K+1)) X(LOC(I,J))=IVAL(K)
  130 CONTINUE
C
C CHECK TO MAKE SURE THAT THE INTEGERS BEING SAMPLED FOR THE LOSP
C   VARIABLES ARE SAMPLED WITHOUT REPLACEMENT.
C
       DO 135 L=1,I
          IF(X(LOC(I,J)).EQ.X(LOC(L,J)).AND.I.NE.L) GO TO 125
  135 CONTINUE
C
C RESET THE STARTING POINT TO THE BEGINNING OF THE NEXT SUBINTERVAL
C   UNLESS A RANDOM SAMPLE HAS BEEN SPECIFIED
       IF(IRS.NE.1)STRTPT=STRTPT+PROBINC
  150 CONTINUE
C
   99  RETURN
C
C  FOR IFL=5
C
C THIS SECTION OF THE SUBROUTINE CONSTRUCTS THE SAMPLE
C VARIABLES BASED ON THE MAXIMUM ENTROPY DISTRIBUTION.
C
300      NSIG  = 4
         NN    = 1
        ITMAX = 20
```

```
      READ (7,*) A, RMU, B
C      THE NEXT LINE IS A DIAGNOSTIC TO HELP DETERMINE
C      IF THE COMBINED EVENTS ARE CORRECTLY POSITIONED
C      IN THE LHS INPUT FILE
C      PRINT *, A, RMU, B
      XX(1) = -1.0 / RMU
      CALL ZSCNT(FCN,NSIG,NN,ITMAX,PAR,XX,FNORM,WK,IER)
      BETA    = XX(1)
      RBETA   = 1.0 / BETA
      EA      = EXP(BETA * A)
      EB      = EXP(BETA * B)
      TERM    = EB - EA
C
C SET THE STARTING POINT (STRTPT) EQUAL TO ZERO AND THE PROBABILITY
C     INCREMENT (PROBINC) EQUAL TO 1/N FOR A LHS WHERE N IS THE
C     SAMPLE SIZE.
C IF A RANDOM SAMPLE HAS BEEN SPECIFIED IN THE PARAMETER LIST THEN
C    THE ARGUMENT IRS HAS BEEN SET EQUAL TO 1 IN THE MAIN PROGRAM,
C    HENCE THE PROBABILITY INCREMENT IS SET EQUAL TO 1 SO THAT ALL
C    OBSERVATIONS ARE SELECTED BY USING THE INTERVAL (0,1).
C
       STRTPT  = 0.0
       PROBINC = 1.0 / FLOAT(N)
       IF (IRS .EQ. 1) PROBINC = 1.0
C
C THIS LOOP WILL OBTAIN THE N SAMPLE VALUES.
C R IS A RANDOMLY SELECTED POINT IN THE CURRENT SUBINTERVAL OBTAINED
C   BY USING THE RANDOM NUMBER GENERATOR RAN.
C GENERATE THE MAXIMUM ENTROPY DEVIATES.
C RESET THE STARTING POINT TO THE BEGINNING OF THE NEXT SUBINTERVAL
C       UNLESS A RANDOM SAMPLE HAS BEEN SPECIFIED.
       DO 380 I = 1,N
         R            = STRTPT + PROBINC * RAN(ISEED)
         X(LOC(I,J)) = RBETA * LOG(TERM * R + EA)
         IF (IRS .NE. 1) STRTPT = STRTPT + PROBINC
380    CONTINUE
      RETURN
C
C   IFL-6  FRONT END IE
C
405    CONTINUE
C
C READ IN THE SAMPLE VALUES FOR THE INITIATING EVENT
C
         OPEN (UNIT = 29, FILE = 'IE.DAT', STATUS = 'OLD')
         READ (29,*) (RIEVAL(K), K = 1,NPIE)
C
C SET THE STARTING POINT (STRTPT) EQUAL TO ZERO AND THE PROBABILITY
C     INCREMENT (PROBINC) EQUAL TO 1/N FOR A LHS WHERE N IS THE
C     SAMPLE SIZE.
C IF A RANDOM SAMPLE HAS BEEN SPECIFIED IN THE PARAMETER LIST THEN
C    THE ARGUMENT IRS HAS BEEN SET EQUAL TO 1 IN THE MAIN PROGRAM,
C    HENCE THE PROBABILITY INCREMENT IS SET EQUAL TO 1 SO THAT ALL
C    OBSERVATIONS ARE SELECTED BY USING THE INTERVAL (0,1).
C
        STRTPT  = 0.0
        PROBINC = 1.0 / FLOAT(N)
        IF (IRS .EQ. 1) PROBINC = 1.0
C
C THIS LOOP WILL OBTAIN THE N SAMPLE VALUES.
C R IS A RANDOMLY SELECTED POINT IN THE CURRENT SUBINTERVAL OBTAINED
C   BY USING THE RANDOM NUMBER GENERATOR RAN.
C THE INNER  LOOP WILL SELECT THE SPECIFIC SAMPLE VALUE CORRESPONDING
C       TO R THROUGH THE INVERSE EMPIRICAL DISTRIBUTION FUNCTION
C       THESE VALUES ARE STORED IN THE VECTOR X THROUGH THE USE
C       OF THE LOC FUNCTION.
C RESET THE STARTING POINT TO THE BEGINNING OF THE NEXT SUBINTERVAL
```

```
C       UNLESS A RANDOM SAMPLE HAS BEEN SPECIFIED.
C
        DO 51 I = 1,N
          R = STRTPT + PROBINC * RAN(ISEED)
          X(LOC(I,J)) = RIEVAL(R*NPIE+1)
          IF (IRS .NE. 1) STRTPT = STRTPT + PROBINC
   51   CONTINUE
       RETURN
C
C  IFL=7********
C
500    REWIND 28
       READ(28,*)(DVAL(I),I=1,MAXDIS)
C SET THE STARTING POINT (STRTPT) EQUAL TO ZERO AND THE PROBABILITY
C INCREMENT (PROBINC) EQUAL TO 1/N FOR A LHS WHERE N IS THE SAMPLE SIZE
C
      STRTPT=0.0
      PROBINC=1.0/FLOAT(N)
C
C IF A RANDOM SAMPLE HAS BEEN SPECIFIED IN THE PARAMETER LIST THEN THE
C ARGUMENT IRS HAS BEEN SET EQUAL TO 1 IN THE MAIN PROGRAM, HENCE THE
C PROBABILITY INCREMENT IS SET EQUAL TO 1 SO THAT ALL OBSERVATIONS ARE
C SELECTED BY USING THE INTERVAL (0,1)
C
      IF(IRS.EQ.1)PROBINC=1.0
C
C THIS LOOP WILL OBTAIN THE N SAMPLE VALUES
C
      DO 204 I=1,N
C
C R IS A RANDOMLY SELECTED POINT IN THE CURRENT SUBINTERVAL OBTAINED
C BY USING THE RANDOM NUMBER GENERATOR RAN
C
        R=STRTPT+PROBINC*RAN(ISEED)
C
C SELECT THE SPECIFIC VALUE OF THE RANDOM VARIABLE CORRESPONDING TO R
C THE VALUE IS STORED BY USE OF THE LOC FUNCTION.
C
C
        K=R*MAXDIS+1
         X(LOC(I,J))=DVAL(K)
C
C RESET THE STARTING POINT TO THE BEGINNING OF THE NEXT SUBINTERVAL
C UNLESS A RANDOM SAMPLE HAS BEEN SPECIFIED
C
        IF(IRS.NE.1)STRTPT=STRTPT+PROBINC
  204 CONTINUE
      RETURN
       END
      SUBROUTINE FCN(XX,F,NN,PAR)
      DIMENSION XX(NN), F(NN), PAR(1)
      COMMON /FXIMSL/ A, RMU, B
      BETA = XX(1)
      EA   = EXP(BETA * A)
      EB   = EXP(BETA * B)
      TERM = (B * EB - A * EA) / (EB - EA)
      F(1) = TERM - (1.0 / BETA) - RMU
      RETURN
      END
```

SUBSECTION E.3

E.3 Extender Code EXTLHS.FOR Listing

```
      PROGRAM EXTLHS
C*********************************************************************
C
C  MODIFIED FROM NEXTLHS TO INCLUDE COMPUTING SAMPLES FOR FLAGGED
C  DISTRIBUTIONS-1/25/89 (AWS)
C  THIS PROGRAM READS IN AN LHS DATA FILE AND THEN                   *
C  CONVERTS THOSE VARIABLES CONTAINING INTEGER REPRESENTATIONS       *
C  (1,2,3,4) INTO THE APPROPRIATE 0-1 SAMPLING SCHEME.               *
C  IT ALSO READS A FILE CONTAINING CONDITIONAL PROBABILITIES OF      *
C  RECOVERY TIME FOR LOSP; BASED ON THE INTEGER VALUES IN THE LAST   *
C  COLUMN OF THE LHS DATA, THE LOSP PROBABILITIES ARE SAMPLED ACROSS *
C  ALL TIMES. THIS FORCES THE LOSP VARIABLES TO HAVE A RANK          *
C  CORRELATION OF EXACTLY ONE.                                       *
C                                                                    *
C*********************************************************************
C                                                                    *
C  NVAR IS THE INITIAL NUMBER OF LHS VARIABLES.                      *
C  NLHS IS THE LHS SAMPLE SIZE.                                      *
C  NTIME IS THE NUMBER OF TIMES (#COLUMNS) IN THE LOSP DATA (BACKEND)
C   PLUS THE ONE FOR THE FRONTEND                                    *
C  NLOSP IS THE NUMBER OF ROWS IN THE LOSP DATA                      *
C  MADD IS AN INTEGER THAT IS ADDED TO THE DIMENSIONING OF X TO MAKE *
C      SURE THAT X WILL BE BIG ENOUGH TO HANDLE THE INITIAL NUMBER   *
C      OF VARIABLES AS WELL AS ALL THOSE THAT ARE ADDED INTO THE MATRIX *
C  ID IS AN ARRAY FOR TRACKING THE NUMBER OF PERCENTAGES UPON        *
C    WHICH THE 0-1 VARIABLES ARE BASED; A "2" INDICATES THAT THE     *
C    VARIABLE IS BASED ON TWO PERCENTAGES; A "3" INDICATES THAT THE  *
C    VARIABLE IS BASED ON THREE PERCENTAGES,ETC;                     *
C  LOC IS A VARIABLE USED TO TRACK THE LOCATION OF EACH 0-1 VARIABLE; *
C    THIS VARIABLE IS "SHIFTED" OR UPDATED EACH TIME A NEW COLUMN IS *
C    INSERTED.                                                       *
C                                                                    *
C*********************************************************************
      PARAMETER(NLHS=250,NVAR=90,MADD=200,NTIME=8,NLOSP=500)
      DIMENSION X(NLHS,NVAR+MADD), ID(NVAR), CPROB(NLOSP,NTIME-2),
     1AC(NLOSP,2),CPROBSAM(NLHS,NTIME),ID8(NVAR),XVAL(100),CP(100),
     2RSAV(NLHS)
      CHARACTER*60 HEAD
      OPEN(5,FILE='LHS.DAT',STATUS='OLD')
      OPEN(6,FILE='PROB.DAT',STATUS='OLD')
      OPEN(8,FILE='LHSLOSP.DAT',STATUS='OLD')
      OPEN(7,FILE='EXTLHS.DAT',STATUS='NEW')
      OPEN(20,FILE='EXTDIS.DAT',STATUS='OLD')
CC
C  INITIALIZE THE ID ARRAY
CC
      DO 10 I=1,NVAR
        ID(I)=0
        ID8(I)=0
  10  CONTINUE
CC
C  READ IN THE THE NECESSARY NO OF BRANCHES FOR THE 0-1 VARIABLES
CC
       ID8( 27) =  3
       ID8( 29) =  2
       ID8( 33) =  6
       JSAV =  33
       ID8( 35) =  2
       ID8( 36) =  9
       ID8( 37) =  4
       ID8( 38) =  2
       ID8( 39) =  9
       ID8( 40) =  4
       ID ( 41) =  2
       ID ( 42) =  3
```

```
      ID ( 43) =  2
      ID ( 44) =  2
      JAM =  44
      ID ( 45) =  2
      ID ( 46) =  2
      ID ( 47) =  4
      ID ( 48) =  4
      ID ( 49) =  3
      ID ( 50) =  3
      ID ( 51) =  4
      ID ( 52) =  3
      ID ( 53) =  3
      ID ( 54) =  2
      ID8( 55) =  6
      JGET =  55
      ID8( 56) =  5
      ID8( 57) =  5
      ID8( 58) =  5
      ID8( 59) =  4
      ID8( 60) =  4
      ID8( 61) =  6
      ID ( 65) =  2
      ID ( 66) =  3
      ID8( 67) =  5
      ID ( 68) =  2
      ID ( 69) =  3
      ID ( 70) =  3
      ID ( 71) =  3
      ID8( 74) =  4
      ID8( 76) = 28
CC
C  CONVERT THE INTEGER REPRESENTATIONS FROM LHS (1,2,3,...)
C  INTO ZEROS OR ONES BASED ON THE PERCENTAGE INTERVALS;
C  THIS IS DONE OVER ALL SAMPLES.
CC
      DO 20 K=1,NLHS
        NTVAR = NVAR
        READ(5,*)(I1,I2,(X(K,I),I=1,NVAR))
        REWIND 20
        LOC=0
        DO 30 J=1,NVAR
          LOC = LOC + 1
          IF(ID(J).EQ.0)GO TO 25
            IF(ID(J).EQ.2)THEN
              DO 40 I=1,NTVAR-LOC
                X(K,NTVAR+ID(J)-I) = X(K,NTVAR+ID(J)-I-1)
  40          CONTINUE
              NTVAR = NTVAR + 1
C   CHECK FOR ALPHA MODE
              IF(J.EQ.JAM)THEN
               X(K,LOC+1) = .1*X(K,LOC)
               LOC=LOC+1
               GO TO 30
              ENDIF
CC
C   ERROR MESSAGE
CC
              IF(NTVAR.GT.NVAR+MADD) STOP ' NTVAR EXCEEDS DIMENSIONS '
              IF(X(K,LOC).EQ.1)THEN
                X(K,LOC) = 1
                X(K,LOC+1) = 0
              ELSE IF(X(K,LOC).EQ.2)THEN
                X(K,LOC) = 0
                X(K,LOC+1) = 1
              ENDIF
              LOC = LOC + 1
C  IF JTH ITEM IN THE ID ARRAY = 3
```

```
            ELSE IF(ID(J).EQ.3)THEN
              DO 50 I=1,NTVAR-LOC
                X(K,NTVAR+ID(J)-I) = X(K,NTVAR+ID(J)-I-2)
  50          CONTINUE
              NTVAR = NTVAR + 2
              IF(X(K,LOC).EQ.1)THEN
                X(K,LOC) = 1
                X(K,LOC+1) = 0
                X(K,LOC+2) = 0
              ELSE IF(X(K,LOC).EQ.2)THEN
                X(K,LOC) = 0
                X(K,LOC+1) = 1
                X(K,LOC+2) = 0
              ELSE IF(X(K,LOC).EQ.3)THEN
                X(K,LOC) = 0
                X(K,LOC+1) = 0
                X(K,LOC+2) = 1
              ENDIF
              LOC = LOC + 2
C  IF JTH ITEM IN THE ID ARRAY = 4
            ELSE IF(ID(J).EQ.4)THEN
              DO 60 I=1,NTVAR-LOC
                X(K,NTVAR+ID(J)-I) = X(K,NTVAR+ID(J)-I-3)
  60          CONTINUE
              NTVAR = NTVAR + 3
              IF(X(K,LOC).EQ.1)THEN
                X(K,LOC) = 1
                X(K,LOC+1) = 0
                X(K,LOC+2) = 0
                X(K,LOC+3) = 0
              ELSE IF(X(K,LOC).EQ.2)THEN
                X(K,LOC) = 0
                X(K,LOC+1) = 1
                X(K,LOC+2) = 0
                X(K,LOC+3) = 0
              ELSE IF(X(K,LOC).EQ.3)THEN
                X(K,LOC) = 0
                X(K,LOC+1) = 0
                X(K,LOC+2) = 1
                X(K,LOC+3) = 0
              ELSE IF(X(K,LOC).EQ.4)THEN
                X(K,LOC) = 0
                X(K,LOC+1) = 0
                X(K,LOC+2) = 0
                X(K,LOC+3) = 1
              ENDIF
              LOC = LOC + 3
            ENDIF
          GO TO 30
C  COMPUTE SAMPLES FOR GIVEN NUMBER OF DISTRIBUTIONS
  55      IF(ID8(J).EQ.0)GO TO 30
              IF(JSAV.EQ.J)RSAV(K)=X(K,LOC)
              NOD=ID8(J)
              R = X(K,LOC)
              IF(JGET.EQ.J)R=1.-RSAV(K)
              DO 65 I=1,NTVAR-LOC
              X(K,NTVAR+NOD-I) = X(K,NTVAR-I+1)
  65          CONTINUE
              NTVAR = NTVAR + NOD-1
           DO 6 ND=1,NOD
              READ(20,'(A)')HEAD
99        FORMAT(A)
              READ(20,*,END=999)IFL,NP,DSR
             DO 5 KK=1,NP
              READ(20,*) XVAL(KK), CP(KK)
C DIVIED BY INPUT VALUE, DSR TO CHANGE VALUES AS REQUIRED
              IF(IFL.EQ.3)XVAL(KK)=XVAL(KK)/DSR
```

