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Evaluation of Severe Accident Risks: Sequoyah, Unit 1

Appendices

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APPENDIX A

SUPPORTING INFORMATION FOR THE ACCIDENT PROGRESSION ANALYSIS

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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 binner that groups 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 11) in the APET for each plant damage state (PDS), and a description of the ac power recovery data used in this analysis.

A.1 ACCIDENT PROGRESSION EVENT TREE

A brief description of the Sequoyah APET is given in Section 2.3, and the binner is treated in Section 2.4. The material in these sections is not repeated here. The 111 questions in the Sequoyah APET are listed concisely in Table 2.3-1. This appendix consists of four subsections. Subsection ..1.1 contains a discussion of each question to the Sequoyah 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 is a detailed discussion of the binner, and Subsection A.1.4 contains a listing of the binner, which, like the APET itself, exists only in computer input format.

A.1.1 Detailed Description of the Sequoyah APET

Question 1. Size and Location of the Reactor Coolant System Break When the Core Uncovers?
6 Branches, Type 1

The branches for this question are:

1.	Brk-A	A large break in the reactor coolant system (RCS), equivalent to the break of a pipe greater than 2 in. in diameter.
2.	Brk-S2	A small break in the RCS, equivalent to the break of a pipe between 0.5 and 2 in. in diameter.
3.	Brk-S3	A very small break in the RCS, equivalent to the break of a pipe less than 0.5 in. in diameter.
4.	Brk-V	A break in an interfacing system has opened a path from inside the RCS to outside the containment. The size is equivalent to an A break.
5.	B-SGTR	A steam generator tube rupture (SGTR) has occurred. The size is equivalent to an S_3 break.
6.	B-PORV	There is no break in the RCS; any loss of coolant will be through the cycling power-operated relief valve (PORV) or safety relief valve (SRV).

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

There is no branch for S_1 breaks; they are grouped with the A breaks. If there is no break in the RCS pressure boundary, the RCS pressure will be maintained near the PORV setpoint, around 2500 psia. B-PORV is used to represent this situation. A stuck-open PORV or SRV is considered to be an S_2 break. Note that this question determines the condition of the RCS pressure boundary at the time the water level had decreased to the top of active fuel (TAF). This is taken to be the onset of core damage and marks the transition from the accident frequency analysis to the accident progression analysis. If an accident initiated by a transient event has had a reactor coolant pump seal failure before the uncovering of top of active fuel (UTAF), the first characteristic of the PDS is "S_3", and the third branch is taken. Similarly, a transient event in which the PORVs stick open before the UTAF is designated an "S_2" PDS and the second branch is indicated at this question of the APET. Thus the branch taken in this question may not reflect the original accident initiator.

For some PDS groups, all the probability is assigned to one branch in an obvious manner, e.g., Branch 6 (B-PORV, no break) for Groups 2 (fast SBO) and 5 (Transients) and Branch 4 (Brk-V) for Group 4 (Event V). Other groups contain several PDSs that have different size breaks or no break at all. For example, PDS Group 1, Slow SBO, contains "T", "S_3", and "S_2" PDSs. For groups like this, the probability is divided among the branches according to the frequency of the relevant PDSs relative to the total group frequency. In the sampling mode, the quantification of this question depends upon the relative frequency of the RCS break classification, as provided by the TEMAC4 Code. For PDS Group 1, the TEMAC4 mean value quantification for this question is:

Branch 1: Brk-A - 0.000
Branch 2: Brk-S2 - 0.028
Branch 3: Brk-S3 - 0.954
Branch 4: Brk-V - 0.000
Branch 5: B-SGTR - 0.000
Branch 6: B-PORV - 0.018

For PDS Group 2, all the probability is assigned to Branch 6, B-PORV.

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

Branch 1: Brk-A - 0.226
Branch 2: Brk-S2 - 0.168
Branch 3: Brk-S3 - 0.606
Branch 4: Brk-V - 0.000
Branch 5: B-SGTR - 0.000
Branch 6: B-PORV - 0.000

For PDS Group 4, all the probability is assigned to Branch 4, Brk-V.

For PDS Group 5, all the probability is assigned to Branch 6, B-PORV.

For PDS Group 6, the TEMAC4 mean value quantification for this question is:

Branch 1: Brk-A - 0.000
Branch 2: Brk-S2 - 0.000
Branch 3: Brk-S3 - 0.757
Branch 4: Brk-V - 0.000
Branch 5: B-SGTR - 0.135
Branch 6: B-PORV - 0.108

For PDS Group 7, all the probability is assigned to Branch 5, B-SGTR.

Question 2. Has the Reaction Been Brought under Control?

2 Branches, Type 1

The branches for this question are:

1. Scram The nuclear reaction in the core has been brought under control by insertion of the control rods or boron injection.
2. no-Scram The nuclear reaction in the core has not been brought under control.

The branch taken in this question depends upon the PDS group being analyzed. No PDS characteristic was defined for the branching in this question.

Branch 1 is taken for all PDS groups except Group 6. PDS Group 6 consists of accidents initiated by ATWS; Branch 2 is taken for this group.

This question is used with the previous question to determine the RCS pressure at UTAF. For example, if the PORVs are stuck open in the absence of steam generator (SG) cooling, the RCS pressure will be much lower at UTAF if scram occurred than if scram did not occur. If scram occurred, the boiling rate in the core would be relatively low, and the RCS pressure with the PORVs stuck open is expected to be around 500 psia or lower. If the control rods cannot be inserted, boiling would occur at a rate high enough to keep the PORVs open all the time, so the RCS would be at the PORV setpoint pressure, determining the RCS pressure at vessel breach (VB). As the water level decreases below TAF, more and more of the core will lose the neutron-moderating effect of the liquid water, and the nuclear reaction will decrease.

Question 3. **For SGTR, Are the Secondary System SRVs Stuck Open?**
2 Branches, Type 1

The branches for this question are:

1. SSRV-SO The safety/relief valves on the secondary system are stuck in the open position.

2. SSRVnSO The safety/relief valves on the secondary system are not stuck in the open position.

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

This question is used to discriminate between those PDSs that have "H" for the first characteristic (SGTR with the SRVs on the secondary system stuck open) and those which have "G" for the first characteristic ("normal" SGTR). This question is used for PDS Groups 6 and 7. Whether the secondary SRVs are stuck open is important in determining the source term. For all PDS groups except Group 7, the second branch is indicated (for PDS Group 6, any SGTR initiator PDS involves a "G" category SGTR). The quantification for Group 7 is a function of the relative frequency of the "G" and "H" PDSs. When the APET is evaluated in the sampling mode, this changes from observation to observation. For each observation, the quantification is provided by TEMAC4.

Question 4. Status of ECCS?
4 Branches, Type 2, 4 Cases

The branches for this question are:

1. B-ECCS The high pressure injection system (HPIS) and low pressure injection system (LPIS) are operating, but not necessarily injecting water into the RCS.

2. BaECCS The ECCS is available and can operate when electric power is restored.

3. BfECCS The ECCS is failed, and is not recoverable.

4. B-LPIS The LPIS is operating; the HPIS is failed.

The branch taken depends upon the second PDS characteristic and upon the branch taken at Questions 1 and 3.

The first branch is taken for those PDSs where both HPIS and LPIS are operating when the TAF is uncovered. However, water may not be actually reaching the core because the RCS pressure is too high. Indeed, the fact that the core is uncovered indicates that sufficient injection is not taking place. Branch 1 is taken, for example, when all auxiliary feedwater (AFW) has failed, the RCS is intact, and bleed and feed has failed because the PORVs cannot be opened.

The second branch is used in blackout situations with no ECCS failures; if or when power is recovered, the ECCS will function. The third branch is selected when the failures are in the ECCS itself, and there is no recovery within the timeframe of this analysis. Since the period in which the ECCS operates in the injection mode occurs before the uncovering of the core, the third branch is taken for those PDSs in which the ECCS never operates as well as those PDSs in which the ECCS operates in the injection mode and fails in the recirculation mode. The fourth branch indicates that HPIS is failed, but that LPIS is operating. As in the situation for which Branch 1 applies, core damage occurs because the RCS pressure is so high that no injection results. The third branch is taken for Event V since much of the water injected by the LPIS goes out the break and a sufficient amount does not reach the core.

Case 1: There was a large break in the RCS when the core uncovered (used for PDS Group 3), or there was a SGTR initiator with a stuck open secondary SRV (used for PDS Group 7). For PDS Group 7, all the probability is assigned to Branch 3, BfECCS. For PDS Group 3, this case is used to single out the A and S_1 PDSs so that the status of the ECCS can be assigned appropriately. In the sampling mode, the quantification of this case depends upon the relative frequency of the A and S_1 PDSs in PDS Group 3, as determined by TEMAC4. Based on the mean values of the PDSs in Group 3, the quantification for this case is:

Branch 1:	B-ECCS	-	0.000
Branch 2:	BaECCS	-	0.000
Branch 3:	BfECCS	-	0.246
Branch 4:	B-LPIS	-	0.754

Case 2: There was a small break in the RCS when the core uncovered. This case is used to single out the S_2 PDSs in PDS Group 3 so that the status of the ECCS can be assigned appropriately. Some portion of PDS Group 1 will also satisfy the requirement for this case, and all the probability is assigned to Branch 2, BaECCS. In the sampling mode for PDS Group 3, the quantification of this case depends upon the relative frequency of the S_2 PDSs, as determined by TEMAC4. Based on the mean values of the PDSs in Group 3, the quantification for this case is:

Branch 1: B-ECCS - 0.000
Branch 2: BaECCS - 0.000
Branch 3: BfECCS - 0.224
Branch 4: B-LPIS - 0.776

Case 3: There was a very small break in the RCS when the core uncovered. This case is used to single out the S_3 PDSs in PDS Groups 3 and 6 so that the status of the ECCS can be assigned appropriately. Some portion of PDS Group 1 will also satisfy the requirement for this case, and all the probability is assigned to Branch 2, BaECCS. For PDS Group 6, all the probability is assigned to Branch 3, BfECCS. In the sampling mode for PDS Group 3, the quantification of this case depends upon the relative frequency of the S_3 PDSs, as determined by TEMAC4. Based on the mean values of the PDSs in Group 3, the quantification for this case is:

Branch 1: B-ECCS - 0.000
Branch 2: BaECCS - 0.000
Branch 3: BfECCS - 0.256
Branch 4: B-LPIS - 0.744

Case 4: This case applies if the RCS is intact when the TAF uncovers, if there is an interfacing systems loss-of-coolant accident (LOCA) (Event V), or if there is an SGTR initiator without a stuck open secondary SRV. The quantification for each PDS Group depends upon the second PDS characteristic.

Question 5. Is the RCS Depressurized by the Operators?
3 Branches, Type 2, 3 Cases

The branches for this question are:

1.	Op-DePr	The operators opened the PORVs to depressurize the RCS before UTAF.
2.	OpmDePr	The operators did not open the PORVs to depressurize the RCS before UTAF, but they may do so after UTAF.
3.	OpnDePr	The operators did not open the PORVs to depressurize the RCS before UTAF when they should have, so no credit can be given for their opening of the PORVs after UTAF.

The branch taken depends upon the PDS Group and upon the branch taken at Questions 1 and 3.

For use in Question 19, it is necessary to know if the operators can be given credit for opening the PORVs after UTAF. The Sequoyah emergency procedures direct the operators to open the PORVs when the core exit thermocouples reach 1200°F if at least one centrifugal charging pump or safety injection pump is running. If the PORVs were not opened before UTAF when they should have been, due to either human error or hardware failures, no credit is given for deliberate opening of the PORVs after UTAF.

For the A, S_1, and S_2 breaks, opening the PORVs will have a negligible effect and the question is moot. For the Transient PDS Group and the S_3 PDSs in the LOCA Group, the operators have failed to open the PORVs before UTAF or the PORVs are stuck closed. In either case, no credit is given for deliberate opening of the PORVs in the accident progression analysis and Branch 3 is chosen. For the anticipated transient without scram (ATWS) initiators, it was estimated that the operators would be too busy attempting to shut down the reaction before UTAF to open the PORVs, and the PORVs would be kept continuously open by the escaping steam in any event. Thus, the operators may open the PORVs after UTAF and Branch 2 is taken. For the SGTR initiators, if the operators failed to follow procedures and did not depressurize the RCS by normal means, no credit is given for their opening the PORVs after UTAF.

Case 1: There was a very small break in the RCS when the core uncovered. This case is used to separate out the S_3 PDSs in PDS Group 3. The operators have failed to open the PORVs before UTAF. No credit is given for deliberate opening of the PORVs. All the probability is assigned to Branch 1, OpnDePr.

Case 2: This case applies only to the SGTRs in PDS Group 7 with stuck open SRVs; the operators failed to follow procedures and did not depressurize the RCS by normal means. No credit is given for their opening the PORVs after UTAF and Branch 1 is specified. When the APET is evaluated in the sampling mode, the quantification of this case depends upon the relative frequency of the SGTR PDSs.

Case 3: This case includes all the initial conditions not covered in the first two cases: RCS intact, or any break except an S_3, or a SGTR in which the SRVs are not stuck open. For PDS Groups 1 and 2, there is no electrical power, and therefore, the required pumps are not running, so the procedures prohibit depressurization and Branch 3 is specified. For PDS Group 3, LOCAs, Branch 3 is chosen. In the other PDSs, the break is more effective in depressurizing the RCS than the open PORVs would be, so whether the PORVs are opened is irrelevant. For PDS Group 4, Event V, the break is large and opening the PORVs will have no effect on the RCS pressure. For PDS Group 5, Transients, Branch 3 is specified since the PORVs cannot be opened from the control room due to hardware failures or the operators failed to open the PORVs before UTAF. For the ATWS Group, Branch 2 is taken as discussed above. In the SGTR Group GLYY-YNY, the PORVs are open (Branch 1) since the operators are attempting to cool the core by bleed and feed.

Question 6. Status of Sprays?

4 Branches, Type 1, 4 Cases

The branches for this question are:

1. B-Sp The containment sprays are operating or are operable in the recirculation mode.
2. BaSp The containment sprays are available and can operate when electric power is restored.
3. BfSp The containment sprays are failed in the recirculation mode and are not recoverable.
4. noB-SW The sprays themselves are operable, but heat removal from the spray heat exchangers by the service water system is failed and cannot be restored.

The branch taken depends upon the third PDS characteristic, and upon the branch taken at Questions 1, 3, and 4.

At Sequoyah, long-term containment heat removal is provided by the containment spray system. The spray system consists of two pump trains capable of drawing suction from the refueling water storage tank (RWST) and discharging through spray headers in the dome of the containment building. Water sprayed into containment passes through drains in the upper compartment floor to the containment sump. When the RWST reaches a low level, the pump suction is transferred by operator action to the sump. In this mode of operation, heat is removed from the containment atmosphere by a heat exchanger in each of the pump trains; the heat exchangers are in turn cooled by a service water system. It is worth noting that the failure to remove the upper compartment drain covers following refueling operations was assessed in RSSMAP[A.1-1] to be an important source of failure for both the spray and core cooling systems in the recirculation phase, since water from spray flow would be trapped in the upper compartment and would never reach the sump. Recent improvements in maintenance procedures have significantly reduced the likelihood that the drain covers could be left in place.

This question concerns the sprays during the period of core degradation, so only the recirculation mode of the containment sprays is of interest. The branch BfSp does not mean that the sprays did not operate in the injection mode. The spray injection pumps are high capacity pumps (4750 gpm) and the entire contents of the RWST can be injected into the containment in about 20 min if both spray injection pumps and all high pressure injection (HPI) pumps are operating at capacity. If little HPI is required, then it may take about half an hour for the spray pumps alone to empty the RWST. Thus, the injection mode of containment spray is over before or shortly after the core uncovers. Whether or not the water from the RWST has been transferred to the containment is addressed in Question 7.

For Event V, it is assumed that due to the break location, pressures high enough to actuate the spray system do not occur in the containment, so the sprays are not initiated. Recirculation sprays and heat removal from the heat exchangers by service water, as well as availability of ice in the IC, are required for containment heat removal. For branch BaSp, service water flow to the heat exchangers is assumed to be restored when the containment sprays are restored to operation following power recovery. The fourth branch is taken for the service water failure sequences which lead to containment failure before core melt (the "Core Vulnerable" sequences). No significant core vulnerable sequences were identified for Sequoyah, so this branch is not used.

Case 1: There was a large break in the RCS when the core uncovered and the ECCS is failed (used for PDS Group 3), or there was an SGTR initiator with a stuck open secondary SRV (used for PDS Group 7). For PDS Group 7, all the probability is assigned to Branch 3, BfSp. For PDS Group 3, this case is used to single out the A and S_1 PDSs so that the status of the sprays can be assigned appropriately. In the sampling mode, the quantification of this case depends upon the relative frequency of the A and S_1 PDSs without ECCS in PDS Group 3, as determined by TEMAC4. Based on the mean values of the PDSs in Group 3, the quantification for this case is:

Branch 1: B-Sp - 0.486
Branch 2: BaSp - 0.000
Branch 3: BfSp - 0.514
Branch 4: noB-SW - 0.000

Case 2: There was a small break in the RCS when the core uncovered and the ECCS is failed. This case is used to single out the S_2 PDSs in PDS Group 3 so that the status of the sprays can be assigned appropriately. Some portion of PDS Group 1 will also satisfy the requirement for this case, and all the probability is assigned to Branch 2, BaSp. In the sampling mode for PDS Group 3, the quantification of this case depends upon the relative frequency of the S_2 PDSs without ECCS, as determined by TEMAC4. Based on the mean values of the PDSs in Group 3, the quantification for this case is:

Branch 1: B-Sp - 0.413
Branch 2: BaSp - 0.000
Branch 3: BfSp - 0.587
Branch 4: noB-SW - 0.000

Case 3: There was a very small break in the RCS when the core uncovered. This case is used to single out the S_3 PDSs in PDS Groups 3 and 6 so that the status of the sprays can be assigned appropriately. Some portion of PDS Group 1 will also satisfy the requirement for this case, and all the probability is assigned to Branch 2, BaSp. For PDS Group 6, all the probability is assigned to Branch 1, B-Sp. In the sampling mode for PDS Group 3, the quantification of this case depends upon the relative frequency of the S_3 PDSs without ECCS, as determined by TEMAC4. Based on the mean values of the PDSs in Group 3, the quantification for this case is:

Branch 1: B-Sp - 0.419
Branch 2: BaSp - 0.000
Branch 3: BfSp - 0.581
Branch 4: noB-SW - 0.000

Case 4: This case applies if the RCS is intact at UTAF, if there is an interfacing systems LOCA (Event V), if there is a LOCA without loss of ECCS, or if there is an SGTR initiator without a stuck open secondary SRV. The quantification for each PDS Group depends upon the third PDS characteristic.

Question 7. Status of ac Power?
3 Branches, Type 1

The branches for this question are:

1. B-ACP ac electrical power is available from offsite or from the diesel generators (DGs) throughout the accident.
2. BaACP ac electrical power is not available, but may be recovered.
3. BfACP ac electrical power is not available, and cannot be recovered.

The branch taken depends upon the fourth PDS characteristic.

For internal events, loss of offsite power and failure of the DGs to start (station blackout) leads to the second branch since offsite power may always be restored. Thus, for PDS Groups 1 and 2, all the probability is assigned to the second branch, BaACP. For the remaining PDS Groups 3 through 7, all the probability is assigned to the first branch, B-ACP.

Question 8. Are the RWST Contents Injected into Containment?
3 Branches, Type 2, 2 Cases

The branches for this question are:

1. RWST-I The contents of the RWST have been injected into the containment.
2. RWSTaI The contents of the RWST have not been injected into the containment, but can be if ac power is recovered.
3. RWSTfI The contents of the RWST have not been injected into the containment, and cannot be injected even if power is recovered.

The branch taken depends upon the fifth PDS characteristic and upon the branch taken at Questions 1 and 3.

For the V breaks, the water in the RWST will be injected into the RCS, but it is assumed that most of it will escape through the break and will not end up in the containment. Thus the third branch is taken for Event V. For some SGTRs, while some of the water in the RWST will escape through the tube rupture and thus out of the containment, it is assumed that a good portion of the water in the RWST will pass out of the RCS through the PORVs and thus will be retained in the containment. Further, the water escaping through the PORVs may cause the containment sprays to be initiated, which will also transfer the water from the RWST to the containment. Enough of the water from the RWST is expected to be transferred into the containment sumps that the first branch is taken for SGTRs.

For all of the PDSs with the exception of V and some SGTRs, if the water from the RWST is transferred from the RWST, it will end up in the containment. If it is not injected directly into the containment by the spray injection system, it is injected into the vessel and escapes into the containment through the break, the PORVs or the SRVs.

The branch taken in this question as well as the amount of ice melt is used to determine the level of water in the reactor cavity. At Sequoyah, there is no connection between the cavity and the sumps at the floor (basemat) level in the lower compartment. If, however, enough water accumulates on the floor of the lower compartment (~52,000 ft^3), it will start to spill over into the reactor cavity. This occurs when the RWST contents have been injected to containment and approximately one quarter of the ice has been melted. Neither RWST injection nor total ice melt alone enable water to enter the reactor cavity. Thus, the only way to fill the cavity, capacity of approximately 18,000 ft^3, is for the RWST to be injected to containment. The amount of ice melt and the level of cavity flooding are addressed in Questions 29 and 63.

> Case 1: This case addresses a PDS in which there is an SGTR initiator and the SRVs on the secondary system stick open (PDS HINY-NXY in PDS Group 7). For this case, there is no RWST injection to containment, and all of the probability is assigned to Branch 3, RWSTfI.
>
> Case 2: This case applies for PDS Groups 1 through 6, or for an SGTR initiator without a stuck open secondary SRV in PDS Group 7. The quantification for each PDS Group depends upon the fifth PDS characteristic.

Question 9. Heat Removal from the Steam Generators?
4 Branches, Type 2, 2 Cases

The branches for this question are:

1.	SG-HR	Heat is removed from the secondary side of the SGs throughout the accident.
2.	SGaHR	There was no heat removal from the secondary side of the SGs at the start of the accident, but it may be recovered if electrical power is recovered.

3. SGfHR Heat removal from the secondary side of the SGs was failed at the start of the accident, and it cannot be recovered.

4. SGdHR There is no heat removal from the secondary side of the SGs at the uncovering of the core, but the steam-turbine-driven auxiliary feedwater (STD-AFW) operated until battery depletion. The electric-motor-driven AFW pumps could be started when power is recovered.

The branch taken depends on the sixth PDS characteristic and upon the branch taken at Questions 1 and 3. Whether the operators depressurize the secondary system by blowing down the steam generators is determined in the next question.

In blackout situations, the sole means of heat removal from the SGs is the STD AFW (STD-AFW) pump, which is not dependent on ac power. The "fast" and "slow" blackout cases are distinguished by the second and fourth branches of this question. If the STD-AFW is failed at the start of the accident as in fast blackouts, core melt ensues rapidly, and Branch 2 of this question is chosen. If the STD-AFW operates for several hours, until battery depletion as in slow blackouts, the onset of core degradation will be considerably delayed and Branch 4 of this question is chosen.

For the cases with an S_3 break, the secondary system may be used initially to reduce the pressure in the primary system. This method is effective if the pressure in the secondary system is reduced to nearly atmospheric or to just enough to run the STD-AFW. By this means, the RCS may be brought down to a few hundred psia; the reduced pressure will reduce the flow out the break. However, if there is no water injection to the primary, eventually enough inventory is lost from the RCS so that the presence of steam in the primary side of the steam generators will limit heat removal by this method. The RCS pressure may then increase to a value limited by the S_3 break.

Case 1: This case applies if there was a SGTR when the core uncovered and the SRVs on the secondary system were not stuck open (PDS GLYY-YNY in PDS Group 7 and PDS GLYY-YXY in PDS Group 6). For the "G" category SGTRs in Group 6, all of the probability is assigned to Branch 1, SG-HR. For the "G" category SGTRs in Group 7, all of the probability is assigned to Branch 3, SGfHR.

Case 2: All situations except those for Case 1 are addressed by this case. The quantification for each PDS Group except Groups 6 and 7 depends upon the sixth PDS characteristic. For PDS Groups 6 and 7, all of the probability is assigned to Branch 1, SG-HR.

Question 10. Is the Secondary Depressurized before the Core Uncovers?
2 Branches, Type 2, 3 Cases

The branches for this question are:

1. SecDP The secondary system has been depressurized before the core uncovers.

2. noSecDP The secondary system has not been depressurized before the core uncovers.

The branching at this question depends upon the branch taken at Questions 1 and 9 and upon the sixth letter of the PDS characteristic.

The procedures direct the operators to depressurize the secondary system in many situations as long as AFW is available. In most cases, reducing the pressure in the secondary system will reduce the pressure and temperature of the water in the primary system as well. It would, for example, reduce the flow rate out a break.

Whether the operators will depressurize the secondary system is most important in the long-term blackout scenario in which there are no temperature-induced breaks in the RCS. In this sequence, the STD-AFW system fails after battery depletion. Although the RCS will repressurize to the setpoint level before core degradation commences, blowdown of the secondary before AFW failure determines whether the accumulators discharge before the core uncovers or at vessel breach.

> Case 1: There is an S_3 break in the RCS and STD-AFWS operated until battery depletion. This case applies to slow blackouts (PDS Group 1) with a very small break. In the sampling mode, the quantification of this case depends upon the relative frequencies of the two S_3 PDSs in Group 1 as determined by TEMAC4. Based on the mean values of these PDSs, the quantification for this case is:
>
> Branch 1: SecDP - 0.978
> Branch 2: noSecDP - 0.022
>
> Case 2: There is an S_2 break in the RCS and STD-AFWS operated until battery depletion. This case applies to slow blackouts (PDS Group 1) with a small break, and all of the probability is assigned to Branch 2, noSecDP.
>
> Case 3: All situations except those for Cases 1 and 2 are included in this case. The quantification for each PDS Group depends upon the sixth PDS characteristic. For PDS Group 1, all of the probability is assigned to Branch 1, SecDP.

Question 11. Cooling for RCP seals?
3 Branches, Type 2, 3 Cases

The branches for this question are:

1. B-PSC Cooling water is delivered to the seals of the RCPs throughout the accident.

2. BaPSC Cooling water is not being delivered to the seals of the RCPs when the core uncovers, but cooling can be recovered if power is recovered.

3. BfPSC Cooling for the seals of the RCPs is failed and cannot be recovered.

The branch taken depends upon the seventh letter of the PDS and upon the branch taken at Questions 1 and 4.

Water to cool the RCP seals normally comes from the charging pumps. If these pumps fail and the alternate means of cooling the seals is not activated, or if all electrical power is lost, there is a good probability that the seals will fail, resulting in an S_3-size break in the RCS.

Case 1: There is a large break LOCA with low pressure injection (LPI) available (PDS Group 3). This case is used to single out the A and S_1 PDSs in PDS Group 3 with LPI available so that the status of the RCP seal cooling can be assigned appropriately. In the sampling mode, the quantification of this case depends upon the relative frequencies of the "A" PDSs in Group 3 as determined by TEMAC4. Based on the mean values of these PDSs, the quantification for this case is:

Branch 1: B-PSC - 0.191
Branch 2: BaPSC - 0.000
Branch 3: BfPSC - 0.809

Case 2: There is an ATWS initiating event, with an S_3-size break and failure of the ECCS (PDS Group 6). For this case, all of the probability is assigned to Branch 3, BfPSC.

Case 3: All situations except those for Cases 1 and 2 are included in this case. The quantification for each PDS Group depends upon the seventh PDS characteristic. For PDS Groups 1 and 2, all of the probability is assigned to Branch 2, BaPSC.

Question 12. Initial Containment Leak or Isolation Failure?
2 Branches, Type 1

The branches for this question are:

1. B-Leak The containment leaks at a rate significantly above the design leak rate; the rate is large enough to preclude further failure overpressurization.

2. noB-Leak The containment is intact and leaks at the design leak rate, or at some slightly greater rate which is insufficient to preclude gradual overpressurization failure.

The split between the two branches is sampled from a distribution that was quantified internally in the accident frequency analysis. The first branch includes both isolation failures and pre-existing leaks, equivalent to a hole between 4 in^2 and 1 ft^2 in size. A hole smaller than 4 in^2 is not of interest because it is too small to arrest a slow pressure buildup.

The probability of a pre-existing leak large enough to be of concern is negligible. The main threat is due to isolation failures which are caused by air lock failures, purge valve failures or other similar, undetected failures of the containment boundary. The size of these failures is on the order of 1 ft^2. The failure of these types of events were considered to be 5.0E-3 per demand, as described in the accident frequency analysis. This is discussed in Section 4.11 of NUREG/CR-4550, Volume 5, Part 1.[A.1-2] In the sampling mode, the mean value of the distribution provided by the accident frequency analysts for the quantification of this question is:

Branch 1: B-Leak	-	0.005
Branch 2: noB-Leak	-	0.995

Question 13. **Do the Operators Turn on the Hydrogen Igniters?**
2 Branches, Type 2, 2 Cases

The branches for this question are:

1.	B-Ig	The igniters are actuated by the operators.
2.	BnIg	The igniters are not actuated by the operators.

This question is not sampled; the quantification was done internally in the accident frequency analysis. The branch taken depends upon the branch taken at Question 7.

The hydrogen ignition system at Sequoyah is provided to help preclude large hydrogen burns by burning relatively small quantities of hydrogen as it is generated. Hydrogen igniters are located in the upper plenum of the IC, the dome, and the lower compartment. The igniters depend upon ac power and must be actuated by the operators. If there is no ac power at the time of UTAF, the igniters will not be switched on. For the times in which ac power is operational, the accident frequency analysts assessed the unavailability of the igniters due to failure of the operators to switch them on.[A.1-2] The igniters are energized as a standard procedural step, not in response to a particular set of containment conditions. The operator actions for igniter activation were considered step-by-step under moderate stress.

Case 1: At UTAF, ac power is operational. This question is not sampled; the accident frequency analysts provided a point value estimate for the probability of igniter activation based on human reliability analysis. The quantification for this case is:

Branch 1: B-Ig	-	0.990
Branch 2: BnIg	-	0.010

Case 2: All situations in which ac power is not operational at UTAF. This case applies for PDS Groups 1 and 2 and all of the probability is assigned to Branch 2, BnIg.

Question 14. Status of Air Return Fans?
3 Branches, Type 2, 2 Cases

The branches for this question are:

1. B-Fan The air return fans (ARFs) are operating during core degradation.

2. BaFan Due to unavailability of ac power, the ARFs are not operating during core degradation, but the fans can operate if power is recovered.

3. BfFan The ARFs have failed and cannot operate upon demand.

This question is not sampled; the quantification was done internally in the accident frequency analysis. The branch taken depends upon the branch taken at Question 7.

The ARF system consists of two recirculation fans, each supplied with its own separate duct system and dampers. The operation of the fans ensures that gas, displaced into the upper containment by the blowdown of steam from the primary system, is returned rapidly to the lower containment. The fans provide mixing of the containment atmosphere, thereby reducing the hydrogen concentration in stagnant areas of containment. The fans draw gases from the dome and dead-ended regions of containment and exhaust into the lower compartment. This maintains forced circulation from the lower compartment through the IC to the dome. A signal for high containment pressure (3 psig) actuates the fans after a short delay time. The ARF system is ac-powered, consists of an exhaust damper, an inlet damper, and a fan, and has two redundant trains. The accident frequency analysts assessed the unavailability of the fans, due to system reliability.[A.1-2]

Case 1: At UTAF, ac power is operational. This question is not sampled; the accident frequency analysts provided a point value estimate for the probability of ARF system failure. The quantification for this case is:

Branch 1: B-Fan = 0.999
Branch 2: BaFan = 0.000
Branch 3: BfFan = 0.001

Case 2: All situations in which ac power is not operational at UTAF. This case applies for PDS Groups 1 and 2 and all the probability is assigned as follows:

Branch 1: B-Fan = 0.000
Branch 2: BaFan = 0.999
Branch 3: BfFan = 0.001

Question 15. Event V - Break Location Scrubbed by Sprays?
2 Branches, Type 1

The branches for this question are:

1. V-Wet The break location outside containment is located so that the radioactive releases will be scrubbed by fire sprays in the auxiliary building.

2. V-Dry The break location outside containment is located so that the radioactive releases will not be scrubbed by fire sprays in the auxiliary building.

The split between the two branches is sampled from a distribution that was quantified internally.

For Sequoyah, the low-pressure pumps are located in the auxiliary building, which has area fire sprays. If the break in the interfacing system is such that the fire sprays scrub the releases, the effects of the V sequence can be mitigated. In Draft NUREG-1150,[A.1-3] this question was addressed within the decontamination factor (DF) for the V-sequence scrubbing and was related to Containment Issue 8 for Surry. For Surry, however, the break location has the potential to actually be submerged. The probability that the break location will be subject to scrubbing from fire sprays is reasonably high. The distribution used here is a uniform distribution from 0.60 to 1.00. The mean of this distribution is 0.80. The mean value of the distribution used to determine the branching gives the following quantification:

Branch 1: V-Wet - 0.80
Branch 2: V-Dry - 0.20

Question 16. **RCS Pressure at the Start of Core Degradation?**
4 Branches, Type 2, 4 Cases

The branches for this question are:

1. E-SSPr The vessel is at the system safety setpoint pressure, approximately 2500 psia.

2. E-HiPr The vessel is at high pressure, about 1000 to 1400 psia.

3. E-ImPr The vessel is at intermediate pressure, about 200 to 600 psia.

4. E-LoPr The vessel is at low pressure, below 200 psia.

This question is not sampled. The branch taken at this question depends upon the branches previously taken at Questions 1, 2, and 10.

The pressure in the vessel at the start of core degradation is largely a function of the break size that has occurred, whether an auxiliary feedwater system (AFWS) is operating, and whether the secondary system has been depressurized. Once core melt is well underway, whether the AFW is operating and whether the secondary system is depressurized are less important since a gas bubble will form in the SGs, rendering this means of cooling ineffective. Thus the system may eventually repressurize to a pressure determined solely by the break size. The relationship between break size, AFWS state, and RCS pressure was primarily determined from the results of many STCP runs, although other code results were consulted as well. The high pressure range is meant to cover all pressures between 600 and 2000 psia. The code results indicate that in the majority of accidents with an S_3 or an S_2 break, where the secondary system has not been depressurized, the RCS will be in the 1000 to 1400 psia range at UTAF, but the pressure at UTAF is a function of the accident timing and the exact size of the break.

If the RCS pressure boundary remains intact and the RCS has been depressurized by operation of the AFWS, repressurization of the primary system is required before the onset of core damage. Core degradation will not begin until a substantial portion of the primary system water inventory has been lost. With no break in the RCS, the only way for water to escape is through the PORVs or SRVs, and the system must be fully repressurized to force open the PORVs or SRVs.

Case 1: There was an initiating large break (A or S_1) or Event V occurred. In either case the RCS pressure is low (below 200 psia). The quantification for this case is:

Branch 1: E-SSPr - 0.0
Branch 2: E-HiPr - 0.0
Branch 3: E-ImPr - 0.0
Branch 4: E-LoPr - 1.0

Case 2: There is no break in the RCS at the time the core uncovers, so the only escape path for the water is through the PORVs or the SRVs. Thus the RCS is at the system setpoint pressure (around 2500 psia). The quantification for this case is:

Branch 1: E-SSPr - 1.0
Branch 2: E-HiPr - 0.0
Branch 3: E-ImPr - 0.0
Branch 4: E-LoPr - 0.0

Case 3: The AFW is either operating or has been operating. The secondary system is depressurized and there is either an S_3 or an S_2 break. SGTR is included here since it is S_3 in size. The RCS pressure is intermediate (200 to 600 psia). The quantification for this case is:

Branch 1: E-SSPr - 0.0
Branch 2: E-HiPr - 0.0
Branch 3: E-ImPr - 1.0
Branch 4: E-LoPr - 0.0

Case 4: Whether or not the AFW is or has been operating, the secondary system is not depressurized when the core uncovers and there is an S_2- or S_3-size break. The RCS pressure is high (1000 to 1400 psia). The quantification for this case is:

Branch 1: E-SSPr - 0.0
Branch 2: E-HiPr - 1.0
Branch 3: E-ImPr - 0.0
Branch 4: E-LoPr - 0.0

Question 17. Do the PORVs or SRVs Stick Open?
2 Branches, Type 2, 2 Cases

The branches for this question are:

1. PORV-SO At least one pressurizer PORV or RCS SRV is stuck open, resulting in an S_2-size leak.

2. PORVnSO There are no PORVs or SRVs stuck open.

This question is sampled; the distribution was determined internally. The branch taken at this question depends upon the branch taken at Question 16.

With no breaks in the RCS pressure boundary, the only route by which water can escape from the RCS is through the PORVs or SRVs. If the PORVs cannot be opened from the control room (as in PDS Group 5), they may still function in their relief mode. If they do not open in this mode, the SRVs will open at a slightly higher pressure. After the water level has decreased below the TAF and core degradation has commenced, the PORVs or SRVs will be passing superheated steam and hydrogen at temperatures well in excess of the temperatures for which they were designed. Further, they will open and close many times as they cycle about their setpoint. Thus, the probability that the valves will stick open during the core melt period may be fairly high. If one or more PORVs or SRVs stick open, the break is of S_2 size.

Case 1: The RCS was at system setpoint pressure (about 2500 psia) at the start of core degradation. PORVs and SRVs stick open occasionally in normal service. After core melt begins, they will be operating at temperatures much higher than those they encounter in normal service, so the single-cycle failure to reclose probability is higher than the probability for failure to reclose at normal operating conditions. Further, the valves are expected to cycle many times during core melt. The distribution for the PORVs or SRVs sticking open during core melt was determined internally. Plausible rates of failure for a single cycle were estimated by increasing the normal failure rate to account for degraded performance at above-design temperatures. The number of cycles was estimated from code simulations. The probability estimates for the PORVs or SRVs sticking open during core melt obtained in this manner ranged from 0.1 to 1.0. In the absence of any data on the operation of these valves at the temperatures in question, a uniform distribution from 0.0 to 1.0 was used for this case. Based on the mean value, the quantification for this case is:

Branch 1: PORV-SO - 0.500
Branch 2: PORVnSO - 0.500

Case 2: The RCS was not at system setpoint pressure at the start of core degradation, so the PORVs or SRVs will not be cycling. Thus, they will not stick open. The quantification for this case is:

Branch 1: PORV-SO - 0.0
Branch 2: PORVnSO - 1.0

Question 18. Temperature-Induced RCP Seal Failure?
2 Branches, Type 2, 4 Cases

The branches for this question are:

1. E-PSS3 Due to lack of cooling, the seals of the RCPs fail, resulting in an "S_3"-size leak.

2. noEPSF The seals of the RCPs do not fail.

Cases 2, 3, and 4 of this question are sampled; the sampling is based on the conclusions of a special ASEP expert panel that considered only the question of RCP seal failures. This question is sampled zero-one; that is, all the probability in an observation is placed in only one branch. The branching at this question depends upon the branches previously taken at Questions 11, 16, and 17.

The accident frequency analysis considered the failure of the RCP seals before the onset of core degradation. The accident progression analysis considers the failure of the RCP seals after the onset of core degradation. The accident frequency analysis considered different modes of failure, each of which resulted in a different flow rate. In the APET, only failure or no failure is considered. Selection of the no-failure branch in Cases 2, 3, and 4 is rank correlated with the success state (design leakage only) in TEMAC. All RCP seal failures in this analysis are considered to be S_3 breaks.

Case 1: Either seal cooling was available all along, or it was lost but re-established when power was recovered before the uncovering of the core. In either case, pump seal failures do not occur. The quantification for this case is:

Branch 1: E-PSS3 - 0.0
Branch 2: noEPSF - 1.0

Case 2: There is no break in the RCS, so the RCS will be at the setpoint pressure determined by the PORVs, about 2500 psia. There is no cooling for the RCP seals by Case 1. The expert panel concluded that seal failure was more likely than not. Based on their aggregate results, the mean probability of seal failure (all the leakage levels above design) for this case is 0.71. As this question is sampled zero-one, that means that 71% of the observations have 1.0 for Branch 1 and 0.0 for Branch 2, and 29% of the observations have 0.0 for Branch 1 and 1.0 for Branch 2. More detail on RCP seal failures can be found in NUREG/CR-4550, Volume 5, Appendix D.5[A.1-4] and NUREG/CR-4550, Volume 2,

Appendix C.4.[A.1-5] Based on the the mean value of the sample, the quantification for this case is:

Branch 1: E-PSS3 = 0.710
Branch 2: noEPSF = 0.290

Case 3: The RCS is at high pressure, about 1000 to 1400 psia. The experts considering this matter concluded that the degradation of the RCP seals is largely a matter of temperature and that the seals would degrade at any temperatures considerably in excess of their normal operating temperatures. Thus, the lower temperatures that accompany the lower RCS pressure (compared to Case 2) do not appreciably decrease the probability of seal failure. The mean failure value from Case 2 was reduced slightly to obtain a mean failure value of 0.65. As in Case 2, the sampling is zero-one. Based on the the mean value of the sample, the quantification for this case is:

Branch 1: E-PSS3 = 0.650
Branch 2: noEPSF = 0.350

Case 4: The RCS is at intermediate or low pressure, below 600 psia. The reasoning for this case follows that for the previous case. The mean failure value from Case 3 was reduced slightly to obtain a mean failure value of 0.60. As in Case 2, the sampling is zero-one. Based on the the mean value of the sample, the quantification for this case is.

Branch 1: E-PSS3 = 0.600
Branch 2: noEPSF = 0.400

Question 19. **Is the RCS Depressurized before Breach by Opening the Pressurizer PORVs?**

2 Branches, Type 2, 3 Cases

The branches for this question are:

1. PriDP The operators open the pressurizer PORVs and depressurize the RCS successfully before VB.
2. noPriDP The operators either do not open the pressurizer PORVs or they open the pressurizer PORVs so late that there is not enough time to depressurize the RCS before VB.

This question is not sampled and was quantified internally. The branch taken at this question depends upon the branch previously taken at Questions 4, 5, and 7.

The pressure in the RCS may be reduced directly if the operators reach the point in the procedures where they are directed to open the PORVs on the pressurizer, and if there is sufficient time to blow down the RCS through the PORVs before core melt. If the accumulators have not been discharged before, reducing the RCS pressure will allow the accumulators to discharge at this time. As opening the PORVs is a last resort action, it is not clear that the operators will reach this step before core melt is well advanced, and, even if they do reach this step and open the PORVs, it is not clear that depressurization of the RCS will have been accomplished before VB.

The procedures at Sequoyah direct the operators to open the pressurizer PORVs when the core exit thermocouples reach 1200°F if at least one centrifugal charging pump or safety injection pump is running. For the operation of the pumps, ac power is required; so, deliberate depressurization is not credible in blackout situations. (Standard human reliability analyses do not consider actions that may be beneficial if they are in in contradiction to procedures.) Furthermore, operator depressurization is not allowed here if the operators have already failed to open the PORVs. The reasoning is that if the operators have already failed to follow procedures, they cannot now be given credit for returning to and following those procedures.

As an example, consider PDS TBYY-YNY in PDS Group 5, Transients. All AFW is failed and Bleed and Feed fails because the PORVs cannot be opened. Both LPIS and HPIS are operating but cannot inject because the RCS pressure is too high. The reason this is a core damage situation is that the operators failed to depressurize the RCS before the onset of core damage. Thus, for TBYY-YNY, no deliberate depressurization of the RCS is allowed in this question. For this PDS, however, when the system pressure reaches the SRV setpoint, the SRVs will be available to operate.

Although theoretically a viable means of reducing the pressure in the RCS, deliberate depressurization by the operators has little effect on the accident progression at Sequoyah. Of the five "T" (RCS intact at core uncovering) PDSs, deliberate depressurization is prohibited in two of them because no ac power is available, and deliberate depressurization is not credited in the other three because hardware faults make it impossible to open the PORVs, or because the operators had failed to depressurize (and avoid core damage) before the core was uncovered.

Branch 1 applies in a few cases where the operators had opened the PORVs before the onset of core damage but this is not reflected in the PDS indicator. This is discussed in Question 5.

Case 1: The operators opened the PORVs before the onset of core degradation. As this was part of their attempt to inject water into the vessel, there is no reason to think they will close the PORVs later. The quantification for this case is:

Branch 1: PriDP - 1.0
Branch 2: noPriDP - 0.0

Case 2: There is ac power available, there is at least one pump running, the PORVs are capable of being opened from the control room (there are no hardware PORV faults), and the operators have not previously failed to depressurize the RCS. Opening the PORVs is directed by procedures in these situations, and the operators should follow the procedures with high reliability. The core exit thermocouples should indicate 1200°F well before core slump, and recent code calculations have shown that opening of the PORVs depressurizes the RCS fairly quickly. There are, however, major uncertainties as to when the operators will reach this step in the procedures, and how much time will be available for depressurization before VB. Therefore, the depressurization probability is not unity. The quantification for this case is:

Branch 1: PriDP - 0.900
Branch 2: noPriDP - 0.100

Case 3: Either ac power is not available, or the operators have already failed to depressurize the RCS by opening the PORVs. In the absence of ac power, opening the PORVs is prohibited by procedures at Sequoyah. If the operators are in a core damage situation because they failed to open the PORVs earlier, no credit is given for them opening the PORVs now. The quantification for this case is:

Branch 1: PriDP - 0.0
Branch 2: noPriDP - 1.0

Question 20. **Temperature-Induced SGTR?**
2 Branches, Type 2, 2 Cases

The branches for this question are:

1. E-SGTR One or two SG tubes rupture, resulting in an "S_3"-size leak.

2. noESGTR There is no temperature-induced SGTR.

Case 1 of this question is sampled; the distribution was provided by the In-Vessel Expert Panel (see Volume 2, Part 1, of this report). The branch taken at this question depends upon the branches taken at the preceding four questions.

SGTRs are possible only if the SGs have dried out and very hot gas is circulating into the intake plenum from the vessel. The probability of the temperature-induced rupture of a nondefective tube before the hot leg or surge line fails is quite small. However, defects appear regularly in SG tubes, and there are so many tubes in a pressurized water reactor that there are certain to be some defective tubes at any time except just after an inspection of all the tubes.

Case 1: There is no break in the RCS, so the RCS will be at the setpoint pressure determined by the PORVs, about 2500 psia. Thermal-hydraulic calculations show that the temperatures to be expected in the SG plenum and in the tube ends near the tube sheet can be quite high but that they lag behind the temperatures in the hot leg and the surge line by a significant margin. If all the tubes were free of defects, temperature-induced SGTR would be highly unlikely. Taking defects into account, however, increases the probability of an SGTR. The mean value of the distribution provided by the experts for this case is:

Branch 1: E-SGTR - 0.014
Branch 2: noESGTR - 0.986

Case 2: There is a break of some size in the RCS, so the RCS will not be at the setpoint pressure. Compared to the setpoint pressure case, the reduced pressure reduces the hoop stress on the tubes as well as the temperatures in the RCS. A temperature-induced SGTR was not considered credible by the experts. The quantification for this case is:

Branch 1: E-SGTR - 0.0
Branch 2: noESGTR - 1.0

Question 21. Temperature-Induced Hot Leg or Surge Line Break?

2 Branches, Type 2, 4 Cases

The branches for this question are:

1. E-HLA An "A"-size break occurs in the hot leg or surge line.
2. noE-HLA There is no failure of a hot leg or surge line.

Cases 1 and 2 of this question are sampled; the distributions were provided by the In-Vessel Expert Panel. The branch taken at this question depends upon the branches taken at Questions 1 and 9 and at the previous five questions.

After much of the core is uncovered, the upper portion of the vessel and the piping connected to it will be subjected to temperatures well above the design temperature. The core will be above 2000°F, so temperatures higher than 1000°F are possible in the vicinity of the hot leg nozzles and the surge line. If the RCS remains at high pressure during degradation, the hoop stress on the hot leg and the surge line will be high, and the elevated temperatures will weaken the metal considerably. It is possible that the piping may fail before VB. Both the hot leg and the surge line are large pipes, so that all failures are of "A" size.

Case 1: There is no break in the RCS, and the AFW is not operating; the RCS will be at the setpoint pressure determined by the PORVs, about 2500 psia. Some calculations show that temperatures high enough to cause creep rupture failure may occur in the hot leg and the surge line (the pipe connecting the hot leg to the pressurizer). Although the surge line is farther from the upper plenum than the hot leg, the surge line has thinner walls than the hot leg, so it may fail before the hot leg. For the accident progression, it is immaterial which fails. The mean value of the experts' distribution for this case is:

Branch 1: E-HLA - 0.768
Branch 2: noE-HLA - 0.232

Case 2: There is an S_3 break in the RCS and the AFW is not operating. In these conditions, some code simulations show the RCS reaching pressures over 2000 psia late in the core melt scenario. There is less stress on the hot leg and surge line than in Case 1, and the natural circulation will not be as vigorous as in Case 1, but creep rupture of the piping is still credible. The mean value of the experts' distribution for this case is:

Branch 1: E-HLA - 0.035
Branch 2: noE-HLA - 0.965

Case 3: The only break in the RCS is a temperature-induced SGTR. The pressure will decrease from the PORV setpoint value after the SGTR occurs, but perhaps not very quickly. This situation is similar enough to the situation in Case 2 that the same distribution is deemed applicable. The mean value of the distribution is:

Branch 1: E-HLA - 0.035
Branch 2: noE-HLA - 0.965

Case 4: The RCS pressure is below 2000 psia. A temperature-induced break of the hot leg or surge line was not considered credible by the experts. The quantification for this case is:

Branch 1: E-HLA - 0.0
Branch 2: noE-HLA - 1.0

Question 22. Is ac Power Recovered Early (Between Core Uncovering and VB)?
3 Branches, Type 2, 7 Cases

The branches for this question are:

1. E-ACP ac power is available in this time period.
2. EaACP ac power is not available in this time period, but it may be recovered in the future.
3. EfACP ac power is not available in this time period, and cannot be recovered.

Cases 3 through 7 of this question are sampled; the distributions were obtained from an analysis of offsite power recovery for the Sequoyah plant. The methods used for offsite power recovery are explained in more detail in Volume 1 of this report and in NUREG/CR-5032.[A.1-6] The branching at this question depends upon the branch taken at Questions 1, 7, 9, and 10.

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. The derivation of the time periods used in Cases 3 through 7 is presented in Subsection A.3.

The period of interest for the injection of water into the RCS is from UTAF to VB. The time period begins roughly 30 min before the UTAF and ends before VB. Because the end of the electric power recovery period in the accident frequency analysis is the start of the power recovery period in this analysis, the start of the power recovery period here cannot be determined by UTAF. Instead, it must be the time at which the accident frequency analysis terminated the consideration of power recovery. This is roughly 30 min before UTAF for some PDSs, but is much earlier for other PDSs.

The power recovery periods are based on the condition of the RCS at UTAF. Of course, temperature-induced failures or deliberate depressurization may change the rate of the accident progression, and thus the time between UTAF and VB, during the core degradation. Some of these occurrences may hasten the time to vessel failure (by allowing the RCS inventory to escape more quickly, for example) while others may delay it (by allowing the accumulators to discharge, for example). There are so many combinations of important factors contributing to the condition of the RCS that it was not possible to treat them all. The factors include original RCS conditions, AFWS status, secondary system status, and RCS pressure boundary failure and failure timing during core melt. Even if all of these possibilities could have been considered, the supporting database from which to obtain the required timing information is lacking. Thus, power recovery was considered for only five time periods, based on the RCS condition at uncovering as explained in the discussions of Cases 3 through 7.

Case 1: Power was available at the start of the accident and remains available. The quantification for this case is:

Branch 1: E-ACP = 1.0
Branch 2: EaACP = 0.0
Branch 3: EfACP = 0.0

Case 2: Power was failed at the start of the accident and is not recoverable. The quantification for this case is:

Branch 1: E-ACP = 0.0
Branch 2: EaACP = 0.0
Branch 3: EfACP = 1.0

Case 3: By the preceding two cases, this case and all the following cases have electric power not initially available, but recovery possible. In this case, the AFWS failed at the start of the accident. The only PDS Group that meets this condition is Fast SBO, so this case applies to PDS TRRR-RSR, when the RCS is intact at UTAF. The recovery period for this case is 1.0 to 2.5 h. The mean value for power recovery in this period (0.410) gives the following quantification:

Branch 1: E-ACP = 0.41
Branch 2: EaACP = 0.59
Branch 3: EfACP = 0.00

Case 4: By the preceding case, the AFWS was operating at the start of the accident but failed after 4 h upon battery depletion. This case applies to the S_2RRR-RCR PDS (slow blackout with stuck-open PORVs). With this large a break in the RCS, whether the operators depressurized the secondary system while the the AFW was operating is not very important. The recovery period for this case is 1.0 to 4.5 h. The mean value for power recovery in this period (0.694) gives the following quantification:

Branch 1: E-ACP = 0.694
Branch 2: EaACP = 0.306
Branch 3: EfACP = 0.000

Case 5: In this case, there is an S_3 break and the operators did not depressurize the secondary system while the AFWS was operating, so the PDS to which this case applies is S_3RRR-RCR. The recovery period for this case is 4.0 to 6.0 h. The mean value for power recovery in this period (0.320) gives the following quantification:

Branch 1: E-ACP = 0.320
Branch 2: EaACP = 0.680
Branch 3: EfACP = 0.000

Case 6: In this case, there is an S_3 break and the operators did depressurize the secondary system while the AFWS was operating. This case applies to the S_3RRR-RCR PDS. The recovery period for this case is 4.0 to 10.5 h. The mean value for power recovery in this period (0.721) gives the following quantification:

Branch 1: E-ACP = 0.721
Branch 2: EaACP = 0.279
Branch 3: EfACP = 0.000

Case 7: In this case, the operators depressurized the secondary system while the the AFWS was operating and the RCS was intact at UTAF, so the applicable PDS is TRRR-RDR. The recovery period for this case is 7.0 to 12.5 h. The mean value for power recovery in this period (0.612) gives the following quantification:

Branch 1: E-ACP = 0.612
Branch 2: EaACP = 0.388
Branch 3: EfACP = 0.000

Question 23. After Power Recovery, Is Core Cooling Re-established Promptly?
2 Branches, Type 2, 2 Cases

The branches for this question are:

1. E-RECC Core cooling is re-established promptly by the operators.
2. EnRECC Core cooling is not re-established promptly by the operators.

This question is not sampled; the quantification was done internally. The branching at this question depends upon the branches previously taken at Questions 4, 7, and 22.

When power is recovered after a blackout, reinstating coolant flow to the core will certainly be the operators' first priority. The probability that the systems required would fail upon demand is so low that it can be neglected. The operators are trained in this operation.

> Case 1: Power has been recovered, and restoration of core cooling in a timely manner is very likely. This is based on the fact that restoration of power and recovery of core injection are covered by both procedures and training. However, this will definitely be a high stress situation. The quantification for this case is:
>
> Branch 1: E-RECC - 0.950
> Branch 2: EnRECC - 0.050
>
> Case 2: Power has not been restored or was never lost: the question is irrelevant. The quantification for this case is:
>
> Branch 1: E-RECC - 0.0
> Branch 2: EnRECC - 1.0

Question 24. Rate of Blowdown to Containment?

4 Branches, Type 2, 4 Cases

The branches for this question are:

1. EBD-A The blowdown is equivalent to an "A" break.

2. EBD-S2 The blowdown is equivalent to an "S_2" break

3. EBD-S3 The blowdown is equivalent to an "S_3" break.

4. noEBD There is no blowdown to containment before vessel breach.

This question is not sampled; the blowdown to containment depends directly upon the size and location of the break in the RCS pressure boundary. The branching at this question depends upon the branches taken at Questions 1, 17, 19, and 21.

Note that this question specifically concerns blowdown to containment. If the blowdown is to some location outside containment, as in Event V, then the fourth branch is chosen. There must, of course, be blowdown to somewhere or the core would not become uncovered. Blowdown due to both initiating and induced failures is considered. The blowdown from a cycling PORV is equivalent to the blowdown from an S_3 break. The blowdown from a stuck-open PORV is equivalent to the blowdown from an S_2 break.

Case 1: There is a large break inside containment. The quantification for this case is:

Branch 1: EBD-A = 1.0
Branch 2: EBD-S2 = 0.0
Branch 3: EBD-S3 = 0.0
Branch 4: noEBD = 0.0

Case 2: Event V has occurred. The break is of large size (A-size), but the blowdown is to the auxiliary building. The SGTRs are not included in this case. It was the opinion of the accident frequency analysts that in an accident initiated by an SGTR, the operators would attempt to reduce the pressure in the RCS to reduce the flow out the tube rupture. Thus, some of the RCS inventory will escape through the PORVs into the containment. As the main use of this question is in determining the baseline pressure inside the containment just before VB, SGTRs fit better in Case 4 of this question even though more water may escape through the ruptured tube than through the PORVs. Thus, only for event V is there considered to be no blowdown to the containment. The quantification for this case is:

Branch 1: EBD-A = 0.0
Branch 2: EBD-S2 = 0.0
Branch 3: EBD-S3 = 0.0
Branch 4: noEBD = 1.0

Case 3: There is an S_2 break inside containment. This case includes deliberate opening of the PORVs and also a stuck-open PORV or SRV. The quantification for this case is:

Branch 1: EBD-A = 0.0
Branch 2: EBD-S2 = 1.0
Branch 3: EBD-S3 = 0.0
Branch 4: noEBD = 0.0

Case 4: There is an S_3 break inside containment. This case includes a cycling PORV and SGTRs as explained in the discussion of Case 2 above. The quantification for this case is:

Branch 1: EBD-A = 0.0
Branch 2: EBD-S2 = 0.0
Branch 3: EBD-S3 = 1.0
Branch 4: noEBD = 0.0

Question 25. **Vessel Pressure just before Breach?**
4 Branches, Type 2, 4 Cases

The branches for this question are:

1. I-SSPr The vessel is at the system safety setpoint pressure, approximately 2500 psia.

2. I-HiPr The vessel is at high pressure just before breach. The pressure is certainly above 1000 psia and may be as high as 2000 psia in some cases.

3. I-ImPr The vessel is at intermediate pressure before breach, about 200 to 600 psia.

4. I-LoPr The vessel is at low pressure before breach, about 200 psia or less.

Cases 2 and 3 of this question are sampled zero-one; the distributions for these cases were determined internally. The branch taken at this question depends upon the branches previously taken at Questions 1, 17, 18, 19, 20, and 24.

The pressure rise in the containment due to RCS depressurization at VB is dependent on the pressure in the RCS at the time the vessel fails. The pressure in the vessel just before breach may be considerably higher than during most of the core degradation process. Many descriptions of the core melt process have a significant repressurization occurring shortly before breach when the core slumps into the bottom head and boils off the water remaining there. This pressure decreases at a rate primarily dependent upon the size of the hole(s) in the RCS pressure boundary. Therefore, the RCS pressure at breach may depend strongly upon the time between slump and breach as the length of this period determines where on the decreasing pressure curve the breach occurs. Recent code calculations have shown the pressure spike due to steam generation at core slump may be faster than that calculated by the source term code package (STCP). Thus, there is considerable uncertainty in the RCS pressure at VB for situations with S_3 or S_2 breaks.

Case 1: There was an initiating or induced large break that resulted in blowdown to the containment, or Event V occurred, which resulted in blowdown at a similar rate outside the containment. In either case, the RCS pressure is low (200 psia or less). Cases with both an S_2 break before UTAF and open PORVs also result in low pressure in the RCS at VB. The quantification for this case is:

Branch 1: I-SSPr - 0.0
Branch 2: I-ImPr - 0.0
Branch 3: I-ImPr - 0.0
Branch 4: I-LoPr - 1.0

Case 2: There was an initiating or induced S_2 break. Cases with both an S_2 break and open PORVs were considered in Case 1. With an S_2-size hole in the RCS, the pressure due to the core slump dies away fairly quickly. The RCS pressure at VB could be in the low or intermediate ranges. The internal analysis, similar to the documented analysis for S_3 breaks considered in the next case, indicated that low pressure was much more likely than intermediate pressure at VB. The sampling was zero-one, so each observation had all the probability assigned to one of these two branches. Taking the average over all the observations, the quantification for this case is:

Branch 1: I-SSPr = 0.00
Branch 2: I-HiPr = 0.00
Branch 3: I-ImPr = 0.20
Branch 4: I-LoPr = 0.80

Case 3: There was an initiating or induced S_3 break. The increased pressure due to core slump dies away fairly slowly. The RCS pressure at the time of VB could be in the low, intermediate, or high pressure ranges. The internal analysis, described in Volume 2, Part 6, of this report, indicated that these three pressure ranges were equally likely. The sampling was zero-one, so each observation had all the probability assigned to one of these three branches. Taking the average over all the observations, the quantification for this case is:

Branch 1: I-SSPr = 0.00
Branch 2: I-HiPr = 0.33
Branch 3: I-ImPr = 0.34
Branch 4: I-LoPr = 0.33

Case 4: There was no initiating break, and no induced break has occurred, so the RCS is near the PORV setpoint pressure (2500 psia). The quantification for this case is:

Branch 1: I-SSPr = 1.0
Branch 2: I-HiPr = 0.0
Branch 3: I-ImPr = 0.0
Branch 4: I-LoPr = 0.0

Question 26. **Is Core Damage Arrested? No VB?**
2 Branches, Type 2, 9 Cases

The branches for this question are:

1. noVB The process of core degradation is arrested and a safe stable state is reached with the vessel intact.
2. VB Core degradation continues, resulting in core melt and VB.

Cases 2, 3, and 5 through 9 of this question are sampled from distributions that were determined internally. The branching at this question depends upon the branches previously taken at Questions 1, 3, 20, and 22.

If water flow to the core is restored, is core damage arrested and VB prevented? If injection from the ECCS is recovered before core degradation has progressed too far, there is certainly some chance that a safe stable state can be reached. The restoration of injection eventually terminated the core damage progression at Three Mile Island (TMI). There is also some chance that the addition of water does not arrest the melting of the core and that it proceeds on to VB. While there was no VB at TMI, some analysts have concluded that TMI came very close to vessel failure. Note that the threat to the bottom head, which occurred when about 15 to 20 tons of molten material relocated from the "crucible" in the center of the core to the bottom head, occurred after core cooling had been re-established for some time.

The injection of cold water could cause vessel failure due to pressurized thermal shock. If RCS failure due to PTS occurs, it is likely to occur in the hot leg or near the hot leg. Failure of the bottom head by PTS is negligible. If the RCS does fail by PTS, it is likely to be a failure equivalent to a temperature-induced hot leg or surge line failure, i.e., it will be a large break which depressurizes the RCS rapidly. While this has some negative impacts on the accident progression (e.g., accelerating the rate of water loss from the vessel), it also has some ameliorative effects (e.g., containment failure is less likely at VB if the RCS is at low pressure). In view of the low probability of the large break due to PTS, and the uncertain effects of such a break, PTS was not explicitly considered in this analysis.

The probability of recovering injection of the ECCS in time to arrest core degradation, establish a safe, stable state, and prevent vessel failure was estimated internally based on the probability of getting power back, the TMI-2 accident, and MELCOR analyses to determine the rate of accident progression for Sequoyah. The electric power recovery periods used were those of Question 22. More detail may be found in Subsection A.3 of this volume and in Volume 2, Part 6, of this document. In the analysis done for this question, power recovery was considered in different time periods for each PDS or group of PDSs. The start of the time period must be the end of the power recovery period used in the accident frequency analysis to avoid gaps or overlap.

Case 1: Core cooling has not been restored, either because power was not recovered, or because the ECCS is failed. Continued core degradation and eventual vessel failure is assured. The quantification for this case is:

Branch 1: noVB - 0.0
Branch 2: VB - 1.0

Case 2: At UTAF, there was a large initial break in the RCS, and the LPIS was operating. The large break (A- or S_1-size) will effectively depressurize the RCS, allowing successful LPI. These PDSs are core damage accidents because the FSAR response criteria require the successful operation of other systems to prevent any core damage. For an "A" initiator, the accumulators and the LPIS must function; the "A" PdSs have the accumulators failed. For an "S_1" initiator, both HPIS and LPIS must operate successfully; the "S_1" PDSs have the HPIS failed. With the LPIS functioning successfully throughout the accident, and a break large enough to rapidly depressurize the RCS below the LPIS shutoff head, extensive core damage seems unlikely. However, there were no code simulations to indicate just how much or how little damage could be expected. It was estimated that the probability of this type of accident progressing to vessel failure was small. The distribution for avoiding VB is uniform from 0.8 to 1.0. The quantification for this case, based on the mean of the distribution, is:

Branch 1: noVB - 0.950
Branch 2: VB - 0.050

Case 3: This case is similar to Case 2, except that the RCS depressurization either occurs later in the accident or the depressurization is slower. This case includes the situations where LPIS has been operating since the start of the accident, but the pressure remains at the PORV setpoint until well after UTAF when an RCP seal fails or the PORVs stick open. If the RCS pressure decreases below 200 psia, as determined in Question 25, then LPI is possible. However, as this injection starts later than in Case 2, the probability of avoiding VB is less. Also included in this case are the accidents where both HPIS and LPIS are operating at the start of the accident, but the RCS pressure is too high to allow sufficient injection (e.g., TBYY-YNY). Any failure of the RCS pressure boundary will allow injection, but whether sufficient injection will occur in time to prevent VB depends on the size of the break and the time it occurs. Thus, halting the core damage process is probable, but not as likely as in the previous case. The distribution for avoiding VB is uniform from 0.8 to 1.0. The quantification for this case, based on the mean of the distribution, is:

Branch 1: noVB - 0.900
Branch 2: VB - 0.100

Case 4: The ECCS is not recoverable when offsite electrical power is recovered. This case includes all the situations in which part of the ECCS is operating but the RCS pressure is not low enough for sufficient injection to occur. Case 1 accounted for the situations where power was not recovered or the ECCS is failed, and Cases 2 and 3 accounted for the situations in which part of the ECCS is operating and the pressure is low enough for injection to occur. All the probability is assigned to Branch 4, VB. The quantification for this case is:

Branch 1: noVB - 0.0
Branch 2: VB - 1.0

Case 5: This case, and all the following cases, by Cases 1 and 4, are cases in which the ECCS is recoverable and electric power has been restored. In this case, heat removal from the SGs was not initially operating, so Case 5 applies to TRRR-RSR, PDS Group 2, Fast SBO. The period during which power must be recovered to ensure injection before VB is 1.0 to 2.5 h. For this case, the internal analysis concluded that the probability of getting power back in time to prevent vessel failure was fairly high; the distribution for avoiding VB is the same as for Case 3. The quantification for this case, based on the mean of the distribution, is:

Branch 1: noVB - 0.900
Branch 2: VB - 0.100

Case 6: By the preceding case, this case and the three following cases all apply to accidents in which the AFWS operated for some hours until the batteries depleted. Case 6 applies to S_2RRR-RCR in PDS Group 1, Slow SBO. The PORVs stuck open before UTAF, so the accident goes to UTAF more rapidly than the other cases in which the AFWS operates for several hours. The electric power recovery period is 1.0 to 4.5 h. For this case, the internal analysis concluded that the probability of getting power back before about half the core was molten was reasonably good, and although not as good as for the previous case. The probability distribution for avoiding VB for Case 6 is quadratic from 0.0 to 1.0. The quantification for this case, based on the mean of the distribution, is:

Branch 1: noVB - 0.780
Branch 2: VB - 0.220

Case 7: This case is similar to Case 6 (AFWS operates for several hours after UTAF), but the break is of size S_3 (RCP seal failure) instead of size S_2. For S_3 breaks, whether the secondary system was depressurized while the AFWS was operating is important in determining the timing. In Case 7, the SGs are not depressurized and the applicable PDS is S_3RRR-RCR. The electric power recovery period is 4.0 to 6.0 h. For this case, the internal analysis concluded that the probability of getting power back after it is too late to prevent VB is a little less than that of getting it back in time to prevent VB. The quantification for this case, based on the mean of the distribution, is:

Branch 1: noVB 0.670
Branch 2: VB - 0.330

Case 8: This case is similar to Case 7, except that in Case 8 the SGs are depressurized. The applicable PDS is S_3RRR-RDR. The electric power recovery period is 4 to 10.5 h. The internal analysis concluded that the probability of getting power back before about half the core was molten is quite good. The distribution for Case 3 is used for this case: uniform from 0.8 to 1.0. The quantification for this case, based on the mean of the distribution, is:

Branch 1: noVB - 0.900
Branch 2: VB - 0.100

Case 9: This case has no break in the RCS before UTAF. The electric power recovery period is 7 to 12.5 h. The internal analysis concluded that the probability of getting power back before about half the core was molten is quite good. The distribution for Case 3 is used for this case also; the quantification for this case, based on the mean of the distribution, is:

Branch 1: noVB - 0.900
Branch 2: VB - 0.100

Question 27. Early Sprays?
3 Branches, Type 2, 4 Cases

The branches for this question are:

1. E-Sp The containment sprays are operating.

2. EaSp The containment sprays are available to operate if power is recovered.

3. EfSp The containment sprays are failed and cannot be recovered.

This question is not sampled; the branch taken depends directly upon the branches taken at previous questions, Questions 6 and 22.

If power has been recovered, and the sprays were initially in the "available" state, the sprays will operate in this period. If the blowdown has raised the containment pressure to the spray actuation setpoint (3 psig), the sprays will come on automatically when power is restored. If the sprays are not actuated by existing pressure when power is restored, they will be actuated by a hydrogen burn (if any) or by VB. There is a good chance that the operators will turn on the sprays before VB even if containment pressure is not high since the sprays are the only way to cool the water in the sumps, and this water is or may be used for recirculation cooling of the core. If power is recovered and the sprays operate, the contents of the RWST will be transferred to the containment regardless of ECCS operation.

Case 1: The sprays were operating at or shortly after the start of the accident and they continue to operate. The quantification for this case is:

Branch 1: E-Sp - 1.0
Branch 2: EaSp - 0.0
Branch 3: EfSp - 0.0

Case 2: The sprays were failed at the start of the accident, or the loss of service water eventually failed the sprays. No recovery is possible, so the sprays remain failed. The quantification for this case is:

Branch 1: E-Sp - 0.0
Branch 2: EaSp - 0.0
Branch 3: EfSp - 1.0

Case 3: The sprays were available to operate at the start of the accident, and power has been recovered so the sprays now operate. The quantification for this case is:

Branch 1: E-Sp - 1.0
Branch 2: EaSp - 0.0
Branch 3: EfSp - 0.0

Case 4: The sprays were available to operate at the start of the accident, but power has not been recovered so the sprays remain available to operate in the future when power is recovered. The quantification for this case is:

Branch 1: E-Sp - 0.0
Branch 2: EaSp - 1.0
Branch 3: EfSp - 0.0

Question 28. **Early ARFs?**
3 Branches, Type 2, 4 Cases

The branches for this question are:

1.	E-Fan	The ARFs are operating.
2.	EaFan	The ARFs are available to operate if power is recovered.
3.	EfFan	The ARFs are failed and cannot be recovered.

This question is not sampled; the branch taken depends directly upon the branches taken at Questions 14 and 22.

If power has been recovered, and the ARFs were initially in the "available" state, the fans will operate in this period. If the blowdown has raised the containment pressure to the fan actuation setpoint (3 psig), the fans will come on automatically when power is restored. If the fans are not actuated by existing pressure when power is restored, they will be actuated by a hydrogen burn (if any) or by VB.

Case 1: The fans were operating at or shortly after the start of the accident and they continue to operate. The quantification for this case is:

Branch 1: E-Fan - 1.0
Branch 2: EaFan - 0.0
Branch 3: EfFan - 0.0

Case 2: The fans were failed at the start of the accident, and no recovery is possible, so the fans remain failed. The quantification for this case is:

Branch 1: E-Fan - 0.0
Branch 2: EaFan - 0.0
Branch 3: EfFan - 1.0

Case 3: The fans were available to operate at the start of the accident, and power has been recovered so the fans now operate. The quantification for this case is:

Branch 1: E-Fan - 1.0
Branch 2: EaFan - 0.0
Branch 3: EfFan - 0.0

Case 4: The fans were available to operate at the start of the accident, but power has not been recovered so the fans remain available to operate in the future when power is recovered. The quantification for this case is:

Branch 1: E-Fan - 0.0
Branch 2: EaFan - 1.0
Branch 3: EfFan - 0.0

Question 29. **Has the Ice Melted out of the Ice Condenser before VB?**
3 Branches, Type 2, 10 Cases

The branches for this question are:

1. E-Mlt1 The level of early ice melt is greater than 90% of the original ice inventory.

2. E-Mlt2 The level of early ice melt is 50 to 90% of the original ice inventory.

3. E-Mlt3 The level of early ice melt is less than 50% of the original ice inventory.

This question is not sampled and was quantified internally. The branch taken depends upon the branches taken at Questions 1, 4, 6, 7, 21, 23, and 24.

To accommodate steam pressures generated during accident conditions, a compartment containing borated ice is located between the upper and lower portions of the containment. The ice condenser (IC) compartment is annular, subtending an angle of 300° at the containment center, and is located between the crane wall and the steel containment shell. As steam is blown down from the primary system during an accident, it is driven up through the ice, where it is condensed, thereby limiting the pressure in containment. The condensed water and melted ice then drains back into the lower compartment of the containment. In addition to its pressure suppression capability, the IC also plays an important role in the scrubbing of fission product releases from the vessel. If the ice is melted from the IC, the benefits of the IC will not be realized. It is therefore important to note the level of ice melt before the vessel is breached.

The melted ice and condensed water drain onto the lower compartment floor where it enters the sump region. If there is enough water, it can overflow into the reactor cavity. The amount of water in the cavity depends upon whether or not the RWST was injected into containment (Question 8) and upon the amount of ice melt. The level of cavity flooding at VB is discussed in Question 63.

There are several analyses that have been done for Sequoyah that indicate the amount of ice melt before VB for various sequences. These analyses include IDCOR Task 23.1, BMI-2104, BMI-2139, BMI-2160, MARCH-HECTR calculations, and NUREG/CP-0071.[A.1-7-A.1-12] The analyses indicate that there can be significant ice melt before UTAF in sequences in which the ECCS initially operates in the injection mode and containment sprays are not operating. The larger the break size, the greater the ice melt before VB. For station blackouts in which the RCS is intact (cycling PORV), the loss of water from the RCS is gradual, and although sprays are not operating, the ice melt is minimal; the available analyses indicate less than 50%. There is a single calculation in BMI-2139, however, for a station blackout in which an induced hot leg LOCA occurs (A-size break), that indicates total ice melt before VB.

Case 1: There is no containment heat removal through the service water heat exchangers. If the service water system cannot remove heat from the containment via the spray system, the ice will eventually melt after a substantial period of time. The quantification for this case is:

Branch 1: E-Mlt1 = 1.0
Branch 2: E-Mlt2 = 0.0
Branch 3: E-Mlt3 = 0.0

Case 2: There is no early blowdown to containment; there will be minimal melt of the ice. The quantification for this case is:

Branch 1: E-Mlt1 = 0.0
Branch 2: E-Mlt2 = 0.0
Branch 3: E-Mlt3 1.0

Case 3: There is a large temperature-induced LOCA with a transient initiator. The BMI-2139 calculation for this accident scenario indicates that the ice is melted before VB. Because core degradation is well underway at the time the induced LOCA is presumed to occur, much of the RCS water inventory is lost as steam when the LOCA occurs. This will cause substantial melting of the ice. The BMI-2139 calculation is the only calculation performed for this scenario, however, and there is much uncertainty associated with the timing of the LOCA with respect to VB. Thus, it is uncertain whether all the ice or simply a large portion will be melted; for this case, the quantification is:

Branch 1: E-Mlt1 - 0.50
Branch 2: E-Mlt2 - 0.50
Branch 3: E-Mlt3 - 0.00

Case 4: There is a large break LOCA (A or S_1) initiator, and ECCS injection is recovered after UTAF. A large portion of the sequences that qualify for this case will never attain VB, so the question of ice melt as far as containment loads at VB is immaterial. For IC scrubbing of in-vessel releases, however, the quantification of this case becomes more important. There are no analyses that explicitly address recovered sequences that progress to VB. It is known, however, that there is a large thermal load on the IC due to the blowdown steam. With ac power functioning, there is a good chance that igniters are operating and that hydrogen burns have occurred, increasing the thermal load on the IC. It is believed that the chance of some ice remaining at VB is more likely than little or no ice remaining. The quantification for this case is:

Branch 1: E-Mlt1 - 0.30
Branch 2: E-Mlt2 - 0.70
Branch 3: E-Mlt3 - 0.00

Case 5: The blowdown is typical of an S_3-size break, and either sprays are operating or there is a station blackout. The transient events with cycling PORVs without temperature-induced RCS failures larger than a pump seal LOCA and S_3-size failures of the RCS are included here. The blowdown rate is relatively low. If sprays are operating, or the ARFS is not operating, the thermal load on the IC is reduced. Also for station blackouts, the ECCS has not operated, so there is less loss of coolant from the RCS. There are station blackout pump seal LOCA calculations in the BMI-2139 and the BMI-2160 reports that indicate about 25% ice melt before VB. There are transient event calculations in the IDCOR, BMI-2104, and HECTR reports that indicate between 35% to 50% ice melt before VB. The IDCOR calculation has an induced pump seal LOCA also. There is a BMI-2160 calculation that indicates about 35% ice melt before VB for an accident with a pump seal LOCA in which the ECCS fails in recirculation but sprays are available throughout the accident. There are transient event calculations in which sprays are operating, in the IDCOR and BMI-2104 reports indicate 30% and 50% ice melt, respectively. It is likely that minimal ice melt will occur. The quantification for this case is:

Branch 1: E-Mlt1 - 0.00
Branch 2: E-Mlt2 - 0.05
Branch 3: E-Mlt3 - 0.95

Case 6: The blowdown is typical of an S_3-size break, and sprays are not operating and there is no station blackout. The transient events with cycling PORVs without temperature-induced RCS failures larger than a pump seal LOCA and S_3-size failures of the RCS are included here. The blowdown rate is relatively low. If sprays are not operating, there is greater thermal load on the IC than in Case 5, above. There are pump seal LOCA calculations in which the ECCS and sprays fail in recirculation in the BMI-2139 and the BMI-2160 reports that indicate about 50% ice melt before VB. It is believed that the chance of minimal ice melt before VB is more likely than greater than 50% ice melt, although the chance of the higher level is not insubstantial. The quantification for this case is:

Branch 1: E-Mlt1 = 0.00
Branch 2: E-Mlt2 = 0.30
Branch 3: E-Mlt3 = 0.70

Case 7: The blowdown is typical of an S_2-size break, and either sprays are operating or there is a station blackout. The transient events with stuck-open PORVs without large temperature-induced RCS hot-leg failures are included here. The blowdown rate is quite substantial compared to the S_3-size blowdown rates of Cases 5 and 6, above. If sprays are operating, or the ARFS is not operating, the thermal load on the IC is reduced. Also for station blackouts, the ECCS has not operated, so there is less loss of coolant from the RCS. There are S_2 LOCA calculations in which the ECCS has failed in injection or recirculation but sprays are operating in the IDCOR and HECTR reports that indicate between 50% to 65% ice melt before VB. It is believed that the chance of greater than 50% ice melt before VB is more likely than minimal ice melt, although the chance of the lower level is not insubstantial. The quantification for this case is:

Branch 1: E-Mlt1 = 0.00
Branch 2: E-Mlt2 = 0.80
Branch 3: E-Mlt3 = 0.20

Case 8: The blowdown is typical of an S_2-size break, and sprays are not operating and there is no station blackout. The transient events with stuck-open PORVs without large temperature-induced RCS hot-leg failures are included here. The blowdown rate is quite substantial compared to the S_3-size blowdown rates of Cases 5 and 6, above. If sprays are not operating, there is greater thermal load on the IC than in Case 7, above. There are S_2 LOCA calculations in which the ECCS and sprays fail in recirculation in the IDCOR and BMI-2139 reports that indicate about 60% to 70% ice melt before VB. It is believed that the chance of greater that 50% ice melt before VB is very likely. The quantification for this case is:

Branch 1: E-Mlt1 = 0.01
Branch 2: E-Mlt2 = 0.99
Branch 3: E-Mlt3 = 0.00

Case 9: The blowdown is typical of an A-size or S_1-size break, and either sprays are operating or there is an SBO. The transient events with large temperature-induced RCS hot-leg failures are not included here, but are addressed in Case 3, above. The blowdown rate is very substantial. If sprays are operating, or the ARFS is not operating, the thermal load on the IC is reduced. Also for station blackouts, the ECCS has not operated, so there is less loss of coolant from the RCS. There is an A-size LOCA calculation in which the ECCS has failed in injection but sprays are operating in the IDCOR report that indicates about 65% ice melt before VB. It is believed that the chance of greater than 50% ice melt before VB is very likely. The quantification for this case is:

Branch 1: E-Mlt1 - 0.00
Branch 2: E-Mlt2 - 0.95
Branch 3: E-Mlt3 - 0.05

Case 10: The blowdown is typical of an A-size or S_1-size break, and sprays are not operating and there is no station blackout. The transient events with large temperature-induced RCS hot-leg failures are not included here, but are addressed in Case 3, above. The blowdown rate is very substantial. If sprays are not operating, there is greater thermal load on the IC than in Case 9, above. There is an S_1 LOCA calculation in which the ECCS and sprays fail in recirculation in the HECTR report that indicates about 80% ice melt before VB. It is believed that the chance of greater that 50% ice melt before VB is very likely. The quantification for this case is:

Branch 1: E-Mlt1 - 0.01
Branch 2: E-Mlt2 - 0.99
Branch 3: E-Mlt3 - 0.00

Question 30. Have Bypass Paths Developed in the IC before VB?
3 Branches, Type 2, [illegible] Cases

The branches for this question are:

1. E-IBP1 The IC is essentially totally bypassed, and is ineffective for condensing steam. This will be referred to in subsequent questions as a "Level 1" bypass.

2. E-IBP2 There is some degree of bypass of the ice in the IC. This will be referred to in subsequent questions as a "Level 2" bypass.

3. E-IBP3 The IC is intact, is not bypassed and is totally effective.

This question is not sampled and was quantified internally. The branch taken depends upon the branch taken at Question 29.

Flow of gases through the IC is generally considered to be axisymmetric. However, substantial concentration and density gradients are apt to be present in the IC due to the condensation of steam. In fact, these gradients may lead to asymmetric flow in the IC. This will in turn lead to asymmetric ice melting and the possibility for developing channels through the IC which in effect bypass the ice and defeat the steam condensation function.$^{A.1-12}$ No test data are available for IC performance under conditions other than those experienced during design basis accidents. As the level of ice melt was addressed in the previous question, this question addresses the degree of bypass due to the level of ice melt.

Case 1: There is 90% or more of the original ice inventory melted. The remaining ice will not be uniformly distributed throughout the IC. It is suspected that there will have been asymmetric melting resulting in severe channeling in the IC and a bypass of level 1 severity. There is a slight chance that the bypass will be of level 2 severity. The quantification for this case is:

Branch 1: E-IBP1 - 0.9
Branch 2: E-IBP2 - 0.1
Branch 3: E-IBP3 - 0.0

Case 2: There is 50% to 90% of the original ice inventory melted. It is suspected that the channeling will not be as likely nor as severe as in Case 1. The quantification for this case is:

Branch 1: E-IBP1 - 0.0
Branch 2: E-IBP2 - 0.1
Branch 3: E-IBP3 - 0.9

Case 3: There is less than 50% of the original ice inventory melted. Channeling should be minimal and the remaining ice is very likely to be fully functional. The quantification for this case is:

Branch 1: E-IBP1 - 0.00
Branch 2: E-IBP2 - 0.01
Branch 3: E-IBP3 - 0.99

Question 31. **Are the ARFs Effective Before Hydrogen Ignition?**
2 Branches, Type 2, 3 Cases

The branches for this question are:

1. E-EffFan The ARFs are effective in mixing the containment atmosphere before hydrogen ignition occurs.

2. EnEffFan The ARFs are not effective in mixing the containment atmosphere before hydrogen ignition occurs.

Case 2 of this question is sampled; the distribution for this case was determined internally. The branch taken at this question depends on the branches previously taken at Questions 14 and 22.

This question is implemented to address station blackout sequences in which power is recovered during the period of core degradation. If power is recovered, the ARFs are automatically initiated after a short period of time, when a signal is received indicating the containment pressure is 3 psig or greater. The subject of concern is whether or not the ARFs can mix the containment atmosphere before any hydrogen ignition occurs. If hydrogen ignition occurs before mixing is achieved, there are potentially high concentrations of hydrogen in certain areas of containment, especially in the IC and the upper plenum of the IC. These high concentrations pose the threat of local detonations in those areas.

If the fans are effective during this time regime, the containment atmosphere is assumed to be well-mixed, and the hydrogen released to containment that was generated in-vessel is distributed uniformly throughout containment. If ignition takes place, the hydrogen concentration is calculated on a global basis. If the fans are not effective and ignition takes place, the hydrogen concentration is calculated for the separate compartments of containment.

Case 1: From the start of the accident, ac power is functioning and the fans initially operate. For this case, the fans are effective, and the hydrogen is uniformly distributed throughout containment. The quantification for this case is:

Branch 1: E-EfFan - 1.0
Branch 2: EnEfFan - 0.0

Case 2: During a station blackout, ac power is recovered and the fans are available to operate upon power recovery. For this case, the probability of ignition itself is incorporated into the distribution. In other words, if Branch 2 is taken for this case, ignition is always assumed in Questions 49 through 51. Although the quantification for this case was performed internally, the distributions provided by the Containment Load Expert Panel for probability of ignition in unrecovered blackouts were considered and used as a basis for quantification. For recovered station blackouts, the chance of hydrogen ignition before the ARFs mix the containment atmosphere was considered to be somewhat unlikely, considering the mechanisms for ignition in the IC and upper plenum. The quantification for this case, based on the mean of the distribution is:

Branch 1: E-EfFan - 0.83
Branch 2: EnEfFan - 0.17

Case 3: Station blackouts without ac power recovery during core degradation or times in which the fans have failed upon demand. For this case, the fans will be ineffective in the time period considered, regardless of hydrogen ignition. The quantification for this case is:

Branch 1: E-EfFan - 0.0
Branch 2: EnEfFan - 1.0

Question 32. Is the Bulk of the Blowdown Flow Diverted from the Lower Compartment to the Upper Compartment via the Floor Drains?

2 Branches, Type 2, 2 Cases

The branches for this question are:

1. E-FDiv Flow is diverted through the floor drain.
2. EnFDiv Flow is not diverted through the floor drain.

Case 1 of this question is sampled; the distribution was provided by the Containment Loads Expert Panel (see Volume 2, Part 2, of this report). The branch taken at this question depends upon the branches taken at Questions 1, 8, 23, 27, and 31.

The IC containment is designed such that during an accident, blowdown gases are directed from the lower compartment to the upper compartment through the IC. There is, however, the potential for part of the blowdown gases to be directed to the upper compartment through two drains located in the refueling canal. These drains allow containment spray water and condensate in the upper compartment to drain into the lower compartment recirculation sump area. If the sprays are operating, the refueling canal floor will be flooded, and the water flow through the drains will preclude the diversionary flow of gases from the lower to the upper compartment through these drains. For times in which the RWST has been injected into containment, the water level on the floor of the lower compartment will be above the location of the drain outlets, again precluding the bypass of the IC.

The accident sequences of interest, in which some of the blowdown gases may be diverted through the two drains, are those in which ARFs are not operating, and there is no RWST injection before VB. These sequences are typically station blackout sequences. In most blackout sequences, HECTR and CONTAIN calculations indicate (using MARCH sources), that the nature of the blowdown is such that the relative amount of flow through these drains is negligible. There is a CONTAIN calculation, however, that indicates that for a station blackout sequence with a pump seal LOCA (S_3-size), the blowdown rate is low and a substantial amount of blowdown gases enter the upper compartment through these drains, effectively bypassing the IC. Consideration of the CONTAIN calculation for this sequence was utilized by the expert panel for quantification of Case 1.

> Case 1: There is an S_3-size break in the RCS before UTAF, fans are not operating, and the RWST has not been injected into containment. This case is described above. The expert panel concluded that for this case, the path from the lower compartment to the upper compartment was more likely to be through the IC than through the refueling canal drains. This case was sampled zero-one, so each observation had all the probability assigned to either of these branches. Taking the mean value of the observations in the sample, the quantification for this case is:
>
> Branch 1: E-FDiv - 0.250
> Branch 2: EnFDiv - 0.750
>
> Case 2: Except for the conditions of Case 1, the diversion of flow through the refueling canal floor drains is assumed to be minimal. The quantification for this case is:
>
> Branch 1: E-FDiv - 0.0
> Branch 2: EnFDiv - 1.0

Question 33: **What is the Steam Concentration in the Lower Compartment and the Oxygen Distribution in Containment During Core Degradation?**
3 Branches, Type 4, 7 Cases

The branches for this question are:

1. E-LCIn1 The steam concentration in the lower compartment is greater than 60% (nominally 75%).
2. E-LCIn2 The steam concentration in the lower compartment is between 25% and 60% (nominally 55%).
3. EnLCIn The steam concentration in the lower compartment is less than 25% (nominally 10%).

Four parameters are defined in this question:

P1. LC-O2 The amount of oxygen in the lower compartment, in kg-moles, is assigned to Parameter 1.

P2. IC-O2 The amount of oxygen in the IC and upper plenum of the IC, in kg-moles, is assigned to Parameter 2.

P3. UC-O2 The amount of oxygen in the upper compartment, in kg-moles, is assigned to Parameter 3.

P4. LC-Stm The amount of steam in the lower compartment, in kg-moles, is assigned to Parameter 4.

This question is not sampled; the quantification was performed internally. The branch taken and the parameters assigned at this question depend upon the branches taken at Questions 24, 27, 30, 31, and 32.

The compartmental nature of an IC is an important feature to the accident progression at Sequoyah. The containment is divided into three major compartments: the lower compartment, the IC, and the upper compartment. The upper plenum of the IC, when not addressed as a separate compartment for this analysis, is assumed to be part of the IC compartment. The compartmental nature poses the need to address the partitioning of the gaseous species in containment. The distribution of steam, hydrogen, and oxygen is important for the consideration of locally high concentrations of hydrogen, and local inerting of the atmosphere due to high steam concentrations, or depletion of oxygen.

There have been many studies conducted to explore the flammability limits of hydrogen-air-steam concentrations. The inerting level for nearly stoichiometric mixtures has been shown to range from about 50% to 60% steam concentration.[A.1-13] The value of 60% steam concentration was chosen to represent the highest level of steam inerting for this question. The containment atmosphere is assumed to be an ideal gas for determining the amounts of the constituents in each compartment. The results of various calculations were used to obtain the temperatures and pressures in containment during core degradation. For initialization of the oxygen in containment, the pressure is considered to be 1 atmosphere and the temperature is considered to be 38°C in the upper and lower compartments and 0°C in the IC.

The distribution of oxygen throughout the compartments was addressed in this question. It was determined that the case structure for assigning the steam concentration to the lower compartment would be adequate for assigning the oxygen distribution. Nitrogen is assumed to be distributed throughout the containment compartments in quantities proportionate to the amount oxygen.

Case 1: No early blowdown to containment. For this case, all of the probability is assigned to the branch in which there is essentially minimal steam-inerting, Branch 3. The quantification for this case is:

Branch 1: E-LCIn1 - 0.0
Branch 2: E-LCIn2 - 0.0
Branch 3: EnLCIn - 1.0

For Branches 1 and 2, the assignment of the parameters is irrelevant. For Branch 3, the assignment of the parameters (kg-moles) is:

Parameter 1: LC-O2 - 88.40
Parameter 2: IC-O2 - 46.70
Parameter 3: UC-O2 - 163.00
Parameter 4: LC-Stm - 46.60

Case 2: There is no ice or sprays in containment to condense the steam. With no containment heat removal, the amount of steam in containment is dependent upon the timing of VB with respect to the time of ice melt. There are still passive heat sinks in containment on which steam condenses until the containment atmosphere and structures attain equilibrium. Also, considering the probable time of the ice melt, it is believed that the amount of steam in containment will most likely correspond to the inert level with a nominal value of 50% steam concentration. It is believed that the highest steam level with a nominal value of 75% steam concentration is very unlikely, and that the minimal value of nominally 10% steam concentration is somewhat likely. The pressures corresponding to the nominal levels of 10%, 50%, and 75% steam concentrations are 21, 38, and 85 psia, respectively. The quantification for this case is:

Branch 1: E-LCIn1 - 0.010
Branch 2: E-LCIn2 - 0.740
Branch 3: EnLCIn - 0.250

The oxygen in containment is assumed to be distributed uniformly throughout the containment, adding the volume in the IC from where the ice has melted. For Branch 1, the assignment of the parameters (kg-moles) is:

Parameter 1: LC-O2 - 86.40
Parameter 2: IC-O2 - 50.70

Parameter 3: UC-O2 - 161.00
Parameter 4: LC-Stm - 1192.50

For Branch 2, the assignment of the parameters (kg-moles) is:

Parameter 1: LC-O2 - 86.40
Parameter 2: IC-O2 - 50.70
Parameter 3: UC-O2 - 161.00
Parameter 4: LC-Stm - 397.50

For Branch 3, the assignment of the parameters (kg-moles) is:

Parameter 1: LC-O2 - 86.40
Parameter 2: IC-O2 - 50.70
Parameter 3: UC-O2 - 161.00
Parameter 4: LC-Stm - 44.20

Case 3: The blowdown is typical of an A-size break, the fans are operating, and the ice is functional, or the sprays are operating. There is available from a MARCH-HECTR analysis,[A.1-11] compartmental gaseous concentration information for an S_1 LOCA calculation in which the ECCS and sprays fail in recirculation. The initial phase of blowdown creates a significant amount of steam (~0.5 mole fraction) in the lower compartment, even when fans have been initiated. The steam concentration decreases (to less than 0.2 mole fraction) until core slump when it again becomes significant, and then decreases until the time of VB. The APET considers only one time period during core degradation. For most of the times when the fans are operating, the igniters will also be operating. Ignition of hydrogen will occur for levels of steam concentration less than 60%, only the burn completeness and amount of oxygen present in the lower compartment will be sensitive to what that level is. The quantification for this case is:

Branch 1: E-LCIn1 - 0.00
Branch 2: E-LCIn2 - 0.400
Branch 3: EnLCIn - 0.600

For Branch 1, the assignment of the parameters is irrelevant. For Branch 2, the assignment of the parameters (kg-moles) is:

Parameter 1: LC-O2 - 51.20
Parameter 2: IC-O2 - 54.50
Parameter 3: UC-O2 - 190.40
Parameter 4: LC-Stm - 232.80

For Branch 3, the assignment of the parameters (kg-moles) is:

Parameter 1: LC-O2 - 88.40
Parameter 2: IC-O2 - 46.70
Parameter 3: UC-O2 - 163.00
Parameter 4: LC-Stm - 46.60

Case 4: The blowdown is typical of an S_2-size break, the fans are operating, and the ice is functional, or the sprays are operating. The MARCH-HECTR analysis provides information for an S_2 LOCA calculation in which the ECCS has failed in injection but sprays are operating. The initial phase of blowdown creates a significant amount of steam (~0.5 mole fraction) in the lower compartment, even when fans have been initiated. The steam concentration decreases (to about 0.2 mole fraction) until core slump when it again becomes significant, and then the vessel is breached. The quantification for this case is:

Branch 1: E-LCIn1 - 0.00
Branch 2: E-LCIn2 - 0.70
Branch 3: EnLCIn - 0.30

For Branch 1, the assignment of the parameters is irrelevant. For Branch 2, the assignment of the parameters (kg-moles) is:

Parameter 1: LC-O2 - 51.20
Parameter 2: IC-O2 - 54.50
Parameter 3: UC-O2 - 190.40
Parameter 4: LC-Stm - 232.80

For Branch 3, the assignment of the parameters (kg-moles) is:

Parameter 1: LC-O2 - 88.40
Parameter 2: IC-O2 - 46.70
Parameter 3: UC-O2 - 163.00
Parameter 4: LC-Stm - 46.60

Case 5: The blowdown is typical of an S_3-size break, the fans are operating, and the ice is functional, or the sprays are operating. The transient events with cycling PORVs without temperature-induced RCS failures larger than a pump seal LOCA and S_3-size failures of the RCS are included here. The MARCH-HECTR analysis provides information for a degraded-core transient initiated event (TMLU) in which sprays and fans are operating. The initial phase of blowdown creates a significant amount of steam (> 0.5 mole fraction) in the LC, even when fans have been initiated. The steam concentration decreases somewhat and maintains a level of about 0.45 mole fraction. The quantification for this case is:

Branch 1: E-LCIn1 - 0.05
Branch 2: E-LCIn2 - 0.95
Branch 3: EnLCIn - 0.00

For Branch 1, the assignment of the parameters (kg-moles) is:

Parameter 1: LC-O2 - 23.30
Parameter 2: IC-O2 - 61.20
Parameter 3: UC-O2 - 213.60
Parameter 4: LC-Stm - 349.10

For Branch 2, the assignment of the parameters (kg-moles) is:

Parameter 1: LC-O2 = 51.20
Parameter 2: IC-O2 = 54.50
Parameter 3: UC-O2 = 190.40
Parameter 4: LC-Stm = 232.80

For Branch 3, the assignment of the parameters is irrelevant.

Case 6: There is diversion of flow from the lower to the upper compartment by way of the floor drains in the refueling canal. This only occurs sometimes for S_3-size breaks (pump seal LOCAs) when the fans and sprays are not operating, as discussed in Question 32. The CONTAIN calculation performed for a station blackout sequence with a pump seal LOCA indicates a steam mole fraction of 0.80 in the lower compartment, with a containment pressure of 40 psia. The uncertainty associated with this case involves the amount of steam that enters the upper compartment by way of the floor drains. It is believed that the steam level with a nominal value of 75% steam concentration is more likely than the steam level with a nominal value of 50% steam concentration. The pressure in containment associated with the 75% level is 35 psia and with the 50% level is 30 psia. The quantification for this case is:

Branch 1: E-LCIn1 = 0.80
Branch 2: E-LCIn2 = 0.20
Branch 3: EnLCIn = 0.00

For Branch 1, the assignment of the parameters (kg-moles) is:

Parameter 1: LC-O2 = 41.00
Parameter 2: IC-O2 = 97.40
Parameter 3: UC-O2 = 159.70
Parameter 4: LC-Stm = 506.20

For Branch 2, the assignment of the parameters (kg-moles) is:

Parameter 1: LC-O2 = 77.30
Parameter 2: IC-O2 = 83.70
Parameter 3: UC-O2 = 137.10
Parameter 4: LC-Stm = 291.00

For Branch 3, the assignment of the parameters is irrelevant.

Case 7: The ARFs are not operating, and the ice is intact and/or the sprays are operating. The MARCH-HECTR calculations for a station blackout sequence (TMLB') and a S_2 LOCA in which fans are not operating, indicate levels of steam in the lower compartment at concentrations well above 60%. For this case, the lower compartment is believed to be at the highest level of steam-inerting. The quantification for this case is:

Branch 1:	E-LCInl	- 1.00
Branch 2:	E-LCIn2	- 0.00
Branch 3:	EnLCIn	- 0.00

For Branch 1, the assignment of the parameters (kg-moles) is:

Parameter 1:	LC-O2	- 23.30
Parameter 2:	IC-O2	- 61.20
Parameter 3:	UC-O2	- 213.60
Parameter 4:	LC-Stm	- 349.10

For Branches 2 and 3, the assignment of the parameters is irrelevant.

Question 34: What is the Steam Concentration in the IC During Core Degradation?
3 Branches, Type 4, 6 Cases

The branches for this question are:

1. E-ICInl The steam concentration in the IC is greater than 60% (nominally 75%).

2. E-ICIn2 The steam concentration in the IC is between 25% and 60% (nominally 55%).

3. EnICIn The steam concentration in the IC is less than 25% (nominally 10%).

One parameter is defined in this question:

P5. IC-Stm The amount of steam in the IC, in kg-moles, is assigned to Parameter 5.

This question is not sampled; the quantification was performed internally. The branch taken and the parameter assigned at this question depend upon the branches taken at Questions 24, 27, 30, 32, and 33.

For this question, the IC refers to the volumes of both the IC and upper plenum of the IC. In general, if the IC is intact, the steam concentration in the IC is minimal. The amount of the steam, however, is dependent upon the pressure in containment. The case structure and quantification for this question is related to that for Question 33.

Case 1: No early blowdown to containment. For this case, all of the probability is assigned to the branch in which there is essentially minimal steam-inerting, Branch 3. This case is directly related to Case 1 in Question 33. The quantification for this case is:

Branch 1:	E-ICInl	- 0.0
Branch 2:	E-ICIn2	- 0.0
Branch 3:	EnICIn	- 1.0

For Branches 1 and 2, the assignment of the parameter is irrelevant. For Branch 3, the assignment of the parameter (kg-moles) is:

Parameter 5: IC-Stm - 25.0

Case 2: There is no ice or sprays in containment to condense the steam, and the lower compartment has a nominal steam concentration of 75%. This case is directly related to Branch 1 of Case 2 in Question 33. The pressure in containment is 85 psia. The quantification for this case is:

Branch 1: E-ICIn1 - 1.0
Branch 2: E-ICIn2 - 0.0
Branch 3: EnICIn - 0.0

For Branch 1, the assignment of the parameter (kg-moles) is:

Parameter 5: IC-Stm - 724.0

For Branches 2 and 3, the assignment of the parameter is irrelevant.

Case 3: There is no ice or sprays in containment to condense the steam, and the lower compartment has a nominal steam concentration of 55%. This case is directly related to Branch 2 of Case 2 in Question 33. The pressure in containment is 38 psia. The quantification for this case is:

Branch 1: E-ICIn1 - 0.0
Branch 2: E-ICIn2 - 1.0
Branch 3: EnICIn - 0.0

For Branch 1, the assignment of the parameter is irrelevant. For Branch 2, the assignment of the parameter (kg-moles) is:

Parameter 5: IC-Stm - 240.50

For Branch 3, the assignment of the parameter is irrelevant.

Case 4: There is diversion of flow from the lower to the upper compartment by way of the floor drains in the refueling canal, and the lower compartment has a nominal steam concentration of 75%. This case is directly related to Branch 1 of Case 6 in Question 33. The pressure in containment is 35 psia. For this case, both the IC and the upper plenum are considered to have minimal amounts of steam, although the steam concentration in the upper compartment is high. It is believed that the communication between the upper plenum and the upper compartment will be low because the upper deck doors will not have been thrown open, as they normally are when the bulk of the flow from the lower to the upper compartment is through the IC. The quantification for this case is:

Branch 1: E-ICIn1 - 0.0
Branch 2: E-ICIn2 - 0.0
Branch 3: EnICIn - 1.0

For Branches 1 and 2, the assignment of the parameter is irrelevant. For Branch 3, the assignment of the parameter (kg-moles) is:

Parameter 5: IC-Stm - 51.10

Case 5: There is diversion of flow from the lower to the upper compartment by way of the floor drains in the refueling canal, and the lower compartment has a nominal steam concentration of 50%. This case is directly related to Branch 2 of Case 6 in Question 33. The pressure in containment is 30 psia. For this case, both the IC and the upper plenum are considered to have minimal amounts of steam, although the steam concentration in the upper compartment is high. It is believed that the communication between the upper plenum and the upper compartment will be low because the upper deck doors will not have been thrown open, as they normally are when the bulk of the flow from the lower to the upper compartment is through the IC. The quantification for this case is:

Branch 1: E-ICIn1 - 0.0
Branch 2: E-ICIn2 - 0.0
Branch 3: EnICIn - 1.0

For Branches 1 and 2, the assignment of the parameter is irrelevant. For Branch 3, the assignment of the parameter (kg-moles) is:

Parameter 5: IC-Stm - 43.80

Case 6: Containment heat removal is available through the sprays or the IC, or if containment heat removal is not available, the lower compartment has minimal steam concentration. For this case, both the IC and upper plenum have minimal steam concentrations. The quantification for this case is:

Branch 1: E-ICIn1 - 0.0
Branch 2: E-ICIn2 - 0.0
Branch 3: EnICIn - 1.0

For Branches 1 and 2, the assignment of the parameter is irrelevant. For Branch 3, the assignment of the parameter (kg-moles) is:

Parameter 5: IC-Stm - 25.0

Question 35: **What is the Steam Concentration in the Upper Compartment During Core Degradation?**
3 Branches, Type 4, 6 Cases

The branches for this question are:

1. E-UCIn1 The steam concentration in the upper compartment is greater than 60% (nominally 75%).

2. E-UCIn2 The steam concentration in the upper compartment is between 25% and 60% (nominally 55%).

3. EnUCIn The steam concentration in the upper compartment is less than 25% (nominally 10%).

One parameter is defined in this question:

P6: UC-Stm The amount of steam in the upper compartment, in kg-moles, is assigned to Parameter 6.

This question is not sampled; the quantification was performed internally. The branch taken and the parameter assigned at this question depend upon the branches taken at Questions 24, 27, 30, 32, and 33.

In general, if the IC is intact, the steam concentration in the upper compartment is minimal. The amount of the steam, however, is dependent upon the pressure in containment. The case structure and quantification for this question is related to that for Question 33.

Case 1: No early blowdown to containment. For this case, all of the probability is assigned to the branch in which there is essentially minimal steam-inerting, Branch 3. This case is directly related to Case 1 in Question 33. The quantification for this case is:

Branch 1: E-UCIn1 - 0.0
Branch 2: E-UCIn2 - 0.0
Branch 3: EnUCIn - 1.0

For Branches 1 and 2, the assignment of the parameter is irrelevant. For Branch 3, the assignment of the parameter (kg-moles) is:

Parameter 6: UC-Stm - 85.80

Case 2: There is no ice or sprays in containment to condense the steam, and the lower compartment has a nominal steam concentration of 75%. This case is directly related to Branch 1 of Case 2 in Question 33. The pressure in containment is 85 psia. The quantification for this case is:

Branch 1: E-UCIn1 - 1.0
Branch 2: E-UCIn2 - 0.0
Branch 3: EnUCIn - 0.0

For Branch 1, the assignment of the parameter (kg-moles) is:

Parameter 6: UC-Stm = 2342.50

For Branches 2 and 3, the assignment of the parameter is irrelevant.

Case 3: There is no ice or sprays in containment to condense the steam, and the lower compartment has a nominal steam concentration of 55%. This case is directly related to Branch 2 of Case 2 in Question 33. The pressure in containment is 38 psia. The quantification for this case is:

Branch 1: E-UCIn1 = 0.0
Branch 2: E-UCIn2 = 1.0
Branch 3: EnUCIn = 0.0

For Branch 1, the assignment of the parameter is irrelevant. For Branch 2, the assignment of the parameter (kg-moles) is:

Parameter 6: UC-Stm = 780.80

For Branch 3, the assignment of the parameter is irrelevant.

Case 4: There is diversion of flow from the lower to the upper compartment by way of the floor drains in the refueling canal, and the lower compartment has a nominal steam concentration of 75%. This case is directly related to Branch 1 of Case 6 in Question 33, and is discussed in detail above. The pressure in containment is 35 psia. The CONTAIN calculation performed for this sequence indicates a steam mole fraction of 0.46 in the upper compartment, with 741 kg-moles of steam, and a containment pressure of 40 psia. The quantification for this case is:

Branch 1: E-UCIn1 = 0.0
Branch 2: E-UCIn2 = 1.0
Branch 3: EnUCIn = 0.0

For Branch 1, the assignment of the parameter is irrelevant. For Branch 2, the assignment of the parameter (kg-moles) is:

Parameter 6: UC-Stm = 722.70

For Branch 3, the assignment of the parameter is irrelevant.

Case 5: There is diversion of flow from the lower to the upper compartment by way of the floor drains in the refueling canal, and the lower compartment has a nominal steam concentration of 50%. This case is directly related to Branch 2 of Case 6 in Question 33. The pressure in containment is 30 psia. The quantification for this case is:

Branch 1: E-UCIn1 = 0.0
Branch 2: E-UCIn2 = 1.0
Branch 3: EnUCIn = 0.0

For Branch 1, the assignment of the parameter is irrelevant. For Branch 2, the assignment of the parameter (kg-moles) is:

Parameter 6: UC-Stm - 619.50

For Branch 3, the assignment of the parameter is irrelevant.

Case 6: CHR is available through the sprays or the IC, or if CHR is not available, the lower compartment has minimal steam concentration. For this cass, the upper compartment has minimal steam concentrations. The quantification for this case is:

Branch 1: E-UCIn1 - 0.0
Branch 2: E-UCIn2 - 0.0
Branch 3: EnUCIn - 1.0

For Branches 1 and 2, the assignment of the parameter is irrelevant. For Branch 3, the assignment of the parameter (kg-moles) is:

Parameter 6: UC-Stm - 85.80

Question 36. **Early Baseline Pressure?**
1 Branch, Type 4, 8 Cases

The single branch for this question is always taken. The branch is:

1. E-PBase The baseline pressure in containment during core degradation.

One parameter is defined in this question:

P7. E-PBase The baseline pressure in containment during core degradation, in kPa, is assigned to Parameter 7.

This question is not sampled; the baseline pressure before VB is a direct function of the amount of steam in the containment. The available codes are in reasonable agreement about the value of the pressure in the containment before VB. The cases for this question depend upon the branches taken at Questions 12, 24, 27, 30, 31, 32, and 33.

Case 1: If there is no blowdown to the containment or if there is failure to isolate the containment, the containment is near normal operating pressure. The assignment of the parameter (kPa) is:

Parameter 7: E-PBase - 103.40

Case 2: There is no containment heat removal and the steam concentration in containment is nominally 75%. The assignment of the parameter (kPa) is:

Parameter 7: E-PBase - 586.10

Case 3: There is no containment heat removal and the steam concentration in containment is nominally 50%. The assignment of the parameter (kPa) is:

Parameter 7: E-PBase - 262.0

Case 4: There is no containment heat removal and the steam concentration in containment is nominally 10%. The assignment of the parameter (kPa) is:

Parameter 7: E-PBase - 144.80

Case 5: Containment heat removal is available and the fans are operating. The assignment of the parameter (kPa) is:

Parameter 7: E-PBase - 144.80

Case 6: There is diversion of flow from the lower to the upper compartment by way of the floor drains in the refueling canal, and the lower compartment has a nominal steam concentration of 75%. The assignment of the parameter (kPa) is:

Parameter 7: E-PBase - 241.30

Case 7: There is diversion of flow from the lower to the upper compartment by way of the floor drains in the refueling canal, and the lower compartment has a nominal steam concentration of 50%. The assignment of the parameter (kPa) is:

Parameter 7: E-PBase - 206.80

Case 8: Containment heat removal is available, but fans are not operating. The assignment of the parameter (kPa) is:

Parameter 7: E-PBase - 144.80

Question 37. **Time of Accumulator Discharge?**
3 Branches, Type 2, 3 Cases

The branches for this question are:

1. E1-Acc The accumulators discharge before core degradation starts.
2. E2-Acc The accumulators discharge during core degradation.
3. I-Acc The accumulators discharge at VB.

This question is not sampled; the time of accumulator discharge may be reliably deduced from the values of the RCS pressure at UTAF and just before VB. The branch taken at this question depends upon the branches previously taken at Questions 9, 10, 16, and 25.

The accumulators discharge at 600 psig. Whether they have discharged by the onset of core degradation or before VB is strictly a function of the pressure history of the RCS. Generally, any small (S_2) or large (A) break will depressurize the RCS enough that accumulator discharge before the onset of degradation is assured. If the AFWS is available and the operators depressurize the secondary system, the RCS pressure should become low enough to result in accumulator discharge even if there is no break or a very small (S_3) break.

Whether the operators will reduce the pressure in the primary system by blowing down the secondary system is particularly important in the long-term blackout scenario if there are no temperature-induced breaks in the RCS. In this sequence, the STD AFWS fails after battery depletion and the RCS repressurizes to the setpoint level before core degradation commences. Blowdown of the secondary before the AFWS failure determines whether the accumulators discharge before core degradation commences, or when the lower head of the vessel fails.

Case 1: The RCS pressure was intermediate or low at the onset of core degradation, or the secondary was depressurized while the AFWS was operating. Accumulator discharge takes place before the core has started to degrade. The quantification for this case is:

Branch 1: E1-Acc - 1.0
Branch 2: E2-Acc - 0.0
Branch 3: I-Acc - 0.0

Case 2: The RCS pressure was intermediate or low just before VB. By Case 1 the pressure was not in this range at the start of core melt. Thus accumulator discharge takes place during core degradation. The quantification for this case is:

Branch 1: E1-Acc - 0.0
Branch 2: E2-Acc - 1.0
Branch 3: I-Acc - 0.0

Case 3: If the accumulators did not discharge before or during core degradation, they must discharge at VB. The quantification for this case is:

Branch 1: E1-Acc - 0.0
Branch 2: E2-Acc - 0.0
Branch 3: I-Acc - 1.0

Question 38. Amount of Hydrogen Release In-Vessel During Core Degradation?
1 Branch, Type 4, 7 Cases

The single branch for this question is always taken. The branch is:

1. E-H2InV The amount of hydrogen generated in-vessel before VB.

One parameter is defined in this question:

P8. E-H2InV The amount of hydrogen generated in-vessel before VB in kg-moles, is assigned to Parameter 8.

All cases of this question are sampled. The distributions for parameter 8 were provided by the In-Vessel Expert Panel. The conclusions of the experts and their aggregate distributions are presented in Volume 2, Part 1, of this report. The applicable case for this question depends upon the branches taken at Questions 16 and 37.

During core degradation, the presence of unoxidized metal in the very hot steam atmosphere leads to a metal-water reaction that produces hydrogen. Zirconium is the primary metal oxidized, but some oxidation of steel and stainless steel may occur as well. The amount of metal oxidized depends upon the temperatures present and the availability of steam. Sometimes a blockage is expected to form in the lower portion, severely limiting the steam available for oxidation in much of the core volume. At other times, it is expected that no blockage forms, that the blockage is ineffective in limiting steam availability, or that the zirconium is effectively oxidized in other locations before or after the blockage limits steam flow. Oxidation of the entire inventory of zirconium in the Sequoyah core would result in production of 507 kg-moles of hydrogen.

Case 1: The RCS is at system setpoint pressure and the accumulators discharge before or after core melt. This is Case 1A/1C of in-vessel Issue 5. The assignment of the parameter (kg-moles) based on the mean value of the aggregate distribution is:

Parameter 8: E-H2InV - 222.80

Case 2: The RCS is at system setpoint pressure and the accumulators discharge during core melt. This is Case 1B of In-Vessel Issue 5. The assignment of the parameter (kg-moles) based on the mean value of the aggregate distribution is:

Parameter 8: E-H2InV - 255.50

Case 3: The RCS is at high pressure and the accumulators discharge before or after core melt. This is Case 2A/2C/5 of In-Vessel Issue 5. The assignment of the parameter (kg-moles) based on the mean value of the aggregate distribution is:

Parameter 8: E-H2InV - 164.0

Case 4: The RCS is at high pressure and the accumulators discharge during core melt. This is Case 2B of In-Vessel Issue 5. The assignment of the parameter (kg-moles) based on the mean value of the aggregate distribution is:

Parameter 8: E-H2InV - 192.30

Case 5: The RCS is at intermediate pressure and the accumulators discharge before or after core melt. This is Case 3A of In-Vessel Issue 5. The assignment of the parameter (kg-moles) based on the mean value of the aggregate distribution is:

Parameter 8: E-H2InV - 243.50

Case 6: The RCS is at intermediate pressure and the accumulators discharge during core melt. This is Case 3B of In-Vessel Issue 5. The assignment of the parameter (kg-moles) based on the mean value of the aggregate distribution is:

Parameter 8: E-H2InV - 263.90

Case 7: The RCS is at low pressure. This is Case 4 of In-Vessel Issue 5. The assignment of the parameter (kg-moles) based on the mean value of the aggregate distribution is:

Parameter 8: E-H2InV - 228.20

Question 39. **Amount of Zirconium Oxidized In-Vessel During Core Degradation?**
2 Branches, Type 5

The branches for this question are:

1. Hi-ZrOx More than 40% of the zirconium in the core is oxidized in-vessel prior to VB.
2. Lo-ZrOx Less than 40% of the zirconium in the core is oxidized in-vessel prior to VB.

This question is not sampled; the branch taken depends directly upon the value of the parameter defined in the previous question.

This question concerns the amount of zirconium oxidized during core melt. Because steel may be oxidized also, it is theoretically possible to have over 100% equivalent zirconium oxidation. The fraction of zirconium oxidized in-vessel is related to the amount of hydrogen produced and is divided into two categories. This information is needed for the source term analysis by the SEQSOR code.

Question 40. **Fraction of In-Vessel Hydrogen Released from the RCS During Core Degradation?**
1 Branch, Type 4, 4 Cases

The single branch for this question is always taken. The branch is:

1. E-H2exV The fraction of hydrogen generated in-vessel that is released from the RCS to containment during core degradation.

One parameter is defined in this question:

P9. E-H2exV The fraction of in-vessel hydrogen released from the RCS is assigned to Parameter 9.

All cases of this question are sampled. The distributions for Parameter 9 were provided by the Containment Loads Expert Panel. The conclusions of the experts and their aggregate distributions are presented in Volume 2, Part 2, of this report. The applicable case for this question depends upon the branches taken at Questions 1, 20, and 24.

At Sequoyah, hydrogen is a threat to the containment during the time of core degradation. The amount of hydrogen generated in-vessel during core degradation is established in Question 38. It is necessary to establish what fraction of the in-vessel hydrogen is then released to containment. There may be areas of the RCS in which hydrogen accumulates and is not released until VB. One area in which hydrogen is believed to accumulate is in the SGs. For sequences in which the RCS is at higher pressures during core degradation, there is less hydrogen released to containment than for those sequences in which the RCS is at lower pressures. The expert panel cited calculations in which the release of hydrogen from the RCS before VB was available.

Case 1: There was a transient initiator with the RCS intact at UTAF. There is quite a bit of hydrogen retention within the RCS for this case because the PORVs are cycling and the system is at high pressure. The assignment of the parameter based on the mean value of the aggregate distribution is:

Parameter 9: E-H2exV - 0.64

Case 2: There was an initial or induced SGTR, or there is blowdown to containment during core degradation that is typical of an S_3-size break. For the SGTRs, the hydrogen will be released outside of containment; this is addressed in Question 42. The assignment of the parameter based on the mean value of the aggregate distribution is:

Parameter 9: E-H2exV - 0.66

Case 3: The rate of blowdown of RCS inventory is typical of an S_2-size break. The assignment of the parameter based on the mean value of the aggregate distribution is:

Parameter 9: E-H2exV - 0.70

Case 4: The rate of blowdown to containment is typical of a large break, or the initiator was an interfacing systems LOCA (Event V). If Event V occurs, the hydrogen is released outside of containment; this is addressed in Question 42. The assignment of the parameter based on the mean value of the aggregate distribution is:

Parameter 9: E-H2exV - 0.85

Question 41. **To What Degree is the Hydrogen Mixed In the Upper Compartment?**
5 Branches, Type 2, 3 Cases

The branches for this question are:

1. W1Mxd	The ARFs are operating, and the hydrogen is uniformly distributed throughout the containment.
2. Mxd1	The ARFs are not operating, and bulk flow exists from the lower to the upper compartment by way of the refueling canal floor drains.
3. Mxd2	The ARFs are not operating, but the upper plenum and upper compartment atmospheres are well-mixed, and a "clear path" exists from the lower to the upper compartment through the IC.
4. Mxd3	The ARFs are not operating, but the upper plenum and upper compartment atmospheres are well-mixed, and no "clear path" exists from the lower to the upper compartment through the IC.
5. UnMxd	The ARFs are not operating, there is no mixing of the upper plenum and upper compartment atmospheres, and no "clear path" exists from the lower to the upper compartment through the IC.

Case 2 of this question is sampled; the quantification of the cases in which fans are not operating was provided by the Containment Loads Expert Panel (see Volume 2, Part 2, of this report). The branch taken at this question depends upon the branches taken at Questions 31 and 32.

The branch taken in this question defines the manner in which the hydrogen will be distributed throughout the containment in Question 42. For the times in which the flow is diverted from the lower to the upper compartment by way of the floor drains in the refueling canal, quantification was based upon the CONTAIN calculation discussed in Question 32. For other times in which the ARFs are not operating, the experts agreed to use a HECTR calculation of a TMLB' accident sequence$^{A.1-12}$ as a "base case" for the quantification of the hydrogen distribution in containment. The experts considered various factors that cause uncertainty associated with the base case quantification. The "clear path" mentioned above involves the intermediate deck doors between the IC and upper plenum. If a significant amount of the doors are stuck open, the path from the IC to the upper plenum and upper compartment is denoted as "clear." If there are few doors stuck open, then the path to the upper containment is denoted as "not clear." The mixing of the upper plenum and upper compartment atmosphere depends upon the opening of the upper deck doors between the upper plenum and upper compartment. Failure to mix could be explained by several upper deck doors remaining closed. If most of the upper deck doors are open, mixing is more likely.

For Branch 3, the base case distribution of hydrogen is used with no adjustments. For Branch 4, the hydrogen in the upper compartment for the base case is decreased by 50% and the remaining hydrogen is distributed throughout the other compartments in a manner proportionate with the compartmental amount for the base case. For Branch 5, the hydrogen in the dome for the base case is decreased by 90% and the remaining hydrogen is distributed throughout the other compartments in a manner proportionate with the compartmental amounts for the base case.

Case 1: There is diversion of flow from the lower to the upper compartment by way of the floor drains in the refueling canal. For this case, the distribution of the hydrogen is based solely upon a CONTAIN calculation that results in this scenario. The quantification for this case is:

Branch 1: WlMxd - 0.0
Branch 2: Mxd1 - 1.0
Branch 3: Mxd2 - 0.0
Branch 4: Mxd3 - 0.0
Branch 5: UnMxd - 0.0

Case 2: The ARFs are not effective in mixing the containment atmosphere before ignition of hydrogen occurs. This case applies always to the station blackouts in which power is not recovered before VB, and sometimes to the station blackouts in which power is recovered before VB. The expert panel believed that Branches 3 and 4 are equally likely and that Branch 5 is less likely to occur. 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: WlMxd - 0.000
Branch 2: Mxd1 - 0.000
Branch 3: Mxd2 - 0.445
Branch 4: Mxd3 - 0.450
Branch 5: UnMxd - 0.105

Case 3: The ARFs are effective in mixing the containment atmosphere before the ignition of hydrogen occurs. This case applies always to sequences that are not station blackouts, and sometimes to the station blackouts in which power is recovered. For this case, the containment atmosphere is well-mixed, and the hydrogen is distributed uniformly throughout the containment. The quantification for this case is:

Branch 1: WlMxd - 1.0
Branch 2: Mxd1 - 0.0
Branch 3: Mxd2 - 0.0
Branch 4: Mxd3 - 0.0
Branch 5: UnMxd - 0.0

Question 42. Distribution of Hydrogen in Containment During Core Degradation?

2 Branches, Type 6, 7 Cases

The branches for this question are:

1. E-H2xV There is hydrogen in containment before VB.

2. EnH2xV There is no hydrogen in containment before VB.

Four parameters are defined in this question:

P10. H2-LC The amount of hydrogen in the lower compartment, in kg-moles, is assigned to Parameter 10.

P11. H2-IC The amount of hydrogen in the IC, in kg-moles, is assigned to Parameter 11.

P12. H2-UP The amount of hydrogen in the upper plenum of the IC, in kg-moles, is assigned to Parameter 12.

P13. H2-UC The amount of hydrogen in the upper compartment, in kg-moles, is assigned to Parameter 13.

For this question, a module within the user function subprogram is evaluated to distribute the hydrogen throughout the containment. The applicable case for this question depends upon the branches taken at Questions 12, 24, and 41.

The user function is a small FORTRAN subprogram that is linked with the EVNTRE code after compilation. The EVNTRE code is the computer code that evaluates the APET. The part of the user function evaluated at this question uses the amount of hydrogen generated in-vessel (Parameter 8, E-H2inV) and the fraction of the hydrogen generated that is released from the RCS before VB (Parameter 9, E-H2exV), to establish the amount of hydrogen in each compartment (Parameters 10, 11, 12, and 13; H2-LC, H2-IC, H2-UP, and H2-UC). In the user function module, E-H2inV is multiplied by E-H2exV and an appropriate factor is applied to distribute the hydrogen to each compartment. The hydrogen that is retained in the RCS will be released to the containment at VB. For the sake of discussion of this question, the product of E-H2inV and E-H2exV will be referred to as the ex-vessel hydrogen (EVH).

Case 1: There is no early blowdown to containment. Hydrogen will be released from the RCS to the outside of containment, but there will be no release of hydrogen to containment. The user function module denoted H2xV1 is called from EVNTRE. The factor applied to EVH to obtain H2-LC, H2-IC, H2-UP, and H2-UC is 0.0.

Case 2: There is an isolation failure of containment. As the isolation failure is quite large, it is assumed that the hydrogen is leaked from containment in quantities sufficient to preclude further failure of containment. The user function module denoted H2xV2 is called from EVNTRE. As in Case 1, the factor applied to EVH to obtain H2-LC, H2-IC, H2-UP, and H2-UC is 0.0.

Case 3: The containment is well-mixed due to the operation of the ARFs. This case is directly related to Case 3 of Question 41. The hydrogen is distributed uniformly throughout containment. The user function module denoted H2xV3 is called from EVNTRE. The factor applied to EVH to obtain H2-LC is 0.31, to obtain H2-IC is 0.10, to obtain H2-UP is 0.04, and to obtain H2-UC is 0.55.

Case 4: The ARFs are not operating and there is diversion of flow from the lower to the upper compartment by way of the floor drains in the refueling canal floor. This case is directly related to Case 1 of Question 41. The values are obtained from a CONTAIN calculation as described in the discussion of Question 32. The user function module denoted H2xV4 is called from EVNTRE. The factor applied to EVH to obtain H2-LC is 0.44, to obtain H2-IC is 0.13, to obtain H2-UP is 0.01, and to obtain H2-UC is 0.42.

Case 5: The ARFs are not operating, but the upper plenum and upper compartment atmospheres are well-mixed, and a "clear path" exists from the lower to the upper compartment through the IC. The values are obtained from a HECTR calculation as described in the discussion of Question 41. The user function module denoted H2xV5 is called from EVNTRE. The factor applied to EVH to obtain H2-LC is 0.35, to obtain H2-IC is 0.36, to obtain H2-UP is 0.03, and to obtain H2-UC is 0.26.

Case 6: The ARFs are not operating, but the upper plenum and upper compartment atmospheres are well-mixed, and no "clear path" exists from the lower to the upper compartment through the IC. For this case, the hydrogen in the upper compartment for Case 5 is decreased by 50% and the remaining hydrogen is distributed throughout the other compartments in a manner proportionate with the compartmental amount for the base case. The user function module denoted H2xV6 is called from EVNTRE. The factor applied to EVH to obtain H2-LC is 0.41, to obtain H2-IC is 0.42, to obtain H2-UP is 0.04, and to obtain H2-UC is 0.13.

Case 7: The ARFs are not operating, there is no mixing of the upper plenum and upper compartment atmospheres, and no "clear path" exists from the lower to the upper compartment through the IC. For Branch 5, the hydrogen in the dome for the base case is decreased by 90% and the remaining hydrogen is distributed throughout the other compartments in a manner proportionate with the compartmental amount for the base case. The user function module denoted H2xV7 is called from EVNTRE. The factor applied to EVH to obtain H2-LC is 0.46, to obtain H2-IC is 0.47, to obtain H2-UP is 0.04, and to obtain H2-UC is 0.03.

Question 43. **What is the Hydrogen Concentration in the Lower Compartment, and the Burn Completeness if Ignited?**
3 Branches, Type 6, 2 Cases

The branches for this question are:

1. HLC>11 The hydrogen concentration in the lower compartment is greater than 11%.
2. HLC>5.5 The hydrogen concentration in the lower compartment is between 5.5% and 11%.
3. LoHLC The hydrogen concentration in the lower compartment is less than 5.5%.

One parameter is defined in this question:

P14. E-LCBC The completeness of combustion in the lower compartment, if hydrogen ignition occurs, is assigned to Parameter 14.

This question is not sampled; the quantification of Parameter 14 was provided by the Containment Loads Expert Panel (see Volume 2, Part 2, of this report), and is calculated in a module within the user function subprogram. The user function module also calculates the hydrogen concentration, which is divided into the three categories defined by the branches. The applicable case for this question depends upon the branch taken at Question 31.

The upward flammability limits for hydrogen-air-steam mixtures and the extent of hydrogen combustion depend upon the hydrogen and steam concentrations. For this question, the amounts of oxygen, steam, and hydrogen in the lower compartment are passed to the user function. The amount of nitrogen is proportionate to the amount of oxygen. The user function module then calculates hydrogen and steam mole fractions. The completeness of combustion is also dependent upon the amount of turbulence in the atmosphere. The completeness of combustion is calculated using an empirical model specified by the experts. The model, developed by C. C. Wong,[A.1-17] is different for times of turbulent mixing than for times in which the atmosphere is quiescent.

Case 1: The ARFs are operating when ignition occurs, the turbulent burn completeness model is used. The user function module denoted H2Cnc1 is called from EVNTRE.

Case 2: The ARFs are not operating when ignition occurs, the quiescent burn completeness model is used. The user function module denoted H2Cnc2 is called from EVNTRE.

Question 44. What is the Hydrogen Concentration in the IC, and the Burn Completeness if Ignited?
6 Branches, Type 6, 2 Cases

The branches for this question are:

1. HIC>21 The hydrogen concentration in the IC is greater than 21%.
2. HIC>16 The hydrogen concentration in the IC is between 16% and 21%.
3. HIC>14 The hydrogen concentration in the IC is between 14% and 16%.
4. HIC>11 The hydrogen concentration in the IC is between 11% and 14%.
5. HIC>5.5 The hydrogen concentration in the IC is between 5.5% and 11%.
6. LoHIC The hydrogen concentration in the IC is less than 5.5%.

One parameter is defined in this question:

P15. E-ICBC The completeness of combustion in the IC, if hydrogen ignition occurs, is assigned to Parameter 15.

This question is not sampled; the quantification of Parameter 15 was provided by the Containment Loads Expert Panel (see Volume 2, Part 2, of *this report), and is calculated in a module* within the user function subprogram. The user function module also calculates the hydrogen concentration, which is divided into the six categories defined by the branches. The applicable case for this question depends upon the branch taken at Question 31.

The hydrogen concentration and burn completeness in the IC are calculated in the user function module as described for the lower compartment in Question 43, above.

> Case 1: The ARFs are operating when ignition occurs, the turbulent burn completeness model is used. The user function module denoted H2Cnc3 is called from EVNTRE.
>
> Case 2: The ARFs are not operating when ignition occurs, the quiescent burn completeness model is used. The user function module denoted H2Cnc4 is called from EVNTRE.

Question 45. What is the Hydrogen Concentration in the Upper Plenum of the IC and the Burn Completeness if Ignited?
6 Branches, Type 6, 2 Cases

The branches for this question are:

1. HUP>21 The hydrogen concentration in the upper plenum is greater than 21%.

2. HUP>16 The hydrogen concentration in the upper plenum is between 16% and 21%.

3. HUP>14 The hydrogen concentration in the upper plenum is between 14% and 16%.

4. HUP>11 The hydrogen concentration in the upper plenum is between 11% and 14%.

5. HUP>5.5 The hydrogen concentration in the upper plenum is between 5.5% and 11%.

6. LoHUP The hydrogen concentration in the upper plenum is less than 5.5%.

One parameter is defined in this question:

P16. E-UPBC The completeness of combustion in the upper plenum, if hydrogen ignition occurs, is assigned to Parameter 16.

This question is not sampled; the quantification of Parameter 16 was provided by the Containment Loads Expert Panel (see Volume 2, Part 2, of this report), and is calculated in a module within the user function subprogram. The user function module also calculates the hydrogen concentration, which is divided into the six categories defined by the branches. The applicable case for this question depends upon the branch taken at Question 31.

The hydrogen concentration and burn completeness in the upper plenum are calculated in the user function module as described for the lower compartment in Question 43.

Case 1: The ARFs are operating when ignition occurs, the turbulent burn completeness model is used. The user function module denoted H2Cnc5 is called from EVNTRE.

Case 2: The ARFs are not operating when ignition occurs, the quiescent burn completeness model is used. The user function module denoted H2Cnc6 is called from EVNTRE.

Question 46. What is the Hydrogen Concentration in the Upper Compartment, and the Burn Completeness If Ignited?
5 Branches, Type 6, 2 Cases

The branches for this question are:

1. HUC>21 The hydrogen concentration in the upper compartment is greater than 21%.

2. HUC>16 The hydrogen concentration in the upper compartment is between 16% and 21%.

3. HUC>11 The hydrogen concentration in the upper compartment is between 11% and 16%.

4. HUC>5.5 The hydrogen concentration in the upper compartment is between 5.5% and 11%.

5. LoHUC The hydrogen concentration in the upper compartment is less than 5.5%.

One parameter is defined in this question:

P17. E-UCBC The completeness of combustion in the upper compartment, if hydrogen ignition occurs, is assigned to Parameter 17.

This question is not sampled; the quantification of Parameter 17 was provided by the Containment Loads Expert Panel (see Volume 2, Part 2, of this report), and is calculated in a module within the user function subprogram. The user function module also calculates the hydrogen concentration, which is divided into the five categories defined by the branches. The applicable case for this question depends upon the branch taken at Question 31.

The hydrogen concentration and burn completeness in the upper compartment are calculated in the user function module as described for the lower compartment in Question 43, above.

> Case 1: The ARFs are operating when ignition occurs, the turbulent burn completeness model is used. The user function module denoted H2Cnc1 is called from EVNTRE.
>
> Case 2: The ARFs are not operating when ignition occurs, the quiescent burn completeness model is used. The user function module denoted H2Cnc2 is called from EVNTRE.

Question 47. Are the Hydrogen Igniters Operating During Core Degradation?
2 Branches, Type 2, 4 Cases

The branches for this question are:

1. E-Ig The igniters are operating during core degradation.

2. EnIg The igniters are not operating during core degradation.

This question is not sampled; the quantification was done internally by the accident frequency analysts. The branch taken depends upon the branches taken at Questions 7, 13, 22, 44, and 46.

If ac power is initially operating, the initiation of the igniters by the operators is addressed in Question 13. This question addresses accidents involved with loss of offsite power and subsequent power recovery. If the hydrogen concentration in containment is less than 6%, the operating procedures instruct the operators to activate the igniters. If the hydrogen concentration is greater than 6%, the operators are directed to refrain from activating the igniters.

Case 1: The operators initially activated the igniters. Either ac power was operating when activation took place, or power was recovered, allowing the igniters to operate. The quantification for this case is:

Branch 1: E-Ig = 1.0
Branch 2: EnIg = 0.0

Case 2: The accident involves a station blackout with power recovery before VB. The hydrogen concentration in containment is less than 5.5%. HRA indicates that failure to initiate will be about 8% of the time. The quantification for this case is:

Branch 1: E-Ig = 0.92
Branch 2: EnIg = 0.08

Case 3: The accident involves a station blackout with power recovery before VB. The hydrogen concentration in containment is greater than 5.5%. HRA indicates that incorrect initiation will occur about 8% of the time. The quantification for this case is:

Branch 1: E-Ig = 0.08
Branch 2: EnIg = 0.92

Case 4: The accident involves a station blackout without power recovery before VB. The igniters will not be operating. The quantification for this case is:

Branch 1: E-Ig = 0.0
Branch 2: EnIg = 1.0

Question 48. Does Hydrogen Ignition Occur in the Lower Compartment During Core Degradation?
2 Branches, Type 4, 5 Cases

The branches for this question are:

1. E-LCDef Ignition of hydrogen occurs in the lower compartment during core degradation.
2. EnLCDef Ignition of hydrogen does not occur in the lower compartment during core degradation.

One parameter is defined in this question:

P18. E-IgLC Ignition in the lower compartment is flagged by assigning a value of 1.0 to Parameter 18.

This question is not sampled; the quantification of this question was performed internally. The branch taken depends upon the branches taken at Questions 7, 22, 33, 43, and 47.

For accidents in which the ARF system is not operating; typically, for station blackout accidents, the lower compartment is steam inerted. For the other compartments in the containment, station blackouts are of concern, because the IC is effective in de-inerting gases that pass through it. The ignition of hydrogen in the other compartment during station blackout accidents was considered by the Containment Loads Expert Panel and will be addressed in Questions 49 through 51. For accidents in which the hydrogen ignition system has been activated, and the lower compartment atmosphere has satisfied the flammability criteria, ignition is certain to occur.

For all cases, the ignition flag will be set if ignition occurs. The assignment of the parameter, if Branch 1 is taken, is:

Parameter 18: E-IgLC = 1.0

If Branch 2 is taken the assignment of the parameter is:

Parameter 18: E-IgLC = 0.0

Case 1: The igniters are operating during core degradation, and the steam concentration in the lower compartment is less than 60%. The ignition of hydrogen is assured. If the flammability limit is not attained, the burn completeness for the lower compartment, Parameter 14, will have been set to zero in Question 43. The quantification for this case is:

Branch 1: E-LCDef = 1.0
Branch 2: EnLCDef = 0.0

Case 2: The igniters are not operating, and either the hydrogen concentration in the lower compartment is less than 5.5%, or the steam concentration is greater than 25%. It is assumed that the probability of ignition will be negligible for times in which there is a large quantity of steam in the lower compartment. The quantification for this case is:

Branch 1: E-LCDef = 0.0
Branch 2: EnLCDef = 1.0

Case 3: Igniters are not operating, the steam concentration is less than 25%, and the hydrogen concentration is greater than 5.5%. For this case, ac power has been operating since UTAF. It is believed that ignition will have occurred before VB due to random ac power sources. The quantification for this case is:

Branch 1: E-LCDef = 1.0
Branch 2: EnLCDef = 0.0

Case 4: Igniters are not operating, the steam concentration is less than 25%, and the hydrogen concentration is greater than 5.5%. For this case, ac power was recovered during core degradation. The probability of ignition of hydrogen in the lower compartment before VB is indeterminate. The quantification for this case is:

Branch 1: E-LCDef - 0.50
Branch 2: EnLCDef - 0.50

Case 5: Igniters are not operating, the steam concentration is less than 25%, and the hydrogen concentration is greater than 5.5%. For this case, ac power has not operated at all in the accident, and ignition, if it occurs, will be due to dc power and static sources only. It is believed that ignition is not very likely to occur before VB. The quantification for this case is:

Branch 1: E-LCDef - 0.15
Branch 2: EnLCDef - 0.85

Question 49. Does Hydrogen Ignition Occur in the IC During Core Degradation?
2 Branches, Type 4, 5 Cases

The branches for this question are:

1. E-ICDef Ignition of hydrogen occurs in the IC during core degradation.

2. EnICDef Ignition of hydrogen does not occur in the IC during core degradation.

One parameter is defined in this question:

P19. E-IgIC Ignition in the IC is flagged by assigning a value of 1.0 to Parameter 19.

Cases 3, 4, and 5 of this question are sampled; the distributions were provided by the Containment Loads Expert Panel (see Volume 2, Part 2, of this report). The branch taken depends upon the branches taken at Questions 7, 22, 31, 34, 44, and 48.

For accidents in which the ARFS is not operating; typically, for station blackout accidents, the IC removes the steam from the gases that pass through it. Ignition of the hydrogen that begins to accumulate within the IC during station blackout accidents was considered by the Containment Loads Expert Panel. The experts believed that the main ignition source for hydrogen in the IC would be due to static discharge caused by the opening and shutting of intermediate deck doors between the IC and upper plenum. The intermediate deck doors consist of a urethane core sandwiched by galvanized steel as described in the Sequoyah FSAR.[A.1-14] They open into the upper plenum and are stopped by impacting adjacent door panels against each other. The lower deck doors are not expected to contribute to probability of ignition because the gases entering the IC are highly steam-inerted. There are no igniters or no ac powered sources located within the IC, but for times in which the ARF system is operating, burns initiated in the lower compartment can propagate into the IC.

For all cases, the ignition flag will be set if ignition occurs. The assignment of the parameter, if Branch 1 is taken, is:

Parameter 19: E-IgIC = 1.0

If Branch 2 is taken the assignment of the parameter is:

Parameter 19: E-IgIC = 0.0

Case 1: Steam concentration in the IC is greater than 60%, or the hydrogen concentration is less than 5.5%. It is certain that ignition of hydrogen will not occur in the IC. The quantification for this case is:

Branch 1: E-ICDef = 0.0
Branch 2: EnICDef = 1.0

Case 2: Combustion is initiated in the lower compartment, and flames propagate to the IC by operation of the ARFs, or there is power recovery during a station blackout and the ARFs are not effective before hydrogen ignition. For times in which the ARFs are not effective, ignition is assumed to occur, by the definition of this criterion as discussed for Case 2 of Question 31. The quantification for this case is:

Branch 1: E-ICDef = 1.0
Branch 2: EnICDef = 0.0

Case 3: Igniters are not operating, the steam concentration is less than 60%, and the hydrogen concentration is greater than 16%. The mean value of the aggregate distribution for probability of ignition is:

Branch 1: E-ICDef = 0.197
Branch 2: EnICDef = 0.803

Case 4: Igniters are not operating, the steam concentration is less than 60%, and the hydrogen concentration is between 11% and 16%. The mean value of the aggregate distribution for probability of ignition is:

Branch 1: E-ICDef = 0.157
Branch 2: EnICDef = 0.843

Case 5: Igniters are not operating, the steam concentration is less than 60%, and the hydrogen concentration is between 5.5% and 11%. The mean value of the aggregate distribution for probability of ignition is:

Branch 1: E-ICDef = 0.123
Branch 2: EnICDef = 0.877

Question 50. Does Hydrogen Ignition Occur in the Upper Plenum During Core Degradation?
2 Branches, Type 4, 8 Cases

The branches for this question are:

1. E-UPDef Ignition of hydrogen occurs in the upper plenum during core degradation.

2. EnUPDef Ignition of hydrogen does not occur in the upper plenum during core degradation.

One parameter is defined in this question:

P20. E-IgUP Ignition in the upper plenum is flagged by assigning a value of 1.0 to Parameter 20.

Cases 6, 7, and 8 of this question are sampled; the distributions were provided by the Containment Loads Expert Panel (see Volume 2, Part 2, of this report). The branch taken depends upon the branches taken at Questions 7, 22, 28, 31, 34, 45, 47, and 49.

For accidents in which the ARFS is not operating; typically, for station blackout accidents, the IC removes the steam from the gases that pass through it. Ignition of the hydrogen that begins to accumulate within the upper plenum during station blackout accidents was considered by the Containment Loads Expert Panel. The experts believed that the main ignition source for hydrogen in the upper plenum would be due to static discharge caused by the opening and shutting of intermediate deck doors between the IC and the upper plenum; the construction of the doors is discussed in Question 49. It is expected that the probability of ignition in the upper plenum will be higher than in the IC, due to the nature of the impacting of the intermediate deck doors. There are igniters located within the upper plenum; thus, for accidents in which the hydrogen ignition system has been activated, and the upper plenum atmosphere has satisfied the flammability criteria, ignition is certain to occur.

For all cases, the ignition flag will be set if ignition occurs. The assignment of the parameter, if Branch 1 is taken, is:

Parameter 20: E-IgUP - 1.0

If Branch 2 is taken, the assignment of the parameter is:

Parameter 20: E-IgUP - 0.0

Case 1: The igniters are operating during core degradation, and the steam concentration in the upper plenum is less than 60%. The ignition of hydrogen is assured. If the flammability limit is not attained, the burn completeness for the upper plenum, Parameter 16, will have been set to zero in Question 45. The quantification for this case is:

Branch 1: E-UPDef = 1.0
Branch 2: EnUPDef = 0.0

Case 2: The igniters are not operating, and either the hydrogen concentration in the upper plenum is less than 5.5%, or the steam concentration is greater than 60%. It is certain that ignition of hydrogen will not occur in the upper plenum. The quantification for this case is:

Branch 1: E-UPDef = 0.0
Branch 2: EnUPDef = 1.0

Case 3: Combustion is initiated in the IC, and flames propagate to the upper plenum by operation of the ARFs, or there is power recovery during a station blackout and the ARFs are not effective before hydrogen ignition. For times in which the ARFs are not effective, ignition is assumed to occur, by the definition of this criterion as discussed for Case 2 of Question 31. The quantification for this case is:

Branch 1: E-UPDef = 1.0
Branch 2: EnUPDef = 0.0

Case 4: Igniters are not operating, the steam concentration is less than 25%, and the hydrogen concentration is greater than 5.5%. For this case, ac power has been operating since UTAF. It is believed that ignition will have occurred before VB due to random ac power sources. The quantification for this case is:

Branch 1: E-UPDef = 1.0
Branch 2: EnUPDef = 0.0

Case 5: Igniters are not operating, the steam concentration is less than 25%, and the hydrogen concentration is greater than 5.5%. For this case, ac power was recovered during core degradation. The probabilty of ignition of hydrogen in the upper plenum before VB is indeterminate. The quantification for this case is:

Branch 1: E-UPDef = 0.500
Branch 2: EnUPDef = 0.500

Case 6: Neither the igniters nor ac power is operating, the steam concentration is less than 60%, and the hydrogen concentration is greater than 16%. The mean value of the aggregate distribution for probability of ignition is:

Branch 1: E-UPDef = 0.347
Branch 2: EnUPDef = 0.653

Case 7: Neither the igniters nor ac power is operating, the steam concentration is less than 60%, and the hydrogen concentration is between 11% and 16%. The mean value of the aggregate distribution for probability of ignition is:

Branch 1: E-UPDef - 0.257
Branch 2: EnUPDef - 0.743

Case 8: Neither the igniters nor ac power is operating, the steam concentration is less than 60%, and the hydrogen concentration is between 5.5% and 11%. The mean value of the aggregate distribution for probability of ignition is:

Branch 1: E-UPDef - 0.178
Branch 2: EnUPDef - 0.822

Question 51. Does Hydrogen Ignition Occur in the Upper Compartment During Core Degradation?

2 Branches, Type 4, 8 Cases

The branches for this question are:

1. E-UCDef Ignition of hydrogen occurs in the upper compartment during core degradation.

2. EnUCDef Ignition of hydrogen does not occur in the upper compartment during core degradation.

One parameter is defined in this question:

P21. E-IgUC Ignition in the upper compartment is flagged by assigning a value of 1.0 to Parameter 21.

Cases 6, 7, and 8 of this question are sampled; the distributions were provided by the Containment Loads Expert Panel (see Volume 2, Part 2, of this report). The branch taken depends upon the branches taken at Questions 7, 22, 31, 35, 46, 47, and 50.

For accidents in which the ARFS is not operating typically, for station blackout accidents, the IC removes the steam from the gases that pass through it. Ignition of the hydrogen that enters the upper compartment during station blackout accidents was considered by the Containment Loads Expert Panel. The experts believed that the likelihood that ignition sources exist in the upper compartment would be small. The upper deck doors that separate the upper plenum and upper compartment are panels of blanketed insulation. The opening of the upper deck doors does not involve the same type of frictional contact as the opening of the intermediate deck doors. There are igniters located within the upper compartment; thus, for accidents in which the hydrogen ignition system has been activated, and the upper compartment atmosphere has satisfied the flammability criteria, ignition is certain to occur.

For all cases, the ignition flag will be set if ignition occurs. The assignment of the parameter, if Branch 1 is taken, is:

Parameter 21: E-IgUC - 1.0

If Branch 2 is taken the assignment of the parameter is:

Parameter 21: E-IgUC - 0.0

Case 1: The igniters are operating during core degradation, and the steam concentration in the upper compartment is less than 60%. The ignition of hydrogen is assured. If the flammability limit is not attained, the burn completeness for the upper compartment, Parameter 17, will have been set to zero in Question 46. The quantification for this case is:

Branch 1: E-UCDef - 1.0
Branch 2: EnUCDef - 0.0

Case 2: The igniters are not operating, and either the hydrogen concentration in the upper compartment is less than 5.5%, or the steam concentration is greater than 60%. It is certain that ignition of hydrogen will not occur in the upper compartment. The quantification for this case is:

Branch 1: E-UCDef - 0.0
Branch 2: EnUCDef - 1.0

Case 3: Combustion is initiated in the upper plenum of the IC, and flames propagate to the upper compartment, or there is power recovery during a station blackout and the ARFs are not effective before hydrogen ignition. For times when the ARFs are not effective, ignition is assumed to occur, by the definition of this criterion as discussed for Case 2 of Question 31. The quantification for this case is:

Branch 1: E-UCDef - 1.0
Branch 2: EnUCDef - 0.0

Case 4: Igniters are not operating, the steam concentration is less than 25%, and the hydrogen concentration is greater than 5.5%. For this case, ac power has been operating since UTAF. It is believed that ignition will have occurred before VB due to random ac power sources. The quantification for this case is:

Branch 1: E-UCDef - 1.0
Branch 2: EnUCDef - 0.0

Case 5: Igniters are not operating, the steam concentration is less than 25%, and the hydrogen concentration is greater than 5.5%. For this case, ac power was recovered during core degradation. The probability of ignition of hydrogen in the upper compartment before VB is indeterminate. The quantification for this case is:

Branch 1: E-UCDef - 0.500
Branch 2: EnUCDef - 0.500

Case 6: Neither the igniters nor ac power is operating, the steam concentration is less than 60%, and the hydrogen concentration is greater than 16%. The mean value of the aggregate distribution for probability of ignition is:

Branch 1: E-UCDef = 0.097
Branch 2: EnUCDef = 0.903

Case 7: Neither the igniters nor ac power is operating, the steam concentration is less than 60%, and the hydrogen concentration is between 11% and 16%. The mean value of the aggregate distribution for probability of ignition is:

Branch 1: E-UCDef = 0.092
Branch 2: EnUCDef = 0.908

Case 8: Neither the igniters nor ac power is operating, the steam concentration is less than 60%, and the hydrogen concentration is between 5.5% and 11%. The mean value of the aggregate distribution for probability of ignition is:

Branch 1: E-UCDef = 0.083
Branch 2: EnUCDef = 0.917

Question 52. Is There a Transition to Detonation (DDT) in the IC During Core Degradation?
2 Branches, Type 2, 4 Cases

The branches for this question are:

1. E-ICDet A deflagration in the IC is accelerated such that DDT occurs.

2. EnICDet There is no detonation in the IC.

Cases 1, 2 and 3 of this question are sampled; the distributions were provided by the Containment Loads Expert Panel (see Volume 2, Part 2, of this report). The branch taken depends upon the branches taken at Questions 13, 44, and 49.

Hydrogen concentrations in the IC can exceed detonable limits for times when fans and igniters are not operating. The expert panel that addressed this question believed a hydrogen-air-steam mixture with a hydrogen mole fraction of 0.14 or greater will result in a non-negligible detonation load if ignition and flame acceleration occur. The panel agreed that spontaneous detonation will not occur; however, the geometry of the IC is such that, if a deflagration occurs, the flames can be accelerated to supersonic speeds, thus resulting in a detonation. The impulsive load imparted by a detonation, if it occurs, is addressed in Question 55.

Case 1: A deflagration has occurred in the IC, and the hydrogen concentration is greater than 21%. The experts believed that it is likely that the deflagration will transition to detonation. The mean value of the aggregate distribution for probability of DDT is:

Branch 1: E-ICDet - 0.720
Branch 2: EnICDet - 0.280

Case 2: A deflagration has occurred in the IC, and the hydrogen concentration is between 16% and 21%. The experts believed that it is fairly likely that the deflagration will transition to detonation. The mean value of the aggregate distribution for probability of DDT is:

Branch 1: E-ICDet - 0.620
Branch 2: EnICDet - 0.380

Case 3: A deflagration has occurred in the IC, and the hydrogen concentration is between 14% and 16%. The experts believed that it is about as likely as not that the deflagration will transition to detonation. The mean value of the aggregate distribution for probability of DDT is:

Branch 1: E-ICDet - 0.453
Branch 2: EnICDet - 0.547

Case 4: A deflagration has occurred in the IC, and the hydrogen concentration is less than 14%. The experts believed that the mixture is not detonable, and the deflagration will not transition to detonation. The value for probability of DDT is:

Branch 1: E-ICDet - 0.0
Branch 2: EnICDet - 1.0

Question 53. **Is there a DDT in the Upper Plenum of the IC During Core Degradation?**
2 Branches, Type 2, 4 Cases

The branches for this question are:

1. E-UPDet A deflagration in the upper plenum is accelerated such that DDT occurs.

2. EnUPDet There is no detonation in the upper plenum.

Cases 1, 2, and 3 of this question are sampled; the distributions were provided by the Containment Loads Expert Panel (see Volume 2, Part 2, of this report). The branch taken depends upon the branches taken at Questions 13, 45, and 50.

Hydrogen concentrations in the upper plenum can exceed detonable limits for times when fans and igniters are not operating. Similarly for detonations in the IC as discussed in Question 52, the expert panel believed a hydrogen mole fraction in the upper plenum of 0.14 or greater will result in a threatening detonation load. The panel agreed that spontaneous detonation will not occur; however, the geometry of the upper plenum is such that, if a deflagration occurs, the flames can be accelerated to supersonic speeds, thus resulting in a detonation. The geometry of the upper plenum is somewhat less conducive to DDT than it is for the IC. However, considering the uncertainty associated with the distributions, the experts believed it was adequate to use the same distribution for DDT in the upper plenum as for DDT in the IC. The impulsive load imparted by a detonation, if it occurs, is addressed in Question 56.

Case 1: A deflagration has occurred in the upper plenum, and the hydrogen concentration is greater than 21%. The experts believed that it is likely that the deflagration will transition to detonation. The mean value of the aggregate distribution for probability of DDT is:

Branch 1: E-UPDet - 0.720
Branch 2: EnUPDet - 0.280

Case 2: A deflagration has occurred in the upper plenum, and the hydrogen concentration is between 16% and 21%. The experts believed that it is fairly likely that the deflagration will transition to detonation. The mean value of the aggregate distribution for probability of DDT is:

Branch 1: E-UPDet - 0.620
Branch 2: EnUPDet - 0.380

Case 3: A deflagration has occurred in the upper plenum, and the hydrogen concentration is between 14% and 16%. The experts believed that it is about as likely as not that the deflagration will transition to detonation. The mean value of the aggregate distribution for probability of DDT is:

Branch 1: E-UPDet - 0.453
Branch 2: EnUPDet - 0.547

Case 4: A deflagration has occurred in the upper plenum, and the hydrogen concentration is less than 14%. The experts believed that the mixture is not detonable, and the deflagration will not transition to detonation. The value for probability of DDT is:

Branch 1: E-UPDet - 0.0
Branch 2: EnUPDet - 1.0

Question 54. Pressure Rise in Containment due to Early Deflagration?
2 Branches, Type 6, 4 Cases

The branches for this question are:

1. E-DPDef There is a pressure rise in containment due to a hydrogen deflagration during core degradation.
2. EnDPDef There is no hydrogen deflagration during core degradation.

One parameter is defined in this question:

P22. DP-EDef The pressure rise in containment due to a hydrogen deflagration during core degradation, in kPa, is assigned to Parameter 22.

This question is not sampled; the quantification of Parameter 22 was provided by the Containment Loads Expert Panel (see Volume 2, Part 2, of this report), and is calculated in a module within the user function subprogram. The applicable case for this question depends upon the branches taken at Questions 13, 27, 30, and 32.

For this question, the existing pressure in containment is passed to the user function. The other variables passed to the user function module are (for each compartment in containment): the flag for ignition, the burn completeness if ignition occurs, and the amounts of oxygen, steam, and hydrogen (the amount of nitrogen is proportionate to the amount of oxygen). The user function module calculates the pressure rise based upon a model provided by the expert panel. The model uses the adiabatic isochoric complete combustion (AICC) pressure ratio, or overpressure, which is then adjusted to account for various phenomena. The first adjustment is to multiply the overpressure by the completeness of combustion. Then, the overpressure is reduced by 5% for heat transfer losses to solid surfaces. This value is then adjusted for isentropic expansion (ideal gas is assumed) into volumes that are not participating in the deflagration. The participating volumes are flagged by Parameters 18 through 21. Even if a detonation has occurred, the static overpressure due to the burn is still calculated. As well as computing the pressure rise in containment due to a burn, the user function also readjusts the values of hydrogen and oxygen due to their consumption in the burn.

Case 1: The igniters are operating at UTAF, the hydrogen is burned as it is released, with minimal pressure rise. For this case, the computed overpressure is decreased by a factor of 20.0 in the user function module. It was believed that if the igniters are operating, there will be negligible threat to containment. The consumption of the hydrogen and oxygen is still needed, and is calculated in the user function for this case. The user function module denoted Burn1 is called from EVNTRE.

Case 2: Igniters are not operating at UTAF, and there is no containment heat removal in the containment. The AICC burn model in the user function module requires the temperature of the containment atmosphere in order to calculate the over pressure. For this case, the containment atmosphere is assumed to be 135°C. The user function module denoted Burn2 is called from EVNTRE.

Case 3: Igniters are not operating at UTAF, and there is diversion of flow from the lower to the upper compartment by way of the floor drains in the refueling canal. The AICC burn model in the user function module requires the temperature of the containment atmosphere in order to calculate the over pressure. For this case, the containment atmosphere is assumed to be 115°C. The user function module denoted Burn3 is called from EVNTRE.

Case 4: Igniters are not operating at UTAF, and there is containment heat removal by the IC and/or the sprays. The AICC burn model in the user function module requires the temperature of the containment atmosphere in order to calculate the over pressure. For this case, the containment atmosphere is assumed to be 38°C. The user function module denoted Burn4 is called from EVNTRE.

Question 55. Impulse from Detonation in IC During Core Degradation?
5 Branches, Type 4, 2 Cases

The branches for this question are:

1. E-ImpIC There is an impulsive load delivered to containment structures due to a detonation in the IC.

2. EnImpIC There is no detonation in the IC; therefore there is no impulsive load delivered to containment structures.

One parameter is defined in this question:

P23. Imp-IC The impulsive load in containment due to a hydrogen detonation in the IC during core degradation, in kPa-s, is assigned to Parameter 23.

This question is sampled; the distribution for Parameter 23 was provided by the Containment Loads Expert Panel (see Volume 2, Part 2, of this report). The applicable case for this question depends upon the branch taken at Question 52.

The probability that a detonation occurs in the IC before VB was addressed in Question 52. The load accompanying the detonation is provided in this question. The expert panel addressing the hydrogen threat before VB provided distributions for the impulsive load imparted by a detonation. The panel believed the load to be independent of hydrogen concentration, provided the concentration is at least high enough for a detonation to occur.

Case 1: A detonation has occurred in the IC before VB. For this case, all of the probability is assigned to the branch in which there is an impulsive load delivered to containment structures. The quantification for this case is:

Branch 1: E-ImpIC - 1.0
Branch 2: EnImpIC - 0.0

For Branch 1, the assignment of the parameter based on the mean value of the aggregate distribution (kPa-s) is:

Parameter 23: Imp-IC - 10.40

For Branch 2, the assignment of the parameter is irrelevant.