```
5             CONTINUE
              DO 3 KK=1,NP-1
              IF(R.LT.CP(KK))GO TO 3
C    R GE CP(KK)
              IF(CP(KK).NE.CP(KK+1))GO TO 7
C    R GE CP(KK) AND CP(KK) = CP(KK+1)
              IF((KK+2).GT.NP)THEN
               X(K,LOC+ND-1)=XVAL(NP)
               GO TO 6
              ENDIF
              IF(R .LT.CP(KK+2))THEN
C     R GE CP(KK) AND R LT CP(KK+2)
               X(K,LOC+ND-1)=XVAL(KK+1)
               GO TO 6
              ENDIF
7             IF(R.GE.CP(KK).AND.R.LT.CP(KK+1)) THEN
                 IF(XVAL(KK).EQ.XVAL(KK+1)) THEN
C
C  DISCRETE PROBABILITY
C
                   X(K,LOC+ND-1)=XVAL(KK)
                  ELSE
C
C  INTERPOLATION
C
                   X(K,LOC+ND-1) = ((R-CP(KK))/(CP(KK+1)-CP(KK)))*
     1                             (XVAL(KK+1)-XVAL(KK))+XVAL(KK)
                  ENDIF
                  GO TO 6
               ENDIF
 3          CONTINUE
       WRITE(99,*)'FELL THRU',J,K
 6         CONTINUE
         LOC = LOC + NOD-1
 30      CONTINUE
 20      CONTINUE
CC
C  READ IN THE MATRIX OF CONDITIONAL PROBABILITIES FOR LOSP FOR BACKEND
CC
      DO 70 I=1,NLOSP
        READ(6,*)(CPROB(I,J),J=1,NTIME)
  70  CONTINUE
CC
C  READ IN THE MATRIX OF AC DATA FOR LOSP FOR FRONTEND
CC
      DO 71 I=1,NLOSP
        READ(8,*)(AC(I,J),J=1,2)
  71  CONTINUE
CC
C  SAMPLE THE CONDITIONAL PROBABILITIES FOR LOSP
CC
      DO 80 I=1,NLHS
        DO 90 J=1,NTIME-2
          CPROBSAM(I,J) = CPROB(X(I,NTVAR),J)
  90    CONTINUE
          CPROBSAM(I,NTIME-1) = AC(X(I,NTVAR),1)
          CPROBSAM(I,NTIME) = AC(X(I,NTVAR),2)
  80  CONTINUE
      DO 100 I=1,NLHS
        I2 = NTVAR - 1 + NTIME
        II2 = I2 - NTIME
CC
C   ERROR MESSAGE
CC
        IF(I2.GT.NVAR+MADD) STOP ' I2 EXCEEDS DIMENSIONS '
        WRITE(7,*)I,I2,(X(I,J),J=1,II2),(CPROBSAM(I,J),J=1,NTIME)
 100  CONTINUE
      STOP 'NORMAL TERMINATION'
 99   WRITE(99,*)IFL,NP,DSR
      END
```

SUBSECTION E.4

E.4 Listing of MODEL.FOR

```
C  12/14/88 - REVISED FOR GRAND GULF
C
C PROGRAM TO IMPLEMENT THE MIXTURE MODEL FOR THE TIME TO RECOVERY OF LOSP
C AS DEVELOPED IN NUREG/CR-5032, SAND87-2428, JANUARY 1988:
C
C    "MODELING TIME TO RECOVERY AND INITIATING EVENT FREQUENCY FOR LOSS OF
C     OFF-SITE POWER INCIDENTS AT NUCLEAR POWER PLANTS"
C     BY RONALD L. IMAN AND STEPHEN C. HORA
C
C THE MIXTURE MODEL MODEL AS GIVEN IN EQUATION (23) OF THAT REPORT IS
C OF THE FORM:
C
C    G(x) = P1*G1(x) + P2*G2(x) + P3*G3(x)
C
C WHERE THE G(x)'s REPRESENT THE FITTED GAMMA DISTRIBUTIONS
C AND THE P's ARE WEIGHTS THAT ARE TREATED WITH A DIRICHLET DISTRIBUTION
C
C TO RUN USE LINK RECOVERY,AMOSLIB,IMSLIBS/[illegible]
C
      PROGRAM MODEL
      PARAMETER(NREP=500,NPLANT=70,K=3,NX=79,NTIME=79)
      DIMENSION RESULTS(NREP,NX),X(NX),OUTPUT(K,NX),FMAX(K),IDT(NTIME)
     1 ,ISWITCH(NPLANT),P(K),S(K),CUMPROB(K),PD(K),B(K),ICOMP(K)
      CHARACTER*1 CANS
      CHARACTER*3 IP
      CHARACTER*21 IPLANT(NPLANT)
      CHARACTER*3 NAME(NPLANT)
      CHARACTER*80 CFILE
      EXTERNAL GAMIC,GAMMAMA,QUANT,SIFT
      COMMON A(3),N(3),NN
      COMMON ISEED,AA
C
C     NX TIME STEPS ARE USED TO GENERATE A GRAPH OF THE RECOVERY CURVE.
C     THE TIME STEPS CORRESPOND TO TIMES OF 1.0 TO 24.0 IN INCREMENTS
C     OF 1/6
C
C     THE VECTOR IDT IS USED TO DETERMINE THE TIMES FOR WHICH THE UNCERTAINTY
C     DISTRIBUTION WILL BE SAVED IN A FILE.  THESE TIMES ARE 1.0 TO 24.0 IN
C     INCREMENTS OF 1/6
C
      CALL ERXSET(100,1)
C
C     READ IN THE PLANT DATA FILE
C
      OPEN(UNIT=10,FILE='REC',STATUS='OLD')
      I=1
    9 READ(10,100,END=5)IPLANT(I),NAME(I),ISWITCH(I)
  100 FORMAT(2A,I4)
      I = I + 1
      GO TO 9
    5 NP = I - 1
      CLOSE(10)
C
C     SELECT THE PLANT WHOSE INITIATING EVENT FREQUENCY IS DESIRED
C
      DO 10 I = 1,21
      WRITE(*,101)NAME(I),IPLANT(I),NAME(I+22),IPLANT(I+22),
     1NAME(I+43),IPLANT(I+43)
   10 CONTINUE
      WRITE(*,101)NAME(22),IPLANT(22)
  101 FORMAT(1X,A,'- ',A19,2X,A,'- ',A19,2X,A,'- ',A19)
      PRINT *,'INPUT THE ABBREVIATION FOR THE PLANT OF INTEREST'
      READ '(A)',IP
      DO 11 I = 1,NP
```

```
        IF(IP.EQ.NAME(I))THEN
          ID=ISWITCH(I)
          LAST = I
          GO TO 12
        ENDIF
   11 CONTINUE
   12 CONTINUE
      NPC = 43
C
C     IDENTIFY THE COMPONENTS TO BE USED IN THE COMPOSITE MODEL
C
C        1 - PLANT CENTERED COMPONENT
C        2 - GRID COMPONENT
C        3 - WEATHER COMPONENT
C
    1 PRINT *,'IS THE PLANT CENTERED COMPONENT TO BE USED IN THE'
      PRINT 105,IPLANT(LAST)
  105 FORMAT(1X,'COMPOSITE MODEL FOR 'A,'?')
      PRINT *,'Y OR N'
      READ '(A)',CANS
      ICOMP(1)=1
      IF(CANS.EQ.'N')ICOMP(1)=0
      PRINT *,'IS THE GRID COMPONENT TO BE USED IN THE'
      PRINT 105,IPLANT(LAST)
      PRINT *,'Y OR N'
      READ '(A)',CANS
      ICOMP(2)=1
      IF(CANS.EQ.'N')ICOMP(2)=0
      PRINT *,'IS THE WEATHER COMPONENT TO BE USED IN THE'
      PRINT 105,IPLANT(LAST)
      PRINT *,'Y OR N'
      READ '(A)',CANS
      ICOMP(3)=1
      IF(CANS.EQ.'N')ICOMP(3)=0
      ISUM = ICOMP(1) + ICOMP(2) + ICOMP(3)
      IF(ISUM.EQ.0)THEN
         PRINT *,'NO COMPONENTS WERE SELECTED'
         GO TO 1
      ENDIF
C
C INPUT SECTION FOR THE GAMMA DISTRIBUTIONS, G(x)'s
C CALCULATE THE PRODUCT, P, OF THE Xs FROM THE GEOMETRIC MEAN
C CALCULATE THE SUM, S, OF THE Xs FROM THE ARITHMETIC MEAN
C
      IF(ICOMP(1).EQ.0)GO TO 2
C
C INPUT THE FLAG FOR SWITCHYARD CONFIGURATION AS DEFINED IN NUREG-1032
C   1 = I1
C   2 = I2
C   3 = I3
C   4 = ALL PLANT CENTERED DATA USED
C
      PRINT *,'THE SWITCHYARD CONFIGURATION PER NUREG-1032 FOR'
      PRINT 106,IPLANT(LAST),ID
  106 FORMAT(1X,A,'IS ',I1)
      PRINT *,'DO YOU WISH TO CHANGE THIS VALUE? Y OR N'
      READ '(A)',CANS
      IF(CANS.EQ.'N')GO TO 13
      PRINT *,'INPUT NUMBER FOR SWITCHYARD CONFIGURATION PER NUREG-1032'
      PRINT *,'ENTER 1 FOR I1 SWITCHYARD'
      PRINT *,'ENTER 2 FOR I2 SWITCHYARD'
      PRINT * 'ENTER 3 FOR I3 SWITCHYARD'
      PRINT *,'ENTER 4 IF CONFIGURATION IS UNKNOWN'
      READ *,ID
   13 IF(ID.EQ.1)THEN
         P(1)=.0855**14
         S(1)=.20536*14
```

```
            N(1)=14
         ELSE IF(ID.EQ.2)THEN
            P(1)=.17413**13
            S(1)=.39231*13
            N(1)=13
         ELSE IF(ID.EQ.3)THEN
            P(1)=.45722**16
            S(1)=1.2523*16
            N(1)=16
         ELSE
            P(1)=.1978**43
            S(1)=.65144*43
            N(1)=43
         ENDIF
    2    CONTINUE
         IF(ICOMP(2).EQ.0)GO TO 3
C
C SET THE PARAMETERS FOR GRID
C
         P(2)=.65429**13
         S(2)=1.23638*13
         N(2)=13
    3    CONTINUE
         IF(ICOMP(3).EQ.0)GO TO 4
C
C SET THE PARAMETERS FOR WEATHER
C
         P(3)=4.108544**7
         S(3)=4.591429*7
         N(3)=7
    4    CONTINUE
C
C INPUT SECTION FOR THE DIRICHLET DISTRIBUTIONS, P's
C
C INPUT THE WEATHER HAZARD RATIO FOR THE SPECIFIC PLANT
C
         RATIO = 1.
         IF(ICOMP(3).EQ.1.AND.ISUM.GT.1)THEN
           PRINT *,'THE GENERIC WEATHER RATIO FOR'
           PRINT 107,IPLANT(LAST)
  107      FORMAT(1X,A,'IS 1')
         PRINT *,'DO YOU WISH TO CHANGE THIS VALUE? Y OR N'
         READ '(A)',CANS
         IF(CANS.EQ.'N')GO TO 14
           PRINT *,'INPUT THE PLANT SPECIFIC WEATHER HAZARD RATIO'
           READ *,RATIO
   14      CONTINUE
         ENDIF
         R1=ICOMP(1)*NPC
         R2=ICOMP(2)*N(2)
         R3=ICOMP(3)*N(3)
C
C        GENERATE THE TIME IN STEPS OF 1/6 FROM 1. TO 12.0 FOR THE RECOVERY CURVE
C
         DO 15 I=1,67
         IDT(I) = I
         X(I) = 1 + (I-1) * (1./6)
         IF (I.EQ.15) X(I) = 3.35
         IF (I.EQ.29) X(I) = 5.6
   15    CONTINUE
C
C        GENERATE THE TIME IN STEPS OF 1 HR. FROM 12. TO 24.0
C
         DO 16 I=68,79
         IDT(I) = I
         X(I) = X(I-1)+1
         IF (I.EQ.70) X(I) = 14.73
```

```
   16 CONTINUE
C
      ISEED=327251
C
C SETUP
C
      DO 50 I=1,K
      IF(ICOMP(I).EQ.0)GO TO 50
C
C     FIND THE MAXIMUM VALUE OF THE VARIABLE THAT MAXIMIZES THE MARGINAL
C     DENSITY OF ALPHA (EQUATION 18 OF THE LOSP REPORT)
C
      CALL RMAX(XMAX,S(I),P(I),N(I))
C
C     FIND THE MAXIMUM VALUE OF THE MARGINAL DENSITY OF ALPHA
C
      FMAX(I)=F(XMAX,N(I),P(I),S(I))
   50 CONTINUE
      DO 6 I = 1,K
    6 PD(I) = 1.
      PRINT *,' '
      PRINT *,'PLEASE WAIT WHILE THE MONTE CARLO IS BEING PERFORMED'
      PRINT *,' '
      IPC = 0
      DO 500 J=1,NREP
  300 DO 70 I=1,K
      IF(ICOMP(I).EQ.0)GO TO 70
      NN=N(I)
C
C     OBTAIN A VALUE OF BETA FROM THE CONDITIONAL DENSITY GIVEN BY
C     EQUATION 17 OF THE LOSP REPORT
C
      CALL GAMPARAM(A(I),B(I),S(I),P(I),FMAX(I))
   70 CONTINUE
C
C
C
      ARG4=.001
      IARG1=1
      IF(ISUM.EQ.1)GO TO 7
      IF(ISUM.EQ.3)THEN
         CALL DIRICHLET(R1,R2,R3,PD(1),PD(2))
         PD(3)=1.-PD(1)-PD(2)
      ELSE IF(ICOMP(1)+ICOMP(2).EQ.2)THEN
         CALL DIRICHLET2(R1,R2,PD(1))
         PD(2)=1.-PD(1)
      ELSE IF(ICOMP(1)+ICOMP(3).EQ.2)THEN
         CALL DIRICHLET2(R1,R3,PD(1))
         PD(3)=1.-PD(1)
      ELSE IF(ICOMP(2)+ICOMP(3).EQ.2)THEN
         CALL DIRICHLET2(R2,R3,PD(2))
         PD(3)=1.-PD(2)
      ENDIF
    7 CONTINUE
      TOT = 0.
      PD(3) = PD(3)*RATIO
      DO 8 I = 1,K
      TOT = TOT + PD(I) * ICOMP(I)
    8 CONTINUE
      DO 410 I=1,NX
      DO 450 IC=1,K
      IF(ICOMP(IC).EQ.0)GO TO 450
      Y=X(I)*B(IC)
      IF(Y.GT.200.) GO TO 300
      CALL GAMIC(Y,A(IC),ARG4,IARG1,CUMPROB(IC),NZ)
  450 CONTINUE
      RESULTS(J,I) = 1. - ICOMP(1)*PD(1)/TOT*CUMPROB(1)
```