Case 2: A detonation has not occurred in the IC before VB. For this case, all of the probability is assigned to the branch in which there is no impulsive load delivered to containment structures. The quantification for this case is:

Branch 1: E-ImpIC - 0.0
Branch 2: EnImpIC - 1.0

For Branch 1, the assignment of the parameter is irrelevant. For Branch 2, the assignment of the parameter (kPa-s) is:

Parameter 23: Imp-IC - 0.0

Question 56. Impulse from Detonation in Upper Plenum of IC During Core Degradation?

2 Branches, Type 4, 2 Cases

The branches for this question are:

1.	E-ImpUP	There is an impulsive load delivered to containment structures due to a detonation in the upper plenum.
2.	EnImpUP	There is no detonation in the upper plenum; therefore, there is no impulsive load delivered to containment structures.

One parameter is defined in this question:

P24. Imp-UP	The impulsive load in containment due to a hydrogen detonation during in the upper plenum core degradation, in kPa-s, is assigned to Parameter 24.

This question is sampled; the distribution for Parameter 24 was provided by the Containment Loads Expert Panel (see Volume 2, Part 2, of this report). The applicable case for this question depends upon the branch taken at Question 53.

The probability that a detonation occurs in the upper plenum before VB is addressed in Question 53. The load accompanying the detonation is provided in this question. The expert panel addressing the hydrogen threat before VB provided distributions for the impulsive load imparted by a detonation. The panel believed the load to be independent of hydrogen concentration, provided the concentration is at least high enough for a detonation to occur. The same distribution for the impulsive load due to a detonation in the IC for Question 55 is applied in this question for a detonation in the upper plenum.

Case 1: A detonation has occurred in the upper plenum before VB. For this case, all of the probability is assigned to the branch in which there is an impulsive load delivered to containment structures. The quantification for this case is:

Branch 1: E-ImpUP = 1.0
Branch 2: EnImpUP = 0.0

For Branch 1, the assignment of the parameter based on the mean value of the aggregate distribution (kPa·s) is:

Parameter 24: Imp-UP = 10.40

For Branch 2, the assignment of the parameter is irrelevant.

Case 2: A detonation has not occurred in the upper plenum before VB. For this case, all of the probability is assigned to the branch in which there is no impulsive load delivered to containment structures. The quantification for this case is:

Branch 1: E-ImpUP = 0.0
Branch 2: EnImpUP = 1.0

For Branch 1, the assignment of the parameter is irrelevant. For Branch 2, the assignment of the parameter (kPa·s) is:

Parameter 24: Imp-UP = 0.0

Question 57. CF Criteria for Pressure and Impulse Loadings?
1 Branch, Type 3

The single branch for this question is always taken. The branch is:

1. CF-Spec The containment failure criteria are specified.

Four parameters are defined in this question:

P25. CF-Pr The containment failure pressure, in kPa, is assigned to Parameter 25.

P26. RndVal A random number between 0.0 and 1.0 is assigned to Parameter 26. This number is used to determine the mode of CF.

P27. CFI-UP The impulsive failure criterion in the UP, in kPa·s, is assigned to Parameter 27.

P28. CFI-IC The impulsive failure criterion in the IC, in kPa·s, is assigned to Parameter 28.

This question is sampled, the distributions for the containment static failure pressure and the dynamic failure impulse were provided by the Structural Response Expert Panel. A detailed description of the conclusions of the structural experts who considered the strength of the Sequoyah containment, and the formation of the aggregate distributions, is contained in Volume 2, Part 3, of this report.

The random number introduced in this question, Parameter 26, is used to determine the mode of containment failure. For both static and dynamic pressure loadings, the comparison of the failure criterion with the loading, and the determination of the mode of failure, take place in a user function module, which is called from the APET in the [illegible] question in the event tree.

Based on the mean value of the experts' aggregate distribution for the failure pressure, the assignment of the parameter is (kPa):

Parameter 25: CF-Pr - 550.90

The mean value of the random number distribution is:

Parameter 26: RndVal - 0.50

The assignment of the dynamic failure criteria, based on the mean values of the experts' aggregate distribution is (kPa-s):

Parameter 27: CFI-UP - 12.00
Parameter 28: CFI-IC - 21.50

Question 58. **Early Containment Failure and Mode of Failure?**
6 Branches, Type 6, 4 Cases

The branches for this question are:

1. EnCF There is no containment failure during core degradation.
2. E-CFUCL The containment fails during core degradation, and the failure is a leak in the upper containment; the nominal hole area is 0.1 ft^2.
3. E-CFLCL The containment fails during core degradation, and the failure is a leak in the lower containment; the nominal hole area is 0.1 ft^2.
4. E-CFUCR The containment fails during core degradation, and the failure is a rupture in the upper containment; the nominal hole size is 1 ft^2.
5. E-CFLCR The containment fails during core degradation, and the failure is a rupture in the lower containment; the nominal hole size is 1 ft^2.
6. E-CFCtR The containment fails during core degradation, and the failure is by catastrophic rupture; the area of the hole is at least 7.0 ft^2 (and may be considerably larger) and there is extensive structural damage.

For this question, a module within the user function subprogram is evaluated to determine whether the containment fails, and, if it fails, the mode of failure. The user function module called in this question depends upon the branches previously taken at Questions 12, 23, 24, 27, 28, 52, 53, and 54. The user function (see Subsection A.2) determines the branch taken at this question.

For a hydrogen detonation, the module of the user function evaluated at this question compares the impulsive load due to a detonation in either the IC or upper plenum, Parameter 23 or 24, to the impulsive criterion in the IC or upper plenum, Parameter 28 or 27. If the impulsive load exceeds the impulsive failure criterion, the containment fails and the failure is a rupture in the upper containment; that is, Branch 4 is taken for this question.

For a hydrogen deflagration, the user function module adds the pressure rise due to a deflagration, Parameter 22, to the existing baseline pressure in containment during core degradation, Parameter 7, to obtain the load pressure. This is then compared to the containment failure pressure, Parameter 25. If the load pressure exceeds the failure pressure, the containment fails. The way in which the random number, Parameter 26, is used to determine the mode of containment failure 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, the experts provided an aggregate conditional probability for each failure mode as a function of failure pressure, and a table containing this information is contained in the user function. 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. The method of determining the mode of containment failure is described briefly in Subsection A.2. (See also Issue 2 in Volume 2, Part 3.)

> Case 1: A detonation has occurred in the IC or the upper plenum of the IC. The user function module denoted CFDet determines if failure occurs. If failure occurs, the branch for failure in the upper containment, Branch 4, is taken.
>
> Case 2: The containment was not isolated at the start of the accident, with an equivalent failure size of a rupture. Further overpressure failures are precluded. The user function module denoted NoCF is called from EVNTRE. The value passed from the user function assures that the no-failure branch, Branch 1, is taken.
>
> Case 3: The pressure rise is rapid compared to the leak depressurization rate, that is, development of a leak does not arrest the pressure rise in this case. The portion of the user function denoted CFFst determines if failure occurs and the mode of failure.
>
> Case 4: The pressure rise is comparable to the leak depressurization rate, that is, development of a leak arrests the pressure rise. This type of pressure rise would be expected if all containment heat removal systems failed before VB, leading to slow overpressure. The portion of

the user function denoted CFSlw determines if failure occurs and the mode of failure.

Question 59. Status of IC before VB?
3 Branches, Type 4, 3 Cases

The branches for this question are:

1. E2-IBP1 The IC is ineffective for condensing steam, and is essentially totally bypassed.

2. E2-IBP2 There is some degree of ice bypass in the IC.

3. E2nIBP The IC is intact and totally effective.

One parameter is defined in this question:

P29. IBPLvl The fractional level of ice bypass is assigned to Parameter 29.

This question is not sampled; the quantification was done internally. The branch taken and the parameter assignment at this question depends upon the branches taken at Questions 28, 30, 52, and 58.

The importance of the IC for its pressure suppression capability and for removal of fission products from the containment atmosphere is discussed in Question 29. The effective bypass of the IC due to melting of all the ice, and the partial bypass due either to the asymmetric melting of ice or to channeling was addressed in Question 30. This question addresses the partial bypass of the IC as a result of a local detonation. The degree to which any partial bypass affects loads and fission product removal is also addressed.

Case 1: The IC is effectively bypassed due to total melting of the ice as established in Question 30, or because the containment has failed early in the lower region of the containment. All the probability is assigned to the highest level of bypass, for which the fractional level of bypass, Parameter 29, assumes a value of 1.0. The quantification for this case is:

Branch 1: E2-IBP1 - 1.0
Branch 2: E2-IBP2 - 0.0
Branch 3: E2nIBP - 0.0

For Branch 1, the assignment of the parameter is:

Parameter 29: IBPLvl - 1.0

For Branches 2 and 3, the assignment of the parameter is irrelevant.

Case 2: There is a detonation in the IC, or there is some degree of early bypass, as established in Question 30. The structural expert panel roughly addressed the degree of structural damage that would be imparted to the structures in the IC. It was believed that, at most, a few dozen ice baskets would be destroyed as a result of a detonation in the IC. This corresponds to less than 5% of the original ice inventory.

Some HECTR calculations were performed to examine the response of the IC to a given steam loading for various configurations of the ice. The pressure in containment was determined with all ice present, with no ice present, and with 25% of the ice removed. Two studies were performed for the times of 25% ice removal. The first study used nominal assumptions concerning cross flow, frictional loss coefficients, etc.; whereas the second study used conservative assumptions. When 25% of the ice is removed, the pressure suppression is essentially 83% effective for the first study, and 60% effective for the second study. Another calculation, performed for 2% ice removal, indicated that only about 7% of the total steam blowdown entered the voided region of the ice bed. Considering either partial bypass due to channeling, asymmetric flow, or detonations, it is believed that effective bypass of the IC will be minimal. The quantification for this case is:

Branch 1: E2-IBP1 - 0.0
Branch 2: E2-IBP2 - 1.0
Branch 3: E2nIBP - 0.0

For Branch 1, the assignment of the parameter is irrelevant; for Branch 2 the assignment of the parameter is:

Parameter 29: IBPLvl - 0.062

For Branch 2, the assignment of the parameter is irrelevant.

Case 3: No early bypass, or no detonations have occurred in the IC. The IC is considered totally effective in its pressure suppression and fission product removal capacity. The quantification for this case is:

Branch 1: E2-IBP1 - 0.0
Branch 2: E2-IBP2 - 0.0
Branch 3: E2nIBP - 1.0

For Branches 1 and 2, the assignment of the parameter is irrelevant; for Branch 3 the assignment of the parameter is:

Parameter 29: IBPLvl - 0.0

Question 60. Are ARFs or Ducting Impaired due to Early Burns?

3 Branches, Type 2, 5 Cases

The branches for this question are:

1. E2-Fan The ARFs are functional and operating before VB.
2. E2aFan The ARFs are functional and are available to operate if power is recovered.
3. E2fFan The ARFs are failed and cannot be recovered.

This question is not sampled; the quantification was done internally. The branch taken at this question depends upon the branches taken at Questions 28, 48, and 51.

The ARFs take suction from the upper containment and discharge into the dead-ended annular region in the lower containment. The fans are fitted to ductwork which serves as the collection and distribution system for the fans. If a global hydrogen burn occurs in the lower or upper compartment, the ARFs may be rendered inoperable due to the collapsing of ductwork, bending of fan blades or the sticking open of dampers. Because there are two independent ARF systems installed on opposite sides of containment, it is believed that it is not likely that both systems will be failed at the same time.

Case 1: There is no burn in the upper or lower compartment during core degradation and the ARFs are operating. The fans will remain operating through VB. The quantification for this case is:

Branch 1: E2-Fan - 1.0
Branch 2: E2aFan - 0.0
Branch 3: E2fFan - 0.0

Case 2: There is no burn in the upper or lower compartment during core degradation and the ARFs are available to operate if power is recovered. The fans will continue to be available through VB. The quantification for this case is:

Branch 1: E2-Fan - 0.0
Branch 2: E2aFan - 1.0
Branch 3: E2fFan - 0.0

Case 3: There is a burn in the upper or lower compartment during core degradation and the ARFs are operating. It is considered likely that fans will remain operating through VB. The quantification for this case is:

Branch 1: E2-Fan - 0.75
Branch 2: E2aFan - 0.00
Branch 3: E2fFan - 0.25

Case 4: There is a burn in the upper or lower compartment during core degradation and the ARFs are available to operate if power is recovered. It is considered likely that fans will remain available through VB. The quantification for this case is:

Branch 1: E2-Fan - 0.00
Branch 2: E2aFan - 0.75
Branch 3: E2fFan - 0.25

Case 5: The fans had initially failed upon demand. The fans will remain failed throughout the accident. The quantification for this case is:

Branch 1: E2-Fan - 0.0
Branch 2: E2aFan - 0.0
Branch 3: E2fFan - 1.0

Question 61. Are sprays Impaired due to Early Containment Failure or Environment?
3 Branches, Type 2, 7 Cases

The branches for this question are:

1. E2-Sp The sprays are functional and operating before VB.
2. E2aSp The sprays are functional and are available to operate if power is recovered.
3. E2fSp The sprays are failed and cannot be recovered.

This question is not sampled; the quantification was done internally. The branch taken at this question depends upon the branches taken at Questions 27 and 58.

The two CSS trains that penetrate containment consist of 12-in. pipes. The residual heat removal (RHR) spray system consists of two 8-in. pipes. The pipes penetrate the shield building in the vicinity of the ECCS penetrations, and span a circumferential arc of about 7 ft. Within the annulus between containment and the shield building, the four pipes rise a vertical distance of about 100 ft. The pipes then penetrate the containment dome at about 40 ft above the containment springline.

The CSS and the RHR spray system might fail before VB due to clogging of the sumps by debris, direct damage to the piping by hydrogen burns, dislocation of the piping, or containment failure. At TMI, the sump water was laden with debris, yet the pumps operated normally. Some pumps in industrial service operate for years with debris laden fluid. The sump screens at Sequoyah are large, and there is a trash curb around the sump, so that blockage of the sumps severe enough to fail the pumps is deemed negligible. Hydrogen burns in the upper containment at Sequoyah would probably impart minimal damage to the sprays. Again, at TMI, the sprays survived the hydrogen burns that occurred. Spray failure due to hydrogen burns in the containment dome is considered negligible for this analysis.

The spray piping can fail due to dislocation of the pipe accompanying the swelling of the containment with an increase in pressure. As the containment wall expands with increasing pressure, the pipe could be dislodged from its supports and subsequently fail. Because of the configuration of the containment within the shield building at Sequoyah, the piping can move due to the containment wall expansion, and yet be constrained at the shield building penetrations. This factor may also lead to mechanical failure of piping or piping supports. This failure mechanism is believed to be unlikely, as the pipes have supports and penetrations designed to accommodate the movements that accompany large changes in temperature.

Structural engineers at SNL who are familiar with reactor containments were consulted about the probability of spray failure upon containment failure at Sequoyah. They agreed that the probability of spray failure for failure modes other than catastrophic rupture was unlikely. For catastrophic rupture, it was their opinion that the probability of spray failure would be assured, as the Sequoyah containment is free-standing steel, and a catastrophic rupture failure would be likely to involve such a large portion of the containment structure that all of the spray trains would be severely damaged. It is quite uncertain as to the probability of piping failure due to rupture failures in the upper containment (mainly at the springline). If the rupture occurs in a location far removed from the spray piping penetrations, the sprays will probably remain intact. For rupture failures in the lower containment (mainly anchorage failures), the containment may be uplifted, and the spray piping threatened. If the containment fails due to a lower containment rupture failure, it is quite likely that the the spray piping will remain intact. Leak failures are of minimal concern with regard to spray piping failure.

Case 1: The sprays are already failed, or the containment fails by catastrophic rupture. As mentioned above, it is believed that catastrophic rupture would involve failure of the sprays. A widely accepted scenario for catastrophic rupture involves the "unzippering" of the containment shell at the springline. Because the spray piping penetrations are located above the springline, the sprays are certain to be damaged. The quantification for this case is:

Branch 1:	E2-Sp	-	0.0
Branch 2:	E2aSp	-	0.0
Branch 3:	E2fSp	-	1.0

Case 2: The sprays are operating, and there is either no containment failure or failure involving a leak in containment. The mechanisms for failing the sprays include clogging of the sumps by debris, direct damage to the piping by hydrogen burns, or dislocation of the piping, as discussed above. It is believed that the threat due to these mechanisms is low. The quantification for this case is:

Branch 1:	E2-Sp	-	0.95
Branch 2:	E2aSp	-	0.00
Branch 3:	E2fSp	-	0.05

Case 3: The sprays are available to operate if power is recovered, and there is either no containment failure or failure involving a leak in containment. As in Case 2, the mechanisms for failing the sprays include clogging of the sumps by debris, direct damage to the piping by hydrogen burns, or dislocation of the piping. The quantification for this case is:

Branch 1: E2-Sp - 0.00
Branch 2: E2aSp - 0.95
Branch 3: E2fSp - 0.05

Case 4: The sprays are operating, and there is a rupture failure in the upper containment. It is believed to be indeterminate whether the sprays will fail. The quantification for this case is:

Branch 1: E2-Sp - 0.50
Branch 2: E2aSp - 0.00
Branch 3: E2fSp - 0.50

Case 5: The sprays are available to operate if power is recovered, and there is a rupture failure in the upper containment. It is believed to be indeterminate whether the sprays will fail. The quantification for this case is:

Branch 1: E2-Sp - 0.00
Branch 2: E2aSp - 0.50
Branch 3: E2fSp - 0.50

Case 6: The sprays are operating, and there is a rupture failure in the lower containment. It is believed that spray failure will be unlikely. The quantification for this case is:

Branch 1: E2-Sp - 0.80
Branch 2: E2aSp - 0.00
Branch 3: E2fSp - 0.20

Case 7: The sprays are available to operate if power is recovered, and there is a rupture failure in the upper containment. It is believed that spray failure will be unlikely. The quantification for this case is:

Branch 1: E2-Sp - 0.00
Branch 2: E2aSp - 0.80
Branch 3: E2fSp - 0.20

Question 62. What Fraction of Hydrogen Released In-Vessel Is in Containment at VB?
2 Branches, Type 5

The branches for this question are:

1. E2-H2Hi The hydrogen in containment at VB is greater than 50% of that which was generated in-vessel. The nominal value is assumed to be 85%.

2. E2-H2Lo The hydrogen in containment at VB is less than 50% of that which was generated in-vessel. The nominal value is assumed to be 25%.

For this question, a module within the user function subprogram is evaluated to determine which branch is taken.

At Sequoyah, when hydrogen ignition occurs before VB, much of the hydrogen that was generated in-vessel is consumed. Ignition occurs before VB when igniters are operating with probability of 1.0, and when the igniters are not operating, ignition occurs with an estimated probability as discussed in Questions 48 through 51. One of the experts addressing containment loads at VB felt that it was necessary to create an additional case-defining parameter to establish the containment hydrogen inventory at the time of VB. Thus, the level of pre-existing hydrogen was added as an additional parameter to consider in the experts' subcase definition. The level of hydrogen was defined to refer to the percentage of hydrogen released in-vessel that still remains in containment at the time of VB.

In this question, the user function module denoted H2Cont is called from EVNTRE. The amount of hydrogen generated in-vessel, the amount of hydrogen generated that is released from the vessel, and the amount of hydrogen in the lower containment, IC, upper plenum, and upper containment are passed to the user function. The amount of hydrogen initially contained in each of the compartments is adjusted for burns in Question 54, as dictated by the burn completeness parameters, Parameters 14, 15, 16, and 17.

Question 63. Level of Cavity Flood at VB?
3 Branches, Type 2, 3 Cases

The branches for this question are:

1. E2-CDry The reactor cavity contains little (less than 3,000 ft^3) or no water at the time of VB.

2. E2-CWet The reactor cavity contains between 3,000 to 10,000 ft^3 of water at VB. The nominal depth of the water is 10 ft.

3. E2-CDp The reactor cavity is deeply flooded at VB, containing more than 10,000 ft^3 of water. The nominal depth of the water is 24 ft.

Case 2 of this question is sampled zero-one, and was quantified internally. For Cases 1 and 3, the amount of water in the reactor cavity may be reliably deduced from the information available about the injection of the RWST water into the containment and the degree of ice melt. The branch taken at this question depends upon the branches previously taken at Questions 8, 22, 24, and 29.

As used here, the cavity includes not only the annular space around the vessel and the cylindrical space directly under the vessel, but also the instrumentation tunnel keyway which is completely open on one end to the cylindrical cavity proper. A personnel access located about 41 ft above the reactor cavity floor, above the ceiling of the instrumentation tunnel, provides a path which allows water on the lower containment floor to overflow into the reactor cavity. The bottom of the reactor vessel is located about 16 ft above the reactor cavity floor. Thus, the bottom of the reactor vessel can potentially be submerged in water, given a substantial amount of water in the cavity. The floor area of the cavity region is about 650 ft^2, and the cavity volume is irregularly shaped. The amount of water needed to contact the bottom of the reactor vessel is about 10,000 ft^3. At 41 ft above the reactor cavity floor, which is about at the location of the hot leg inlet to the reactor vessel, the volume of water is approximately 18,000 ft^3.

The cavity at Sequoyah has no direct connection at or near the basemat elevation with the sumps from the lower containment floor. Thus, the water that will collect in the cavity is due to the accumulation of water on the lower containment floor that overflows into the cavity, as described above. The amount of water needed on the lower containment floor for overflow into the cavity is about 51,000 ft^3. The injection of the RWST into containment before VB can occur by operation of the ECCS and subsequent release through a break or the PORVs, or by operation of the sprays. Whether or not the RWST is injected into containment is addressed in Question 8. If the RWST is injected, the amount of water in the lower containment is about 45,000 ft^3. The amount of water in the IC is about 39,000 ft^3. The level of ice melt before VB is addressed in Question 29. Neither injection of the RWST alone nor melt of all the ice alone is sufficient to assure water in the cavity. If one quarter of the ice melts, and the RWST is injected into containment, there will be about 3,750 ft^3 of water in the cavity, corresponding to a depth of about 5.5 ft. If half of the ice melts, and the RWST is injected into containment, there will be about 13,500 ft^3 of water in the cavity, corresponding to a depth of about 22 ft.

If the only water in the cavity is that due to accumulator dump at VB, the water depth will be at least 5 ft. What is of interest here is the presence of water for the DCH and ex-vessel steam explosion (EVSE) events. The magnitude of the pressure rise due to DCH depends upon whether there is water in the cavity. Whether an EVSE occurs also depends upon whether there is water in the cavity. If the accumulators discharge at VB, the accumulator water will enter the cavity only after the the molten core enters the cavity and after DCH occurs. Thus, whether the accumulators discharge at vessel breach is irrelevant for these two events.

Case 1: The RWST was not injected into the containment before breach, so the reactor cavity contains little or no water at breach. The quantification for this case is:

Branch 1:	E2-CDry	-	1.0
Branch 2:	E2-CWet	-	0.0
Branch 3:	E2-CDp	-	0.0

Case 2: The RWST was injected into the containment before breach and there is less than half of the ice melted. If there is blowdown of the RCS inventory to containment, there will be a substantial thermal load placed on the IC, as discussed in Question 29. It is believed that at least one quarter of the ice will be melted, which corresponds to a wet cavity as defined above. If as much as half of the ice is melted, the cavity will be deeply flooded. Much uncertainty exists with respect to the exact amounts of water involved and the amount of ice melt. As this case was sampled zero-one, each observation had all the probability assigned to one of these two branches. Taking the average over all the observations, the quantification for this case is:

Branch 1: E2-CDry - 0.00
Branch 2: E2-CWet - 0.50
Branch 3: E2-CDp - 0.50

Case 3: The RWST was injected into the containment before breach, and there is more than half of the ice melted. The cavity is assumed to be deeply flooded. The quantification of this case is:

Branch 1: E2-CDry - 0.0
Branch 2: E2-CWet - 0.0
Branch 3: E2-CDp - 1.0

Question 64. Does an Alpha Mode Event Fail Both the Vessel and the Containment?
2 Branches, Type 2, 3 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 The vessel does not fail in this manner.

This question is sampled; the distribution used was developed internally from the opinions expressed by the steam explosion review group as documented in NUREG-1116.[A.1-15] The experts' individual distributions and the aggregation of them are presented in Volume 2, Part 6, of this report. The branch taken at this question depends upon the branches previously taken at Questions 25 and 26.

Case 1: There is VB with the RCS at low pressure. Steam explosions are more likely when the RCS is at low pressure than when the RCS is at some higher pressure. The aggregate distribution developed from distribution in the SERG was used for this case. This distribution covers many orders of magnitude. Based on the mean value of the distribution, the quantification for this case is:

Branch 1: Alpha - 0.008
Branch 2: noAlpha - 0.992

Case 2: There is VB and the RCS is not at low pressure. Steam explosions are less likely when the RCS is not at low pressure. The aggregate distribution used in the preceding case was decreased by an order of magnitude for use in this case. Based on the mean value of the distribution, the quantification for this case is:

Branch 1: Alpha = 0.0008
Branch 2: noAlpha = 0.9992

Case 3: The core degradation process has been arrested and there is no VB. The quantification for this case is:

Branch 1: Alpha = 0.0
Branch 2: noAlpha = 1.0

Question 65. **Type of VB?**
5 Branches, Type 2, 6 Cases

The branches for this question are:

1.	PrEj	The molten core material is ejected under considerable pressure from a hole in the bottom of the vessel.
2.	Pour	The molten core material pours slowly from the vessel, primarily driven by gravity.
3.	BtmHd	A large portion of the bottom head fails, perhaps due to a circumferential failure.
4.	Alpha	Alpha mode failure has occurred.
5.	noVB	There is no failure of the reactor pressure vessel.

Cases 2, 3, and 4 are sampled zero-one; the type of VB was determined by the In-Vessel Expert Panel. The conclusions of the experts and their aggregate distributions are presented in Volume 2, Part 1, of this report. The branch taken at this question depends upon the branches previously taken at Questions 23, 24, and 35.

The pressurized ejection failure mode requires that the RCS be at high pressure (greater than 200 psia) when the vessel fails. The expert panel generally had in mind the failure of one or a few penetrations in the bottom head when discussing this failure mode. Although the pour failure mode is often considered to occur only with the RCS at low pressure (less than 200 psia), at least one expert concluded that the probability of this failure mode with the RCS at high pressure at VB was non-zero. The scenario envisaged is that the RCS fails before the bulk of the core debris relocates in the bottom head of the vessel. The failure occurs due to a small amount of molten debris that "dribbles" to the bottom head along an instrumentation tube and fails near a penetration. The RCS then blows down through this break, but no core debris is expelled. After the blowdown, the bulk of the debris locates to the lower head, subsequently failing it, and the core debris pours out into the cavity. Although there could be a small driving force due to the gas pressure in the RCS, the pour failure mode is distinguished by the fact that gravity is the primary force causing the molten core debris to leave the vessel.

The bottom head failure mode can occur at any RCS pressure; the failure could be a circumferential failure in which the whole bottom head falls into the cavity or some other failure in which a substantial portion of the bottom head fails. Bottom head failure at high pressure has effects similar to high pressure melt ejection (HPME); bottom head failure at low pressure has effects similar to a pour failure. Branches 4 and 5 are used to indicate that none of the three preceding branches applies.

Case 1: The core degradation process has been arrested and there is no VB. The quantification for this case is:

Branch 1: PrEj - 0.0
Branch 2: Pour - 0.0
Branch 3: BtmHd - 0.0
Branch 4: Alpha - 0.0
Branch 5: noVB - 1.0

Case 2: An Alpha mode failure of both the vessel and the containment has occurred. The quantification for this case is:

Branch 1: PrEj - 0.0
Branch 2: Pour - 0.0
Branch 3: BtmHd - 0.0
Branch 4: Alpha - 1.0
Branch 5: noVB - 0.0

Case 3: The vessel fails when the RCS is at system setpoint pressure. The most likely failure mode is failure of a penetration, leading to HPME. This is Case 1 of In-Vessel Issue 6. The sampling was zero-one, so each observation had all the probability assigned to one of these three branches. Taking the average over all the observations, the quantification for this case is:

Branch 1: PrEj - 0.79
Branch 2: Pour - 0.08
Branch 3: BtmHd - 0.13
Branch 4: Alpha - 0.00
Branch 5: noVB - 0.00

Case 4: The vessel fails when the RCS is at high pressure. The most likely failure mode is penetration failure leading to HPME, which is about twice as likely as the pour failure mode, and four times as likely as the gross bottom head failure mode. This is Case 2 of In-Vessel Issue 6. The sampling was zero-one, so each observation had all the probability assigned to one of these three branches. Taking the average over all the observations, the quantification for this case is:

Branch 1: PrEj - 0.60
Branch 2: Pour - 0.27
Branch 3: BtmHd - 0.13
Branch 4: Alpha - 0.00
Branch 5: noVB - 0.00

Case 5: The vessel fails when the RCS is at intermediate pressure. This is Case 3 of In-Vessel Issue 6. The branch assignment is identical to that for Case 2. Taking the average over all the observations, the quantification for this case is:

Branch 1: PrEj - 0.60
Branch 2: Pour - 0.27
Branch 3: BtmHd - 0.13
Branch 4: Alpha - 0.00
Branch 5: noVB - 0.00

Case 6: The vessel fails when the RCS is at low pressure. The failure mode is gravity pour. The quantification for this case is:

Branch 1: PrEj - 0.0
Branch 2: Pour - 1.0
Branch 3: BtmHd - 0.0
Branch 4: Alpha - 0.0
Branch 5: noVB - 0.0

Question 66. **Fraction of the Core Released from the Vessel at Breach?**
1 Branch, Type 4, 2 Cases

The single branch for this question is always taken. The branch is:

1. FCorVB The fraction of the core released from the vessel at breach.

One parameter is defined in this question:

P30. FCorVB The fraction of core released from the vessel is assigned to Parameter 30.

This question is sampled; the distribution was provided by the In-Vessel Expert Panel as part of Issue 6. The conclusions of the experts and their aggregate distributions are presented in Volume 2, Part 1, of this report. The case selected in this question depends upon the branch taken at Question 26.

Case 1: VB occurs. Parameter 30 is primarily used to determine the amount of the core that participates in DCH as a result of HPME. Based on the mean value of the experts' aggregate distribution, the assignment of the parameter is:

Parameter 30: FCorVB - 0.30

Case 2: VB does not occur. There is no core that escapes from the vessel. The assignment of the parameter is:

Parameter 30: FCorVB - 0.0

Question 67. Level of the Core Released from the Vessel at Breach?
3 Branches, Type 5

The branches for this question are:

1.	Hi-FCoR	More than 40% of the core is released promptly from the vessel at breach.
2.	Md-FCoR	Less than 40% but more than 20% of the core is released promptly from the vessel at breach.
3.	Lo-FCoR	Less than 20% of the core is released promptly from the vessel at breach.

This question assigns the fraction of the core released at VB, Parameter 30, to one of three groups as designated by the branches.

Question 68. Fraction of the Core Released at VB that is Diverted to the In-Core Instrumentation Room?
1 Branch, Type 4, 8 Cases

The single branch for this question is always taken. The branch is:

1.	CorIR	The fraction of core released at VB that is diverted to the ICIR.

One parameter is defined in this question:

P31. CorIR	The fraction of the core released from the vessel that is diverted to the ICIR is assigned to Parameter 31.

Cases 2 through 8 for this question are sampled; the distributions were determined internally. The case selected in this question depends upon the branches taken at Questions 1, 24, 25, 63, 65, and 67.

The ejection of molten corium under high pressure from the vessel at breach may lead to a containment failure involving direct thermal attack of the containment liner in the in-core instrumentation room, where the seal table is located. This failure mode is described in detail in SAND86-2141C.[A.1-16] One of the ways for dispersed debris to exit the reactor cavity is directly through the personnel access to the instrumentation tunnel as described for Question 63. Another exit from the cavity is deemed possible if the seal table fails. The seal table is the plate at which the instrumentation tubes terminate. In this scenario, seal table failure is assumed to occur by a combination of thermal attack and mechanical loads. Debris is then inertially driven to enter the instrumentation room and accumulates on the floor. If a substantial amount of debris piles up against the wall, the debris may melt through the 1.5 in.-thick steel containment wall. Input to the quantification of this question was obtained from an ad hoc panel composed of M. Pilch and W. Tarbell of SNL. M. Pilch executed a series of GASBLOW calculations to aid in the quantification of the amount of debris expected to enter the instrumentation room.

Case 1: HPME does not occur and the level of core ejected from the vessel is less than 40% of the initial core inventory, there is a very large break in the RCS assuring full depressurization, or the cavity is deeply flooded. The panel formed for quantification of this issue required that HPME occur as described for Question 65, with one exception. If the RCS is not fully depressurized, but at low pressure when the vessel fails, e.g., 200 psia, and more than 40% of the core is involved in the ejection of debris from the vessel, they believed that a small amount of the debris could enter the instrumentation room. If the initial break in the system was large (A-size or S_1-size), there will be no core debris that enters the instrumentation room. If the cavity is flooded with water, it is believed that there will be minimal dispersal of debris from the cavity. For this case, the assignment of the parameter is:

Parameter 31: CorIR - 0.0

Case 2: HPME does not occur and the level of core ejected from the vessel is more than 40% of the initial core inventory. Based on the mean value of the distribution, the assignment of the parameter is:

Parameter 31: CorIR - 0.146

Case 3: HPME occurs with the RCS at intermediate pressure (between 200 and 600 psia), and more than 40% of the core is ejected at VB. Based on the mean value of the distribution, the assignment of the parameter is:

Parameter 31: CorIR - 0.331

Case 4: HPME occurs with the RCS at intermediate pressure, and 20% to 40% of the core is ejected at VB. Based on the mean value of the distribution, the assignment of the parameter is:

Parameter 31: CorIR - 0.326

Case 5: HPME occurs with the RCS at intermediate pressure, and less than 20% of the core is ejected at VB. Based on the mean value of the distribution, the assignment of the parameter is:

Parameter 31: CorIR - 0.307

Case 6: HPME occurs with the RCS at high pressure (greater than 1000 psia), and more than 40% of the core is ejected at VB. Based on the mean value of the distribution, the assignment of the parameter is:

Parameter 31: CorIR - 0.419

Case 7: HPME occurs with the RCS at high pressure, and 20% to 40% of the core is ejected at VB. Based on the mean value of the distribution, the assignment of the parameter is:

Parameter 31: CorIR - 0.417

Case 8: HPME occurs with the RCS at intermediate pressure, and less than 20% of the core is ejected at VB. Based on the mean value of the distribution, the assignment of the parameter is:

Parameter 31: CorIR - 0.417

Question 69. Level of the Core Ejected to the In-Core Instrumentation Room at VB?
5 Branches, Type 5

The branches for this question are:

1. 60T-IR More than 50 metric tons of the core (nominally 60 metric tons) is released to the instrumentation room at VB.
2. 40T-IR From 30 to 50 metric tons of the core (nominally 40 metric tons) is released to the instrumentation room at VB.
3. 20T-IR From 10 to 30 metric tons of the core (nominally 20 metric tons) is released to the instrumentation room at VB.
4. 5T-IR Less than 10 metric tons of the core (nominally 5 metric tons) is released to the instrumentation room at VB.

This question operates on the fraction of core released at VB, Parameter 30, and the fraction of Parameter 30 that is ejected to the instrumentation room, Parameter 31. The parameters are multiplied, and then assigned to one of five groups as designated by the branches.

Question 70. Does the Vessel Become a "Rocket" and Fail the Containment or Bypass the IC?
3 Branches, Type 2, 2 Cases

The branches for this question are:

1. Rkt-CF When the vessel fails it is accelerated upward at high speed and fails the containment.

2. Rkt-IBP When the vessel fails, it is accelerated upward and impacts and damages the missile shield, thereby compromising the seal between the lower and upper compartment and effectively bypassing the IC.

3. noRkt When the vessel fails, it is not accelerated upward at high speed and does not fail the containment, nor does it bypass the IC.

This question is not sampled and was quantified internally. The branch taken at this question depends upon the branches taken at Questions 25 and 65.

The "rocket" problem has not been well studied. A possible scenario is: there is gross failure of the bottom head of the vessel at high pressure. The gas inside the vessel is at about 2500 psia and its escape from the bottom of the vessel accelerates the vessel upwards. The bolts holding down the vessel fail, the t legs a l cold legs are sheared off, and the vessel attains enough momen ris lear of the shield wall. Striking the containment wall, the vessel [illegible] the pressure boundary. Before striking the containment wall or dome, the vessel must dislodge the control rod drive missile shield and avoid or dislodge the polar crane. If the containment is failed by the Rocket mode, it is assumed that the IC is totally bypassed.

Case 1: There is gross failure of the bottom head of the vessel with the RCS at system setpoint pressure. The rocket type of event may be credible. The Sequoyah cavity is much larger than those in German PWRs, so the Rocket failure mode of containment is considered to be less likely than estimated for German reactors. It is believed that the probability Rocket mode failure of containment is about the same as the mean probability value for Alpha mode failure of containment. The compromise of the seal between the lower and upper compartments is deemed more likely than containment failure. The quantification for this case is:

Branch 1: Rkt-CF - 0.01
Branch 2: Rkt-IBP - 0.04
Branch 3: NoRkt - 0.95

Case 2: There is gross failure of the bottom head of the vessel with the RCS at high pressure. The rocket failure of containment is not credible. However, the compromise of the seal between the lower and upper compartments in the cavity is considered possible, though not very likely. The quantification for this case is:

Branch 1: Rkt-CF - 0.00
Branch 2: Rkt-IBP - 0.05
Branch 3: NoRkt - 0.95

Case 3: There is no gross failure of the bottom head of the vessel at system setpoint pressure or high pressure: failure of containment or the control rod drive missile shield by the Rocket mode is not credible. The quantification for this case is:

Branch 1: Rkt-CF - 0.0
Branch 2: Rkt-IBP - 0.0
Branch 3: NoRkt - 1.0

Question 71. **Ex-Vessel Steam Explosion at VB?**
3 Branches, Type 2, 4 Cases

The branches for this question are:

1.	EVSE	An energetic molten fuel-coolant interaction occurs in the reactor cavity upon VB.
2.	EVSE-CF	An energetic molten fuel-coolant interaction occurs in the reactor cavity upon VB, resulting in containment failure.
3.	noEVSE	No energetic molten fuel-coolant interaction occurs in the reactor cavity upon VB.

This question is not sampled and was quantified internally. The branch taken at this question depends upon the branches previously taken at Questions 25, 63, 65, and 37.

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 SNL, steam explosions were observed in 86% of the tests where hot metal was dropped into water. Some of these explosions were extremely energetic, others were not very energetic. In a severe reactor accident, a steam explosion may occur when the core slumps into the lower head of the vessel, known as an in-vessel steam explosion (IVSE), or when the lower head of the vessel fails and the core falls or is expelled into water in the reactor cavity beneath the vessel. This latter event is known as an EVSE. The Sequoyah containment is typically considered invulnerable to failure due to an EVSE. Only for times when the cavity is deeply flooded is it considered possible for failure to occur. The scenario involves the transmission of the impulse from an EVSE through the instrumentation tunnel that terminates at the seal table. If enough energy is imparted to the concrete skirt at the base of the seal table, it is possible that a missile could be generated and driven through the containment wall. The static pressure rise due to an EVSE was addressed by the containment loads expert panel that addressed pressure rise at VB. A discussion of the quantification of this issue is in Vol. 2, Part 6, of this report.

The effects of EVSEs are considered in two places in this APET. If the RCS is at high pressure (greater than 200 psia) at VB, the effects of an EVSE at VB are considered in Questions 74 and 75. The experts who considered pressure rise at VB included the pressure rise due to EVSEs in their distributions for total pressure rise. The other effects of an EVSE are considered to be small when compared with the effects of HPME.

As an EVSE is not deemed capable of failing the containment, whether an EVSE occurs following a low pressure VB determines:

1. Whether the debris bed in the reactor cavity after VB is in a coolable configuration;
2. If the pressure rise for a low pressure VB is fast or slow; and
3. The amount of core involved in CCI.

A small steam explosion that involves only a very small fraction of the core will not have any discernible effect on this analysis. A "significant" EVSE is one that involves a considerable portion of the released core material and affects at least one of the three aspects of the analysis listed above.

Case 1: The cavity is dry at VB, the vessel fails by an Alpha mode event, or there is no VB. An EVSE is not possible. The quantification of this case is:

Branch 1: EVSE - 0.0
Branch 2: EVSE-CF - 0.0
Branch 3: noEVSE - 1.0

Case 2: HPME accompanies vessel failure and the water level in the reactor cavity is below the bottom head of the vessel. The quantification for this case is:

Branch 1: EVSE - 0.86
Branch 2: EVSE-CF - 0.00
Branch 3: noEVSE - 0.14

Case 3: The vessel failure resulted in the melt pouring out, driven primarily by gravity, and the water level in the reactor cavity is below the bottom head of the vessel; or the cavity is deeply flooded with less than 20% of the core ejected at VB. The probability of an EVSE is the same as for Case 2. The quantification for this case is:

Branch 1: EVSE - 0.86
Branch 2: EVSE-CF - 0.00
Branch 3: noEVSE - 0.14

Case 4: The reactor cavity is deeply flooded and more than 20% of the core is ejected at VB. This is the only case in which containment failure is deemed possible, and the likelihood of failure is believed to be very small. The probability of an EVSE is the same as for Cases 2 and 3. The quantification for this case is:

Branch 1: EVSE - 0.85
Branch 2: EVSE-CF - 0.01
Branch 3: noEVSE - 0.14

Question 72. **Size of Hole in Vessel (After Ablation)?**
2 Branches, Type 2, 2 Cases

The branches for this question are:

1.	LgHole	The hole size, after ablation, exceeds 0.4 m^2. The nominal large hole size is 2.0 m^2.
2.	SmHole	The hole size, after ablation, does not exceed 0.4 m^2. The nominal small hole size is 0.1 m^2.

Case 1 is sampled zero-one; this question was quantified internally. The branch taken at this question depends upon the branch previously taken at Question 65.

In situations with HPME, the pressure rise at VB depends upon the size of the hole in the vessel. Note that this is the hole size after ablation, that is, the hole size after any enlargement during the expulsion of the molten core debris and at the beginning of the gas blowdown. It is the high-speed jet of gas impinging on the molten corium in the cavity, entraining it, and dispersing it throughout the containment, that is responsible for DCH pressure rise. The experts who determined the distributions for pressure rise at VB concluded that the pressure rise depended on hole size.

Computer simulations for melt masses varying from 25 metric tons to 75 metric tons and for pressures ranging from 100 psia to 2500 psia have shown that the failure of one PWR bottom head penetration will result in a hole, after ablation, that has an area on the order of 0.1 to 0.2 m^2, or smaller. Holes sizes on the order of 0.4 m^2 are be observed in computer simulations only if a number of penetrations fail simultaneously. At 2500 psia, the time required for melt ejection is about 3 to 4 s, and at 500 psia, the time required for melt ejection is about 6 to 8 s. For the multiple penetration failures to be considered simultaneous, they must occur within a fraction of the melt ejection time. Thus, to be effective, the multiple penetration failures must occur within a fraction of a second of each other. This appears to be very unlikely. More information on the analysis used to determine hole size distribution may be found in Volume 2, Part 6, of this report.

Case 1: The failure of the vessel is accompanied by HPME. The hole size is important in determining the pressure rise in the containment. It was concluded that the probability of a small hole in the vessel when it fails in the HPME mode is 0.90. As this question is sampled zero-one, 90% of the observations have 1.0 for the probability of the small hole branch and 10% of the observations have 1.0 for the probability of the large hole branch. Taking the average over all the observations, the quantification for this case is:

Branch 1: LgHole - 0.10
Branch 2: SmHole - 0.90

Case 2: The failure of the vessel is not accompanied by HPME, the mode of failure involves a large portion of the bottom head, or the hole size is irrelevant. The quantification for this case is:

Branch 1: LgHole - 1.0
Branch 2: SmHole - 0.0

Question 73. **Maximum Peak Pressure Rise at VB? (For cases that do not involve HPME with subsequent dispersal from the reactor cavity.)**
2 Branches, Type 4, 9 Cases

The branches for this question are:

1. DP1-VB The events at VB do not involve containment pressurization due to events associated with high pressure ejection of the molten core from the vessel with subsequent dispersal from the reactor cavity.

2. nDP1-VB The pressure rise at VB involves HPME and debris dispersal from the reactor cavity.

Two parameters are defined in this question:

P32. DP1-VB The peak pressure rise in containment, in kPa, is assigned to Parameter 32. The pressure rise for this question is due to all the events that occur at VB for the times when HPME is not involved in the expulsion of melt from the vessel, or the cavity is deeply flooded. The IC is totally functional.

P33. DP1-IBP The peak pressure rise in containment, in kPa, is assigned to Parameter 33. The pressure rise for this question is due to all the events that occur at VB for the times when HPME is not involved in the expulsion of melt from the vessel, or the cavity is deeply flooded. The IC is totally ineffective.

The parameter values in Cases 4 through 8 are sampled. Distributions for the pressure rise at VB were provided by the containment loads expert panel. The branch taken at this question depends upon the branches previously taken at Questions 25, 27, 30, 33, 62, 63, 64, 65, 70, and 71.

The experts provided distributions for pressure rise at VB that included the effects of all the events that accompany vessel failure. These include EVSE, vessel blowdown, hydrogen combustion, and DCH. The effects of the various events are inseparable, so there is no way to extract, for example, the contribution of DCH or hydrogen combustion to the total pressure rise. Because of the number of cases defined by the experts, three questions are used to determine pressure rise at VB. This question considers the Alpha and Rocket mode failures, the times when the melt is expelled from the vessel in a gravity-driven manner, and the times when the reactor cavity is deeply flooded. The next two questions consider the pressure rise for times in which HPME occurs and the cavity is not deeply flooded.

The experts provided distributions for pressure for times in which the IC was assumed to be fully effective, and for times in which it was assumed to be fully ineffective (as in the case of total ice melt). Parameters 32, 34, and 36 (DP1-VB, DP2-VB, and DP3-VB) are adjusted in Question 77 if it is determined that there is any degree of ice bypass at VB. The adjustment is made by considering the effective level of ice bypass as defined in Question 76, and by using Parameters 33, 35, and 37 (DP1-IBP, DP2-IBP, and DP3-IBP).

More information on the determination of the aggregate distributions for pressure rise at VB by the Containment Loads Expert Panel can be found in Volume 2, Part 2, of this report.

Case 1: The core degradation process has been arrested and there is no VB. The pressure rise is zero. The quantification for this case is:

Branch 1: DP1-VB - 1.0
Branch 2: nDP1-VB - 0.0

For Branch 1, the assignment of the parameters is:

Parameter 32: DP1-VB - 0.0
Parameter 33: DP1-IBP - 0.0

For Branch 2, the assignment of the parameters is irrelevant.

Case 2: The vessel failure involves low system pressure or gravity-driven expulsion of the melt, the sprays are not operating, the IC is ineffective, and the containment atmosphere has a steam concentration greater than 60%. There will be no hydrogen burn at vessel failure, because the atmosphere is steam inert. The existing containment pressure at VB is high due to the steam partial pressure as specified in Question 36, Case 2. There will be minimal pressure rise at VB. The quantification for this case is:

Branch 1: DP1-VB - 1.0
Branch 2: nDP1-VB - 0.0

For Branch 1, the assignment of the parameters is:

Parameter 32: DP1-VB - 0.0
Parameter 33: DP1-IBP - 0.0

For Branch 2, the assignment of the parameters is irrelevant.

Case 3: There is an Alpha or Rocket mode failure of the vessel and the containment, or the containment fails by an EVSE at VB. The pressure rise at VB is set to an arbitrary high value to ensure that containment failure occurs in Question 77. The quantification for this case is:

Branch 1: DP1-VB - 1.0
Branch 2: nDP1-VB - 0.0

For Branch 1, the assignment of the parameters is:

Parameter 32: DP1-VB - 9999.0
Parameter 33: DP1-IBP - 9999.0

For Branch 2, the assignment of the parameters is irrelevant.

Case 4: The reactor cavity is deeply flooded at VB, with water depth in the cavity nominally 24 ft. The experts believed that DCH would be mitigated regardless of system pressure at vessel failure. The quantification of this case is the same as for Case 7 of this question, which involves VB without HPME, a wet cavity, and a significant amount of hydrogen burned before VB (it is assumed that ignition has occurred because ac power is required for flooding of the cavity). The quantification for this case is:

Branch 1: DP1-VB - 1.0
Branch 2: nDP1-VB - 0.0

For Branch 1, the assignment of the parameters, based on the mean values of the aggregate distributions, is:

Parameter 32: DP1-VB - 134.30
Parameter 33: DP1-IBP - 147.90

For Branch 2, the assignment of the parameters is irrelevant.

Case 5: VB does not involve HPME, the reactor cavity is wet (nominal depth of 10 ft), and a significant amount of hydrogen remains in containment at VB. The quantification for this case is:

Branch 1: DP1-VB - 1.0
Branch 2: nDP1-VB - 0.0

For Branch 1, the assignment of the parameters, based on the mean values of the aggregate distributions, is:

Parameter 32: DP1-VB - 325.10
Parameter 33: DP1-IBP - 357.40

For Branch 2, the assignment of the parameters is irrelevant.

Case 6: VB does not involve HPME, the reactor cavity is dry, and a significant amount of hydrogen remains in containment at VB. The quantification for this case is:

Branch 1: DP1-VB - 1.0
Branch 2: nDP1-VB - 0.0

For Branch 1, the assignment of the parameters, based on the mean values of the aggregate distributions, is:

Parameter 32: DP1-VB - 215.10
Parameter 33: DP1-IBP - 292.30

For Branch 2, the assignment of the parameters is irrelevant.

Case 7: VB does not involve HPME, the reactor cavity is wet (nominal depth of 10 ft), and a significant amount of hydrogen is burned before VB. The quantification for this case is:

Branch 1: DP1-VB - 1.0
Branch 2: nDP1-VB - 0.0

For Branch 1, the assignment of the parameters, based on the mean values of the aggregate distributions, is:

Parameter 32: DP1-VB - 134.30
Parameter 33: DP1-IBP - 147.90

For Branch 2, the assignment of the parameters is irrelevant.

Case 8: VB does not involve HPME, the reactor cavity is dry, and a significant amount of hydrogen is burned before VB. The quantification for this case is:

Branch 1: DP1-VB - 1.0
Branch 2: nDP1-VB - 0.0

For Branch 1, the assignment of the parameters, based on the mean values of the aggregate distributions, is:

Parameter 32: DP1-VB - 56.30
Parameter 33: DP1-IBP - 63.50

For Branch 2, the assignment of the parameters is irrelevant.

Case 9: VB involves HPME, and dispersal of the debris from the reactor cavity. These scenarios are quantified in Questions 74 and 75, with assignment of values to the parameters involved with HPME at intermediate and high pressures. Parameters 32 and 33 are therefore assigned values of zero. The quantification for this case is:

Branch 1: DP1-VB - 0.0
Branch 2: nDP1-VB - 1.0

For Branch 1, the assignment of the parameters, is irrelevant. For Branch 2, the assignment of the parameters is:

Parameter 32: DP1-VB - 0.0
Parameter 33: DP1-IBP - 0.0

Question 74. Maximum Peak Pressure Rise at VB? (For cases that involve HPME with the RCS at intermediate pressure and significant hydrogen present at VB.)
2 Branches, Type 4, 20 Cases

The branches for this question are:

1. DP2-VB The events at VB involve containment pressurization due to events associated with high pressure ejection of the molten core from the vessel with the system at intermediate pressure and with a significant amount of hydrogen present in the containment at VB.

2. nDP2-VB The pressure rise at VB either does not involve HPME or involves HPME in a situation other than that stated for Branch 1.

Two parameters are defined in this question:

P34. DP2-VB The peak pressure rise in containment, in kPa, is assigned to Parameter 34. The pressure rise for this question is due to all the events that occur at VB for the times when HPME at intermediate pressure occurs and there is a significant amount of hydrogen in the containment at VB. The IC is totally functional.

P35. DP2-IBP The peak pressure rise in containment, in kPa, is assigned to Parameter 35. The pressure rise for this question is due to all the events that occur at VB for the times when HPME at intermediate pressure occurs and there is a significant amount of hydrogen in the containment at VB. The IC is totally ineffective.

The parameter values in Cases 2 through 19 are sampled. Distributions for the pressure rise at VB were provided by the Containment Loads Expert Panel. The branch taken at this question depends upon the branches previously taken at Questions 25, 39, 62, 63, 67, 72, and 73.

Because of the number of cases for pressure rise at VB, three questions are used. The previous question addressed no vessel failure, Alpha and Rocket mode failures, and vessel failures in which HPME does not occur or debris dispersal from the reactor cavity does not occur, because it is deeply flooded. This question addresses vessel failures involving HPME when the system is at intermediate pressure (200 to 600 psia), and there is a significant amount of hydrogen in the containment (as discussed in Question 62). The following question will address vessel failures involving HPME when the system is at intermediate pressure and a significant amount of hydrogen was burned before VB, and vessel failures involving HPME when the system is at high or setpoint pressure (greater than 1000 psia).

Case 1: The pressure rise at VB was either quantified in Question 73, or it will be quantified in Question 75. The quantification for this case is:

Branch 1: DP2-VB - 0.0
Branch 2: nDP2-VB - 1.0

For Branch 1, the assignment of the parameters is irrelevant. For Branch 2, the assignment of the parameters is:

Parameter 34: DP2-VB - 0.0
Parameter 35: DP2-IBP - 0.0

Case 2: VB involves HPME with the reactor at intermediate pressure, the reactor cavity is wet (nominal depth of 10 ft), a significant amount of hydrogen remains in the containment at VB, the fraction of core ejected from the vessel is high (greater than 40%), and the vessel hole size after ablation is large (greater than 0.4 m^2). The quantification for this case is:

Branch 1: DP2-VB - 1.0
Branch 2: nDP2-VB - 0.0

For Branch 1, the assignment of the parameters, based on the mean values of the aggregate distributions, is:

Parameter 34: DP2-VB - 363.10
Parameter 35: DP2-IBP - 590.20

For Branch 2, the assignment of the parameters is irrelevant.

Case 3: VB involves HPME with the reactor at intermediate pressure, the reactor cavity is wet, a significant amount of hydrogen remains in the containment at VB, the fraction of core ejected from the vessel is moderate (from 20% to 40%), and the vessel hole size after ablation is large. The quantification for this case is:

Branch 1: DP2-VB - 1.0
Branch 2: nDP2-VB - 0.0

For Branch 1, the assignment of the parameters, based on the mean values of the aggregate distributions, is:

Parameter 34: DP2-VB - 252.70
Parameter 35: DP2-IBP - 413.30

For Branch 2, the assignment of the parameters is irrelevant.

Case 4: VB involves HPME with the reactor at intermediate pressure, the reactor cavity is wet, a significant amount of hydrogen remains in the containment at VB, the fraction of core ejected from the vessel is small (less than 20%), and the vessel hole size after ablation is large. The quantification for this case is:

Branch 1: DP2-VB - 1.0
Branch 2: nDP2-VB - 0.0

For Branch 1, the assignment of the parameters, based on the mean values of the aggregate distributions, is:

Parameter 34: DP2-VB - 193.80
Parameter 35: DP2-IBP - 238.50

For Branch 2, the assignment of the parameters is irrelevant.

Case 5: VB involves HPME with the reactor at intermediate pressure, the reactor cavity is wet, a significant amount of hydrogen remains in the containment at VB, the fraction of core ejected from the vessel is high, the vessel hole size after ablation is small (less than 0.4 m^2), and the amount of in-vessel zirconium oxidation was high (greater than 40%). The quantification for this case is:

Branch 1: DP2-VB - 1.0
Branch 2: nDP2-VB - 0.0

For Branch 1, the assignment of the parameters, based on the mean values of the aggregate distributions, is:

Parameter 34: DP2-VB - 328.20
Parameter 35: DP2-IBP - 567.60

For Branch 2, the assignment of the parameters is irrelevant.

Case 6: VB involves HPME with the reactor at intermediate pressure, the reactor cavity is wet, a significant amount of hydrogen remains in the containment at VB, the fraction of core ejected from the vessel is moderate, the vessel hole size after ablation is small, and the amount of in-vessel zirconium oxidation was high. The quantification for this case is:

Branch 1: DP2-VB - 1.0
Branch 2: nDP2-VB - 0.0

For Branch 1, the assignment of the parameters, based on the mean values of the aggregate distributions, is:

Parameter 34: DP2-VB - 252.70
Parameter 35: DP2-IBP - 413.30

For Branch 2, the assignment of the parameters is irrelevant.

Case 7: VB involves HPME with the reactor at intermediate pressure, the reactor cavity is wet, a significant amount of hydrogen remains in the containment at VB, the fraction of core ejected from the vessel is small, the vessel hole size after ablation is small, and the amount of in-vessel zirconium oxidation was high. The quantification for this case is:

Branch 1: DP2-VB - 1.0
Branch 2: nDP2-VB - 0.0

For Branch 1, the assignment of the parameters, based on the mean values of the aggregate distributions, is:

Parameter 34: DP2-VB - 193.80
Parameter 35: DP2-IBP - 238.50

For Branch 2, the assignment of the parameters is irrelevant.

Case 8: VB involves HPME with the reactor at intermediate pressure, the reactor cavity is wet, a significant amount of hydrogen remains in the containment at VB, the fraction of core ejected from the vessel is high, the vessel hole size after ablation is small, and the amount of in-vessel zirconium oxidation was low (less than 40%). The quantification for this case is:

Branch 1: DP2-VB - 1.0
Branch 2: nDP2-VB - 0.0

For Branch 1, the assignment of the parameters, based on the mean values of the aggregate distributions, is:

Parameter 34: DP2-VB - 311.30
Parameter 35: DP2-IBP - 536.50

For Branch 2, the assignment of the parameters is irrelevant.

Case 9: VB involves HPME with the reactor at intermediate pressure, the reactor cavity is wet, a significant amount of hydrogen remains in the containment at VB, the fraction of core ejected from the vessel is moderate, the vessel hole size after ablation is small, and the amount of in-vessel zirconium oxidation was low. The quantification for this case is:

Branch 1: DP2-VB - 1.0
Branch 2: nDP2-VB - 0.0

For Branch 1, the assignment of the parameters, based on the mean values of the aggregate distributions, is:

Parameter 34: DP2-VB - 252.70
Parameter 35: DP2-IBP - 413.30

For Branch 2, the assignment of the parameters is irrelevant.

Case 10: VB involves HPME with the reactor at intermediate pressure, the reactor cavity is wet, a significant amount of hydrogen remains in the containment at VB, the fraction of core ejected from the vessel is small, the vessel hole size after ablation is small, and the amount of in-vessel zirconium oxidation was low. The quantification for this case is:

Branch 1: DP2-VB - 1.0
Branch 2: nDP2-VB - 0.0

For Branch 1, the assignment of the parameters, based on the mean values of the aggregate distributions, is:

Parameter 34: DP2-VB - 193.80
Parameter 35: DP2-IBP - 238.50

For Branch 2, the assignment of the parameters is irrelevant.

Case 11: VB involves HPME with the reactor at intermediate pressure, the reactor cavity is dry, a significant amount of hydrogen remains in the containment at VB, the fraction of core ejected from the vessel is high, the vessel hole size after ablation is large, and the amount of in-vessel zirconium oxidation was high. The quantification for this case is:

Branch 1: DP2-VB - 1.0
Branch 2: nDP2-VB - 0.0

For Branch 1, the assignment of the parameters, based on the mean values of the aggregate distributions, is:

Parameter 34: DP2-VB - 427.80
Parameter 35: DP2-IBP - 590.20

For Branch 2, the assignment of the parameters is irrelevant.

Case 12: VB involves HPME with the reactor at intermediate pressure, the reactor cavity is dry, a significant amount of hydrogen remains in containment at vessel breach, the fraction of core ejected from the vessel is moderate, the vessel hole size after ablation is large, and the amount of in-vessel zirconium oxidation was high. The quantification for this case is:

Branch 1: DP2-VB - 1.0
Branch 2: nDP2-VB - 0.0

For Branch 1, the assignment of the parameters, based on the mean values of the aggregate distributions, is:

Parameter 34: DP2-VB - 323.00
Parameter 35: DP2-IBP - 413.30

For Branch 2, the assignment of the parameters is irrelevant.

Case 13: VB involves HPME with the reactor at intermediate pressure, the reactor cavity is dry, a significant amount of hydrogen remains in the containment at VB, the fraction of core ejected from the vessel is small, the vessel hole size after ablation is large, and the amount of in-vessel Zirconium oxidation was high. The quantification for this case is:

Branch 1: DP2-VB - 1.0
Branch 2: nDP2-VB - 0.0

For Branch 1, the assignment of the parameters, based on the mean values of the aggregate distributions, is:

Parameter 34: DP2-VB - 189.70
Parameter 35: DP2-IBP - 238.50

For Branch 2, the assignment of the parameters is irrelevant.

Case 14: VB involves HPME with the reactor at intermediate pressure, the reactor cavity is dry, a significant amount of hydrogen remains in the containment at VB, the fraction of core ejected from the vessel is high, the vessel hole size after ablation is large, and the amount of in-vessel zirconium oxidation was low. The quantification for this case is:

Branch 1: DP2-VB - 1.0
Branch 2: nDP2-VB - 0.0

For Branch 1, the assignment of the parameters, based on the mean values of the aggregate distributions, is:

Parameter 34: DP2-VB - 418.70
Parameter 35: DP2-IBP - 590.20

For Branch 2, the assignment of the parameters is irrelevant.

Case 15: VB involves HPME with the reactor at intermediate pressure, the reactor cavity is dry, a significant amount of hydrogen remains in the containment at VB, the fraction of core ejected from the vessel is moderate, the vessel hole size after ablation is large, and the amount of in-vessel zirconium oxidation was low. The quantification for this case is:

Branch 1: DP2-VB - 1.0
Branch 2: nDP2-VB - 0.0

For Branch 1, the assignment of the parameters, based on the mean values of the aggregate distributions, is:

Parameter 34: DP2-VB - 304.50
Parameter 35: DP2-IBP - 413.30

For Branch 2, the assignment of the parameters is irrelevant.

Case 16: VB involves HPME with the reactor at intermediate pressure, the reactor cavity is dry, a significant amount of hydrogen remains in the containment at VB, the fraction of core ejected from the vessel is small, the vessel hole size after ablation is large, and the amount of in-vessel zirconium oxidation was low. The quantification for this case is:

Branch 1: DP2-VB - 1.0
Branch 2: nDP2-VB - 0.0

For Branch 1, the assignment of the parameters, based on the mean values of the aggregate distributions, is:

Parameter 34: DP2-VB - 180.50
Parameter 35: DP2-IBP - 238.50

For Branch 2, the assignment of the parameters is irrelevant.

Case 17: VB involves HPME with the reactor at intermediate pressure, the reactor cavity is dry, a significant amount of hydrogen remains in the containment at VB, the fraction of core ejected from the vessel is high, and the vessel hole size after ablation is small. The quantification for this case is:

Branch 1: DP2-VB - 1.0
Branch 2: nDP2-VB - 0.0

For Branch 1, the assignment of the parameters, based on the mean values of the aggregate distributions, is:

Parameter 34: DP2-VB - 342.40
Parameter 35: DP2-IBP - 567.60

For Branch 2, the assignment of the parameters is irrelevant.

Case 18: VB involves HPME with the reactor at intermediate pressure, the reactor cavity is dry, a significant amount of hydrogen remains in the containment at VB, the fraction of core ejected from the vessel is moderate, and the vessel hole size after ablation is small. The quantification for this case is:

Branch 1: DP2-VB - 1.0
Branch 2: nDP2-VB - 0.0

For Branch 1, the assignment of the parameters, based on the mean values of the aggregate distributions, is:

Parameter 34: DP2-VB - 252.10
Parameter 35: DP2-IBP - 413.30

For Branch 2, the assignment of the parameters is irrelevant.

Case 19: VB involves HPME with the reactor at intermediate pressure, the reactor cavity is dry, a significant amount of hydrogen remains in the containment at VB, the fraction of core ejected from the vessel is small, and the vessel hole size after ablation is small. The quantification for this case is:

Branch 1: DP2-VB - 1.0
Branch 2: nDP2-VB - 0.0

For Branch 1, the assignment of the parameters, based on the mean values of the aggregate distributions, is:

Parameter 34: DP2-VB - 180.5
Parameter 35: DP2-IBP - 238.5

For Branch 2, the assignment of the parameters is irrelevant.

Case 20: VB involves HPME with the reactor at intermediate pressure and a significant amount of hydrogen was burned before VB, or the VB involves HPME with the reactor at high or system setpoint pressure. These scenarios are quantified in Question 75. Parameters 32 and 33 are therefore assigned values of zero. The quantification for this case is:

Branch 1: DP2-VB - 0.0
Branch 2: nDP2-VB - 1.0

For Branch 1, the assignment of the parameters, is irrelevant. For Branch 2, the assignment of the parameters is:

Parameter 34: DP2-VB - 0.0
Parameter 35: DP2-IBP - 0.0

Question 75. **Maximum Peak Pressure Rise at VB? (For cases that involve HPME with the RCS at intermediate pressure and significant hydrogen burned before VB, or HPME occurs with the RCS at high pressure.)**
2 Branches, Type 4, 20 Cases

The branches for this question are:

1. DP3-VB The events at VB involve containment pressurization due to events associated with high pressure ejection of the molten core from the vessel with the system at intermediate pressure with a significant amount of hydrogen burned before VB, or the HPME occurs with the system at high pressure.

2. nDP3-VB The pressure rise at VB either does not involve HPME or involves HPME in a situation other than that stated for Branch 1.

Two parameters are defined in this question:

P36. DP3-VB The peak pressure rise in containment, in kPa, is assigned to Parameter 34. The pressure rise for this question is due to all the events that occur at VB for the times when HPME at intermediate pressure occurs and a significant amount of hydrogen has burned before VB, or HPME occurs with the system at high pressure. The IC is totally functional.

P37. DP3-IBP The peak pressure rise in containment, in kPa, is assigned to Parameter 35. The pressure rise for this question is due to all the events that occur at VB for the times when HPME at intermediate pressure occurs and a significant amount of hydrogen has burned before VB, or HPME occurs with the system at high pressure. The IC is totally ineffective.

The parameter values in Cases 2 through 19 are sampled. Distributions for the pressure rise at VB were provided by the containment loads expert panel. The branch taken at this question depends upon the branches previously taken at Questions 25, 62, 63, 67, 73, and 74.

Because of the number of cases for pressure rise at VB, three questions are used. The previous two questions addressed no vessel failure, Alpha and Rocket mode failures, vessel failures in which HPME does not occur, and vessel failures involving HPME when the system is at intermediate pressure (200 to 600 psia), and there is a significant amount of hydrogen in the containment. This question addresses vessel failures involving HPME when the system is at intermediate pressure and a significant amount of hydrogen was burned before VB, and vessel failures involving HPME when the system is at high or setpoint pressure (greater than 1000 psia).

Case 1: The pressure rise at VB was either quantified in Question 73 or Question 74. The quantification for this case is:

Branch 1: DP3-VB - 0.0
Branch 2: nDP3-VB - 1.0

For Branch 1, the assignment of the parameters is irrelevant. For Branch 2, the assignment of the parameters is:

Parameter 36: DP3-VB - 0.0
Parameter 37: DP3-IBP - 0.0

Case 2: VB involves HPME with the reactor at intermediate pressure, the reactor cavity is wet (nominal depth of 10 ft), a significant amount of hydrogen was burned before VB, and the fraction of core ejected from the vessel is high (greater than 40%). The quantification for this case is:

Branch 1: DP3-VB - 1.0
Branch 2: nDP3-VB - 0.0

For Branch 1, the assignment of the parameters, based on the mean values of the aggregate distributions, is:

Parameter 36: DP3-VB - 307.70
Parameter 37: DP3-IBP - 497.50

For Branch 2, the assignment of the parameters is irrelevant.

Case 3: The VB involves HPME with the reactor at intermediate pressure, the reactor cavity is wet, a significant amount of hydrogen was burned before VB, and the fraction of core ejected from the vessel is moderate (from 20% to 40%). The quantification for this case is:

Branch 1: DP3-VB - 1.0
Branch 2: nDP3-VB - 0.0

For Branch 1, the assignment of the parameters, based on the mean values of the aggregate distributions, is:

Parameter 36: DP3-VB - 231.10
Parameter 37: DP3-IBP - 366.00

For Branch 2, the assignment of the parameters is irrelevant.

Case 4: The VB involves HPME with the reactor at intermediate pressure, the reactor cavity is wet, a significant amount of hydrogen was burned before VB, and the fraction of core ejected from the vessel is low (less than 20%). The quantification for this case is:

Branch 1: DP3-VB - 1.0
Branch 2: nDP3-VB - 0.0

For Branch 1, the assignment of the parameters, based on the mean values of the aggregate distributions, is:

Parameter 36: DP3-VB - 183.00
Parameter 37: DP3-IBP - 214.70

For Branch 2, the assignment of the parameters is irrelevant.

Case 5: The VB involves HPME with the reactor at intermediate pressure, the reactor cavity is dry, a significant amount of hydrogen was burned before VB, the fraction of core ejected from the vessel is high, and the vessel hole size after ablation is large (greater than 0.4 m^2). The quantification for this case is:

Branch 1: DP3-VB - 1.0
Branch 2: nDP3-VB - 0.0

For Branch 1, the assignment of the parameters, based on the mean values of the aggregate distributions, is:

Parameter 36: DP3-VB - 385.40
Parameter 37: DP3-IBP - 497.50

For Branch 2, the assignment of the parameters is irrelevant.

Case 6: VB involves HPME with the reactor at intermediate pressure, the reactor cavity is dry, a significant amount of hydrogen was burned before VB, the fraction of core ejected from the vessel is moderate, and the vessel hole size after ablation is large. The quantification for this case is:

Branch 1: DP3-VB - 1.0
Branch 2: nDP3-VB - 0.0

For Branch 1, the assignment of the parameters, based on the mean values of the aggregate distributions, is:

Parameter 36: DP3-VB - 290.30
Parameter 37: DP3-IBP - 366.00

For Branch 2, the assignment of the parameters is irrelevant.

Case 7: VB involves HPME with the reactor at intermediate pressure, the reactor cavity is dry, a significant amount of hydrogen was burned before VB, the fraction of core ejected from the vessel is low, and the vessel hole size after ablation is large. The quantification for this case is:

Branch 1: DP3-VB - 1.0
Branch 2: nDP3-VB - 0.0

For Branch 1, the assignment of the parameters, based on the mean values of the aggregate distributions, is:

Parameter 36: DP3-VB - 173.30
Parameter 37: DP3-IBP - 214.70

For Branch 2, the assignment of the parameters is irrelevant.

Case 8: VB involves HPME with the reactor at intermediate pressure, the reactor cavity is dry, a significant amount of hydrogen was burned before VB, the fraction of core ejected from the vessel is high, and the vessel hole size after ablation is small (less than 0.4 m^2). The quantification for this case is:

Branch 1: DP3-VB - 1.0
Branch 2: nDP3-VB - 0.0

For Branch 1, the assignment of the parameters, based on the mean values of the aggregate distributions, is:

Parameter 36: DP3-VB - 311.30
Parameter 37: DP3-IBP - 497.50

For Branch 2, the assignment of the parameters is irrelevant.

Case 9: VB involves HPME with the reactor at intermediate pressure, the reactor cavity is dry, a significant amount of hydrogen was burned before VB, the fraction of core ejected from the vessel is moderate, and the vessel hole size after ablation is small. The quantification for this case is:

Branch 1: DP3-VB - 1.0
Branch 2: nDP3-VB - 0.0

For Branch 1, the assignment of the parameters, based on the mean values of the aggregate distributions, is:

Parameter 36: DP3-VB - 232.30
Parameter 37: DP3-IBP - 366.00

For Branch 2, the assignment of the parameters is irrelevant.

Case 10: VB involves HPME with the reactor at intermediate pressure, the reactor cavity is dry, a significant amount of hydrogen was burned before VB, the fraction of core ejected from the vessel is low, and the vessel hole size after ablation is small. The quantification for this case is:

Branch 1: DP3-VB - 1.0
Branch 2: nDP3-VB - 0.0

For Branch 1, the assignment of the parameters, based on the mean values of the aggregate distributions, is:

Parameter 36: DP3-VB - 144.30
Parameter 37: DP3-IBP - 214.70

For Branch 2, the assignment of the parameters is irrelevant.

Case 11: VB involves HPME with the reactor at high or system pressure, the reactor cavity is wet, and the fraction of core ejected from the vessel is high. The quantification for this case is:

Branch 1: DP3-VB - 1.0
Branch 2: nDP3-VB - 0.0

For Branch 1, the assignment of the parameters, based on the mean values of the aggregate distributions, is:

Parameter 36: DP3-VB - 372.10
Parameter 37: DP3-IBP - 641.40

For Branch 2, the assignment of the parameters is irrelevant.

Case 12: VB involves HPME with the reactor at high or system pressure, the reactor cavity is wet, and the fraction of core ejected from the vessel is moderate. The quantification for this case is:

Branch 1: DP3-VB - 1.0
Branch 2: nDP3-VB - 0.0

For Branch 1, the assignment of the parameters, based on the mean values of the aggregate distributions, is:

Parameter 36: DP3-VB - 289.90
Parameter 37: DP3-IBP - 464.40

For Branch 2, the assignment of the parameters is irrelevant.

Case 13: VB involves HPME with the reactor at high or system pressure, the reactor cavity is wet, and the fraction of core ejected from the vessel is low. The quantification for this case is:

Branch 1: DP3-VB - 1.0
Branch 2: nDP3-VB - 0.0

For Branch 1, the assignment of the parameters, based on the mean values of the aggregate distributions, is:

Parameter 36: DP3-VB - 212.30
Parameter 37: DP3-IBP - 263.90

For Branch 2, the assignment of the parameters is irrelevant.

Case 14: VB involves HPME with the reactor at high or system pressure, the reactor cavity is dry, the fraction of core ejected from the vessel is high, and the vessel hole size after ablation is large. The quantification for this case is:

Branch 1: DP3-VB - 1.0
Branch 2: nDP3-VB - 0.0

For Branch 1, the assignment of the parameters, based on the mean values of the aggregate distributions, is:

Parameter 36: DP3-VB - 458.90
Parameter 37: DP3-IBP - 641.40

For Branch 2, the assignment of the parameters is irrelevant.

Case 15: VB involves HPME with the reactor at high or system pressure, the reactor cavity is dry, the fraction of core ejected from the vessel is moderate, and the vessel hole size after ablation is large. The quantification for this case is:

Branch 1: DP3-VB - 1.0
Branch 2: nDP3-VB - 0.0

For Branch 1, the assignment of the parameters, based on the mean values of the aggregate distributions, is:

Parameter 36: DP3-VB - 337.20
Parameter 37: DP3-IBP - 464.40

For Branch 2, the assignment of the parameters is irrelevant.

Case 16: VB involves HPME with the reactor at high or system pressure, the reactor cavity is dry, the fraction of core ejected from the vessel is low, and the vessel hole size after ablation is large. The quantification for this case is:

Branch 1: DP3-VB - 1.0
Branch 2: nDP3-VB - 0.0

For Branch 1, the assignment of the parameters, based on the mean values of the aggregate distributions, is:

Parameter 36: DP3-VB - 196.80
Parameter 37: DP3-IBP - 263.90

For Branch 2, the assignment of the parameters is irrelevant.

Case 17: VB involves HPME with the reactor at high or system pressure, the reactor cavity is dry, the fraction of core ejected from the vessel is high, and the vessel hole size after ablation is small. The quantification for this case is:

Branch 1: DP3-VB - 1.0
Branch 2: nDP3-VB - 0.0

For Branch 1, the assignment of the parameters, based on the mean values of the aggregate distributions, is:

Parameter 36: DP3-VB - 364.40
Parameter 37: DP3-IBP - 641.40

For Branch 2, the assignment of the parameters is irrelevant.

Case 18: VB involves HPME with the reactor at high or system pressure, the reactor cavity is dry, the fraction of core ejected from the vessel is moderate, and the vessel hole size after ablation is small. The quantification for this case is:

Branch 1: DP3-VB - 1.0
Branch 2: nDP3-VB - 0.0

For Branch 1, the assignment of the parameters, based on the mean values of the aggregate distributions, is:

Parameter 36: DP3-VB - 263.60
Parameter 37: DP3-IBP - 464.40

For Branch 2, the assignment of the parameters is irrelevant.

Case 19: VB involves HPME with the reactor at high or system pressure, the reactor cavity is dry, the fraction of core ejected from the vessel is low, and the vessel hole size after ablation is small. The quantification for this case is:

Branch 1: DP3-VB - 1.0
Branch 2: nDP3-VB - 0.0

For Branch 1, the assignment of the parameters, based on the mean values of the aggregate distributions, is:

Parameter 36: DP3-VB - 160.00
Parameter 37: DP3-IBP - 263.90

For Branch 2, the assignment of the parameters is irrelevant.

Case 20: This case is not used, as all relevant cases have been explicitly defined. The quantification of this case is:

Branch 1: DP3-VB - 0.0
Branch 2: nDP3-VB - 1.0

For Branch 1, the assignment of the parameters, is irrelevant. For Branch 2, the assignment of the parameters, based on the mean values of the aggregate distributions, is:

Parameter 36: DP3-VB - 160.00
Parameter 37: DP3-IBP - 263.90

Question 76. **Level of Ice Bypass at VB?**
3 Branches, Type 4, 6 Cases

The branches for this question are:

1.	I-IBP1	The IC is ineffective for condensing steam, and is essentially totally bypassed.
2.	I-IBP2	There is some degree of ice bypass in the IC.
3.	InIBP	The IC is intact and totally effective.

One parameter is updated in this question:

P29. IBPLvl The value of the fractional level of ice bypass, Parameter 29, is updated.

This question is not sampled; the quantification was done internally. The branch taken and the parameter assignment at this question depend upon the branches taken at Questions 59, 63, 64, 70, and 71.

The status of the IC at and immediately after VB is important because of its pressure suppression capability and capacity for removal of fission products from the containment atmosphere. This question addresses the degree of bypass of the IC as a result of events at VB. The events involve either the loss of the integrity of the seal between the upper and lower compartments of containment above the reactor vessel, or the direct release of fission products to the atmosphere by way of a path that bypasses the IC. The seal between the upper and lower compartments is formed by the missile shield. The seal may be compromised due to events involving VB resulting in Alpha mode failure of containment, upward acceleration of the vessel due to gross bottom head failure at system pressure (Rocket mode vessel failure), or vessel failure resulting in an EVSE. Both total and partial bypass of the IC are addressed.

Case 1: The IC is effectively bypassed as established in Question 59, or the containment fails by an Alpha mode event, a Rocket mode event, or by an EVSE. Alpha and Rocket mode failures of containment both involve compromise of the seal between the upper and lower compartments. Failure of containment by an EVSE could involve bypass due to compromise of the seal, or failure of containment in the in-core instrumentation room in which the seal table is located. For these times, it is assumed that the IC is effectively bypassed. All the probability is assigned to the highest level of bypass, for which the fractional level of bypass, Parameter 29, assumes a value of 1.0. The quantification for this case is:

Branch 1: I-IBP1 - 1.0
Branch 2: I-IBP2 - 0.0
Branch 3: InIBP - 0.0

For Branch 1, the assignment of the parameter is:

Parameter 29: IBPLvl = 1.0

For Branches 2 and 3, the assignment of the parameter is irrelevant.

Case 2: The vessel is accelerated upward at VB, resulting in compromise of the seal between the upper and lower compartments. It is considered to be indeterminate whether the bypass will be total or partial. The value that the Parameter 29 assumes for partial bypass is discussed in Question 59. The quantification for this case is:

Branch 1: I-IBP1 = 0.50
Branch 2: I-IBP2 = 0.50
Branch 3: InIBP = 0.00

For Branch 1, the assignment of the parameter is:

Parameter 29: IBPLvl = 1.0

For Branch 2, the assignment of the parameter is:

Parameter 29: IBPLvl = 0.062

For Branch 3, the assignment of the parameter is irrelevant.

Case 3: The IC is partially bypassed prior to VB, and an EVSE occurs that does not fail the containment. It is considered unlikely that total bypass will result. The quantification for this case is:

Branch 1: I-IBP1 = 0.01
Branch 2: I-IBP2 = 0.99
Branch 3: InIBP = 0.00

For Branch 1, the assignment of the parameter is:

Parameter 29: IBPLvl = 1.0

For Branch 2, the assignment of the parameter is:

Parameter 29: IBPLvl = 0.062

For Branch 3, the assignment of the parameter is irrelevant.

Case 4: The IC is totally effective prior to VB, and an EVSE occurs that does not fail the containment. It is considered unlikely that either total or partial bypass will result. The quantification for this case is:

Branch 1: I-IBP1 = 0.01
Branch 2: I-IBP2 = 0.01
Branch 3: InIBP = 0.98

For Branch 1, the assignment of the parameter is:

Parameter 29: IBPLvl = 1.0

For Branch 2, the assignment of the parameter is:

Parameter 29: IBPLvl = 0.062

For Branch 3, the assignment of the parameter is:

Parameter 29: IBPLvl = 0.0

Case 5: The IC is partially bypassed prior to VB. The events at VB that result in physical bypass of the IC are addressed in Cases 1 through 4. The bypass of the IC due to melting by thermal loading at VB will be addressed in Question 83. The quantification for this case is:

Branch 1: I-IBP1 = 0.0
Branch 2: I-IBP2 = 1.0
Branch 3: InIBP = 0.0

For Branch 1, the assignment of the parameter is irrelevant. For Branch 2, the assignment of the parameter is:

Parameter 29: IBPLvl = 0.062

For Branch 3, the assignment of the parameter is irrelevant.

Case 6: The IC is totally effective prior to VB. The events at VB that result in physical bypass of the IC are addressed in Cases 1 through 4. The bypass of the ice condenser due to melting by thermal loading at VB will be addressed in Question 83. The quantification for this case is:

Branch 1: I-IBP1 = 0.0
Branch 2: I-IBP2 = 0.0
Branch 3: InIBP = 1.0

For Branches 1 and 2, the assignment of the parameter is irrelevant. For Branch 3, the assignment of the parameter is:

Parameter 29: IBPLvl = 0.0

Question 77. Peak Pressure Rise at VB? (Correction for times of ice bypass.)
2 Branches, Type 6, 3 Cases

The branches for this question are:

1. IDP-VB The events at VB involve pressurization of the containment.

2. IDPnVB The events at VB do not involve pressurization of the containment.

For this question, a module within the user function subprogram is evaluated to determine the containment pressure rise associated with VB for times of partial IC bypass. The case selected in this question depends upon the branches previously taken at Questions 73 and 74.

For times in which there is a pressure rise in containment at VB, the resulting absolute pressure is calculated in Question 82 by summing the baseline pressure, Parameter 7, and one of the values of Parameters 32, 34, or 36. If the IC is determined in Question 76 to be totally effective and functional at VB, Parameters 32, 34, and 36 with no corrections are utilized for the pressure rise at breach. If the IC is determined to be totally bypassed at VB, Parameters 32, 34, and 36 assume the values of Parameters 33, 35, and 37, respectively. If the IC is partially bypassed, the degree of effective bypass, Parameter 29, operates on Parameters 32 and 33, 34, and 35, and 36 and 37 to establish the new values of Parameters 32, 34, and 36. The quantification of Parameter 29 is discussed in Question 59.

Case 1: The pressure rise at VB was established in Question 73. The correction for IC bypass is determined in the user function module DPVB.

Case 2: The pressure rise at VB was established in Question 74. The correction for IC bypass is determined in the user function module DPVB.

Case 3: The pressure rise at VB was established in Question 75, or no pressure rise occurs at VB. The correction for IC bypass is determined in the user function module DPVB.

Question 78. Containment Failure by Direct Core Contact with the Containment Wall?
2 Branches, Type 2, 5 Cases

The branches for this question are:

1. I-CFDCn The containment fails when molten core debris in the ICIR room accumulates on the floor by the containment wall, subsequently melting through the wall.

2. InCFDCn The containment does not fail by direct contact with molten core debris.

Cases 2 through 5 for this question are sampled; the distributions were determined internally. The case selected in this question depends upon the branches taken at Questions 69 and 71.

The direct contact mode of containment failure is discussed in Question 65. Questions 68 and 69 establish the amount of molten core debris that relocates to the in-core instrumentation room. This question addresses the probability of failure due to the amount of core debris that enters the room. The distributions established for occurrence of failure include the consideration of the distribution of the debris in the room and the mass and depth of debris needed for subsequent melting of the wall. Input to the quantification was obtained from an ad hoc panel composed of M. Pilch and W. Tarbell of SNL.

Case 1: There is no core debris that relocates to the in-core instrumentation room, or an EVSE has occurred at VB. If a steam explosion occurs, it is assumed that the debris will not accumulate in the instrumentation room in the same amounts as when HPME is involved. The quantification for this case is:

Branch 1: ICF-DCn - 0.0
Branch 2: ICFnDCn - 1.0

Case 2: A nominal level of 5 metric tons of core debris is released to the instrumentation room. It is believed to be unlikely that meltthrough will occur. The quantification for this case, based on the mean value of the distribution is:

Branch 1: ICF-DCn - 0.01
Branch 2: ICFnDCn - 0.99

Case 3: A nominal level of 20 metric tons of core debris is released to the instrumentation room. It is believed that meltthrough is about half as likely to occur as no meltthrough. The quantification for this case, based on the mean value of the distribution is:

Branch 1: ICF-DCn - 0.31
Branch 2: ICFnDCn - 0.69

Case 4: A nominal level of 40 metric tons of core debris is released to the instrumentation room. It is believed that meltthrough is about as likely to occur as no meltthrough. The quantification for this case, based on the mean value of the distribution is:

Branch 1: ICF-DCn - 0.53
Branch 2: ICFnDCn - 0.47

Case 5: A nominal level of 60 metric tons of core debris is released to the instrumentation room. It is believed that meltthrough is a little more likely to occur than no meltthrough. The quantification for this case, based on the mean value of the distribution is:

Branch 1: ICF-DCn - 0.60
Branch 2: ICFnDCn - 0.40

Question 79. What Fraction of Potentially Oxidizable Metal in the Ejected Core Is Oxidized at VB?
1 Branch, Type 4, 2 Cases

The single branch for this question is always taken. The branch is:

1. I-MtlOx Fraction of available metal in the core released at VB that is oxidized in the reactor cavity at VB.

One parameter is defined in this question:

P38. I-MtlOx The fractional level of available metal in the core released at VB that is oxidized in the reactor cavity at VB is assigned to Parameter 38.

This question is sampled; the distribution for the fraction of metal oxidized was provided by the Containment Loads Expert Panel. The parameter assignment at this question depends upon the branches taken at Questions 25 and 65.

Case 1: When the reactor vessel is breached, the RCS is at low pressure (less than 200 psia), or the vessel failure involves a gravity driven pour. The experts that addressed this question believed that the amount of metal oxidized for VB at low system pressure is about 10% of the amount when high pressure ejection of the melt occurs. Based on the mean value of the experts' aggregate distribution, the assignment of the parameter is:

Parameter 38: I-MtlOx - 0.070

Case 2: VB involves high pressure ejection of the molten core. It was believed that the level of metal oxidation would be quite high for this case. Based on the mean value of the experts' aggregate distribution, the assignment of the parameter is:

Parameter 38: I-MtlOx - 0.075

Question 80. **What Amount of Hydrogen Is Released to Containment at VB?**
2 Branches, Type 5

The branches for this question are:

1. I-H2@VB There is hydrogen released to containment at VB.

2. InH2@VB There is no hydrogen released to containment because there is no VB.

Two parameters are defined in this question:

P39. I-H2@VB The amount of hydrogen released to containment at VB, including the amount generated in-vessel that remains in the RCS, in kg-moles, is assigned to Parameter 39.

P40. I-FrZr The fraction of initial zirconium that remains in the core for participation in core-concrete interaction (CCI).

For this question, a module within the user function subprogram is evaluated to determine the values of Parameters 39 and 40.
For times in which the vessel is breached, the amount of hydrogen released to containment and the fraction of zirconium in the initial core inventory that is available for participation in CCI are calculated. The other variables passed to the user function to determine these parameters are: the amount of in-vessel hydrogen production, the amount of in-vessel hydrogen released from the RCS before VB, the amount of core released from the vessel at breach, and the fraction of metal in the core that is released at breach that is oxidized. The user function module denoted H2VB is called from EVNTRE.

Question 81. **What Fraction of Hydrogen in Containment Is Consumed at VB?**
1 Branch, Type 3

The single branch for this question is always taken. The branch is:

1. I-ActBC The burn completeness at VB.

One parameter is defined in this question:

P41. I-ActBC The fractional level of hydrogen that is in containment at VB that is burned upon breach is assigned to Parameter 41.

This question is sampled; the distribution for the fraction of metal oxidized was provided by the Containment Loads Expert Panel.

Whether hydrogen combustion is possible after CCI depends in part on the fate of the hydrogen produced before or at VB. If this hydrogen is either burned at VB or escapes from the containment, it will not be available for combustion after CCI.

Question 82. **Containment Failure at VB and Mode of Containment Failure?**
6 Branches, Type 6, 6 Cases

The branches for this question are:

1. InCF There is no containment failure at VB.

2. I-CFUCL The containment fails at VB, and the failure is a leak in the UC; the nominal hole area is 0.1 ft^2.

3. I-CFLCL The containment fails at VB, and the failure is a leak in the lower compartment; the nominal hole area is 0.1 ft^2.

4. I-CFUCR The containment fails at VB, and the failure is a rupture in the UC; the nominal hole size is 1 ft^2.

5. I-CFLCR The containment fails at VB, and the failure is a rupture in the lower compartment; the nominal hole size is 1 ft^2.

6. I-CFCtR The containment fails at VB, and the failure is by catastrophic rupture; the area of the hole is at least 7.0 ft^2 (and may be considerably larger) and there is extensive structural damage.

For this question, a module within the user function subprogram is evaluated to determine whether the containment fails, and if it fails, the mode of failure. The user function module called in this question depends upon the branches previously taken at Questions 12, 58, 64, 70, 71, 73, and 74.

For times in which the containment fails at VB by an Alpha event, the Rocket mode of failure, or an EVSE, the user function directly assigns the correct mode of failure. For a quasi-static pressure load as established in Question 73, 74, or 75, the user function adds the pressure rise due to events at VB, Parameter 32, 34, or 36, to the existing baseline pressure in containment at VB, Parameter 7, to obtain the load pressure. This is then compared to the containment failure pressure, Parameter 25. If the load pressure exceeds the failure pressure, the containment fails. The random number, Parameter 26, is used to determine the mode of containment failure. The method of determining the mode of containment failure is described briefly in Subsection A.2. (See also Issue 2 in Volume 2, Part 3.)

Case 1: The containment is failed by either an Alpha mode event or a Rocket event. The user function assigns a comparison value so that rupture in the upper compartment, Branch 4, is selected. The user function module denoted AlphCF is called from EVNTRE.

Case 2: The containment is failed by an EVSE. The user function assigns a comparison value so that rupture in the lower compartment, Branch 5, is selected. The user function module denoted StExCF is called from EVNTRE.

Case 3: The containment was not isolated at the start of the accident, with an equivalent failure size of a rupture, or the containment failed during core degradation due to a hydrogen combustion or detonation. Further overpressure failures are precluded. The user function assigns a comparison value so that the no-failure branch, Branch 1, is taken. The user function module denoted NoCF is called from EVNTRE.

Case 4: VB involves low RCS pressure or events that do not involve ejection of the core debris from the cavity to containment (the pressure rise was quantified in Question 73). The pressure rise involves events such as hydrogen combustion and steam explosions, and is rapid compared to the leak depressurization rate, that is, development of a leak does not arrest the pressure rise in this case. The user function module denoted CFFst is called from EVNTRE.

Case 5: VB involves intermediate RCS pressure and a significant amount of hydrogen exists in containment (the pressure rise was quantified in Question 74). The pressure rise involves events such as DCH and hydrogen combustion, and is rapid compared to the leak depressurization rate, that is, development of a leak does not arrest the pressure rise in this case. The user function module denoted CFFst is called from EVNTRE.

Case 6: VB involves intermediate RCS pressure and a significant amount of hydrogen burned before breach, or VB involves high or setpoint RCS pressure (the pressure rise was quantified in Question 75). The pressure rise involves events such as DCH and hydrogen combustion, and is rapid compared to the leak depressurization rate, that is, development of a leak does not arrest the pressure rise in this case. The user function module denoted CFFst is called from EVNTRE.

Question 83. **Status of the IC Immediately after VB?**
3 Branches, Type 2, 3 Cases

The branches for this question are:

1. I2-IBP1 The IC is ineffective for condensing steam, and is essentially totally bypassed.
2. I2-IBP2 There is some degree of ice bypass in the IC.
3. I2nIBP The IC is intact and totally effective.

This question is not sampled; the quantification was done internally. The branch taken and the parameter assignment at this question depends upon the branches taken at Questions 28, 76, 78, and 82.

The effectiveness of the IC for 5 to 30 min after VB can considerably reduce the amount of fission products released to the environment for the scenarios in which the RCS is at high or setpoint pressure just before breach. In these scenarios, a large fraction of the fission products released from the fuel is still within the vessel at the time of breach, so their first exposure to the decontaminating effects of the IC is immediately after vessel failure. Total or partial bypass of the IC for events involving the loss of the integrity of the seal between the upper and lower compartments of containment above the reactor vessel is addressed in Question 76. This question addresses the total bypass of the IC as a result of a rupture failure in containment in the lower compartment.

Case 1: The IC is effectively bypassed as established in Question 76, or because the containment has failed by rupture in the lower region of containment at VB. All the probability is assigned to the highest level of bypass; the quantification for this case is:

Branch 1: I2-IBP1 - 1.0
Branch 2: I2-IBP2 - 0.0
Branch 3: I2nIBP - 0.0

Case 2: The IC is partially bypassed as established in Question 76. The quantification for this case is:

Branch 1: I2-IBP1 - 0.0
Branch 2: I2-IBP2 - 1.0
Branch 3: I2nIBP - 0.0

Case 3: There is no bypass of containment. The quantification for this case is:

Branch 1: I2-IBP1 - 0.0
Branch 2: I2-IBP2 - 0.0
Branch 3: I2nIBP - 1.0

Question 84. **Are ARFs or Ducting Impaired due to Burns at VB?**
3 Branches, Type 2, 5 Cases

The branches for this question are:

1. I2-Fan The ARFs are functional and operating after VB.

2. I2aFan The ARFs are functional and are available to operate if power is recovered.

3. I2fFan The ARFs are failed and cannot be recovered.

This question is not sampled; the quantification was done internally. The branch taken at this question depends upon the branches taken at Questions 60, 63, and 65.

The energetic events that may accompany VB can render the ARFs inoperable due to the collapsing of ductwork, bending of fan blades, or the sticking open of dampers. Because there are two independent ARF systems installed on opposite sides of the containment, it is believed that it is not likely that both systems will be failed at the same time.

Case 1: There is a deeply flooded cavity at VB or there is no VB and the fans are operating. It is assumed that the threat to the fans will be minimal in the case of the deeply flooded cavity, because the pressure rise at breach is due to EVSE or hydrogen burns. The fans will remain operating after VB. The quantification for this case is:

Branch 1: I2-Fan - 1.0
Branch 2: I2aFan - 0.0
Branch 3: I2fFan - 0.0

Case 2: There is a deeply flooded cavity at VB or there is no VB and the fans are available to operate if power is recovered. The fans will remain available after VB. The quantification for this case is:

Branch 1: I2-Fan - 0.0
Branch 2: I2aFan - 1.0
Branch 3: I2fFan - 0.0

Case 3: VB occurs, the cavity is not deeply flooded and the ARFs are operating. It is considered likely that fans will remain operating after VB. The quantification for this case is:

Branch 1: I2-Fan - 0.75
Branch 2: I2aFan - 0.00
Branch 3: I2fFan - 0.25

Case 4: VB occurs, the cavity is not deeply flooded and the ARFs are available to operate if power is recovered. It is considered likely that fans will remain available after VB. The quantification for this case is:

Branch 1: I2-Fan - 0.00
Branch 2: I2aFan - 0.75
Branch 3: I2fFan - 0.25

Case 5: The fans had initially failed upon demand, or were damaged before VB. The fans will remain failed throughout the accident. The quantification for this case is:

Branch 1: I2-Fan - 0.0
Branch 2: I2aFan - 0.0
Branch 3: I2fFan - 1.0

Question 85. **Are Sprays Impaired due to Containment Failure or Environment at VB?**
3 Branches, Type 2, 7 Cases

The branches for this question are:

1. I2-Sp The sprays are functional and operating after VB.

2. I2aSp The sprays are functional and are available to operate if power is recovered.

3. I2fSp The sprays are failed and cannot be recovered.

This question is not sampled; the quantification was done internally. The branch taken at this question depends upon the branches taken at Questions 61 and 82.

As with the functioning of the IC after VB, the operation of the sprays for 5 to 30 min after breach can considerably reduce the amount of fission products released to the environment for the scenarios in which the RCS is at high or setpoint pressure just before breach. In these scenarios, a large fraction of the fission products released from the fuel is still within the vessel at the time of breach, so their first exposure to the decontaminating effects of the sprays is immediately after vessel failure. The means by which the spray piping can fail and the quantification of failure probability are discussed in Question 61.

Case 1: The sprays are already failed, or the containment fails by catastrophic rupture. It is believed that catastrophic rupture would involve failure of the sprays. A widely accepted scenario for catastrophic rupture involves the "unzippering" of the containment shell at the springline. Because the spray piping penetrations are located above the springline, the sprays are certain to be damaged. The quantification for this case is:

Branch 1: I2-Sp - 0.0
Branch 2: I2aSp - 0.0
Branch 3: I2fSp - 1.0

Case 2: The sprays are operating at VB, and there is either no containment failure or failure involving a leak in containment. The mechanisms for failing the sprays include clogging of the sumps by debris, direct damage to the piping by hydrogen burns, or dislocation of the piping, as discussed above. It is believed that the threat due to these mechanisms is low. The quantification for this case is:

Branch 1: I2-Sp - 0.95
Branch 2: I2aSp - 0.00
Branch 3: I2fSp - 0.05

Case 3: The sprays are available to operate if power is recovered, and there is either no containment failure or failure involving a leak in containment. As in Case 2, the mechanisms for failing the sprays include clogging of the sumps by debris, direct damage to the piping by hydrogen burns, or dislocation of the piping. The quantification for this case is:

Branch 1: I2-Sp - 0.00
Branch 2: I2aSp - 0.95
Branch 3: I2fSp - 0.05

Case 4: The sprays are operating, and there is a rupture failure in the upper containment. It is believed to be indeterminate whether the sprays will fail. The quantification for this case is:

Branch 1: I2-Sp - 0.50
Branch 2: I2aSp - 0.00
Branch 3: I2fSp - 0.50

Case 5: The sprays are available to operate if power is recovered, and there is a rupture failure in the upper containment. It is believed to be indeterminate whether the sprays will fail. The quantification for this case is:

Branch 1: I2-Sp - 0.00
Branch 2: I2aSp - 0.50
Branch 3: I2fSp - 0.50

Case 6: The sprays are operating, and there is a rupture failure in the lower containment. It is believed that spray failure will be unlikely. The quantification for this case is:

Branch 1: I2-Sp - 0.80
Branch 2: I2aSp - 0.00
Branch 3: I2fSp - 0.20

Case 7: The sprays are available to operate if power is recovered, and there is a rupture failure in the upper containment. It is believed that spray failure will be unlikely. The quantification for this case is:

Branch 1: I2-Sp - 0.00
Branch 2: I2aSp - 0.80
Branch 3: I2fSp - 0.20

Question 86. Fraction of Core Not Participating in HPME That Is Available for CCI?
1 Branch, Type 4. 9 Cases

The single branch for this question is always taken. The branch is:

1. Fr-CCI Fraction of core not participating in HPME that is available for CCI.

One parameter is defined in this question:

P42. Fr-CCI The fractional level of core not participating in HPME that is available for CCI is assigned to Parameter 42.

This question is not sampled; it was quantified internally. The branch taken and the parameter assignment at this question depends upon the branches previously taken at Questions 25, 26, 65, 67, 70, and 71.

How much of the molten corium is available to interact with the concrete depends upon the mode of VB and the events that accompany VB. A high energy event may distribute the corium widely throughout the containment. A significant CCI will not take place if the corium is spread out in a thin uniform sheet throughout the containment. It is estimated that almost all of the core eventually leaves the reactor vessel. Most of the core not involved in the events that accompany vessel failure will melt and flow out of the vessel in the next few hours. This material is considered to be available for CCI.

Although SEQSOR subtracts out the fraction of the core material that participates in HPME, there is no double subtraction of this fraction as the HPME case is explicitly considered in the binner. See the discussion of binning Characteristic 10 in Section 2.4.1 and later in this appendix.

Case 1: An Alpha mode failure of the vessel and containment has taken place or containment failure due to an EVSE has occurred. Some portion of the core debris is likely to be widely distributed throughout the containment. The assignment of the parameter is:

Parameter 42: Fr-CCI - 0.80

Case 2: The containment has failed by the Rocket mode. Some portion of the core debris is likely to be widely distributed throughout the containment. The assignment of the parameter is:

Parameter 42: Fr-CCI - 0.75

Case 3: The vessel failure resulted in HPME. Most of the material ejected at breach is expected to be widely distributed throughout the containment, so it is not available for CCI. The core debris that is available for CCI is the material that leaves the vessel after the HPME event, and the material that was expelled from the vessel in the HPME but was not entrained and ejected from the cavity by the ensuing gas blowdown. Although SEQSOR subtracts out the fraction of the core material that participates in HPME, there is no double subtraction of this fraction as the HPME case is explicitly considered in the binner. See the discussion of binning Characteristic 10 in section 2.4.1 and later in this appendix. The assignment of the parameter is:

Parameter 42: Fr-CCI - 1.0

Case 4: The vessel failed at low pressure or otherwise resulted in a gravity pour, and an EVSE did not occur. Essentially all of the core debris will be available for participation in CCI. The assignment of the parameter is:

Parameter 42: Fr-CCI - 1.0

Case 5: There was an EVSE involving more than 40% of the core. It is assumed that most of the core participating in the EVSE will be distributed outside the cavity. The assignment of the parameter is:

Parameter 42: Fr-CCI - 0.70

Case 6: There was an EVSE involving 20 to 40% of the core. It is assumed that about half of the core participating in the EVSE will be distributed outside the cavity. The assignment of the parameter is:

Parameter 42: Fr-CCI - 0.85

Case 7: There was an EVSE involving less than 20% of the core. It is assumed that some of the core participating in the EVSE will be distributed outside the cavity. The assignment of the parameter is:

Parameter 42: Fr-CCI - 0.95

Case 8: The vessel failed at low pressure or otherwise resulted in a gravity pour. There was no EVSE. Essentially all of the core debris will remain in the cavity and will be available for CCI. The assignment of the parameter is:

Parameter 42: Fr-CCI - 0.95

Case 9: Core degradation was arrested and there was no VB. CCI does not take place. The assignment of the parameter is:

Parameter 42: Fr-CCI - 0.0

Question 87. **Level of Core Not Participating in HPME That Is Available for CCI?**
3 Branches, Type 5

The branches for this question are:

1.	CCI-Hi	Over 60% of the core is available for CCI.
2.	CCI-Med	Between 30 and 60% of the core is available for CCI.
3.	CCI-Lo	Less than 30% of the core is available for CCI.

This question is not sampled; the branch taken depends directly upon the value of the parameter defined in the previous question. The fraction of the core not participating in HPME that is available for CCI, Parameter 42, is assigned to one of three groups as designated by the branches.

Question 88. **Is the Debris Bed in a Coolable Configuration?**
2 Branches, Type 2, 7 Cases

The branches for this question are:

1.	L-CDB	The debris bed is coolable; no CCI takes place as long as the debris remains covered with water.
2.	LnCDB	The debris bed is not coolable. CCI will begin as soon as the melt reheats whether water is present or not.

This question is not sampled and was quantified internally. The branch taken at this question depends upon the branches previously taken at Questions 4, 25, 63, 65, and 71.

CCIs will not occur if the debris bed is inherently coolable, and if there is water present to cool it. This question determines whether the debris bed is coolable depending upon the timing of arrival of water and the amount of water in the cavity. Whether the water is replenished is determined in the next question. The portion of the molten core that participates in DCH is unavailable for CCI. Thus the core debris considered in this question is the debris expelled at VB that remains in the cavity and the debris that leaves the vessel some time after VB. More discussion of debris coolability topic can be found in Volume 2, Part 6, of this report.

When water is present in the reactor cavity, in order for the debris to form a coolable debris bed, it must fragment when it hits the water, the resulting particles must quench while falling through the water, and the size of the bulk of the particles must fall within a 1.0 μm size range. Further, if a portion of the debris bed is noncoolable, the available evidence is that this portion of the bed will grow in size until essentially the entire bed has become noncoolable.

Case 1: There was no vessel failure; CCI does not occur. The quantification of this case is:

Branch 1: L-CDB - 1.0
Branch 2: LnCDB - 0.0

Case 2: The reactor cavity is dry and vessel failure results in HPME or gross bottom head failure at a pressure greater than 200 psia. The core debris involved in HPME is likely to be widely distributed throughout the containment. Water from the accumulators or LPIS enters the cavity before the remaining debris pours out of the vessel. The quantification for this case is:

Branch 1: L-CDB - 0.80
Branch 2: LnCDB - 0.20

Case 3: At vessel failure, debris arrives in a dry cavity coincident with water from the accumulators or LPIS. It is not likely that the debris will be coolable. The quantification for this case is:

Branch 1: L-CDB - 0.16
Branch 2: LnCDB - 0.84

Case 4: At vessel failure, debris arrives in a dry cavity without coincident water. The debris will not be coolable. The quantification for this case is:

Branch 1: L-CDB - 0.0
Branch 2: LnCDB - 1.0

Case 5: The reactor cavity is wet and vessel failure results in HPME or gross bottom head failure at a pressure greater than 200 psia. The core debris involved in HPME exits the cavity with the cavity water, but the water spills back into the cavity. This case is similar to Case 2; the quantification for this case is:

Branch 1: L-CDB - 0.80
Branch 2: LnCDB - 0.20

Case 6: The reactor cavity is deeply flooded and vessel failure results in HPME or gross bottom head failure at a pressure greater than 200 psia. As discussed in Question 73, it is assumed that the bulk of the core debris involved in HPME does not exit the cavity, but fragments as it passes through the cavity water. The later debris deposits on top of the fragments. This case is similar to Case 3; it is unlikely that the debris will be cooled. The quantification for this case is:

Branch 1: L-CDB - 0.16
Branch 2: LnCDB - 0.84

Case 7: The reactor cavity is wet or deeply flooded and the vessel failed at low pressure or otherwise resulted in a gravity pour. The pouring of the debris into the cavity may cause reagglomeration of the debris. The quantification for this case is:

Branch 1: L-CDB - 0.16
Branch 2: LnCDB - 0.84

Question 89. What is the Nature of the Prompt CCI?
5 Branches, Type 2, 6 Cases

The branches for this question are:

1.	DryCCI	CCI occurs promptly after VB in a dry cavity.
2.	SScrCCI	CCI occurs promptly after VB with limited water from accumulator dump.
3.	DScrCCI	CCI occurs promptly after VB in a wet or deeply flooded cavity, i.e. water depth is at least 10 ft.
4.	SDlyCCI	A coolable debris bed boils off limited water from the accumulator dump, then after a short delay, prompt CCI ensues in a dry cavity.
5.	noPrCCI	Prompt CCI does not occur.

This question is not sampled; whether prompt CCI occurs follows logically from the information available about the coolability of the core debris and the presence of water in the reactor cavity. The branch taken at this question depends upon the branches previously taken at Questions 4, 25, 63, 65, and 88.

Case 1: There is no VB. Prompt CCI does not occur; the quantification for this case is:

Branch 1: DryCCI - 0.0
Branch 2: SScrCCI - 0.0

Branch 3: DScrCCI - 0.0
Branch 4: SDlyCCI - 0.0
Branch 5: noPrCCI - 1.0

Case 2: The debris is non-coolable, there is only accumulator water in the cavity, and the water source in nonreplenishable. The prompt CCI is scrubbed only by a shallow pool. The quantification for this case is:

Branch 1: DryCCI - 0.0
Branch 2: SScrCCI - 1.0
Branch 3: DScrCCI - 0.0
Branch 4: SDlyCCI - 0.0
Branch 5: noPrCCI - 0.0

Case 3: The cavity is dry at VB, and accumulator dump has occurred before breach. The debris is non-coolable and CCI is initiated promptly. The quantification for this case is:

Branch 1: DryCCI - 1.0
Branch 2: SScrCCI - 0.0
Branch 3: DScrCCI - 0.0
Branch 4: SDlyCCI - 0.0
Branch 5: noPrCCI - 0.0

Case 4: The debris is non-coolable and the cavity is wet or deeply flooded. There is at least 10 ft of water that covers the debris. CCI is initiated promptly with maximal scrubbing. The quantification for this case is:

Branch 1: DryCCI - 0.0
Branch 2: SScrCCI - 0.0
Branch 3: DScrCCI - 1.0
Branch 4: SDlyCCI - 0.0
Branch 5: noPrCCI - 0.0

Case 5: The debris bed is coolable and entered the cavity with accumulator water only, and the cavity water is not replenished. The water boils off after a short delay, and then CCI ensues. The quantification for this case is:

Branch 1: DryCCI - 0.0
Branch 2: SScrCCI - 0.0
Branch 3: DScrCCI - 0.0
Branch 4: SDlyCCI - 1.0
Branch 5: noPrCCI - 0.0

Case 6: The debris bed is coolable and either entered a wet or deeply flooded cavity, or the water supply is replenishable. CCI will not occur in this time period. If the water supply is non-replenishable, the question of long-delayed CCI is addressed in Question 111. The quantification for this case is:

Branch 1: DryCCI - 0.0
Branch 2: SScrCCI - 0.0
Branch 3: DScrCCI - 0.0
Branch 4: SDlyCCI - 0.0
Branch 5: noPrCCI - 1.0

Question 90. **Is ac Power Recovered Late?**
3 Branches, Type 2, 7 Cases

The branches for this question are:

1. L-ACP ac power is available during prompt CCI.
2. LaACP ac power is not available for this time period, but may be recovered in the future.
3. LfACP ac power is not available for this time period, and cannot be recovered.

Cases 3 through 7 of this question are sampled; the distributions were obtained from an analysis of the recovery of offsite power (ROSP) for Sequoyah as discussed above for Question 22. The branching at this question depends upon the branches taken at Questions 1, 9, 10, and 22.

The time period of interest here is between VB and the end of the initial portion of prompt CCI. Because CCI tapers off very gradually, the end of this time period is somewhat arbitrary, but it is intended to be after the bulk of the hydrogen and radionuclides have been released. To simplify the number of cases in the next question about power recovery, the end of this period of CCI has been taken to be 9 h for Cases 3, 4, and 5, and 17 h for Cases 6 and 7. In general, then, the initial period of prompt CCI was taken to be between 3.0 and 6.5 h.

The probability of power recovery is the probability that offsite electrical power is recovered in the period in question given that power was not recovered prior to the period.

Case 1: Power was available at the start of the accident and remains available. The quantification for this case is:

Branch 1: L-ACP - 1.0
Branch 2: LaACP - 0.0
Branch 3: LfACP - 0.0

Case 2: Power was not available at the start of the accident and is not recoverable. The quantification for this case is:

Branch 1: L-ACP - 0.0
Branch 2: LaACP - 0.0
Branch 3: LfACP - 1.0

Case 3: Power was not initially available, but recovery was possible. The AFWS was failed at the start of the accident, and the RCS was intact when the water level dropped below the TAF. This case applies to PDS TRRR-RSR (fast blackout). The recovery period for this case is 2.5 to 9.0 h. The mean value for power recovery in this period (0.823) gives the following quantification:

Branch 1: L-ACP - 0.823
Branch 2: LaACP - 0.177
Branch 3: LfACP - 0.000

Case 4: Power was not initially available, but recovery was possible. The AFWS was operating at the start of the accident but failed after 4 h upon battery depletion and there is an S_2 break in the RCS at UTAF. This case applies to the S_2RRR-RCR PDS (slow blackout with stuck-open PORVs). With this large a break in the RCS, whether the operators depressurized the secondary system while the the AFWS was operating is not very important. The recovery period for this case is 4.5 to 9.0 h. The mean value for power recovery in this period (0.667) gives the following quantification for this case:

Branch 1: L-ACP - 0.667
Branch 2: LaACP - 0.333
Branch 3: LfACP - 0.000

Case 5: Power was not initially available, but recovery was possible. The AFWS was operating at the start of the accident but failed after 4 h upon battery depletion. The operators did not depressurize the secondary system while the AFWS was operating. There is an S_3 break in the RCS at UTAF. This case applies to the S_3RRR-RCR PDS (slow blackout with reactor coolant pumps (RCP) seal failure and the secondary not depressurized). The recovery period for this case is 6.0 to 9.0 h. The mean value for power recovery in this period (0.521) gives the following quantification:

Branch 1: L-ACP - 0.521
Branch 2: LaACP - 0.479
Branch 3: LfACP - 0.000

Case 6: Power was not initially available, but recovery was possible. The AFWS was operating at the start of the accident but failed after 4 h upon battery depletion. The operators depressurized the secondary system while the the AFWS was operating. There is an S_3 break in the RCS at UTAF. This case applies to the S_3KRR-RDR PDS (slow blackout with RCP seal failure and the secondary depressurized). The recovery period for this case is 10.5 to 17 h. The mean value for power recovery in this period (0.697) gives the following quantification:

Branch 1: L-ACP - 0.697
Branch 2: LaACP - 0.303
Branch 3: LfACP - 0.000

Case 7: Power was not initially available, but recovery was possible.

The AFWS was operating at the start of the accident, but failed after 4 h upon battery depletion. The operators did depressurize the secondary system while the the AFWS was operating. The RCS was intact when the core uncovered. This case applies to the TRRR-RDR PDS (slow blackout). The recovery period for this case is 12.5 to 17 h. The mean value for power recovery in this period (0.578) gives the following quantification:

Branch 1: L-ACP = 0.578
Branch 2: LaACP = 0.422
Branch 3: LfACP = 0.000

Question 91. **Late Sprays?**
3 Branches, Type 2, 4 Cases

The branches for this question are:

1. L-Sp The containment sprays are operating during prompt CCI.
2. LaSp The containment sprays are available and will operate when electric power is restored.
3. LfSp The containment sprays are failed and cannot be recovered.

This question is not sampled; if power has been recovered, and the sprays were "available" before, the sprays will operate in this period. The branch taken at this question depends upon the branches taken at Questions 85 and 90.

The time period of interest is the same as in the preceding question. If sprays are recovered during this period, the release from CCI will be considerably reduced. If the debris bed is coolable and water was present but was not being replenished, spray recovery can also prevent dryout and the start of CCI.

Case 1: The sprays were operating shortly after VB. The sprays continue to operate. The quantification is:

Branch 1: L-Sp = 1.0
Branch 2: LaSp = 0.0
Branch 3: LfSp = 0.0

Case 2: The sprays were failed in the previous time period, so the sprays remain failed. The quantification for this case is:

Branch 1: L-Sp = 0.0
Branch 2: LaSp = 0.0
Branch 3: LfSp = 1.0

Case 3: The sprays were available to operate and power has been recovered, so the sprays are initiated during this time period. The quantification for this case is:

Branch 1: L-Sp - 1.0
Branch 2: LaSp - 0.0
Branch 3: LfSp - 0.0

Case 4: The sprays were available to operate, but power has not been recovered so the sprays remain available. The quantification for this case is:

Branch 1: L-Sp - 0.0
Branch 2: LaSp - 1.0
Branch 3: LfSp - 0.0

Question 92. **Late ARFs?**
3 Branches, Type 2, 4 Cases

The branches for this question are:

1. L-Fan The ARFs are operating during prompt CCI.

2. LaFan The ARFs are available to operate if power is recovered.

3. LfFan The ARFs are failed and cannot be recovered.

This question is not sampled. The branch chosen for this question depends upon the branches taken at Questions 84 and 90.

The ARFs are important in the time in which CCI occurs in order to establish the degree of mixing of the containment atmosphere. Whether or not the atmosphere is mixed establishes the conditions for hydrogen burns if ignition occurs.

Case 1: The fans were operating shortly after VB. The fans continue to operate. The quantification is:

Branch 1: L-Fan - 1.0
Branch 2: LaFan - 0.0
Branch 3: LfFan - 0.0

Case 2: The fans were failed in the previous time period, so the fans remain failed. The quantification for this case is:

Branch 1: L-Fan - 0.0
Branch 2: LaFan - 0.0
Branch 3: LfFan - 1.0

Case 3: The fans were available to operate and power has been recovered, so the fans are activated during this time period. The quantification for this case is:

Branch 1: L-Fan - 1.0
Branch 2: LaFan - 0.0
Branch 3: LfFan - 0.0

Case 4: The fans were available to operate, but power has not been recovered so the fans remain available. The quantification for this case is:

Branch 1: L-Fan = 0.0
Branch 2: LaFan = 1.0
Branch 3: LfFan = 0.0

Question 93. Is the Ice Melted or Bypassed Within the First Hour of Prompt CCI?
2 Branches, Type 2, 5 Cases

The branches for this question are:

1. L-IBP The IC is ineffective for condensing steam or for removal of fission products from the atmosphere during prompt CCI.

2. LnIBP The IC is intact during this period.

This question is not sampled; the branch chosen depends directly upon the branches taken at Questions 24 and 83.
The IC is important during the initial phase of CCI not only for its heat removal capability, but especially for its contribution to decontamination of the containment atmosphere. The analyses referenced in Question 29 for level of ice melt before VB also give some indication of ice melt after VB. These analyses include IDCOR Task 23.1, BMI-2104, BMI-2139, BMI-2160, MARCH-HECTR calculations, and NUREG/CP-0071.[A.1-7-A.1-12] The analyses indicate that a quarter to half the ice can remain up to 1 h or so past breach. Also indicated is that more ice remains for smaller initial breaks and for times in which the RCS is intact at breach than for larger initial breaks. These analyses include thermal loading on the IC due to blowdown at VB and hydrogen burns; not included in the thermal loading are events such as DCH and steam explosions.

Case 1: There was partial bypass immediately after VB, and there was either no early blowdown to containment, or the blowdown was typical of a small break or cycling PORV. It is quite likely that the IC will still be effective. The quantification for this case is:

Branch 1: L-IBP = 0.15
Branch 2: LnIBP = 0.85

Case 2: The IC was intact immediately after VB, and there was either no early blowdown to containment, or the blowdown was typical of a small break or cycling PORV. It is more likely than for Case 1 that the IC will still be effective. The quantification for this case is:

Branch 1: L-IBP = 0.05
Branch 2: LnIBP = 0.95

Case 3: There was partial bypass immediately after VB, and the early blowdown to containment was typical of a large break. It is indeterminate whether the IC will still be effective. The quantification for this case is:

Branch 1: L-IBP = 0.50
Branch 2: LnIBP = 0.50

Case 4: The IC was intact immediately after VB, and the early blowdown to containment was typical of a large break. It is more likely than for Case 3 that the IC will still be effective. The quantification for this case is:

Branch 1: L-IBP = 0.25
Branch 2: LnIBP = 0.75

Case 5: The IC was totally ineffective or bypassed immediately after VB. It will remain ineffective for this time period. The quantification for this case is:

Branch 1: L-IBP = 1.0
Branch 2: LnIBP = 0.0

Question 94. **Late Baseline Pressure?**
1 Branch, Type 4, 6 Cases

The single branch for this question is always taken. The branch is:

1. L-PBase The late baseline pressure in containment.

One parameter is defined in this question:

P43. L-PBase The late baseline pressure, in kPa, is assigned to Parameter 43.

Cases 4 through 6 of this question are sampled; the distribution for the parameter was determined internally. The assignment of the parameter depends upon the branches taken at Questions 12, 58, 65, 78, 82, 89, 91, 92, and 93.

The late baseline pressure in containment is established to determine the pressure rise if a hydrogen burn occurs. It is then added to the pressure rise to establish whether containment failure occurs.

Case 1: Either the containment failed before or at VB, or VB was averted. The baseline pressure will be minimal. The assignment of the parameter is:

Parameter 43: L-PBase = 103.40

Case 2: No prior containment failure has occurred and containment heat removal exists either because sprays are operating, the IC is functional and not bypassed, or both. The assignment of the parameter is:

Parameter 43: L-PBase = 131.0

Case 3: No prior containment failure has occurred and the IC is functional, but the sprays or fans are not operating. The assignment of the parameter is:

Parameter 43: L-PBase = 151.70

Case 4: No prior containment failure has occurred and no containment heat removal exists. The CCI was prompt or slightly delayed without production of much steam. The assignment of the parameter, based on the mean value of the distribution is:

Parameter 43: L-PBase = 241.30

Case 5: No prior containment failure has occurred and no containment heat removal exists. The CCI was prompt but deeply scrubbed, involving the production of more steam than for Case 4. The assignment of the parameter, based on the mean value of the distribution is:

Parameter 43: L-PBase = 275.80

Case 6: No prior containment failure has occurred and no containment heat removal exists. No prompt CCI has occurred. The assignment of the parameter, based on the mean value of the distribution is:

Parameter 43: L-PBase = 206.80

Question 95. **Amount of Hydrogen (Plus Hydrogen-Equivalent of Carbon Monoxide and Carbon Dioxide) Generated During Prompt CCI?**
2 Branches, Type 6, 3 Cases

The branches for this question are:

1.	L-CCI	Prompt CCI takes place and combustible gas is generated.
2.	LnCCI	No prompt CCI takes place with combustible gas generation.

Two parameters are defined in this question:

P44.	L-H2	The amount of hydrogen and equivalent carbon monoxide produced during prompt CCI in kg-moles, is assigned to Parameter 44.
P45.	L-CO2	The amount of carbon dioxide produced during prompt CCI, in kg-moles, is assigned to Parameter 45.

This question is not sampled, and was quantified internally. Modules in the user function subroutine are used to calculate the amount of hydrogen, carbon monoxide and carbon dioxide produced during CCI. The user function module utilized in this question depends upon the branches previously taken at Questions 65 and 89. The value that the user function returns for each case determines which branch is taken.

Hydrogen, carbon dioxide, carbon monoxide, and other inert gases are produced by the decomposition of the concrete in the reactor cavity caused by reaction with the non-coolable core debris. At Sequoyah, the concrete is limestone coarse aggregate. 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 are 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 the correlations may be found in Volume 2, Part 6, of this report. The variables passed to the user function modules from the event tree include: fraction of the core released at VB, the fraction of initial zirconium that remains in the core for participation in CCI, and the fractional level of core not participating in HPME that is available for 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 hydrogen 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: Prompt CCI does not occur. No hydrogen, carbon monoxide, or carbon dioxide is produced from reaction of the core debris and the concrete in the cavity. The user function module denoted CCI1 is called from EVNTRE.

Case 2: Prompt CCI occurs and the release of the core debris from the vessel involved HPME. When 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 that is released after vessel breach participates in CCI and is involved in the production of hydrogen, carbon monoxide, or carbon dioxide. The user function module denoted CCI2 is called from EVNTRE.

Case 3: Prompt CCI occurs and the release of the core debris did not involve HPME. The fraction of the core available to participate in CCI, Parameter 42, was determined in the Question 86. The user function uses this parameter to determine what amounts of hydrogen, carbon monoxide, or carbon dioxide are produced. The user function module denoted CCI3 is called from EVNTRE.

Question 96. What Amount of Oxygen Remains in the Containment Late?
2 Branches, Type 5

The branches for this question are:

1.	L-O2	There is oxygen remaining in containment during prompt CCI.
2.	LnO2	There is no oxygen remaining in containment during this time period.

One parameter is defined in this question:

P46. L-O2	The amount of oxygen remaining in containment during prompt CCI, in kg-moles, is assigned to Parameter 46.

This question is not sampled, and was quantified internally. A module in the user function subroutine is used to calculate the amount of oxygen remaining in the containment during prompt CCI. The value that the user function returns for each case determines which branch is taken.

The amount of oxygen that exists in the containment after the initial portion of CCI occurs is needed to determine whether the atmosphere will support late combustion of hydrogen or carbon monoxide. The oxygen initially in the containment has most probably been depleted by prior hydrogen burns. If burns occur during core degradation, whether ignition occurs by igniters or by random sources, the amount of oxygen consumed in the burns is determined in a user function module in Question 54. The amount of oxygen consumed at VB is computed in the user function called in this question. The user function module denoted O2Late is called from EVNTRE.

Question 97. Amount of Hydrogen in the Containment after Prompt CCI?
2 Branches, Type 6, 3 Cases

The branches for this question are:

1.	L-H2	There is hydrogen in the containment after the period of prompt CCI.
2.	LnH2	There is no hydrogen in the containment after the period of prompt CCI.

One parameter is updated in this question:

P44. L-H2	The amount of hydrogen and hydrogen-equivalent of carbon monoxide produced during prompt CCI in kg-moles is updated.

This question is not sampled, and was quantified internally. Modules in the user function subroutine are used to calculate the amount of hydrogen (and hydrogen-equivalent carbon monoxide) in containment after the bulk of gases have been released during CCI. The user function module used in this question depends upon the branches previously taken at Questions 12, 26, 58, 78, and 82. The value that the user function returns for each case determines which branch is taken.

The amount of hydrogen in the containment after CCI is calculated by summing the amount remaining after VB and the amount generated during CCI. These combustible gases can participate in combustion events during this late time period. The in-vessel hydrogen released to the containment during core degradation that remains after pre-vessel breach deflagrations is determined in a user function module in Question 54. The amount of hydrogen that is released from the RCS or produced at VB and consumed immediately after breach is computed in the user function called in this question.

> Case 1: Containment rupture occurs before VB, or there is no VB. The amount of hydrogen in the containment is assumed to either be negligible or irrelevant. For the case of prior containment rupture, a negligible amount is assumed due to purging of the hydrogen through the rupture, or the amount is irrelevant because a rupture failure of containment precludes further failures. The user function module denoted H2CCI1 is called from EVNTRE.
>
> Case 2: Containment rupture occurs at VB. As in Case 1, the amount of hydrogen in the containment is assumed to be negligible or irrelevant. The user function module denoted H2CCI1 is called from EVNTRE.
>
> Case 3: No prior containment ruptures have occurred. The amount of hydrogen and hydrogen equivalent is computed accordingly. The user function module denoted H2CCI2 is called from EVNTRE.

Question 98. **How Much Steam Is in Containment Late?**
2 Branches, Type 4, 3 Cases

The branches for this question are:

1. L-HiStm The steam concentration in containment is greater than 60% (nominally 75%).

2. L-LoStm The steam concentration in containment is less than 60% (nominally 10%).

One parameter is defined in this question:

P47. L-Stm The amount of steam in containment during prompt CCI, in kg-moles, is assigned to Parameter 47.

This question is not sampled, and was quantified internally. The branch taken and the parameter assignment at this question depends upon the branches taken at Questions 91, 92, and 93.

If the containment atmosphere is steam inert after the bulk of combustible gases has been released from CCI, combustion will be precluded. In general, if some form of containment heat removal is functional (IC or sprays), the steam concentration in the containment should be low. Hence, a nominal value of 10% was chosen for the low steam branch. If containment heat removal is not functional, the steam concentration will probably be above the 60% cut-off for flammability limits.

Case 1: Either the containment sprays are operating or the IC is functional and the fans are operating. The steam level will be minimal. The quantification for this case is:

Branch 1: L-HiStm - 0.0
Branch 2: L-LoStm - 1.0

For Branch 1, the assignment of the parameter is irrelevant, for Branch 2, the assignment of the parameter is:

Parameter 47: L-Stm - 157.40

Case 2: The ice was not bypassed during the first hour of prompt CCI. The ice may be melted by the time combustion might occur. It is indeterminate whether the steam concentration is at the high or low level.

Branch 1: L-HiStm - 0.50
Branch 2: L-LoStm - 0.50

For Branch 1, the assignment of the parameter is:

Parameter 47: L-Stm - 2000.0

For Branch 2, the assignment of the parameter is:

Parameter 47: L-Stm - 500.0

Case 3: There is no containment heat removal of any kind. The steam level, and pressure in containment, will be high.

Branch 1: L-HiStm - 1.0
Branch 2: L-LoStm - 0.0

For Branch 1, the assignment of the parameter is:

Parameter 47: L-Stm - 4259.0

For Branch 2, the assignment of the parameter is irrelevant.

Question 99. What Is the Inert Level in Containment, and Is There Sufficient Hydrogen or Oxygen for Burns?

4 Branches, Type 5

The branches for this question are:

1. L-Inert The containment atmosphere is steam inert, i.e., the steam concentration is greater than 60%.
2. L-noH2 There is an insufficient amount of combustible gas in containment for combustion, i.e., the atmosphere is fuel-starved.
3. L-noO2 There is an insufficient amount of oxygen to support combustion, i.e., the atmosphere is oxygen-starved.
4. LnInert The flammability limits for combustion are satisfied, and if ignited, the containment atmosphere will deflagrate.

This question is not sampled, and was quantified internally. A module in the user function subroutine is used to calculate the gaseous species concentrations in the containment and establish the flammability of the atmosphere. The value that the user function returns for each case determines which branch is taken.

For late burns in the containment, the APET does not divide the containment volumes as was done for burns before VB. This is done to save computational time, and also because the state of containment compartmentalization at this late time period is unknown. If a large amount of channeling has occurred in the IC, and many doors leading into or exiting the IC and upper plenum are stuck open or damaged, re-circulation flow can occur between the lower and upper compartments of the containment. To address the late burns in containment, it is assumed that the containment compartments communicate with each other freely. The gaseous constituents are assumed to be homogeneously mixed. The nitrogen that was in the containment initially acts as a diluent, as well as the carbon dioxide that is generated during CCI. The carbon dioxide is treated as steam, i.e., it is assumed that the inerting qualities of carbon dioxide are similar to steam. The user function module denoted LtConc is called from EVNTRE.

Question 100. Late Hydrogen Igniters?

2 Branches, Type 2, 4 Cases

The branches for this question are:

1. L-Ig The igniters are operating during prompt CCI.
2. LnIg The igniters are not operating during prompt CCI.

This question is not sampled; the quantification was done internally by the accident frequency analysts. The branch taken depends upon the branches taken at Questions 22, 47, 90, and 99.

If the igniters are operating at the time of VB, the threat from deflagration of the combustible gases generated during CCI is minimal. If the igniters are initiated during CCI, the containment may be threatened by a large-scale global burn. If the hydrogen concentration in containment is less than 5%, the operating procedures instruct the operators to activate the igniters. If the hydrogen concentration is greater than 6%, the operators are directed to refrain from activating the igniters. The actuation of the igniters by the operators during this time is a moot point because if ac power is recovered, it is assumed that if the flammability criteria as mentioned in Question 99 are met, random sources will eventually ignite the atmosphere.

Case 1: The igniters were operating before VB, and will continue to operate through this time period. The quantification for this case is:

Branch 1: L-Ig - 1.0
Branch 2: LnIg - 0.0

Case 2: The accident involves an SBO with power recovery during prompt CCI. The hydrogen concentration in the containment is less than 5.5%. Human reliability analysis (HRA) indicates that failure to initiate will be about 8% of the time. The quantification for this case is:

Branch 1: L-Ig - 0.92
Branch 2: LnIg - 0.08

Case 3: The accident involves an SBO with power recovery during prompt CCI. The hydrogen concentration in the containment is greater than 5.5%. HRA indicates that incorrect initiation will occur about 8% of the time. The quantification for this case is:

Branch 1: L-Ig - 0.08
Branch 2: LnIg - 0.92

Case 4: The accident involves a station blackout without power recovery before or during prompt CCI, or the igniters were not actuated earlier. The igniters will not be operating in this time period. The quantification for this case is:

Branch 1: L-Ig - 0.0
Branch 2: LnIg - 1.0

Question 101. Is There a Late Deflagration in the Containment?
2 Branches, Type 2, 4 Cases

The branches for this question are:

1. L-Def Ignition of combustible gases occurs during prompt CCI.
2. LnDef Ignition of combustible gases does not occur during prompt CCI.

This question is not sampled; the quantification of this question was performed internally. The branch taken depends upon the branches taken at Questions 90, 99, and 100.

If the flammability criteria are not met, late ignition of combustible gas in the containment atmosphere does not occur. If igniters are operating, ignition is assured. If ac power is available, it is assumed that operation of electrical equipment will provide an ignition source for a flammable atmosphere. If ac power is not operating, static sources provide an ignition source with a lower probability.

Case 1: The flammability criteria are not met; a late deflagration does not occur. The quantification for this case is:

Branch 1: L-Def - 0.0
Branch 2: LnDef - 1.0

Case 2: The flammability criteria are met and igniters are operating. Ignition is assured. The quantification for this case is:

Branch 1: L-Def - 1.0
Branch 2: LnDef - 0.0

Case 3: The flammability criteria are met and ac power is operable. Eventual ignition is assured. The quantification for this case is:

Branch 1: L-Def - 1.0
Branch 2: LnDef - 0.0

Case 4: The flammability criteria are met and ac power is not operable. Ignition is by static sources only, and considered to be unlikely. The quantification for this case is:

Branch 1: L-Def - 0.15
Branch 2: LnDef - 0.85

Question 102. Pressure Rise due to Late Deflagration?

2 Branches, Type 6, 2 Cases

The branches for this question are:

1. L-DPDef Late hydrogen combustion occurs.
2. LnDPDef Late hydrogen combustion does not occur.

One parameter is defined in this question:

P48. DP-LDef The pressure rise in containment due to a late hydrogen deflagration, in kPa, is assigned to Parameter 48.

This question is not sampled; Parameter 22 is calculated in modules within the user function subprogram. The applicable user function module for this question depends upon the branches taken at Questions 47, 91, 92, 93 and 101.

For this question, the variables passed to the user function module are the amounts of oxygen, steam, carbon dioxide, and combustible gases (hydrogen and carbon monoxide) in containment. The user function module calculates the burn completeness based on the model described in Question 43, and the pressure rise based on the model described in Question 54. The burn completeness model, developed by C. C. Wong,[A.1-17] is different for times of turbulent mixing than for times when the atmosphere is quiescent.

Case 1: The igniters are operating at VB, and the hydrogen is burned as it is released during CCI with minimal pressure rise. The fans are operating, so the turbulent burn model is used to establish burn completeness. The user function module denoted Brn1 is called from EVNTRE.

Case 2: The igniters are operating at VB, and the hydrogen is burned as it is released during CCI. The fans are not operating, so the quiescent burn model is used to establish burn completeness. The user function module denoted Brn2 is called from EVNTRE.

Case 3: Igniters are not operating at VB, there is containment heat removal by the IC and/or the sprays, and the fans are operating. The AICC burn model in the user function module requires the temperature of the containment atmosphere in order to calculate the overpressure. For this case, the containment atmosphere is assumed to be 38°C, and the turbulent burn model is used to establish burn completeness. The user function module denoted Brn3 is called from EVNTRE.

Case 4: Igniters are not operating at VB, there is no containment heat removal, and the fans are operating. For this case, the containment atmosphere is assumed to be 135°C, and the turbulent burn model is used to establish burn completeness. The user function module denoted Brn4 is called from EVNTRE.

Case 5: Igniters are not operating at VB, there is containment heat removal by the IC and/or the sprays, and the fans are not operating. For this case, the containment atmosphere is assumed to be 38°C, and the quiescent burn model is used to establish burn completeness. The user function module denoted Brn5 is called from EVNTRE.

Case 6: Igniters are not operating at VB, there is no containment heat removal, and the fans are not operating. For this case, the containment atmosphere is assumed to be 135°C, and the quiescent burn model is used to establish burn completeness. The user function module denoted Brn6 is called from EVNTRE.

Case 7: There is no late deflagration. The user function module denoted NoBurn is called from EVNTRE, and assigns a value of 0.0 to Parameter 48.

Question 103. Late Containment Failure and Mode of Failure?
6 Branches, Type 6, 4 Cases

The branches for this question are:

1.	LnCF	There is no late containment failure.
2.	L-CFUCL	There is a late containment failure, which is a leak in the upper containment; the nominal hole area is 0.1 ft^2.
3.	L-CFLCL	There is a late containment failure, which is a leak in the lower containment; the nominal hole area is 0.1 ft^2.
4.	L-CFUCR	There is a late containment failure, which is a rupture in the upper containment; the nominal hole size is 1 ft^2.
5.	L-CFLCR	There is a late containment failure, which is a rupture in the lower containment; the nominal hole size is 1 ft^2.
6.	L-CFCtR	There is a late containment failure, which is by catastrophic rupture; the area of the hole is at least 7.0 ft^2 (and may be considerably larger) and there is extensive structural damage.

For this question, a module within the user function subprogram is evaluated to determine whether the containment fails, and if it fails, the mode of failure. The user function module called in this question depends upon the branches previously taken at Questions 12, 58, 78, 82, and 101.

For the quasi-static pressure load experienced for a late burn, the user function adds the pressure rise, Parameter 48, to the late baseline pressure in containment, Parameter 43, to obtain the load pressure. This is then compared to the containment failure pressure, Parameter 25. If the load pressure exceeds the failure pressure, the containment fails. The random number, Parameter 26, is used to determine the mode of containment failure. The method of determining the mode of containment failure is described briefly in Subsection A.2. (See also Issue 2 in Volume 2, Part 3.)

Case 1: The containment was not isolated at the start of the accident, with an equivalent failure size of a rupture, or the containment failed by rupture during core degradation. Further overpressure failures are precluded. The user function assigns a comparison value so that the no-failure branch, Branch 1, is taken. The user function module denoted NoCF is called from EVNTRE.

Case 2: The containment failed by rupture at VB. Further overpressure failures are precluded. The user function assigns a comparison value so that the no-failure branch, Branch 1, is taken. The user function module denoted NoCF is called from EVNTRE.

Case 3: There is no previous rupture, and a late deflagration occurs. The pressure rise is rapid compared to the leak depressurization rate, that is, development of a leak does not arrest the pressure rise in this case. The user function module denoted CFFst is called from EVNTRE.

Case 4: The pressure rise is comparable to the leak depressurization rate, that is, development of a leak arrests the pressure rise. This type of pressure rise would be expected if all containment heat removal systems have failed, leading to slow overpressure. The user function module denoted CFSlw is called from EVNTRE.

Question 104. **Are Sprays Impaired due to Late Containment Failure or Environment?**
3 Branches, Type 2, 7 Cases

The branches for this question are:

1. L2-Sp The sprays are functional and operating after the bulk of CCI has occurred.
2. L2aSp The sprays are functional and are available to operate if power is recovered.
3. L2fSp The sprays are failed and cannot be recovered.

This question is not sampled; the quantification was done internally. The branch taken at this question depends upon the branches taken at Questions 91 and 103. The mechanisms by which the sprays are failed are discussed in Question 61.

Case 1: The sprays are already failed, or the containment fails by catastrophic rupture. It is believed that catastrophic rupture would involve failure of the sprays. A widely accepted scenario for catastrophic rupture involves the "unzippering" of the containment shell at the springline. Because the spray piping penetrations are located above the springline, the sprays are certain to be damaged. The quantification for this case is.

Branch 1: L2-Sp - 0.0
Branch 2: L2aSp - 0.0
Branch 3: L2fSp - 1.0

Case 2: The sprays are operating, and there is either no containment failure or failure involving a leak in containment. The mechanisms for failing the sprays include clogging of the sumps by debris, direct damage to the piping by hydrogen burns, or dislocation of the piping. It is believed that the threat due to these mechanisms is low. The quantification for this case is:

Branch 1: L2-Sp - 0.95
Branch 2: L2aSp - 0.00
Branch 3: L2fSp - 0.05

Case 3: The sprays are available to operate if power is recovered, and there is either no containment failure or failure involving a leak in containment. As in Case 2, the mechanisms for failing the sprays include clogging of the sumps by debris, direct damage to the piping by hydrogen burns, or dislocation of the piping. The quantification for this case is:

Branch 1: L2-Sp - 0.00
Branch 2: L2aSp - 0.95
Branch 3: L2fSp - 0.05

Case 4: The sprays are operating, and there is a rupture failure in the upper containment. It is believed to be indeterminate whether the sprays will fail. The quantification for this case is:

Branch 1: L2-Sp - 0.50
Branch 2: L2aSp - 0.00
Branch 3: L2fSp - 0.50

Case 5: The sprays are available to operate if power is recovered, and there is a rupture failure in the upper containment. It is believed to be indeterminate whether the sprays will fail. The quantification for this case is:

Branch 1: L2-Sp - 0.00
Branch 2: L2aSp - 0.50
Branch 3: L2fSp - 0.50

Case 6: The sprays are operating, and there is a rupture failure in the lower containment. It is believed that spray failure will be unlikely. The quantification for this case is:

Branch 1: L2-Sp - 0.80
Branch 2: L2aSp - 0.00
Branch 3: L2fSp - 0.20

Case 7: The sprays are available to operate if power is recovered, and there is a rupture failure in the upper containment. It is believed that spray failure will be unlikely. The quantification for this case is:

Branch 1: L2-Sp - 0.00
Branch 2: L2aSp - 0.80
Branch 3: L2fSp - 0.20

Question 105. Is ac Power Recovered Very Late?
3 Branches, Type 2, 4 Cases

The branches for this question are:

1. L2-ACP ac power is available after prompt CCI.
2. L2aACP ac power is not available, but may be recovered in the future.
3. L2fACP ac power is not available for this time period, and cannot be recovered.

Cases 3 and 4 of this question are sampled. The distributions are based on the power recovery analysis for Sequoyah discussed in Question 22. The branch taken at this question depends upon the branches previously taken at Questions 1, 9, 10, and 90.

The time period of interest here is from the end of the period considered in Question 90 to 24 h. The start of this period is generally after almost all the fission products have been released from the CCI. If power is restored during this period, sprays will become available.

Case 1: Power was available at the start of the accident and remains available. The quantification for this case is:

Branch 1: L2-ACP - 1.0
Branch 2: L2aACP - 0.0
Branch 3: L2fACP - 0.0

Case 2: Power was not available at the start of the accident and is not recoverable. The quantification for this case is:

Branch 1: L2-ACP - 0.0
Branch 2: L2aACP - 0.0
Branch 3: L2fACP - 1.0

Case 3: By Cases 1 and 2, this case and the following case have electrical power not initially available, but recoverable. The AFWS was operating at the start of the accident but failed a few hours later after battery depletion; the operators depressurized the secondary system while the the AFWS was operating. Either there was no fail of the RCS pressure boundary before the TAF was uncovered or an S_3-[illegible] pump seal failure occurred. This case applies to PDSs TRRR-RDR, and S_3RRR-RDR. The recovery period for this case is 17 to 24 h. The mean value for power recovery in this period gives the following quantification:

Branch 1: L2-ACP - 0.897
Branch 2: L2aACP - 0.103
Branch 3: L2fACP - 0.000

Case 4: This case includes the blackout PDSs not included in the previous case: TRRR-RSR, S_2RRR-RCR, and S_3RRR-RCR. The recovery period for this case is 9 to 24 h. This case applies to PDSs. The mean value for power recovery in this period gives the following quantification:

Branch 1: L2-ACP - 0.672
Branch 2: L2aACP - 0.328
Branch 3: L2fACP - 0.000

Question 106. Very Late Sprays?
3 Branches, Type 2, 4 Cases

The branches for this question are:

1. L2-Sp The containment sprays are operating after prompt CCI.
2. L2aSp The containment sprays are available and will operate when electric power is restored.
3. L2fSp The containment sprays are failed and cannot be recovered.

This question is not sampled: if ac power is recovered, the sprays operate if they are not failed. The branch taken at this question depends upon the branches previously taken at Questions 104 and 105.

The period of interest here is the same as in the previous question. If power has been recovered, and the sprays were "available" before, the sprays operate in this period. If sprays are recovered during this time period, and if the debris bed is coolable, spray operation during this period is required to prevent dryout and subsequent concrete attack.

Case 1: The sprays were operating in the previous period or power has been recovered and the containment did not fail by catastrophic rupture. The sprays operate during this period. The quantification for this case is:

Branch 1: L2-Sp - 1.0
Branch 2: L2aSp - 0.0
Branch 3: L2fSp - 0.0

Case 2: The sprays were failed earlier and cannot be recovered. The sprays remain failed. The quantification for this case is:

Branch 1: L2-Sp - 0.0
Branch 2: L2aSp - 0.0
Branch 3: L2fSp - 1.0

Case 3: The sprays were available to operate when power was recovered, and power has been recovered. The quantification for this case is:

Branch 1: L2-Sp - 1.0
Branch 2: L2aSp - 0.0
Branch 3: L2fSp - 0.0

Case 4: The sprays were available to operate when power was recovered, power has not been recovered, so the sprays remain unavailable. The quantification for this case is:

Branch 1: L2-Sp - 0.0
Branch 2: L2aSp - 1.0
Branch 3: L2fSp - 0.0

Question 107. Eventual Basemat Meltthrough (BMT)?
2 Branches, Type 2, 7 Cases

The branches for this question are:

1. BMT The prompt CCI eventually penetrates the basemat in the reactor cavity.
2. noBMT The basemat does not melt through, or the meltthrough is irrelevant because the containment has failed by some other mechanism.

This question is not sampled; it was quantified internally. The branch taken at this question depends upon the branches previously taken at Questions 4, 25, 58, 65, 78, 82, 87, 89, 103, and 106.

The question of eventual BMT is considered here without respect to whether eventual overpressure failure of the containment occurs. From a risk perspective, if overpressure failure occurs, whether BMT occurs is irrelevant since most of the fission products released will be released through the aboveground failure. If the debris bed is coolable and there is a replenishable water supply, BMT is not credible. The basemat at Sequoyah consists of about 10 ft of limestone concrete. Thus, even with a large fraction of the core involved in CCI and no water available, eventual penetration of the basemat by the core debris is not assured. The amount of time required for meltthrough of the basemat is on the order of a few days. This question was quantified by the analysts involved; advice was solicited from D. R. Bradley of SNL.

Case 1: The containment is failed already, or there is no VB. In the first case, the probability of BMT is irrelevant, and in the second case, it is 0.0. The quantification is:

Branch 1: BMT - 0.0
Branch 2: noBMT - 1.0

Case 2: There is no prompt CCI; BMT is not possible at this time. If the debris bed is coolable and eventually boils off the cavity water, BMT would occur after late overpressure failure of containment and thus would be irrelevant. The quantification for this case is:

Branch 1: BMT - 0.0
Branch 2: noBMT - 1.0

Case 3: For this case and the following cases, CCI occurs and is of interest for Cases 1 and 2. For Case 3, a large fraction of the core is involved in CCI and the water supply to the core debris in the cavity is replenishable. There will be more heat loss upward into the water covering the debris than if the cavity were dry. Whether the concrete attack will penetrate the basemat is not known with any certainty but no meltthrough is estimated to be more likely than meltthrough. The quantification for this case is:

Branch 1: BMT - 0.25
Branch 2: noBMT - 0.75

Case 4: A large fraction of the core is involved in CCI and the water supply to the core debris in the cavity is not replenishable. More of the decay heat will be directed downward into the concrete than in Case 3, so BMT is more likely than in Case 3. The quantification for this case is:

Branch 1: BMT - 0.40
Branch 2: noBMT - 0.60

Case 5: An intermediate fraction of the core is involved in CCI and the water supply to the core debris in the cavity is replenishable. BMT is less likely than if a large portion of the core were involved in CCI. Considering the thickness of the Sequoyah basemat, BMT is unlikely. The quantification for this case is:

Branch 1: BMT - 0.05
Branch 2: noBMT - 0.95

Case 6: An intermediate fraction of the core is involved in CCI and the water supply to the core debris in the cavity is not replenishable. BMT is less likely than if a large portion of the core were involved in CCI in a dry cavity (Case 4), but more likely than if an intermediate fraction of the core is involved and the water supply is replenishable (Case 5). The quantification is:

Branch 1: BMT - 0.20
Branch 2: noBMT - 0.80

Case 7: Only a small fraction of the core is involved in CCI. BMT is less likely than if a larger fraction of the core is involved, and does not depend strongly on whether the water supply to the debris is replenishable. The quantification for this case is:

Branch 1: BMT - 0.02
Branch 2: noBMT - 0.98

Question 108. What Is the Very Late Pressure in the Containment?
1 Branch, Type 4, 5 Cases

The single branch for this question is always taken. The branch is:

1. L2-PBase The baseline pressure in containment during the very late time period.

One parameter is updated in this question:

P43. L-PBase The late baseline pressure, Parameter 43, is updated in this question.

Cases 4 and 5 of this question are sampled; the distribution for the parameter was determined internally. The assignment of the parameter depends upon the branches taken at Questions 4, 25, 58, 63, 65, 78, 82, 88, 89, 103, and 106.

The baseline pressure in containment at a very late time is established to determine if eventual overpressure occurs. Late overpressure can be caused by condensible gases, noncondensible gases, or both.

If there is no containment heat removal, and the vessel has been breached, late overpressure by steam is assured. An IDCOR calculation[A.1-7] for an S2HF sequence (small LOCA with failure of ECCS and sprays in recirculation) indicates overpressure by steam at about 7 h after vessel failure and about 5 h after the ice has melted. A BMI-2160 calculation[A.1-10] for an S3HF sequence (small LOCA with failure of ECCS and sprays in recirculation) indicates overpressure by steam at about 12 h after vessel failure and about 3 h after the ice has melted.

If there is containment heat removal, and prompt CCI occurs, it is not known with any certainty if the containment will fail due to noncondensible gases alone. A BMI-2104 calculation[A.1-8] for a TMLB′δ sequence (fast station blackout with late failure) indicates that overpressure occurs due to noncondensibles about 7 h after vessel failure while the IC is still functional. IDCOR calculations[A.1-7] for a TMLB′ sequence (fast station blackout with temperature-induced pump seal failure) and an S2HF sequence (small LOCA with failure of ECCS and sprays in recirculation and retention of water in the upper containment) indicate that overpressure occurs due to noncondensibles more than 20 h after vessel failure. A BMI-2160[A.1-10] calculation for an S3H sequence (small LOCA with failure of ECCS in recirculation, but operation of sprays) indicates that the containment never fails by overpressure due to noncondensibles when the calculation has been carried out to a time about 16 h after vessel failure. Essentially all of the metals in the debris were predicted to be consumed at the end of the calculation, and by overpressurization did not appear to be imminent.

Case 1: Either the containment failed before VB, at VB, or after the bulk of hydrogen and radionuclides release during CCI, or VB was averted. The baseline pressure will be minimal. The assignment of the parameter is:

Parameter 43: L-PBase - 103.40

Case 2: No prior containment failure has occurred and CCI was not initiated promptly at VB. Either sprays are operating or there is late heat removal from the debris bed in the cavity due to a replenishable water supply. The containment pressure should be quite low. The assignment of the parameter is:

Parameter 43: L-PBase - 131.0

Case 3: No prior containment failure failure has occurred and there is no containment heat removal. There is a large amount of steam in containment. Containment failure is assured as discussed above. Failure should occur by about 12 h after VB. The pressure is set artificially high to assure failure in Question 109. The assignment of the parameter is:

Parameter 43: L-PBase - 999.0

Case 4: No prior containment failure has occurred and containment heat removal exists. The CCI was prompt or slightly delayed. If containment failure occurs, it will be due to noncondensibles generated during CCI, and it will occur about 20 h after VB. The assignment of the parameter, based on the mean value of the distribution is:

Parameter 43: L-PBase - 189.60

Case 5: No prior containment failure has occurred and no containment heat removal exists. The CCI was prompt and there is minimal steam in containment. The pressure will be somewhat higher than for Case 4. The assignment of the parameter, based on the mean value of the distribution is:

Parameter 43: L-PBase - 241.30

Question 109. Very Late Containment Failure and Mode of Failure?
6 Branches, Type 6, 2 Cases

The branches for this question are:

1. L2nCF There is no very late containment failure.
2. L2-CFUCL There is a very late containment failure, which is a leak in the upper containment; the nominal hole area is 0.1 ft^2.
3. L2-CFLCL There is a very late containment failure, which is a leak in the lower containment; the nominal hole area is 0.1 ft^2.
4. L2-CFUCR There is a very late containment failure, which is a rupture in the upper containment; the nominal hole size is 1 ft^2.

5. L2-CFLCR There is a very late containment failure, which is a rupture in the lower containment; the nominal hole size is 1 ft^2.

6. L2-CFCtR There is a very late containment failure, which is by catastrophic rupture; the area of the hole is at least 7.0 ft^2 (and may be considerably larger) and there is extensive structural damage.

For this question, a module within the user function subprogram is evaluated to determine whether the containment fails, and, if it fails, the mode of failure. The user function module called in this question depends upon the branch taken in Question 108.

For the quasi-static pressure load experienced for long-term overpressure of the containment, the user function assigns the very late baseline pressure in containment, Parameter 43, to the load pressure. This is then compared to the containment failure pressure, Parameter 25. If the load pressure exceeds the failure pressure, the containment fails. The random number, Parameter 26, is used to determine the mode of containment failure. The method of determining the mode of containment failure is described briefly in Subsection A.2. (See also Issue 2 in Volume 2, Part 3.)

Case 1: The pressure rise is comparable to the leak depressurization rate, that is, development of a leak arrests the pressure rise. This type of pressure rise is expected for overpressure failures. The user function module denoted CFSlw is called from EVNTRE.

Case 2: Since Case 1 is always taken, this case becomes irrelevant. It is provided to insure that no containment failure occurs during the very late time period. The user function module denoted NoCF is called from EVNTRE.

Question 110. Sprays After Very Late Containment Failure?
2 Branches, Type 2, 4 Cases

The branches for this question are:

1. L3-Sp The sprays are functional and operating after the very late time period.

2. L3nSp The sprays are failed and cannot be recovered.

This question is not sampled; the quantification was done internally. The branch taken at this question depends upon the branches taken at Questions 105, 106, and 109.

If the containment is still intact and is not bypassed, operation of the sprays in the final time period will prevent a coolable debris bed from drying out. The time period of interest here is 24 h or more after the start of the accident. It is assumed that if ac power is not failed by this time period, it will always be recovered. If sprays were not failed before this time, or do not fail by late overpressurization of containment, they will still operate or be initiated. The mechanisms by which the sprays are failed are discussed in Question 61.

Case 1: The sprays are already failed, ac power is nonrecoverable, or the containment fails by catastrophic rupture. It is believed that catastrophic rupture would involve failure of the sprays. A widely accepted scenario for catastrophic rupture involves the "unzippering" of the containment shell at the springline. Because the spray piping penetrations are located above the springline, the sprays are certain to be damaged. The quantification for this case is:

Branch 1: L3-Sp - 0.0
Branch 2: L3nSp - 1.0

Case 2: The sprays are operating or ac power has been recovered, and there is either no containment failure or failure involving a leak in containment. The mechanisms for failing the sprays include clogging of the sumps by debris, direct damage to the piping by hydrogen burns, or dislocation of the piping. It is believed that the threat due to these mechanisms is low. The quantification for this case is:

Branch 1: L3-Sp - 0.95
Branch 2: L3nSp - 0.05

Case 3: The sprays are operating or ac power has been recovered, and there is a rupture failure in the upper containment. It is believed to be indeterminate whether the sprays will fail. The quantification for this case is:

Branch 1 L3-Sp - 0.50
Branch 2: L3nSp - 0.50

Case 4: The sprays are operating or ac power has been recovered, and there is a rupture failure in the lower containment. It is believed that spray failure will be unlikely. The quantification for this case is:

Branch 1: L3-Sp - 0.80
Branch 2: L3nSp - 0.20

Question 111. Does Core Concrete Attack After Late Boiloff and Very Late Containment Failure?
2 Branches, Type 2, 3 Cases

The branches for this question are:

1. L3-CCI CCI occurs after a long delay to boil off the water in the cavity.

2. L3nCCI Very late CCI does not occur.

Case 2 of this question is sampled zero-one, and was quantified internally. The branch taken at this question depends upon the branches previously taken at Questions 4, 25, 26, 63, 86, and 110.

If the debris bed is coolable, and there is a replenishable water supply, very late CCI will not occur. If the debris bed is coolable and there is no replenishable source of water to the cavity, core-concrete attack may occur after the cavity water is boiled off. When this is the situation, late overpressurization of the containment is assured, as is addressed in Questions 108 and 109. The time to boil the water from a deeply flooded cavity is on the order of 30 h. E. Copus of SNL performed HOTROX calculations in which the amount of zirconium metal and zirconium oxide in the debris was varied. Features of the HOTROX model for analysis of solidified core debris interaction with concrete are: transient conduction equations, zirconium interaction with gaseous by-products, and a three-dimensional energy balance. The calculations indicated that remelting of the core debris would occur in less than 4 h regardless of zirconium metal content, and CCI would initiate soon after at rates ranging from 10 to 40 cm/h.

Case 1: The debris bed is coolable, and the water supply to the cavity is replenishable. CCI will not be initiated at a very late time. The quantification for this case is:

Branch 1: L3-CCI - 0.0
Branch 2: L3nCCI - 1.0

Case 2: The debris bed is coolable, the cavity was deeply flooded at VB, and at containment failure there is not a replenishable water supply to the cavity. It is believed that late concrete attack will ensue after very late containment failure, if there is no water supplied to the debris. There is much uncertainty involved with whether there will be any means or attempts to supply water to the cavity when the time elapse since containment failure is on the order of a day. It is assumed to be likely that a water supply at this time will be unavailable. As this case was sampled zero-one, each observation had all the probability assigned to one of these two branches. Taking the average over all the observations, the quantification for this case is:

Branch 1: L3-CCI - 0.75
Branch 2: L3nCCI - 0.25

Case 3: Prompt CCI has already occurred. The quantification for this case is:

Branch 1: L3-CCI - 0.0
Branch 2: L3nCCI - 1.0

A.1.2 Listing of the Accident Progression Event Tree

This subsection of Appendix A lists the Sequoyah APET. The 111 questions in the Sequoyah 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 Sequoyah APET used in the accident progression analyses for NUREG-1150[A.1-18] consists of 2690 lines that form a computer input file. This file is designed to be easily understood, with mnemonic abbreviations for each branch of every question. The structure of the input file is defined in the EVNTRE reference manual, NUREG/CR-5174.[A.1-19]

The APET was developed on a PC spreadsheet program, which greatly facilitates keeping track of the references to previous questions when questions are added or subtracted, or when the order of the questions is changed in the course of the development of the tree. The APET appears as developed on the spreadsheet program. Comments that describe the cases in the APET appear to the right and are ignored by EVNTRE. Comments that introduce the parameters in the APET begin with a "$" character, and are also ignored by ENVTRE.