```
     1 - ICOMP(2)*PD(2)/TOT*CUMPROB(2) - ICOMP(3)*PD(3)/TOT*CUMPROB(3)
  410 CONTINUE
      IF(MOD(J,NREP/100).EQ.0)THEN
        IPC=IPC+1
        PRINT 109,IPC
  109   FORMAT('+THE CALCULATION IS ',I3,'% COMPLETE')
      ENDIF
  500 CONTINUE
C
C     WRITE OUT THE FILE CONTAINING THE UNCERTAINTY DISTRIBUTION AT
C     EACH OF THE NTIME SPECIFIED TIME POINTS
C
C     THIS FILE WILL BE AN NREP x NTIME MATRIX WITH EACH COLUMN CONTAINING
C     THE UNCERTAINTY DISTRIBUTION AT A GIVEN TIME POINT.  THESE DISTRIBUTIONS
C     ARE USED BY THE LHS PROGRAM IN THE UNCERTAINTY ANALYSIS.  THE VALUES IN
C     EACH COLUMN HAVE BEEN SORTED FROM SMALLEST TO LARGEST.
C
      OPEN (UNIT = 11, FILE = IP//'.DAT', STATUS = 'NEW')
      DO 800 I=1,NX
      CALL SIFT(NREP,RESULTS(1,I))
  800 CONTINUE
      DO 9000 I = 1,NREP
      WRITE (11,*) (RESULTS(I,IDT(J)),J=1,NTIME)
 9000 CONTINUE
      CLOSE (UNIT = 11)
C
C     WRITE OUT FILE FOR MAPPER WITH 90% UNCERTAINTY BOUNDS
C     AND FILE WITH THE COMPLETE UNCERTAINTY DISTRIBUTION
C     FOR THOSE TIME POINTS IDENTIFIED IN IDT
C
      PRINT *,'DO YOU WANT TO CREATE A MAPPER FILE FOR PLOTTING? Y OR N'
      READ '(A)',CANS
      IF(CANS.EQ.'N')GO TO 802
      DO 801 I=1,NX
      CALL QUANT(.05,NREP,RESULTS(1,I),OUTPUT(1,I))
      CALL QUANT(.50,NREP,RESULTS(1,I),OUTPUT(2,I))
      CALL QUANT(.95,NREP,RESULTS(1,I),OUTPUT(3,I))
  801 CONTINUE
      CALL MAPPER(OUTPUT,X,IPLANT(LAST),IP)
  802 CONTINUE
      STOP
      END
C
C     SUBROUTINE TO SELECT A RANDOM VARIABLE FROM A GAMMA DISTRIBUTION
C     USING THE ACCEPTANCE-REJECTION METHOD
C
      SUBROUTINE GAMPARAM(AA,B,S,P,FMAX)
      COMMON A(3),N(3),NN
      COMMON ISEED,AAA
      EXTERNAL GAMIC,GAMMAMA,QUANT,SIFT
  300 T=RAN(ISEED)
      PB=RAN(ISEED)
      AA=T/(1.-T)
      AAA=AA
C
C     IF ALPHA IS TOO LARGE OR TOO SMALL, TRY ANOTHER VALUE.
C     THIS AVOIDS NUMERICAL PROBLEM:
C
      IF (AA.LT.(5.0E-3)) GOTO 300
      IF(AA.GT..999999) GOTO 300
      F1·~(T,NN,P,S)
C
C     ACCEPT OR REJECT THE VALUE OF ALPHA
C
      IF (F1/FMAX.LT.RAN(ISEED)) GOTO 300
      ARG1=2.*PB*AA*NN
      ARG2=0.1*NN*AA
```

```
      ARG3=.0001*NN*AA
      ARG4=1.
      IF(AA.GT.20.) GOTO 300
C
C     FIND A VALUE OF BETA CORRESPONDING TO A CUMULATIVE PROBABILITY P
C
      CALL FINVER(GAMMAMA,PB,ARG1,ARG2,ARG3,ARG3,ARG4)
      B=ARG1/B
  300 CONTINUE
      RETURN
      END
C
C
C
      REAL FUNCTION F(T N,P,S)
      DIMENSION P(1),S(1),N(1)
      A=T/(1.-T)
      NN=N(1)
      SS=S(1)
      PP=P(1)
      FL=(A-1.)*LOG(PP)+GAMLN(NN*A)-NN*GAMLN(A)
     X -NN*A*LOG(SS)-2*LOG(1.-T)-LOG(A)
      F=EXP(FL)
      FTEST=F
      RETURN
      END
C
C
C
      REAL FUNCTION FNEG(T,P,S,N,N2,N3)
      DIMENSION P(1),S(1),N(1)
      FNEG=-F(T,N,P,S)
      FTEST=FNEG
      RETURN
      END
C
C     FINDS THE VALUE OF THE VARIABLE THAT MAXIMIZES THE DENSITY F
C
      SUBROUTINE RMAX(XMIN,S,P,N)
      DIMENSION P(1),S(1),N(1)
      EXTERNAL FNEG
      E=.01
      A=E
      B=1.-E
      TOL=.001
      CALL ZXGSP(FNEG,P,S,N,IP4,IP5,A,B,TOL,XMIN,IER)
      FTEST=XMIN
      RETURN
      END
C
C
C
      SUBROUTINE GAMMAMA(X,FOFX)
      COMMON A(3),B(3),NN
      COMMON ISEED,AA
      IF (X.LT.0.0) THEN
        FOFX=0.
        RETURN
      ENDIF
      TOL=1.E-5
      NUNIT=1
      XX=X
      AAA=AA*NN
      IF (X.GT.5.*AAA) THEN
        FOFOX=1.0
        RETURN
      ENDIF
```

```
      CALL GAMIC(X,AAA,TOL,NUNIT,FOFX,NZ)
      FOFXX=FOFX
      RETURN
      END
C
C
      SUBROUTINE DIRICHLET(R1,R2,R3,P1,P2)
      COMMON A(3),N(3),NN
      COMMON ISEED,AA
      CONL=GAMLN(R1+R2+R3)-GAMLN(R1)-GAMLN(R2)-GAMLN(R3)
      RN=R1+R2+R3
      P1MAX=(R1-1.)/(RN-1.)
      P2MAX=(R2-1.)/(RN-1.)
      FMAX=CONL+(R1-1.)*LOG(P1MAX)+(R2-1.)*LOG(P2MAX)+(R3-1.)*
     X LOG(1.-P1MAX-P2MAX)
  100 CONTINUE
      P1=RAN(ISEED)
      P2=RAN(ISEED)
      P3=RAN(ISEED)
      IF(P1+P2.GT.1.) GOTO 100
      F=CONL+(R1-1.)*LOG(P1)+(R2-1.)*LOG(P2)+(R3-1.)*LOG(1-P1-P2)
      IF (P3.LT.EXP(F-FMAX)) RETURN
      GOTO 100
      END
C
C
      SUBROUTINE DIRICHLET2(R1,R2,P1)
      COMMON A(3),N(3),NN
      COMMON ISEED,AA
      CONL=GAMLN(R1+R2)-GAMLN(R1)-GAMLN(R2)
      RN=R1+R2
      P1MAX=(R1-1.)/(RN-1.)
      FMAX=CONL+(R1-1.)*LOG(P1MAX)+(R2-1.)*LOG(1.-P1MAX)
  100 CONTINUE
      P1=RAN(ISEED)
      P2=RAN(ISEED)
      F=CONL+(R1-1.)*LOG(P1)+(R2-1.)*LOG(1-P1)
      IF (P2.LT.EXP(F-FMAX)) RETURN
      GO TO 100
      END
C
C
C
      SUBROUTINE QUANT(QNT,N,X,XQNT)
      DIMENSION X(N)
      IF (MOD(FLOAT(N)*QNT,1.0) .EQ. 0.0) THEN
        IQNT = N * QNT
        JQNT = IQNT + 1
      ELSE
        IQNT = N * QNT + 1
        JQNT = IQNT
      ENDIF
      XQNT = 0.5 * (X(IQNT) + X(JQNT))
      RETURN
      END
      SUBROUTINE SIFT (N,XV)
      DIMENSION XV(N)
      M=N
   10 M=M/2
      IF (M) 30,20,30
   20 RETURN
   30 K=N-M
      J=1
   40 I=J
   50 L=I+M
      IF (XV(I)-XV(L)) 70 70,60
   60 A=XV(I)
```

```
      XV(I)=XV(L)
      XV(L)=A
      I=I-M
      IF (I) 70,70,50
   70 J=J+1
      IF (J-K) 40,40,10
      END
C
C     SUBROUTINE TO WRITE OUT MAPPER FILE FOR PLOTTING
C
      SUBROUTINE MAPPER(XQ,X,IPLANT,IP)
      PARAMETER (K=3,N=139)
      DIMENSION XQ(K,N),X(N)
      CHARACTER*(*) IPLANT,IP
      OPEN (UNIT=2, FILE= IP//'.MAP', STATUS='NEW')
C
C     WRITE OUT THE TITLE IN THE PLOT FILE FOR MAPPER
C
      WRITE (2,104)
      WRITE (2,105)IPLANT
C
C WRITE OUT LOWER 5% POINTS
C
      ONE=1.0
      ZERO=0.0
      WRITE (2,106)
      WRITE (2,101) ZERO,ONE
      DO 40 I = 1,N-1
      WRITE (2,102) X(I), XQ(1,I)
   40 CONTINUE
      WRITE (2,103) X(N), XQ(1,N)
C
C WRITE OUT 50% POINTS
C
      WRITE (2,107)
      WRITE (2,101) ZERO,ONE
      DO 50 I = 1,N-1
      WRITE (2,102) X(I), XQ(2,I)
   50 CONTINUE
      WRITE (2,103) X(N), XQ(2,N)
C
C WRITE OUT UPPER 5% POINTS
C
      WRITE (2,108)
      WRITE (2,101) ZERO,ONE
      DO 60 I = 1,N-1
      WRITE (2,102) X(I), XQ(3,I)
   60 CONTINUE
      WRITE (2,103) X(N), XQ(3,N)
      CLOSE (2)
  101 FORMAT ('SLINE(',E14.7,',',E14.7,',1')
  102 FORMAT (E14.7,',',E14.7)
  103 FORMAT (E14.7, ',',E14.7,',2',/,'RETURN')
  104 FORMAT ('*TITLE*',/'LABEL(1.,8.5,9.5,11,2,0')
  105 FORMAT ('&I.35>RECOVERY CURVE FOR ',A,/,'RETURN')
  106 FORMAT ('*LOWER*')
  107 FORMAT ('*MEDIAN*')
  108 FORMAT ('*UPPER*')
      RETURN
      END
```

SUBSECTION E.5

E.5 Listing of LOSP.FOR

```fortran
C
C     Program Written By R.L. Iman (Sandia National Laboratories)
C
      PROGRAM LOSP
      DIMENSION XDC(6) YDC(6),XAC(9),YAC(9),TINT(6,2),IC(6),
     1           PROB(6),ICP(6)
      DATA XAC/0.,1.,3.35,5.,12.,14.5,16.5,24.,24./
      DATA YAC/8*0.,1./
      DATA XDC/0.,4.,8.,12.,18.,24./
      DATA YDC/.0,.01,.05,.10,.5,1./
      DATA TINT/1.,3.35,5.5,12.,14.5,16.5,3.35,5.5,24.,14.5,16.5,24./
      OPEN(UNIT=5,FILE='AC.DAT',STATUS='OLD')
      OPEN(UNIT=6,FILE='PROB.OUT',STATUS='NEW')
      ISEED = 73159581
      NREP = 10000
C
C     LOOP OVER THE NUMBER OF OBSERVATIONS IN THE AC.DAT FILE
C
   12 READ(5,*,END=11)(YAC(I),I=2,8)
C
C     CONVERT THE VALUES IN AC.DAT TO CUMULATIVE PROBABILITIES
C
      DO 4 I = 2,8
      YAC(I) = 1. - YAC(I)
    4 CONTINUE
C
C     SET THE COUNTERS TO ZERO FOR EACH INTERVAL OF INTEREST
C
      DO 9 I = 1,6
      IC(I) = 0
      ICP(I) = 0
    9 CONTINUE
      DO 1 M = 1,NREP
C
C     SELECT THE RANDUM PROBABILITIES FOR THE AC AND DC DISTRIBUTIONS
C
      RAC = RAN(ISEED)
      RDC = RAN(ISEED)
C
C     FIND THE TIME TO DC LOST CORRESPONDING TO RDC
C
      DO 5 J=1,5
      IF(RDC .GT. YDC(J) .AND. RDC .LT. YDC(J+1))THEN
        TDC = XDC(J)+ ((RDC - YDC(J))/(YDC(J+1) - YDC(J)))*
     1          (XDC(J+1) - XDC(J))
        GO TO 6
      ENDIF
    5 CONTINUE
    6 CONTINUE
C
C     FIND THE TIME TO AC RECOVERY CORRESPONDING TO RAC
C
      DO 7 J=1,8
      IF(RAC .GT. YAC(J) .AND. RAC .LT. YAC(J+1))THEN
        TAC = XAC(J)+ ((RAC - YAC(J))/(YAC(J+1) - YAC(J)))*
     1          (XAC(J+1) - XAC(J))
        GO TO 8
      ENDIF
    7 CONTINUE
    8 CONTINUE
C
C     IS TIME TO AC RECOVERY < TIME TO DC LOSS W.R.T. EACH INTERVAL
C
      IF(TAC .LT. TDC)THEN
       DO 13 I = 1,6
```

```
    IF(TAC .GT. TINT(I,1) .AND. TAC .LT. TINT(I,2))IC(I)=IC(I)+1
    IF(TAC .LE. TINT(I,1))ICP(I)=ICP(I)+1
13  CONTINUE
   ENDIF
 1 CONTINUE
   DO 10 I =1,6
   PROB(I) = (FLOAT(IC(I))/FLOAT(NREP))
  1           /(1. - FLOAT(ICP(I))/FLOAT(NREP))
10 CONTINUE
   WRITE(6,*)PROB
   GO TO 12
11 CONTINUE
   STOP
   END
```

SUBSECTION E.6

E.6 AC Power Recovery Probabilities

Accident Frequency Analysis - Probability of Failure to Restore Power

LHSLOSP.DAT