The APET listing that is presented in this section is the one that was used for plant damage state Group 2, Fast Station Blackout. For the other PDS groups, quantification of Questions 1 through 11 may be different, depending upon the differences in the PDS group definition. Questions 1 through 11 are referred to as initialization questions, and a listing of these questions for each PDS group is provided in Subsection A.3.

```
SEQUOYAH Accident Progression Event Tree - Fast Station Blackout
          111
       NQuest
   1    1.000
  Cent  PInit
 1 Size and location of the RCS break when the core uncovers?                   PDS - 1st Letter
   6    Brk-A      Brk-S2      Brk-S3       Brk-V      B-SGTR      B-PORV
   1        1           2           3           4           5           6
        0.000       0.000       0.000       0.000       0.000       1.000
 2 Has the reaction been brought under control?
   2    Scram     noScram
   1        1           2
        1.000       0.000
 3 For SGTR, are the secondary system SRVs stuck open?                          PDS - 1st Letter
   2  SSRV-SO     SSRVnSO
   1        1           2
        0.000       1.000
 4 Status of ECCS?                                                              PDS - 2nd Letter
   4   B-ECCS      BaECCS      BfECCS      B-LPIS
   2        1           2           3           4
   4
   3        1           1           3                                      Case 1: Large break in the RCS, used for
            1   +       5   *       1                                        PDS Group 3, or SGTR with stuck open SRV
        Brk-A  or  B-SGTR   & SSRV-SO                                        used for PDS Group 7.
        0.000       1.000       0.000       0.000
   1        1                                                              Case 2: Small break in the RCS, used for
            2                                                                 PDS Group 3.
       Brk-S2
        0.000       1.000       0.000       0.000
   1        1                                                              Case 3: Very small break in the RCS, used
            3                                                                for PDS Groups 3 and 6.
       Brk-S3
        0.000       1.000       0.000       0.000
      Otherwise                                                            Case 4: V, SGTR, or no break in the RCS.
        0.000       1.000       0.000       0.000
 5 Is the RCS depressurized by the operators?
   3  Op-DePr     OpmDePr     OpnDePr
   2        1           2           3
   3
   1        1                                                              Case 1: Very small breaks, used for PDS
            3                                                                Group 6.
       Brk-S3
        0.000       0.000       1.000
   2        1           3                                                  Case 2: SGTRs with stuck open SRVs, used
            5   *       1                                                    for PDS Group 7.
       B-SGTR  &  SSRV-SO
        0.000       0.000       1.000
      Otherwise                                                            Case 3: A breaks, V, no breaks, or SGTRs
        0.000       0.000       1.000                                        with reclosing SRVs.
 6 Status of sprays?                                                            PDS - 3rd Letter
   4     B-Sp        BaSp        BfSp      noB-Sw
   2        1           2           3           4
   4
   4        1           4           1           3                          Case 1: Large break in the RCS, with ECCS
            1   *       3   +       5   *       1                            failure, used in PDS Group 3, or SGTR
        Brk-A   &  BfECCS  or  B-SGTR   & SSRV-SO                            with stuck-open relief valve, used in
        0.000       1.000       0.000       0.000                            PDS Group 7.
   2        1           4                                                  Case 2: Small break in the RCS, with ECCS
            2   *       3                                                    failure, used in PDS Group 3.
       Brk-S2   &  BfECCS
        0.000       1.000       0.000       0.000
   2        1           4                                                  Case 3: Very small break in the RCS, with
            3   *       3                                                    ECCS failure, used in PDS Group 3.
       Brk-S3   &  BfECCS
        0.000       1.000       0.000       0.000
      Otherwise                                                            Case 4: LOCAs w/o ECCS failure, SGTRs w/o
        0.000       1.000       0.000       0.000                            stuck open SRVs, and other PDS Groups.
 7 Status of AC power?                                                          PDS - 4th Letter
   3    B-ACP       BaACP       BfACP
```

```
   1       1           2           3
       0.000       1.000       0.000
8 Are the refueling water storage tank contents injected into containment?     PDS - 5th Letter
   3  RWST-I      RWSTaI      RWSTfI
   2       1           2           3
   2
   2       1           3                                                    Case 1: SGTR with secondary SRVs stuck
           5 *         1                                                      open, used in PDS Group 7.
      B-SGTR  &  SSRV-SO
       0.000       1.000       0.000
     Otherwise                                                              Case 2: SGTR with secondary SRVs not stuck
       0.000       1.000       0.000                                          open and PDSs not in Group 7.
9 Heat removal from the steam generators?                                        PDS - 6th Letter
   4   SG-HR       SGaHR       SGfHR      SGdHR
   2       1           2           3          4
   2
   2       1           3                                                    Case 1: SGTR with secondary SRVs not stuck
           5 *         2                                                      open in PDS Group 7 and SGTR in Group 6.
      B-SGTR  &  SSRVnSO
       0.000       1.000       0.000      0.000
     Otherwise                                                              Case 2: SGTR with secondary SRVs stuck open
       0.000       1.000       0.000      0.000                               and PDSs not in Group 7 or w/o SGTR.
10 Is the secondary depressurized before the core uncovers?                      PDS - 6th Letter
   2   SecDP     noSecDP
   2       1           2
   3
   2       1           9                                                    Case 1: Slow blackouts with S3-size break,
           3 *         4                                                      in PDS Group 1.
      Brk-S3  &    SGdHR
       0.000       1.000
   2       1           9                                                    Case 2: Slow blackouts with S2-size break,
           2 *         4                                                      in PDS Group 1.
      Brk-S2  &    SGdHR
       0.000       1.000
     Otherwise                                                              Case 3: Slow blackouts with no break and
       0.000       1.000                                                      PDSs not in Group 1.
11 Cooling for reactor coolant pump seals?                                       PDS - 7th Letter
   3   B-PSC       BaPSC       BfPSC
   2       1           2           3
   3
   4       1           9           1          4                             Case 1: Slow blackouts with RCS intact in
           6 *         4   +       1 *        4                               PDS Group 1, and large break LOCAS with
      B-PORV  &    SGdHR  or    Brk-A  &   B-LPIS                             LPIS available in PDS Group 3.
       0.000       1.000       0.000
   2       1           4                                                    Case 2: ATWSs with small break and failure
           3 *         3                                                      of ECCS, in PDS Group 6.
      Brk-S3  &   BfECCS
       0.000       1.000       0.000
     Otherwise                                                              Case 3: Other PDSs in Groups 1, 3 and 6,
       0.000       1.000       0.000                                          and other PDS Groups.
12 Initial containment leak or isolation failure?
   2  B-Leak    noB-Leak
   1       1           2
       0.005       0.995
13 Do the operators turn on the hydrogen igniters?
   2    B-Ig        BnIg
   2       1           2
   2
   1       7                                                                Case 1: AC power available
           1
       B-ACP
       0.990       0.010
     Otherwise                                                              Case 2: Station blackout
       0.000       1.000
14 Status of air return fans?
   3   B-Fan       BaFan       BfFan
   2       1           2           3
   2
   1       7                                                                Case 1: AC power available
```

```
             1
         B-ACP
         0.999       0.000       0.001
       Otherwise
         0.000      !14,1,1     !14,1,3               Case 2: Station blackout
15 Event V - break location scrubbed by sprays?
    2    V-Wet       V-Dry
    1        1           2
         0.800       0.200
16 RCS pressure at the start of core degradation?
    4   E-SSPr      E-HiPr      E-ImPr      E-LoPr
    2        1           2           3           4
    4
    2        1           1                            Case 1: Large break - low pressure.
             1   +       4
         Brk-A  or   Brk-V
         0.000       0.000       0.000       1.000
    2        1           2                            Case 2: No break or reactor not scrammed -
             6   +       2                              system setpoint pressure.
        B-PORV  or noScram
         1.000       0.000       0.000       0.000
    1       10                                        Case 3: Secondary depressurization and
             1                                          S3 or S2 break, or SGTR - intermediate
         SecDP                                          pressure.
         0.000       0.000       1.000       0.000
       Otherwise                                      Case 4: S3 break with AFW or S2 break with
         0.000       1.000       0.000       0.000      noDePr - high pressure.
17 Do the pressurizer PORVs stick open?
    2  PORV-SO     PORVnSO
    2        1           2
    2
    1       16                                        Case 1: PORVs are cycling.
             1
        E-SSPr
         0.500       0.500
       Otherwise                                      Case 2: RCS not at setpoint pressure,
         0.000       1.000                              water loss is not through the PORVs.
18 Temperature-induced RCP seal failure?
    2   E-PSS3      noEPSF
    2        1           2
    4
    1       11                                        Case 1: Have seal cooling
             1
         B-PSC
         0.000       1.000
    2       16          17                            Case 2: RCS at system setpoint pressure,
             1   *       2                              distribution from ASEP special panel.
        E-SSPr   &  PORVnSO
         0.710       0.290
    1       16                                        Case 3: RCS at high pressure.
             2
        E-HiPr
         0.650       0.350
       Otherwise
         0.600       0.400                            Case 4: RCS at IM or low pressure.
19 Is the RCS depressurized before VB by opening the pressurizer PORVs?
    2    PriDP     noPriDP
    2        1           2
    3
    1        5
             1                                        Case 1: The operators have opened the
       Op-DePr                                          PORVs before the core uncovered.
         1.000       0.000
    4        5           7           4           4
             2   *       1  * (      1   +       4 )  Case 2: The operators are directed to open
      OpmDePr    &   B-ACP  & ( B-ECCS   or  B-LPIS )   the PORVS by procedures (must have AC
         0.900       0.100                              power and pumps running).
       Otherwise
         0.000       1.000                            Case 3: Opening the PORVs is prohibited, or
                                                        the operator failed to follow procedures
```

```
20 Temperature-induced SGTR?
   2   E-SGTR     noESGTR
   2       1           2
   2
   4      16          19          17          18               Case 1: No breaks and no AFW, RCS at
           1   *       2   *       2   *       2                 setpoint pressure. In-Vessel Issue #2.
      E-SSPr  &  noPriDP  &  PORVnSO  &   noEPSF
       0.014       0.986
     Otherwise                                                 Case 2: RCS not at setpoint pressure.
       0.000       1.000
21 Temperature-induced hot leg or surge line break?
   2   E-HLA      noE-HLA
   2       1           2
   4
   5      16          19          17          18          20   Case 1: No breaks and no AFW, RCS pressure
           1   *       2   *       2   *       2   *       2     at about 2500 psia, In-Vessel Issue #1.
      E-SSPr  &  noPriDP  &  PORVnSO  &   noEPSF  &  noESGTR
       0.768       0.232
   6       1           1           9           9          19          17 Case 2: RCS around 2000 psia.
    (      3   +       5  ) *(     2   +       4  ) *      2   *       2
    ( Brk-S3  or  B-SGTR  ) &(  SGaHR  or   SGdHR  ) & noPriDP  &  PORVnSO
       0.035       0.965
   1      20                                                   Case 3: T-I induced SGTR, pressure is reduced
           1                                                     somewhat, about equivalent to S3 break.
      E-SGTR
      !21,2,1     !21,2,2
     Otherwise                                                 Case 4: RCS not at 2000-2500 psia.
       0.000       1.000
22 Is AC power recovered early (Between uncovering and VB)?
   3   E-ACP       EaACP       EfACP
   2       1           2           3
   7
   1       7
           1                                                   Case 1: Power initially functioning.
      B-ACP
      1.000        0.000       0.000
   1       7
           3                                                   Case 2: Power initially failed.
      BfACP
      0.000        0.000       1.000
   2       9           9
           2   +       3                                       Case 3: No initial AFW (fast TMLB'),
      SGaHR   or   SGfHR                                         recovery period is 1 to 2.5 hours.
      0.410        0.590       0.000
   1       1
           2                                                   Case 4: Initial AFW and S2 break,
      Brk-S2                                                     recovery period is 1 to 4.5 hours.
      0.694        0.306       0.000
   2       1          10
           3   *       2                                       Case 5: Initial AFW and no secondary DePr
      Brk-S3   & noSecDP                                         with S3 break, recovery period is 4 to
      0.320        0.680       0.000                             6 hours.
   2       1          10
           3   *       1                                       Case 6: Initial AFW and secondary DePr,
      Brk-S3   &   SecDP                                         with S3 break, recovery period is 4 to
      0.721        0.279       0.000                             10.5 hours.
     Otherwise
      0.612        0.388       0.000                           Case 7: Initial AFW and secondary DePr,
23 After power recovery, is core cooling re-established?         with no break, recovery 7 to 12.5 hours.
   2   E-RECC      EnRECC
   2       1           2
   2
   3       7          22           4                           Case 1: If AC power is restored then core
           2   *       1   *       2                             cooling should be obtained.
      BaACP   &   E-ACP   &  BaECCS
      0.950        0.050
     Otherwise                                                 Case 2: AC power not restored.
      0.000        1.000
24 Rate of blowdown to containment?
```

```
    4    EBD-A      EBD-S2      EBD-S3       noEBD
    2        1           2           3           4
    4
    2        1          21                                           Case 1: Large break - initial or induced.
             1  +        1
         Brk-A  or   E-HLA
         1.000       0.000       0.000       0.000
    1        1                                                       Case 2: Event V - no blowdown to contain-
             4                                                         ment.
         Brk-V
         0.000       0.000       0.000       1.000
    3        1          19          17                               Case 3: S2 break - initial, induced, or
             2  +        1  +        1                                 deliberate, includes stuck open PORV.
        Brk-S2  or   PriDP  or PORV-SO
         0.000       1.000       0.000       0.000
      Otherwise                                                      Case 4: S3 break - initial or induced, or
         0.000       0.000       1.000       0.000                     cycling PORV, or SGTR (w/ cycling PORV).
25 Vessel pressure before VB?
    4   I-SSPr      I-HiPr      I-ImPr      I-LoPr
    2        1           2           3           4
    4
    5       24           1           1          19          17       Case 1: Large break or S2 break with PORVs
             1  +        4 + (       2 * (       1  +        1  ))     open, low pressure, 200 psia or less.
         EBD-A  or   Brk-V or ( Brk-S2 & (   PriDP  or PORV-SO  ))
         0.000       0.000       0.000       1.000
    1       24                                                       Case 2: S2 break, intermediate pressure,
             2                                                         200-600 psia.
        EBD-S2
         0.000       0.000       0.200       0.800
    4        1           1          18          20                   Case 3: S3 break, high pressure, 1000-2000
             3  +        5  +        1  +        1                     psia (EBD-S3 includes B-PORV).
        Brk-S3  or  B-SGTR  or  E-PSS3  or  E-SGTR
         0.000       0.330       0.340       0.330
      Otherwise                                                      Case 4: RCS pressure boundary intact,
         1.000       0.000       0.000       0.000                     system setpoint pressure, ~2500 psia.
26 Is core damage arrested?  No vessel breach?
    2     noVB          VB
    2        1           2
    9
    4       22           4          23           7                   Case 1: No power, no initial ECCS, or
            -1  +        3  +        2  *        2                     no recovered ECCS.
         EnACP  or  BfECCS  or  EnRECC  &    BaACP
         0.000       1.000
    2        1           4                                           Case 2: Large break with LPIS available.
             1  *        4                                             RCS will depressurize before core damage
         Brk-A  &   B-LPIS                                             has progressed very far.
         0.950       0.050
    4       25           4          25           4                   Case 3: Depressurization was either later
             4  *        4  +       -1  *        1                     or earlier than case 2.
       I-LoPr   &   B-LPIS  or  InSSPr  &   B-ECCS
         0.900       0.100
    1        4                                                       Case 4: Sequences without recoverable ECCS
            -2                                                         - includes nondepressurized cases with
      nBaECCS                                                          LPIS available.
         0.000       1.000
    2        9           9                                           Case 5: Recovered SBO with no initial AFW
             2  +        3                                             (fast TMLB'), recovery period is 1 to
         SGaHR  or   SGfHR                                             2.5 hours.
       !26,3,1     !26,3,2
    1        1                                                       Case 6: Recovered SBO with initial AFW and
             2                                                         S2 break, recovery period is 1 to 4.5
        Brk-S2                                                         hours.
         0.780       0.220
    2        1          10                                           Case 7: Recovered SBO with initial AFW, no
             3           2                                             secondary DePr and S3 break, recovery
        Brk-S3     noSecDP                                             period is 4 to 6 hours.
         0.670       0.330
    2        1          10                                           Case 8: Recovered SBO with initial AFW,
             3           1                                             secondary DePr and S3 break, recovery
```

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       Brk-S3       SecDP                                       period is 4 to 10.5 hours.
       !26,3,1     !26,3,2
      Otherwise                                                 Case 9: Recovered SBO with initial AFW,
       !26,3,1     !26,3,2                                        no break, recovery 7 to 12.5 hours
27 Early sprays?
   3     E-Sp         EaSp          EfSp
   2        1            2             3
   4
   1        6                                                   Case 1: Sprays operated initially.
            1
         B-Sp
        1.000        0.000         0.000
   2        6            6                                      Case 2: Sprays were initially failed,
            3     +      4                                        or loss of service water eventually
         BfSp    or noB-SW                                        failed sprays.
        0.000        0.000         1.000
   2        6           22                                      Case 3: Sprays were initially available,
            2     *      1                                        and power was recovered.
         BaSp     &  E-ACP
        1.000        0.000         0.000
      Otherwise                                                 Case 4: No power recovery.
        0.000        1.000         0.000
28 Early air return fans?
   3    E-Fan        EaFan         EfFan
   2        1            2             3
   4
   1       14                                                   Case 1: Fans operated initially.
            1
        B-Fan
        1.000        0.000         0.000
   1       14                                                   Case 2: Fans were initially failed.
            2
        BfFan
        0.000        0.000         1.000
   2       14           22                                      Case 3: Fans were initially availiable,
            2     *      1                                        and power was recovered.
        BaFan     &  E-ACP
        1.000        0.000         0.000
      Otherwise                                                 Case 4: No power recovery.
        0.000        1.000         0.000
29 Has the ice melted from the ice condenser before VB?
   3   E-Mlt1       E-Mlt2        E-Mlt3
   2        1            2             3
  10
   1        6                                                   Case 1:  No containment heat removal
            4                                                     - ice is melted.
       noB-SW
        1.000        0.000         0.000
   1       24                                                   Case 2: No early blowdown to containment.
            4
        noEBD
        0.000        0.000         1.000
   2        1           21                                      Case 3: Large induced LOCA with a
            6     *      1                                        transient initiator.
       B-PORV     &  E-HLA
        0.500        0.500         0.000
   3        4           23            24                        Case 4: A-size early blowdown with ECCS
     (      1     +      1 )   *       1                          injection after power recovery.
     ( B-ECCS    or E-RECC )   &   EBD-A
        0.300        0.700         0.000
   3        6            7            24                        Case 5: S3-size blowdown with either spray
     (      1     +     -1 )   *       3                          or station blackout.
     (   B-Sp    or  BnACP )   &  EBD-S3
        0.000        0.050         0.950
   1       24                                                   Case 6: S3-size blowdown without sprays
            3                                                     (ECCS failed in either recirc. or inj.)
       EBD-S3
        0.000      !29,4,1       !29,4,2
   3        6            7            24                        Case 7: S2-size blowdown with either spray
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  (      1   +      -1 ) *       2                              or station blackout.
  (   B-Sp  or   BnACP ) &   EBD-S2
      0.000        0.800       0.200
 1       24                                                      Case 8: S2-size blowdown without sprays
          2                                                        (ECCS failed in either recirc. or inj.)
     EBD-S2
      0.010        0.990       0.000
 3        6            7          24                             Case 9: A-size blowdown with either sprays
  (       1   +       -1 ) *       1                               or station blackout.
  (    B-Sp  or    BnACP ) &   EBD-A
      0.000      !29,5,3     !29,5,2
    Otherwise                                                    Case 10: A-size blowdown without sprays
     !29,8,1      !29,8,2      0.000                               (ECCS failed in either recirc. or inj.)
30 Have bypass paths developed in the ice condenser before VB?
  3   E-IBP1        E-IBP2       EnIBP
  2        1             2           3
  3
  1       29                                                     Case 1: 90% or more of the ice is melted.
           1
     E-Mlt1
      0.900        0.100       0.000
  1       29                                                     Case 2: 50%-90% of the ice is melted.
           2
     E-Mlt2
      0.000      !30,1,2     !30,1,1
    Otherwise                                                    Case 4: Less than 50% of the ice is melted
      0.000        0.010       0.990
31 Are the air return fans effective before hydrogen ignition?
  2  E-EfFan      EnEfFan
  2        1            2
  3
  1       14                                                     Case 1: Fans initially operating.
           1
      B-Fan
      1.000        0.000
  2       14           22                                        Case 2: Recovered station blackout, with
           2   *        1                                          fans available.
      BaFan   &    E-ACP
      0.830        0.170
    Otherwise                                                    Case 3: Fans are either available or
      0.000        1.000                                           failed.
32 Is the bulk of blowdown flow diverted from the LC to the UC via the floor drains?
  2   E-FDiv      EnFDiv
  2        1           2
  2
  5        1          31          8            27          23    Case 1: S3 break, no fans, and no RWST
           3   *       2   *     -1 *  (       -1    +      2 )    injection before VB (provided in Loads
     Brk-S3   &  EnEfFan   &  noRWSTI &  (   noESp   or  EnRECC )  Issue #2).
      0.250        0.750
    Otherwise                                                    Case 2: Blowdown is forced through the IC
      0.000        1.000                                           or the drains are blocked by water.
33 What is the steam concentration in the LC and O2 distribution in containment during CD?
  3  E-LCIn1     E-LCIn2     E-LCIn3
  3        1           2           3
  7                                  $   LC-O2   - Parameter   1   Amount of O2 in lower compartment, kg-mole.
  1       24                         $   IC-O2   - Parameter   2   Amount of O2 in ice condenser, kg-mole.
           4                         $   UC-O2   - Parameter   3   Amount of O2 in upper compartment, kg-mole.
      noEBD                          $  LC-Stm   - Parameter   4   Amount of steam in lower compartment, kg-mole.
      0.000        0.000       1.000                                Case 1: No blowdown to containment.
  4
  1    23.30       51.20       88.40
  2   104.70       78.60       46.70
  3   170.10      168.30      163.00
  4   349.10      232.80       46.60
  2       30          27                                          Case 2:  Containment has neither ice
           1   *      -1                                            nor sprays to condense steam.
     E-IBP1   &   noE-Sp                                              (p=85,38,21 psia)
      0.010        0.740       0.250
  4
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1    86.40       86.40       86.40
2    50.70       50.70       50.70
3   161.00      161.00      161.00
4  1192.50      397.50       44.20
2       31          24                                        Case 3: A-blowdown, fans operating,
         1  *        1                                          and ice is functional or sprays are
   E-EfFan  &    EBD-A                                          operating.
     0.000       0.400       0.600
4
1    23.30       51.20       88.40
2    61.20       54.50       46.70
3   213.60      190.40      163.00
4   349.10      23_.80       46.60
2       31          24                                        Case 4: S2-blowdown, fans operating,
         1  *        2                                          and ice is functional or sprays are
   E-EfFan  &   EBD-S2                                          operating.
     0.000       0.700       0.300
4
1    23.30       51.20       88.40
2    61.20       54.50       46.70
3   213.60      190.40      163.00
4   349.10      232.80       46.60
1       31                                                    Case 5: S3-blowdown, fans operating,
         1                                                      and ice is functional or sprays are
   E-EfFan                                                      operating.
     0.050       0.950       0.000
4
1    23.30       51.20       88.40
2    61.20       54.50       46.70
3   213.60      190.40      163.00
4   349.10      232.80       46.60
1       22                                                    Case 6: Flow is diverted directly from
         1                                                      the lower compartment to the upper
    E-FDiv                                                      compartment via the floor drains in the
     0.800       0.200       0.000                              refueling canal.  For LC steam = 75%,
4                                                               P = 35 psia, for LC steam = 50%, P = 30
1    41.00       77.30       88.40                              psia.
2    97.40       83.70       46.70
3   159.70      137.10      163.00
4   506.20      291.00       46.60
  Otherwise                                                   Case 7: All other cases when fans not
     1.000       0.000       0.000                              operating, ice or sprays are intact.
4
1    23.30       51.20       88.40
2    61.20       54.50       46.70
3   213.60      190.40      163.00
4   349.10      232.80       46.60
34 What is the steam concentration in the ice condenser during core degradation?
 3 E-ICIn1      E-ICIn2      EnICIn
 4       1            2           3
 6                                      5  IC-Stm   - Parameter   5  Amount of steam in ice condenser, kg-mole.
 1      24                                                          Case 1: No blowdown to containment.
         4
     noEBD
     0.000        0.000       1.000
 1
 5  187.60       125.10       25.00
 3      30           27          33                                 Case 2: Containment has neither ice nor
         1  *        -1  *        1                                   sprays to condense steam, and lower
    E-IBP1  &    noE-Sp  &  E-LCIn1                                   compartment is level 1 inert, pressure
     1.000        0.000       0.000                                   = 85 psia.
 1
 5  724.00       240.50       26.80
 3      30           27          33                                 Case 3: Containment has neither ice nor
         1  *        -1  *        2                                   sprays to condense steam, and lower
    E-IBP1  &    noE-Sp  &  E-LCIn2                                   compartment is level 2 inert, pressure
     0.000        1.000       0.000                                   = 38 psia.
 1
 5  724.00       240.50       26.80
```

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    2      32           33                                             Case 4: Flow is diverted directly from
            1    *       1                                               the lower compartment to the upper
       E-FDiv   &   E-LCIn1                                              compartment via the floor drains in the
        0.000        0.000        1.000                                  refueling canal, and the concentration
    1                                                                    of steam in the LC is 75%, P = 35 psia.
    5  382.80       255.20        51.10
    2      32           33                                             Case 5: Flow is diverted directly from
            1    *       2                                               the lower compartment to the upper
       E-FDiv   &   E-LCIn2                                              compartment via the floor drains in the
        0.000        0.000        1.000                                  refueling canal, and the concentration
    1                                                                    of steam in the LC is 50%, P = 30 psia.
    5  328.10       218.80        43.80
      Otherwise                                                        Case 6:  All other cases with sprays
        0.000        0.000        1.000                                  operating, no ice bypass, or ice bypass
    1                                                                    with lower compartment not inert.
    5  187.60       125.10        25.00
35 What is the steam concentration in the upper compartment during core degradation?
    3  E-UCIn1      E-UCIn2      EnUCIn
    4       1            2            3
    6                                      $  UC-Stm   - Parameter   6  Amount of steam in upper compartment, kg-mole.
    1      24                                                          Case 1: No blowdown to containment.
            4
        noEBD
        0.000        0.000        1.000
    1
    6  643.60       429.10        85.80
    3      30           27           33                                Case 2: Containment has neither ice nor
            1    *      -1    *       1                                  sprays to condense steam, and lower
       E-IBP1   &   noE-Sp   &  E-LCIn1                                  compartment is level 1 inert, pressure
        1.000        0.000        0.000                                  = 85 psia.
    1
    6 2342.50       780.80        86.60
    3      30           27           33                                Case 3: Containment has neither ice nor
            1    *      -1    *       2                                  sprays to condense steam, and lower
       E-IBP1   &   noE-Sp   &  E-LCIn2                                  compartment is level 2 inert, pressure
        0.000        1.000        0.000                                  = 38 psia.
    1
    6 2342.50       780.80        86.80
    2      32           33                                             Case 4: Flow is diverted directly from
            1    *       1                                               the lower compartment to the upper
       E-FDiv   &   E-LCIn1                                              compartment via the floor drains in the
        0.000        1.000        0.000                                  refueling canal, and the concentration
    1                                                                    of steam in the LC is 75%, P = 35 psia.
    6 1084.00       722.70       144.50
    2      32           33                                             Case 5: Flow is diverted directly from
            1    *       2                                               the lower compartment to the upper
       E-FDiv   &   E-LCIn2                                              compartment via the floor drains in the
        0.000        1.000        0.000                                  refueling canal, and the concentration
    1                                                                    of steam in the LC is 50%, P = 30 psia.
    6  929.10       619.50       123.90
      Otherwise                                                        Case 6:  All other cases with sprays
        0.000        0.000        1.000                                  operating, no ice bypass, or ice bypass
    1                                                                    with lower compartment not inert.
    6  643.60       429.10        85.80
36 Early baseline pressure?
    1  E-PBase
    4       1                              $ E-Pbase   - Parameter   7   Early baseline pressure in containment (KPa)
    8
    2      24           12                                             Case 1:  No blowdown or early containment
            4    +       1                                               isolation failure.
        noEBD   or  B-Leak
        1.000
    1
    7  103.42
    3      27           30           33                                Case 2: No sprays or ice, and containment
           -1    *       1    *       1                                  is level 1 steam inert.
        noESp   &   E-IBP1   &  E-LCIn1
        1.000

    1
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    7   586.06
    3      27          30          33                                    Case 3: No sprays or ice, and containment
            -1  *        1  *        2                                     is level 2 steam inert.
         noESp  &  E-IBP1  &  E-LCIn2
         1.000
    1
    7   262.00
    3      27          30          33                                    Case 4: No sprays or ice, and containment
            -1           1  *        3                                     is not steam inert.
         noESp  &  E-IBP1  &   EnLCIn
         1.000
    1
    7   144.79
    1      31                                                            Case 5: Fans operating with either sprays
             1                                                             or ice or both.
       E-EfFan
         1.000
    1
    7   144.79
    2      32          33                                                Case 6: Flow is diverted directly from
             1  *        1                                                 the lower compartment to the upper
        E-FDiv  &  E-LCIn1                                                 compartment via the floor drains in the
         1.000                                                             refueling canal, and the concentration
    1                                                                      of steam in the LC is 75%.
    7   241.32
    2      32          33                                                Case 7: Flow is diverted directly from
             1  *        2                                                 the lower compartment to the upper
        E-FDiv  &  E-LCIn2                                                 compartment via the floor drains in the
         1.000                                                             refueling canal, and the concentration
    1                                                                      of steam in the LC is 50%.
    7   206.84
       Otherwise                                                         Case 8: No fans with either sprays or ice
         1.000                                                             or both.
    1
    7   144.79
37 Time of accumulator discharge?
    3   E1-Acc      E2-Acc       I-Acc
    2       1           2           3
    3
    4      16          16           9          10                        Case 1: RCS pressure low or intermediate
             3  +        4  + (        4  *        1 )                     at UTAF, or secondary is depressurized.
        E-ImPr  or  E-LoPr or (  SGdHR   &   SecDP )
         1.000       0.000       0.000
    2      25          25                                                Case 2: RCS pressure low or intermediate
             3  +        4                                                 just before VB and not earlier.
        I-ImPr  or  I-LoPr
         0.000       1.000       0.000
       Otherwise                                                         Case 3: If not discharged before, must
         0.000       0.000       1.000                                     discharge at VB.
38 Amount of hydrogen released in-vessel during core degradation?
    1  E-H2inV
    4       1                                8 E-H2inV   - Parameter   8  Hydrogen generated in-vessel before VB (kg-moles)
    7
    2      16          37                                                Case 1: RCS at system setpoint pressure,
             1  *       -2                                                 accum. dump before or after core melt.
        E-SSPr  &   E2nAcc                                                 In-Vessel Issue #5, Case 1a,1c (44% Zr)
         1.000
    1
    8   222.80
    1      16
             1                                                           Case 2: RCS at system setpoint pressure,
        E-SSPr                                                             accumulator dump during core melt.
         1.000                                                             In-Vessel Issue #5, Case 1b (50% Zr)
    1
    8   255.50
    2      16          37                                                Case 3: RCS at high pressure, accumulator
             2  *       -2                                                 dump before or after core melt.
        E-HiPr  &   E2nAcc                                                 In-Vessel Issue #5, Case 2a,2c,5 (32% Zr)
         1.000
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    1
    8   164.00
    1        16                                                                Case 4: RCS at high pressure, accumulator
              2                                                                  dump during core melt.
        E-HiPr                                                                   In-Vessel Issue #5, Case 2b (38% Zr)
         1.000
    1
    8   182.30
    2        16          37                                                    Case 5: RCS at intermediate pressure,
              3  *       -2                                                      accum. dump before or after core melt.
        E-ImPr  &    E2nAcc                                                      In-Vessel Issue #5, Case 3a (48% Zr)
         1.000
    1
    8   243.50
    1        16                                                                Case 6: RCS at intermediate pressure,
              3                                                                  accumulator dump during core melt.
        E-ImPr                                                                   In-Vessel Issue #5, Case 3b (52% Zr)
         1.000
    1
    8   263.90
       Otherwise - E-LoPr                                                      Case 7: RCS at low pressure.
         1.000                                                                   In-Vessel Issue #5, Case 4 (45% Zr)
    1
    8   228.20
39 Amount of Zr oxidized in-vessel during core degradation?
    2  Hi-ZrOx      Lo-ZrOx
    5         1          2
    1         8                                                                Assign fraction of Zr oxidized to 2
        E-H2inV                                                                  categories - necessary for SEQSOR.
           AND
        THRESH            1      202.70
                                H2 generation equivalent to 40% Zr fraction
40 Fraction of in-vessel hydrogen released from the RCS during CD?
    1  E-H2exV
    4         1                          S E-H2exV   - Parameter   9   Fraction of in-vessel H2 released from RCS
    4                                                                S     before VB (provided in Loads Issue #2.)
    1         1                                                                Case 1: Transient initiator with cycling
              6                                                                  PORV.
        B-PORV
         1.000
    1
    9    0.636
    3         1          20           24                                       Case 2: SGTR initiator (equivalent to S3
              5  +        1    +       3                                         break), transient initiator with induced
        B-SGTR or    E-SGTR  or  EBD-S3                                          SGTR of S3 size, or blowdown equivalent
         1.000                                                                   to an S3 LOCA.
    1
    9    0.562
    1        24                                                                Case 3: Rate of blowdown equivalent
              2                                                                  to an S2 LOCA.
        EBD-S2
         1.000
    1
    9    0.700
       Otherwise                                                               Case 4: Rate of blowdown equivalent to a
         1.000                                                                   large LOCA, or Event V has occurred.
    1
    9    0.850
41 To what degree is the hydrogen mixed in the upper compartment?
    5  WlMxd          Mxd1         Mxd2         Mxd3        UnMxd
    2         1           2            3            4            5
    3
    1        32
              1
        E-FDiv                                                                 Case 1: Flow is diverted in S3B sequence
         0.000        1.000        0.000        0.000       0.000                  (provided in Loads Issue #2).
    1        31                                                                Case 2: All other cases of ineffective
              2                                                                  fans (provided in Loads Issue #2).
       EnEfFan
```

```
        0.000       0.000       0.445       0.450       0.105
      Otherwise                                                             Case 3: Fans are effective.
        1.000       0.000       0.000       0.000       0.000
42 Distribution of hydrogen in containment during CD?
   2   E-H2xV      EnH2xV
   6        1           2            $  H2-LC   - Parameter  10   Amount of H2 in lower compartment, kg-mole.
   7                                 $  H2-IC   - Parameter  11   Amount of H2 in ice condenser, kg-mole.
   1       24                        $  H2-UP   - Parameter  12   Amount of H2 in IC upper plenum, kg-mole.
            4                        $  H2-UC   - Parameter  13   Amount of H2 in upper compartment, kg-mole.
        noEBD                                                       Case 1:  No early blowdown, no hydrogen
   6        8           9          10          11          12          13     released during core degradation.
       E-H2inV     E-H2exV      H2-LC       H2-IC       H2-UP       H2-UC
     FUN-H2xV1
       THRESH           1       0.001

   1       12                                                       Case 2: Isolation failure comparable to
            1                                                         a rupture, hydrogen is leaked from
       B-Leak                                                         containment.
   6        8           9          10          11          12          13
       E-H2inV     E-H2exV      H2-LC       H2-IC       H2-UP       H2-UC
     FUN-H2xV2
       THRESH           1       0.001

   1       41                                                       Case 3: Fans operating.
            1
        W1Mxd
   6        8           9          10          11          12          13
       E-H2inV     E-H2exV      H2-LC       H2-IC       H2-UP       H2-UC
     FUN-H2xV3
       THRESH           1       0.001

   1       41                                                       Case 4: Fans not operating and diversion
            2                                                         of flow from the LC to the UC.
         Mxd1
   6        8           9          10           1          12          13
       E-H2inV     E-H2exV      H2-LC       H2-IC       H2-UP       H2-UC
     FUN-H2xV4
       THRESH           1       0.001

   1       41                                                       Case 5: Fans not operating, but UC is
            3                                                         mixed and there is a "clear path" from
         Mxd2                                                         the LC to the UC through the IC.
   6        8           9          10          11          12          13
       E-H2inV     E-H2exV      H2-LC       H2-IC       H2-UP       H2-UC
     FUN-H2xV5
       THRESH           1       0.001

   1       41                                                       Case 6: Fans not operating, but UC is
            4                                                         mixed and there is no "clear path" from
         Mxd3                                                         the LC to the UC through the IC.
   6        8           9          10          11          12          13
       E-H2inV     E-H2exV      H2-LC       H2-IC       H2-UP       H2-UC
     FUN-H2xV6
       THRESH           1       0.001

      Otherwise                                                     Case 7: Fans not operating and the UC
   6        8           9          10          11          12          13     is unmixed.
       E-H2inV     E-H2exV      H2-LC       H2-IC       H2-UP       H2-UC
     FUN-H2xV7
       THRESH           1       0.001
43 What is the H2 concentration in the LC and burn completeness, if ignited?
   3   HLC>11      HLC>5.5      LoHLC
   6        1           2           3
   2
   1       31                        $  E-LCBC  - Parameter  14   Burn completeness in LC (for H2/O2 consumption).
            1                                                       Case 1: Fans operating, turbulent burn
       E-EfFan                                                        completeness model.
   4        1           4          10          14
```

```
     LC-O2       LC-Stm       H2-LC       E-LCBC
   FUN-H2Cnc1
   GETHRESH   2   0.110        0.055
            Determine H2 mole fraction and parse into discrete levels     Case 2: Fans operating, quiescent burn
    Otherwise                                                               completeness model.
 4       1            4           10          14
     LC-O2       LC-Stm       H2-LC       E-LCBC
   FUN-H2Cnc2
   GETHRESH   2   0.110        0.055
            Determine H2 mole fraction and parse into discrete levels
44 What is the H2 concentration in the IC and burn completeness, if ignited?
  6   HIC>21      HIC>16      HIC>14      HIC>11      HIC>5.5      LoHIC
  6      1           2           3           4           5           6
  2
  1      31                        $ E-ICBC   - Parameter  15   Burn completeness in IC (for H2/O2 consumption).
         1                                                          Case 1: Fans operating, turbulent burn
   E-EfFan                                                            completeness model.
 4       2            5           11          15
     IC-O2       IC-Stm       H2-IC       E-ICBC
   FUN-H2Cnc3
   GETHRESH   5   0.210       0.160       0.140       0.110       0.055
            Determine H2 mole fraction and parse into discrete levels     Case 2: Fans operating, quiescent burn
    Otherwise                                                               completeness model.
 4       2            5           11          15
     IC-O2       IC-Stm       H2-IC       E-ICBC
   FUN-H2Cnc4
   GETHRESH   5   0.210       0.160       0.140       0.110       0.055
            Determine H2 mole fraction and parse into discrete levels
45 What is the H2 concentration in the UP and burn completeness, if ignited?
  6   HUP>21      HUP>16      HUP>14      HUP>11      HUP>5.5      LoHUP
  6      1           2           3           4           5           6
  2
  1      31                        $ E-UPBC   - Parameter  16   Burn completeness in UP (for H2/O2 consumption).
         1                                                          Case 1: Fans operating, turbulent burn
   E-EfFan                                                            completeness model.
 4       2            5           12          16
     IC-O2       IC-Stm       H2-UP       E-UPBC
   FUN-H2Cnc5
   GETHRESH   5   0.210       0.160       0.140       0.110       0.055
            Determine H2 mole fraction and parse into discrete levels     Case 2: Fans operating, quiescent burn
    Otherwise                                                               completeness model.
 4       2            5           12          16
     IC-O2       IC-Stm       H2-UP       E-UPBC
   FUN-H2Cnc6
   GETHRESH   5   0.210       0.160       0.140       0.110       0.055
            Determine H2 mole fraction and parse into discrete levels
46 What is the H2 concentration in the UC and burn completeness, if ignited?
  5   HUC>21      HUC>16      HUC>11      HUC>5.5      LoHUC
  6      1           2           3           4           5
  2
  1      31                        $ E-UCBC   - Parameter  17   Burn completeness in UC (for H2/O2 consumption).
         1                                                          Case 1: Fans operating, turbulent burn
   E-EfFan                                                            completeness model.
 4       3            6           13          17
     UC-O2       UC-Stm       H2-UC       E-UCBC
   FUN-H2Cnc1
   GETHRESH   4   0.210       0.150       0.110       0.055
            Determine H2 mole fraction and parse into discrete levels     Case 2: Fans operating, quiescent burn
    Otherwise                                                               completeness model.
 4       3            6           13          17
     UC-O2       UC-Stm       H2-UC       E-UCBC
   FUN-H2Cnc2
   GETHRESH   4   0.210       0.150       0.110       0.055
            Determine H2 mole fraction and parse into discrete levels
47 Are the hydrogen igniters operating during core degradation?
  2     E-Ig          EnIg
  2       1             2
  4
  2      13            22                                           Case 1: Operators turned on igniters
```

```
           1   *      1                                                   initially and either had AC power
        B-Ig   &   E-ACP                                                  initially or recovered power.
       1.000      0.000
  4        7         22         46         44                            Case 2: Station blackout initially w/o
          -1   *      1    *     5    *     6                              igniters turned on. Now power is
     noB-ACP   &   E-ACP   &  LoHUC   &  LoHIC                             recovered and H2 conc. <6%.
       0.920      0.080
  2        7         22                                                  Case 3. Station blackout initially w/o
          -1   *      1                                                    igniters turned on. Now power is
     noB-ACP   &   E-ACP                                                   recovered and H2 conc. >6%.
       0.080      0.920
     Otherwise                                                           Case 4: No power recovery.
       0.000      1.000
48 Does hydrogen ignition occur in the lower compartment during CD?
  2  E-LCDef     EnLCDef
  4        1          2                $ E-IgLC   - Parameter  18  Flag for ignition in LC.
  5
  2       47         33                                                  Case 1: Early igniters, and <60% steam.
           1   *     -1
        E-Ig   & EnLCIn1
       1.000      0.000
  1
 18    1.000      0.000
  3       33         33         43                                       Case 2: Lower compartment inert, or
           1   +      2    +     3                                         insufficient hydrogen for burn.
     E-LCIn1  or E-LCIn2  or  LoHLC
       0.000      1.000
  1
 18    1.000      0.000
  2        7         47                                                  Case 3:  No station blackout, no igniters
           1   *      2                                                    - random AC ignition sources.
       B-ACP   &   EnIg
       1.000      0.000
  1
 18    1.000      0.000
  2        7         22                                                  Case 4: Station blackout, AC power is
           2   *      1                                                    recovered - random AC ignition sources.
       BaACP   &   E-ACP
       0.500      0.500
  1
 18    1.000      0.000
     Otherwise                                                           Case 5: DC and static sources only, in a
       0.150      0.850                                                    relatively steamy environment.
  1
 18    1.000      0.000
49 Does hydrogen ignition occur in the ice condenser during CD?
  2  E-ICDef     EnICDef
  4        1          2                $ E-IgIC   - Parameter  19  Flag for ignition in IC.
  5
  2       34         44                                                  Case 1: Ice condenser inert or insufficent
           1   +      6                                                    hydrogen for burn.
     E-ICIn1  or  LoHIC
       0.000      1.000
  1
 19    1.000      0.000
  5       48         31          7         22         31                 Case 2: Propagation of combustion flames
           1   *      1   +      2    *     1    *     1                   from LC, fans on, and >5.5% H2 conc.
     E-LCDef   & E-EfFan  or  BaACP   &  E-ACP   & E-EfFan                 (no igniters in ice condenser), or
       1.000      0.000                                                    recovered blackout with fans ineffective
  1                                                                        before H2 ignition.
 19    1.000      0.000
  2       44         44                                                  Case 3: Station blackout, H2 concentration
           1   +      2                                                    in IC >16%, Loads Issues #2.
      HIC>21  or  HIC>16
       0.197      0.803
  1
 19    1.000      0.000
  1       44                                                             Case 4: Station blackout, H2 concentration
           4                                                               in IC 11-16%, Loads Issue #2.
```

```
      HIC>11
       0.157       0.843
 1
19     1.000       0.000                                                      Case 5: Station blackout, H2 concentration
     Otherwise                                                                  in IC 5.5-11%, Loads Issue #2.
       0.123       0.877
 1
19     1.000       0.000
50 Does hydrogen ignition occur in the upper plenum during CD?
 2  E-UPDef      EnUPDef
 4        1            2            $  E-IgUP   - Parameter  20  Flag for ignition in UP.
 8
 2       47           34                                                      Case 1: Early igniters, and <60% steam.
          1           -1
       E-Ig      EnICIn1
      1.000        0.000
 1
20    1.000        0.000                                                      Case 2: Upper plenum inert or insufficent
 2       34           45                                                        hydrogen for burn.
          1    +       6
    E-ICIn1   or   LoHUP
      0.000        1.000
 1
20    1.000        0.000
 5       49           28        7         22          31                      Case 3: Propagation of combustion flames
          1    *       1   +    2    *     1     *     1                        from IC, fans on, and >5.5% H2 conc., or
    E-ICDef   &    E-Fan  or  BaACP  &   E-ACP   & E-EfFan                      recovered blackout with fans ineffective
      1.000        0.000                                                        before H2 ignition.
 1
20    1.000        0.000
 2        7           47                                                      Case 4: No station blackout, no igniters
          1    *       2                                                        - random AC ignition sources.
      B-ACP   &     EnIg
    !48,3,1      !48,3,2
 1
20    1.000        0.000
 2        7           22                                                      Case 5: Station blackout, AC power is
          2    *       1                                                        recovered - random AC ignition sources.
      BaACP   &    E-ACP
    !48,4,1      !48,4,2
 1
20    1.000        0.000
 2       45           45                                                      Case 6: Station blackout, H2 concentration
          1    +       2                                                        in UP >16%, Loads Issue #2.
     HUP>21   or  HUP>16
      0.347        0.653
 1
20    1.000        0.000
 1       45                                                                   Case 7: Station blackout, H2 concentration
          4                                                                     in UP 11-16%, Loads Issue #2.
     HUP>11
      0.257        0.743
 1
20    1.000        0.000
    Otherwise                                                                 Case 8: Station blackout, H2 concentration
      0.178        0.822                                                        in UP 5.5-11%, Loads Issue #2.
 1
20    1.000        0.000
51 Does hydrogen ignition occur in the upper compartment during CD?
 2  E-UCDef      EnUCDef
 4        1            2            $  E-IgUC   - Parameter  21  Flag for ignition in UC.
 8
 2       47           35                                                      Case 1: Early igniters, and <60% steam.
          1           -1
       E-Ig      EnUCIn1
      1.000        0.000
 1
21    1.000        0.000
 2       35           46                                                      Case 2: Upper compartment inert, or
```

```
           1   +       5                                  insufficient hydrogen for burn.
      E-UCInl  or   LoHUC
        0.000       1.000
  1
 21     1.000       0.000
  4        50           7          22          31        Case 3: No igniters and propagation of
            1   +       2   *       1   *       1          flames from UP with >5.5% H2 conc.
      E-UPDef  or   BaACP   &   E-ACP   & E-EfFan          (provided in Loads Issue #2), or
        1.000       0.000                                  recovered blackout with fans ineffective
  1                                                        before H2 ignition.
 21     1.000       0.000
  2         7          47                                Case 4: No station blackout, no igniters
            1   *       2                                  - random AC ignition sources.
        B-ACP   &    EnIg
      !48,3,1     !48,3,2
  1
 21     1.000       0.000
  2         7          22                                Case 5: Station blackout, AC power is
            2   *       1                                  recovered - random AC ignition sources.
        BaACP   &   E-ACP
      !48,4,1     !48,4,2
  1
 21     1.000       0.000
  2        46          46                                Case 6: Station blackout, H2 concentration
            1   +       2                                  in UC >16%, Loads Issue #2.
       HUC>21  or  HUC>16
        0.097       0.903
  1
 21     1.000       0.000
  1        46                                            Case 7: Station blackout, H2 concentration
            3                                              in UC 11-16%, Loads Issue #2.
       HUC>11
        0.092       0.908
  1
 21     1.000       0.000
    Otherwise                                            Case 8: Station blackout, H2 concentration
        0.083       0.917                                  in UC 5.5-11%, Loads Issue #2.
  1
 21     1.000       0.000
52 Is there a transition to detonation (DDT) in the ice condenser during CD?
  2 E-ICDet     EnICDet
  2         1           2
  4
  3        49          44          13                    Case 1: A deflagration occurs in the IC,
            1   *       1   *       2                      with H2 concentration >21%, Loads Issue
      E-ICDef   &  HIC>21   &    BnIg                      #2.
        0.720       0.280
  3        49          44          13                    Case 2: A deflagration occurs in the IC,
            1   *       2   *       2                      with H2 concentration 16-21%, Loads
      E-ICDef   &  HIC>16   &    BnIg                      Issue #2.
        0.620       0.380
  3        49          44          13                    Case 3: A deflagration occurs in the IC,
            1   *       3   *       2                      with H2 concentration 14-16%, Loads
      E-ICDef   &  HIC>14   &    BnIg                      Issue #2.
        0.453       0.547
    Otherwise                                            Case 4: A deflagration occurs in the IC,
        0.000       1.000                                  with H2 conc. <14%, Loads Issue #2.
53 Is there a transition to detonation (DDT) in the upper plenum during CD?
  2 E-UPDet     EnUPDet
  2         1           2
  4
  3        50          45          13                    Case 1: A deflagration occurs in the UP,
            1   *       1   *       2                      with H2 concentration >21%, Loads Issue
      E-UPDef   &  HUP>21   &    BnIg                      #2.
      !52,1,1     !52,1,2
  3        50          45          13                    Case 2: A deflagration occurs in the UP,
            1   *       2   *       2                      with H2 concentration 16-21%, Loads
      E-UPDef   &  HUP>16   &    BnIg                      Issue #2.
      !52,2,1     !52,2,2
```

```
    3       50          45         13                                  Case 3: A deflagration occurs in the UP,
             1 *         3  *       2                                    with H2 concentration 14-16%, Loads
      E-UPDef &    HUP>14   &   BnIg                                     Issue #2.
      !52,3,1     !52,3,2
      Otherwise                                                        Case 4: A deflagration occurs in the UP,
        0.000       1.000                                                with H2 conc. <14%, Loads Issue #2.
54 Pressure rise in containment due to early deflagration?
    2 E-DPDef     EnDPDef
    6        1           2           $ DP-EDef  - Parameter  22   Pressure rise due to early burn (kPa)
    4                                                                    (H2, O2, and steam and ignition flags
    1       13                                                            passed to user function implicitly)
             1                                                         Case 1: Igniters are operating early in
         B-Ig                                                            the accident, H2 is burned as it is
    6        7          14         15         16          17         22  released, with minimal pressure rise.
      E-Pbase      E-LCBC     E-ICBC      E-UPBC      E-UCBC    DP-EDef
     FUN-Burn1
       THRESH            1      0.001

    2       30          27                                             Case 2: Igniters are not operating and
             1 *        -1                                               there is no containment heat removal.
       E-IBF1 &   noE-Sp
    6        7          14         15         16          17         22
      E-Pbase      E-LCBC     E-ICBC      E-UPBC      E-UCBC    DP-EDef
     FUN-Burn2
       THRESH            1      0.001

    1       32                                                         Case 3: Igniters are not operating and
             1                                                           there is flow diversion from the LC
       E-FDiv                                                            to the UC via the floor drains.
    6        7          14         15         16          17         22
      E-Pbase      E-LCBC     E-ICBC      E-UPBC      E-UCBC    DP-EDef
     FUN-Burn3
       THRESH            1      0.001

      Otherwise                                                        Case 4: Igniters are not operating, and
    6        7          14         15         16          17         22  there is containment heat removal with
      E-Pbase      E-LCBC     E-ICBC      E-UPBC      E-UCBC    DP-EDef  no ice bypass.
     FUN-Burn4
       THRESH            1      0.001

55 Impulse from detonation in ice condenser?
    2 E-ImpIC     EnImpIC
    4        1           2           $  Imp-IC  - Parameter  23   Impulse due to early detonation in IC (kPa-s).
    2
    1       52                                                         Case 1: A detonation has occurred in
             1                                                           the IC, Loads Issue #2.
       E-ICDet
         1.000       0.000
    1
   23    10.36        0.00
       Otherwise                                                       Case 2: No detonation has occurred in
         1.000       1.000                                               the IC.
    1
   23     0.00        0.00
56 Impulse from detonation in upper plenum?
    2 E-ImpUP     EnImpUP
    4        1           2           $  Imp-UP  - Parameter  24   Impulse due to early detonation in UP (kPa-s).
    2
    1       53                                                         Case 1: A detonation has occurred in
             1                                                           the UP.
       E-UPDet
         1.000       0.000
    1
   24  !55,1,1,1      0.00
       Otherwise                                                       Case 2: No detonation has occurred in
         0.000       1.000                                               the UP.
    1
   24     0.00        0.00
57 Containment failure criteria for pressure and impulse loadings?
```

```
   1  CF-Spec
   3       1                            $   CF-Pr    - Parameter  25   Containment failure pressure.
       1.000                            $  RndVal    - Parameter  26   Random number for failure mode.
   4                                    $  CFI-UP    - Parameter  27   Impulsive failure criterion in UP.
  25   550.0                            $  CFI-IC    - Parameter  28   Impulsive failure criterion in IC.
  26     0.5                            $     (Pressure criterion in kPa, impulsive criteria in kPa-s)
  27   12.00
  28   21.58
58 Early containment failure and mode of failure?
   6    EnCF     E-CFUCL     E-CFLCL     E-CFUCR     E-CFLCR     E-CFCtR
   6       1           2           3           4           5           6
   4
   2      53          52                                                     Case 1: Detonation in the IC or UP.
           1  +        1
    E-UPDet  or E-ICDet
   4      24          23          27          28
      Imp-UP      Imp-IC      CFI-UP      CFI-IC
    FUN-CFDet
    GETHRESH  5      6.0         5.0         4.0         3.0         2.0

   1      12                                                                 Case 2: Isolation failure, equivalent
           1                                                                   to rupture, precludes later failures.
      B-Leak
   1       7
     E-Pbase
    FUN-NoCF
    GETHRESH  5      6.0         5.0         4.0         3.0         2.0

   1      54                                                                 Case 3: A deflagration has occurred.
           1
     E-DPDef
   4       7          22          25          26
     E-Pbase     DP-EDef       CF-Pr      RndVal
    FUN-CFFst
    GETHRESH  5      6.0         5.0         4.0         3.0         2.0

     Otherwise                                                               Case 4: Failure by early overpressure.
   3       7          25          26
     E-Pbase       CF-Pr      RndVal
    FUN-CFSlw
    GETHRESH  5      6.0         5.0         4.0         3.0         2.0

59 Status of ice condenser before VB?
   3  E2-IBP1     E2-IBP2      E2nIBP  $ IBPLvl   - Parameter  29
   4       1           2           3             $   Ice bypass level.
   3
   4      30          58          58          28                         Case 1: Early 100% ice bypass, including
           1  +        5  + (      3   *      -1 )                         LC rupture failure and LC leak with
     E-IBP1  or E-CFLCR or (E-CFLCL   &  noEFan )                          no fans.
       1.000       0.000       0.000
   1
  29   1.000       0.000       0.000
   2      52          30                                                 Case 2: Detonation in IC or early level 2
           1  +        2                                                   ice bypass.
     E-ICDet  or  E-IBP2
       0.000       1.000       0.000
   1
  29   0.000       0.062       0.000
     Otherwise                                                           Case 3: No early bypass, or detonations.
       0.000       0.000       1.000
   1
  29   0.000       0.000       0.000
60 Are air return fans or ducting impaired due to early burns?
   3  E2-Fan      E2aFan      E2fFan
   2       1           2           3
   5
   3      48          51          28                                     Case 1: No early burns, early fans.
           2  *        2  *        1
     EnLCDef  &  EnUCDef  &    E-Fan
```

```
        1.000       0.000       0.000
    3      48          51          28                                     Case 2: No early burns, fans available.
            2  *        2  *        2
   EnLCDef  &  EnUCDef  &     EaFan
        0.000       1.000       0.000
    3      48          51          28                                     Case 3: Early burn(s), early fans.
     (      1  +        1 )  *      1
    (E-LCDef or  E-UCDef )  &  E-Fan
        0.750       0.000       0.250
    3      48          51          28                                     Case 4: Early burn(s), fans available.
     (      1  +        1 )  *      2
    (E-LCDef or  E-UCDef )  &  EaFan
        0.000      !60,3,1     !60,3,3
    Otherwise                                                             Case 5: Fans failed early.
        0.000       0.000       1.000
61 Are sprays impaired due to early containment failure or environment?
    3    E2-Sp        E2aSp       E2fSp
    2        1            2           3
    7
    2       58           27                                               Case 1: Sprays failed early, or the
             6   +        3                                                 containment failed by catastrophic
      E-CFCtR   or     EfSp                                                 rupture.
        0.000        0.000        1.000
    4       58           58          58           27                      Case 2: Early sprays, and either a leak
     (       1   +        3   +       2 )  *       1                        failure or no containment failure.
     (    EnCF   or E-CFLCL   or E-CFUCL )  &   E-Sp
        0.950        0.000        0.050
    4       58           58          58           27                      Case 3: Sprays available and either a
     (       1   +        3   +       2 )  *       2                        leak failure or no containment failure.
     (    EnCF   or E-CFLCL   or E-CFUCL )  &   EaSp
        0.000       !61,2,1     !61,2,3
    2       58           27                                               Case 4: Rupture in upper compartment and
             4    *       1                                                 early sprays.
      E-CFUCR    &    E-Sp
        0.500        0.000        0.500
    2       58           27                                               Case 5: Rupture in upper compartment and
             4    *       2                                                 sprays available.
      E-CFUCR    &    EaSp
        0.000       !61,4,1     !61,4,3
    2       58           27                                               Case 6: Rupture in lower compartment and
             5    *       1                                                 early sprays.
      E-CFLCR    &    E-Sp
        0.800        0.000        0.200
      Otherwise                                                           Case 7: Rupture in lower compartment and
        0.000       !61,6,1     !61,6,3                                     sprays available.
62 What fraction of H2 released in-vessel is in containment at VB?
    2  E2-H2Hi      E2-H2Lo
    5        1            2
    6        8            9          10          11          12          13
      E-H2inV      E-H2exV       H2-LC       H2-IC       H2-UP       H2-UC
     FUN-H2Cont
       THRESH   1   0.500

63 Level of cavity flood at vessel breach?
    3  E2-CDry      E2-CWet       E2-CDp
    2        1            2           3
    3
    4        8           22           8          24                       Case 1: No RWST injection, or no early
     (       2   *       -1 )  +      3   +       4                         blowdown to containment (V or SGTR)
     ( RWSTaI    &    EnACP ) or RWSTfI   or   noEBD
        1.000        0.000        0.000
    1       29                                                            Case 2: RWST injection and less than
             3                                                              half ice melt (1/4 melted - ~3750 ft^3
       E-Mlt3                                                               1/2 melted - ~13500 ft^3; water touches
        0.000        0.500        0.500                                     bottom head of vessel at ~10000 ft^3.
      Otherwise                                                           Case 3: RWST injection and more than
        0.000        0.000        1.000                                     half the ice melted.
64 Does an Alpha mode event fail both the vessel and containment?
    2    Alpha      noAlpha
```

```
    2        1           2
    3
    2       26          25                                                 Case 1: Core damage not arrested and low
             2   *       4                                                   RCS pressure.
            VB   &  I-LoPr
        0.0084      0.9916
    2       26          25                                                 Case 2: Core damage not arrested and not
             2   *      -4                                                   low RCS pressure.
            VB   &  InLoPr
        0.0008      0.9992
       Otherwise                                                           Case 3: No vessel breach.
         0.000       1.000
65 Type of vessel breach?
    5     PrEj        Pour       BtmHd       Alpha        noVB
    2        1           2           3           4           5
    6
    1       26                                                             Case 1: No vessel breach.
             1
          noVB
         0.000       0.000       0.000       0.000       1.000
    1       64                                                             Case 2: Alpha mode failure
             1
         Alpha
         0.000       0.000       0.000       1.000       0.000
    1       25                                                             Case 3: RCS at system setpoint pressure
             1                                                               at VB, IV Issue #6, Case 1.
        I-SSPr
         0.790       0.080       0.130       0.000       0.000
    1       25                                                             Case 4: RCS at high pressure at VB, IV
             2                                                               Issue #6, Case 2.
        I-HiPr
         0.600       0.270       0.130       0.000       0.000
    1       25                                                             Case 5: RCS at intermediate pressure at
             3                                                               VB, IV Issue #6, Case 3.
        I-ImPr
       !65,4,1     !65,4,2     !65,4,3       0.000       0.000
       Otherwise                                                           Case 6: RCS at low pressure at VB.
         0.000       1.000       0.000       0.000       0.000
66 Fraction of core released from vessel at vessel breach?
    1   FCorVB
    4        1                         S  FCorVB   - Parameter  30   Fraction of core released at VB.
    2                                                                      Case 1: Vessel breach occurs, In-Vessel
    1       26                                                               Issue #6.
             2
            VB
         1.000
    1
   30     0.30
       Otherwise                                                           Case 2: No vessel breach.
         1.000
    1
   30     0.00
67 Level of core released from vessel at vessel breach?
    3  Hi-FCor     Md-FCor     Lo-FCor
    5        1           2           3
    1       30
        FCorVB                                                             The values from the previous question are
           AND                                                               parsed into discrete levels.
      GETHRESH   2     0.4         0.2

68 Fraction of core released that is diverted to in-core instrument tube seal room (ICIR)?
    1    CorIR
    4        1                         S   CorIR   - Parameter  31   Fraction of core released that is diverted to IC
    8
    6       63          25          65          67          24          1 Case 1: Deeply flooded cavity, or no HPME
             3 + (       4 +         2 ) *      -1   +       1    +      4    and intermediate or low core fraction
        E2-CDp or ( I-LoPr  or    Pour ) & nHiFCor   or  EBD-A    or Brk-V    released from vessel at VB, or A-size
         1.000                                                                break in the RCS.
    1
```

```
   31    0.00
    3      25        65        67                             Case 2: Low pressure or no HPME and high
     (      4  +      2 ) *     1                               core fraction released from vessel at VB
     ( I-LoPr  or     Pour ) & Hi-FCor
        1.000
    1
   31   0.146
    2      25        67                                       Case 3: Intermediate pressure and high
            3  *      1                                         core fraction released from vessel.
       I-ImPr  & Hi-FCor
        1.000
    1
   31   0.331
    2      25        67                                       Case 4: Intermediate pressure and medium
            3  *      2                                         core fraction released from vessel.
       I-ImPr  & Md-FCor
        1.000
    1
   31   0.326
    2      25        67                                       Case 5: Intermediate pressure and low
            3  *      3                                         core fraction released from vessel.
       I-ImPr  & Lo-FCor
        1.000
    1
   31   0.307
    1      67                                                 Case 6: High pressure and high core
            1                                                   fraction released from vessel.
      Hi-FCor
        1.000
    1
   31   0.419
    1      67                                                 Case 7: High pressure and medium core
            2                                                   fraction released from vessel.
      Md-FCor
        1.000
    1
   31   0.417
      Otherwise                                               Case 8: High pressure and low core
        1.000                                                   fraction released from vessel.
    1
   31   0.418
69 Level of core ejected to in-core instrument tube seal room?
    5  60T-IR    40T-IR    20T-IR     5T-IR    NoEjIR
    5       1         2         3         4         5
    2      30        31
       FCorVB     CorIR
         MULT
     GETHRESH 4  0.3759    0.2256    0.0752    0.0001         The core in the ICIR is parsed.

70 Does the vessel become a "rocket" and fail the containment or bypass the ice condenser?
    3  Rkt-CF   Rkt-IBP     noRkt
    2       1         2         3
    3
    2      65        25                                       Case 1: Gross bottom head failure and
            3         1                                         system is at setpoint pressure @ VB.
        BtmHd    I-SSPr
        0.010     0.040     0.950
    2      65        25                                       Case 2: Gross bottom head failure and
            3         2                                         system is at high pressure @ VB.
        BtmHd    I-HiPr
        0.000     0.050     0.950
      Otherwise                                               Case 3: Other forms of vessel failure,
        0.000     0.000     1.000                               or no VB.
71 Ex-vessel steam explosion at vessel breach?
    3    EVSE   EVSE-CF    noEVSE
    2       1         2         3
    4
    3      63        65        65                             Case 1: Dry cavity, alpha-mode failure
            1  +      4 +       5                               of vessel and containment, or no VB.
```

```
       E2-CDry   or  Alpha  or     noVB
         0.000       0.000        1.000
    3       25          65           63                                     Case 2: HPME with wet cavity (water level
            -4    *     -2   *        2                                       is below the bottom head of the vessel).
        InLoPr    & noPour    & E2-CWet
         0.860       0.000        0.140
    3       63          63           67                                     Case 3: Vessel at low pressure with wet
             2    +      3   *        3                                       cavity, or deeply flooded cavity with
       E2-CWet   or E2-CDp    & Lo-FCor                                       less than 20% of the core ejected at VB.
         0.860       0.000        0.140
      Otherwise                                                             Case 4: Deeply flooded cavity with 20-60%
         0.850       0.010        0.140                                       of the core ejected at VB.
72 Size of hole in vessel (after ablation)?
    2   LgHole      SmHole
    2        1           2
    2
    1       65                                                              Case 1: Molten core ejected under pressure
             1
          PrEj
         0.100       0.900
      Otherwise                                                             Case 2: Core not ejected under pressure,
         1.000       0.000                                                    bottom head failure, or irrelevant.
73 Maximum peak pressure rise at VB? (Low pressure, non-HPME, or deeply flooded cavity)
    2   DP1-VB     nDP1-VB
    4        1           2
    9                                  $  DP1-VB    - Parameter  32   Pressure rise @ VB (low RCS pr., no ice bypass)
    1       65                         $ DP1-IBP    - Parameter  33   Pressure rise @ VB (low RCS pr., 100% bypass)
             5                                                              Case 1: No vessel breach.
          noVB
         1.000       0.000
    2
   32     0.00        0.00
   33     0.00        0.00
    5       25          65           27          30          33             Case 2: Low pressure or no HPME and the
      (      4   +       2 ) *       -1 *         1 *         1               containment has neither ice nor sprays
      ( I-LoPr   or    Pour ) &    noESp &    E-IBP1 &  E-LCIn1               to condense steam, and containment has
         1.000       0.000                                                    >60% steam concentration.
    2
   32     0.00        0.00
   33     0.00        0.00
    3       64          70           71                                     Case 3: Alpha mode CF, Rocket CF, or
             1    +      1   +        2                                       CF by ex-vessel steam explosion.
         Alpha   or  Rkt-CF  or EVSE-CF
         1.000       0.000
    2
   32  9999.00        0.00
   33  9999.00        0.00
    1       63                                                              Case 4: Deeply flooded cavity at VB.
             3
        E2-CDp
         1.000       0.000
    2
   32   134.30        0.00
   33   147.90        0.00
    4       25          65           62          63                         Case 5: Low pressure or no HPME, wet
      (      4   +       2 ) *        1 *         2                           cavity, and insignificant H2 burned
      ( I-LoPr   or    Pour ) & E2-H2Hi &   E2-CWet                           before VB. Loads Issue #8, Case 4.
         1.000       0.000
    2
   32   325.10        0.00
   33   357.40        0.00
    3       25          65           62                                     Case 6: Low pressure or no HPME, dry
      (      4   +       2 ) *        1                                       cavity, and insignificant H2 burned
      ( I-LoPr   or    Pour ) & E2-H2Hi                                       before VB. Loads Issue #8, Case 4a, 4b.
         1.000       0.000
    2
   32   215.10        0.00
   33   292.30        0.00
    4       25          65           62          63                         Case 7: Low pressure or no HPME, wet
```

```
     (       4    +        2 ) *       2   *       2                        cavity, and significant H2 burned
     ( I-LoPr   or     Pour ) & E2-H2Lo   &  E2-CWet                        before VB. Loads Issue #8, Case 4.
        1.000        0.000
    2
   32  !73,4,1,1       0.00
   33  !73,4,2,1       0.00
    3       25          65         62                                     Case 8: Low pressure or no HPME, dry
     (       4    +        2 ) *       2                                    cavity, and significant H2 burned
     ( I-LoPr   or     Pour ) & E2-H2Lo                                     before VB. Loads Issue #8, Case 4a, 4b.
        1.000        0.000
    2
   32     56.25        0.00
   33     63.45        0.00
      Otherwise                                                           Case 9: Intermediate pressure with HPME
        0.000        1.000                                                  or high pressure with HPME.
    2
   32      0.00        0.00
   33      0.00        0.00
74 Maximum peak pressure rise at VB? (Int. pressure w/ H2 present at VB)
    2   DP2-VB     nDP2-VB
    4        1           2
   20                                  $  DP2-VB   - Parameter  34   Pressure rise @ VB (int. RCS pr., no ice bypass)
    3       73          25         62  $ DP2-IBP   - Parameter  35   Pressure rise @ VB (int. RCS pr., 100% bypass)
             1    +      3   *      2                                     Case 1: Pressure rise quantified in
       DP1-VB   or  I-ImPr   & E2-H2Lo                                      previous question.
        0.000        1.000
    2
   34      0.00        0.00
   35      0.00        0.00
    4       25          67          72          63                        Case 2: HPME at intermediate pressure,
             3   *       1   *       1   *       2                          high core fraction, large hole in
       I-ImPr   &  Hi-FCor   &  LgHole   &  E2-CWet                         vessel, and wet cavity. Loads Issue #8,
        1.000        0.000                                                  Case 3, 3b.
    2
   34    363.10        0.00
   35    590.20        0.00
    4       25          67          72          63                        Case 3: HPME at intermediate pressure,
             3   *       2   *       1   *       2                          medium core fraction, large hole in
       I-ImPr   &  Md-FCor   &  LgHole   &  E2-CWet                         vessel, and wet cavity. Loads Issue #8,
        1.000        0.000                                                  Case 3, 3b.
    2
   34    252.70        0.00
   35    413.30        0.00
    4       25          67          72          63                        Case 4: HPME at intermediate pressure,
             3   *       3   *       1   *       2                          low core fraction, large hole in
       I-ImPr   &  Lo-FCor   &  LgHole   &  E2-CWet                         vessel, and wet cavity. Loads Issue #8,
        1.000        0.000                                                  Case 3, 3b.
    2
   34    193.80        0.00
   35    238.50        0.00
    5       25          67          72          63          39            Case 5: HPME at intermediate pressure,
             3   *       1   *       2   *       2   *       1              high core fraction, small hole in
       I-ImPr   &  Hi-FCor   &  SmHole   &  E2-CWet   &  Hi-ZrOx            vessel, wet cavity, high in-vessel Zr
        1.000        0.000                                                  oxidation. Loads Issue #8, Case 3, 3b.
    2
   34    328.20        0.00
   35    567.60        0.00
    5       25          67          72          63          39            Case 6: HPME at intermediate pressure,
             3   *       2   *       2   *       2   *       1              medium core fraction, small hole in
       I-ImPr   &  Md-FCor   &  SmHole   &  E2-CWet   &  Hi-ZrOx            vessel, wet cavity, high in-vessel Zr
        1.000        0.000                                                  oxidation. Loads Issue #8, Case 3, 3b.
    2
   34  !74,3,1,1       0.00
   35  !74,3,2,1       0.00
    5       25          67          72          63          39            Case 7: HPME at intermediate pressure,
             3   *       3   *       2   *       2   *       1              low core fraction, small hole in
       I-ImPr   &  Lo-FCor   &  SmHole   &  E2-CWet   &  Hi-ZrOx            vessel, wet cavity, high in-vessel Zr
        1.000        0.000                                                  oxidation. Loads Issue #8, Case 3, 3b.
    2
```

```
34  !74,4,1,1      0.00
35  !74,4,2,1      0.00
 4       25          67          72          63
          3  *        1  *        2  *        2
     I-ImPr  &  Hi-FCor  &   SmHole  &  E2-CWet
      1.000       0.000
```

Case 8: HPME at intermediate pressure, high core fraction, small hole in vessel, wet cavity, low in-vessel Zr oxidation. Loads Issue #8, Case 3, 3b.

```
 2
34   311.30        0.00
35   536.50        0.00
 4       25          67          72          63
          3  *        2  *        2  *        2
     I-ImPr  &  Md-FCor  &   SmHole  &  E2-CWet
      1.000       0.000
```

Case 9: HPME at intermediate pressure, medium core fraction, small hole in vessel, wet cavity, low in-vessel Zr oxidation. Loads Issue #8, Case 3, 3b.

```
 2
34  !74,3,1,1      0.00
35  !74,3,2,1      0.00
 4       25          67          72          63
          3  *        3  *        2  *        2
     I-ImPr  &  Lo-FCor  &   SmHole  &  E2-CWet
      1.000       0.000
```

Case 10: HPME at intermediate pressure, low core fraction, small hole in vessel, wet cavity, low in-vessel Zr oxidation. Loads Issue #8, Case 3, 3b.

```
 2
34  !74,4,1,1      0.00
35  !74,4,2,1      0.00
 4       25          67          72          39
          3  *        1  *        1  *        1
     I-ImPr  &  Hi-FCor  &   LgHole  &  Hi-ZrOx
      1.000       0.000
```

Case 11: HPME at intermediate pressure, high core fraction, large hole in vessel, dry cavity, high in-vessel Zr oxidation. Loads Issue #8, Case 3a, 3b.

```
 2
34   427.80        0.00
35  !74,2,2,1      0.00
 4       25          67          72          39
          3  *        2  *        1  *        1
     I-ImPr  &  Md-FCor  &   LgHole  &  Hi-ZrOx
      1.000       0.000
```

Case 12: HPME at intermediate pressure, medium core fraction, large hole in vessel, dry cavity, high in-vessel Zr oxidation. Loads Issue #8, Case 3a, 3b.

```
 2
34   323.00        0.00
35  !74,3,2,1      0.00
 4       25          67          72          39
          3  *        3  *        1  *        1
     I-ImPr  &  Lo-FCor  &   LgHole  &  Hi-ZrOx
      1.000       0.000
```

Case 13: HPME at intermediate pressure, low core fraction, large hole in vessel, dry cavity, high in-vessel Zr oxidation. Loads Issue #8, Case 3a, 3b.

```
 2
34   189.70        0.00
35  !74,4,2,1      0.00
 3       25          67          72
          3  *        1  *        1
     I-ImPr  &  Hi-FCor  &   LgHole
      1.000       0.000
```

Case 14: HPME at intermediate pressure, high core fraction, large hole in vessel, dry cavity, low in-vessel Zr oxidation. Loads Issue #8, Case 3a, 3b.

```
 2
34   418.70        0.00
35  !74,2,2,1      0.00
 3       25          67          72
          3  *        2  *        1
     I-ImPr  &  Md-FCor  &   LgHole
      1.000       0.000
```

Case 15: HPME at intermediate pressure medium core fraction, large hole in vessel, dry cavity, low in-vessel Zr oxidation. Loads Issue #8, Case 3a, 3b.

```
 2
34   304.50        0.00
35  !74,3,2,1      0.00
 3       25          67          72
          3  *        3  *        1
     I-ImPr  &  Lo-FCor  &   LgHole
      1.000       0.000
```

Case 16: HPME at intermediate pressure, low core fraction, large hole in vessel, dry cavity, low in-vessel Zr oxidation. Loads Issue #8, Case 3a, 3b.

```
 2
34   180.50        0.00
35  !74,4,2,1      0.00
 3       25          67          72
          3  *        1  *        2
     I-ImPr  &  Hi-FCor  &   SmHole
      1.000       0.000
```

Case 17: HPME at intermediate pressure, high core fraction, small hole in vessel, and dry cavity. Loads Issue #8, Case 3a, 3b.

```
   2
  34   342.40        0.00
  35  !74,5,2,1      0.00
   3        25          67          72                         Case 18: HPME at intermediate pressure,
             3  *        2  *        2                           medium core fraction, small hole in
       I-ImPr  &  Md-FCor  &   SmHole                            vessel, and dry cavity. Loads Issue #8,
        1.000       0.000                                        Case 3a, 3b.
   2
  34   252.10        0.00
  35  !74,3,2,1      0.00
   3        25          67          72                         Case 19: HPME at intermediate pressure,
             3  *        3  *        2                           low core fraction, small hole in
       I-ImPr  &  Lo-FCor  &   SmHole                            vessel, and dry cavity. Loads Issue #8,
        1.000       0.000                                        Case 3a, 3b.
   2
  34   154.20        0.00
  35  !74,4,2,1      0.00
      Otherwise                                                Case 20: Intermediate RCS pressure with
        0.000       1.000                                        HPME and insignificant H2 present at VB,
   2                                                             and High RCS pressure with HPME.
  34     0.00        0.00
  35     0.00        0.00
75 Maximum peak pressure rise at vessel breach? (Int. pressure w/o H2, or high pressure cases)
   2   DP3-VB     nDP3-VB
   4        1           2
  20                                   $ DP3-VB   - Parameter  36   Pressure rise @ VB (high RCS pr., no ice bypass)
   2        73          74             $ DP3-IBP  - Parameter  37   Pressure rise @ VB (high RCS pr., 100% bypass)
             1  +        1                                     Case 1: Pressure rise quantified in
       DP1-VB  or  DP2-VB                                        previous questions.
        0.000       1.000
   2
  36     0.00        0.00
  37     0.00        0.00
   4        25          67          63          62             Case 2: HPME at intermediate pressure,
             3  *        1  *        2  *        2               high core fraction, wet cavity, and
       I-ImPr  &  Hi-FCor  &  E2-CWet  &  E2-H2Lo                significant H2 burned before VB. Loads
        1.000       0.000                                        Issue #8, Case 3, 3b.
   2
  34   307.70        0.00
  35   497.50        0.00
   4        25          67          63          62             Case 3: HPME at intermediate pressure,
             3  *        2  *        2  *        2               medium core fraction, wet cavity, and
       I-ImPr  &  Md-FCor  &  E2-CWet  &  E2-H2Lo                significant H2 burned before VB. Loads
        1.000       0.000                                        Issue #8, Case 3, 3b.
   2
  34   231.10        0.00
  35   366.00        0.00
   4        25          67          63          62             Case 4: HPME at intermediate pressure,
             3  *        3  *        2  *        2               low core fraction, wet cavity, and
       I-ImPr  &  Lo-FCor  &  E2-CWet  &  E2-H2Lo                significant H2 burned before VB. Loads
        1.000       0.000                                        Issue #8, Case 3, 3b.
   2
  34   183.00        0.00
  35   214.70        0.00
   4        25          67          72          62             Case 5: HPME at intermediate pressure,
             3  *        1  *        1  *        2               high core fraction, large hole in
       I-ImPr  &  Hi-FCor  &   LgHole  &  E2-H2Lo                vessel, dry cavity, and significant H2
        1.000       0.000                                        burned before VB. Loads Issue #8, Case
   2                                                             3a, 3b.
  34   385.40        0.00
  35  !75,2,2,1      0.00
   4        25          67          72          62             Case 6: HPME at intermediate pressure,
             3  *        2  *        1  *        2               medium core fraction, large hole in
       I-ImPr  &  Md-FCor  &   LgHole  &  E2-H2Lo                vessel, dry cavity, and significant H2
        1.000       0.000                                        burned before VB. Loads Issue #8, Case
   2                                                             3a, 3b.
  34   [illegible]90.30        0.00
  35  !75,3,2,1      0.00
   4        25          67          72          62             Case 7: HPME at intermediate pressure,
```

```
         3  *       3  *        1  *        2
    I-ImPr  &  Lo-FCor  &   LgHole  &  E2-H2Lo
     1.000      0.000
 2
34   173.30        0.00
35  !75,4,2,1      0.00
 3       25          67            62
```

low core fraction, large hole in vessel, dry cavity, and significant H2 burned before VB. Loads Issue #8, Case 3a, 3b.

```
         3  *       1  *        2
    I-ImPr  &  Hi-FCor  &  E2-H2Lo
     1.000      0.000
 2
34   311.30        0.00
35  !75,2,2,1      0.00
 3       25          67            62
```

Case 8: HPME at intermediate pressure, high core fraction, small hole in vessel, dry cavity, and significant H2 burned before VB. Loads Issue #8, Case 3a, 3b.

```
         3  *       2  *        2
    I-ImPr  &  Md-FCor  &  E2-H2Lo
     1.000      0.000
 2
34   232.30        0.00
35  !75,3,2,1      0.00
 3       25          67            62
```

Case 9: HPME at intermediate pressure, medium core fraction, small hole in vessel, dry cavity, and significant H2 burned before VB. Loads Issue #8, Case 3a, 3b.

```
         3  *       3  *        2
    I-ImPr  &  Lo-FCor  &  E2-H2Lo
     1.000      0.000
 2
34   144.30        0.00
35  !75,4,2,1      0.00
 2       67          63
```

Case 10: HPME at intermediate pressure, low core fraction, small hole in vessel, dry cavity, and significant H2 burned before VB. Loads Issue #8, Case 3a, 3b.

```
         1  *       2
   Hi-FCor  &  E2-CWet
     1.000      0.000
 2
36   372.10        0.00
37   641.40        0.00
 2       67          63
```

Case 11: HPME at high or setpoint pressure high core fraction, wet cavity. Loads Issue #8, Case 1, 1b.

```
         2  *       2
   Md-FCor  &  E2-CWet
     1.000      0.000
 2
36   289.90        0.00
37   464.40        0.00
 2       67          63
```

Case 12: HPME at high or setpoint pressure medium core fraction, wet cavity. Loads Issue #8, Case 1, 1b.

```
         3  *       2
   Lo-FCor  &  E2-CWet
     1.000      0.000
 2
36   212.30        0.00
37   263.90        0.00
 2       67          72
```

Case 13: HPME at high or setpoint pressure low core fraction, wet cavity. Loads Issue #8, Case 1, 1b.

```
         1  *       1
   Hi-FCor  &   LgHole
     1.000      0.000
 2
36   458.90        0.00
37  !75,11,2,1     0.00
 2       67          72
```

Case 14: HPME at high or setpoint pressure high core fraction, large hole in vessel, and dry cavity. Loads Issue #8, Case 1a, 1b.

```
         2  *       1
   Md-FCor  &   LgHole
     1.000      0.000
 2
36   337.20        0.00
37  !75,12,2,1     0.00
 2       67          72
```

Case 15: HPME at high or setpoint pressure medium core fraction, large hole in vessel, and dry cavity. Loads Issue #8, Case 1a, 1b.

```
         3  *       1
   Lo-FCor  &   LgHole
     1.000      0.000
 2
36   196.80        0.00
37  !75,13,2,1     0.00
```

Case 16: HPME at high or setpoint pressure low core fraction, large hole in vessel, and dry cavity. Loads Issue #8, Case 1a, 1b.

```
   2        67          72                                                Case 17: HPME at high or setpoint pressure
             1  *        2                                                  high core fraction, small hole in
       Hi-FCor  &   SmHole                                                  vessel, and dry cavity. Loads Issue #8,
         1.000       0.000                                                  Case 1a, 1b.
   2
  36    364.40        0.00
  37  !75,11,2,1      0.00
   2        67          72                                                Case 18: HPME at high or setpoint pressure
             2  *        2                                                  medium core fraction, small hole in
       Md-FCor  &   SmHole                                                  vessel, and dry cavity. Loads Issue #8,
         1.000       0.000                                                  Case 1a, 1b.
   2
  36    263.60        0.00
  37  !75,12,2,1      0.00
   2        67          72                                                Case 19: HPME at high or setpoint pressure
             3  *        2                                                  low core fraction, small hole in
       Lo-FCor  &   SmHole                                                  vessel, and dry cavity. Loads Issue #8,
         1.000       0.000                                                  Case 1a, 1b.
   2
  36    160.00        0.00
  37  !75,13,2,1      0.00
       Otherwise                                                          Case 20: No vessel failure.
         0.000       1.000
   2
  36      0.00        0.00
  37      0.00        0.00
76 Level of ice bypass at vessel breach?
   3   I-IBP1       I-IBP2        InIBP
   4         1           2            3
   6
   4        59          70           64           71                      Case 1: Early ice bypass, rocket mode CF,
             1  +        1  +         1  +         2                        Alpha-mode CF, or CF by ex-vessel steam
       E2-IBP1  or  Rkt-CF  or    Alpha  or EVSE-CF                         explosion.
         1.000       0.000        0.000
   1
  29      1.00        0.00         0.00
   1        70                                                            Case 2: The vessel becomes a rocket at VB,
             2                                                              resulting in ice condenser bypass.
       Rkt-IBP
         0.500       0.500        0.000
   1
  29      1.00    !59,2,1,2        0.00
   3        71          63           59                                   Case 3: Ex-vessel steam explosion in a
             1  *        3  *         2                                     deeply flooded cavity with early level 2
          EVSE  &   E2-CDp  &   E2-IBP2                                     ice bypass.
         0.010       0.990        0.000
   1
  29      1.00    !59,2,1,2        0.00
   2        71          63                                                Case 4: Ex-vessel steam explosion in a
             1  *        3                                                  deeply flooded cavity with no early ice
          EVSE  &   E2-CDp                                                  bypass.
         0.010       0.010        0.980
   1
  29      1.00    !59,2,1,2        0.00
   1        59                                                            Case 5: Early level 2 ice bypass.
             2
       E2-IBP2
         0.000       1.000        0.000
   1
  29      1.00    !59,2,1,2        0.00
       Otherwise                                                          Case 6: No early ice bypass.
         0.000       0.000        1.000
   1
  29      1.00    !59,2,1,2        0.00
77 Peak pressure rise at vessel breach? (Correction for ice bypass cases)
   2   IDP-VB      IDPnVB
   6         1           2
   3
   1        73                                                            Case 1: A correction is made for ice
```

```
            1                                                               bypass.  The pressure rise calculated
      DP1-VB                                                                in Question 73 is corrected for bypass
    3      29          32          33                                       utilizing the pressure rise for an
      IBPLvl      DP1-VB     DP1-IBP                                        effective IC and a bypassed IC, as
     FUN-DPVB                                                               well as the degree of bypass.
       THRESH           1        0.00

    1      74                                                             Case 2: A correction is made for ice
            1                                                               bypass.  The pressure rise calculated
      DP2-VB                                                                in Question 74 is corrected for bypass
    3      29          34          35                                       utilizing  the pressure rise for an
      IBPLvl      DP2-VB     DP2-IBP                                        effective IC and a bypassed IC, as
     FUN-DPVB                                                               well as the degree of bypass.
       THRESH           1        0.00

     Otherwise                                                            Case 3: A correction is made for ice
    3      29          36          37                                       bypass.  The pressure rise calculated
      IBPLvl      DP3-VB     DP3-IBP                                        in Question 75 is corrected for bypass
     FUN-DPVB                                                               utilizing the pressure rise for an
       THRESH           1        0.00                                       effective IC and a bypassed IC, as
                                                                            well as the degree of bypass.
78 Containment failure by direct core contact with containment wall?
    2  I-CFDCn      InCFDCn
    2        1            2
    5
    2       69           71                                               Case 1: No core released to seal table
             5   +       -3                                                 room at VB, or ex-vessel steam explosion
      NoEjIR    or     EVSE
       0.000          1.000
    1       69                                                            Case 2: Less than 10 MT of core debris
             4                                                              released to ICIR (5 MT nom.)
       5T-IR
       0.010          0.990
    1       69                                                            Case 3: 10 to 30 MT of core debris
             3                                                              released to ICIR (20 MT nom.)
      20T-IR
       0.310          0.690
    1       69                                                            Case 4: 30 to 50 MT of core debris
             2                                                              released to ICIR (40 MT nom.)
      40T-IR
       0.530          0.470
     Otherwise                                                            Case 5: Greater than 50 MT of core debris
       0.600          0.400                                                 released to ICIR (60 MT nom.)
79 What fraction of potentially oxidizable metal in the ejected core is oxidized at VB?
    1  I-MtlOx
    4        1                          $ I-MtlOx   - Parameter  38   Fraction of available metal oxidized at VB
    2
    2       25           65                                               Case 1: Low pressure or no HPME.
             4   +        2
      I-LoPr    or     Pour
       1.000
    1
   38    0.075
     Otherwise                                                            Case 2: HPME.
       1.000
    1
   38    0.750
80 What amount of hydrogen is released to containment at vessel breach?
    2  I-H2@VB      InH2@VB
    5        1            2             $ I-H2@VB   - Parameter  39   H2 released at VB (includes remainder in RCS).
    6        8            9          30          38          39          40
     E-H2inV     E-H2exV       FCorVB     I-MtlOx     I-H2@VB      I-FrZr
     FUN-H2VB                           $  I-FrZr   - Parameter  40   Fraction of initial Zr remaining for CCI.
       THRESH             1       0.000

81 What fraction of hydrogen in containment is consumed at vessel breach?
    1  I-ActBC
    3        1                          $ I-ActBC   - Parameter  41   Burn completeness at vessel breach.
       1.000
```

```
 1
41    0.775
82 Containment failure at vessel breach and mode of failure?
 6     InCF      I-CFUCL     I-CFLCL     I-CFUCR     I-CFLCR     I-CFCtR
 6        1            2           3           4           5           6
 6                                                                        Case 1: Alpha or Rocket, CF is a rupture
 2       64           70                                                    in UC.
          1    +       1
     Alpha  or  Rkt-CF
 1       32
    DP1-VB
   FUN-AlphCF
   GETHRESH   5     6.0         5.0         4.0         3.0         2.0

                                                                          Case 2: Containment failure by ex-vessel
 1       71                                                                 steam explosion, CF mode is one in which
          2                                                                 the ice condenser is bypassed.
   EVSE-CF
 1       32
    DP1-VB
   FUN-StExCF
   GETHRESH   5     6.0         5.0         4.0         3.0         2.0

 4       12           58          58          58                          Case 3: Isolation failure, equivalent
          1    +       6    +      4    +      5                            to rupture, and early ruptures preclude
     B-Leak  or E-CFCtR  or E-CFUCR  or E-CFLCR                             later failures.
 1        7
    E-Pbase
   FUN-NoCF
   GETHRESH   5     6.0         5.0         4.0         3.0         2.0

 1       73                                                               Case 4: Low pressure or non-HPME pressure
          1                                                                 increments.
    DP1-VB
 4        7           32          25          26
    E-Pbase      DP1-VB       CF-Pr      RndVal
   FUN-CFFst
   GETHRESH   5     6.0         5.0         4.0         3.0         2.0

 1       74                                                               Case 5: Intermed. pressure HPME pressure
          1                                                                 increments w/ significant H2 present at
    DP2-VB                                                                  VB.
 4        7           34          25          26
    E-Pbase      DP2-VB       CF-Pr      RndVal
   FUN-CFFst
   GETHRESH   5     6.0         5.0         4.0         3.0         2.0

    Otherwise                                                             Case 6: Intermed. pressure HPME pressure
 4        7           36          25          26                            increments w/o significant H2 present at
    E-Pbase      DP3-VB       CF-Pr      RndVal                             VB, or high pressure HPME pressure rises
   FUN-CFFst
   GETHRESH   5     6.0         5.0         4.0         3.0         2.0

83 Status of ice condenser immediately after vessel breach?
 3  I2-IBP1     I2-IBP2      I2nIBP
 2        1           2           3
 3                                                                        Case 1: Total ice bypass at vessel breach,
 5       76          82          76          82          28                 or LC rupture failure, or CF by direct
          1    +      5    +      1    +      3    *     -1                 contact, or LC leak w/o fans.
   I-IBP1  or I-CFLCR or  I-CFDCn  or I-CFLCL   &  noEFan
     1.000       0.000       0.000                                        Case 2: Level 2 bypass at vessel breach.
 1       76
          2
   I-IBP2
     0.000       1.000       0.000                                        Case 3: No bypass at vessel breach.
    Otherwise
     0.000       0.000       1.000
84 Are air return fans or ducting impaired due to burns @ VB?
 3  I2-Fan      I2aFan      I2fFan
 2        1           2           3
```

```
    5
    3       63          65         60                                    Case 1: Deeply flooded cavity @ VB or no
      (      3  +        5 ) *      1                                      VB, and early fans.
      ( E2-CDp  or    noVB ) & E2-Fan
         1.000       0.000      0.000
    3       63          65         60                                    Case 2: Deeply flooded cavity @ VB or no
      (      3  +        5 ) *      2                                      VB, and fans available.
      ( E2-CDp  or    noVB ) & E2aFan
         0.000       1.000      0.000
    1       60                                                           Case 3: Cavity is not deeply flooded at
             1                                                             VB, early fans.
        E2-Fan
       !60,3,1     !60,3,2    !60,3,3
    1       60                                                           Case 4: Cavity is not deeply flooded at
             2                                                             VB, fans available.
        E2aFan
       !60,4,1     !60,4,2    !60,4,3
      Otherwise                                                          Case 5: Fans already failed.
         0.000       0.000      1.000
85 Are sprays impaired due to containment failure or environment @ VB?
    3    I2-Sp       I2aSp      I2fSp
    2        1           2          3
    7
    2       82          61                                               Case 1: Sprays failed earlier, or the
             6  +        3                                                 containment failed by catastrophic
       I-CFCtR or   E2fSp                                                  rupture.
         0.000       0.000      1.000
    4       82          82         82           61                       Case 2: Sprays before vessel breach, and
      (      1  +        3  +        2 ) *       1                         either a leak failure or no containment
      (   InCF  or I-CFLCL or I-CFUCL ) &   E2-Sp                          failure.
       !61,2,1       0.000    !61,2,3
    4       82          82         82           61                       Case 3: Sprays available, and either a
      (      1  +        3  +        2 ) *       2                         leak failure or no containment failure.
      (   InCF  or I-CFLCL or I-CFUCL ) &   E2aSp
         0.000     !61,3,2    !61,3,3
    2       82          61                                               Case 4: Rupture in upper compartment and
             4  *        1                                                 sprays operating.
       I-CFUCR  &    E2-Sp
       !61,4,1       0.000    !61,4,3
    2       82          61                                               Case 5: Rupture in upper compartment and
             4  *        2                                                 sprays available.
       I-CFUCR  &    E2aSp
         0.000     !61,5,2    !61,5,3
    2       82          61                                               Case 6: Rupture in lower compartment and
             5  *        1                                                 sprays operating.
       I-CFLCR  &    E2-Sp
       !61,6,1       0.000    !61,6,3
      Otherwise                                                          Case 7: Rupture in lower compartment and
         0.000     !61,7,2    !61,7,3                                      sprays available.
86 Fraction of core not participating in HPME that is available for CCI?
    1   Fr-CCI
    4        1                        $ Fr-CCI   - Parameter  42  Core fraction available for CCI.
    9
    2       65          71                                               Case 1: Alpha mode containment failure, or
             4  +        2                                                 failure by ex-vessel steam explosion.
         Alpha  or EVSE-CF
         1.000
    1
   42     0.80
    1       70                                                           Case 2: Rocket mode containment failure.
             1
        Rkt-CF
         1.000
    1
   42     0.75
    1       65                                                           Case 3: Pressurized ejection, the remainder
             1                                                             of the core expelled from the vessel is
          PrEj                                                             available for CCI.
         1.000
```

```
   1
  42      1.00
   4        25          26          65          71          Case 4: Low pressure or no HPME, and no
      (      4     *     2    +      2 ) *       3            ex-vessel steam explosion.
      ( I-LoPr     &    VB   or   Pour ) &  noEVSE
         1.000
   1
  42      1.00
   2        71          67                                  Case 5: Ex-vessel steam explosion and high
             1    *      1                                    level of core fraction released from
          EVSE    &  Hi-FCor                                  vessel at VB.
         1.000
   1
  42      0.70
   2        71          67                                  Case 6: Ex-vessel steam explosion and
             1    *      2                                    medium level of core fraction released
          EVSE    &  Md-FCor                                  from vessel at VB.
         1.000
   1
  42      0.85
   2        71          67                                  Case 7: Ex-vessel steam explosion and low
             1    *      3                                    level of core fraction released from
          EVSE    &  Lo-FCor                                  vessel at VB.
         1.000
   1
  42      0.95
   2        65          65                                  Case 8: VB without HPME, alpha, rocket, or
             2           3                                    ex-vessel steam explosion.
          Pour      BtmHd
         1.000
   1
  42      1.00
      Otherwise                                             Case 9: No vessel breach.
         1.000
   1
  42      0.00
87 Level of core not participating in HPME that is available for CCI?
   3    CCI-Hi     CCI-Med      CCI-Lo
   5         1           2           3
   1        42
        Fr-CCI
         'AND'                                              Parse the fraction of core available
      GETHRESH   2    0.60        0.30                        for CCI into discrete levels.

88 Is the debris bed in a coolable configuration?
   2     L-CDB       LnCDB
   2         1           2
   7
   1        65                                              Case 1: No vessel breach.
             5
          noVB
         1.000       0.000
   4        63          25          65          65          Case 2: At VB, most of debris leaves the
             1    *     -4   * (     1    +      3 )          cavity, the later debris enters cavity
       E2-CDry    &  InLoPr  & (  PrEj   or  BtmHd )          with water from accumulators and/or LPIS
         0.800       0.200                                    in the cavity.
   3        63           4          25                      Case 3: At VB, debris arrives in a dry
             1  * (      4    +     -4 )                      cavit , coincident with water from the
       E2-CDry  & ( B-LPIS   or InLoPr )                      accumulators and/or LPIS.
         0.160       0.840
   1        63                                              Case 4: At VB, debris arrives in a dry
             1                                                cavity, without coincident water.
       E2-CDry
         0.000       1.000
   5        63          25          65          65          71   Case 5: At VB, most of debris leaves the
             2 * (      -4   * (     1    +      3 )  +     -3 )   cavity with the cavity water; the later
      E2-CWet & (   InLoPr   & (  PrEj   or  BtmHd ) or   EVSE )   debris receives water from the LPIS or
       !88,2,1     !88,2,2                                         from LC water spilling back into cavity.
   4        63          25          65          65               Case 6: At VB, the debris is fragmented
```

```
          3    *       -4   * (       1    +       3 )
      E2-CDp   &  InLoPr   & (    PrEj   or    BtmHd )
     !88,3,1      !88,3,2
     Otherwise
       0.280        0.720
89 What is the nature of the prompt core-concrete interaction?
   5    DryCCI      SScrCCI      DScrCCI      SDlyCCI      ncPrCCI
   2         1            2            3            4            5
   6
   1        65
             5
          noVB
       0.000        0.000        0.000        0.000        1.000
   4        63           25            4           88
             1    *      -4     *     -4     *      2
     E2-CDry   &  InLoPr    &  BnLPIS    &  LnCDB
       0.000        1.000        0.000        0.000        0.000
   1        63
             1
       E2-CDry
       1.000        0.000        0.000        0.000        0.000
   4        63           25            4           88
    (       -1  + (      -4     *      4 )) *       2
    ( InCDry or ( InLoPr    &  B-LPIS )) &  LnCDB
       0.000        0.000        1.000        0.000        0.000
   4        63           25            4           88
             1    *      -4     *     -4     *      1
     E2-CDry   &  InLoPr    &  BnLPIS    &  L-CDB
       0.000        0.000        0.000        1.000        0.000
     Otherwise
       0.000        0.000        0.000        0.000        1.000
90 Is AC power recovered late?
   3    L-ACP        LaACP        LfACP
   2         1            2            3
   7
   1        22
             1
        E-ACP
       1.000        0.000        0.000
   1        22
             3
        EfACP
       0.000        0.000        1.000
   2         9            9
             2    +       3
       SGaHR   or    SGfHR
       0.823        0.177        0.000
   1         1
             2
       Brk-S2
       0.667        0.333        0.000
   2         1           10
             3    *       2
       Brk-S3  &  noSecDP
       0.521        0.479        0.000
   2         1           10
             3    *       1
       Brk-S3  &     SecDP
       0.697        0.303        0.000
     Otherwise     - B-PORV
       0.578        0.422        0.000
91 Late sprays?
   3      L-Sp         LaSp         LfSp
   2         1            2            3
   4
   1        85
             1
         I2-Sp
       1.000        0.000        0.000
```

as it passes through the cavity water, and is held up in the cavity, the later debris deposits on top of the fragments.

Case 7: At VB, low RCS pressure may cause reagglomeration of debris in cavity.

Case 1: No vessel breach.

Case 2: Accumulator water only in cavity, with a non-replenishable water source, and a nCDB.

Case 3: Dry cavity and no accumulator dump, nCDB.

Case 4: Flooded cavity with a nCDB.

Case 5: Accumulator water only in cavity, with a non-replenishable water source, and a CDB.

Case 6: Flooded cavity, or replenishable water supply with a CDB.

Case 1: Power functioning earlier.

Case 2: Power failed initially.

Case 3: No initial AFW (Fast TMLB'), recovery period is 2.5 to 9 hours.

Case 4: Initial AFW and S2 break, recovery period is 4.5 to 9 hours.

Case 5: Initial AFW and S3 break, no secondary depressurization, recovery period is 6 to 9 hours.

Case 6: Initial AFW and S3 break, secondary depressurization, recovery period is 10.5 to 17 hours.

Case 7: Initial AFW and no break, secDP, recovery period is 12.5 to 17 hours.

Case 1: Sprays operated after VB.

```
                                                                      Case 2: Sprays failed earlier.
 1        85
          3
      I2fSp
      0.000        0.000        1.000                                 Case 3: Sprays were available and power
 2        85          90                                                has been recovered.
          2    *       1
      I2aSp    &  L-ACP
      1.000        0.000        0.000                                 Case 4: AC power not recovered.
    Otherwise
      0.000        1.000        0.000
92 Late air return fans?
 3     L-Fan       LaFan        LfFan
 2        1           2            3
 4                                                                    Case 1: Fans operated at vessel breach.
 1        84
          1
     I2-Fan
      1.000        0.000        0.000                                 Case 2: Fans failed after vessel breach.
 1        84
          3
     I2fFan
      0.000        0.000        1.000                                 Case 3: Fans available after vessel
 2        84          80                                                breach, power is recovered.
          2    *       1
     I2aFan    &   L-ACP
      1.000        0.000        0.000                                 Case 4: Fans available after vessel
    Otherwise                                                           breach, power not recovered.
      0.000        1.000        0.000
93 Is the ice melted or bypassed within the first hour of prompt CCI?
 2    L-IBP       LnIBP
 2        1           2
 5
 3        83          24           24                                 Case 1: Level 2 ice bypass at VB, and
          2   * (      3     +      4 )                                 early S3-size blowdown, or no early
    I2-IBP2   & ( EBD-S3    or  noEBD )                                 blowdown.
      0.150        0.850
 3        83          24           24                                 Case 2: Ice intact at vessel breach,
          3   * (      3     +      4 )                                 early S3-size blowdown, or no early
     I2nIBP   & ( EBD-S3    or  noEBD )                                 blowdown.
      0.050        0.950
 1        83                                                          Case 3: Level 2 ice bypass after VB,
          2                                                             with A or S2 blowdown.
    I2-IBP2
      0.500        0.500
 1        83                                                          Case 4: Ice intact after VB, with other
          3                                                             than A or S2 blowdown.
     I2nIBP
      0.250        0.750                                              Case 5: Total bypass at vessel breach.
    Otherwise
      1.000        0.000
94 Late baseline pressure?
 1  L-PBase
 4        1                                 $ L-PBase   - Parameter  43    Late baseline pressure (KPa)
 6
 5        58          82          65           12    .    78          Case 1: Containment failed before or at
          -1    +     -1    +      5    +       1    +     1            VB, or no vessel breach.
       E-CF   or    I-CF   or   noVB   or  B-Leak   or I-CFDCn
      1.000
 1
43   103.42
 3        92          93          91                                  Case 2: No containment failure, fans
          1   * (      2    +      1 )                                  operating, ice intact or sprays
      L-Fan   & (  LnIBP   or   L-Sp )                                  operating, or both.
      1.000
 1
43   131.00
 3        92          93          91                                  Case 3: No containment failure, ice
         -1   * (      2    +      1 )                                  intact, but no fans or sprays.
     L2nFan   & (  LnIBP   or   L-Sp )
```

```
         1.000
    1
   43   151.69
    3       89          89          89                                    Case 4: Prompt CCI with little or no
             1  +        2  +        4                                      steam, no containmnet heat removal.
        DryCCI  or SScrCCI  or SDlyCCI
         1.000
    1
   43   241.32
    1       89                                                            Case 5: Deeply scrubbed prompt CCI, no
             3                                                              containment heat removal.
       DScrCCI
         1.000
    1
   43   275.79
       Otherwise                                                          Case 6: No prompt CCI, no containment
         1.000                                                              heat removal.
    1
   43   206.84
95 Amount of H2 (plus H2-equivalent of CO) and CO2 generated during prompt CCI?
    2     L-CCI       LnCCI
    6        1           2
    3                                  $   L-H2   - Parameter  44   H2 (CO) in containment after prompt CCI
    1       89                         $  L-CO2   - Parameter  45   CO2 in containment after prompt CCI
             5                                                            Case 1: No prompt CCI.
        noPrCCI
    5       30          40          42          44          45
        FCorVB      I-FrZr      Fr-CCI        L-H2       L-CO2
      FUN-CCI1
      GETHRESH           1      0.001

    1  ,    65                                                            Case 2. Prompt CCI and prior HPME.
             1
          PrEj
    5       30          40          42          44          45
        FCorVB      I-FrZr      Fr-CCI        L-H2       L-CO2
      FUN-CCI2
      GETHRESH           1      0.001

       Otherwise                                                          Case 3: Prompt CCI without prior HPME.
    5       30          40          42          44          45
        FCorVB      I-FrZr      Fr-CCI        L-H2       L-CO2
      FUN-CCI3
      GETHRESH           1      0.001

96 What amount of oxygen remains in containment late?
    2      L-O2        LnO2
    5        1           2                 $   L-O2   - Parameter  46  Oxygen remaining in containment after VB.
    6        1           2           3          39          41          46
         LC-O2       IC-O2       UC-O2     I-H2@VB     I-ActBC        L-O2
      FUN-O2Late
        THRESH           1      0.001

97 Amount of hydrogen in containment after CCI?
    2      L-H2        LnH2
    6        1           2
    3
    5       12          26          58          58          58            Case 1: Previous containment rupture.
             1  +        1  +        6  +        4  +        5
       B-Leak  or     noVB  or E-CFCtR  or E-CFUCR  or E-CFLCR
    3       39          41          44
       I-H2@VB     I-ActBC        L-H2
      FUN-H2CCI1
        THRESH           1      0.001

    4       82          82          82          78                        Case 2: Previous containment rupture.
             6  +        4  +        5  +        1
       I-CFCtR  or I-CFUCR  or I-CFLCR  or I-CFDCn
    3       39          41          44
```

```
      I-H2@VB     I-ActBC        L-H2
     FUN-H2CCI1
       THRESH           1        0.001
                                                                         Case 3: No prior containment rupture and
      Otherwise                                                            vessel is breached.
   3       39          41          44
      I-H2@VB     I-ActBC        L-H2
     FUN-H2CCI2
       THRESH           1        0.001

98 How much steam is in containment late?
   2  L-HiStm     L-LoStm
   4        1           2              8   L-Stm   - Parameter  47   Steam in containment at late time
   3
   3       91          93          92                                    Case 1: Late sprays or ice intact with
            1 +  (      2   *       1 )                                    fans operating.
         L-Sp or (  LnIBP   &    L-Fan )
        0.000       1.000
   1
  47   157.40      157.40                                                Case 2: Ice intact with no fans or sprays.
   1       93
            2
        LnIBP
        0.500       0.500
   1
  47  2000.00      500.00
       Otherwise                                                         Case 3: No CHR of any kind.
         1.000      0.000
   1
  47  4259.00      500.00
99 What is the inert level in containment, and is there sufficient H2 or O2 for burns?
   4  L-Inert       L-noH2       L-noO2      LnInert
   5        1            2            3            4
   4       44           45           46           47                    Determine species concentrations and
         L-H2        L-CO2         L-O2        L-Stm                      flammability limits.
     FUN-LtConc
     GETHRESH   3      3.0          2.0          1.0

100 Late hydrogen igniters?
   2      L-Ig         LnIg
   2         1            2
   4
   2        47           90                                              Case 1: Igniters already operating.
             1    *       1
          E-Ig    &   L-ACP
         1.000        0.000
   3        22           90           99                                 Case 2: Station blackout with power
            -1    *       1    *       2                                   recovery and <6% H2 conc.
       noE-ACP    &   L-ACP    &  L-noH2
       !47,2,1      !47,2,2
   2        22           90                                              Case 3: Station blackout with power
            -1    *       1                                                recovery and >6% H2 conc.
       noE-ACP    &   L-ACP
       !47,3,1      !47,3,2                                              Case 4: Station blackout w/o recovery,
       Otherwise                                                           or igniters not initiated earlier.
         0.000        1.000
101 Is there a late deflagration in containment?
   2     L-Def        LnDef
   2         1            2
   4
   3        99           99           99                                 Case 1: Flammability criteria not met.
             1    +       2    +       3
       L-Inert   or   L-noH2   or   L-noO2
         0.000        1.000
   1       100                                                           Case 2: Late hydrogen igniters, with
             1                                                             flammability criteria met.
          L-Ig
         1.000        0.000
   1        90                                                           Case 3: Random AC ignition sources, with
```

```
              1                                                                flammability criteria met.
          L-ACP
        !48,3,1     !48,3,2
        Otherwise                                                            Case 4: DC sources only.
        !48,5,1     !48,5,2
102 Pressure rise due to late deflagration?
     2  LDP-Def     LDPnDef
     6        1           2             8 LDP-Def   - Parameter  48   Pressure rise due to late burn.
     7
     2       47          92                                                  Case 1: Igniters operating at VB, H2 is
              1  *        1                                                    burned as it is released with minimal
           E-Ig  &    L-Fan                                                    pressure rise. Fans are operating, so
     6       43          44          45          46          47          48    turbulent burn model is used.
        L-PBase        L-H2       L-CO2        L-O2       L-Stm     LDP-Def
       FUN-Brn1
         THRESH           1       0.001

     1       47                                                              Case 2: Igniters operating at VB, but fans
              1                                                                are not operating, quiescent burn model
           E-Ig                                                                is used.
     6       43          44          45          46          47          48
        L-PBase        L-H2       L-CO2        L-O2       L-Stm     LDP-Def
       FUN-Brn2
         THRESH           1       0.001

     4      101          92          93          91                          Case 3: Late deflagration with fans
              1  *        1  * (      2   +       1 )                          operating, and CHR available.
          L-Def  &    L-Fan  & (  LnIBP  or    L-Sp )
     6       43          44          45          46          47          48
        L-PBase        L-H2       L-CO2        L-O2       L-Stm     LDP-Def
       FUN-Brn3
         THRESH           1       0.001

     2      101          92                                                  Case 4: Late deflagration with fans
              1  *        1                                                    operating, and CHR not available.
          L-Def  &    L-Fan
     6       43          44          45          46          47          48
        L-PBase        L-H2       L-CO2        L-O2       L-Stm     LDP-Def
       FUN-Brn4
         THRESH           1       0.001

     3      101          93          91                                      Case 5: Late deflagration without fans
              1  * (      2   +       1 )                                      operating, and CHR available.
          L-Def  & (  LnIBP  or    L-Sp )
     6       43          44          45          46          47          48
        L-PBase        L-H2       L-CO2        L-O2       L-Stm     LDP-Def
       FUN-Brn5
         THRESH           1       0.001

     1      101                                                              Case 6: Late deflagration without fans
              1                                                                operating, and CHR not available.
          L-Def
     6       43          44          45          46          47          48
        L-PBase        L-H2       L-CO2        L-O2       L-Stm     LDP-Def
       FUN-Brn6
         THRESH           1       0.001

        Otherwise
     1       48                                                              Case 7: No late deflagration.
        LDP-Def
       FUN-NoBurn
         THRESH           1       0.001

103 Late containment failure and mode of failure?
     6     LnCF     L-CFUCL     L-CFLCL     L-CFUCR     L-CFLCR     L-CFCtR
     6        1           2           3           4           5           3
     4
     4       12          58          58          58                          Case 1: Previous containment rupture or
              1   +       6   +       4   +       5                            equivalent.
```

```
     E-Leak  or E-CFCtR  or E-CFUCR  or E-CFLCR
   1      43
     L-PBase
    FUN-NoCF
    GETHRESH   5     6.0         5.0         4.0         3.0         2.0

   4      82          82          82          78                          Case 2: Previous containment rupture.
           6   +       4   +       5   +       1
     I-CFCtR  or I-CFUCR  or I-CFLCR  or I-CFDCn
   1      43
     L-PBase
    FUN-NoCF
    GETHRESH   5     6.0         5.0         4.0         3.0         2.0

   1      101                                                             Case 3: No previous rupture, and a burn
            1                                                               occurs.
       L-Def
   4      43          45          25          26
     L-PBase     LDP-Def       CF-Pr      RndVal
    FUN-CFFst
    GETHRESH   5     6.0         5.0         4.0         3.0         2.0

     Otherwise                                                            Case 4: No previous rupture and no burn.
   3      45          25          26
     L-PBase       CF-Pr      RndVal
    FUN-CFSlw
    GETHRESH   5     6.0         5.0         4.0         3.0         2.0

104 Are sprays impaired due to late containment failure or environment?
   3    L2-Sp       L2aSp       L2fSp
   2        1           2           3
   7
   2      103          91                                                 Case 1: Sprays failed earlier, or the
            6   +       3                                                   containment failed by catastrophic
     L-CFCtR  or     LfSp                                                   rupture.
       0.000       0.000       1.000
   4      103         103         103          91                         Case 2: Sprays operating earlier, and
     (      1   +       3   +       2 ) *       1                           either a leak failure or no containment
     (   LnCF  or L-CFLCL  or L-CFUCL ) &    L-Sp                           failure.
      161,2,1      0.000     161,2,3
   4      103         103         103          91                         Case 3: Sprays available, and either a
     (      1   +       3   +       2 ) *       2                           leak failure or no containment failure.
     (   LnCF  or L-CFLCL  or L-CFUCL ) &    LaSp
       0.000     161,3,2     161,3,3
   2      103          91                                                 Case 4: Rupture in upper compartment and
            4   *       1                                                   sprays operating.
     L-CFUCR   &     L-Sp
      161,4,1      0.000     161,4,3
   2      103          91                                                 Case 5: Rupture in upper compartment and
            4   *       2                                                   sprays available.
     L-CFUCR   &     LaSp
       0.000     161,5,2     161,5,3
   2      103          91                                                 Case 6: Rupture in lower compartment and
            5   *       1                                                   sprays operating.
     L-CFLCR   &     L-Sp
      161,6,1      0.000     161,6,3
     Otherwise                                                            Case 7: Rupture in lower compartment and
       0.000     161,7,2     161,7,3                                        sprays available.
105 Is AC Power recovered very late?
   3   L2-ACP      L2aACP      L2fACP
   2        1           2           3
   4
   1       90                                                             Case 1: Power functioning earlier.
            1
        L-ACP
        1.000       0.000       0.000
   1       90                                                             Case 2: Power failed initially and is
            3                                                               not recoverable.
        L-ACP
```

```
        0.000         0.000         1.000
    4         9             1             1           10     Case 3: Initial AFW and (no break w/
              4 * (         6  + (        3    *        1 ))   secondary depressurization). Recovery
        SGdHR & (  B-PORV or ( Brk-S3   &   SecDP ))            period is 17 to 24 hours.
        0.897         0.103         0.000
      Otherwise                                                 Case 4: All other blackouts, recovery
        0.672         0.328         0.000                         period is 9 to 24 hours.
106 Very late sprays (7 hours or longer after CCI)?
     3    L2-Sp         L2aSp         L2fSp
     2        1             2             3
     4
     1      104                                                 Case 1: Sprays operated after VB.
              1
        L2-Sp
        1.000         0.000         0.000
     1      104                                                 Case 2: Sprays failed earlier.
              3
        L2fSp
        0.000         0.000         1.000
     2      104           105                                   Case 3: Sprays were available and
              2     *       1                                     power was recovered.
        L2aSp     & L2-ACP
        1.000         0.000         0.000
      Otherwise
        0.000         1.000         0.000                       Case 4: AC power not recovered.
107 Eventual basemat melt-through?
     2      BMT         noBMT
     2        1             2
     7
     5       65            58            82           103           78
              5    +       -1    +       -1    +       -1    +       1    Case 1: No VB, or containment is already
        noVB   or      E-CF   or     I-C:  or      L-CF   or I-CFDCn      failed, melt-thru is irrelevant to risk.
        0.000         1.000
     1       89
              5                                                 Case 2: No prompt CCI, melt-thru is not
      noPrCCI                                                     possible at this time.  If CDB and late
        0.000         1.000                                       water boiloff, BMT would occur after CF.
     4       87           106            25             4
              1  * (        1    +       -4    *        4 )     Case 3: Large amount of core is involved
       CCI-Hi  & (  L2-Sp  or  InLoPr   &  B-LPIS )               in prompt CCI and water supply to cavity
        0.250         0.750                                       is replenishable.
     1       87
              1                                                 Case 4: Large amount of core is involved
       CCI-Hi                                                     in prompt CCI and water supply to cavity
        0.400         0.600                                       is not replenishable.
     4       87           106            25             4
              2  * (        1    +       -4    *        4 )     Case 5: Intermediate amount of core is
      CCI-Med  & (  L2-Sp  or  InLoPr   &  B-LPIS )               involved in prompt CCI and water supply
        0.050         0.950                                       to cavity is replenishable.
     1       87
              2                                                 Case 6: Intermediate amount of core is
      CCI-Med                                                     involved in prompt CCI and water supply
        0.200         0.800                                       to cavity is not replenishable.
      Otherwise
        0.020         0.980                                     Case 7: Small amount of core is involved
108 What is the very late pressure in containment?                in CCI.
     1  L2-PBase
     4        1
     5
     5       65            58            82           103           78
              5    +       -1    +       -1    +       -1  +         1    Case 1: Containment failed or no VB.
        noVB   or      E-CF   or      I-CF   or      L-CF or  I-CFDCn
        1.000

     1
    43   103.42
     4       89           106            25             4
              5  * (        1    +       -4    *       -4 )     Case 2: No prompt CCI and either late
      noPrCCI & (  L2-Sp  or  InLoPr   &   BnLPIS )               sprays, or late heat removal from the
        1.000                                                     debris.
```

```
     1
    43   131.00
     4      106          88          63          89                          Case 3: No sprays, with either deep
             -1  * (      1  *        3  +        3 )                          scrubbed CCI, or CDB that boils off
          L2nSp  & (  L-CDB   &  E2-CDp  or DScrCCI )                          flooded cavity water.  CF is about 12
           1.000                                                               hours after VB.
     1
    43   999.00
     2      106          89                                                  Case 4: Prompt CCI occurs with sprays, or
              1  +        1                                                    dry CCI, pressure due to noncondensibles
          L2-Sp or    DryCCI                                                   If CF occurs, it will be later than 15
           1.000                                                               hours after VB.
     1
    43   189.60
        Otherwise                                                            Case 5: Prompt CCI with little water and
           1.000                                                               no sprays.
     1
    43   241.30
109 What is the mode of very late containment failure?
     6   L2nCF      L2-CFUCL    L2-CFLCL    L2-CFUCR    L2-CFLCR    L2-CFCtR
     6       1           2           3           4           5           6
     2
     1      106                                                              Case 1: Containment fails due to late
              1                                                                overpressurization.
        L2-PBase
     3       43          25          26
         L-PBase      CF-Pr      RndVal
       FUN-CFSlw
       GETHRESH   5     6.0         5.0         4.0         3.0         2.0

        Otherwise                                                            Case 2: No very late containment failure,
     1       43                                                                or basemat melt-through.
         L-PBase
       FUN-NoCF
       GETHRESH   5     6.0         5.0         4.0         3.0         2.0

110 Sprays after very late containment failure?
     2   L3-Sp       L3nSp              $ Assume AC power always recovered
     2       1           2              $   by this time if recoverable.
     4
     3      109         106         105                                      Case 1: Sprays or AC power unrecoverable
              6  +        3  +        3                                        or containment fails by catastrophic
        L2-CFCtR or   L2fSp  or  L2fACP                                        rupture.
          0.000       1.000
     3      109         109         109                                      Case 2: Either a leak failure or no
              1  +        3  +        2                                        containment failure.
          L2nCF  or L2-CFLCL or L2-CFUCL
        !61,2,1     !61,2,3
     1      109                                                              Case 3: Rupture in upper compartment.
              4
        L2-CFUCR
        !61,4,1     !61,4,3
        Otherwise                                                            Case 4: Rupture in lower compartment.
        !61,6,1     !61,6,3
111 Does core concrete attack occur after late boiloff and very late CF?
     2  L3-CCI      L3nCCI
     2       1           2
     3
     5       88          63         110          25          4               Case 1: Coolable debris bed with late
              1 * (       3  *        1  +       -4  *        4 )              water replenishment.
          L-CDB & (  E2-CDp  &    L3-Sp  or  InLoPr   &  B-LPIS )
          0.000       1.000
     4       63          88         110          26                          Case 2: Coolable debris bed with deeply
              3  *        1  *        2  *        2                            flooded cavity at VB, with no water
         E2-CDp  &    L-CDB  &    L3nSp    &     VB                            replenishment.
          0.750       0.250
        Otherwise                                                            Case 3: Prompt CCI.
          0.000       1.000
```

A.1.3 Description of the Sequoyah Binner

The binner is the computer input that instructs EVNTRE how to group the outcomes that are produced in the evaluation of the APET. There are too many outcomes for them 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 (APB). The term "binner" refers to the set of computer input that defines these bins.

Section 2.4 of this volume gives a general description of the APBs and defines each attribute of each characteristic. 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 section of Appendix A contains a case by case description of the binner.

Characteristic 1. **CF-Time (Time of containment failure)**
7 Attributes, 11 Cases

The attributes for this characteristic are:

A.	V-Dry	Check valve failures resulted in a pipe break in an interfacing low pressure system. The releases are not scrubbed.
B.	V-Wet	Check valve failures resulted in a pipe break in an interfacing low pressure system. The releases are scrubbed.
C.	CF-Early	The containment failed during the period of core degradation.
D.	CF-atVB	The containment failed at the time of VB.
E.	CF-Late	The containment failed in the very late period, during the initial part of CCI (nominally a few hours after VB).
F.	CF-VLate	The containment failed in the very late period (from 12 to 24 h after VB) during the latter part of CCI.
G.	NoCF	The containment did not fail, nor did Event V occur.

This characteristic primarily concerns the time of containment failure. In addition to four time periods in which the containment may fail, there is an attribute for no containment failure and two attributes concerning Event V, which initiates the accident and provides a large bypass of the containment at the same time.

Case 1: This case defines the conditions for Attribute A, V-Dry. The conditions for this case are an Event V initiator and that the break is located such that the fire sprays in the auxiliary building will not scrub the releases.

Case 2: This case defines the conditions for Attribute B, V-Wet. The conditions for this case are an Event V initiator and that the break is located such that the fire sprays in the auxiliary building will scrub the releases.

Case 3: This case defines the conditions for Attribute G, NoCF. For this characteristic, no containment failure is interpreted to mean no failure of the containment pressure boundary itself and no bypass by Event V. If an SGTR occurred, and there was no other failure or bypass of the containment, it is included in this case. SGTRs are considered separately in Characteristic 6, as they can occur in addition to failures of the containment itself. The size or type of containment failure is treated in Characteristic 10, and bypass of the containment is specifically identified there.

Case 4: This case defines the conditions for Attribute C, CF-Early, when there is a rupture failure of the containment. Early containment failure here means failure during core degradation, before VB, if it occurs. Containment failure due to hydrogen combustion before VB, as well as failures to isolate the containment (from failure to properly secure an airlock, for example) are included in this case. Isolation failures would provide an equivalent failure area of about 1 ft^2, and thus are included in the rupture case.

Case 5: This case defines the conditions for Attribute D, CF-atVB, when there is a rupture failure of the containment. The containment fails within several minutes of VB due to the events accompanying vessel failure.

Case 6: This case defines the conditions for Attribute E, CF-Late, when there is a rupture failure of the containment. The containment fails during the initial part of CCI. It could occur anywhere from a few tens of minutes after VB to several hours after VB. Failure in this time period is due to a burning of combustible gases created during CCI.

Case 7: This case defines the conditions for Attribute F, CF-VLate, when there is a rupture failure of the containment. The containment fails from several hours after VB to about 24 h after UTAF. Failure in this time period is by eventual overpressurization of the containment due to steam and noncondensible gases.

Case 8: This case defines the conditions for Attribute C, CF-Early, when there is a leak failure of the containment. The containment fails by combustion or detonation of hydrogen during core degradation.

Case 9: This case defines the conditions for Attribute D, CF-atVB, when there is a leak failure of the containment. The containment fails by the events that accompany vessel failure.

Case 10: This case defines the conditions for Attribute E, CF-Late, when there is a leak failure of the containment. The containment fails by burning of combustible gases created during CCI.

Case 11: This case defines the conditions for Attribute F, CF-VLate, when there is a leak failure of the containment. Failure for this case is by eventual overpressurization of the containment due to steam and noncondensible gases and BMT is also included in this case.

Characteristic 2. Sprays (Operation of containment sprays)
9 Attributes, 9 Cases

The attributes for this characteristic are:

A.	Sp-Early	The sprays operate only in the early period, that is, during the time of core degradation.
B.	Sp-E+I	The sprays operate only in the early and intermediate periods, that is, before during core degradation, and immediately after VB.
C.	Sp-E+I+L	The sprays operate only in the early, intermediate, and late periods, that is, from UTAF through the initial part of CCI.
D.	SpAlways	The sprays always operate during the periods of interest for fission product removal, that is, for at least 24 h starting at UTAF.
E.	Sp-Late	The sprays operate only in the late period, that is, during the initial part of CCI.
F.	Sp-L+VL	The sprays operate only in the late and very late periods, that is, from the start of CCI through the release of almost all the fission products from CCI.
G.	Sp-VL	The sprays operate only in the very late period, that is, during the latter part of CCI.
H.	Sp-Never	The sprays never operate during the accident.
I.	Sp-Final	The sprays operate only during the final period, which is not of interest for fission product removal.

This characteristic concerns the operation of the containment sprays. The sprays are important for reduction of aerosol concentrations in the containment atmosphere.

Case 1: This case defines the conditions for Attribute A, Sp-Early. In this case, the sprays operate only in the period during core degradation, before the VB (if it occurs).

Case 2: This case defines the conditions for Attribute B, Sp-E+I. In this case, the sprays operate only before and at VB.

Case 3: This case defines the conditions for Attribute C, Sp-E+I+L. In this case, the sprays operate only from the start of the accident through the initial part of CCI.

Case 4: This case defines the conditions for Attribute D, SpAlways. In this case, the sprays operate continuously from UTAF for at least 24 h.

Case 5: This case defines the conditions for Attribute E, Sp-Late. In this case, the sprays operate only during the initial part of CCI.

Case 6: This case defines the conditions for Attribute F, Sp-L+VL. In this case, the sprays operate only during the late and very late periods, that is, from the start of CCI through the release of almost all the fission products from CCI.

Case 7: This case defines the conditions for Attribute G, Sp-VL. In this case, the sprays operate only during the latter part of CCI, which includes release of almost all of the fission products from CCI.

Case 8: This case defines the conditions for Attribute H, Sp-Never. In this case, the containment sprays do not operate at all when they could contribute to fission product removal.

Case 9: This case defines the conditions for Attribute I, Sp-Final. In this case, the sprays first operate 24 h or more after the start of the accident.

Characteristic 3. **CCI (Core-concrete interactions)**
6 Attributes, 6 Cases

The attributes for this characteristic are:

A.	Prmt-Dry	CCI takes place promptly following VB in a dry cavity. There is no overlying water pool to scrub the releases.
B.	PrmtShl	CCI takes place promptly following VB. There is a shallow (about 5 ft) overlying water pool to scrub the releases.
C.	No-CCI	CCI does not take place.
D.	PrmtDp	CCI takes place promptly following VB. There is a deep (at least 10 ft) overlying water pool to scrub the releases.
E.	SDly-Dry	CCI takes place after a short delay, in a dry cavity. The debris bed is initially coolable, but the limited amount of water in the cavity is not replenished. The delay time is the time needed to boil off the accumulator water.
F.	LDly-Dry	CCI takes place after a long delay, in a dry cavity. The debris bed is coolable, but the water in the cavity is not replenished. The delay is the time needed to boil off the water in a deep cavity.

This characteristic concerns the CCI; if it takes place, when it takes place, and whether there is overlying pool of water to scrub the fission products released from the CCI.

Case 1: This case defines the conditions for Attribute A, Prmt-Dry. CCI takes place promptly following VB in a dry cavity. As there is no water in the cavity after VB, whether the debris bed is coolable is not relevant. The cavity was dry before breach and the accumulators did not discharge at VB.

Case 2: This case defines the conditions for Attribute B, PrmtShl. CCI takes place promptly following VB. The cavity was either dry just before vessel failure and the accumulators discharge at VB, or the amount of water in the cavity was minimal and the debris was not coolable. When CCI starts there is about 5 ft of water in the cavity.

Case 3: This case defines the conditions for Attribute C, No-CCI. If neither prompt CCI nor delayed CCI takes place, there is no CCI. Either there was no VB, or the debris is coolable, water was present at VB, and the water supply is continuously replenished.

Case 4: This case defines the conditions for Attribute D, PrmtDp. CCI takes place promptly following VB, and the cavity water is deep (at least 10 ft) when CCI commences.

Case 5: This case defines the conditions for Attribute E, SDly-Dry. CCI takes place after a short delay. The debris bed is initially coolable, and the cavity contains a limited amount of water (5 ft or less). The delay before the onset of CCI is the time needed to boil off the water.

Case 6: This case defines the conditions for Attribute F, LDly-Dry. CCI takes place after a long delay. The debris bed is initially coolable, and the cavity is full of water at VB. After all the water is boiled away, CCI commences in a dry cavity.

Characteristic 4. RCS-Pres (RCS pressure before VB)
4 Attributes, 4 Cases

The attributes for this characteristic are:

A. SSPr Just before VB, the RCS is at system setpoint pressure, about 2500 psia. This pressure is determined by the setpoint of the PORVs.

B. HiPr Just before VB, the RCS is in the range denoted high pressure. The hole in the RCS pressure boundary is small enough that the pressure spike that follows core slump decays away relatively slowly. The pressure at VB can range from 1000 to 2000 psia.

C. ImPr Just before VB, the RCS is in the range denoted intermediate pressure. The hole in the RCS is larger than for Attribute B, so the pressure at breach is within the range of 200 to 1000 psia.

D. LoPr Just before VB, the RCS is at low pressure, less than 200 psia.

This characteristic determines the pressure in the RCS just before the failure of the vessel. This pressure, together with the mode of VB, Characteristic 5, largely determines the events that take place in the containment immediately following VB. In most detailed, mechanistic analyses of core degradation, vessel failure follows the relocation or slumping of many tons of molten core material into the lower head of the vessel. The lower head usually contains some water at this time, so the core slump generates a large amount of steam. This will increase the vessel pressure, at least temporarily, if the RCS was below the PORV setpoint pressure at the time of the slump. The pressure at VB depends upon how fast the RCS pressure decreases after core slump and the delay between core slump and vessel failure.

Case 1: This case defines the conditions for Attribute A, SSPr. The RCS is at system setpoint pressure, about 2500 psia, when the vessel fails.

Case 2: This case defines the conditions for Attribute B, HiPr. The RCS is in the range denoted high pressure, 1000 to 2000 psia, when the vessel fails.

Case 3: This case defines the conditions for Attribute C, ImPr. The RCS is in the range denoted intermediate pressure, 200 to 1000 psia, when the vessel fails.

Case 4: This case defines the conditions for Attribute D, LoPr. The RCS is at low pressure, less than 200 psia, when the vessel fails.

Characteristic 5. VB-Mode (Mode of vessel breach)
6 Attributes, 6 Cases

The attributes for this characteristic are:

A. VB-HPME VB occurs when one or more penetration(s) fails and the vessel is above 200 psia. These conditions ensure HPME.

B. VB-Pour Molten core material pours out of the vessel at breach, driven primarily by the effects of gravity.

C. VB-BtmHd Either there is a circumferential failure of the bottom head of the vessel, or a large portion of the bottom head of the vessel fails.

D.	Alpha	An Alpha mode failure occurs - resulting in containment failure as well as vessel failure.
E.	Rocket	Upward acceleration of the vessel occurs, which results in containment failure as well as vessel failure (Rocket mode).
F.	No-VB	No VB occurs.

This characteristic determines the mode of vessel failure. The mode of vessel failure and the pressure in the RCS just before the failure of the vessel, Characteristic 4, largely determine the events that take place in the containment immediately following VB. In two of the failure modes, the failure of the vessel directly causes the failure of the containment as well. Characteristic 5 is not used in SEQSOR. The information SEQSOR requires about HPME is obtained from Characteristic 9.

Case 1: This case defines the conditions for Attribute A, VB-HPME. HPME results when one or more penetration(s) fails and the vessel is above 200 psia.

Case 2: This case defines the conditions for Attribute B, VB-Pour. The molten core pours out of the vessel, driven primarily by the effects of gravity. This mode of vessel failure always occurs if the vessel is at low pressure when it fails. It can also occur when the vessel is at higher pressures if the gases in the vessel escape before an appreciable amount of molten core material leaves the vessel.

Case 3: This case defines the conditions for Attribute C, VB-BtmHd, and the rocket mode failure of containment does not occur. The vessel failure involves a substantial part of the bottom head.

Case 4: This case defines the conditions for Attribute D, Alpha. Alpha mode failure is defined to be a steam explosion in the vessel that fails the vessel and also results in containment failure.

Case 5: This case defines the conditions for Attribute E, Rocket. If gross bottom head failure occurs and the vessel is at very high pressure, it is conceivable that the entire vessel could be propelled upward and somehow fail the containment.

Case 6: This case defines the conditions for Attribute F, No-VB. Core damage was arrested in time to preclude VB.

Characteristic 6. SGTR
3 Attributes, 3 Cases

The attributes for this characteristic are:

A.	SGTR	A steam generator tube rupture (SGTR) occurs. The SRVs on the secondary system are not stuck open.
B.	SG-SRVO	An SGTR occurs. The SRVs on the secondary system are stuck open.

C. No-SGTR An SGTR does not occur.

This characteristic determines whether an SGTR occurs and, if it does, whether the SRVs on the secondary system are stuck open. Because the SGTR bypasses the containment, and can occur in addition to a direct containment failure, SGTRs are considered separately in this characteristic. The situation in which there was an SGTR but no failure of the containment pressure boundary itself was considered to be No-CF in Characteristic 1.

Case 1: This case defines the conditions for Attribute A, SGTR. An SGTR occurred and the SRVs on the secondary system are not stuck open. For a temperature-induced SGTR, the secondary SRVs do not stick open.

Case 2: This case defines the conditions for Attribute B, SG-SRVO. An SGTR occurred and the SRVs on the secondary system are stuck open.

Case 3: This case defines the conditions for Attribute C, No-SGTR. There is no SGTR.

Characteristic 7. **Amt-CCI (Amount of core not in HPME available for CCI)**
4 Attributes, 4 Cases

The attributes for this characteristic are:

A. Hi-CCI A large amount of the core (70-100%) not involved in HPME participates in the CCI.

B. Med-CCI An intermediate amount of the Core (30-70%) not involved in HPME participates in the CCI.

C. Lo-CCI A small amount of the core (0-30%) not involved in HPME participates in the CCI.

D. No-CCI There is no CCI.

This characteristic determines how much of the core that is not in HPME participates in the CCI. Whether the CCI occurs at all and the timing and the conditions of the CCI are determined in Characteristic 3. The selection of one of the first three attributes in this characteristic implies that CCI occurs. The definition of this binning characteristic is different from the definition used in the APET itself. In the APET, the amount of core in CCI was the amount of the total core available to participate in CCI, without respect to whether HPME had occurred. This value was used in determining the amount of hydrogen produced during CCI and the likelihood of BMT. The primary use of this binning characteristic is to pass information on to SEQSOR for the source term analysis. SEQSOR internally subtracts out the amount of core involved in HPME from the amount passed to it in this characteristic. (The fraction of the core involved in HPME is determined by Characteristic 9.) Therefore, in the binner it is necessary to define this characteristic as the amount of the core not involved in HPME that takes part in the CCI. Otherwise, the amount of the core participating in CCI would be subtracted twice.

Case 1: This case defines the conditions for Attribute D, No-CCI. If there is no prompt CCI and there is no delayed CCI, then there is no CCI.

Case 2: This case defines the conditions for Attribute A, Hi-CCI. Either a large amount of the core (70-100%) was determined to be available for CCI in the APET, or HPME occurred. In SEQSOR, the fraction of the core involved in HPME will be subtracted from the total amount of core material. Setting Characteristic 7 to large here ensures that a large fraction of the core not involved in HPME is available for CCI. HPME is meant to include all the events in which core material leaves the vessel first under high gas pressure, followed by blowdown of the gas. The PrEj case in the APET includes only those cases where the hole in the vessel involves only a small fraction of the area of the bottom head. Thus the situation where the bottom head fails at any pressure above a few hundred psia has to be specifically included.

Case 3: This case defines the conditions for Attribute B, Med-CCI. An intermediate amount of the core (30-70%) was determined to be available for CCI in the APET.

Case 4: This case defines the conditions for Attribute C, Lo-CCI. A small amount of the core (0-30%) was determined to be available for CCI in the APET.

Characteristic 8. **Zr-Ox (Zirconium oxidation in-vessel)**
2 Attributes, 2 Cases

The attributes for this characteristic are:

A. Lo-ZrOx A small amount of the core zirconium was oxidized in the vessel prior to VB. This implies a range from 0 to 40% oxidized, with a nominal value of 25%.

B. Hi-ZrOx A large amount of the core zirconium was oxidized in the vessel prior to VB. This implies that more than 40% of the zirconium was oxidized, with a nominal value of 65%.

This characteristic determines how much of the zirconium in the core was oxidized in the vessel before VB. The amount is really the amount of equivalent zirconium oxidized since it is possible to oxidize some of the iron and chromium in the stainless steel as well. Thus, the amount oxidized can exceed 100% at the very upper end of the distribution provided by the In-Vessel Expert Panel.

Case 1: This case defines the conditions for Attribute A, Lo-ZrOx. The fraction of equivalent zirconium oxidized in the vessel prior to breach was low.

Case 2: This case defines the conditions for Attribute B, Hi-ZrOx. The fraction of equivalent zirconium oxidized in the vessel prior to breach was high.

Characteristic 9. HPME
4 Attributes, 4 Cases

The attributes for this characteristic are:

A. Hi-HPME A high fraction (> 40%) of the core was ejected under pressure from the vessel at failure.

B. Md-HPME A moderate fraction (20-40%) of the core was ejected under pressure from the vessel at failure.

C. Lo-HPME A low fraction (< 20%) of the core was ejected under pressure from the vessel at failure.

D. No-HPME There was no HPME at vessel failure.

This characteristic determines how much of the core participated in HPME. As mentioned in the discussion of Characteristic 7, HPME is not limited to vessel failure in which only a small part of the bottom head failed. Thus, the requirements for Cases 1, 2, and 3 here are similar to those for Case 2 in Characteristic 7.

Case 1: This case defines the conditions for Attribute A, Hi-HPME. A high fraction (> 40%) of the core was ejected under pressure from the vessel at failure. Pressurized ejection, as defined in the APET, implies ejection through one or a small number of penetration failures. If the entire bottom head, or a large portion of it, fails at elevated pressure, the resulting situation is so similar to ejection through a relatively small hole that both are considered to be HPME. If the cavity is deeply flooded at breach, nominally 24 ft deep with submergence of the vessel bottom, there will be little dispersal of the core debris from the cavity; if this is the case, Attribute D, No-HPME, is specified.

Case 2: This case defines the conditions for Attribute B, Md-HPME. A moderate fraction (20-40%) of the core was ejected under pressure from the vessel at failure. HPME is defined as in Case 1.
Case 3: This case defines the conditions for Attribute C, Lo-HPME. A low fraction (< 20%) of the core was ejected under pressure from the vessel at failure. HPME is defined as in Case 1.

Case 4: This case defines the conditions for Attribute D, No-HPME. There was no HPME at vessel failure. This case includes the Pour mode of vessel failure, bottom head failures at low pressure, Alpha mode failures, situations where there was no VB, and deep flooding of the cavity (as discussed in Case 1).

Characteristic 10. CF-Size (Containment failure size or type)
6 Attributes, 6 Cases

The attributes for this characteristic are:

A. Cat-Rpt	The containment failed by catastrophic rupture, resulting in a very large hole and gross structural failure.
B. Rupture	The containment failed by the development of a large hole or rupture; nominal hole size is 7 ft^2.
C. Leak	The containment failed by the development of a small hole or a leak; nominal hole size is 0.10 ft^2.
D. BMT	The containment failed by BMT, and there was no above-ground failure or bypass.
E. Bypass	The containment did not fail, but was bypassed by Event V or an SGTR.
F. No-CF	The containment did not fail, and was not bypassed

This characteristic determines how the containment failed. The first three attributes define the hole size if the containment pressure boundary failed above ground. The fourth attribute is an underground failure. The fifth attribute implies that the pressure boundary itself did not fail, but that it was bypassed by Event V or an SGTR. Only the most severe mode of failure is counted. That is, if the containment ruptures, a subsequent BMT is not of interest since essentially all the radioactive release will take place through the above-ground failure. Bypass takes precedence over all the direct failure modes since it provides a direct path from the RCS to the outside of the containment during core degradation.

Case 1: This case defines the conditions for Attribute A, Cat-Rpt. The containment failed by catastrophic rupture or major structural failure. This can occur by events accompanying VB, by a hydrogen burn during core degradation or after VB, or by late overpressure failure of the containment.

Case 2: This case defines the conditions for Attribute B, Rupture. The containment failed by the development of a large hole, denoted rupture in this analysis. This can occur by isolation failures, by a hydrogen detonation or burn during core degradation, by events accompanying vessel breach, by a hydrogen burn after VB, or by late overpressure failure of the containment.

Case 3: This case defines the conditions for Attribute C, Leak. The containment failed by the development of a small hole, denoted a leak in this analysis. This can occur due to a hydrogen burn during core degradation or after VB, by events accompanying VB, or by late overpressure failure of the containment.

Case 4: This case defines the conditions for Attribute D, BMT. The containment failed by BMT. There are no above-ground containment failures and the containment is not bypassed.

Case 5: This case defines the conditions for Attribute E, Bypass. The containment was bypassed by Event V or an SGTR. The SGTR may be either initiating or temperature-induced during the core melt. Even if core degradation is arrested before the vessel fails, a substantial portion of the fission products in the core may be released from the fuel and escape to the environment before a safe, stable state is reached.

Case 6: This case defines the conditions for Attribute F, No-CF. The containment did not fail above ground or below ground, and it was not bypassed.

Characteristic 11. RCS-Hole (Number of large holes in the RCS)
2 Attributes, 2 Cases

The attributes for this characteristic are:

A.	1-Hole	There is only a single large hole in the RCS following VB.
B.	2-Holes	There are two large holes in the RCS following VB.

This characteristic determines if there is effective natural circulation through the reactor vessel in the period following its breach. The source term experts gave two distributions for the parameter that determines the late release of fission products from the vessel; one distribution applied when there was natural circulation, and the other distribution applied when there was no natural circulation through the vessel. For effective natural circulation to take place, two large holes are required, neither of which involves a long path between the vessel and the containment atmosphere. The vessel failure, of course, creates one such hole. The question, then, is whether there is another hole that is not very small or does not lie at the end of a long or circuitous length of pipe.

Case 1: This case defines the conditions for Attribute A, 1-Hole. There is only one large hole in the RCS following VB. "A" and "S_2"-size breaks are considered to be large holes, so they are excluded. Event V is included here, as the pathway is too long for effective natural circulation. The same holds true for SGTR. "S_3"-size breaks are too small to allow effective natural circulation, and most S_3 breaks are pump seal failures, in which case the path is too long anyway.

Case 2: This case defines the conditions for Attribute B, 2-Holes. There are two large holes in the RCS following VB. A-size breaks are obviously large holes, and S_2 breaks are also considered to be large holes. The typical scenario for Alpha mode failure has the entire head of the vessel torn off. Natural circulation may be expected to be vigorous in this case due to the heat production in the vessel. In the

Rocket mode situation, there was gross failure of the bottom head, and the upward motion of the vessel tore off the hot and cold legs, so again natural circulation will be very effective.

Characteristic 12. **E2-IC (Early ice condenser function)**
3 Attributes, 3 Cases

The attributes for this characteristic are:

A. E2-InByp There is no bypass of the IC during the early period, i.e., during the RCS releases. The IC is intact.

B. E2-IpByp There is partial bypass of the IC during the early period.

C E2-IByp There is total bypass of the IC or the ice is completely melted during the early period.

This characteristic in conjunction with Characteristic 14 determines what DF should be credited to the IC for the RCS releases. The ice may be partially bypassed due to hydrogen detonations or preferential melting and subsequent channeling. The IC may be totally bypassed due to a rupture failure of containment in the LC or due to breach of the boundary between the lower and upper compartments. For times of containment failure in which catastrophic rupture occurs, the IC is assumed to be totally bypassed; however, Characteristic 12 does not reflect this mode of bypass because SEQSOR already assumes ice bypass when catastrophic rupture occurs. Complete ice melt also constitutes total ice bypass.

Case 1: This case defines the conditions for Attribute A, E2-InByp. The IC is totally functional and is credited with the full DF for the RCS releases.

Case 2: This case defines the conditions for Attribute B, E2-IpByp. There is partial bypass of the IC during the early period. The effective bypass level is nominally 10%; i.e., the IC is credited with an effective DF that is 90% of the DF for E2-InByp.

Case 3: This case defines the conditions for Attribute C, E2-IByp. There is total bypass of the IC during the early period. If the ice is melted and the fans are operating, the IC is credited with an effective DF that is 20% of the DF for E2-InByp.

Characteristic 13. **I2-IC (Late IC function)**
3 Attributes, 3 Cases

The attributes for this characteristic are:

A. I2-InByp There is no bypass of the IC during the late period, i.e., during CCI releases. The IC is intact.

B. I2-IpByp There is partial bypass of the IC during the late period.

C. I2-IByp There is total bypass of the IC or the ice is completely melted during the late period.

This characteristic, in conjunction with Characteristic 14, determines what decontamination factor DF should be credited to the IC for the late releases. The same mechanisms for bypass as discussed above for Characteristic 12 apply here.

Case 1: This case defines the conditions for Attribute A, I2-InByp. The IC is totally functional and is credited with the full DF for the late releases.

Case 2: This case defines the conditions for Attribute B, I2-IpByp. There is partial bypass of the ice condenser during the late period. The effective bypass level is nominally 10%; i.e., the IC is credited with an effective DF that is 90% of the DF for I2-InByp.

Case 3: This case defines the conditions for Attribute C, I2-IByp. There is total bypass of the IC during the late period. If the ice is melted and the fans are operating, the IC is credited with an effective DF that is 20% of the DF for I2-InByp.

Characteristic 14. **ARFans (Status of ARFs)**

The attributes for this characteristic are:

A. ARF-Erly The ARFs operate only in the early period, i.e., during the RCS releases.

B. ARF-E+L The ARFs operate in both the early and late periods, i.e., during RCS and CCI releases.

C. ARF-Late The ARFs operate only in the late period, i.e., during the CCI releases.

D. No-ARF The ARFs do not operate for the early or late periods.

This characteristic concerns the operation of the ARFs before VB and during the initial phase of CCI. This characteristic is used in conjunction with Characteristics 12 and 13 to establish the IC DF. The Source Term Expert Panel members who evaluated the IC DF, determined that the DF was sensitive to the number of passes through the IC. If fans are operating, there is more than one pass through the ice beds and larger DFs are attributed to the IC. If the fans are not operating, the aerosol-laden gases make only a single pass through the ice, and the DF is not as substantial as when they are operating.

Case 1: This case defines the conditions for Attribute A, ARF-Erly. The fans are operating only for the early period.

Case 2: This case defines the conditions for Attribute B, ARF-E+L. The fans are operating for both the early and late periods.

Case 3: This case defines the conditions for Attribute C, ARF-Late. The fans operate only for the late period.

Case 4: This case defines the conditions for Attribute D, No-ARF. The fans do not operate for either the early or late periods.

A.1.4 Listing of the Sequoyah Binner

Section 2.4 of this volume gives a general description of the APBs and defines each attribute of each characteristic. That material is not repeated here. Subsection A.1.3 is a detailed case-by-case description of the binner. The binner itself, a computer input file read by EVNTRE, is listed in this section. When used as computer input, the binner follows directly behind the APET without any break in the input file. It has been separated here for clarity.

The Sequoyah binner used in the accident progression analyses for NUREG-1150[A.1-3] consists of 225 lines of computer input. 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.[A.1-10]

The binner was developed along with the APET on a PC spreadsheet program, which greatly facilitates keeping track of the references to APET questions when questions are added or subtracted, or when the order of the questions is changed in the course of the development of the tree. The binner appears below as developed on the spreadsheet program.

```
Sequoyah Binning       14 Characteristics
16      CF-Time     Spreys        CCI   RCS-Pres   VB-Mode      SGTR
        Amt-CCI      Zr-Ox       HPME    CF-Size  RCS-Hole     E2-IC
          I2-IC     ARFans
 7 11     V-Dry      V-Wet   CF-Early    CF-atVB   CF-Late  CF-VLate
           NoCF
 2  1         1         15
              4   *      2
          Brk-V   &  V-Dry
 2  2         1         15
              4   *      1
          Brk-V   &  V-Wet
 7  7        12         58         82         78       103       107        109
              2   *      1  *       1 *        2 *       1  *      2  *       1
       noB-Leak   &   EnCF  &    InCF  & InCFDCn &    LnCF  &  noBMT  &   L2nCF
 4  3        12         58         58         58
              1  +       4  +       5 +        6
         B-Leak or E-CFUCR or E-CFLCR or E-CFCtR
 4  4        82         82         82         78
              4  +       5  +       6 +        1
        I-CFUCR or I-CFLCR or I-CFCtR or I-CFDCn
 3  5       103        103        103
              4  +       5  +       6
        L-CFUCR or L-CFLCR or L-CFCtR
 3  6       109        109        109
              4  +       5  +       6
       L2-CFUCRor L2-CFLCRor L2-CFCtR
 2  3        58         58
              2  +       3
        E-CFUCL or E-CFLCL
 2  4        82         82
              2  +       3
        I-CFUCL or I-CFLCL
 2  5       103        103
              2  +       3
        L-CFUCL or L-CFLCL
 3  6       109        109        107
              2  +       3  +       1
       L2-CFUCLor L2-CFLCL or      BMT
 9  9  Sp-Early     Sp-E+I   Sp-E+I+L   SpAlways   Sp-Late   Sp-L+VL
          Sp-VL   Sp-Never   Sp-Final
 4  1        27         85         91        106
              1   *     -1  *      -1  *      -1
           E-Sp   &  I2nSp  &    LnSp  &   L2nSp
 4  2        27         85         91        106
              1   *      1  *      -1  *      -1
           E-Sp   &  I2-Sp  &    LnSp  &   L2nSp
 4  3        27         85         91        106
              1   *      1  *       1  *      -1
           E-Sp   &  I2-Sp  &    L-Sp  &   L2nSp
 4  4        27         85         91        106
              1   *      1  *       1  *       1
           E-Sp   &  I2-Sp  &    L-Sp  &   L2-Sp
 4  5        27         85         91        106
             -1   *     -1  *       1  *      -1
           EnSp   &  I2nSp  &    L-Sp  &   L2nSp
 4  6        27         85         91        106
             -1   *     -1  *       1  *       1
           EnSp   &  I2nSp  &    L-Sp  &   L2-Sp
 4  7        27         85         91        106
             -1   *     -1  *      -1  *       1
           EnSp   &  I2nSp  &    LnSp  &   L2-Sp
 4  8        27         85         91        106
             -1   *     -1  *      -1  *      -1
           EnSp   &  I2nSp  &    LnSp  &   L2nSp
 1  9       110
              1
          L3-Sp
 6  6  Prmt-Dry   Prmt-Shl     No-CF     Prmt-Dp    SDly-Dry LDly-Dry
```

```
1 1        89
            1
       DryCCI
1 2        89
            2
       SBcrCCI
2 3        89       111
            5  *      2
       noPrCCI  & L3nCCI
1 4        89
            3
       DScrCCI
1 5        89
            4
       SDlyCCI
1 6       111
            1
       L3-CCI
4 4      SSPr      HiPr       ImPr       LoPr
1 1        25
            1
       I-SSPr
1 2        25
            2
       I-HiPr
1 3        25
            3
       I-ImPr
1 4        25
            4
       I-LoPr
6 6    VB-HPME    VB-Pour    VB-BtmHd    Alpha    Rocket    No-VB
1 1        65
            1
         PrEj
1 2        65
            2
         Pour
2 3        65        70
            3  *      3
        BtmPd  & nRocket
1 4        65
            4
        Alpha
1 5        70
           -3
       Rocket
1 6        65
            5
         noVB
3 3      SGTR    SG-SRVO    No-SGTR
3 1         1          3         20
            5  *       2  +       1
       B-SGTR  & SSRVnSO  or E-SGTR
2 2         1          3
            5  *       1
       B-SGTR  & SSRV-SO
2 3         1         20
           -5  *       2
      noBSGTR  & noESGTR
4 4    Hi-CCI    Med-CCI     Lo-CCI     No-CCI
2 4        89        111
            5  *       2
      noPrCCI  &  L3nCCI
1 1        87
            1
       CCI-Hi
1 2        87
            2
```

```
      CCI-Med
1  3       87
            3
      CCI-Lo
2  2  Lo-ZrOx    Hi-ZrOx
1  1       39
            2
      Lo-ZrOx
1  2       39
            1
      Hi-ZrOx
4  4  Hi-HPME    Md-HPME    Lo-HPME    No-HPME
5  1       65         65         25         67         63
     (      1  +      3  *     -4 )*      1  *     -3
     (   PrEj  or  BtmHd  &  InLoPr )* Hi-FCor  & InoRCDp
5  2       65         65         25         67         63
     (      1  +      3  *     -4 )*      2  *     -3
     (   PrEj  or  BtmHd  &  InLoPr )* Md-FCor  & InoRCDp
5  3       65         65         25         67         63
     (      1  +      3  *     -4 )*      3  *     -3
     (   PrEj  or  BtmHd  &  InLoPr )* Lo-FCor  & InoRCDp
2  4       65         63
           -1  +      3
      NoPrEj  or E2-CDp
6  6  Cat-Rpt    Rupture       Leak        BMT     Bypass      No-CF
4  1       58         82        103        109
            6  +       6  +       6  +       6
      E-CFCtR or I-CFCtR or L-CFCtR or L2-CFCtR
4  2       58         82        103        109
            4  +       4  +       4  +       4
      E-CFUCR or I-CFUCR or L-CFUCR or L2-CFUCR
4  2       58         82        103        109
            5  +       5  +       5  +       5
      E-CFLCR or I-CFLCR or L-CFLCR or L2-CFLCR
5  3       58         82        103        109         12
            2  +       2  +       2  +       2  +       1
      E-CFUCL or I-CFUCL or L-CFUCL or L2-CFUCL or B-Leak
5  3       58         82        103        109         78
            3  +       3  +       3  +       3  +       1
      E-CFLCL or I-CFLCL or L-CFLCL or L2-CFLCLor I-CFDCn
1  4      107
            1
          BMT
3  5        1          1         20
            4  +       5  +       1
        Brk-V or  B-SGTR or  E-SGTR
6  6       12         58         82        103        107        109
            2  *       1  *       1  *       1  *       2  *       1
      noB-Leak  &   EnCF   &   InCF   &   LnCF   &  noBMT  &  L2nCF
2  2   1-Hole    2-Holes
4  1       24         24         64         70
           -1  *      -2  *       2  *       3
      noEBD-A  & noEBD-S2 & noAlpha   &nRocket
4  2       24         24         64         70
            1  +       2  +       1  +      -3
        EBD-A  or EBD-S2  or  Alpha  or Rocket
3  3  E2-InByP   E2-IpByP   E2-IByP
1  1       59
            3
       E2nIBP
1  2       59
            2
      E2-IBP2
2  3       59         58
            1  +       5
      E2-IBP1 or E-CFLCR
3  3  I2-InByP   I2-IpByP   I2-IByP
1  1       83
            3
```

```
      I2nIBP
1  2        83
             2
      I2-IBP2
5  3        83          58          82
             1  +        5  +        5
      I2-IBP1 or E-CFLCR or I-CFLCR
4  4  ARF-Erly    ARF-E+L     ARF-Late     No-ARF
2  1        28          92
             1   *      -1
         E-Fan   &  LnFan
2  2        28          92
             1   *       1
         E-Fan   &  L-Fan
2  3        28          92
            -1   *       1
         EnFan   &  L-Fan
2  4        28          92
            -1   *      -1
         EnFan   &  LnFan
```

A.1.5 Description of the Sequoyah Rebinner

Section 2.4 of this volume gives a general description of the APBs and defines each attribute of each characteristic. That material is not repeated here. The Sequoyah rebinner used in the accident progression analyses for NUREG-1150[A.1-5] makes very few changes in the original binning of the APET output.

For binning Characteristic 2, containment spray operation, Attribute 8, Sp-Never, and Attribute 9, Sp-Final, are combined into one attribute in the rebinner because operation of the sprays in the final period does not affect the fission product release as calculatted by SEQSOR. For Characteristic 10, containment failure size, two pairs of attributes are coalesced. Attributes 3, Leak, and 4, BMT, are combined because SEQSOR treats BMT as a leak when computing releases. Attributes 5, Bypass, and 6, No-CF, are combined because in either case the primary mode of fission product release is not through a failure of the containment. For SGTR, in which early containment failure is much more likely than for Event V, releases due to containment failure are calculated separately and added to the SGTR releases.

A.1.6 Listing of the Sequoyah Rebinner

Section 2.4 of this volume gives a general description of rebinning and defines each attribute of each characteristic of the accident progression bins. That material is not repeated here. Subsection A.1.5 describes the function of the rebinner. The rebinner itself, a computer input file read by the EVNTRE postprocessing code, PSTEVNT, is listed in this section.