```
7.8794422E-02  2.2558868E-04
8.5901774E-02  3.5417452E-04
8.7056696E-02  3.9152056E-04
9.9756189E-02  3.9403141E-04
0.1007567      4.1712821E-04
0.1008827      5.8925152E-04
0.1039087      6.4211339E-04
0.1053379      6.7840517E-04
0.1054513      8.3363056E-04
0.1056214      8.7039173E-04
0.1072977      9.2697889E-04
0.1081488      1.0097027E-03
0.1091165      1.0221228E-03
0.1098356      1.0520965E-03
0.1098790      1.0948703E-03
0.1103809      1.1283979E-03
0.1114173      1.2600422E-03
0.1122436      1.2772419E-03
0.1122605      1.3160333E-03
0.1144732      1.5204176E-03
0.1147016      1.6123652E-03
0.1164860      1.6711205E-03
0.1167319      1.7063916E-03
0.1184245      1.7331094E-03
0.1184302      1.7493516E-03
0.1190311      1.8153302E-03
0.1190582      1.8365234E-03
0.1193146      1.8383414E-03
0.1200874      1.8982217E-03
0.1209129      1.9197389E-03
0.1210983      1.9474179E-03
0.1214489      2.0675063E-03
0.1215020      2.0795241E-03
0.1218372      2.0912215E-03
0.1228233      2.1547414E-03
0.1232736      2.1602660E-03
0.1248818      2.1642558E-03
0.1264736      2.1819943E-03
0.1279022      2.1955743E-03
0.1283704      2.2358894E-03
0.1290165      2.3005158E-03
0.1290888      2.3107007E-03
0.1296740      2.3397878E-03
0.1298090      2.3754463E-03
0.1300259      2.5083423E-03
0.1301228      2.5227293E-03
0.1304177      2.5459751E-03
0.1326118      2.5659874E-03
0.1327455      2.5888905E-03
0.1328955      2.6195459E-03
0.1333409      2.6457012E-03
0.1333429      2.6576892E-03
0.1336073      2.7621910E-03
0.1336141      2.7704351E-03
0.1337110      2.8523505E-03
0.1344235      2.8584749E-03
0.1346671      2.8836779E-03
0.1347392      2.9071718E-03
0.1349017      2.9151142E-03
0.1357550      2.9706508E-03
0.1361356      2.9740706E-03
```

0.1361725	3.0274764E-03
0.1366904	3.0377656E-03
0.1368643	3.0580387E-03
0.1369783	3.0639172E-03
0.1371537	3.0715466E-03
0.1372940	3.0825064E-03
0.1373282	3.0898824E-03
0.1375166	3.1567290E-03
0.1376955	3.1660423E-03
0.1383062	3.1858049E-03
0.1385009	3.2297745E-03
0.1389142	3.3292584E-03
0.1389930	3.3574775E-03
0.1399394	3.4655370E-03
0.1399830	3.5262406E-03
0.1403240	3.6365017E-03
0.1405199	3.6490038E-03
0.1408374	3.7639327E-03
0.1414460	3.9498769E-03
0.1416489	3.9950088E-03
0.1419491	4.0101409E-03
0.1431381	4.0123314E-03
0.1433261	4.0218532E-03
0.1436273	4.0639192E-03
0.1439265	4.0857717E-03
0.1439327	4.0950440E-03
0.1439329	4.1192845E-03
0.1440633	4.1322187E-03
0.1450991	4.1529238E-03
0.1460806	4.1652918E-03
0.1461121	4.1838437E-03
0.1462118	4.1859299E-03
0.1463068	4.1960999E-03
0.1464476	4.2041615E-03
0.1467625	4.2054653E-03
0.1484477	4.2335689E-03
0.1488594	4.3013506E-03
0.1490858	4.3900311E-03
0.1493708	4.3950826E-03
0.1495307	4.4681728E-03
0.1496549	4.4754148E-03
0.1509384	4.5040995E-03
0.1510926	4.6209432E-03
0.1511139	4.6278238E-03
0.1512201	4.7300011E-03
0.1513327	4.7492310E-03
0.1514643	4.7569573E-03
0.1517463	4.8693791E-03
0.1518854	4.9100742E-03
0.1521592	4.9684197E-03
0.1529649	4.9894750E-03
0.1531189	4.9978346E-03
0.1536847	5.0797015E-03
0.1540754	5.1054358E-03
0.1545816	5.1165670E-03
0.1550739	5.1663369E-03
0.1558614	5.1744580E-03
0.1563536	5.2397996E-03
0.1564167	5.3178295E-03
0.1565666	5.4152422E-03
0.1568288	5.4210313E-03
0.1571389	5.4243207E-03
0.1571507	5.4305494E-03
0.1572312	5.5407509E-03
0.1572314	5.5484027E-03
0.1576090	5.5805072E-03
0.1579974	5.5846795E-03

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0.1581552      5.6030154E-03
0.1587439      5.6167543E-03
0.1588283      5.7437122E-03
0.1590277      5.7556778E-03
0.1590698      5.7786107E-03
0.1591241      5.8401078E-03
0.1596221      5.8522485E-03
0.1596562      5.8549307E-03
0.1602487      5.8933645E-03
0.1606148      5.9654564E-03
0.1606546      5.9800223E-03
0.1612732      6.1449558E-03
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0.1647413      6.7304745E-03
0.1647451      6.8825483E-03
0.1651001      6.8879873E-03
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0.1656373      6.9671720E-03
0.1661578      7.0085675E-03
0.1670970      7 0648193E-03
0.1672850      7.2254241E-03
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0.1673070      7.3733628E-03
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0.1691425      7.8214668E-03
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0.1779779      8.8638365E-03
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0.1788720      9.1194212E-03
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0.1804444      9.5893592E-03
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0.1810278      9.6361637E-03
0.1811448      9.7265616E-03
0.1812379      9.8184347E-03
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0.2160687       1.7998151E-02
0.2162233       1.8006988E-02
0.2164070       1.8040918E-02
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0.2170020       1.8473417E-02
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0.2456424      2.7766734E-02
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0.3208228      5.9662953E-02
0.3224621      6.0811117E-02
0.3259569      6.2010311E-02
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0.3502851      7.7652946E-02
 .3541158      9.9557742E-02
 .4091691      0.1506062
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Accident Progression Analysis - Probability of Recovering AC power

PROB.DAT

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  0.8161490     0.5810806     0.6774176     4.3477807E-02  9.0908781E-02  0.0000000E+00
  0.7706212     0.5517249     0.7912070     9.5238507E-02  0.0000000E+00  0.0000000E+00
  0.7609466     0.5544550     0.7666664     8.0000073E-02  8.6955614E-02  0.0000000E+00
  0.7847084     0.4766361     0.7946421     0.1071433      [illegible]0000073E-02  0.0000000E+00
  0.7645913     0.5247929     0.7478260     3.0302927E-0[illegible]  [illegible]00052E-02  6.4516589E-02
  0.7626311     0.5381522     0.7304347     0.1142862      [illegible]00000E+00  0.0000000E+00
  0.7667612     0.4493929     0.7720593     8.8234581E-02  0.0000000E+00  0.0000000E+00
  0.7813689     0.5043478     0.7719309     0.0000000E+00  0.0000000E+00  3.7037432E-02
  0.7288628     0.43[illegible]6921     0.7911393     0.1499997      2.9411525E-02  0.0000000E+00
  0.7438162     0.4689658     0.8246757     9.6774884E-02  3.5714440E-02  0.0000000E+00
  0.7330755     0.4565219     0.7933341     6.5714661E-02  3.1250052E-02  0.0000000E+00
  0.7516161     0.5092938     0.8333343     0.2121205      3.8461328E-02  0.1200001
  0.7300274     0.5102043     0.8333330     0.2000009      0.1071433      4.0000036E-02
  0.7174310     0.5097405     0.8145694     0.1176461      3.3333100E-02  3.4482706E-02
  0.7358320     0.5536327     0.8294578     7.6922655E-02  4.1666996E-02  4.3477807E-02
  0.6942731     0.4812683     0.8222219     5.4053791E-02  2.8571552E-02  5.8823049E-02
  0.7306337     0.4999998     0.81[illegible]9048     8.8234581E-02  6.4516589E-02  3.4482706E-02
  0.7390931     0.4393443     0.7894748     0.1304351      7.4999854E-02  2.7026895E-02
  0.7170619     0.4811325     0.8181821     0.1951208      6.0605854E-02  3.2258295E-02
  0.7444255     0.5268456     0.8014176     8.8234581E-02  6.4516589E-02  3.4482706E-02
  0.7160392     0.4149859     0.8423657     0.1860466      5.7143103E-02  3.0302927E-02
  0.7464672     0.4918033     0.7677415     0.1914891      2.6315963E-02  2.7026895E-02
  0.7116404     0.4342507     0.7945959     0.2040825      2.5641080E-02  0.0000000E+00
  0.7230372     0.4361368     0.8066288     0.1777789      0.0000000E+00  5.4053791E-02
  0.7174103     0.3777090     0.[illegible]656718     0.2162152      6.8965413E-02  0.0000000E+00
  0.7080479     0.4780059     0.8033720     0.2173919      0.0000000E+00  2.7777767E-02
  0.7103685     0.4437869     0.8297863     0.1707307      5.8823049E-02  0.0000000E+00
  0.7161824     0.4502922     0.8404246     0.1282054      8.8234581E-02  3.2258295E-02
  0.7002416     0.4408605     0.8413464     0.1111118      9.9999793E-02  8.3333306E-02
  0.6951422     0.4450547     0.7920787     0.1071433      8.0000073E-02  8.6956739E-02
  0.7149531     0.5027323     0.8406603     0.1707307      8.8234581E-02  6.4516589E-02
  0.7045812     0.4893047     0.8534027     0.2249995      3.2258295E-02  6.6666201E-02
  0.7055464     0.4598342     0.8256403     0.1555565      5.2631926E-02  5.5555534E-02
  0.6903798     0.4464755     0.8066038     0.2321439      2.3255823E-02  2.3809627E-02
  0.6797439     0.5024997     0.8040192     0.2656254      0.1063829      7.1428888E-02
  0.6797798     0.5012283     0.7980307     0.1929827      8.6956739E-02  2.3809627E-02
  0.7002323     0.4728684     0.8284318     0.1521743      7.6923251E-02  2.7777767E-02
  0.6913109     0.4567903     0.8272722     0.1400001      0.1162791      0.0000000E+00
  0.6872763     0.4935731     0.8020308     0.1481481      4.3478370E-02  0.1136360
  0.6883789     0.5059381     0.8509617     0.2826094      3.0302927E-02  3.1250052E-02
  0.7189016     0.4568967     0.8359798     0.2195109      3.1250052E-02  0.0000000E+00
  0.6947792     0.4157896     0.8603608     0.1739135      5.2631926E-02  0.1388889
  0.6954510     0.4227848     0.8728059     0.2553189      0.1714293      0.0000000E+00
  0.6860556     0.4390865     0.8235305     0.1851851      6.8181589E-02  4.8780192E-02
  0.6861701     0.4406780     0.8131812     0.1403511      8.1633009E-02  6.6667087E-02
  0.6909233     0.4784810     0.8009701     0.1346146      4.4444721E-02  4.6511646E-02
  0.6729751     0.4444443     0.8208337     0.1578950      8.3332956E-02  2.2727195E-02
  0.6866465     0.4866828     0.8490565     0.2127657      0.1081076      3.0302927E-02
  0.6932155     0.4750617     0.8256887     0.1063829      2.3809627E-02  7.3170297E-02
  0.6811807     0.4722221     0.8508762     0.2800003      0.0000000E+00  5.5555534E-02
  0.6849212     0.4285715     0.8541671     0.1923067      0.1190481      5.4053791E-02
  0.6809008     0.4549876     0.8348206     0.1296296      0.1276594      9.7560383E-02
  0.6953543     0.4424998     0.8475334     0.2909081      5.1282160E-02  8.1080690E-02
  0.6987767     0.4162439     0.7913043     0.1911766      7.2727025E-02  5.8823396E-02
  0.6961285     0.5120193     0.7980307     0.1000003      0.2037036      4.6511646E-02
  0.6980057     0.4457547     0.8425523     0.2500007      8.8889442E-02  9.7560383E-02
  0.7078221     0.4409448     0.7746472     0.1999998      7.6922655E-02  0.0000000E+00
  0.6845284     0.4521528     0.8515289     0.25000[illegible]1      0.1428578      5.5555534E-02
  0.6924189     0.4460096     0.7881362     0.2083333      8.7719426E-02  3.8461328E-02
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  0.6907368     0.4127358     0.8353407     0.1724135      0.14[illegible]8327      0.0000000E+00
  0.6713339     0.4843048     0.8130434     0.1754389      6[illegible].9720E-02  2.2727195E-02
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0.5699819     0.2918419     0.6912112     0.1286089     9.0361379E-02   0.1390728
0.5700254     0.2876481     0.6652706     0.1397060     9.1168135E-02   0.1191223
0.5779579     0.2768559     0.6243963     0.1202830     6.4343184E-02   0.1088825
0.5785688     0.2969203     0.6565532     0.1018277     7.2674446E-02   0.1128527
0.5794036     0.3190437     0.6731235     0.1017811     9.3484372E-02   0.1562500
0.5700001     0.3056478     0.6411484     0.1393643     6.5340914E-02   8.8145964E-02
0.5643244     0.2952854     0.6502346     0.1401425     5.5248640E-02   0.1286549
0.5803477     0.3161453     0.6378244     0.1585366     6.3768111E-02   9.2879273E-02
```

0.5720816	0.3032046	0.6356131	0.1524250	8.7193437E-02	7.7611901E-02
0.5750877	0.2782824	0.6475971	0.1666666	7.4656619E-02	0.1123920
0.5699189	0.2915643	0.6612718	0.1751153	8.9385524E-02	0.1012270
0.5658400	0.3057120	0.6187716	0.1406594	7.6726362E-02	8.8642731E-02
0.5860049	0.2922564	0.5870590	0.1341719	7.5060539E-02	[illegible]
0.5650661	0.2928000	0.6097285	0.1290322	0.1157407	[illegible]
0.5854167	0.2881072	0.6258825	0.1645022	0.1010362	8.3573543E-02
0.5687978	0.2707493	0.6066298	0.1198347	7.5117409E-02	9.6446745E-02
0.5811789	0.3185185	0.6147345	0.1406927	8.5642383E-02	0.1212121
0.5869060	0.2920354	0.6170455	0.1512097	0.1021377	0.1084656
0.5798995	0.3102073	0.5907515	0.1298174	8.8578038E-02	9.4629176E-02
0.5776972	0.2875000	0.5964913	0.1375969	8.9887656E-02	9.1358058E-02
0.5755755	0.3089622	0.6029580	0.1553785	7.5471692E-02	0.1096939
0.5818556	0.2993474	0.5844004	0.1555117	7.2261028E-02	0.1030151
0.5683690	0.3229008	0.5783540	0.1386322	9.4420634E-02	0.1137440
0.5644212	0.3003003	0.5901286	0.1128405	7.4561410E-02	9.4786666E-02
0.5750962	0.2960726	0.5461372	9.5149234E-02	3.5051547E-02	9.6153803E-02
0.5796344	0.2655280	0.5792810	0.1050656	5.8700223E-02	0.1135857
0.5581169	0.2689199	0.5386934	0.1178396	5.7513911E-02	9.6456647E-02
0.5777851	0.2607338	0.5501585	0.1095152	2.2177417E-02	0.1210495
0.5624798	0.2678967	0.5655242	0.1064189	0.1077504	[illegible]
0.5546369	0.2318624	0.5326193	6.4620338E-02	0.1053540	[illegible]
0.5664962	0.2588496	0.5631841	0.1026490	8.3025835E-02	0.1167002
0.5697026	0.2426206	0.5494297	0.1257862	[illegible]	8.6705148E-02
0.5574891	0.2331460	0.5338828	0.1062874	[illegible]	9.2691608E-02
0.5565266	0.2113156	0.5332757	0.1014706	6.0556460E-02	5.8233464E-02
0.5406404	0.1977212	0.5588972	0.1095101	5.9870549E-02	9.1222055E-02
0.4752299	0.2447710	0.5711078	0.1074380	7.0987627E-02	4.8172776E-02
0.4405340	0.2787418	0.6067669	0.1306902	5.5743255E-02	6.4400740E-02
0.4437028	0.2613459	0.6002824	0.1505945	4.5101088E-02	7.8175902E-02
0.4472808	0.2424699	0.5102717	2.0833330E-02	8.7609477E-03	6.6819163E-02
0.4421488	0.2192593	0.4263124	7.7788189E-02	5.2845530E-02	2.6824025E-02
0.3883145	0.1442610	0.2775838	7.3065028E-02	4.0080164E-02	5.7063326E-02