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 makes use of 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.1-20]

```
Sequoyah Rebinning     14 Attributes
14     CF-Time      Sprays          CCI    RCS-Pres   VB-Mode      SGTR
       Amt-CCI       Zr-Ox         HPME    CF-Size    RCS-Hole    E2-IC
         I2-IC      ARFans
 7  7    V-Dry       V-Wet     CF-Early   CF-atVB     CF-Late   CF-VLate
          NoCF
 1  1        1
             1
         V-Dry
 1  2        1
             2
         V-Wet
 1  3        1
             3
      CF-Early
 1  4        1
             4
       CF-atVB
 1  5        1
             5
       CF-Late
 1  6        1
             6
      CF-VLate
 1  7        1
             7
          NoCF
 8  8  Sp-Early     Sp-E+I     Sp-E+I+L   SpAlways    Sp-Late    Sp-L+VL
         Sp-VL    Sp-NonOp
 1  1        2
             1
      Sp-Early
 1  2        2
             2
        Sp-E+I
 1  3        2
             3
      Sp-E+I+L
 1  4        2
             4
      SpAlways
 1  5        2
             5
       Sp-Late
 1  6        2
             6
       Sp-L+VL
 1  7        2
             7
         Sp-VL
 2  8        2           2
             8   +       9
      Sp-Never orSp-Final
 6  6  Prmt-Dry   Prmt-Shl      No-CCI     Prmt-Dp    SDly-Dry  LDly-Dry
 1  1        3
             1
      Prmt-Dry
 1  2        3
             2
      Prmt-Shl
 1  3        3
             3
        No-CCI
 1  4        3
             4
       Prmt-Dp
 1  5        3
             5
      SDly-Dry
 1  6        3
             6
```

```
     LDly-Dry
 4  4     SSPr      HiPr       ImPr       LoPr
 1  1        4
             1
          SSPr
 1  2        4
             2
          HiPr
 1  3        4
             3
          ImPr
 1  4        4
             4
          LoPr
 6  6  VB-HPME    VB-Pour    VB-BtmHd    Alpha     Rocket     No-VB
 1  1        5
             1
       VB-HPME
 1  2        5
             2
       VB-Pour
 1  3        5
             3
      VB-BtmHd
 1  4        5
             4
         Alpha
 1  5        5
             5
        Rocket
 1  6        5
             6
         No-VB
 3  3     SGTR    SG-SRVO    No-SGTR
 1  1        6
             1
          SGTR
 1  2        6
             2
       SG-SRVO
 1  3        6
             3
       No-SGTR
 4  4   Hi-CCI    Med-CCI     Lo-CCI     No-CCI
 1  1        7
             1
        Hi-CCI
 1  2        7
             2
       Med-CCI
 1  3        7
             3
        Lo-CCI
 1  4        7
             4
        No-CCI
 2  2  Lo-ZrOx    Hi-ZrOx
 1  1        8
             1
       Lo-ZrOx
 1  2        8
             2
       Hi-ZrOx
 4  4  Hi-HPME    Md-HPME    Lo-HPME    No-HPME
 1  1        9
             1
       Hi-HPME
 1  2        9
             2
       Md-HPME
 1  3        9
```

```
             3
      Lo-HPME
 1  4        8
             4
      No-HPME
 4  4 Cat-Rpt    Rupture       Leak      No-CF
 1  1       10
             1
      Cat-Rpt
 1  2       10
             2
      Rupture
 2  3       10          10
             3   +       4
          Leak   or    BMT
 2  4       10          10
             5   +       6
        Bypass   or  No-CF
 2  2   1-Hole    2-Holes
 1  1       11
             1
        1-Hole
 1  2       11
             2
       2-Holes
 3  3 E2-InByP   E2-IpByP   E2-IByP
 1  1       12
             1
      E2-InByP
 1  2       12
             2
      E2-IpByP
 1  3       12
             3
       E2-IByP
 3  3 I2-InByP   I2-IpByP   I2-IByP
 1  1       13
             1
      I2-InByP
 1  2       13
             2
      I2-IpByP
 1  3       13
             3
       I2-IByP
 4  4 ARF-Erly   ARF-E+L    ARF-Late    No-ARF
 1  1       14
             1
      ARF-Erly
 1  2       14
             2
       ARF-E+L
 1  3       14
             3
      ARF-Late
 1  4       14
             4
        No-ARF
```

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A.2 DESCRIPTION AND LISTING OF THE USER FUNCTION

A.2.1 Description of the User Function for the Sequoyah APET

The user function is a FORTRAN function subprogram that is 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 Sequoyah APET, however, an executable module of EVNTRE specific for Sequoyah 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 that are performed in the user function in support of the Sequoyah APET are:

- Compute the amount and distribution of hydrogen in the containment during the various time periods;
- Compute the concentration and the flammability of the atmosphere in the containment during the various time periods;
- Calculate the pressure rise due to hydrogen burns and adjust the amounts of gases consumed in the burns accordingly; and
- Determine whether the containment fails and the mode of failure.

The Sequoyah user function consists of a series of computational modules. Each module is identified by a character string, or name, that can consist of up to six characters. 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-H2xV1 in Question 42 accesses the computational module H2xV1 in the user function. The various computational modules in the Sequoyah 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 is also included in this table.

The Sequoyah user function uses four other FORTRAN functions: PSLOW, PFAST, H2BURN and XINTRP. The functions PSLOW and PFAST determine whether the containment 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 in conjunction 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 linearly interpolate between points in a distribution.

The method of determining containment failure and the mode of failure warrants additional discussion. Furthermore, the method as explained below considers three modes of failure: leak, rupture, and catastrophic rupture. Two of the modes are associated with two failure locations: leak or rupture can occur in either the lower or upper containment, thus establishing whether the IC is bypassed when the containment fails. Catastrophic rupture is considered to be a global type of failure and thus there is no failure location variation for this failure mode. The 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 for determining the mode of containment failure for a pressure rise that is slow compared to the leak rate is straightforward, but the method for determining the mode of containment failure for a pressure rise which is fast compared to the leak rate is more complex. 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 can either be a fixed value or it 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 412 kPa and the load pressure is greater than 412 kPa. The data statement for the array PCONC in the user function supplies random values for the modes and locations in the following order: leak, lower compartment leak, upper compartment; rupture, lower compartment; rupture, upper compartment; catastrophic rupture; and no failure (to fill the array). The conditional probability for leak at 412 kPa is 0.15, so if the random number is less than 0.15 the failure mode is leak. The interval conditional probability for rupture is 0.78, so if the number is between 0.15 and 0.93, the failure mode is a rupture. The interval conditional probability of catastrophic rupture is 0.07, so if the random number is between 0.93 and 1.0 the failure mode is catastrophic 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 catastrophic rupture. The bulk of the failures are shown as leaks in this illustration, and for them the pressure rises to the next step, where again a fraction are converted to rupture and catastrophic rupture. 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 catastrophic rupture.

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 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 412 kPa and the load pressure is 446 kPa. If the containment fails by rupture or catastrophic rupture at 412 kPa, the failure is so large that the pressure rises no further. However, if a leak develops at 412 kPa, the pressure will keep on rising, and a rupture or catastrophic rupture may develop between 412 and 446 kPa. The probability of an additional failure between 412 and 446 kPa is proportional to the failure probability density (FPD) for this pressure interval. The portion of the cumulative failure probability (CFP) distribution below 412 kPa is discounted since failure has occurred at 412 kPa. Thus, the probability used to determine if an additional failure will occur between 412 and 446 kPa is not FPD(interval 412 to 446) = 0.041 (i.e., CFP(446) - CFP(412)), but FPD(interval 412 to 446) / (1 - CFP(412)) = 0.041 /(1 - 0.083) = 0.045. The conditional probability of additional ruptures forming between 412 and 446 kPa is the conditional leak probability at 412 kPa times the conditional rupture probability for the interval times the failure probability for the interval. For the conditional rupture probability, C_{rp}, for the interval between 412 and 446 kPa, the average of the rupture values for 412 and 446 kPa is used: (0.78 + 0.83) / 2 = 0.81. Thus, the total conditional probability of rupture, for rapid pressure rise with a failure pressure of 412 kPa and a load pressure of 446 kPa, is:

$$0.78 + 0.22 * 0.81 * 0.045 = 0.79.$$

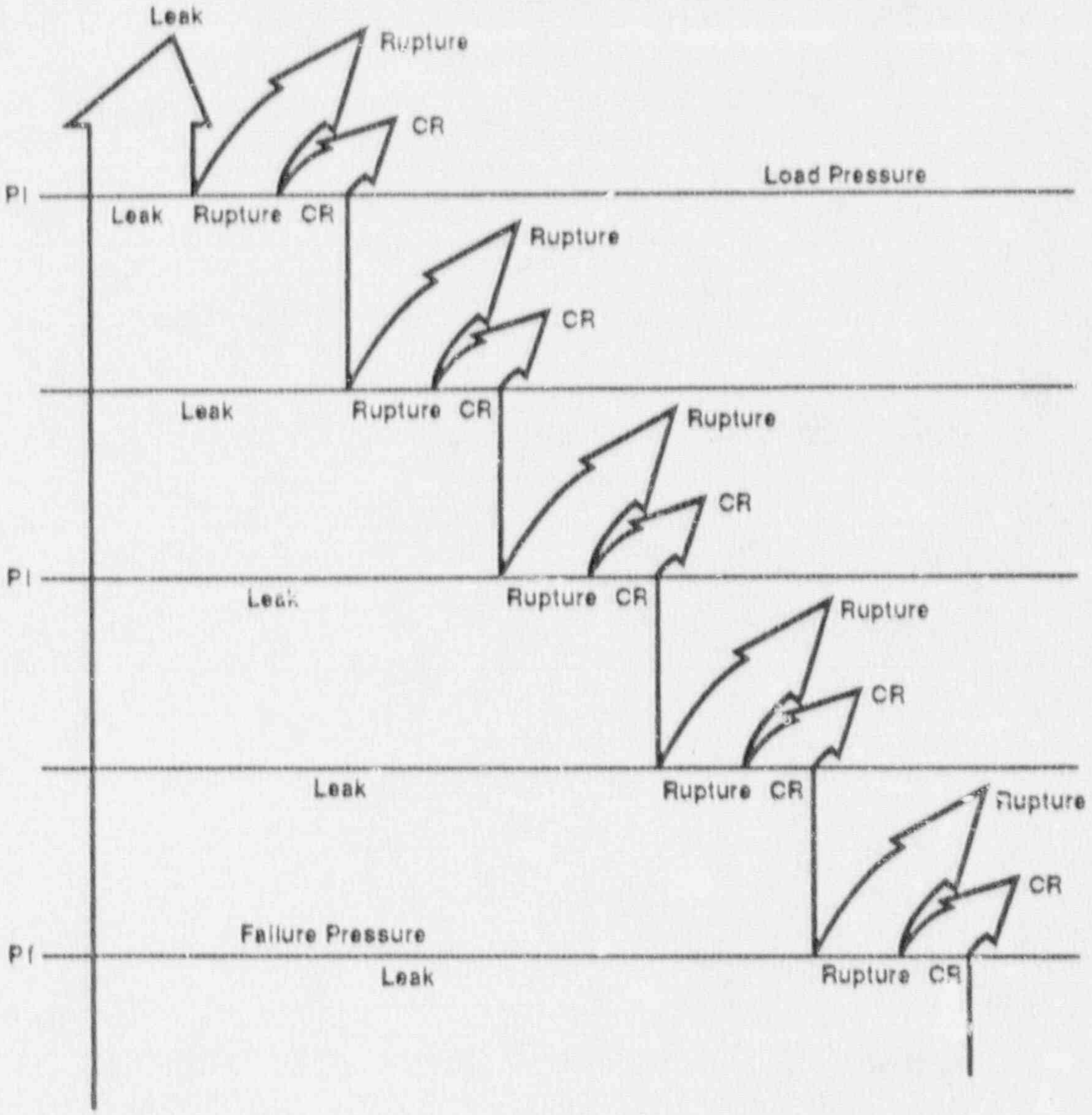

Figure A.2-1. Process Used to Determine the Mode of Containment Failure for Fast Pressure Rise

In general terms, this is:

$$R_{rp}(i) = R_{rp}(i-1) + R_{lk}(i-1) * 0.5 * (C_{rp}(i) + C_{rp}(i-1)) \\ * FPD(i) / (1 - CFP(i-1))$$

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 412 kPa, and a load pressure of 446 kPa, the conditional probabilities of leak, rupture, and catastrophic rupture may be shown to be 0.13 and 0.79, and 0.08 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 0.13 the failure mode is leak. If the random number is between 0.13 and 0.92 the failure mode is rupture, and if the random number is greater than 0.92, the failure mode is catastrophic rupture.

So, to find the conditional failure mode probabilities for fast pressure rise, function PFAST integrates from the failure pressure to the load pressure in 34.5 kPa increments, incrementing the rupture and catastrophic rupture 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
Sequoyah User Function Description

UFUN Name	Question Number	Description
H2xV#	42	During the time of core degradation, the hydrogen distribution between the four containment compartments is calculated (# = 1-7).
H2Cnc#	43,44,45,46	Computes the hydrogen concentration (mole %) and burn completeness (if ignition occurs) in the four containment compartments during the time of core degradation (# = 1-6).
Burn#	54	Calculates the pressure rise in containment due to a hydrogen deflagration during the time of core degradation (# = 1-4).
CFDet	58	Determines whether the containment fails during core degradation by hydrogen detonation. The failure mode is always set to upper compartment rupture.
NoCF	58,82,103,109	This is a dummy function that returns a value associated with no containment failure. This function is called either if no events occur to cause failure or if an earlier rupture has occurred, thus precluding subsequent overpressure failure.
CFFst	58,82,103	Determines whether the containment fails and the mode of failure from quasi-static pressurization events.
CFSlw	58,103,109	Determines whether the containment fails and the mode of failure caused by slow pressurization events.
H2Cont	62	Calculates the fraction of hydrogen released in-vessel that exists in containment immediately before VB.

Table A.2-1 (continued)

UFUN Name	Question Number	Description
DPVB	77	Calculates the peak pressure rise at VB when a correction is made for ice bypass (if any occurs).
H2VB	80	Determines the amount of hydrogen that is released to containment at VB.
AlphCF	82	This is a dummy function that returns a value associated with a rupture failure of containment and is called if Alpha mode failure of the vessel and containment occurs.
StExCF	82	This is a dummy function that returns a value associated with a rupture failure of containment, and is called if a steam explosion that fails containment occurs.
CCI#	95	Calculates the amount of hydrogen, carbon monoxide (as well as its hydrogen equivalent), and carbon dioxide generated during prompt CCI (# = 1-3).
O2Late	96	Determines the amount of oxygen that remains in containment after VB.
H2CCI#	97	Determines the amount of combustible gas that is in containment for the late time period (# = 1-2).
LtConc	99	Calculates the concentrations (mole %) of hydrogen, oxygen, carbon dioxide and steam that exist in containment during the late time period.
Brn#	102	Calculates the pressure rise in containment due to a late hydrogen deflagration (# = 1-6).
NoBurn	102	This is a dummy function that returns a value of zero for the pressure rise when no burn occurs.

A.2.2 Listing of the Sequoyah APET User Function

This section contains a listing of the FORTRAN function subprogram SEQUFUN.FOR

```
C
C
C  SEQUOYAH APET USER FUNCTION SUBROUTINE
C
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 FOR ALL THE PARAMETERS DEFINED IN THE TREE PRIOR
C  TO THE CALL FOR THE USER FUNCTION.  NARG IS THE NUMBER OF PARAMETERS LISTED
C  FOR 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., "H2xV1" FROM "FUN-H2xV1")
C
      FUNCTION UFUN(NAME,NARG,IDARG,ARG)
C
      DIMENSION ARG(*),IDARG(*),PTABLE(5,5),PX(5),PY(5),PC(20),PTC(20),
     1 PCONC(20,3,2),MPC(5)
      CHARACTER*6 NAME
      REAL N2,INERTS
C
C  INPUT DATA
C
      DATA C11H2, C12H2, C21H2, C22H2 /1400., 0., 839., 140./
      DATA C11CO, C12CO, C21CO, C22CO /2000., 0., 959., 260./
      DATA C11CO2, C12CO2, C21CO2, C22CO2/160., 0., 120.0, 10./
C
C  STRUCTURAL CAPACITY INPUT FOR THE CONTAINMENT FOR QUASI-STATIC LOADS
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 AND PTC
C    MPC(K) = TOTAL NUMBER OF MODES AT LOCATION K
C
       DATA PC/     273.7, 308.2, 342.6, 412.1, 411.6, 446.1, 480.5,
     *              412.0, 549.5, 584.0, 618.4, 652.9, 687.4, 721.9,
     *              756.3, 790.8, 825.3, 859.8, 894.2, 928.7/
C
       DATA PTC/    0.000, 0.018, 0.038, 0.060, 0.083, 0.124, 0.197,
     *              0.395, 0.527, 0.706, 0.780, 0.833, 0.878, 0.922,
     *              0.948, 0.975, 0.987, 0.994, 0.997, 1.000/
C
C       DATA PCONC/  0.091, 0.091, 0.091, 0.026, 0.026, 0.000, 0.000,
C     *              0.000, 0.014, 0.207, 0.001, 0.001, 0.010, 0.008,
C     *              0.011, 0.007, 0.007, 0.007, 0.007, 0.007,
C     *              0.152, 0.152, 0.152, 0.026, 0.026, 0.014, 0.014,
C     *              0.000, 0.145, 0.040, 0.143, 0.077, 0.000, 0.000,
C     *              0.000, 0.000, 0.000, 0.000, 0.000, 0.000,
C     *              0.086, 0.086, 0.086, 0.107, 0.107, 0.239, 0.211,
C     *              0.039, 0.039, 0.070, 0.024, 0.019, 0.019, 0.019,
C     *              0.019, 0.019, 0.019, 0.019, 0.019, 0.019,
C     *              0.338, 0.338, 0.338, 0.483, 0.483, 0.306, 0.167,
C     *              0.039, 0.039, 0.019, 0.080, 0.198, 0.339, 0.339,
C     *              0.019, 0.019, 0.019, 0.019, 0.019, 0.019,
C     *              0.333, 0.333, 0.333, 0.359, 0.359, 0.442, 0.608,
C     *              0.922, 0.762, 0.664, 0.752, 0.705, 0.633, 0.635,
C     *              0.952, 0.956, 0.956, 0.956, 0.956, 0.956,
C     *              0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000,
```

```
C     *            0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000,
C     *            0.100, 0.000, 0.000, 0.000, 0.000, 0.000/
C
      DATA PCONC/ 1.000, 0.273, 0.250, 0.076, 0.075, 0.000, 0.000,
     *            0.000, 0.018, 0.390, 0.000, 0.004, 0.029, 0.023,
     *            0.032, 0.021, 0.020, 0.021, 0.022, 0.022,
     *            0.000, 0.455, 0.417, 0.076, 0.075, 0.041, 0.023,
     *            0.000, 0.177, 0.075, 0.004, 0.000, 0.000, 0.000,
     *            0.000, 0.000, 0.000, 0.000, 0.000, 0.000,
     *            0.000, 0.091, 0.097, 0.154, 0.154, 0.571, 0.340,
     *            0.034, 0.050, 0.107, 0.023, 0.000, 0.000, 0.000,
     *            0.000, 0.000, 0.000, 0.000, 0.000, 0.000,
     *            0.000, 0.182, 0.236, 0.619, 0.622, 0.255, 0.240,
     *            0.034, 0.050, 0.009, 0.024, 0.000, 0.000, 0.000,
     *            0.000, 0.000, 0.000, 0.000, 0.000, 0.000,
     *            0.000, 0.000, 0.000, 0.076, 0.075, 0.133, 0.397,
     *            0.933, 0.704, 0.419, 0.950, 0.996, 0.971, 0.977,
     *            0.968, 0.979, 0.980, 0.979, 0.978, 0.978,
     *            0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000,
     *            0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000,
     *            0.000, 0.000, 0.000, 0.000, 0.000, 0.000/
      DATA NPLC, NPPC, MPC/2, 20, 3, 3, 3*0/
C
C=========================================================================
C
C  DISTRIBUTION OF HYDROGEN IN CONTAINMENT BEFORE VESSEL BREACH
C      QUESTION 39 IN THE CET
C        User Functions - H2xV(1-7)
C                 The following values are in kg-moles:
C             ARG(I1) = E-H2inV, Amount of H2 generated in-vessel
C             ARG(I2) = E-H2exV, Fraction of H2 released before VB
C             ARG(I3) = H2-LC, Amount of H2 in lower compartment
C             ARG(I4) = H2-IC, Amount of H2 in ice condenser
C             ARG(I5) = H2-UP, Amount of H2 in upper plenum
C             ARG(I6) = H2-UC, Amount of H2 in upper compartment
C
      IF(NAME(:4).EQ.'H2xV')THEN
       I1=IDARG(1)
       I2=IDARG(2)
       I3=IDARG(3)
       I4=IDARG(4)
       I5=IDARG(5)
       I6=IDARG(6)
C
C          'XLC' = Fraction released to lower compartment
C          'XIC' = Fraction released to ice condenser
C          'XUP' = Fraction released to upper plenum
C          'XUC' = Fraction released to upper compartment
C
C        For releases to containment, these fractions are subject
C        to the constraint:
C                 XLC + XIC + XUP + XUC = 1.0
C
C  No early blowdown, no hydrogen released to containment.
        IF(NAME(5:6).EQ.'1 ')THEN
         XLC=0.0
         XIC=0.0
         XUP=0.0
         XUC=0.0
         GO TO 10
C  Isolation failure, hydrogen released from vessel is leaked from
C  containment
        ELSEIF(NAME(5:6).EQ.'2 ')THEN
         XLC=0.0
         XIC=0.0
         XUP=0.0
         XUC=0.0
```

```
          ARG(I1)=(1-ARG(I2))*ARG(I1)
          GO TO 15
C  Fans operating, and thus the hydrogen is well-mixed in containment.
C  Compartment volumes are:
C        LC - 10912 m^3, IC - 3475 m^3, UP - 1330 m^3, UC - 19355 m^3
        ELSEIF(NAME(5:6).EQ.'3 ')THEN
          XLC=0.31
          XIC=0.10
          XUP=0.04
          XUC=0.55
          GO TO 10
C  Fans not operating and flow diversion from the lower compartment to the upper compartment through
C  the floor drains.  The expert specified values to be obtained from the
C  CONTAIN S3B calculation
        ELSEIF(NAME(5:6).EQ.'4 ')THEN
          XLC=0.44
          XIC=0.13
          XUP=0.01
          XUC=0.42
          GO TO 10
C  Fans not operating but upper containment well-mixed and there is a
C  "clear path" from the lower compartment to the upper compartment through the IC.  The experts specified
C  that values be obtained from HECTR calculations.
        ELSEIF(NAME(5:6).EQ.'5 ')THEN
          XLC=0.35
          XIC=0.36
          XUP=0.03
          XUC=0.26
          GO TO 10
C  Fans not operating but upper containment well-mixed and there is no
C  "clear path" from the lower compartment to the upper compartment through the IC.  The experts specified
C  that values be obtained from HECTR calculations, with 50% of the HECTR
C  fraction of hydrogen in the dome, with the remainder distributed in
C  proportionate quantities throughout the other compartments.
        ELSEIF(NAME(5:6).EQ.'6 ')THEN
          XLC=0.35 + 0.35/0.74 * 0.26*0.5
          XIC=0.36 + 0.36/0.74 * 0.26*0.5
          XUP=0.03 + 0.03/0.74 * 0.26*0.5
          XUC=0.26*0.5
          GO TO 10
C  Fans not operating and no mixing.  The experts specified that values
C  be obtained from HECTR calculations, with 10% of the HECTR fraction
C  of hydrogen in the dome, with the remainder distributed in proportionate
C  quantities throughout the other compartments.
        ELSEIF(NAME(5:6).EQ.'7 ')THEN
          XLC=0.35 + 0.35/0.74 * 0.26*0.9
          XIC=0.36 + 0.36/0.74 * 0.26*0.9
          XUP=0.03 + 0.03/0.74 * 0.26*0.9
          XUC=0.26*0.1
        ENDIF
C Define the arguments and user function
   10   ARG(I3) = XLC*ARG(I1)*ARG(I2)
        ARG(I4) = XIC*ARG(I1)*ARG(I2)
        ARG(I5) = XUP*ARG(I1)*ARG(I2)
        ARG(I6) = XUC*ARG(I1)*ARG(I2)
        ARG(I1) = (1-ARG(I2))*ARG(I1)
        UFUN = ARG(I3)+ARG(I4)+ARG(I5)+ARG(I6)
   15   RETURN
C
C=======================================================================
C
C  WHAT IS THE HYDROGEN CONCENTRATION IN THE LOWER COMPARTMENT, ICE
C     CONDENSER, UPPER PLENUM AND UPPER COMPARTMENT BEFORE VB?
C        QUESTIONS 40, 41, 42, AND 43 IN THE CET
```

```
C        User functions - H2Cnc(1-6)
C              The following values are in kg-moles:
C            ARG(I1) = (Cmpt)-O2, Amount of O2 in Cmpt
C            ARG(I2) = (Cmpt)-Stm, Amount of steam in Cmpt
C            ARG(I3) = H2-(Cmpt), Amount of H2 in Cmpt
C            ARG(I4) = Burn completeness (given ignition) in Cmpt
C            N2 = Amount of N2 in Cmpt
C
      ELSEIF(NAME(:5).EQ.'H2Cnc')THEN
       I1=IDARG(1)
       I2=IDARG(2)
       I3=IDARG(3)
       I4=IDARG(4)
       O2=ARG(I1)
       H2O=ARG(I2)
       H2=ARG(I3)
       N2 = O2/0.21*0.79
C  Hydrogen concentration in lower compartment and upper compartment, fans operating, turbulent burn
C  completeness model
        IF(NAME(6:6).EQ.'1')THEN
         TOTAL = H2+H2O+O2+N2
         X1 = 28.638
         X2 = 1.0463
         GO TO 20
C  Hydrogen concentration in lower compartment and upper compartment, fans not operating, quiescent
C  burn completeness model
        ELSEIF(NAME(6:6).EQ.'2')THEN
         TOTAL = H2+H2O+O2+N2
         X1 = 30.499
         X2 = 1.2827
         GO TO 20
C  Hydrogen concentration in IC, fans operating, turbulent burn
C  completeness model
        ELSEIF(NAME(6:6).EQ.'3')THEN
         TOTAL = H2+(H2O+O2+N2)*3475./(1330.+3475.)
         X1 = 28.638
         X2 = 1.0463
         GO TO 20
C  Hydrogen concentration in IC, fans not operating, quiescent burn
C  completeness model
        ELSEIF(NAME(6:6).EQ.'4')THEN
         TOTAL = H2+(H2O+O2+N2)*3475./(1330.+3475.)
         X1 = 30.499
         X2 = 1.2827
         GO TO 20
C  Hydrogen concentration in UP, fans operating, turbulent burn
C  completeness model
        ELSEIF(NAME(6:6).EQ.'5')THEN
         TOTAL = H2+(H2O+O2+N2)*1330./(1330.+3475.)
         X1 = 28.638
         X2 = 1.0463
         GO TO 20
C  Hydrogen concentration in UP, fans not operating, quiescent burn
C  completeness model
        ELSEIF(NAME(6:6).EQ.'6')THEN
         TOTAL = H2+(H2O+O2+N2)*1330./(1330.+3475.)
         X1 = 30.499
         X2 = 1.2827
        ENDIF
   20   UFUN = H2/TOTAL
        XSTM = H2O/TOTAL
        A = XSTM*(-4.1966+3.3985*XSTM)
        ARG(I4) = AMIN1((X1*UFUN - X2)*EXP(A),1.0)
        RETURN
C
```

```
C=========================================================================
C
C  PRESSURE INCREMENT FROM HYDROGEN BURNS
C      QUESTION 51 IN THE CET
C        User functions - Burn(1-4)
C              The values of O2, Stm, and H2 are in kg-moles:
C            ARG(I1) = E-PBase, Early baseline pressure, kPa
C            ARG(I2) = E-LCBC, Burn completeness in LC
C            ARG(I3) = E-ICBC, Burn completeness in IC
C            ARG(I4) = E-UPBC, Burn completeness in UP
C            ARG(I5) = E-UCBC, Burn completeness in UC
C            ARG(I6) = DP-EDef, Pressure rise in containment, kPa
C            ARG(1) = LC-O2, Amount of O2 in LC
C            ARG(2) = IC-O2, Amount of O2 in IC, UP
C            ARG(3) = UC-O2, Amount of O2 in UC
C            ARG(4) = LC-Stm, Amount of steam in LC
C            ARG(5) = IC-Stm, Amount of steam in IC, UP
C            ARG(6) = UC-Stm, Amount of steam in UC
C            ARG(10) = H2-LC, Amount of H2 in LC
C            ARG(11) = H2-IC, Amount of H2 in IC
C            ARG(12) = H2-UP, Amount of H2 in UP
C            ARG(13) = H2-UC, Amount of H2 in UC
C            ARG(18) = E-IgLC, Flag for ignition in LC
C            ARG(19) = E-IgIC, Flag for ignition in IC
C            ARG(20) = E-IgUP, Flag for ignition in UP
C            ARG(21) = E-IgUC, Flag for ignition in UC
C            N2 = Amount of N2 in combustion compartments
C
      ELSEIF(NAME(:4).EQ.'Burn')THEN
       I1=IDARG(1)
       I2=IDARG(2)
       I3=IDARG(3)
       I4=IDARG(4)
       I5=IDARG(5)
       I6=IDARG(6)
       PBASE=ARG(I1)
       BCLC=ARG(I2)
       BCIC=ARG(I3)
       BCUP=ARG(I4)
       BCUC=ARG(I5)
       O2LC=ARG(1)
       O2IC=ARG(2)
       O2UC=ARG(3)
       H2OLC=ARG(4)
       H2OIC=ARG(5)
       H2OUC=ARG(6)
       H2LC=ARG(10)
       H2IC=ARG(11)
       H2UP=ARG(12)
       H2UC=ARG(13)
       FLGLC=ARG(18)
       FLGIC=ARG(19)
       FLGUP=ARG(20)
       FLGUC=ARG(21)
C  Determine combustion volume and non-participating expansion volume.
C  The compartment volumes are included in the combustion volume if the
C  ignition flag is non-zero.
       VBRN = FLGLC*10912. + FLGIC*3475. + FLGUP*1330.
     1  + FLGUC*19355.
       VEXP = 35072. - VBRN
       IF(VBRN.LT.0.0001) GO TO 30
C  Adjust burn completeness for times of insufficient oxygen
       IF(O2LC.LT.H2LC*BCLC/2.) BCLC=BCLC*2.*O2LC/H2LC
       IF(O2IC*3475./(1330.+3475.).LT.H2IC*BCIC/2.) BCIC=BCIC*2.*
     1  O2IC*3475./(1330.+3475.)/H2IC
       IF(O2IC*1330./(1330.+3475.).LT.H2UP*BCUP/2.) BCUP=BCUP*2.*
     1  O2IC*1330./(1330.+3475.)/H2UP
```

```
      IF(O2UC.LT.H2UC*BCUC/2.) BCUC=BCUC*2.*O2UC/H2UC
C  Determine oxygen, hydrogen, steam and nitrogen in combustion volume
      O2 = O2LC*FLGLC + O2IC*3475./(1330.+3475.)*FLGIC +
     1  O2IC*1330./(1330.+3475)*FLGUP + O2UC*FLGUC
      H2 = H2LC*FLGLC + H2IC*FLGIC + H2UP*FLGUP +
     1  H2UC*FLGUC
      H2O = H2OLC*FLGLC + H2OIC*3475./(1330.+3475.)*FLGIC +
     1  H2OIC*1330./(1330.+3475.)*FLGUP + H2OUC*FLGUC
      N2 = O2/.21*.79
C  Determine combustion completeness in combustion volume
      IF(H2.EQ.0.0)THEN
        CCOMP=0.0
        GO TO 30
      ENDIF
      CCOMP = (BCLC*H2LC*FLGLC + BCIC*H2IC*FLGIC +
     1  BCUP*H2UP*FLGUP + BCUC*H2UC*FLGUC)/H2
C  The temperature of the containment atmosphere is low when containment
C  heat removal is available, or there is no ice bypass.  When the igniters
C  are operating early, temperature is irrelevant to the burn pressure rise.
      IF(NAME(5:5).EQ.'1'.OR.NAME(5:5).EQ.'4') TI = 38.0
C  Temperature is high for times without containment heat removal
      IF(NAME(5:5).EQ.'2') TI = 135.0
C  Temperature is high for times of flow diversion bypass of ice condenser
      IF(NAME(5:5).EQ.'3') TI = 115.0
C  Compute final pressure for AICC burn and corresponding overpressure
      PFAICC = H2BURN(H2,H2O,O2,N2,CCOMP,PBASE,TI)
      OVERP = PFAICC - PBASE
C  Burn with igniters operating, minimal pressure rise
      IF(NAME(5:5).EQ.'1') OVERP = OVERP * .05
C  Overpressure correction with 5% reduction for heat transfer to
C  solid surfaces
      P1 = OVERP*.95 + PBASE
C  Isentropic expansion correction for non-participating volumes
      DV1 = ((P1/PBASE)**(1/1.4) - 1) / ((VEXP/VBRN) +
     1   (P1/PBASE)**(1/1.4))
      DV2 = DV1 * VEXP/VBRN
      P3 = P1/(1 + DV2)**1.4
C  Assign adjusted parametric values
      ARG(1) = O2LC - H2LC*BCLC/2.0
      ARG(2) = O2IC - H2IC*BCIC/2.0 - H2UP*BCUP/2.0
      ARG(3) = O2UC - H2UC*BCUC/2.0
      ARG(10) = H2LC - H2LC*BCLC
      ARG(11) = H2IC - H2IC*BCIC
      ARG(12) = H2UP - H2UP*BCUP
      ARG(13) = H2UC - H2UC*BCUC
      ARG(I6)=P3 - PBASE
      UFUN=P3 - PBASE
      RETURN
   30 ARG(I6)=0.0
      UFUN=0.0
      RETURN
C
C=========================================================================
C
C  CONTAINMENT FAILURE AND MODE OF FAILURE?
C       QUESTION 55 IN THE CET
C         User Function - CFDet
C                 The following values are in kPa-s:
C              ARG(I1) = Imp-UP, Impulse due to detonation in UP
C              ARG(I2) = Imp-IC, Impulse due to detonation in IC
C              ARG(I3) = CFI-UP, UP impulsive failure criterion
C              ARG(I4) = CFI-IC, IC impulsive failure criterion
C
      ELSEIF(NAME(1:5).EQ.'CFDet')THEN
       I1=IDARG(1)
       I2=IDARG(2)
       I3=IDARG(3)
```

```
       I4=IDARG(4)
C
C  The value of UFUN indicates type of containment failure:
C        0 < X < 2 for catastrophic rupture
C        2 < X < 3 for lower compartment rupture
C        3 < X < 4 for upper compartment rupture
C        4 < X < 5 for lower compartment leak
C        5 < X < 6 for upper compartment leak
C        6 < X < 7 for no containment failure
C
C  Initialize X for no containment failure
       X = 6.5
C  Detonation containment failure always results in upper compartment
C  rupture
       IF(ARG(I1).GT.ARG(I3)) X = 3.5
       IF(ARG(I2).GT.ARG(I4)) X = 3.5
       UFUN = X
       RETURN
C
C=========================================================================
C
C  CONTAINMENT FAILURE AND MODE OF FAILURE?
C       QUESTIONS 55, 79, 100, AND 106 IN THE CET
C          User Function - NoCF
C                 ARG(I1) = X-PBase, Baseline pressure at time 'X'
C                 ARG(I2) = Pressure rise in containment, kPa
C
C  The value of UFUN indicates type of containment failure:
C        6 < UFUN < 7 for no containment failure
C
C  No containment failure at very late time
       ELSEIF(NAME(1:4).EQ.'NoCF')THEN
        UFUN = 6.5
        RETURN
C
C=========================================================================
C
C  CONTAINMENT FAILURE AND MODE OF FAILURE?
C       QUESTIONS 55, 79, AND 100 IN THE CET
C          User Function - CFFst
C                    The following values are in kPa:
C                 ARG(I1) = X-PBase, Baseline pressure at time 'X'
C                 ARG(I2) = Pressure rise in containment
C                 ARG(I3) = CF-Pr, Containment failure pressure
C                 ARG(I4) = RndmVal, Random number for failure mode
C
       ELSEIF(NAME(1:5).EQ.'CFFst')THEN
        I1=IDARG(1)
        I2=IDARG(2)
        I3=IDARG(3)
        I4=IDARG(4)
        PL = ARG(I1) + ARG(I2)
        PF = ARG(I3)
        RN = ARG(I4)
C
C  The value of UFUN indicates type of containment failure:
C        0 < X < 2 for catastrophic rupture
C        2 < X < 3 for lower compartment rupture
C        3 < X < 4 for upper compartment rupture
C        4 < X < 5 for lower compartment leak
C        5 < X < 6 for upper compartment leak
C        6 < X < 7 for no containment failure
C
         UFUN  = PFAST(PL,PF,RN,PC,PTC,PCONC,NPLC,MPC,NPPC)
        RETURN
C
C
```

```
C
C===========================================================================
C
C  CONTAINMENT FAILURE AND MODE OF FAILURE?
C      QUESTIONS 55, 79, 100 AND 106 IN THE CET
C        User Function - CFSlw
C               The following values are in kPa:
C             ARG(I1) = X-PBase, Baseline pressure at time 'X'
C             ARG(I2) = CF-Pr, Containment failure pressure
C             ARG(I3) = RndmVal, Random number for failure mode
C
      ELSEIF(NAME(1:5).EQ.'CFSlw')THEN
       I1=IDARG(1)
       I2=IDARG(2)
       I3=IDARG(3)
       PL = ARG(I1)
       PF = ARG(I2)
       RN = ARG(I3)
C
C  The value of UFUN indicates type of containment failure:
C       0 < X < 2 for catastrophic rupture
C       2 < X < 3 for lower compartment rupture
C       3 < X < 4 for upper compartment rupture
C       4 < X < 5 for lower compartment leak
C       5 < X < 6 for upper compartment leak
C       6 < X < 7 for no containment failure
C
        UFUN = PSLOW(PL,PF,RN,PC,PTC,PCONC,NPLC,MPC,NPPC)
        RETURN
C
C===========================================================================
C
C  CONTAINMENT FAILURE AND MODE OF FAILURE?
C      QUESTION 79 IN THE CET
C        User Functions - AlphCF, StExCF
C             ARG(I1) = X-PBase, Baseline pressure at time 'X'
C
C  The value of UFUN indicates type of containment failure:
C       0 < X < 2 for catastrophic rupture
C       2 < X < 3 for lower compartment rupture
C       3 < X < 4 for upper compartment rupture
C       4 < X < 5 for lower compartment leak
C       5 < X < 6 for upper compartment leak
C       6 < X < 7 for no containment failure
C
C  Alpha-mode or rocket containment failure always results in upper
C  compartment rupture
      ELSEIF(NAME(1:6).EQ.'AlphCF')THEN
       UFUN = 3.5
       RETURN
C  Containment failure by steam explosion always results in rupture that
C  bypasses the ice condenser (equivalent to lower compartment rupture)
      ELSEIF(NAME(1:6).EQ.'StExCF')THEN
       UFUN = 2.5
       RETURN
C
C===========================================================================
C
C  WHAT FRACTION OF H2 RELEASED IN VESSEL IS IN CONTAINMENT AT VB?
C      QUESTION 59 IN THE CET
C        User function - H2Cont
C               Hydrogen values are in kg-moles:
C             ARG(I1) = E-H2inV, Amount of H2 generated in-vessel
C             ARG(I2) = E-H2exV, Fraction of H2 released before VB
C             ARG(I3) = H2-LC, Amount of H2 in lower compartment
C             ARG(I4) = H2-IC, Amount of H2 in ice condenser
C             ARG(I5) = H2-UP, Amount of H2 in upper plenum
```

```
C            ARG(I6) = H2-UC, Amount of H2 in upper compartment
C            ARG(14) = E-LCBC, Burn completeness in LC
C            ARG(15) = E-ICBC, Burn completeness in IC
C            ARG(16) = E-UPBC, Burn completeness in UP
C            ARG(17) = E-UCBC, Burn completeness in UC
C            ARG(18) = E-IgLC, Flag for ignition in LC
C            ARG(19) = E-IgIC, Flag for ignition in IC
C            ARG(20) = E-IgUP, Flag for ignition in UP
C            ARG(21) = E-IgUC, Flag for ignition in UC
C
      ELSEIF(NAME(:6).EQ.'H2Cont')THEN
       I1=IDARG(1)
       I2=IDARG(2)
       I3=IDARG(3)
       I4=IDARG(4)
       I5=IDARG(5)
       I6=IDARG(6)
C  Determine the amount of hydrogen in containment now
      H2NOW = (ARG(I3)+ARG(I4)+ARG(I5)+ARG(I6))
C  Determine the amount of hydrogen generated in-vessel
      IF(ARG(I2).NE.1.) THEN
        H2INV = ARG(I1)/(1.-ARG(I2))
      ELSE
        H2LC = 0.0
        H2IC = 0.0
        H2UP = 0.0
        H2UC = 0.0
        BCLC = ARG(14)*ARG(18)
        BCIC = ARG(15)*ARG(19)
        BCUP = ARG(16)*ARG(20)
        BCUC = ARG(17)*ARG(21)
        IF(BCLC.NE.1.) H2LC = ARG(I3)/(1.-BCLC)
        IF(BCIC.NE.1.) H2IC = ARG(I4)/(1.-BCIC)
        IF(BCUP.NE.1.) H2UP = ARG(I5)/(1.-BCUP)
        IF(BCUC.NE.1.) H2UC = ARG(I6)/(1.-BCUC)
        H2INV = H2LC + H2IC + H2UP + H2UC
      ENDIF
      IF(H2INV.EQ.0.) H2 = 0.0
      IF(H2INV.NE.0.) H2 = H2NOW/H2INV
      UFUN = H2
      RETURN
C
C=======================================================================
C
C  PEAK PRESSURE AT VESSEL BREACH? (CORRECTION FOR ICE BYPASS)
C      QUESTION 74 IN THE CET
C        User function - DPVB
C               Pressure rise values are in kPa:
C             ARG(I1) = IBPLvl, Ice bypass level - volume
C                        fraction of voided region
C             ARG(I2) = DPx-VB, Pressure rise with no bypass
C             ARG(I3) = DPx-IBP, Pressure rise with total
C                        bypass
C
      ELSEIF(NAME(:5).EQ.'DPVB')THEN
       I1=IDARG(1)
       I2=IDARG(2)
       I3=IDARG(3)
C  Model by S. Dingman using HECTR calculations indicated 40% bypass
C  level for 25% void region, and 7% bypass for 2% void region
       IF(ARG(I1).LE.0.02)THEN
         BP = 3.5*ARG(I1)
         GO TO 70
       ELSEIF(ARG(I1).LE.0.25)THEN
         BP = (3.5 - (ARG(I1)-.02)/.23*1.9) * ARG(I1)
         GO TO 70
       ELSEIF(ARG(I1).LE.1.0)THEN
```

```
        BP = (1.6 - (ARG(I1)-.25)/.75*.6) * ARG(I1)
      ENDIF
   70 ARG(I2) = (ARG(I3) - ARG(I2))*BP + ARG(I2)
      UFUN = ARG(I2)
      RETURN
C
C======================================================================
C
C  WHAT AMOUNT OF HYDROGEN IS RELEASED TO CONTAINMENT AT VESSEL BREACH?
C      QUESTION 77 IN THE CET
C        User function - H2VB
C             Hydrogen values are in kg-moles:
C           ARG(I1) = E-H2inV, Amount of H2 generated in-vessel
C           ARG(I2) = E-H2exV, Fraction of H2 released before VB
C           ARG(I3) = FCorVB, Fraction of core released at VB
C           ARG(I4) = I-MtlOx, Fraction of available metal that
C                     is oxidized at VB
C           ARG(I5) = I-H2@VB, Hydrogen released at VB
C           ARG(I6) = I-FrZr, Fraction of initial Zr potentially
C                     available for CCI
C
      ELSEIF(NAME(:5).EQ.'H2VB')THEN
       I1=IDARG(1)
       I2=IDARG(2)
       I3=IDARG(3)
       I4=IDARG(4)
       I5=IDARG(5)
       I6=IDARG(6)
C  Zr in Sequoyah is 253.2 kg-moles and Fe is 392.0 kg-moles, assume
C  uniform quantity of oxidizable metal in ejected debris
       ARG(I5)=ARG(I3)*ARG(I4)*(1290.4-ARG(I1))+ARG(I1)*(1.0-ARG(I2))
C  Assume Zr is preferentially oxidized before VB
       ARG(I6) = 1. - (ARG(I1)/506.4)
       IF(ARG(I1).GT.506.4) ARG(I6) = 0.0
       UFUN = ARG(I5)
       RETURN
C
C======================================================================
C
C  AMOUNT OF H2 (PLUS EQUIVALENT CO) AND CO2 GENERATED DURING PROMPT CCI?
C      QUESTION 92 IN THE CET
C        User function - CCI(1-3)
C             Hydrogen values are in kg-moles:
C           ARG(I1) = FCorVB, Fraction of core released at VB
C           ARG(I2) = I-FrZr, Fraction of initial Zr potentially
C                     available for CCI
C           ARG(I3) = Fr-CCI, Fraction of core not participating
C                     in HPME that is available for CCI
C           ARG(I4) = L-H2, H2 (CO) in containment after prompt CCI
C           ARG(I5) = L-CO2, CO2 in containment after prompt CCI
C
      ELSEIF(NAME(:3).EQ.'CCI')THEN
       I1=IDARG(1)
       I2=IDARG(2)
       I3=IDARG(3)
       I4=IDARG(4)
       I5=IDARG(5)
C
C  FCCI   = FRACTION OF CORE THAT PARTICIPATES IN CCI
C  ZRCCI  = FRACTION OF UNOXIDIZED Zr IN CAVITY
C
C  When there is no prompt CCI, there is no gas liberation
       IF(NAME(4:4).EQ.'1')THEN
         ARG(I4) = 0.0
         ARG(I5) = 0.0
         UFUN = 0.0
         RETURN
```

```
C  When there is prompt CCI with prior HPME, the amount of core ejected
C     at vessel breach is subtracted from the core available for CCI
        ELSEIF(NAME(4:4).EQ.'2')THEN
          FCCI = (1.0-ARG(I1))*ARG(I3)
          ZRCCI = ARG(I2)*(1.0-ARG(I1))*ARG(I3)
          GO TO 72
C  When there is prompt CCI with no HPME, the amount of core that
C     participates in CCI is Pr-CCI
        ELSEIF(NAME(4:4).EQ.'3')THEN
          FCCI = ARG(I3)
          ZRCCI = ARG(I2)*ARG(I3)
        ENDIF
   72  CONTINUE
C
C  H2CCI  = Hydrogen produced during CCI (kg-mole)
C  COCCI  = Carbon monoxide produced during CCI (kg-mole)
C  CO2CCI = Carbon dioxide produced during CCI (kg-mole)
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( ZRCCI .LE. 0.85 )THEN
         H2CCI  = ( C11H2*ZRCCI  + C12H2  )*FCCI/3.4
         COCCI  = ( C11CO*ZRCCI  + C12CO  )*FCCI/3.4
         CO2CCI = ( C11CO2*ZRCCI + C12CO2 )*FCCI/3.4
       ELSE
         H2CCI  = ( C21H2*ZRCCI  + C22H2  )*FCCI/3.4
         COCCI  = ( C21CO*ZRCCI  + C22CO  )*FCCI/3.4
         CO2CCI = ( C21CO2*ZRCCI + C22CO2 )*FCCI/3.4
       ENDIF
         H2EQV  = H2CCI + COCCI*1.17
       ARG(I4) = H2EQV
       ARG(I5) = CO2CCI
       UFUN = H2EQV
       RETURN

C
C=====================================================================
C
C  WHAT AMOUNT OF OXYGEN REMAINS IN CONTAINMENT LATE?
C      QUESTION 93 IN THE CET
C        User function - O2Late
C               Oxygen and hydrogen values are in kg-moles:
C              ARG(I1) = LC-O2, Amount of O2 in LC
C              ARG(I2) = IC-O2, Amount of O2 in IC, UP
C              ARG(I3) = UC-O2, Amount of O2 in UC
C              ARG(I4) = I-H2@VB, Hydrogen released at VB
C              ARG(I5) = I-ActBC, Burn completeness at VB
C              ARG(I6) = L-O2, Amount of O2 in containment late
C
       ELSEIF(NAME(:6).EQ.'O2Late')THEN
        I1=IDARG(1)
        I2=IDARG(2)
        I3=IDARG(3)
        I4=IDARG(4)
        I5=IDARG(5)
        I6=IDARG(6)
C  Determine amount of oxygen before vessel breach, and maximum amount
C  of oxygen consumed (when hydrogen is burned). Then adjust hydrogen burn
C  completeness accordingly to correspond to oxygen consumption
        O2BVB = ARG(I1) + ARG(I2) + ARG(I3)
        O2MAX = ARG(I4)*(1.-ARG(15))/2.
        IF(O2BVB.LT.0.001)THEN
          ARG(I5)=0.0
          ARG(I6)=0.0
          UFUN=0.0
          RETURN
```

```
      ELSEIF(O2BVB.GT.O2MAX)THEN
        ARG(I6) = O2BVB - O2MAX
        UFUN=ARG(I6)
        RETURN
      ELSEIF(O2BVB.LE.O2MAX)THEN
        ARG(I6) = 0.0
        ARG(I5) = 2.0*O2BVB/ARG(I4)
        UFUN=ARG(I6)
        RETURN
       ENDIF
C
C========================================================================
C
C  AMOUNT OF HYDROGEN IN CONTAINMENT AFTER CCI?
C      QUESTION 94 IN THE CET
C        User functions - H2CCI(1-2)
C               Hydrogen values are in kg-moles:
C             ARG(I1) = I-H2@VB, Hydrogen released at VB
C             ARG(I2) = I-ActBC, Burn completeness at VB
C             ARG(I3) = L-H2, Hydrogen generated during CCI
C
      ELSEIF(NAME(:5).EQ.'H2CCI')THEN
       I1=IDARG(1)
       I2=IDARG(2)
       I3=IDARG(3)
C  Previous containment failure or no vessel breach
       IF(NAME(6:6).EQ.'1')THEN
         ARG(I3)=0.0
         UFUN=0.0
         RETURN
C  No containment failure and vessel breach
       ELSEIF(NAME(6:6).EQ.'2')THEN
         ARG(I3)=ARG(I1)*(1.-ARG(I2))+ARG(I3)
         UFUN=ARG(I3)
         RETURN
       ENDIF
C
C========================================================================
C
C  WHAT IS THE INERT LEVEL IN CONTAINMENT, AND IS THERE SUFFICIENT
C    H2 OR O2 FOR BURNS?
C      QUESTION 96 IN THE CET
C        User function - LtConc
C               The following values are in kg-moles:
C             ARG(I1) = L-H2, Amount of H2 in containment
C             ARG(I2) = L-CO2, Amount of CO2 in containment
C             ARG(I3) = L-O2, Amount of O2 in containment
C             ARG(I4) = L-Stm, Amount of steam in containment
C
      ELSEIF(NAME(:6).EQ.'LtConc')THEN
       I1=IDARG(1)
       I2=IDARG(2)
       I3=IDARG(3)
       I4=IDARG(4)
       H2=ARG(I1)
       CO2=ARG(I2)
       O2=ARG(I3)
       H2O=ARG(I4)
       N2=1120.3
       TOTAL = H2 + CO2 + O2 + H2O + N2
C  Initialize the concentration to be non-inert
       UFUN = 0.5
C  Check for steam/CO2 inerting
       IF((CO2+H2O)/TOTAL.GE.0.55)THEN
         UFUN = 3.5
         RETURN
C  Check for insufficient hydrogen
```

```
      ELSEIF(H2/TOTAL.LT.0.05)THEN
        UFUN = 2.5
        RETURN
C  Check for insufficient oxygen
      ELSEIF(O2/TOTAL.LT.0.05)THEN
        UFUN = 1.5
        RETURN
      ENDIF
      RETURN
C
C=====================================================================
C
C  PRESSURE RISE DUE TO VERY LATE DEFLAGRATION?
C      QUESTION 99 IN THE CET
C        User functions - Brn(1-6)
C             The values of O2, Stm, and H2 are in kg-moles:
C           ARG(I1) = L-PBase, Late baseline pressure, kPa
C           ARG(I2) = L-H2, Amount of H2 in containment
C           ARG(I3) = L-CO2, Amount of CO2 in containment
C           ARG(I4) = L-O2, Amount of O2 in containment
C           ARG(I5) = L-Stm, Amount of steam in containment
C           ARG(I6) = Pressure rise in containment, kPa
C           N2 = Amount of N2 in combustion compartments
C
     ELSEIF(NAME(:3).EQ.'Brn')THEN
      I1=IDARG(1)
      I2=IDARG(2)
      I3=IDARG(3)
      I4=IDARG(4)
      I5=IDARG(5)
      I6=IDARG(6)
      PBASE=ARG(I1)
      H2=ARG(I2)
      CO2=ARG(I3)
      O2=ARG(I4)
      H2O=ARG(I5)
      INERTS=H2O+CO2
      N2=1120.3
      TOTAL = H2 + CO2 + O2 + H2O + N2
      XH2 = H2/TOTAL
      XSTM = H2O/TOTAL
      A = XSTM*(-4.1966+3.3985*XSTM)
C  Fans operating, turbulent burn completeness model
      IF(NAME(4:4).EQ.'1'.OR.NAME(4:4).EQ.'2')
     1      BC = AMIN1((28.638*XH2 - 1.0463)*EXP(A),1.0)
C  Fans not operating, quiescent burn completeness model
      IF(NAME(4:4).EQ.'2'.OR.NAME(4:4).EQ.'4')
     1      BC = AMIN1((30.499*XH2 - 1.2827)*EXP(A),1.0)
C  Readjust burn completeness if insufficient oxygen
      IF(O2.LT.H2*BC/2.) BC=BC*2.*O2/H2
C  The temperature of the containment atmosphere is low when containment
C  heat removal is available, and irrelevant if igniters are operating
C  throughout the period of H2 liberation
      IF(NAME(4:4).EQ.'1'.OR.NAME(4:4).EQ.'2'.OR.NAME(4:4).EQ.'3'.OR.
     + NAME(4:4).EQ.'5') TI = 38.0
      IF(NAME(4:4).EQ.'4'.OR.NAME(4:4).EQ.'6') TI = 135.0
C  Compute final pressure for AICC burn and corresponding overpressure
      PFAICC = H2BURN(H2,INERTS,O2,N2,BC,PBASE,TI)
      OVERP = PFAICC - PBASE
C  Burn with igniters operating, minimal pressure rise
      IF(NAME(4:4).EQ.'1'.OR.NAME(4:4).EQ.'2') OVERP=OVERP*.05
C  Overpressure correction with 5% reduction for heat transfer to
C  solid surfaces
      P3 = OVERP*.95 + PBASE
      ARG(I6)=P3-PBASE
      UFUN=P3-PBASE
      RETURN
```

```
C
C=======================================================================
C
C  PRESSURE RISE DUE TO VERY LATE DEFLAGRATION?
C      QUESTION 96 IN THE CET
C        User function - NoBurn
C             ARG(I1) = Pressure rise in containment, kPa
C
      ELSEIF(NAME(:6).EQ.'NoBurn')THEN
      I1=IDARG(1)
       ARG(I1)=0.0
       UFUN=0.0
       RETURN
      ENDIF
      WRITE(6,500) NAME
  500 FORMAT(1X,'USER FUNCTION NAME',A8,' NOT FOUND')
      STOP
      END
C
C=======================================================================
C=======================================================================
C
C  THIS FUNCTION CALCULATES THE PRESSURE RISE RATIO (Pf/Pi) 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-mole) 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
       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  PRESSURE RISE RATIO (Pf/Pi) 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=======================================================================
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)+2.446E-6*(
     +         TI**3-TREF**3)-8.983E-10*(TI**4-TREF**4))
C
C  INTERNAL ENERGY OF OXYGEN
C
      UO2=(20.79*(TI-TREF)+5.79E-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=======================================================================
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=======================================================================
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
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
C       A module 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 MODULE)
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=1
             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 - FRINTO)
               ELSE
                 FX=FRINTO
               ENDIF
               CX=CD(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 UP 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  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
```

A.3. SUPPORTING INFORMATION FOR THE ACCIDENT PROGRESSION ANALYSIS

A.3.1 Summary of Plant Information

Sequoyah Nuclear Power Station, Unit 1

Type of Reactor	Pressurized Water Reactor	
Manufacturer	Westinghouse	
Date of Commercial Operation	1981	
Reactor Core		
Nominal Power	3570 MWt	1217 E7 Btu/h
Number of fuel assemblies	193	
Fuel rods per assembly	264	
Number of fuel rods	50,952	
Core weight, total	132,940 kg	292,810 lb
Uranium dioxide	101,120 kg	222,740 lb
Zircaloy	23,120 kg	50,910 lb
Miscellaneous	8,700 kg	19,160 lb
Reactor Vessel		
Inside diameter	4.4 m	173 in
Overall height	13.4 m	43.8 ft
Thickness at beltline	0.216 m	8.5 in
Head thickness	0.140 m	5.5 in
RCS		
Volume (nominal)	374 m^3	13,200 ft^3
Water in system (nominal)	248,520 kg	547,400 lb
Operating temperature (nominal)	304°C	580°F
Operating pressure (nominal)	15.6 MPa	2265 psia
PORV setpoint (nominal)	17.2 MPa	2500 psia
Number of RCPs	4	
Number of SGs	4	
Containment		
Inside diameter	35.1 m	115 ft
Cylinder height	34.7 m	114 ft
Free volume	36,400 m^3	1,286,000 ft^3
Free volume upper compartment	11,000 m^3	388,000 ft^3
Free volume lower compartment	20,300 m^3	716,000 ft^3
Free volume ice condenser	5,100 m^3	182,000 ft^3
Design leak rate	0.25%/day	
Design pressure	176 kPa	10.8 psig
Operating temperature	48.9°C	120°F
Construction	Steel	
Bottom liner plate thickness	0.63 cm	0.25 in
Cylinder thickness	3.5 to 1.3 cm	1.4 to 0.5 in
Dome thickness	1.1 to 2.4 cm	0.44 to 0.94 in
Basemat thickness	2.7 m	9.0 ft
Floor thickness above liner	0.61 m	2.0 ft

Reactor Cavity		
Annular Cavity	5.2 m dia	17 ft dia
Floor Area	16 m^2	650 ft^2
Water Capacity (including instrumentation tunnel)	510 m^3	18,000 ft^3
Shield Building		
Inside diameter	38.1 m	125 ft
Cylinder height	45.7 m	150 ft
Wall Thickness	0.9 m	3 ft
Construction	Reinforced concrete	
IC		
Weight of Ice	1.1 E6 kg	2.4 E6 lb
Ice temperature	-6.7°C	20°F
RWST	1325 m^3	46,800 ft^3
Containment spray pumps		
Number	2	
Design flow (each)	300 l/s	4750 gpm
Containment spray heat exchangers		
Number	2	
Design capacity (each)	28 MW	95 E6 Btu/h
Accumulators		
Number	4	
Pressure	4.6 MPa	660 psig
Water capacity (total)	153 m^3	5400 ft^3

Sources of Information:
Sequoyah FSAR[A.1-14]
BMI-2104[A.1-8]

A.3.2 Initialization Questions

The first 11 questions of the Sequoyah 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 the uncovering of the top of active fuel (UTAF), although it is realized that actual core damage will not start until a short time after UTAF. The first 11 questions were distinguished between the different PDS groups. The branch probabilities and parameter values are the same for the remaining 100 questions in the APET, but the branch probabilities for the first 11 questions depend on the PDS group to be analyzed. This section concerns how the branch probabilities are determined for these first 11 questions. This group of APET questions is often referred to as the "tree top."

The branch probabilities for most of the first 11 questions in the APET follow directly from the definition of the PDS. For example, in the LOCA PDS group, three PDSs have "S_3" for the first characteristic, indicating that there is a very small break in the RCS. This implies that in the first question, Branch 3, Brk-S3, should have a probability of 1.0.

Ideally, the PDS groups would contain so few PDSs, and the case structure of the initialization questions would be so detailed that all the probability would be associated with only one branch of each initialization question. This was not practical; to obtain a reasonable number of PDS groups, it was sometimes necessary to group together several different PDSs with the result that not all the probability could be assigned to only one branch for all the questions for some PDS groups. And making the case structure detailed enough to consider every combination of PDSs was not feasible either. Therefore fractional branch probabilites are required for most PDS groups. Determining the fractions to be assigned to each branch of the questions for which fractional branch probabilites are required is the subject of this appendix. The information required comes from manipulating the results of the accident frequency analysis.

The fractional branch probabilities are determined by taking the ratio of the frequency of one or more PDSs to the frequency of a group of PDSs. These ratios are defined below for each PDS group. The frequency of each PDS varies from one observation to the next in the sample, so each fractional branch probability varies with the observation as well. That is, the file prepared by TEMAC for the APET evaluation for internal initiators contains 22 pieces of information for each observation: the frequency for each of the 7 PDS groups, and the values of the 11 fractional branch probabilities defined below.

A PDS is by definition all the cut sets that are indistinguishable for the accident progression analysis. So, each PDS has all the probability assigned to only one branch for each initialization question. Thus, there are no fractional branch probabilities for PDS groups which have only a single PDS. The seven PDS groups for internal initiators are:

1. Slow Blackout,
2. Fast Blackout,

3. Loss of Coolant Accidents,
4. Event V,
5. Transients,
6. ATWS, and
7. SGTRs.

Groups 2, 4, and 5 are single-PDS groups (see Table 2.2-2) and require no fractional branch probabilities in the initialization questions. The other four PDS groups for internal initiators require fractional branch probabilities for at least one question, and will be discussed in turn. Note that most of the cases where fractional branch probabilities are required involve only two branches. The final branch is the complement of the sum of the other branches and is calculated by EVNTRE. The following abbreviations are utilized:

FP(Br.n) = the fractional probability of branch n,

f(PDSn) = the frequency of PDSn, and

Σf(PDSm + PDSn) = the sum of the frequencies of PDSm and PDSn.

PDS Group 1 - Slow Blackout

PDS Group 1 consists of four slow blackout PDSs. One of these PDSs has the RCS intact at UTAF, two have S_3 breaks, and one has S_2 breaks. Therefore, Question 1, which determines the condition of the RCS at the start of the accident progression analysis, must have fractional branch probabilities.

Fractional Branch Probabilities for PDS Group 1 - Slow Blackout
Question 1 - RCS State at UTAF

Brk-S2: FP(Br.2) = f(S_2RRR-RCR) / Σf(all)
Brk-S3: FP(Br.3) = Σf(S_3RRR-RCR + S_3RRR-RDR) / (Σf(all)
                * (1 - FP(Br.2)))
B-PORV: FP(Br.6) -- Calculated by EVNTRE

Brk-S2 is a mnemonic abbreviation for Branch 2 of Question 1, etc., and Σf(all) is the sum of the frequencies of all the PDSs in the group.

The difference between the two "S_3" PDSs in PDS Group 1 is whether the secondary system is depressurized while the AFW is operating before the core uncovers. This requires fractional branch probabilities for Case 1 of Question 10.

Fractional Branch Probabilities for PDS Group 1 - Slow Blackout
Question 10 - Secondary System Depressurization, Case 1 - S_3 breaks

SecDP: FP(Br.1) = f(S_3RRR-RDR) / Σf(S_3RRR-RDR + S_3RRR-RCR)
noSecDP: FP(Br.2) -- Calculated by EVNTRE

PDS Group 3 - LOCAs

PDS Group 3 consists of 13 LOCA PDSs. Four of the PDSs have an A-size break, and three of the PDSs have an S_1-size break, which is considered to be the same thing in this portion of the analysis. There are three PDSs with an S_2-size break and three PDSs with an S_3-size break. Therefore, Question 1 must have fractional branch probabilities.

Fractional Branch Probabilities for PDS Group 3 - LOCAs
Question 1 - RCS State at UTAF

Brk-A: FP(Br.1) = Σf(AINY-YYN + AIYY-YYN + ALYY-YYN + ALYY-YYY +
S_1INY-YYN + S_1IYY-YYN + S_1LYY-YYN) / Σf (all)
Brk-S2: FP(Br.2) = Σf(S_2INY-YYN + S_2IYY-YYN + S_2LYY-YYN) / (Σf(all)
* (1 - FP(Br.1)))
Brk-S3: FP(Br.3) -- Calculated by EVNTRE

Five of the PDSs in this group have the LPIS operating at the onset of core damage as discussed in Section 2.2.2. For Question 4, the "A" and "S_1" breaks are treated in Case 1, the "S_2" breaks are treated in Case 2 and the "S_3" breaks are treated in Case 3.

Fractional Branch Probabilities for PDS Group 3 - LOCAs
Question 4 - Status of ECCS, Case 1 - Large Break

B-LPIS: FP(Br.4) = Σf(ALYY-YYN + ALYY-YYY + S_1LYY-YYN) / Σf(AINY-YYN
\+ AIYY-YYN + ALYY-YYN + ALYY-YYY + S_1INY-YYN
\+ S_1IYY-YYN + S_1LYY-YYN)
BfECCS: FP(Br.3) -- Calculated by EVNTRE

Fractional Branch Probabilities for PDS Group 3 - LOCAs
Question 4 - Status of ECCS, Case 2 - Small Break

B-LPIS: FP(Br.4) = f(S_2LYY-YYN) / Σf(S_2INY-YYN + S_2IYY-YYN + S_2LYY-YYN)
BfECCS: FP(Br.3) -- Calculated by EVNTRE

Fractional Branch Probabilities for PDS Group 3 - LOCAs
Question 4 - Status of ECCS, Case 3 - Very Small Break

B-LPIS: FP(Br.4) = f(S_3LYY-YYN) / Σf(S_3INY-YYN + S_3IYY-YYN + S_3LYY-YYN)
BfECCS: FP(Br.3) -- Calculated by EVNTRE

Four of the PDSs in this group have the sprays failed at the onset of core damage as discussed in Section 2.2.2. For Question 6, the "A" and "S_1" breaks are treated in Case 1, the "S_2" breaks are treated in Case 2 and the "S_3" breaks are treated in Case 3.

Fractional Branch Probabilities for PDS Group 3 - LOCAs
Question 6 - Status of Sprays, Case 1 - Large Break with ECCS failure

BfSp: FP(Br.3) = Σf(AINY-YYN + S_1INY-YYN) / Σf(AINY-YYN + AIYY-YYN
\+ S_1INY-YYN + S_1IYY-YYN)
B-Sp: FP(Br.1) -- Calculated by EVNTRE

Fractional Branch Probabilities for PDS Group 3 - LOCAs
Question 6 - Status of Sprays, Case 2 - Small Break with ECCS failure

BfSp: FP(Br.3) = f(S_2INY-YYN) / Σf(S_2INY-YYN + S_2IYY-YYN)
B-Sp: FP(Br.1) -- Calculated by EVNTRE

Fractional Branch Probabilities for PDS Group 3 - LOCAs
Question 6 - Status of Sprays, Case 3 - Very Small Break with ECCS failure

BfSp: FP(Br.3) = f(S_3INY-YYN) / Σf(S_3INY-YYN + S_3IYY-YYN)
B-Sp: FP(Br.1) -- Calculated by EVNTRE

One of the PDSs in PDS Group 3 has cooling for the RCP seals operating. The split for the large breaks for Question 11 is treated in Case 1.

Question 11 - Status of RCP Seal Cooling, Case 1 - Large Break with ECCS

B-PSC: FP(Br.1) = f(ALYY-YYY) / Σf(ALYY-YYN + ALYY-YYY + S_1LYY-YYN)
BfPSC: FP(Br.3) -- Calculated by EVNTRE

PDS Group 6 - ATWS

Group 6 contains the three ATWS PDSs. There are many differences between these three PDSs, but most of them are treated in the case structure of the initialization questions. Only the differences in the RCS state at the onset of core damage need be treated by fractional branch probabilities.

Fractional Branch Probabilities for PDS Group 6 - ATWS
Question 1 - RCS State at UTAF

Brk-S3: FP(Br.3) = f(S_3NYY-YXN) / Σf(all)
B-SGTR: FP(Br.5) = f(GLYY-YXY) / (Σf(all) * (1 - FP(Br.3))
B-PORV: FP(Br.6) -- Calculated by EVNTRE

PDS Group 7 - SGTRs

PDS Group 7 consists of two PDSs that are initiated by SGTRs and that do not have scram failures. PDS HINY-NXY has stuck-open SRVs in the secondary system while PDS GLYY-YNY does not. The difference requires fractional branch probabilities for Question 3, and the remaining differences are treated in the case structure of other questions.

Fractional Branch Probabilities for PDS Group 7 - SGTRs
Question 3 - Secondary SRVs Stuck Open

SSRV-SO: FP(Br.1) = f(HINY-NXY) / Σf(all)
SSRVnSO: FP(Br.2) -- Calculated by EVNTRE

Listing of the First 11 APET Questions for PDS Group 1.

```
   SEQUOYAH Accident Progression Event Tree - PDS Group 1 (Slow Blackouts)
         111
        NQuest
   1     1.000
   Cent  PInit
1 Size and location of initial break?
   6     Brk-A      Brk-S2      Brk-S3       Brk-V      B-SGTR      B-PORV
   1         1           2           3           4           5           6
         0.000       0.028       0.954       0.000       0.000       0.018
2 Has the reaction been brought under control?
   2     Scram     noScram
   1         1           2
         1.000       0.000
3 For SGTR, are the secondary system SRVs stuck open?
   2   SSRV-SO     SSRVnSO
   1         1           2
         0.000       1.000
4 Status of ECCS?
   4    B-ECCS      BaECCS      BfECCS      B-LPIS
   2         1           2           3           4
   4
   3         1           1           3
             1   +       5  *        1
         Brk-A  or  B-SGTR  & SSRV-SO
         0.000       1.000       0.000       0.000
   1         1
             2
        Brk-S2
         0.000       1.000       0.000       0.000
   1         1
             3
        Brk-S3
         0.000       1.000       0.000       0.000
      Otherwise
         0.000       1.000       0.000       0.000
5 Is the RCS depressurized by the operators?
   3   Op-DePr     OpmDePr     OpnDePr
   2         1           2           3
   3
   1         1
             3
        Brk-S3
         0.000       0.000       1.000
   2         1           3
             5  *        1
        B-SGTR  &   SSRV-SO
         0.000       0.000       1.000
     Otherwise
         0.000       0.000       1.000
6 Status of sprays?
   4      B-Sp        BaSp        BfSp      noB-SW
   2         1           2           3           4
   4
   4         1           4           1           3
             1   *       3   +       5   *       1
         Brk-A   &  BfECCS  or  B-SGTR   & SSRV-SO
         0.000       1.000       0.000       0.000
   2         1           4
             2   *       3
        Brk-S2   &  BfECCS
         0.000       1.000       0.000       0.000
```

```
   2        1         4
            3   *     3
       Brk-S3   &  BfECCS
        0.000       1.000       0.000       0.000
      Otherwise
        0.000       1.000       0.000       0.000
 7 Status of ac power?
   3    B-ACP       BaACP       BfACP
   1        1           2           3
        0.000       1.000       0.000
 8 Are the refueling water storage tank contents injected into containment?
   3   RWST-I      RWSTaI      RWSTfI
   2        1           2           3
   2
   2        1           3
            5   *       1
       B-SGTR   &  SSRV-SO
        0.000       1.000       0.000
      Otherwise
        0.000       1.000       0.000
 9 Heat removal from the steam generators?
   4    SG-HR       SGaHR       SGfHR       SGdHR
   2        1           2           3           4
   2
   2        1           3
            5   *       2
       B-SGTR   &  SSRVnSO
        0.000       0.000       0.000       1.000
      Otherwise
        0.000       0.000       0.000       1.000
10 Is the secondary depressurized before the core uncovers?
   2    SecDP     noSecDP
   2        1           2
   3
   2        1           9
            3   *       4
       Brk-S3   &   SGdHR
        0.978       0.022
   2        1           9
            2   *       4
       Brk-S2   &   SGdHR
        0.000       1.000
      Otherwise
        1.000       0.000
11 Cooling for reactor coolant pump seals?
   3    B-PSC       BaPSC       BfPSC
   2        1           2           3
   3
   4        1           9           1           4
            6   *       4   +       1   *       4
       B-PORV   &   SGdHR   or  Brk-A   &   B-LPIS
        0.000       1.000       0.000
   2        1           4
            3   *       3
       Brk-S3   &  BfECCS
        0.000       1.000       0.000
      Otherwise
        0.000       1.000       0.000
```

Listing of the First 11 APET Questions for PDS Group 2.

```
SEQUOYAH Accident Progression Event Tree - PDS Group 2 (Fast Blackouts)
     111
    NQuest
```

```
   1    1.000
  Cent  PInit
1 Size and location of initial break?
   6    Brk-A      Brk-S2      Brk-S3       Brk-V      B-SGTR      B-PORV
   1        1           2           3           4           5           6
        0.000       0.000       0.000       0.000       0.000       1.000
2 Has the reaction been brought under control?
   2    Scram     noScram
   1        1           2
        1.000       0.000
3 For SGTR, are the secondary system SRVs stuck open?
   2  SSRV-SO     SSRVnSO
   1        1           2
        0.000       1.000
4 Status of ECCS?
   4   B-ECCS      BaECCS      BfECCS      B-LPIS
   2        1           2           3           4
   4
   3        1           1           3
            1   +       5   *       1
        Brk-A  or  B-SGTR   & SSRV-SO
        0.000       1.000       0.000       0.000
   1        1
            2
       Brk-S2
        0.000       1.000       0.000       0.000
   1        1
            3
       Brk-S3
        0.000       1.000       0.000       0.000
      Otherwise
        0.000       1.000       0.000       0.000
5 Is the RCS depressurized by the operators?
   3  Op-DePr     OpmDePr     OpnDePr
   2        1           2           3
   3
   1        1
            3
       Brk-S3
        0.000       0.000       1.000
   2        1           3
            5   *       1
       B-SGTR   &  SSRV-SO
        0.000       0.000       1.000
      Otherwise
        0.000       0.000       1.000
6 Status of sprays?
   4     B-Sp        BaSp        BfSp      noB-SW
   2        1           2           3           4
   4
   4        1           4           1           3
            1   *       3   +       5   *       1
        Brk-A   &  BfECCS  or  B-SGTR   &  SSRV-SO
        0.000       1.000       0.000       0.000
   2        1           4
            2   *       3
       Brk-S2   &  BfECCS
        0.000       1.000       0.000       0.000
   2        1           4
            3   *       3
       Brk-S3   &  BfECCS
        0.000       1.000       0.000       0.000
      Otherwise
        0.000       1.000       0.000       0.000
```

```
7 Status of ac power?
   3    B-ACP       BaACP        BfACP
   1        1           2            3
        0.000       1.000        0.000
8 Are the refueling water storage tank contents injected into containment?
   3   RWST-I      RWSTaI       RWSTfI
   2        1           2            3
   2
   2        1           3
            5  *        1
       B-SGTR  &  SSRV-SO
        0.000       1.000        0.000
      Otherwise
        0.000       1.000        0.000
 9 Heat removal from the steam generators?
   4    SG-HR       SGaHR        SGfHR        SGdHR
   2        1           2            3            4
   2
   2        1           3
            5  *        2
       B-SGTR  &  SSRVnSO
        0.000       1.000        0.000        0.000
      Otherwise
        0.000       1.000        0.000        0.000
10 Is the secondary depressurized before the core uncovers?
    2    SecDP     noSecDP
    2        1           2
    3
    2        1           9
             3  *        4
        Brk-S3  &    SGdHR
         0.000       1.000
    2        1           9
             2  *        4
        Brk-S2  &    SGdHR
         0.000       1.000
       Otherwise
         0.000       1.000
11 Cooling for reactor coolant pump seals?
    3    B-PSC       BaPSC        BfPSC
    2        1           2            3
    3
    4        1           9            1           4
             6  *        4   +        1  *        4
        B-PORV  &    SGdHR  or    Brk-A  &   B-LPIS
         0.000       1.000        0.000
    2        1           4
             3  *        3
        Brk-S3  &   BfECCS
         0.000       1.000        0.000
       Otherwise
         0.000       1.000        0.000
```

Listing of the First 11 APET Questions for PDS Group 3.

```
SEQUOYAH Accident Progression Event Tree - PDS Group 3 (LOCAs)
       111
     NQuest
  1   1.000
Cent  PInit
1 Size and location of initial break?
  6    Brk-A       Brk-S2       Brk-S3        Brk-V       B-SGTR       B-PORV
  1        1            2            3            4            5
       0.226        0.168        0.606        0.000        0.000        0.000
```

```
2 Has the reaction been brought under control?
   2    Scram     noScram
   1        1           2
        1.000       0.000
3 For SOTR, are the secondary system SRVs stuck open?
   2  SSRV-SO     SSRVnSO
   1        1           2
        0.000       1.000
4 Status of ECCS?
   4   B-ECCS      BaECCS      BfECCS      B-LPIS
   2        1           2           3           4
   4
   3        1           1           3
            1   +       5    *      1
        Brk-A  or  B-SOTR  & SSRV-SO
        0.000       0.000       0.246       0.754
   1        1
            2
       Brk-S2
        0.000       0.000       0.224       0.776
   1        1
            3
       Brk-S3
        0.000       0.000       0.256       0.744
      Otherwise
        0.000       0.000       0.000       1.000
5 Is the RCS depressurized by the operators?
   3  Op-DePr     OpmDePr     OpnDePr
   2        1           2           3
   3
   1        1
            3
       Brk-S3
        0.000       0.000       1.000
   2        1           3
            5   *       1
       B-SOTR   &  SSRV-SO
        0.000       0.000       1.000
      Otherwise
        0.000       0.000       1.000
6 Status of sprays?
   4     B-Sp        BaSp        BfSp      noB-SW
   2        1           2           3           4
   4
   4        1           4           1           3
            1   *       3   +       5    *      1
        Brk-A   &  BfECCS  or  B-SOTR    & SSRV-SO
        0.486       0.000       0.514       0.000
   2        1           4
            2   *       3
       Brk-S2   &  BfECCS
        0.413       0.000       0.587       0.000
   2        1           4
            3   *       3
       Brk-S3   &  BfECCS
        0.419       0.000       0.581       0.000
      Otherwise
        1.000       0.000       0.000       0.000
7 Status of ac power?
   3    B-ACP       BaACP       BfACP
   1        1           2           3
        1.000       0.000       0.000
8 Are the refueling water storage tank contents injected into containment?
   3   RWST-I      RWSTaI      RWSTfI
```

```
   2      1         2         3
   2
   2      1         3
          5  *      1
      B-SGTR & SSRV-SO
      1.000     0.000     0.000
     Otherwise
      1.000     0.000     0.000
9 Heat removal from the steam generators?
   4  SG-HR     SGaHR     SGfHR     SGdHR
   2      1         2         3         4
   2
   2      1         3
          5  *      2
      B-SGTR & SSRVnSO
      1.000     0.000     0.000     0.000
     Otherwise
      1.000     0.000     0.000     0.000
10 Is the secondary depressurized before the core uncovers?
   2  SecDP   noSecDP
   2      1         2
   3
   2      1         9
          3  *      4
      Brk-S3 &  SGdHR
      1.000     0.000
   2      1         9
          2  *      4
      Brk-S2 &  SGdHR
      1.000     0.000
     Otherwise
      1.000     0.000
11 Cooling for reactor coolant pump seals?
   3  B-PSC     BaPSC     BfPSC
   2      1         2         3
   3
   4      1         9         1         4
          6  *      4   +     1  *      4
      B-PORV &  SGdHR  or Brk-A  &  B-LPIS
      0.191     0.000     0.809
   2      1         4
          3  *      3
      Brk-S3 & BfECCS
      0.000     0.000     1.000
     Otherwise
      0.000     0.000     1.000
```