SUBSECTION E.7

E.7 Listing of EXTDIS.DAT

```
USER DISTRIBUTION  Q18CASE1P21
1  21 0.
    195.0     0.000
    223.0     0.022
    251.0     0.042
    279.0     0.115
    307.0     0.223
    335.0     0.330
    363.0     0.438
    391.0     0.545
    419.0     0.653
    447.0     0.760
    475.0     0.868
    503.0     0.952
    531.0     0.958
    559.0     0.965
    587.0     0.971
    615.0     0.978
    643.0     0.984
    671.0     0.990
    699.0     0.994
    727.0     0.997
    755.0     1.000
USER DISTRIBUTION  Q19CASE1P26
1  21   0.
    260.0     0.000
    297.0     0.022
    334.0     0.044
    371.0     0.099
    408.0     0.168
    445.0     0.237
    482.0     0.306
    519.0     0.375
    556.0     0.444
    593.0     0.513
    630.0     0.582
    667.0     0.651
    704.0     0.720
    741.0     0.789
    778.0     0.858
    815.0     0.927
    852.0     0.957
    889.0     0.968
    926.0     0.979
    963.0     0.989
   1000.0     1.000
USER DISTRIBUTION  Q19CASE1P30
1 21 0.
    260.0     0.000
    297.0     0.022
    334.0     0.044
    371.0     0.099
    408.0     0.168
    445.0     0.237
    482.0     0.306
    519.0     0.375
    556.0     0.444
    593.0     0.513
    630.0     0.582
    667.0     0.651
    704.0     0.720
    741.0     0.789
    778.0     0.858
    815.0     0.927
    852.0     0.957
    889.0     0.968
```

```
   926.0    0.979
   963.0    0.989
  1000.0    1.000
USER DISTRIBUTION  Q18CASE1P24
1  42  0.
0.       0.
2.5      0.026
5.0      0.130
7.5      0.273
10.0      0.360
12.5      0.445
15.0      0.525
17.5      0.590
20.0      0.652
22.5      0.709
25.0      0.747
27.5      0.771
30.0      0.795
32.5      0.818
35.0      0.836
37.5      0.852
40.0      0.869
42.5      0.885
45.0      0.902
47.5      0.916
50.0      0.929
52.5      0.939
55.0      0.950
57.5      0.957
60.0      0.965
62.5      0.971
65.0      0.977
67.5      0.980
70.0      0.983
72.5      0.986
75.0      0.989
77.5      0.991
80.0      0.993
82.5      0.994
85.0      0.996
87.5      0.997
90.0      0.996
92.5      0.998
95.0      0.999
97.5      0.999
100.0      0.999
102.5      1.000
USER DISTRIBUTION  Q19CASE1P34
1  51  0.
2.5      0.000
5.0      0.020
7.5      0.055
10.0      0.104
12.5      0.165
15.0      0.234
17.5      0.313
20.0      0.385
22.5      0.450
25.0      0.506
27.5      0.551
30.0      0.595
32.5      0.637
35.0      0.670
37.5      0.698
40.0      0.723
42.5      0.747
45.0      0.770
47.5      0.791
```

```
50.0      0.811
52.5      0.828
55.0      0.844
57.5      0.855
60.0      0.867
62.5      0.877
65.0      0.887
67.5      0.895
70.0      0.902
72.5      0.909
75.0      0.916
77.5      0.922
80.0      0.928
82.5      0.934
85.0      0.939
87.5      0.945
90.0      0.950
92.5      0.954
95.0      0.959
97.5      0.963
 100.0     0.968
 102.5     0.972
 105.0     0.977
 107.5     0.981
 110.0     0.982
 112.5     0.984
 115.0     0.986
 117.5     0.987
 120.0     0.989
 122.5     0.991
 125.0     0.993
 125.0     1.000
 USER DISTRIBUTION  Q35CASE5P2
 3  9  .0576
  2.100E+00 0.000E+00
  4.651E+00 1.000E-02
  7.740E+00 5.000E-02
  1.681E+01 2.500E-01
  2.442E+01 5.000E-01
  3.436E+01 7.500E-01
  4.594E+01 9.500E-01
  5.393E+01 9.900E-01
  7.000E+01 1.000E+00
 USER DISTRIBUTION  Q35CASE3P2
 3  9  .0576
  0.000E+00 0.000E+00
  0.000E+00 1.000E-02
  0.000E+00 5.000E-02
  3.526E+00 2.500E-01
  1.487E+01 5.000E-01
  3.237E+01 7.500E-01
  4.745E+01 9.500E-01
  5.600E+01 9.900E-01
  6.000E+01 1.000E+00
 USER DISTRIBUTION  Q35CASE6P2
 3  9 .0576
  0.000E+00 0.000E+00
  5.200E+00 1.000E-02
  9.596E+00 5.000E-02
  1.790E+01 2.500E-01
  2.520E+01 5.000E-01
  3.417E+01 7.500E-01
  4.719E+01 9.500E-01
  5.960E+01 9.900E-01
  7.400E+01 1.000E+00
 USER DISTRIBUTION  Q35CASE4P2
 3  9 .0576
  0.000E+00 0.000E+00
```

```
 0.000E+00 1.000E-02
 0.000E+00 5.000E-02
 5.860E+00 2.500E-01
 1.461E+01 5.000E-01
 2.492E+01 7.500E-01
 3.650E+01 9.500E-01
 4.320E+01 9.900E-01
 5.200E+01 1.000E+00
USER DISTRIBUTION  Q35CASE2P2
3  9  .0576
 0.000E+00 0.000E+00
 3.601E+00 1.000E-02
 8.600E+00 5.000E-02
 1.956E+01 2.500E-01
 2.551E+01 5.000E-01
 3.313E+01 7.500E-01
 4.577E+01 9.500E-01
 5.303E+01 9.900E-01
 7.300E+01 1.000E+00
USER DISTRIBUTION Q35CASE1P2
3  9 .0576
 0.000E+00 0.000E+00
 0.000E+00 1.000E-02
 0.000E+00 5.000E-02
 0.000E+00 2.500E-01
 9.501E+00 5.000E-01
 2.102E+01 7.500E-01
 3.484E+01 9.500E-01
 4.806E+01 9.900E-01
 5.500E+01 1.000E+00
USER DISTRIBUTION  Q41CASE4
1 5 0.
0.    0.
0.095 0.1
0.12  0.5
0.16  0.9
0.17  1.0
USER DISTRIBUTION  Q41CASE5
1 5 0.
0.    0.
0.0475 0.1
0.06   0.5
0.08   0.9
0.085  1.0
USER DISTRIBUTION  Q43C4
1  14  0.
   0.000E+00   0.000E+00
   1.000E-03   6.668E-01
   1.800E-01   6.933E-01
   3.200E-01   7.233E-01
   4.200E-01   7.500E-01
   5.000E-01   7.767E-01
   5.600E-01   8.067E-01
   6.100E-01   8.333E-01
   6.400E-01   8.600E-01
   6.700E-01   8.900E-01
   6.900E-01   9.167E-01
   7.000E-01   9.433E-01
   7.100E-01   9.733E-01
   7.200E-01   1.000E+00
USER DISTRIBUTION  Q43CASE5
1 30  0.
   0.          0.
   0.000E+00   1.667E-01
   2.000E-02   1.857E-01
   3.000E-02   2.169E-01
   4.000E-02   3.065E-01
   5.000E-02   3.977E-01
```

```
    6.000E-02   4.326E-01
    8.000E-02   4.959E-01
    1.000E-01   5.558E-01
    1.200E-01   6.124E-01
    1.300E-01   6.373E-01
    1.400E-01   6.602E-01
    1.600E-01   6.692E-01
    1.800E-01   6.783E-01
    2.000E-01   6.841E-01
    2.200E-01   6.898E-01
    2.300E-01   6.910E-01
    2.400E-01   6.928E-01
    2.700E-01   7.015E-01
    3.860E-01   7.223E-01
    4.930E-01   7.500E-01
    5.670E-01   7.777E-01
    6.190E-01   8.057E-01
    6.560E-01   8.333E-01
    6.810E-01   8.610E-01
    7.000E-01   8.890E-01
    7.130E-01   9.167E-01
    7.230E-01   9.443E-01
    7.300E-01   9.723E-01
    7.350E-01   1.000E+00
USER DISTRIBUTION  Q43CASE6
1  30  0.
    0.          0.
    0.000E+00   1.667E-01
    2.000E-02   1.864E-01
    3.000E-02   2.179E-01
    4.000E-02   3.077E-01
    5.000E-02   3.993E-01
    6.000E-02   4.345E-01
    8.000E-02   4.984E-01
    1.000E-01   5.590E-01
    1.200E-01   6.162E-01
    1.300E-01   6.414E-01
    1.400E-01   6.646E-01
    1.600E-01   6.743E-01
    1.800E-01   6.840E-01
    1.820E-01   6.847E-01
    2.000E-01   6.913E-01
    2.200E-01   6.988E-01
    2.400E-01   7.029E-01
    2.700E-01   7.123E-01
    3.190E-01   7.223E-01
    4.240E-01   7.500E-01
    5.030E-01   7.777E-01
    5.630E-01   8.057E-01
    6.080E-01   8.333E-01
    6.420E-01   8.610E-01
    6.680E-01   8.890E-01
    6.880E-01   9.167E-01
    7.030E-01   9.443E-01
    7.140E-01   9.723E-01
    7.230E-01   1.000E+00
USER DISTRIBUTION  Q43CASE7
1  31  0.
    0.000E+00   0.000E+00
    2.000E-02   1.866E-02
    4.000E-02   5.731E-02
    6.000E-02   1.093E-01
    7.000E-02   1.520E-01
    8.000E-02   2.155E-01
    1.000E-01   3.358E-01
    1.100E-01   3.926E-01
    1.200E-01   4.235E-01
    1.400E-01   4.785E-01
```

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    1.600E-01   5.236E-01
    1.800E-01   5.653E-01
    2.000E-01   6.004E-01
    2.200E-01   6.355E-01
    2.400E-01   6.639E-01
    2.700E-01   6.869E-01
    2.780E-01   6.890E-01
    2.900E-01   6.929E-01
    3.100E-01   6.961E-01
    3.300E-01   7.027E-01
    4.520E-01   7.223E-01
    5.630E-01   7.500E-01
    6.320E-01   7.777E-01
    6.760E-01   8.057E-01
    7.030E-01   8.333E-01
    7.200E-01   8.610E-01
    7.310E-01   8.890E-01
    7.380E-01   9.167E-01
    7.430E-01   9.443E-01
    7.450E-01   9.723E-01
    7.470E-01   1.000E+00
USER DISTRIBUTION  Q43CASE8
1  32 0.
    0.000E+00   0.000E+00
    2.000E-02   1.866E-02
    4.000E-02   5.731E-02
    6.000E-02   1.093E-01
    7.000E-02   1.520E-01
    8.000E-02   2.155E-01
    1.000E-01   3.358E-01
    1.100E-01   3.926E-01
    1.200E-01   4.235E-01
    1.400E-01   4.785E-01
    1.600E-01   5.236E-01
    1.800E-01   5.653E-01
    2.000E-01   6.004E-01
    2.200E-01   6.355E-01
    2.400E-01   6.639E-01
    2.500E-01   6.827E-01
    2.700E-01   6.869E-01
    2.780E-01   6.890E-01
    2.900E-01   6.929E-01
    3.100E-01   6.961E-01
    3.300E-01   7.027E-01
    4.520E-01   7.223E-01
    5.630E-01   7.500E-01
    6.320E-01   7.777E-01
    6.760E-01   8.057E-01
    7.030E-01   8.333E-01
    7.200E-01   8.610E-01
    7.310E-01   8.890E-01
    7.380E-01   9.167E-01
    7.430E-01   9.443E-01
    7.450E-01   9.723E-01
    7.470E-01   1.000E+00
USER DISTRIBUTION  Q43CASE9
1  36  0.
    0.000E+00   0.000E+00
    2.000E-02   4.809E-03
    4.000E-02   1.962E-02
    6.000E-02   4.100E-02
    8.000E-02   7.257E-02
    1.000E-01   1.074E-01
    1.200E-01   1.455E-01
    1.400E-01   1.803E-01
    1.600E-01   2.118E-01
    1.800E-01   2.399E-01
    2.000E-01   2.648E-01
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    2.200E-01   2.862E-01
    2.400E-01   3.044E-01
    2.700E-01   3.199E-01
    2.800E-01   3.407E-01
    2.900E-01   3.747E-01
    3.100E-01   4.462E-01
    3.300E-01   5.110E-01
    3.500E-01   5.358E-01
    3.700E-01   5.606E-01
    3.750E-01   5.668E-01
    3.900E-01   5.866E-01
    4.100E-01   6.095E-01
    4.300E-01   6.359E-01
    4.800E-01   6.933E-01
    5.000E-01   7.130E-01
    5.630E-01   7.223E-01
    6.560E-01   7.500E-01
    7.030E-01   7.777E-01
    7.270E-01   8.057E-01
    7.380E-01   8.333E-01
    7.440E-01   8.610E-01
    7.470E-01   8.890E-01
    7.490E-01   9.443E-01
    7.500E-01   9.723E-01
    7.500E-01   1.0
USER DISTRIBUTION  Q43CASE10
1  37  0.
    0.000E+00   0.000E+00
    2.000E-02   4.910E-03
    4.000E-02   1.982E-02
    6.000E-02   4.140E-02
    8.000E-02   7.297E-02
    1.000E-01   1.079E-01
    1.200E-01   1.461E-01
    1.400E-01   1.810E-01
    1.600E-01   2.126E-01
    1.800E-01   2.409E-01
    2.000E-01   2.658E-01
    2.200E-01   2.873E-01
    2.400E-01   3.056E-01
    2.700E-01   3.213E-01
    2.800E-01   3.421E-01
    2.900E-01   3.762E-01
    3.100E-01   4.478E-01
    3.300E-01   5.127E-01
    3.500E-01   5.376E-01
    3.510E-01   5.388E-01
    3.700E-01   5.639E-01
    3.900E-01   5.903E-01
    4.100E-01   6.133E-01
    4.300E-01   6.397E-01
    4.800E-01   6.973E-01
    5.000E-01   7.170E-01
    5.350E-01   7.223E-01
    6.330E-01   7.500E-01
    6.850E-01   7.777E-01
    7.140E-01   8.057E-01
    7.290E-01   8.333E-01
    7.380E-01   8.610E-01
    7.430E-01   8.890E-01
    7.460E-01   9.167E-01
    7.480E-01   9.443E-01
    7.490E-01   9.723E-01
    .75         1.
USER DISTRIBUTION  Q43CASE11
1  43  0.
    0.000E+00   0.000E+00
    2.000E-02   4.316E-03
```

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    4.000E-02   8.632E-03
    6.000E-02   1.962E-02
    8.000E-02   3.726E-02
    1.000E-01   5.491E-02
    1.200E-01   7.256E-02
    1.400E-01   9.355E-02
    1.600E-01   1.179E-01
    1.800E-01   1.388E-01
    2.000E-01   1.632E-01
    2.200E-01   1.841E-01
    2.400E-01   2.018E-01
    2.700E-01   2.233E-01
    2.900E-01   2.409E-01
    3.100E-01   2.586E-01
    3.300E-01   2.729E-01
    3.500E-01   2.839E-01
    3.700E-01   2.982E-01
    3.900E-01   3.092E-01
    4.100E-01   3.168E-01
    4.300E-01   3.245E-01
    4.500E-01   3.321E-01
    4.600E-01   3.509E-01
    4.700E-01   3.718E-01
    4.900E-01   4.170E-01
    5.100E-01   4.588E-01
    5.300E-01   4.973E-01
    5.400E-01   5.182E-01
    5.500E-01   5.304E-01
    5.630E-01   5.462E-01
    5.700E-01   5.557E-01
    5.900E-01   5.797E-01
    6.100E-01   6.037E-01
    6.300E-01   6.311E-01
    6.900E-01   7.031E-01
    7.000E-01   7.217E-01
    7.030E-01   7.223E-01
    7.380E-01   7.500E-01
    7.470E-01   7.777E-01
    7.490E-01   8.057E-01
    7.500E-01   9.723E-01
    .75         1.0
USER DISTRIBUTION  Q43CASE12
1  46  0.
    0.000E+00   0.000E+00
    2.000E-02   4.513E-03
    4.000E-02   9.026E-03
    6.000E-02   2.021E-02
    8.000E-02   3.805E-02
    1.000E-01   5.590E-02
    1.200E-01   7.375E-02
    1.400E-01   9.493E-02
    1.600E-01   1.194E-01
    1.800E-01   1.406E-01
    2.000E-01   1.651E-01
    2.200E-01   1.863E-01
    2.400E-01   2.042E-01
    2.700E-01   2.259E-01
    2.900E-01   2.438E-01
    3.100E-01   2.616E-01
    3.300E-01   2.761E-01
    3.500E-01   2.873E-01
    3.700E-01   3.018E-01
    3.900E-01   3.130E-01
    4.100E-01   3.209E-01
    4.300E-01   3.287E-01
    4.500E-01   3.365E-01
    4.600E-01   3.555E-01
    4.690E-01   3.744E-01
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   4.700E-01   3.766E-01
   4.900E-01   4.242E-01
   5.100E-01   4.684E-01
   5.300E-01   5.083E-01
   5.400E-01   5.315E-01
   5.500E-01   5.448E-01
   5.700E-01   5.716E-01
   5.900E-01   5.950E-01
   6.100E-01   6.184E-01
   6.300E-01   6.452E-01
   6.330E-01   6.487E-01
   6.900E-01   7.303E-01
   6.970E-01   7.450E-01
   7.000E-01   7.530E-01
   7.250E-01   7.777E-01
   7.380E-01   8.057E-01
   7.440E-01   8.333E-01
   7.470E-01   8.610E-01
   7.490E-01   9.167E-01
   7.500E-01   9.723E-01
    .75         1.
USER DISTRIBUTION  Q44CASE2
1   4 0.
   0.000E+00 0.000E+00
   1.000E-04 6.667E-01
   6.639E-01 6.667E-01
   6.639E-01 1.000E+00
USER DISTRIBUTION  Q44CASE4
1   4 0.
   0.000E+00 0.000E+00
   1.000E-04 6.667E-01
   7.490E-01 6.667E-01
   7.490E-01 1.000E+00
USER DISTRIBUTION  Q44CASE5
1  37 0.
   0.        0.
   0.000E+00 1.667E-01
   2.000E-02 1.701E-01
   4.000E-02 1.786E-01
   6.000E-02 1.905E-01
   8.000E-02 2.042E-01
   1.000E-01 2.186E-01
   1.200E-01 2.329E-01
   1.400E-01 2.467E-01
   1.600E-01 2.595E-01
   1.800E-01 2.712E-01
   1.990E-01 2.811E-01
   1.990E-01 6.154E-01
   2.200E-01 6.241E-01
   2.400E-01 6.320E-01
   2.700E-01 6.388E-01
   2.900E-01 6.444E-01
   3.100E-01 6.492E-01
   3.300E-01 6.530E-01
   3.500E-01 6.562E-01
   3.700E-01 6.587E-01
   3.900E-01 6.607E-01
   4.100E-01 6.622E-01
   4.300E-01 6.634E-01
   4.500E-01 6.643E-01
   4.700E-01 6.650E-01
   4.900E-01 6.655E-01
   5.079E-01 6.658E-01
   5.079E-01 9.991E-01
   5.100E-01 9.992E-01
   5.300E-01 9.995E-01
   5.500E-01 9.996E-01
   5.700E-01 9.998E-01
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   5.900E-01 9.999E-01
   6.100E-01 9.999E-01
   6.300E-01 9.999E-01
   6.500E-01 1.000E+00
USER DISTRIBUTION  Q44CASE7
1  36  0.
   0.000E+00 0.000E+00
   2.000E-02 6.767E-03
   4.000E-02 2.390E-02
   6.000E-02 4.763E-02
   8.000E-02 7.497E-02
   1.000E-01 1.038E-01
   1.200E-01 1.325E-01
   1.400E-01 1.600E-01
   1.600E-01 1.857E-01
   1.800E-01 2.091E-01
   2.000E-01 2.299E-01
   2.200E-01 2.482E-01
   2.400E-01 2.640E-01
   2.700E-01 2.775E-01
   2.900E-01 2.889E-01
   3.100E-01 2.983E-01
   3.300E-01 3.060E-01
   3.500E-01 3.123E-01
   3.700E-01 3.173E-01
   3.900E-01 3.213E-01
   4.100E-01 3.244E-01
   4.300E-01 3.268E-01
   4.500E-01 3.286E-01
   4.700E-01 3.300E-01
   4.900E-01 3.310E-01
   4.990E-01 3.313E-01
   4.990E-01 6.647E-01
   5.100E-01 6.650E-01
   5.300E-01 6.656E-01
   5.500E-01 6.659E-01
   5.700E-01 6.662E-01
   5.900E-01 6.664E-01
   6.100E-01 6.665E-01
   6.300E-01 6.666E-01
   6.990E-01 6.666E-01
   7.010E-01 1.000E+00
USER DISTRIBUTION  Q44CASE2P20
1 10 0.
   2.771    0.000
   2.850    0.025
   3.565    0.250
   4.704    0.322
   4.833    0.355
   6.000    0.654
   7.120    0.769
   7.515    0.810
  11.667    0.975
  12.296    1.000
USER DISTRIBUTION  Q44CASE5P20
1  73 0.
   0.000E+00 0.000E+00
   1.000E+00 3.778E-03
   1.353E+00 5.111E-03
   1.397E+00 1.361E-02
   1.793E+00 9.011E-02
   2.000E+00 9.870E-02
   2.667E+00 1.264E-01
   2.750E+00 1.384E-01
   3.000E+00 1.738E-01
   3.500E+00 2.446E-01
   3.770E+00 2.612E-01
   3.990E+00 2.747E-01
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    4.000E+00 2.750E-01
    5.000E+00 2.988E-01
    6.000E+00 3.223E-01
    7.000E+00 3.763E-01
    7.250E+00 3.898E-01
    7.667E+00 4.121E-01
    8.000E+00 4.233E-01
    9.000E+00 4.570E-01
    1.000E+01 4.907E-01
    1.100E+01 5.247E-01
    1.200E+01 5.583E-01
    1.300E+01 6.007E-01
    1.400E+01 6.430E-01
    1.500E+01 6.857E-01
    1.600E+01 7.280E-01
    1.700E+01 7.703E-01
    1.800E+01 8.127E-01
    1.900E+01 8.241E-01
    2.000E+01 8.351E-01
    2.100E+01 8.465E-01
    2.200E+01 8.579E-01
    2.300E+01 8.690E-01
    2.400E+01 8.804E-01
    2.500E+01 8.918E-01
    2.600E+01 9.002E-01
    2.700E+01 9.069E-01
    2.800E+01 9.140E-01
    2.900E+01 9.207E-01
    3.000E+01 9.278E-01
    3.100E+01 9.318E-01
    3.200E+01 9.359E-01
    3.300E+01 9.400E-01
    3.400E+01 9.437E-01
    3.500E+01 9.477E-01
    3.600E+01 9.518E-01
    3.700E+01 9.559E-01
    3.800E+01 9.599E-01
    3.900E+01 9.640E-01
    4.000E+01 9.681E-01
    4.100E+01 9.721E-01
    4.200E+01 9.762E-01
    4.300E+01 9.779E-01
    4.400E+01 9.797E-01
    4.500E+01 9.814E-01
    4.600E+01 9.831E-01
    4.700E+01 9.848E-01
    4.800E+01 9.862E-01
    4.900E+01 9.880E-01
    5.000E+01 9.897E-01
    5.100E+01 9.914E-01
    5.200E+01 9.932E-01
    5.300E+01 9.949E-01
    5.400E+01 9.966E-01
    5.500E+01 9.970E-01
    5.600E+01 9.974E-01
    5.700E+01 9.981E-01
    5.800E+01 9.985E-01
    5.900E+01 9.989E-01
    6.000E+01 9.997E-01
    6.200E+01 9.997E-01
    6.300E+01 1.000E+00
USER DISTRIBUTION  Q46CASE2P18
3   4  130.3
    0.000E+00 0.000E+00
    1.000E-03 6.667E-01
    3.100E+01 6.667E-01
    3.100E+01 1.000E+00
USER DISTRIBUTION  Q46CASE4P18
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3  22 379.7
   0.000E+00 0.000E+00
   0.000E+00 5.000E-01
   9.801E+01 5.000E-01
   1.039E+02 5.002E-01
   1.099E+02 5.006E-01
   1.158E+02 5.019E-01
   1.218E+02 5.054E-01
   1.277E+02 5.127E-01
   1.336E+02 5.256E-01
   1.396E+02 5.451E-01
   1.455E+02 5.699E-01
   1.515E+02 5.968E-01
   1.574E+02 6.216E-01
   1.633E+02 6.410E-01
   1.693E+02 6.540E-01
   1.752E+02 6.613E-01
   1.812E+02 6.647E-01
   1.871E+02 6.661E-01
   1.930E+02 6.665E-01
   1.990E+02 6.666E-01
   2.432E+02 6.667E-01
   2.432E+02 1.000E+00
USER DISTRIBUTION  Q46CASE5P18
3  20  287.3
   0.000E+00 0.000E+00
   0.000E+00 1.667E-01
   5.465E+01 1.667E-01
   5.465E+01 5.000E-01
   1.102E+02 5.000E-01
   1.125E+02 5.013E-01
   1.125E+02 8.346E-01
   1.162E+02 8.367E-01
   1.221E+02 8.400E-01
   1.281E+02 8.467E-01
   1.340E+02 8.600E-01
   1.400E+02 8.800E-01
   1.459E+02 9.033E-01
   1.519E+02 9.300E-01
   1.579E+02 9.533E-01
   1.638E+02 9.733E-01
   1.698E+02 9.867E-01
   1.757E+02 9.933E-01
   1.817E+02 9.967E-01
   1.876E+02 1.000E+00
USER DISTRIBUTION  Q46CASE6P18
3  26  619.1
   0.000E+00 0.000E+00
   0.000E+00 3.333E-01
   1.797E+02 3.333E-01
   1.894E+02 3.334E-01
   1.991E+02 3.334E-01
   2.088E+02 3.336E-01
   2.185E+02 3.344E-01
   2.282E+02 3.364E-01
   2.379E+02 3.412E-01
   2.476E+02 3.510E-01
   2.574E+02 3.689E-01
   2.671E+02 3.971E-01
   2.768E+02 4.363E-01
   2.865E+02 4.838E-01
   2.962E+02 5.340E-01
   3.059E+02 5.800E-01
   3.156E+02 6.166E-01
   3.253E+02 6.414E-01
   3.351E+02 6.558E-01
   3.448E+02 6.627E-01
   3.545E+02 6.655E-01
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   3.690E+02 6.664E-01
   3.788E+02 6.666E-01
   3.885E+02 6.667E-01
   5.737E+02 6.667E-01
   5.737E+02 1.000E+00
USER DISTRIBUTION  Q46CASE7P18
3  20  468.6
   2.336E+02 0.000E+00
   2.336E+02 3.387E-01
   2.386E+02 3.412E-01
   2.484E+02 3.510E-01
   2.581E+02 3.689E-01
   2.678E+02 3.971E-01
   2.776E+02 4.363E-01
   2.850E+02 4.725E-01
   2.850E+02 8.059E-01
   2.873E+02 8.171E-01
   2.970E+02 8.673E-01
   3.068E+02 9.134E-01
   3.165E+02 9.499E-01
   3.263E+02 9.748E-01
   3.360E+02 9.891E-01
   3.457E+02 9.961E-01
   3.555E+02 9.988E-01
   3.701E+02 9.997E-01
   3.798E+02 9.999E-01
   3.896E+02 1.000E+00
USER DISTRIBUTION  Q46CASE8P18
3  25  855.8
   0.000E+00 0.000E+00
   0.000E+00 3.333E-01
   3.567E+02 3.333E-01
   3.702E+02 3.334E-01
   3.836E+02 3.335E-01
   3.971E+02 3.338E-01
   4.105E+02 3.345E-01
   4.240E+02 3.363E-01
   4.375E+02 3.403E-01
   4.509E+02 3.483E-01
   4.644E+02 3.626E-01
   4.778E+02 3.85[illegible]E-01
   4.913E+02 4.202E-01
   5.115E+02 4.647E-01
   5.250E+02 5.157E-01
   5.384E+02 5.665E-01
   5.519E+02 6.095E-01
   5.653E+02 6.397E-01
   5.788E+02 6.567E-01
   5.923E+02 6.640E-01
   6.057E+02 6.662E-01
   6.192E+02 6.666E-01
   6.326E+02 6.667E-01
   7.220E+02 6.667E-01
   7.220E+02 1.000E+00
USER DISTRIBUTION Q46CASE9P18
3  24 647.9
   3.523E+02 0.000E+00
   3.656E+02 3.333E-05
   3.789E+02 1.333E-04
   3.922E+02 4.333E-04
   3.970E+02 7.086E-04
   3.970E+02 3.340E-01
   4.055E+02 3.345E-01
   4.188E+02 3.363E-01
   4.321E+02 3.403E-01
   4.454E+02 3.483E-01
   4.587E+02 3.626E-01
   4.720E+02 3.860E-01
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    4.853E+02 4.202E-01
    5.052E+02 4.647E-01
    5.183E+02 5.149E-01
    5.183E+02 8.484E-01
    5.185E+02 8.491E-01
    5.318E+02 8.998E-01
    5.451E+02 9.428E-01
    5.584E+02 9.731E-01
    5.717E+02 9.901E-01
    5.850E+02 9.974E-01
    5.983E+02 9.995E-01
    6.116E+02 1.000E+00
USER DISTRIBUTION  Q46CASE10P18
3  23 1013.3
    0.000E+00 0.000E+00
    0.000E+00 3.333E-01
    4.892E+02 3.333E-01
    5.052E+02 3.334E-01
    5.213E+02 3.334E-01
    5.373E+02 3.336E-01
    5.533E+02 3.340E-01
    5.694E+02 3.351E-01
    5.854E+02 3.373E-01
    6.095E+02 3.419E-01
    6.255E+02 3.501E-01
    6.416E+02 3.636E-01
    6.576E+02 3.834E-01
    6.736E+02 4.092E-01
    6.897E+02 4.380E-01
    7.057E+02 4.648E-01
    7.218E+02 4.847E-01
    7.378E+02 6.622E-01
    7.538E+02 6.660E-01
    7.699E+02 6.666E-01
    7.859E+02 6.667E-01
    7.917E+02 6.667E-01
    7.917E+02 1.000E+00
USER DISTRIBUTION Q46CASE11P18
3  22 832.5
    4.510E+02 0.000E+00
    4.510E+02 3.333E-01
    5.299E+02 3.333E-01
    5.473E+02 3.334E-01
    5.647E+02 3.334E-01
    5.821E+02 3.336E-01
    5.994E+02 3.340E-01
    6.168E+02 3.351E-01
    6.342E+02 3.373E-01
    6.603E+02 3.419E-01
    6.660E+02 3.446E-01
    6.660E+02 6.779E-01
    6.776E+02 6.834E-01
    6.950E+02 6.969E-01
    7.124E+02 7.168E-01
    7.298E+02 7.426E-01
    7.471E+02 7.713E-01
    7.645E+02 7.982E-01
    7.819E+02 8.180E-01
    7.993E+02 9.955E-01
    8.166E+02 9.993E-01
    8.340E+02 1.000E+00
USER DISTRIBUTION  Q46C2P19
1  23  0.
    0.000E+00 0.000E+00
    0.000E+00 2.500E-01
    2.990E-01 2.500E-01
    2.990E-01 7.500E-01
    3.300E-01 7.501E-01
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   3.500E-01 7.502E-01
   3.700E-01 7.509E-01
   3.900E-01 7.529E-01
   4.100E-01 7.581E-01
   4.300E-01 7.690E-01
   4.500E-01 7.884E-01
   4.700E-01 8.176E-01
   4.900E-01 8.548E-01
   5.100E-01 8.951E-01
   5.300E-01 9.323E-01
   5.500E-01 9.615E-01
   5.700E-01 9.810E-01
   5.900E-01 9.919E-01
   6.100E-01 9.971E-01
   6.300E-01 9.991E-01
   6.500E-01 9.998E-01
   6.700E-01 9.999E-01
   6.900E-01 1.000E+00
USER DISTRIBUTION  Q46CASE6P19
1  24 0.
   3.700E-01 0.000E+00
   3.900E-01 5.000E-05
   4.100E-01 1.000E-04
   4.300E-01 4.500E-04
   4.500E-01 1.550E-03
   4.700E-01 4.600E-03
   4.900E-01 1.175E-02
   5.100E-01 2.655E-02
   5.300E-01 5.335E-02
   5.500E-01 9.570E-02
   5.700E-01 1.544E-01
   5.900E-01 2.256E-01
   6.100E-01 3.009E-01
   6.300E-01 3.701E-01
   6.500E-01 4.249E-01
   6.700E-01 4.622E-01
   6.900E-01 4.837E-01
   7.100E-01 4.941E-01
   7.300E-01 4.983E-01
   7.600E-01 4.996E-01
   7.800E-01 4.999E-01
   8.000E-01 5.000E-01
   8.840E-01 5.000E-01
   8.860E-01 1.000E+00
USER DISTRIBUTION Q46CASE8P19
1  23 0.
   5.300E-01 0.000E+00
   5.500E-01 5.000E-05
   5.700E-01 2.000E-04
   5.900E-01 6.500E-04
   6.100E-01 1.800E-03
   6.300E-01 4.500E-03
   6.500E-01 1.050E-02
   6.700E-01 2.245E-02
   6.900E-01 4.395E-02
   7.100E-01 7.905E-02
   7.300E-01 1.303E-01
   7.600E-01 1.971E-01
   7.800E-01 2.736E-01
   8.000E-01 3.497E-01
   8.200E-01 4.142E-01
   8.400E-01 4.596E-01
   8.600E-01 4.851E-01
   8.800E-01 4.961E-01
   9.000E-01 4.993E-01
   9.200E-01 4.999E-01
   9.400E-01 5.000E-01
   9.900E-01 5.000E-01
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   1.000E+00 1.000E+00
USER DISTRIBUTION  Q48CASE10P19
1  22  0.
   5.900E-01 0.000E+00
   6.100E-01 2.500E-05
   6.300E-01 5.000E-05
   6.500E-01 1.500E-04
   6.700E-01 4.000E-04
   6.900E-01 1.050E-03
   7.100E-01 2.625E-03
   7.300E-01 6.000E-03
   7.600E-01 1.278E-02
   7.800E-01 2.507E-02
   8.000E-01 4.535E-02
   8.200E-01 7.515E-02
   8.400E-01 1.138E-01
   8.600E-01 1.570E-01
   8.800E-01 1.972E-01
   9.000E-01 2.270E-01
   9.200E-01 4.932E-01
   9.400E-01 4.989E-01
   9.600E-01 4.999E-01
   9.800E-01 5.000E-01
   9.900E-01 5.000E-01
   1.000E+00 1.000E+00
 USER DISTRIBUTION  Q68C6
 3  9  .000576
  0.000E+00 0.000E+00
  1.778E-03 1.000E-02
  8.889E-03 5.000E-02
  3.556E-02 2.500E-01
  6.991E-02 5.000E-01
  2.728E-01 7.500E-01
  3.097E-01 9.500E-01
  3.186E-01 9.900E-01
  3.600E-01 1.000E+00
 USER DISTRIBUTION  Q68C4
 3  9  .000576
  0.000E+00 0.000E+00
  0.000E+00 1.000E-02
  0.000E+00 5.000E-02
  1.000E-02 2.500E-01
  2.336E-02 5.000E-01
  4.144E-02 7.500E-01
  8.142E-02 9.500E-01
  1.103E-01 9.900E-01
  1.500E-01 1.000E+00
 USER DISTRIBUTION  Q68C7
 3  9  .000576
  0.000E+00 0.000E+00
  3.077E-04 1.000E-02
  1.538E-03 5.000E-02
  7.692E-03 2.500E-01
  2.762E-02 5.000E-01
  4.606E-02 7.500E-01
  9.500E-02 9.500E-01
  1.600E-01 9.900E-01
  2.400E-01 1.000E+00
 USER DISTRIBUTION  Q68C5
 3  9  .000576
  0.000E+00 0.000E+00
  0.000E+00 1.000E-02
  0.000E+00 5.000E-02
  3.448E-03 2.500E-01
  8.620E-03 5.000E-01
  2.363E-02 7.500E-01
  4.600E-02 9.500E-01
  6.605E-02 9.900E-01
```

```
 9.000E-02 1.000E+00
USER DISTRIBUTION  Q68C3
3  9  .000576
 0.000E+00 0.000E+00
 1.000E-03 1.000E-02
 5.000E-03 5.000E-02
 2.222E-02 2.500E-01
 3.750E-02 5.000E-01
 5.598E-02 7.500E-01
 1.315E-01 9.500E-01
 2.383E-01 9.900E-01
 3.700E-01 1.000E+00
USER DISTRIBUTION  Q68C2
3  9  .000576
 0.000E+00 0.000E+00
 0.000E+00 1.000E-02
 0.000E+00 5.000E-02
 6.922E-03 2.500E-01
 2.375E-02 5.000E-01
 4.205E-02 7.500E-01
 8.436E-02 9.500E-01
 2.464E-01 9.900E-01
 4.500E-01 1.000E+00
USER DISTRIBUTION  Q70CASE2P13
3  9  0.01
    0.00 0.00
    0.33 0.01
    0.57 0.05
    2.25 0.25
    3.62 0.50
    5.72 0.75
    9.25 0.95
   14.00 0.99
   20.00 1.00
USER DISTRIBUTION  Q70CASE3P13
3  9  0.01
    0.00 0.00
    0.20 0.01
    0.35 0.05
    1.66 0.25
    2.47 0.50
    3.48 0.75
    8.75 0.95
   14.00 0.99
   20.00 1.00
USER DISTRIBUTION  Q70CASE6P13
3  9  0.01
    0.00 0.00
    0.33 0.01
    0.57 0.05
    2.25 0.25
    3.52 0.50
    5.45 0.75
    9.25 0.95
   14.00 0.99
   20.00 1.00
USER DISTRIBUTION  Q70CASE7P13
3  9  0.01
    0.00 0.00
    0.20 0.01
    0.35 0.05
    1.20 0.25
    2.10 0.50
    3.39 0.75
    8.75 0.95
   14.00 0.99
   20.00 1.00
USER DISTRIBUTION  Q76CASE2P40
```

```
1  9  0.
  3.35  0.00
  4.21  0.01
  7.22  0.05
 27.00  0.25
 41.30  0.50
 61.20  0.75
113.00  0.95
166.00  0.99
227.00  1.00
USER DISTRIBUTION  Q70CASE4P13
3  9  0.01
   0.33 0.00
   0.39 0.01
   0.60 0.05
   2.07 0.25
   3.49 0.50
   5.60 0.75
   8.01 0.95
   9.10 0.99
   9.50 1.00
USER DISTRIBUTION  Q70CASE5P13
3  9  0.01
   0.20 0.00
   0.24 0.01
   0.36 0.05
   1.30 0.25
   2.50 0.50
   3.43 0.75
   4.44 0.95
   4.97 0.99
   5.31 1.00
USER DISTRIBUTION  Q70CASE8P13
3  9  0.01
   0.33 0.00
   0.39 0.01
   0.60 0.05
   1.80 0.25
   3.13 0.50
   4.53 0.75
   6.89 0.95
   8.19 0.99
   8.85 1.00
USER DISTRIBUTION  Q70CASE9P13
3  9  0.01
   0.20 0.00
   0.24 0.01
   0.36 0.05
   1.30 0.25
   2.27 0.50
   3.04 0.75
   3.98 0.95
   4.91 0.99
   5.31 1.00
USER DISTRIBUTION  Q76CASE3P40
1  9  0.
 4.36  0.00
 4.99  0.01
 7.52  0.05
24.00  0.25
40.30  0.50
56.80  0.75
76.90  0.95
87.80  0.99
92.50  1.00
USER DISTRIBUTION  Q70CASE10P13
3  9  0.01
   0.00 0.00
```

```
    0.30 0.01
    0.32 0.05
    0.44 0.25
    1.62 0.50
    3.97 0.75
    8.75 0.95
   14.00 0.99
   20.00 1.00
USER DISTRIBUTION  Q70CASE11P13
3  9  0.01
    0.00 0.00
    0.17 0.01
    0.27 0.05
    0.39 0.25
    0.85 0.50
    2.70 0.75
    8.50 0.95
   14.00 0.99
   20.00 1.00
USER DISTRIBUTION  Q70CASE12P13
3  9  0.01
    0.00 0.00
    0.11 0.01
    0.16 0.05
    0.35 0.25
    1.62 0.50
    3.97 0.75
    8.75 0.95
   14.00 0.99
   20.00 1.00
USER DISTRIBUTION  Q70CASE13P13
3  9  0.01
    0.00 0.00
    0.11 0.01
    0.15 0.05
    0.31 0.25
    0.85 0.50
    2.70 0.75
    8.50 0.95
   14.00 0.99
   20.00 1.00
USER DISTRIBUTION  Q76CASE4P40
1  9  0.
   2.36  0.00
   2.76  0.01
   3.58  0.05
   5.88  0.25
  18.61  0.50
  46.60  0.75
 108.70  0.95
 166.00  0.99
 227.00  1.00
USER DISTRIBUTION  Q71CASE2P39
3  13  .01
    5.500E+00 0.000E+00
    6.000E+00 5.000E-03
    8.000E+00 2.500E-02
    1.500E+01 1.250E-01
    2.000E+01 1.667E-01
    3.000E+01 3.750E-01
    4.000E+01 5.694E-01
    4.800E+01 7.850E-01
    5.000E+01 8.368E-01
    6.000E+01 9.456E-01
    6.500E+01 9.750E-01
    8.000E+01 9.950E-01
    8.375E+01 1.000E+00
USER DISTRIBUTION  Q71CASE3P39
```

```
3  13  .01
    4.680E+00 0.000E+00
    5.1[illegible]00 5.000E-03
    6.[illegible] 2.500E-02
    1.2[illegible]E+0[illegible] 1.250E-01
    1.500[illegible] 1.471E-01
    2.500E[illegible] 4.951E-01
    2.550E+01 5.067E-01
    4.000E+01 8.185E-01
    4.080E+01 8.290E-01
    5.000E+01 9.387E-01
    5.525E+01 9.750E-01
    6.800E+01 9.950E-01
    7.119E+01 1.000E+00
USER DISTRIBUTION  Q71CASE6P39
3  13  .01
    4.400E+00 0.000E+00
    4.800E+00 5.000E-03
    6.400E+00 2.500E-02
    1.200E+01 1.250E-01
    2.000E+01 2.083E-01
    2.400E+01 3.000E-01
    3.840E+01 6.050E-01
    4.000E+01 6.368E-01
    5.000E+01 9.103E-01
    5.200E+01 9.350E-01
    6.000E+01 9.883E-01
    6.400E+01 9.950E-01
    6.700E+01 1.000E+00
USER DISTRIBUTION  Q71CASE7P39
3  13  .01
    3.740E+00 0.000E+00
    4.080E+00 5.000E-03
    5.440E+00 2.500E-02
    1.000E+01 1.208E-01
    1.020E+01 1.300E-01
    2.000E+01 4.951E-01
    2.040E+01 5.080E-01
    3.000E+01 7.980E-01
    3.264E+01 8.382E-01
    4.000E+01 9.387E-01
    4.420E+01 9.750E-01
    5.440E+01 9.950E-01
    5.695E+01 1.000E+00
USER DISTRIBUTION  Q71CASE4P39
3  13  .01
    3.850E+00 0.000E+00
    4.200E+00 5.000E-03
    5.600E+00 2.500E-02
    1.050E+01 1.250E-01
    2.000E+01 2.381E-01
    2.100E+01 2.625E-01
    3.360E+01 5.450E-01
    4.000E+01 6.788E-01
    4.550E+01 8.350E-01
    5.000E+01 9.336E-01
    5.600E+01 9.750E-01
    5.863E+01 9.931E-01
    6.000E+01 1.000E+00
USER DISTRIBUTION  Q71CASE5P39
3  13  .01
    0.000E+00 0.000E+00
    3.270E+00 5.450E-02
    3.570E+00 6.450E-02
    4.760E+00 1.043E-01
    8.930E+00 2.738E-01
    1.500E+01 4.601E-01
    1.785E+01 5.570E-01
```

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   2.500E+01 7.835E-01
   2.856E+01 8.428E-01
   3.500E+01 9.386E-01
   3.868E+01 9.750E-01
   4.760E+01 9.950E-01
   4.983E+01 1.000E+00
USER DISTRIBUTION  Q71CASE8P39
3  13  .01
   3.080E+00 0.000E+00
   3.360E+00 5.000E-03
   4.480E+00 2.500E-02
   8.400E+00 1.250E-01
   1.680E+01 2.500E-01
   2.000E+01 2.897E-01
   2.688E+01 4.610E-01
   3.640E+01 6.600E-01
   4.000E+01 7.336E-01
   4.480E+01 8.410E-01
   4.690E+01 8.860E-01
   5.000E+01 9.500E-01
   6.000E+01 1.000E+00
USER DISTRIBUTION  Q71CASE9P39
3  13  .01
   2.620E+00 0.000E^00
   2.860E+00 5.000E-03
   3.810E+00 2.500E-02
   5.000E+00 6.074E-02
   7.140E+00 2.014E-01
   1.200E+01 4.601E-01
   1.428E+(, 5.570E-01
   2.000E+01 7.834E-01
   2.285E+01 8.535E-01
   2.500E+01 9.016E-01
   3.094E+01 9.750E-01
   3.808E+01 9.950E-01
   3.986E+01 1.000E+00
USER DISTRIBUTION  Q71CASE10P39
3  9  .01
   2.00 0.00
   2.16 0.01
   2.79 0.05
   4.62 0.25
   7.92 0.50
  14.00 0.75
  29.00 0.95
  38.00 0.99
  42.00 1.00
USER DISTRIBUTION  Q71CASE11P39
3  9  .01
   1.38 0.00
   1.63 0.01
   2.10 0.05
   3 40 0.25
   5.85 0.50
   9.86 0.75
  16.91 0.95
  21.60 0.99
  24.00 1.00
USER DISTRIBUTION  Q71CASE13P39
3  9  .01
   0.69 0.00
   0.81 0.01
   1.06 0.05
   2.43 0.25
   4.47 0.50
   7.37 0.75
  12.00 0.95
  21.60 0.99
```

```
  24.00 1.00
USER DISTRIBUTION  Q71CASE14F39
3  9  .01
   1.00 0.00
   1.12 0.01
   1.60 0.05
   3.76 0.25
   6.06 0.50
  12.55 0.75
  29.00 0.95
  38.00 0.99
  42.00 1.00
USER DISTRIBUTION  Q71CASE15F39
3  9  .01
   1.00 0.00
   1.12 0.01
   1.53 0.05
   2.50 0.25
   4.68 0.50
   7.75 0.75
  14.91 0.95
  19.00 0.99
  21.00 1.00
USER DISTRIBUTION  Q71CASE17F39
3  9  .01
   0.69 0.00
   0.81 0.01
   1.05 0.05
   1.88 0.25
   3.50 0.50
   5.90 0.75
   9.54 0.95
  14.40 0.99
  16.00 1.00
USER DISTRIBUTION  Q83CASE3
1  45  0.
   1.000E-01 0.000E+00
   1.200E-01 3.333E-05
   1.400E-01 1.000E-04
   1.600E-01 2.333E-04
   1.800E-01 5.333E-04
   2.000E-01 1.033E-03
   2.200E-01 1.867E-03
   2.400E-01 3.200E-03
   2.700E-01 5.200E-03
   2.900E-01 8.000E-03
   3.100E-01 1.183E-02
   3.300E-01 1.690E-02
   3.500E-01 2.337E-02
   3.700E-01 3.137E-02
   3.900E-01 4.107E-02
   4.100E-01 5.250E-02
   4.300E-01 6.567E-02
   4.500E-01 8.050E-02
   4.700E-01 9.683E-02
   4.900E-01 1.145E-01
   5.100E-01 1.333E-01
   5.300E-01 1.528E-01
   5.500E-01 1.726E-01
   5.700E-01 1.925E-01
   5.870E-01 2.090E-01
   5.900E-01 2.157E-01
   5.990E-01 2.356E-01
   5.990E-01 5.734E-01
   6.100E-01 5.930E-01
   6.300E-01 6.355E-01
   6.500E-01 6.765E-01
   6.700E-01 7.159E-01
```

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    6.900E-01 7.535E-01
    7.100E-01 7.892E-01
    7.200E-01 8.061E-01
    7.300E-01 8.188E-01
    7.600E-01 8.508E-01
    7.800E-01 8.728E-01
    8.000E-01 8.934E-01
    8.200E-01 9.128E-01
    8.400E-01 9.312E-01
    8.600E-01 9.490E-01
    8.800E-01 9.662E-01
    9.000E-01 9.832E-01
    9.200E-01 1.000E+00
USER DISTRIBUTION  Q83CASE4
1  48  0.
    4.000E-02 0.000E+00
    6.000E-02 3.333E-05
    8.000E-02 1.333E-04
    1.000E-01 4.667E-04
    1.200E-01 1.267E-03
    1.400E-01 2.833E-03
    1.600E-01 5.567E-03
    1.800E-01 9.900E-03
    2.000E-01 1.617E-02
    2.200E-01 2.470E-02
    2.400E-01 3.570E-02
    2.700E-01 4.920E-02
    2.900E-01 6.517E-02
    3.100E-01 8.330E-02
    3.300E-01 1.032E-01
    3.500E-01 1.245E-01
    3.700E-01 1.466E-01
    3.900E-01 1.689E-01
    4.100E-01 1.909E-01
    4.300E-01 2.119E-01
    4.500E-01 2.317E-01
    4.700E-01 2.498E-01
    4.900E-01 2.660E-01
    5.100E-01 2.802E-01
    5.300E-01 2.923E-01
    5.500E-01 3.024E-01
    5.540E-01 3.040E-01
    5.660E-01 3.256E-01
    5.700E-01 3.331E-01
    5.900E-01 3.689E-01
    5.990E-01 3.844E-01
    5.990E-01 7.212E-01
    6.100E-01 7.366E-01
    6.300E-01 7.698E-01
    6.500E-01 8.019E-01
    6.580E-01 8.300E-01
    6.700E-01 8.319E-01
    6.900E-01 8.498E-01
    7.100E-01 8.672E-01
    7.300E-01 8.844E-01
    7.600E-01 9.097E-01
    7.800E-01 9.265E-01
    8.000E-01 9.433E-01
    8.200E-01 9.600E-01
    8.400E-01 9.767E-01
    8.480E-01 9.833E-01
    8.600E-01 9.933E-01
    8.680E-01 1.000E+00
USER DISTRIBUTION  Q83CASE5
1  40  0.
    0.        0.
    2.000E-02 2.000E-04
    4.000E-02 2.100E-03
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   6.000E-02 7.600E-03
   8.000E-02 1.777E-02
   1.000E-01 3.293E-02
   1.200E-01 5.260E-02
   1.400E-01 7.590E-02
   1.600E-01 1.017E-01
   1.800E-01 1.286E-01
   2.000E-01 1.557E-01
   2.200E-01 1.819E-01
   2.400E-01 2.064E-01
   2.700E-01 2.288E-01
   2.900E-01 2.486E-01
   3.100E-01 2.659E-01
   3.300E-01 2.805E-01
   3.500E-01 2.926E-01
   3.630E-01 2.991E-01
   3.690E-01 3.187E-01
   3.700E-01 3.217E-01
   3.900E-01 3.789E-01
   4.100E-01 4.341E-01
   4.300E-01 4.680E-01
   4.500E-01 5.080E-01
   4.700E-01 5.270E-01
   4.900E-01 5.453E-01
   5.100E-01 5.630E-01
   5.300E-01 5.803E-01
   5.500E-01 5.973E-01
   5.700E-01 6.141E-01
   5.900E-01 6.308E-01
   5.990E-01 6.382E-01
   5.990E-01 9.732E-01
   6.100E-01 9.807E-01
   6.130E-01 9.831E-01
   6.300E-01 9.974E-01
   6.330E-01 9.999E-01
   6.500E-01 9.999E-01
   6.700E-01 1.000E+00
USER DISTRIBUTION  Q63CASE6
1  37  0.
   0.000E+00 0.000E+00
   0.000E+00 1.667E-01
   2.000E-02 1.676E-01
   4.000E-02 1.725E-01
   6.000E-02 1.820E-01
   8.000E-02 1.952E-01
   1.000E-01 2.110E-01
   1.200E-01 2.278E-01
   1.330E-01 2.387E-01
   1.360E-01 2.563E-01
   1.400E-01 2.683E-01
   1.600E-01 3.555E-01
   1.800E-01 4.412E-01
   2.000E-01 4.774E-01
   2.200E-01 5.117E-01
   2.400E-01 5.441E-01
   2.700E-01 5.868E-01
   2.900E-01 6.160E-01
   3.060E-01 6.384E-01
   3.100E-01 6.440E-01
   3.200E-01 6.575E-01
   3.300E-01 6.591E-01
   3.500E-01 6.614E-01
   3.700E-01 6.631E-01
   3.900E-01 6.643E-01
   4.100E-01 6.651E-01
   4.300E-01 6.657E-01
   4.500E-01 6.661E-01
   4.700E-01 6.663E-01
```

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    4.900E-01 6.664E-01
    5.100E-01 6.665E-01
    5.300E-01 6.666E-01
    5.500E-01 6.666E-01
    5.700E-01 6.666E-01
    5.900E-01 6.666E-01
    5.990E-01 6.667E-01
    5.990E-01 1.000E+00
USER DISTRIBUTION  Q63CASE7
1   7  0.
    0.000E+00 0.000E+00
    0.000E+00 6.667E-01
    5.000E-03 6.667E-01
    6.000E-03 8.333E-01
    1.200E-02 8.333E-01
    3.300E-02 8.333E-01
    3.500E-02 1.000E+00
USER DISTRIBUTION  Q110CASE4
1  38  0.
    0.000E+00   0.000E+00
    2.000E-02   3.333E-03
    4.000E-02   6.667E-03
    6.000E-02   1.667E-02
    8.000E-02   3.333E-02
    1.000E-01   5.000E-02
    1.200E-01   6.667E-02
    1.400E-01   8.667E-02
    1.600E-01   1.100E-01
    1.800E-01   1.300E-01
    2.000E-01   1.533E-01
    2.200E-01   1.733E-01
    2.400E-01   1.900E-01
    2.700E-01   2.100E-01
    2.900E-01   2.267E-01
    3.100E-01   2.433E-01
    3.300E-01   2.567E-01
    3.500E-01   2.667E-01
    3.700E-01   2.800E-01
    3.900E-01   2.900E-01
    4.100E-01   2.967E-01
    4.300E-01   3.033E-01
    4.500E-01   3.100E-01
    4.600E-01   3.263E-01
    4.700E-01   3.487E-01
    4.900E-01   3.829E-01
    5.100E-01   4.337E-01
    5.300E-01   4.712E-01
    5.400E-01   4.817E-01
    5.500E-01   5.033E-01
    5.700E-01   5.267E-01
    5.900E-01   5.467E-01
    6.100E-01   5.667E-01
    6.300E-01   5.900E-01
    6.800E-01   6.500E-01
    7.000E-01   6.667E-01
    7.490E-01   6.667E-01
    7.500E-01   1.000E+00
USER DISTRIBUTION  Q110CASE5
1  27  0.
    0.000E+00   0.000E+00
    2.000E-02   3.333E-03
    4.000E-02   1.667E-02
    6.000E-02   3.667E-02
    8.000E-02   6.667E-02
    1.000E-01   1.000E-01
    1.200E-01   1.367E-01
    1.400E-01   1.700E-01
    1.600E-01   2.000E-01
```

```
   1.800E-01   2.267E-01
   2.000E-01   2.500E-01
   2.200E-01   2.700E-01
   2.400E-01   2.867E-01
   2.700E-01   3.000E-01
   2.800E-01   3.200E-01
   2.900E-01   3.533E-01
   3.100E-01   4.233E-01
   3.300E-01   4.867E-01
   3.500E-01   5.100E-01
   3.700E-01   5.333E-01
   3.900E-01   5.567E-01
   4.100E-01   5.767E-01
   4.300E-01   6.000E-01
   4.800E-01   6.500E-01
   5.000E-01   6.667E-01
   7.490E-01   6.667E-01
   7.500E-01   1.000E+00
USER DISTRIBUTION  Q110CASE6
1  22  0.
   0.000E+00   0.000E+00
   2.000E-02   1.667E-02
   4.000E-02   5.333E-02
   6.000E-02   1.033E-01
   7.000E-02   1.450E-01
   8.000E-02   2.075E-01
   1.000E-01   3.258E-01
   1.100E-01   3.817E-01
   1.200E-01   4.115E-01
   1.400E-01   4.646E-01
   1.600E-01   5.077E-01
   1.800E-01   5.474E-01
   2.000E-01   5.805E-01
   2.200E-01   6.136E-01
   2.400E-01   6.400E-01
   2.500E-01   6.578E-01
   2.700E-01   6.600E-01
   2.900E-01   6.633E-01
   3.100E-01   6.633E-01
   3.300E-01   6.667E-01
   7.490E-01   6.667E-01
   7.500E-01   1.000E+00
USER DISTRIBUTION  Q110CASE7
1  20  0.
   0.000E+00   0.
   0.000E+00   1.667E-01
   2.000E-02   1.833E-01
   3.000E-02   2.133E-01
   4.000E-02   3.017E-01
   5.000E-02   3.917E-01
   6.000E-02   4.254E-01
   8.000E-02   4.863E-01
   1.000E-01   5.437E-01
   1.200E-01   5.970E-01
   1.300E-01   6.217E-01
   1.400E-01   6.433E-01
   1.600E-01   6.500E-01
   1.800E-01   6.567E-01
   2.000E-01   6.600E-01
   2.200E-01   6.633E-01
   2.400E-01   6.633E-01
   2.700E-01   6.667E-01
   7.490E-01   6.667E-01
   7.500E-01   1.000E+00
USER DISTRIBUTION  Q121CASE3 1HR
3 10 100.
  0.0000000E+00  0.0000000E+00
   5.853478       0.2500000
```

```
    16.64806       0.4861985
    17.61362       0.5117597
    23.49041       0.6703745
    28.39725       0.7576681
    29.37848       0.7708541
    51.46236       0.9888418
    53.08035       0.9999926
    53.08253        1.000000
USER DISTRIBUTION  Q121CASE4 1HR
3  18 100.
  0.0000000E+00  0.0000000E+00
    4.093530       0.2209128
    5.334964       0.2666074
    11.41873       0.4728452
    11.42960       0.4731953
    13.43750       0.5224683
    19.46350       0.6536177
    21.67472       0.6957226
    25.34775       0.7522194
    25.37491       0.7526503
    27.87279       0.7924019
    29.11012       0.8105679
    36.42460       0.9112193
    37.32767       0.9214275
    39.09656       0.9352708
    51.47277       0.9945450
    53.08035       0.9999964
    53.08253        1.000000
USER DISTRIBUTION  Q121CASE5 1HR
3  9 100.
  0.0000000E+00  0.0000000E+00
    3.551772       0.2500000
    8.712790       0.5000000
    19.46350       0.6909575
    25.34775       0.7787747
    25.37491       0.7792329
    36.42460       0.9774911
    37.32767       0.9892573
    39.09656        1.000000
USER DISTRIBUTION  Q121CASE6 1HR
3 26  100.
    2.270435       0.0000000E+00
    2.274242       1.9338406E-05
    2.292922       3.8502249E-04
    8.002968       0.1887912
    8.041298       0.1899554
    10.47471       0.2556697
    11.14722       0.2732998
    11.54255       0.2840690
    12.19428       0.3016863
    16.95935       0.4320823
    18.41677       0.4764471
    18.84840       0.4904125
    20.18964       0.5336965
    21.29881       0.5723103
    21.31329       0.5728332
    22.35411       0.6110032
    23.86576       0.6580960
    26.28955       0.7202799
    28.38547       0.7635713
    29.89638       0.7874333
    29.95587       0.7883382
    41.25035       0.9418595
    41.26198       0.9419897
    42.96329       0.9572882
    58.43262       0.9975109
    60.34173        1.000000
USER DISTRIBUTION  Q121CASE7 1HR
```

```
3 10 100.
    2.270435       0.0000000E+00
    2.292922       3.2181581E-04
    11.00492       0.2135701
    14.58827       0.2822474
    24.89499       0.4796280
    26.90180       0.5323169
    32.65723       0.7161146
    34.79766       0.7594882
    60.49671       0.9984084
    60.85576        1.000000
USER DISTRIBUTION  Q121CASE8 1HR
3 10 100.
    2.270435       0.0000000E+00
    2.292922       3.2181581E-04
    11.00492       0.2135701
    14.58827       0.2822474
    24.89499       0.4799000
    26.86987       0.5360594
    31.74091       0.7137173
    33.73302       0.7585528
    60.49671       0.9984584
    60.85576        1.000000
USER DISTRIBUTION  Q121CASE9 1HR
3  9 100.
    2.274242       0.0000000E+00
    2.292922       4.0487255E-04
    8.041098       0.2026839
    11.54255       0.2904972
    18.84840       0.4684659
    21.31329       0.5305390
    28.93754       0.7461098
    29.18244       0.7521805
    42.97687        1.000000
USER DISTRIBUTION  Q121CASE3 3HR
3  9 100.
  0.0000000E+00  0.0000000E+00
    16.50000       0.2500000
    31.39897       0.4960751
    31.75829       0.5029814
    41.44250       0.7128878
    43.37365       0.7438735
    45.18155       0.7647842
    72.68594       0.9872532
    75.03593        1.000000
USER DISTRIBUTION  Q121CASE4  3HR
3 18 100.
  0.0000000E+00  0.0000000E+00
    11.20000       0.2256808
    13.90534       0.2676052
    24.24086       0.4579495
    24.48396       0.4621632
    30.21343       0.5451938
    30.50451       0.5500473
    30.51007       0.5501481
    37.99240       0.6918840
    39.73213       0.7219386
    40.29735       0.7299435
    42.12517       0.7537074
    42.47548       0.7574492
    44.40321       0.7766545
    68.56992       0.9778116
    68.57191       0.9778221
    72.68594       0.9938764
    75.03593        1.000000
USER DISTRIBUTION  Q121CASE5  3HR
3  9 100.
  0.0000000E+00  0.0000000E+00
```

```
   9.976905      0.2500000
   20.84160      0.4969369
   21.14689      0.5010033
   37.99240      0.7224541
   40.29735      0.7477712
   42.47548      0.7686370
   68.56992      0.9999946
   68.57191       1.000000
USER DISTRIBUTION  Q121CASE6  3HR
3 26 100.
   7.483674      0.0000000E+00
   7.486670      5.6199556E-06
   10.93431      2.4654103E-02
   10.93467      2.4657412E-02
   23.14310      0.1992948
   23.43725      0.2036555
   26.54735      0.2506082
   26.91058      0.2564894
   29.69595      0.3024129
   33.11627      0.3643242
   36.23957      0.4290231
   37.61887      0.4577365
   37.88377      0.4632180
   41.25822      0.5341565
   41.63695      0.5426631
   42.39139      0.5590905
   48.92722      0.6890982
   49.06990      0.6917475
   50.84887      0.7218159
   50.85258      0.7218712
   56.50129      0.7883639
   58.36134      0.8080113
   70.18518      0.9225063
   82.45173      0.9930394
   82.62984      0.9937555
   85.20407       1.000000
USER DISTRIBUTION  Q121CASE7  3HR
3  9  100.
   7.483674      0.0000000E+00
   10.93431      1.8968534E-02
   30.22285      0.2315526
   33.56226      0.2771508
   45.59721      0.4925308
   46.36205      0.5057690
   62.16943      0.7247473
   66.17133      0.7715705
   85.36031       1.000000
USER DISTRIBUTION  Q121CASE8  3HR
3  9 100.
   7.483674      0.0000000E+00
   10.93431      1.8979644E-02
   30.20954      0.2314791
   33.56226      0.2808905
   43.77651      0.4917875
   44.49478      0.5048906
   62.13498      0.7267240
   66.17133      0.7717239
   85.36031       1.000000
USER DISTRIBUTION  Q121CASE9  3HR
3  9 100.
   7.486670      0.0000000E+00
   10.93467      2.7020972E-02
   23.43725      0.2228237
   26.91058      0.2802631
   37.78364      0.4831552
   39.47709      0.5168284
   50.36245      0.7474766
   50.58673      0.7508047
```

```
   65.20407        1.000000
USER DISTRIBUTION  Q121CASE3  6HR
3 11 100.
   14.80008       0.0000000E+00
   35.07825       0.2471076
   35.42505       0.2519239
   49.59284       0.4777925
   50.09953       0.4881303
   53.89096       0.5534931
   62.24906       0.7367463
   62.62326       0.7428733
   63.50159       0.7527924
   125.9930       0.9999978
   125.9947        1.000000
USER DISTRIBUTION  Q121CASE4  6HR
3 21 100.
   14.80147       0.0000000E+00
   14.80377       1.4645632E-05
   28.84921       0.2130869
   29.08835       0.2183968
   34.30488       0.2951210
   34.52401       0.2985436
   43.21150       0.4423561
   43.50312       0.4474013
   43.51390       0.4475986
   49.11921       0.5496912
   49.62220       0.5591701
   52.58738       0.6181189
   54.20509       0.6530864
   54.61517       0.6605917
   58.47718       0.7184174
   60.71692       0.7486778
   61.07057       0.7521956
   62.89659       0.7651647
   125.9930       0.9999502
   125.9947       0.9999544
   126.0204        1.000000
USER DISTRIBUTION  Q121CASE5  6HR
3  9 100.
   14.80780       0.0000000E+00
   28.31448       0.2474420
   28.52501       0.2512681
   42.15010       0.4957758
   42.50441       0.5024689
   53.70161       0.7243053
   54.10917       0.7301272
   57.85686       0.7591311
   126.0204        1.000000
USER DISTRIBUTION  Q121CASE6  6HR
3 25 100.
   22.61046       0.0000000E+00
   22.65701       9.1329704E-05
   23.56597       3.7710315E-03
   23.65908       4.2109773E-03
   28.19901       4.0727314E-02
   30.29651       6.1510261E-02
   43.49620       0.2169338
   43.85057       0.2237365
   43.85248       0.2237639
   44.22194       0.2296692
   50.53968       0.3355620
   50.94539       0.3430231
   54.98781       0.4228816
   55.20806       0.4268721
   58.84415       0.4863113
   59.08053       0.4900942
   62.46499       0.5425693
   63.26223       0.5532392
```

```
   75.94279      0.6969824
   75.95174      0.6970835
   77.15455      0.7074027
   92.82503      0.8027300
   94.44394      0.8123923
   125.9385      0.9999247
   125.9562       1.000000
USER DISTRIBUTION  Q121CASE7  6HR
3  9 100.
   28.19201      0.0000000E+00
   30.27719      1.0013564E-02
   54.22150      0.2485800
   54.49663      0.2536617
   63.61385      0.4957535
   63.93447      0.5013221
   93.92844      0.7443324
   95.35299      0.7555629
   125.9385       1.000000
USER DISTRIBUTION  Q121CASE8  6HR
3  9 100.
   28.19201      0.0000000E+00
   30.27719      1.1802075E-02
   50.27694      0.2474164
   50.69002      0.2541859
   62.88141      0.4922035
   63.69179      0.5032628
   93.92844      0.7443758
   95.35299      0.7555629
   125.9385       1.000000
USER DISTRIBUTION  Q121CASE9  6HR
3  9 100.
   22[illegible]1046      0.0000000E+00
   2[illegible]5908      6.1790231E-03
   43.82384      0.2478112
   44.18324      0.2541743
   54.58604      0.4974172
   54.80552      0.5012841
   75.95174      0.7432726
   77.15455      0.7530078
   125.9385       1.000000
USER DISTRIBUTION  Q121CASE3 10HR
3 11 100.
   35.93404      0.0000000E+00
   37.44417      5.0581465E-03
   60.81345      0.2208209
   65.40042      0.2745192
   66.15594      0.2870260
   75.12340      0.4686491
   76.04572      0.4846863
   78.77850      0.5190694
   103.2986      0.7479482
   103.6202      0.7507136
   140.8582       1.000000
USER DISTRIBUTION  Q121CASE4 10HR
3 20 100.
   25.33301      0.0000000E+00
   26.43104      1.8174783E-03
   35.94230      4.9765345E-02
   37.46914      6.0054641E-02
   50.50585      0.1871284
   51.04259      0.1929443
   60.48418      0.3009084
   65.04509      0.3589621
   65.29419      0.3627655
   65.69302      0.3695122
   70.46380      0.4440060
   73.69032      0.4930381
   74.41317      0.5041347
```

```
   75.33038       0.5168090
   78.54359       0.5529810
   94.58462       0.7101160
   102.9761       0.7715912
   103.2957       0.7738169
   140.9422       0.9998799
   140.9868        1.000000
USER DISTRIBUTION  Q121CASE5 10HR
3  9 100.
   25.34092       0.0000000E+00
   26.45000       3.7745268E-03
   49.82702       0.2454434
   50.48410       0.2534916
   65.50931       0.4510683
   70.26614       0.5022364
   73.48371       0.5345715
   94.03905       0.7500000
   140.9868        1.000000
USER DISTRIBUTION  Q121CASE6 10HR
3 28 100.
   28.60406       0.0000000E+00
   28.61439       1.4554505E-05
   29.70165       3.0857241E-03
   29.72723       3.1937172E-03
   37.59109       4.7601342E-02
   37.59586       4.7636058E-02
   58.03986       0.2302156
   58.18284       0.2318863
   58.97623       0.2432597
   59.50978       0.2517601
   62.83578       0.3104179
   63.10903       0.3153948
   68.03225       0.4073481
   68.44721       0.4136242
   72.76861       0.4684906
   72.94049       0.4703584
   81.84275       0.5507236
   82.62659       0.5569847
   106.0197       0.7212209
   106.0833       0.7216733
   106.2427       0.7227992
   106.2599       0.7229221
   117.9992       0.8064034
   118.3063       0.8086247
   140.9259       0.9704351
   140.9520       0.9705591
   150.6532       0.9934782
   156.6557        1.000000
USER DISTRIBUTION  Q121CASE7 10HR
3 10 100.
   37.59109       0.0000000E+00
   37.59586       1.9804362E-05
   67.39520       0.2487847
   67.68781       0.2525317
   81.84275       0.4933529
   82.63774       0.5025158
   121.3426       0.7489895
   121.6580       0.7513453
   150.6532       0.9785609
   156.6557        1.000000
USER DISTRIBUTION  Q121CASE8 10HR
3 10 100.
   37.59109       0.0000000E+00
   37.59586       1.7863198E-05
   70.65191       0.2488519
   70.95837       0.2533701
   82.01888       0.4930539
   82.66965       0.5020687
```

```
    121.3426       0.7489887
    121.6580       0.7513453
    150.6532       0.9765609
    156.6557        1.000000
USER DISTRIBUTION  Q121CASE9 10HR
3  9 100.
    29.70165       0.0000000E+00
    29.72723       1.0725110E-04
    58.97623       0.2477625
    59.50978       0.2538947
    76.10048       0.4986625
    76.27991       0.5007481
    106.0833       0.7492636
    106.2599       0.7506337
    140.9259        1.000000
```

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In support of the Nuclear Regulatory Commission's (NRC's) assessment of the risk from severe accidents at commercial nuclear power plants in the U.S. report in NUREG-1150, the Severe Accident Risk Reduction Program (SARRP) has completed a revised calculation of the risk to the general public from severe accidents at the Grand Gulf Nuclear Station, Unit 1. This power plant, located in Port Gibson, Mississippi, is operated by the System Energy Resources, Inc. (SERI).

The emphasis in this risk analysis was not on determining a "so-called" point estimate of risk. Rather, it was to determine the distribution of risk, and to discover the uncertainties that account for the breadth of this distribution. Off-site risk initiated by events internal to the power plant was assessed.

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