Listing of the First 11 APET Questions for PDS Group 4.

```
   SEQUOYAH Accident Progression Event Tree - PDS Group 4 (Event V)
          111
       NQuest
    1   1.000
   Cent PInit
  1 Size and location of initial break?
    6   Brk-A    Brk-S2    Brk-S3     Brk-V    B-SGTR    B-PORV
    1       1         2         3         4         5         6
        0.000     0.000     0.000     1.000     0.000     0.000
  2 Has the reaction been brought under control?
    2   Scram   noScram
    1       1         2
        1.000     0.000
  3 For SGTR, are the secondary system SRVs stuck open?
    2 SSRV-SO   SSRVnSO
```

```
   1        1           2
        0.000       1.000
4 Status of ECCS?
   4   B-ECCS      BaECCS      BfECCS      B-LPIS
   2        1           2           3           4
   4
   3        1           1           3
            1   +       5   *       1
        Brk-A  or  B-SGTR   & SSRV-SO
        0.000       0.000       1.000       0.000
   1        1
            2
       Brk-S2
        0.000       0.000       1.000       0.000
   1        1
            3
       Brk-S3
        0.000       0.000       1.000       0.000
      Otherwise
        0.000       0.000       1.000       0.000
5 Is the RCS depressurized by the operators?
   3  Op-DePr     OpmDePr     OpnDePr
   2        1           2           3
   3
   1        1
            3
       Brk-S3
        0.000       0.000       1.000
   2        1           3
            5  *        1
       B-SGTR  &  SSRV-SO
        0.000       0.000       1.000
      Otherwise
        0.000       0.000       1.000
6 Status of sprays?
   4     B-Sp        BaSp        BfSp      noB-SW
   2        1           2           3           4
   4
   4        1           4           1           3
            1   *       3   +       5   *       1
        Brk-A   &  BfECCS  or  B-SGTR   &  SSRV-SO
        0.000       0.000       1.000       0.000
   2        1           4
            2   *       3
       Brk-S2   &  BfECCS
        0.000       0.000       1.000       0.000
   2        1           4
            3   *       3
       Brk-S3   &  BfECCS
        0.000       0.000       1.000       0.000
      Otherwise
        0.000       0.000       1.000       0.000
7 Status of ac power?
   3    B-ACP       BaACP       BfACP
   1        1           2           3
        1.000       0.000       0.000
8 Are the refueling water storage tank contents injected into containment?
   3   RWST-I      RWSTaI      RWSTfI
   2        1           2           3
   2
   2        1           3
            5   *       1
       B-SGTR   &  SSRV-SO
        0.000       0.000       1.000
```

```
      Otherwise
        0.000       0.000       1.000
 9 Heat removal from the steam generators?
    4    SG-HR        SGaHR       SGfHR       SGdHR
    2        1            2           3           4
    2
    2        1            3
             5  *         2
       B-SGTR  &  SSRVnSO
        1.000       0.000       0.000       0.000
      Otherwise
        1.000       0.000       0.000       0.000
10 Is the secondary depressurized before the core uncovers?
    2    SecDP      noSecDP
    2        1            2
    3
    2        1            9
             3  *         4
       Brk-S3  &    SGdHR
        1.000       0.000
    2        1            9
             2  *         4
       Brk-S2  &    SGdHR
        1.000       0.000
      Otherwise
        1.000       0.000
11 Cooling for reactor coolant pump seals?
    3    B-PSC        BaPSC       BfPSC
    2        1            2           3
    3
    4        1            9           1           4
             6  *         4   +       1   *       4
       B-PORV  &    SGdHR  or   Brk-A  &   B-LPIS
        1.000       0.000       0.000
    2        1            4
             3  *         3
       Brk-S3  &   BfECCS
        1.000       0.000       0.000
      Otherwise
        1.000       0.000       0.000
```

Listing of the First 11 APET Questions for PDS Group 5.

```
   SEQUOYAH Accident Progression Event Tree - PDS Group 5 (Transients)
          111
        NQuest
    1   1.000
   Cent  PInit
 1 Size and location of initial break?
    6    Brk-A       Brk-S2      Brk-S3       Brk-V       B-SGTR      B-PORV
    1        1            2           3           4            5           6
         0.000        0.000       0.000       0.000        0.000       1.000
 2 Has the reaction been brought under control?
    2    Scram     noScram
    1        1            2
         1.000        0.000
 3 For SGTR, are the secondary system SRVs stuck open?
    2  SSRV-SO     SSRVnSO
    1        1            2
         0.000        1.000
 4 Status of ECCS?
    4   B-ECCS       BaECCS      BfECCS      B-LPIS
    2        1            2           3           4
    4
```

```
   3         1             1             3
             1   +         5   *         1
        Brk-A   or  B-SGTR   & SSRV-SO
         1.000         0.000         0.000         0.000
   1         1
             2
        Brk-S2
         1.000         0.000         0.000         0.000
   1         1
             3
        Brk-S3
         1.000         0.000         0.000         0.000
       Otherwise
         1.000         0.000         0.000         0.000
5 Is the RCS depressurized by the operators?
   3  Op-DePr      OpmDePr      OpnDePr
   2         1             2             3
   3
   1         1
             3
        Brk-S3
         0.000         0.000         1.000
   2         1             3
             5   *         1
        B-SGTR  &  SSRV-SO
         0.000         0.000         1.000
       Otherwise
         0.000         0.000         1.000
6 Status of sprays?
   4      B-Sp          BaSp          BfSp        noB-SW
   2         1             2             3             4
   4
   4         1             4             1             3
             1   *         3   +         5   *         1
         Brk-A   &  BfECCS   or  B-SGTR   &   SSRV-SO
         1.000         0.000         0.000         0.000
   2         1             4
             2   *         3
        Brk-S2   &  BfECCS
         1.000         0.000         0.000         0.000
   2         1             4
             3   *         3
        Brk-S3   &  BfECCS
         1.000         0.000         0.000         0.000
       Otherwise
         1.000         0.000         0.000         0.000
7 Status of ac power?
   3     B-ACP         BaACP         BfACP
   1         1             2             3
         1.000         0.000         0.000
8 Are the refueling water storage tank contents injected into containment?
   3    RWST-I        RWSTaI        RWSTfI
   2         1             2             3
   2
   2         1             3
             5   *         1
        B-SGTR  &  SSRV-SO
         1.000         0.000         0.000
       Otherwise
         1.000         0.000         0.000
9 Heat removal from the steam generators?
   4     SG-HR         SGaHR         SGfHR         SGdHR
   2         1             2             3             4
   2
```

```
    2        1           3
             5  *        2
        B-SGTR  &  SSRVnSO
         0.000       0.000       1.000       0.000
      Otherwise
         0.000       0.000       1.000       0.000
10 Is the secondary depressurized before the core uncovers?
    2    SecDP     noSecDP
    2        1           2
    3
    2        1           9
             3  *        4
        Brk-S3  &    SGdHR
         0.000       1.000
    2        1           9
             2  *        4
        Brk-S2  &    SGdHR
         0.000       1.000
      Otherwise
         0.000       1.000
11 Cooling for reactor coolant pump seals?
    3    B-PSC       BaPSC       BfPSC
    2        1           2           3
    3
    4        1           9           1           4
             6  *        4   +       1  *        4
        B-PORV  &    SGdHR  or   Brk-A  &   B-LPIS
         1.000       0.000       0.000
    2        1           4
             3  *        3
        Brk-S3  &   BfECCS
         1.000       0.000       0.000
      Otherwise
         1.000       0.000       0.000
```

Listing of the First 11 APET Questions for PDS Group 6.

```
   SEQUOYAH Accident Progression Event Tree - PDS Group 6 (ATWSs)
           111
        NQuest
    1    1.000
   Cent  PInit
 1 Size and location of initial break?
    6    Brk-A      Brk-S2      Brk-S3       Brk-V      B-SGTR      B-PORV
    1        1           2           3           4           5           6
         0.000       0.000       0.757       0.000       0.135       0.108
 2 Has the reaction been brought under control?
    2    Scram     noScram
    1        1           2
         0.000       1.000
 3 For SGTR, are the secondary system SRVs stuck open?
    2  SSRV-SO     SSRVnSO
    1        1           2
         0.000       1.000
 4 Status of ECCS?
    4   B-ECCS      BaECCS      BfECCS      B-LPIS
    2        1           2           3           4
    4
    3        1           1           3
             1   +       5   *       1
         Brk-A  or  B-SGTR   & SSRV-SO
         0.000       0.000       1.000       0.000
    1        1
             2
```

```
      Brk-S2
        0.000       0.000       1.000       0.000
   1        1
            3
      Brk-S3
        0.000       0.000       1.000       0.000
     Otherwise
        0.000       0.000       0.000       1.000
5 Is the RCS depressurized by the operators?
   3  Op-DePr     OpmDePr     OpnDePr
   2        1           2           3
   3
   1        1
            3
      Brk-S3
        0.000       0.000       1.000
   2        1           3
            5  *        1
      B-SGTR  &  SSRV-SO
        0.000       1.000       0.000
     Otherwise
        0.000       1.000       0.000
6 Status of sprays?
   4     B-Sp        BaSp        BfSp      noB-SW
   2        1           2           3           4
   4
   4        1           4           1           3
            1  *        3  +        5  *        1
       Brk-A  &  BfECCS  or  B-SGTR  &  SSRV-SO
        1.000       0.000       0.000       0.000
   2        1           4
            2  *        3
      Brk-S2  &  BfECCS
        1.000       0.000       0.000       0.000
   2        1           4
            3  *        3
      Brk-S3  &  BfECCS
        1.000       0.000       0.000       0.000
     Otherwise
        1.000       0.000       0.000       0.000
 7 Status of ac power?
   3    B-ACP       BaACP       BfACP
   1        1           2           3
        1.000       0.000       0.000
 8 Are the refueling water storage tank contents injected into containment?
   3   RWST-I      RWSTaI      RWSTfI
   2        1           2           3
   2
   2        1           3
            5  *        1
      B-SGTR  &  SSRV-SO
        1.000       0.000       0.000
     Otherwise
        1.000       0.000       0.000
 9 Heat removal from the steam generators?
   4    SG-HR       SGaHR       SGfHR       SGdHR
   2        1           2           3           4
   2
   2        1           3
            5  *        2
      B-SGTR  &  SSRVnSO
        1.000       0.000       0.000       0.000
     Otherwise
        1.000       0.000       0.000       0.000
```

```
10 Is the secondary depressurized before the core uncovers?
    2     SecDP   noSecDP
    2         1         2
    3
    2         1         9
              3 *       4
         Brk-S3 &   SGdHR
          0.000     1.000
    2         1         9
              2 *       4
         Brk-S2 &   SGdHR
          0.000     1.000
      Otherwise
          0.000     1.000
11 Cooling for reactor coolant pump seals?
    3     B-PSC     BaPSC     BfPSC
    2         1         2         3
    3
    4         1         9         1         4
              6 *       4 +       1 *       4
         B-PORV &   SGdHR or  Brk-A &  B-LPIS
          1.000     0.000     0.000
    2         1         4
              3 *       3
         Brk-S3 &  BfECCS
          0.000     0.000     1.000
      Otherwise
          1.000     0.000     0.000
```

<u>Listing of the First 11 APET Questions for PDS Group 7</u>.

```
   SEQUOYAH Accident Progression Event Tree - PDS Group 7 (SGTRs)
            111
         NQuest
    1     1.000
   Cent   PInit
 1 Size and location of initial break?
    6     Brk-A    Brk-S2    Brk-S3     Brk-V    B-SGTR    B-PORV
    1         1         2         3         4         5         6
          0.000     0.000     0.000     0.000     1.000     0.000
 2 Has the reaction been brought under control?
    2     Scram   noScram
    1         1         2
          1.000     0.000
 3 For SGTR, are the secondary system SRVs stuck open?
    2   SSRV-SO   SSRVnSO
    1         1         2
          0.792     0.208
 4 Status of ECCS?
    4    B-ECCS    BaECCS    BfECCS    B-LPIS
    2         1         2         3         4
    4
    3         1         1         3
              1 +       5 *       1
          Brk-A or B-SGTR & SSRV-SO
          0.000     0.000     1.000     0.000
    1         1
              2
         Brk-S2
          0.000     0.000     0.000     1.000
    1         1
              3
         Brk-S3
          0.000     0.000     0.000     1.000
```

```
      Otherwise
        0.000       0.000       0.000       1.000
5 Is the RCS depressurized by the operators?
   3  Op-DePr     OpmDePr     OpnDePr
   2        1           2           3
   3
   1        1
            3
       Brk-S3
        0.000       0.000       1.000
   2        1           3
            5  *        1
       B-SGTR  &  SSRV-SO
        0.000       0.000       1.000
      Otherwise
        1.000       0.000       0.000
6 Status of sprays?
   4     B-Sp        BaSp        BfSp      noB-SW
   2        1           2           3           4
   4
   4        1           4           1           3
            1  *        3  +        5  *        1
        Brk-A  &  BfECCS  or  B-SGTR  &  SSRV-SO
        0.000       0.000       1.000       0.000
   2        1           4
            2  *        3
       Brk-S2  &   BfECCS
        1.000       0.000       0.000       0.000
   2        1           4
            3  *        3
       Brk-S3  &   BfECCS
        1.000       0.000       0.000       0.000
      Otherwise
        1.000       0.000       0.000       0.000
7 Status of AC power?
   3    B-ACP       BaACP       BfACP
   1        1           2           3
        1.000       0.000       0.000
8 Are the refueling water storage tank contents injected into containment?
   3   RWST-I      RWSTaI      RWSTfI
   2        1           2           3
   2
   2        1           3
            5  *        1
       B-SGTR  &  SSRV-SO
        0.000       0.000       1.000
      Otherwise
        1.000       0.000       0.000
9 Heat removal from the steam generators?
   4    SG-HR       SGaHR       SGfHR       SGdHR
   2        1           2           3           4
   2
   2        1           3
            5  *        2
       B-SGTR  &  SSRVnSO
        0.000       0.000       1.000       0.000
      Otherwise
        1.000       0.000       0.000       0.000
10 Is the secondary depressurized before the core uncovers?
   2    SecDP     noSecDP
   2        1           2
   3
   2        1           9
            3  *        4
```

```
        Brk-S3  &    SGdHR
         0.000       1.000
    2        1           9
             2  *        4
        Brk-S2  &    SGdHR
         0.000       1.000
       Otherwise
         0.000       1.000
11 Cooling for reactor coolant pump seals?
    3    B-PSC       BaPSC       BfPSC
    2        1           2           3
    3
    4        1           9           1           4
             6  *        4   +       1  *        4
        B-PORV  &    SGdHR  or   Brk-A  &   B-LPIS
         1.000       0.000       0.000
    2        1           4
             3  *        3
        Brk-S3  &   BfECCS
         1.000       0.000       0.000
       Otherwise
         1.000       0.000       0.000
```

A.3.3 Additional Discussions of Selected Questions

This section contains additional discussions for two questions in the APET that are too lengthy to fit conveniently in Subsection A.1.1. The two questions are:

22. Is ac power recovered early? (Also relevant to the other offsite power recovery Questions - 90 and 105.)

26. Is core damage arrested? No VB?

Question 21. Is ac power recovered early?

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.1-6] These distributions reflect the type of electrical switchyard at Sequoyah, as explained in NUREG-1032.[A.3-1] Figure A.3-1 is a plot of 5 percentile, median, and 95 percentile of this set of distributions. A single curve of the set summarized in Figure A.3-1 gives the probability that the time to offsite power recovery will be greater than time t, where t is measured from the start of the accident, i.e., from the LOSP. Figure A.3-1 shows that the probability of power recovery is quite high in the first 2-3 h and that the probability of power recovery is fairly small after 6 or 8 h.

The remainder of the discussion in this section concerns the determination of the lengths of the periods used for the ROSP in the Sequoyah APET. The APET considers three time periods:

Early - from the end of the recovery period considered in the accident frequency analysis to vessel failure;

Late - from vessel failure to the end of prompt CCI; and

Very Late - from the end of prompt CCI to 24 h.

It may be possible to arrest the core degradation process, achieve a safe stable state, and avoid vessel failure if power is recovered in the early period. For internal initiators, it is estimated that power will almost always be recovered about a day after the initial LOSP. The use of exactly 24 h for the end of the Very Late period is arbitrary. In the interface with the accident frequency analysis, it is important to account for all the time since the start of the accident, and not count any period twice.

There are three questions in the Sequoyah APET concerning the ROSP: Question 22 for the Early period; Question 90 for the Late period; and Question 105 for the Very Late period.

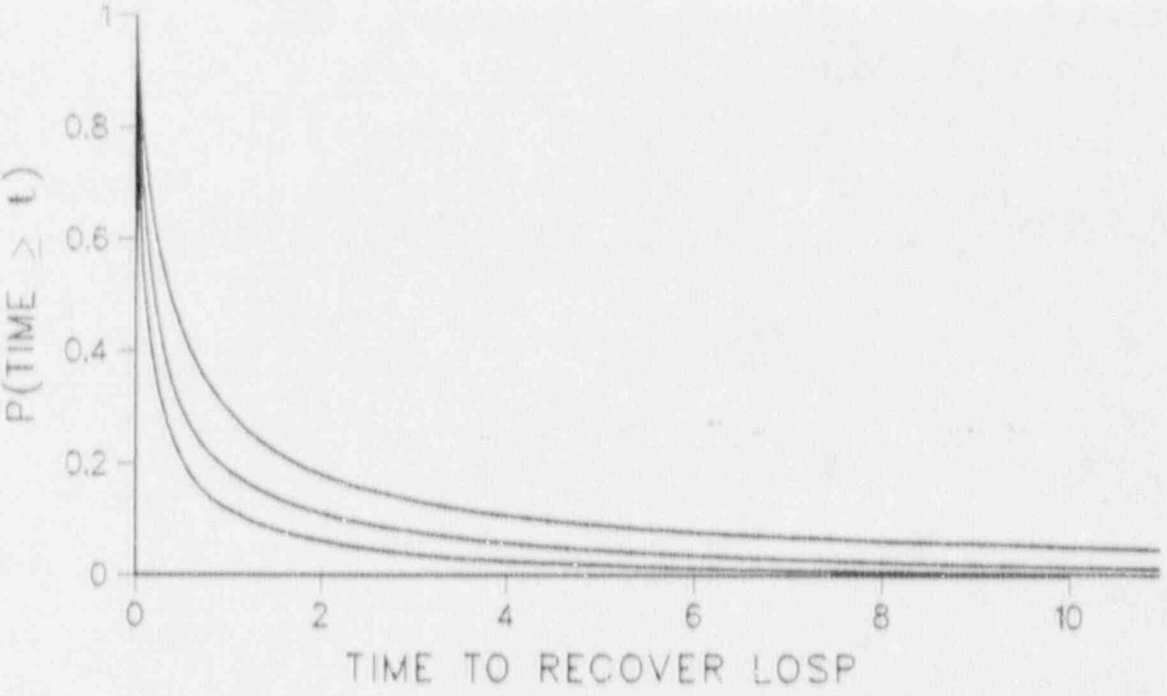

Figure A.3-1. Mean and 90% Bounds of the Offsite Power Recovery Distributions for Sequoyah

The five SBO PDSs for Sequoyah are given below with the percentage each PDS contributes (see Table 2.2-2) to the total mean core damage frequency and the nominal times to which power recovery was considered in the accident frequency analysis.

Table A.3-1
SBO PDSs for Sequoyah

PDS	% MCDF	Accident Frequency Analysis (AFA) Recovery Time (h)
TRRR-RSR	17	1.0
S_2RRR-RCR	<1	1.0
S_3RRR-RCR	<1	2.5-7.0 (4.0)
S_3RRR-RDR	7	2.5-7.0 (4.0)
TRRR-RDR	<1	7.0

PDS TRRR-RSR is the only PDS in the Fast SBO group; the other four PDSs constitute the Slow SBO group. The AFWS driven by the steam turbine runs until battery depletion in the Slow SBO accidents; whereas it fails at or shortly after the start of the accident in the Fast SBO group. The start and end of the offsite power recovery time periods in clock time depend upon the PDS since some of the accidents develop much faster than others. Both whether the AFWS operates until battery depletion and the size of the break in the RCS determine the time until core damage commences, and the rate at which it progresses.

The end of the time period for electric power recovery is a sampled variable in the accident frequency analysis. Because the start of the period is fixed at the start of the accident, this is feasible for the accident frequency analysis. Treating both the start of the period, the end of the period, and the power recovery distribution itself did not prove feasible in the accident progression analysis. Therefore, fixed time periods are used in the accident progression analysis. The start of the early power recovery period is fixed at the nominal time for the end of the period used in the accident frequency analysis. These times are given above.

The power recovery times for the S_3RRR-RCR and S_3RRR-RDR PDSs depend upon the cutset, and varied from 150 min to 420 min, as explained in the report of the accident frequency analysis.[A.1-2] The bulk of the frequency for S_3RRR-RCR is concentrated in cutsets for which power recovery times of 201 min (3.4 h) and 246 min (4.1 h) were used, and the bulk of the frequency for S_3RRR-RDR is concentrated in cutsets for which power recovery times of 216 min (3.6 h) and 252 min (4.2 h) were used. Therefore, 4 h is used as the start of the early power recovery period in the accident progression analysis for these two PDSs. For the TRRR-RSR, the power recovery times were 1 h and 234 min (3.9 h), where the bulk of the cutsets considered power recovery at 1 h; thus, 1 h was used as the start of the early power recovery period for this PDS. For S_2RRR-RCR and TRRR-RDR the power recovery times in the accident frequency analysis were 1 h and 7 h, respectively.

The time to the UTAF, taken to be the nominal time for the start of core degradation, and the time of VB, are taken from analyses[A.1-8,A.1-10,A.3-2-5] performed for the NUREG-1150 project that used the STCP. While it would have been preferable to rely on other codes that perform detailed modeling of the core melt progression as well, this did not prove feasible. The time from the start of the accident to UTAF is determined primarily by a water boil-off calculation, and this does not vary greatly from code to code. The rate of progression for the core melt and the time from core slump to VB may differ from code to code, but these differences are considered to be small relative to the uncertainty in the time at which offsite power will be recovered.

Tables A.3-2 and A.3-3 summarize the information available from the STCP runs made in the last few years for NUREG-1150.[A.1-3] The information in these tables was analyzed to determine UTAF and VB times that were applicable to the five PDSs for SBO at Sequoyah. The results are summarized in Table A.3-4. The end of the period for which power recovery was considered in the accident frequency analysis forms the start of the early APET period. This must be the case to avoid a period in which power recovery is not considered, even though the start of the early period is conceptually at UTAF. The end of the early period is at VB.

Table A.3-2
Timing in STCP PWR Blackout Sequences

[All columns are times in minutes except the last column which is in psia]

Plant	Sequence	Break Time	AFW On	AFW Off	SG Depres. Start	SG Depres. End	Accum. Disch. Start	Accum. Disch. End	UTAF	VB	RCS Pr. at VB	Source
Surry	TB	--	0	300	90	150	250	340	668	758	2518	Letter
Surry	TMLB'	--	--	--	--	--	155	155	96	155	2365	2104 & 2139
Sequoyah	TMLB'	--	--	--	--	--	158	158	98	158	2375	2104
Surry	S_3B	60	0	300	70	100	101	141	521	628	1900	Letter
Surry	S_3B	0	--	--	--	--	146	146	88	146	2012	2160
Sequoyah	S_3B	60	0	300	70	100	121	143	507	617	1509	Letter
Sequoyah	S_3B	0	0	300	--	--	374	374	237	374	1996	2139
Sequoyah	S_3B(del)	180	0	∞	10	70	30	510	362	510	724	2160
Sequoyah	TBA	572	0	300	--	--	572	572	518	986	15	2139

Table A.3-3
Timing in STCP PWR LOCA Sequences

[All columns are times in minutes except the last column which is in psia.]

Plant	Sequence	AFW On	AFW Off	SG Depres. Start	SG Depres. End	Accum. Disch. Start	Accum. Disch. End	PORVs Open	UTAF	VB	RCS Pr. at VB	Source
Surry	S_3DS	0	∞	30	60	40	80	--	525	835	1659	Letter
Surry	S_3DZ	0	∞	30	60	40	80	658	525	849	22	Letter
Sequoyah	S_3D	0	∞	30	70	52	73	--	541	962	32	Letter
Sequoyah	S_3HF	0	∞	--	--	410	410	--	272	410	1993	2139
Sequoyah	S_3HF	0	∞	--	--	428	428	--	274	428	2159	2160
Surry	S_2DY	0	∞	30	60	44	65	148	115	314	16	Letter
Surry	$S_2D\text{-}\gamma$	-	-	--	--	55	91	--	28	164	617	2104
Surry	$S_2D\text{-}\epsilon$	-	-	--	--	55	91	--	28	227	18	2104
Surry	S_2HF	-	-	--	--	before	UTAF	--	163	260	41	2104

Table A.3-4
Timing Information for Sequoyah Blackout PDSs
(Times in h)

PDS	Start Early Period	UTAF	VB	Relevant Sequences*
TRRR-RSR	1.0	1.6	2.6	Q,R-TMLB'
S_2RRR-RCR	1.0	1.9	5.2	R-S_2HF, R-S_2DY, Q-S_3HF, Q-S_3D
S_3RRR-RCR	4.0	4.0	6.2	Q-S_3B (2139)
S_3RRR-RDR	4.0	8.6	10.4	Q,R-S_3B (Letter)
TRRR-RDR	7.0	11.1	12.6	R-TB

*Q indicates a Sequoyah sequence; R indicates a Surry sequence. Where there are two sequences with the same identifier, the source is indicated in parentheses.

Estimating the time of VB for the S_2 blackout PDS is more difficult than for the other PDSs since there are no STCP results for blackout accidents with the PORVs stuck open, so the UTAF and VB times are estimated from other sequences. For S_2RRR-RCR, the operators do not depressurize the SGs and there are no comparable STCP analyses. Comparing Sequoyah S_3D with S_3HF shows a very marked effect of depressurizing the SGs. But RCS pressures will be much lower in an S_2 sequence, so this may not apply. The UTAF time is actually longer for the Surry S_2HF sequence than for the Surry S_2DY sequence even though the S_2HF run did not have the AFW operating. It was estimated that the stuck-open PORVs will depressurize the RCS enough so that the effects of the depressurization of the secondary system are minimal, so 4.5 h appears to be a reasonable VB time.

Table A.3-5 recapitulates the start and end times of the early period, the period in which electric power recovery may lead to the arrest of the core degradation process. Times have been rounded off to the nearest half hour. Table A.3-5 also contains two times for the end of rapid CCI. The time from VB to the start of CCI will depend on the amount of water to be boiled off if the core debris is coolable. Table A.3-5 shows the end of rapid CCI times for a cavity which is dry at VB and receives no substantial amount of additional water, and for a cavity which is dry at VB but receives the accumulator contents shortly after VB.

Table A.3-5
Electric Power Recovery Times for Sequoyah
(Time in hours)

PDS	% Total MCDF	Start of Early Period	End Of Early Period	End CCI Dry Cavity	End CCI Partially Wet Cavity
TRRR-RSR	17	1.0	2.5	8.0	9.0
S_2RRR-RCR	<1	1.0	4.5	10.0	11.0
S_3RRR-RCR	<1	4.0	6.0	11.5	12.5
S_3RRR-RDR	7	4.0	10.5	16.0	17.0
TRRR-RDR	<1	7.0	12.5	18.0	19.0

The containment sumps are not connected to the cavity at a low level in the Sequoyah containment. The only way for water to overflow into the cavity is if the RWST is injected into the containment (through the break or by the sprays), and at least about one-quarter of the ice melts. As electric power is required to operate the spray or ECCS pumps, it is not possible to have a wet cavity at VB for the blackout PDSs. The exception is the case in which electric power is recovered just before VB, but too late to arrest core damage and prevent VB. In this case, it is conceivable that the cavity could be wet (see the discussion of Question 63 in Subsection A.1.1). If power is recovered 1 h before VB, the chances of arresting core damage are very good. Thus, the probability of a full cavity at VB for SBO accidents is negligible.

The period of rapid CCI denotes the period in which most of the fission products that will eventually be released from the CCI are indeed released. As the releases decrease slowly over time, this period cannot be rigidly defined. A length of about 5 to 6 h is used for this period here.

The power recovery distributions (Figure A.3-1) are very flat after 8 to 10 h, so many of the time distinctions in Table A.3-5 are not significant compared to the variation between the curves in the distribution. Therefore the simplified electric power recovery periods in Table A.3-6 are used. This scheme preserves the differences between cases in the early period in which power recovery is more likely and more important, but condenses cases at long times when power recovery is less likely and less important.

Table A.3-6
Electric Power Recovery Periods for Sequoyah
(Times in hours)

PDS	% Total MCDF	Start Early Period	Start Late Period	Start Very Late Period
TRRR-RSR	17	1.0	2.5	9.0
S_2RRR-RCR	<1	1.0	4.5	9.0
S_3RRR-RCR	<1	4.0	6.0	9.0
S_3RRR-RDR	7	4.0	10.5	17.0
TRRR-RDR	<1	7.0	12.5	17.0

Given the time periods for each PDS as shown in Table A.3-5, the case structure for the offsite power recovery questions can be defined. The cases are listed below for the three offsite electric power recovery questions in the Sequoyah APET.

Question 22. Is ac power recovered early?

Case 1: Had power initially - have power now
Case 2: Power failed initially, not recoverable
Case 3: TRRR-RSR, recovery period = 1.0 - 2.5 h
Case 4: S_2RRR-RCR, recovery period = 1.0 - 4.5 h
Case 5: S_3RRR-RCR, AFW, no secondary depressurization, recovery period = 4.0 - 6.0 h
Case 6: S_3RRR-RDR, AFW, secondary depressurization, recovery period = 4.0 - 10.5 h
Case 7: TRRR-RDR, recovery period = 7.0 - 12.5 h

Question 90. Is ac power recovered late?

Case 1: Had power earlier - have power now
Case 2: Power failed, not recoverable
Case 3: TRRR-RSR, recovery period = 2.5 - 9.0 h
Case 4: S_2RRR-RCR, recovery period = 4.5 - 9.0 h
Case 5: S_3RRR-RCR, AFW, no secondary depressurization, recovery period = 6.0 - 9.0 h
Case 6: S_3RRR-RDR, AFW, secondary depressurization, recovery period = 10.5 - 17 h
Case 7: TRRR-RDR, recovery period = 12.5 - 17 h

Question 105. Is ac power recovered very late?

Case 1: Had power earlier - have power now
Case 2: Power failed, not recoverable
Case 3: S_3RRR-RDR and TRRR-RDR, recovery period = 17 - 24 h

Case 4: TRRR-RSR, S_2RRR-RCR, and S_3RRR-RCR,
recovery period = 9 - 24 h

Question 26. Is core damage arrested? No VB?

The problem of arresting core damage before VB has received little attention since the accidents which are most important to risk are those which proceed on to core melt. The TMI-2 accident is the primary source of information on this subject. Based on the current understanding of the TMI-2 accident, a method has been devised for estimating the probability of core damage arrest for each of the SBO PDSs. This method uses the electric power recovery periods defined in the previous portion of Subsection A.3.3 (see Question 22). The application of this method to the Sequoyah APET is described here, following a brief recapitulation of the relevant parts of the TMI-2 accident.

The TMI-2 Accident. The TMI-2 core was finally quenched in a series of events starting about 200 min after the start of the accident when HPI operated for 17 min and filled the vessel.[A.3-6,7] Evidently the core was not in a coolable configuration when first covered with water as the steaming rate was less than the decay heat generation rate until the relocation of about 25 metric tons of melt to the lower plenum at 224 min (Ref. A.3-6, p. 56). After the relocation or slump, the core assumed a coolable configuration and the temperature in all parts of the core began to decrease. However, the temperature decrease of the molten material in the center of the lower part of the core may have been quite slow due to the thick insulating crust around it. The temperature decrease of the molten material that flowed down into the lower plenum is believed to have been much more rapid.

For reference, the estimated end state of the TMI-2 core is as follows (Ref. A.3-6, Table 1, p. 26, updated with information from Ref. A.3-8):

Region	Fraction of Total Core Mass
Upper Core Debris (Rubble Bed)	.24
Previously Molten Zone	.26
Standing Rods	.32
Debris in Lower Plenum	.18

If it is assumed that all of the lower plenum debris came from the molten zone at the time of relocation, then the molten zone at one time contained about 45% of the core (mass). Note that the computer simulations often track "fraction relocated" or some other measure of core damage, which may be reported as fraction of core molten. By these measures, the mass in the rubble bed would count as well; and the value for "core no longer in original geometry" would be about 60%. Some computer codes assume core "slump" and vessel failure when the fraction molten or otherwise damaged reaches a threshold value. These threshold values have ranged from 50% to about 85%.

Background. The problem is to determine distributions for the probability that power recovery in the early time period (see the discussion of Question 22 above) will arrest the core degradation process and prevent vessel failure. Core damage arrest is envisaged to result in a safe stable state as in TMI-2, although the extent of damage may be much less than that at TMI-2. As discussed under Question 22, the period of interest for power recovery is from the end of the power recovery period used in the accident frequency analysis to VB. Once power is restored, the initiation of appropriate core injection systems is considered highly likely as the operators are periodically trained in this procedure (see the discussion of Question 23 in Subsection A.1.1).

The power recovery period in the APET that is of interest here is the Early period. The beginning and end of this period (in minutes) for the SBO PDSs are given below:

PDS	Power Recovery Period		Accident Frequency Analysis (AFA)	STCP UTAF
	Start	End		
TRRR-RSR	60	150	60	102
S_2RRR-RCR	60	270	60	111
S_3RRR-RCR	240	360	240	240
S_3RRR-RDR	240	630	240	516
TRRR-RDa	420	750	420	660

The accident frequency analysis UTAF column contains the nominal time used for UTAF and the onset of core damage in the accident frequency analysis. The STCP UTAF column contains UTAF times derived from STCP analyses as explained above in the discussion of Question 22. (The start of the early period is constrained to be the end of the power recovery period used in the accident frequency analysis so that there are no gaps in the times for which power recovery is considered.) The end of the APET early period was obtained by determining the VB times from available STCP calculations. This value was then rounded to the nearest 30 min as discussed above (see Question 22).

Basis of the Method. From the TMI-2 data[A.3-8] and subsequent analyses, it has been estimated for a core and vessel size similar to TMI-2, that if less than about 30 metric tons of the core is in debris form when ECCS flow refills the vessel, the chances of VB are small; and if more than 60 metric tons is in debris form when the vessel is refilled, the chances of VB are large. If the amount of debris is between 30 and 60 metric tons, it is difficult to say what the outcome would be. If less than 30 metric tons is in debris form, then either all the debris is coolable in the core, or, if part of the debris relocates to the bottom head, then the mass in the bottom head is small enough that the bottom head will not be heated to the failure point. If more than 60 metric tons is in debris form, then it is not coolable. This was shown at TMI where the debris in the "crucible" or "teacup" in the central core region continued to heat up after the core was reflooded. If 60 metric tons of the core is in debris form, then about half that amount may relocate into the bottom head as at TMI. With 30 metric tons of core debris located in the bottom head, heat transfer analyses show that the head will probably heat up to the point where its loss of strength is significant.

If an appropriate scaling could be done for the Sequoyah core and reactor vessel, and if the ends of the power recovery periods were fairly close to UTAF and VB, then the relative amounts of time from UTAF to the equivalent of 30 and 60 metric tons of debris (as derived from the STCP runs) could be used to estimate the conditional probability of core damage arrest. This approach cannot be used because the start of the power recovery period is often not very close to the time of UTAF as shown above. Further, it appears that the STCP overestimates the rate of core degradation.

A comparison of the results of the different detailed, mechanistic codes indicates that the newer codes such as MELCOR, MELPROG, CORMLT, and MAAP predict a slower core melt progression than the MARCH module of the STCP. Therefore, the method used to estimate the probability of core damage arrest is based on a MELCOR run[A.3-9] for Surry for which UTAF occurred at 100 min and with the PORVs stuck open (RCS at 6.6 MPa). Allowing a few minutes for refilling the vessel to the TAF, this simulation showed that injection had to start at 47 min after UTAF to have the core covered before 30 metric tons of the core was in debris form, and that injection had to start at 63 min after UTAF to have the core covered before 60 metric tons of the core was in debris form.

<u>Application to Sequoyah</u>. The results of the Surry MELCOR run can be scaled to Sequoyah with respect to percent of the total core that is molten if the ratio of the core mass to the surface area of the lower head is roughly the same for the two reactors. The mass of the Surry core is 103 metric tons and the inner diameter of the vessel is 3.99 m. For Sequoyah, the core mass is 133 metric tons, and the inner diameter of the vessel is 4.39 m. Thus, the ratio of core mass to the surface area of the lower head for Sequoyah is about 1.07 times that for Surry. Therefore, the MELCOR results for Surry can be applied to Sequoyah when considering relocation in terms of fraction of the total core. For Surry, 30 metric tons is about 30% of the core and 60 metric tons is about 60% of the core.

The results of MELCOR run are applied to the Sequoyah blackout PDSs according to the decay heat level by means of a multiplier on the times for 30% and 60% of the core in debris form. This multiplier is comprised of two factors: one based on the decay power level, and the other based on the latent heat of vaporization. These two factors suffice for this purpose because the rate of core degradation is largely a function of the rate at which water is boiled off. The rate of water boiloff depends directly on the heat available and the amount of heat necessary to change liquid water to steam, which is a function of pressure.

The following table gives the reactor power at UTAF (time derived from the STCP runs), the nominal pressure, latent heat of vaporization, and the total multiplier (MPX). The MPX is used to scale the MELCOR times and is calculated from the equation

$$\mathrm{MPX} = [1.11 / \%\mathrm{RP}] * [h_{fg} / 1530] * 1.07$$

where 1.11 is the reactor power at 100 min (% of rated power) and 1530 is the latent heat of vaporization (kJ/kg) at 6.6 MPa. For the S_3 PDSs, values of h_{fg} in the middle of the range were used.

PDS	Reactor Power (%)	RCS Pressure (MPa)	h_{fg} (kJ/kg)	MPX
MELCOR Run	1.11	6.6	1530	1.00
TRRR-RSR	1.10	15.2	990	0.66
S_2RRR-RCR	1.06	2.8	1810	1.23
S_3RRR-RCR	0.85	7-14	1500-1100	1.10
S_3RRR-RDR	0.66	7-14	1500-1100	1.43
TRRR-RDR	0.57	15.2	990	1.25

Using the multipliers given above, the times when 30% and when 60% of the core is in debris form can be calculated for each PDS from the MELCOR results. That is, for the time after UTAF when 30% is in debris form, the value of 47 min calculated by MELCOR is scaled by the appropriate MPX. The time when 60% is in debris form is similarly calculated from the 63 minute MELCOR value. The results are as follows:

		Relative to UTAF		Relative to Accident	
PDS	STCP UTAF (min)	30% Core Debris (min)	60% Core Debris (min)	30% Core Debris (min)	60% Core Debris (min)
TRRR-RSR	102	31	41	133	143
S_2RRR-RCR	111	58	78	169	189
S_3RRR-RCR	240	52	70	292	310
S_3RRR-RDR	516	67	90	583	606
TRRR-RDR	660	59	79	719	739

For example, for TRRR-RSR, MPX is 0.66, so 47 min is multiplied by this value to obtain 31 min for the time to 30% core debris for TRRR-RSR relative to UTAF. UTAF is estimated by the STCP to occur 102 min after the start of the accident, so, for TRRR-RSR, 30% of the core is estimated to be in debris form 133 min after the start of the accident.

These times can be used to estimate the conditional probability for each PDS or groups of PDSs that, given power recovery in the period before VB, when the vessel has been refilled the core will have less than 30% in debris form, between 30% and 60% is debris form, or more than 60% in debris form.

<u>S_2RRR-RCR</u>. The MELCOR analysis is almost directly applicable to S_2RRR-RCR as the uncovering time and the pressures are close to those used in the MELCOR run. The nominal value for the intermediate pressure range (400 psia = 2.8 MPa) is somewhat lower than the pressure observed as typical during core degradation in the MELCOR run, so there is an adjustment for the latent heat of vaporization. The total multiplier is 1.23 as given in the table above. The SCTP UTAF time for the S_2 PDS is 111 min (decay power = 1.06%).

Let t_u(30mR) be the time (minutes), relative to UTAF, at which injection has to start to refill the vessel to TAF before 30% of the core is in debris form. Let t_u (60mR) be the analogous time for 60%. Using the multiplier defined above, for S_2RRR-RCR, t_u(30mR) = 58 and t_u(60mR) = 78.

Let t_a(30mR) be the time (minutes), relative to the start of the accident, at which injection has to start to refill the vessel to TAF before 30% of the core is in debris form. Let t_a (60mR) be the analogous time for 60%. From the table above, the UTAF time is 111 min, so t_a(30mR) = 169 min. Based on these definitions, the relevant times for S_2RRR-RCR may be summarized:

t_a(30mR) = 169
t_a(60mR) = 189

where the times are in minutes.

Let $\Delta(<30)$ be the period when less than 30% of the core is in debris form, which extends from the start of the APET power recovery period to t_a(30mR). If power is recovered in this period, core damage arrest and the prevention of VB is very likely (on the order of 0.90). Let $\Delta t(30\text{-}60)$ be the period when between 30% and 60% is in debris form. This period extends from t_a(30mR) to t_a(60mR). If power is recovered in this period, the probability of arresting core damage and preventing of VB is indeterminate (about 0.50). Finally, let $\Delta t(>60)$ be the period when more than 60% of the core is in debris form. This period extends from t_a(60mR) to the end of the power recovery period. If power is recovered in this period, core damage arrest and the prevention of VB is very unlikely (on the order of 0.10).

Based on the information above, the lengths (minutes) of these three periods can be found for S_2RRR-RCR:

$\Delta t(>30)$ = 109
$\Delta t(30\text{-}60)$ = 20
$\Delta t(>60)$ = 81

If power recovery is equally likely at all times during the early period for S_2RRR-RCR, the probability of core damage arrest would be on the order of 0.45. However, from 1 to 4 h, the power recovery curve is not flat, and the probability of power recovery is much higher in the earlier part of the period than in the latter part. Considering the relative lengths of the three periods given above, and the shape of the power recovery curves (see Figure A.3-1 above in the discussion of Question 22), a cumulative probability distribution defined by $y = x^2$, where y is the probability and x varies from 0.0 to 1.0, was selected for the S_2 PDS. The mean and median values for this distribution are around 0.8.

S_3RRR-RCR. The STCP UTAF time for S_3RRR-RCR is 240 min (decay power = 0.85%). Compared with the previous case, the longer time to UTAF results in a lower decay power at UTAF. But this is not as important as the lower value of the latent heat of vaporization due to the higher pressure in the

RCS. The result is that MPX = 1.10 for this PDS. Scaling the 30% and 60% debris times from the MELCOR reference case by this value gives the following values:

$t_u(30mR) = 52$
$t_u(60mR) = 70$

$t_a(30mR) = 292$
$t_a(60mR) = 310$

and

$\Delta t(<30) = 52$
$\Delta t(30\text{-}60) = 18$
$\Delta t(>60) = 50$

Based on the lengths of these three periods, the probability of core damage arrest would be about 0.41 if power recovery is equally likely for all times in the early period for S_3RRR-RCR. For the 4 to 6 h period for this PDS, the power recovery curves are not as nonlinear as they are for the 1 to 4 h period considered for the previous case. Nonetheless, the probability of power recovery early in the period is greater than that of recovery late in the period. Therefore, a uniform distribution from 0.33 to 1.0 was selected for the recovery probability density for this PDS, and is the maximum entropy distribution for this variable, indicating maximum uncertainty. The mean and median values for this distribution are 0.67.

S_3RRR-RDR. The STCP UTAF time for S_3RRR-RDR is 516 min (decay power = 0.66%). Scaling the 30% and 60% debris times from the MELCOR reference case by the multiplier of 1.43 based on the ratios of the decay power at UTAF and the latent heat of vaporization gives the following values:

$t_u(30mR) = 67$
$t_u(60mR) = 90$

$t_a(30mR) = 583$
$t_a(60mR) = 606$

and

$\Delta t(<30) = 343$
$\Delta t(30\text{-}60) = 23$
$\Delta t(>60) = 24$

For this PDS, the start of the power recovery period is so late that the power recovery curve is quite flat for the time period of interest. The length of $\Delta t(<30)$ is much greater than the lengths of the other two periods together. Thus, the arrest of the core degradation process and the prevention of VB is quite likely. However, there are so many uncertainties involved in core melt progression and lower head failure, that core damage arrest cannot be considered certain or nearly certain. A linear cumulative distribution from 0.8 to 1.0 is considered appropriate for core damage arrest for S_3RRR-RDR. This results in a uniform probability density from 0.8 to 1.0. The median and mean values of this curve are 0.90.

TRRR-RSR. The STCP UTAF time for TRRR-RSR is 102 min (decay power = 1.10%), so the scaling by ratio of the decay power at UTAF is negligible. However, the difference in h_{fg} between this PDS and the reference MELCOR conditions is large. Thus, the total multiplier is 0.66 as explained above. This results in the following times:

$t_u(30mR) = 31$
$t_u(60mR) = 41$

$t_a(30mR) = 133$
$t_a(60mR) = 143$

and

$\Delta t(<30) = 73$
$\Delta t(30\text{-}60) = 10$
$\Delta t(>60) = 7$

If the RCS pressure boundary could be assumed to remain intact until VB, the relative lengths of these three periods, together with the steep descent of the power recovery curves for the times of interest for TRRR-RSR, imply that the arrest of core damage and the prevention of VB is likely. However, the probability of at least one depressurization event occurring after UTAF is large. If the hot leg or surge line fails, a great deal of the remaining core inventory is likely to be lost by flashing as the vessel depressurizes. This is more than compensated for by the discharge of the accumulators, however, so the time to $t_a(60mR)$ will probably be longer than if the hot leg failure did not occur. The hot leg failure will not occur until some time after UTAF, and whether it precedes or follows $t_a(30mR)$ is indeterminate.

The effects of a PORV sticking open, or a RCP seal failure are more uncertain. Which depressurization event will occur is uncertain, and the effects and the timing of the depressurization events are uncertain as well. Even though the period before 30% is in debris form is much longer than the period after 30% is in debris form, core damage arrest cannot be assured due to the many uncertainties involved. Therefore, the linear cumulative core damage arrest distribution from 0.8 to 1.0 used for S_3RRR-RDR is applicable to TRRR-RSR as well.

TRRR-RDR. This PDS is very lengthy due to the operation of the STD-AFWS until battery depletion and the absence of a break in the RCS at UTAF. The STCP UTAF time for TRRR-RDR is 660 min (decay power = 0.57%). These two PDSs should not be confused with TRRR-RSR in which the STD AFWS fails at the start of the accident and the UTAF time is 102 min. The value of MPX (1.25) for TRRR-RDR is not as large as might be expected from the from the low decay power level due to the low value of h_{fg}. The following times are obtained for TRRR-RDR:

$t_u(30mR) = 59$
$t_u(60mR) = 79$

$t_a(30mR) = 719$
$t_a(60mR) = 739$

and

$\Delta t(<30)$ = 299
$\Delta t(30\text{-}60)$ = 20
$\Delta t(>60)$ = 11

As in S_3RRR-RDR, $\Delta t(<30)$ is much greater than $\Delta t(30\text{-}60)$ and $\Delta t(>60)$ together, and the power recovery curves are relatively flat. So the arrest of core damage in time to avoid vessel failure is rather likely. In addition to the uncertainties involved in core melt progression and lower head failure, TRRR-RDR has the uncertainties involved with the inadvertent, temperature-induced RCS depressurization events that were discussed above with respect to TRRR-RSR, so arrest cannot be considered certain or nearly certain. The linear cumulative core damage arrest distribution from 0.8 to 1.0 used for S_3RRR-RDR and TRRR-RSR is appropriate for TRRR-RDR also.

A.3.4 References

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A.3-7. E.L. Tolman et al., "TMI-2 Accident Scenario Update," Trans. 15th Water Reactor Safety Information Meeting, Gaithersburg, MD, Oct. 26-29, 1987, pp. 22-3 to 22-6, published by the U. S. Nuclear Regulatory Commission, 1987.

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APPENDIX B

SUPPORTING INFORMATION FOR THE SOURCE TERM ANALYSIS

CONTENTS

FIGURES

TABLES

APPENDIX B

SUPPORTING INFORMATION FOR THE SOURCE TERM ANALYSIS

INTRODUCTION

Appendix B contains information and details about the source term analysis. Subsection B.1 contains a listing of the SEQSOR computer model. Subsection B.2 provides a listing of the data file used by SEQSOR that contains the distributions for the source term variables described in Subsection 3.2. Subsection B.3 contains results from the source term analysis for Sequoyah internal events, and Subsection B.4 provides information that was used in the partitioning of the source terms.

B.1 LISTING OF SEQSOR

```
      PROGRAM SEQSOR

C     CALCULATE SOURCE TERMS FOR SEQUOYAH (CENTRAL AND/OR LHS)
C     MAXIMUM NUMBER OF BIN ENTRIES = 5000
C     MAXIMUM NO. OF ST GROUPS = 9
C     MAXIMUM NO. OF ISSUES = 300
C     NISST= TOTAL NO. OF ISSUES IN SAMPLE
C     NISS= TOTAL NO. OF ST ISSUES (MAX=20)
C     NSP= ACTUAL NUMBER OF SOURCE TERM GROUPS
C          UTILIZED IN THE ANALYSIS.
C     IPRINT = UNIT NO. FOR "PRINT" FILE
C     IBINNR = UNIT NO. FOR "BIN" FILE
C     ISAMPL = UNIT NO. FOR "SAMPLE" FILE
C     IRELOUT = UNIT NO. FOR "RELEASE" FILE
C     IWROUT = UNIT NO. FOR "WEIGHTS" FILE
C     ISTDAT = UNIT NO. FOR "SOURCE TERM DATA" FILE
      DIMENSION ST(9),STE(9),STL(9),XNDX(300)
      DIMENSION ISSST(20)
      DATA NSP/9/
      DATA NTOT/0/
      CHARACTER BINJ(5000)*20
      CHARACTER NAMRUN*80,NAMBIN*80
      CHARACTER BINOUT*20
      LOGICAL EARLY,I1CALL,I2CALL,DIAG,BYOBS
C     GET THE RUN TITLE
      READ (5,1000)NAMRUN
C     GET THE I/O UNIT NUMBERS
      READ(5,*)IPRINT,IBINNR,ISAMPL,IWROUT,IRELOUT,
     $ISTDAT
C     GET THE ISSUE NUMBERS
      READ (5,*)NISST,NISS,NSAM
C     READ WHICH ISSUE NO. APPLIES TO EACH ST ISSUE
      READ(5,*)(ISSST(K),K=1,NISS)
C     IF DIAGNOSTICS ARE REQUIRED, DIAG = .TRUE.
C     IF SOURCE TERMS ARE TO BE READ BY OBSERVATION,
C     BYOBS = .TRUE.
      READ(5,999)DIAG,BYOBS
C     WRITE THE IDENTIFICATION  AND UNIT NUMBER
      WRITE(IPRINT,1004)NAMRUN,NSAM,IPRINT,ISAMPL,IBINNR,IRELOUT,
     $     IWROUT,ISTDAT
      WRITE(IPRINT,1044)NISST,NISS
      I1CALL=.TRUE.
      IF(.NOT.BYOBS) THEN
        READ(IBINNR,1000)NAMBIN
        READ(IBINNR,*)NDIM,NBIN
        NTOT=NBIN*NSAM
        WRITE(IPRINT,1005)NAMBIN,NDIM,NBIN,NTOT
        READ(IBINNR,1006)(BINJ(J),J=1,NBIN)
C     PUT A HEADER ON THE "RELEASE" OUTPUT FILE
        WRITE(IRELOUT,2002)NAMRUN,NDIM,NSP,NTOT,NSAM
      ELSE
        DO 890 ISAM=1,NSAM
C     PUT A HEADER ON THE "RELEASE" OUTPUT FILE
          READ(IBINNR,1001)IOBSD,NAMBIN
          READ(IBINNR,*)NDIM,NBIN
          NTOT=NTOT+NBIN
          READ(IBINNR,1006)(BINJ(J),J=1,NBIN)
 890    CONTINUE
      WRITE(IPRINT,1007)NAMBIN,NDIM,NTOT
      WRITE(IRELOUT,2002)NAMRUN,NDIM,NSP,NTOT,NSAM
      REWIND IBINNR
      ENDIF
      DO 900 ISAM=1,NSAM
C     STEP THROUGH SAMPLE
          READ(ISAMPL,*)IOBSD,NLHS,(XNDX(J),J=1,NISST)
```

```
      I2CALL=.TRUE.
C     STEP THROUGH MASTER BIN LIST, BY OBSERVATION
           IF(BYOBS) THEN
             READ(IBINNR,1001)IOBSD,NAMBIN
             READ(IBINNR,*)NDIM,NBIN
             READ(IBINNR,1006)(BINJ(J),J=1,NBIN)
           END IF
C     CALCULATE SOURCE TERMS
           DO 910 IB=1,NBIN
                CALL SORST(NSP,I1CALL,BINJ(IB),NISS,ISSST,I2CALL,
     $               XNDX,ST,STL,EARLY,ISTDAT,DIAG,IPRINT,
     $               TW,T1,DT1,E1,T2,DT2,E2,ELEV,ISAM)
C
                I1CALL=.FALSE.
                I2CALL=.FALSE.
C     GET EARLY AND LATE EFFECT WEIGHTS
C     WEE = EARLY EFFECT OF EARLY RELEASE
C     WLE = LATE EFFECT OF EARLY RELEASE
C     WEL = EARLY EFFECT OF LATE RELEASE
C     WLL = LATE EFFECT OF LATE RELEASE
                DO 770 ISP=1,NSP
                     IF(EARLY)THEN
                          STE(ISP)=ST(ISP)
                          ST(ISP)=STE(ISP)+STL(ISP)
                     ELSE
                          STE(ISP)=0.
                          STL(ISP)=ST(ISP)+STL(ISP)
                          ST(ISP)=STL(ISP)
                     END IF
 770            CONTINUE
                IF(EARLY)THEN
                     CALL WEIGHT(NSP,STE,WEE,WLE)
                     CALL WEIGHT(NSP,STL,WEL,WLL)
                ELSE
                     WEE=0.
                     WLE=0.
                     CALL WEIGHT(NSP,ST,WEL,WLL)
                END IF
                DO 888 IJ=1,20
                IF(IJ.LE.NDIM)THEN
                  BINOUT(IJ:IJ)=BINJ(IB)(IJ:IJ)
                                ELSE
                  BINOUT(IJ:IJ)=' '
                END IF
888             CONTINUE
                WRITE(IRELOUT,1775) ISAM,BINOUT,TW,T1,DT1,T2,DT2,ELEV
                WRITE(IRELOUT,17751) E1,(STE(IS),IS=1,NSP)
                WRITE(IRELOUT,17751) E2,(STL(IS),IS=1,NSP)
                WET=WEE+WEL
                WLT=WLE+WLL
C               WRITE(IWROUT,1777) ISAM,IB,WEE,WLE,WEL,WLL,WET,WLT
                IF(DIAG)THEN
                     WRITE(IPRINT,2010)IB,BINJ(IB),ISAM,(STE(ISP),
     $                   ISP=1,NSP),(STL(ISP),ISP=1,NSP),
     $                   (ST(ISP),ISP=1,NSP)
                     WRITE(IPRINT,2011),WEE,WLE,WEL,WLL,WET,WLT
                END IF
 910       CONTINUE
 900  CONTINUE
 999  FORMAT(L1,1X,L1)
 1000 FORMAT(A)
 1001 FORMAT(I5,A)
 1004 FORMAT(5X,'RUN TITLE:  ',A80/
     $       5X,'SAMPLE SIZE = ',I3/
     $       5X,'PRINT FILE ON UNIT ',I2/
```

```
     $        5X,'INPUT SAMPLE FILE ON UNIT ',I2/
     $        5X,'INPUT BIN FILE ON UNIT ',I2/
     $        5X,'OUTPUT ST FILE ON UNIT ',I2/
     $        5X,'OUTPUT WEIGHTS FILE ON UNIT ',I2/
     $        5X,'INPUT PARAMETERS ON UNIT ',I2)
 1005 FORMAT(5X,'BIN TITLE: ',A80/5X,'DIMENSIONS: ',I3/
     $           5X,'NUMBER OF BINS: ',I4/
     $           5X,'TOTAL NUMBER OF SOURCE TERMS: ',I7)
 1006 FORMAT(1X,A20)
 1007 FORMAT(5X,'BIN TITLE: ',A80/5X,'DIMENSIONS: ',I3/
     $           5X,'TOTAL NUMBER OF SOURCE TERMS: ',I7)
 1044 FORMAT(5X,'TOTAL NO. OF ISSUES =',I3/5X,'NO. OF ST ISSUES=',I3)
 1775 FORMAT(I4,2X,A20/6(1PE12.3))
 1777 FORMAT(2I5,6(1PE11.3))
 2002 FORMAT(2X,A80/4I7)
 2010 FORMAT(//5X,'OUTPUT FOR BIN ENTRY # ',I4,2X,A20/5X,
     $           'SAMPLE MEMBER',I4/5X,'STE = ',9(1PE9.1)/
     $           5X,'STL = ',9(1PE9.1)/5X,'STT = ',9(1PE9.1))
 2011 FORMAT(5X,'  WEE = ',F8.4,'  WLE = ',F8.4,'  WEL = ',F8.4,
     $     '  WLL = ',F8.4/5X,'  WET = ',F8.4,'  WLT = ',F8.4)
17751 FORMAT(10(1PE12.3))
      END

      SUBROUTINE SORST(NSP,I1CALL,BIN,NISS,ISSST,I2CALL,XNDX,ST,
     $                 STL,EARLY,ISTDAT,DIAG,IPRINT,TW,T1,
     $                 DT1,E1,T2,DT2,E2,ELEV,ISAM)
C
C
C
C
C     2-ND GENERATION PROGRAM TO CALCULATE SOURCE TERMS FOR SEQUOYAH
C
C     THE SOURCE TERM FOR SPECIES GROUP I (I.NE.2 OR 3) IS
C     APPROXIMATED BY:
C     ST(I)=FCOR(I)*(FISG(I)*FOSG(I)+(1-FISG(I))*FVES(I)*((1.-FBYPV)
C       /DFICV+FBYPV)*FCONV/DFE
C       +FPART*(1-FCOR(I))*FCCI(I)*((1.-FBYPC)/DIFCC+FBYPC)*FCONC(I)/DFL
C       +(1-FCOR(I))*FPME*FDCH(I)*FCONV*((1.-FBYPV)/DFICDH+FBYPV)+
C       +FLATE(I)*(FCOR(I)*(1-FVES(I))+FREM*(1-FCOR(I))*FCONRL(I)/DFL(I)
C     WHERE:
C     ST(I)=FRACTION OF INITIAL INVENTORY RELEASED TO ENVIRONMENT.
C     FISG(I)=FRACTION OF INITIAL INVENTORY RELEASED INTO STEAM GENERATO
C     FOSG(I)=FRACTION OF INITIAL INVENTORY RELEASED FROM STEAM GENERATO
C     FCOR(I)=FRACTION OF INITIAL INVENTORY RELEASED FROM FUEL PRIOR TO
C     BREACH.
C     FVES(I)=FRACTION OF FCOR NOT DEPOSITED IN THE VESSEL.
C     FCONV=FRACTION OF MATERIAL RELEASED TO CONTAINMENT PRIOR TO
C     OR AT VESSEL BREACH WHICH WOULD BE RELEASED FROM CONTAINMENT IN
C     THE ABSENCE OF DECONTAMINATION MECHANISMS.
C     FBYPV=EFFECTIVE BYPASS FRACTION OF ICE CONDENSER UP TO THE TIME OF
C     VESSEL BREACH
C     DFICV=DECONTAMINATION FACTOR FOR ICE CONDENSER UP TO THE TIME OF
C     VESSEL BREACH
C     DFE=DECONTAMINATION FACTOR APPLICABLE TO RCS RELEASE.
C     FPART=FRACTION OF CORE INVOLVED IN CCI
C     FCCI(I)=FRACTION OF INVENTORY REMAINING IN THE MELT
C     RELEASED DURING CORE-CONCRETE INTERACTION (CCI).
C     FCONC(I)=FRACTION OF CCI RELEASE ESCAPING CONTAINMENT.
C     FBYPC=EFFECTIVE BYPASS FRACTION FOR ICE CONDENSER DURING CCI RELEA
C     DFICC=DECONTAMINATION FACTOR FOR ICE CONDENSER DURING CCI RELEASE
C     DFL(I)=DECONTAMINATION FACTOR APPLICABLE TO CCI RELEASE.
C     FPME=FRACTION OF CORE INVOLVED IN PRESSURIZED MELT EJECTION.
C     FDCH(I)=FRACTION OF MATERIAL INVOLVED IN PRESSURIZED MELT
C     EJECTION RELEASED FROM CONTAINMENT DUE TO DIRECT HEATING
C     DFICDH=DECONTAMINATION FACTOR FOR ICE CONDENSER APPLICABLE TO
```

```
C     DCH RELEASE
C     FLATE(I)=FRACTION OF MATERIAL REMAINING IN THE RCS AFTER VESSEL
C     BREACH WHICH IS REVOLATILIZED LATER.
C     FREM=FRACTION OF CORE MATERIAL REMAINING IN VESSEL AFTER BREACH.
C     FCONRL(I)=FRACTION OF LATE REVOLATILIZED MATERIAL WHICH WOULD BE
C     RELEASED FROM CONTAINMENT IN THE ABSENCE OF DECONTAMINATION
C     MECHANISMS.
C
C     FOR IODINE, AN ADDITIONAL TERM IS ADDED:
C           +XLATE*(RELIV-RELIC)
C     WHERE:
C     XLATE IS THE FRACTION OF IODINE REMAINING IN CONTAINMENT LATE
C     IN THE ACCIDENT WHICH IS CONVERTED TO ORGANIC IODIDES.
C     RELIV=FRACTION OF INITIAL INVENTORY OF IODINE RELEASED TO
C     CONTAINMENT.
C     RELIC = FRACTION OF INITIAL INVENTORY OFIODINE RELEASED FROM
C     CONTAINMENT.
C
C     NISS=NUMBER OF ST ISSUES
C     ISSUE-1: IN-VESSEL RELEASE FROM FUEL (FCOR)
C     ISSUE-2: RELEASE FROM VESSEL (IN-VESSEL RETENTION) (FVES)
C     ISSUE-3: V-SEQ. DF WITH SUBMERGED RELEASE (VDF)
C     ISSUE-4: RELEASE OF RCS SPECIES FROM CONTAINMENT (FCONV)
C     ISSUE-5: RELEASES FROM MELT IN CCI (FCCI)
C     ISSUE-6: RELEASE OF CCI SPECIES FROM CONTAINMENT (FCONC)
C     ISSUE-7: SPRAY DF'S (SPRDF)
C     ISSUE-8: LATE IODINE RELEASES FROM CONTAINMENT (XLATE)
C     ISSUE 9: LATE REVOLATILIZATION (FLATE)
C     ISSUE-10: RELEASE DUE TO DIRECT HEATING (FDCH)
C     ISSUE-11: DECONTAMINATION FACTOR FOR ICE CONDENSER
C     ISSUE-12: STEAM GENERATOR TUBE RUPTURE FISG & FOSG
C     ISSUE-13: POOL SCRUBBING OF CCI
C
C     ST BINS ARE DEFINED BY A 14 LETTER WORD, "BIN"
C     1ST LETTER: CONTAINMENT FAILURE MODE.
C     A=CONT. BYPASS, NOT SUBMERGED
C     B=CONT. BYPASS, SUBMERGED
C     C=CONT. FAILURE BEFORE VESSEL BREACH
C     D=CONT. FAILURE NEAR THE TIME OF VESSEL FAILURE
C     E=LATE (CA. 6 HRS AFTER VB) CONTAINMENT FAILURE
C     F=VERY LATE (CA. 24 HRS AFTER VB) CONTAINMENT FAILURE
C     G=NO CONTAINMENT FAILURE
C
C     2ND LETTER: SPRAY OPERATION
C     (E=EARLY, UP TO VESSEL BREACH)
C     (I=INTERMEDIATE, VB TO VB+45MIN)
C     (L=LATE, VB+45MIN TO END OF CCI)
C     (V=VERY LATE, AFTER CCI)
C     (-=NON-OPERATION)
C     A=E---
C     B=EI--
C     C=EIL-
C     D=EILV
C     E=--L-
C     F=--LV
C     G=---V
C     H=----
C
C     3RD LETTER: CORE-CONCRETE INTERACTION
C     A=PROMPT DRY--FULL UNSCRUBBED CCI
C     B=PROMPT SHALLOW SCRUBBED
C     C=NO CCI
C     D= PROMPT DEEP SCRUBBED
C     E=SHORT DELAYED, THEREAFTER DRY
C     F=LONG DELAYED, THEREAFTER DRY
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C
C     4TH LETTER: PRESSURE IN RCS AT VB
C     A=AT SYSTEM SETPOINT; T SEQUENCES; OUTFLOW THROUGH CYCLING PORV
C     B=HIGH PRESSURE; S3 SEQUENCES; VERY SMALL LEAK W/O SG COOLING
C     C=INTERMEDIATE PRESSURE; S2 SEQUENCES; ACCUMULATORS DISCHARGE
C     D=LOW PRESSURE; A/S1 SEQUENCES; NEAR ATMOSPHERIC PRESSURE
C
C     5TH LETTER: MODE OF VESSEL BREACH
C     A=HPME
C     B=POUR
C     C=GROSS BOTTOM HEAD FAILURE
C     D=ALPHA MODE
C     E=ROCKET
C     F=NO VESSEL BREACH
C
C     6TH LETTER: SGTR
C     A=OCCURS (EITHER S2 OR S3), SRV CLOSES
C     B=OCCURS, SRV REMAINS OPEN
C     C=NONE
C
C     7TH LETTER: AMOUNT OF CORE IN CCI
C     A=LARGE AMOUNT (70-100%) NOMINALLY 85%
C     B=MODERATE AMOUNT (30-70%) NOMINALLY 50%
C     C=SMALL AMOUNT(0-30%) NOMINALLY 15%
C     D=NONE
C
C     8TH LETTER: ZR OXIDATION
C     A=LOW ZR OXIDATION (0-40%) NOMINALLY 25%
C     B=HIGH ZR OXIDATION (>40%) NOMINALLY 55%
C
C     9TH LETTER: HIGH PRESSURE MELT EJECTION
C     A=HIGH HPME (75TH PERCENTILE OF IN-VESSEL PANEL)
C     B=MODERATE HPME (50TH PERCENTILE OF IN-VESSEL PANEL)
C     C=LOW HPME (25TH PERCENTILE OF IN-VESSEL PANEL)
C     D=NO HPME
C
C     10TH LETTER: CONTAINMENT FAILURE SIZE
C     A=CATASTROPHIC RUPTURE--GROSS STRUCTURAL FAILURE
C     B=RUPTURE--NOMINALLY 7 SQ. FT.
C     C=LEAK--NOMINALLY 0.1 SQ. FT.
C     D=NO FAILURE
C
C     11TH LETTER: HOLES IN RCS
C     A=ONE LARGE HOLE
C     B=TWO LARGE HOLES
C
C     12TH LETTER: ICE CONDENSER FUNCTION BEFORE VESSEL BREACH
C     A=NO BYPASS; IC FUNCTIONS AS DESIGNED
C     B=PARTIALLY BYPASSED
C     C=COMPLETELY BYPASSED OR ICE MELTED
C
C     13TH LETTER: ICE CONDENSER FUNCTION DURING CCI
C     A=NO BYPASS; IC FUNCTIONS AS DESIGNED
C     B=PARTIAL BYPASS
C     C=COMPLETELY BYPASSED OR ICE MELTED
C
C     14TH LETTER: AIR RETURN FANS
C     A=EARLY; FANS OPERATE ONLY UP TO VESSEL BREACH
C     B=EARLY AND LATE; FANS OPERATE BEFORE AND AFTER VESSEL BREACH
C     C=LATE ONLY; FANS OPERATE ONLY AFTER VESSEL BREACH
C     D=NEVER; AIR RETURN FANS NEVER OPERATE
C
C
C     PARAMETERS TO BE SET BY ISSUES HAVE 10 LEVELS-- LEVELS 1-9
C     DEFINE THE CDF, I.E., THEY ARE MINUMUM, MAXIMUM, AND 7 INTERMEDIATE
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C     PERCENTILES, (1%, 5%, 25%, 50%, 75%, 95%, 99%) OF CDF.
C     LEVEL 10 FOR ANY ISSUE INDICATES THE "CENTRAL" LEVEL, HENCE IF ALL
C     LEVELS ARE SET TO 10, THE "CENTRAL" RELEASE WILL BE GIVEN.
C
C     THE LEVELS FOR EACH SAMPLE MEMBER ARE SET BY A VECTOR, XNDX, WHERE
C     XNDX(I) IS A REAL NUMBER.  IF XNDX(I) IS SET TO A VALUE GREATER THAN
C     OR EQUAL TO 1.0, THE "MAXIMUM" PERCENTILE VALUES FOR THE GIVEN PARAMETER
C     ARE SELECTED.  IF XNDX(I) IS SET TO 0.0, THE "MINIMUM" PERCENTILE VALUES
C     FOR THE GIVEN PARAMETER ARE SELECTED.  IF XNDX(I) IS SPECIFIED AS
C     A REAL VALUE BETWEEN 0.0 AND 1.0, EITHER A LINEAR OR A LOGARITHMIC
C     INTERPOLATION SCHEME IS INVOKED TO SELECT THE PROPER VALUE FOR A GIVEN
C     PARAMETER.  TO GET THE "CENTRAL" RELEASE MENTIONED IN THE PREVIOUS
C     PARAGRAPH, SPECIFY A NEGATIVE REAL VALUE FOR XNDX(I).
C
      DIMENSION FCORL(10,9,4),FCOR(9),FVHH(10,9),FVHP(10,9),FVIP(10,9),
     $    FVLP(10,9),FVV(10,9),FVSG(10,9),FVES(9),
     $    FCONVI(10,6),VDFL(10),DFICVI(10,5),DFICCI(10,5),
     $CCI(10,9,4),FCCI(9),FCONCI(10,9,6),DFSPR1(10),
     $DFSPR2(10),DFSPRC(10),FPMEL(4),FPARTL(4),
     $LATEIL(10),FLATE(10,9,4),FLATEX(9),FCONC(9),
     $FDCHL(10,9,2),DLATE(9),DFL(9),FCONRLX(9),
     $LVL(20),XNDX(300),VPSL(10,9,2),VPS(9),
     $XSG(9),ST(9),STL(9),FISG(10,9,2),FOSG(10,9,2),XOSG(9),
C    $FCONRL(9),DST(9),ISSST(20)
     $DST(9),ISSST(20)
      REAL LATEIL,LVL
      LOGICAL ISPR(4),IFAN(2),DIAG,EARLY,TEST,I1CALL,I2CALL
      CHARACTER*20 BIN
      CHARACTER CHE
C     FRACTION OF CORE REMAINING IN VESSEL; THIS MAY EVENTUALLY BE
C     PASSED BY CET.  FOR THE PRESENT, THIS QUANTITY IS FIXED AT 5%.
      DATA FREM/.05/
      DATA FPARTL /1.,.5,.15,0./
C     FOR THE FIRST CALL TO THIS SUBROUTINE, READ IN ST DATA
      IF(.NOT.I1CALL) GOTO 8550
C      BLOCK 1: FCOR=FRACTION OF EACH NUCLIDE RELEASED FROM CORE
C      CASE 1=LOW ZR OXIDATION (HIGH ZR REMAINING)
C      CASE 2=HIGH ZR OXIDATION (LOW ZR REMAINING)
      READ(ISTDAT,*)(((FCORL(L,ISP,IC),ISP=1,NSP),L=1,10),IC=1,2)
       IF(DIAG)WRITE(IPRINT,2004)(((FCORL(L,ISP,IC),ISP=1,NSP),
     $     L=1,10),IC=1,2)
 2004  FORMAT(/5X,'FCORL:'/(9(1PE10.1)))
C      BLOCK 2: FVES, FRACTION RELEASED FROM VESSEL
C      BASED ON RCS PRESSURE AT TIME OF VESSEL BREACH
C      FVHH: SYSTEM SETPOINT PRESSURE
C      FVHP: HIGH PRESSURE (LUMPED WITH INTERM. BY EXPERTS)
C      FVIP: HIGH OR INTERMEDIATE PRESSURE
C      FVLP: LOW PRESSURE
C      FVV: LARGE INTERFACING SYSTEM LOCA
C
      READ(ISTDAT,*)((FVHH(L,ISP),ISP=1,NSP),L=1,10)
       IF(DIAG)WRITE(IPRINT,2010)((FVHH(L,ISP),ISP=1,NSP),
     $     L=1,10)
 2010  FORMAT(/5X,'FVHH:'/(9(1PE10.1)))
      READ(ISTDAT,*)((FVHP(L,ISP),ISP=1,NSP),L=1,10)
       IF(DIAG)WRITE(IPRINT,2011)((FVHP(L,ISP),ISP=1,NSP),
     $     L=1,10)
 2011  FORMAT(/5X,'FVHP:'/(9(1PE10.1)))
      READ(ISTDAT,*)((FVIP(L,ISP),ISP=1,NSP),L=1,10)
       IF(DIAG)WRITE(IPRINT,2012)((FVIP(L,ISP),ISP=1,NSP),
     $    L=1,10)
 2012  FORMAT(/5X,'FVIP:'/(9(1PE10.1)))
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      READ(ISTDAT,*)((FVLP(L,ISP),ISP=1,NSP),L=1,10)
       IF(DIAG)WRITE(IPRINT,2014)((FVLP(L,ISP),ISP=1,NSP),
     $    L=1,10)
 2014  FORMAT(/5X,'FVLP:'/(9(1PE10.1)))
      READ(ISTDAT,*)((FVV(L,ISP),ISP=1,NSP),L=1,10)
       IF(DIAG)WRITE(IPRINT,2016)((FVV(L,ISP),ISP=1,NSP),
     $    L=1,10)
 2016  FORMAT(/5X,'FVV:'/(9(1PE10.1)))
C      FVES FOR SGTR
      READ(ISTDAT,*)((FVSG(L,ISP),ISP=1,NSP),L=1,10)
       IF(DIAG)WRITE(IPRINT,2018)((FVSG(L,ISP),ISP=1,NSP),
     $   L=1,10)
 2018  FORMAT(/5X,'FVSG:'/(9(1PE10.1)))
C      BLOCK 3: FISG AND FOSG
C       FISG=FRACTION ENTERING SG IN SGTR
C      FOSG=FRACTION LEAVING STEAM GENERATOR
C      CASE 1: SRV CLOSES.  CASE 2: SRV DOES NOT CLOSE
      READ(ISTDAT,*)(((FISG(L,ISP,IC),ISP=1,NSP),L=1,10),IC=1,2)
       IF(DIAG)THEN
         DO 20201 IC=1,2
           WRITE(IPRINT,2020)IC,((FISG(L,ISP,IC),ISP=1,NSP),
     $       L=1,10)
20201    CONTINUE
       ENDIF
 2020  FORMAT(/5X,'FISG:'/5X,'CASE ',I3/(9(1PE10.1)))
      READ(ISTDAT,*)(((FOSG(L,ISP,IC),ISP=1,NSP),L=1,10),IC=1,2)
       IF(DIAG)THEN
         DO 20221 IC=1,2
           WRITE(IPRINT,2022)IC,((FOSG(L,ISP,IC),ISP=1,NSP),
     $       L=1,10)
20221    CONTINUE
       ENDIF
 2022   FORMAT(/5X,'FOSG:'/5X,'CASE ',I3/(9(1PE10.1)))
C      BLOCK 4: VDF=DF APPLIED TO SCRUBBED V SEQUENCE.
      READ(ISTDAT,*)(VDFL(L),L=1,10)
       IF(DIAG)WRITE(IPRINT,2024)(VDFL(L),L=1,10)
 2024  FORMAT(/5X,'VDF:'/(5(1PE10.1)))
C
C      BLOCK 5: FCONV=FRACTION OF RCS RELEASE LEAVING
C      CONTAINMENT; SIX CASES
C      CASE 1:  EARLY LEAK, DRY CONTAINMENT
C       CASE 2:  EARLY LEAK, WET CONTAINMENT
C      CASE 3:  EARLY RUPTURE, UPPER COMPARTMENT
C       CASE 4:  EARLY RUPTURE, LOWER COMPARTMENT
C      CASE 5:  LATE RUPTURE
C      CASE 6:  V SEQUENCE
C
      READ(ISTDAT,*)((FCONVI(L,ICASE),L=1,10),ICASE=1,6)
      IF(DIAG)THEN
         DO 2222 ICASE=1,6
           WRITE(IPRINT,2025)ICASE,(FCONVI(L,ICASE),L=1,10)
2222     CONTINUE
      END IF
2025  FORMAT(5X,'FCONV--CASE ',I3/(10(1PE10.1)))
C
C      BLOCK 6: FCONC=FRACTION OF CCI RELEASE LEAVING
C      CONTAINMENT; FIVE CASES
C      CASE 1:  EARLY LEAK (BEFORE CCI), DRY CONTAINMENT
C       CASE 2:  EARLY LEAK (BEFORE CCI), WET CONTAINMENT
C      CASE 3:  EARLY RUPTURE (BEFORE CCI), UPPER COMP.
C       CASE 4:  EARLY RUPTURE (BEFORE CCI), UPPER COMP.
C      CASE 5:  LATE RUPTURE (AFTER CCI)
C      CASE 6:  V-SEQUENCE
C
      READ(ISTDAT,*)(((FCONCI(L,ISP,ICASE),ISP=1,NSP),L=1,10),
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     $      ICASE=1,6)
        IF(DIAG)THEN
          DO 2223 ICASE=1,6
            WRITE(IPRINT,2026)ICASE,((FCONCI(L,ISP,ICASE),
     $       ISP=1,NSP),L=1,10)
2223      CONTINUE
        END IF
2026    FORMAT(5X,'FCONC--CASE ',I3/(9(1PE10.1)))
C       BLOCK 7: CCI=FRACTION OF MATERIAL REMAINING IN DEBRIS
C       RELEASED IN CCI
C       CASE 1: LOW ZR OXIDATION (HIGH ZR REMAINING), NO WATER
C       CASE 2: HIGH ZR OXIDATION (LOW ZR REMAINING), NO WATER
C       CASE 3: LOW ZR OXIDATION, WATER PRESENT
C       CASE 4: HIGH ZR OXIDATION, WATER PRESENT
       READ(ISTDAT,*)(((CCI(L,ISP,IC),ISP=1,NSP),L=1,10),IC=1,4)
        IF(DIAG)WRITE(IPRINT,2028)(((CCI(L,ISP,IC),ISP=1,NSP),
     $    L=1,10),IC=1,4)
 2028   FORMAT(/5X,'CCI:'/(9(1PE10.1)))
C       BLOCK 8:  SPRAY DF-S
C        DFSPR1=SPRAY DF FOR HIGH PRESSURE, EARLY
C       CONTAINMENT RUPTURE  FOR RCS RELEASE.
C       CURRENTLY ONE VALUE FOR ALL NUCLIDE GROUPS (EXCEPT NG).
       READ(ISTDAT,*)(DFSPR1(L),L=1,10)
        IF(DIAG)WRITE(IPRINT,2034)(DFSPR1(L),L=1,10)
 2034   FORMAT(/5X,'DFSPR1:'/(10(1PE10.1)))
C       DFSPR2=SPRAY DF FOR ALL OTHER CASES, FOR RCS RELEASE.
       READ(ISTDAT,*)(DFSPR2(L),L=1,10)
        IF(DIAG)WRITE(IPRINT,2036)(DFSPR2(L),L=1,10)
 2036   FORMAT(/5X,'DFSPR2:'/(10(1PE10.1)))
C       DFSPRC=SPRAY DF FOR CCI RELEASE
       READ(ISTDAT,*)(DFSPRC(L),L=1,10)
        IF(DIAG)WRITE(IPRINT,2038)(DFSPRC(L),L=1,10)
 2038   FORMAT(/5X,'DFSPRC:'/(10(1PE10.1)))
C       BLOCK 9:  FRACTION OF IODINE REMAINING IN CONTAINMENT
C       WHICH IS CONVERTED TO VOLATILE FORMS
       READ(ISTDAT,*)(LATEIL(L),L=1,10)
        IF(DIAG)WRITE(IPRINT,2044)(LATEIL(L),L=1,10)
 2044   FORMAT(/5X,'LATEIL:'/(10(1PE10.1)))
C       BLOCK 10:  FRACTION OF MATERIAL REMAINING IN RCS WHICH IS
C       REVOLATILIZED LATE IN THE ACCIDENT.
C       CASE 1: ONE HOLE IN RCS
C       CASE 2: TWO HOLES IN RCS
       READ(ISTDAT,*)(((FLATE(L,ISP,IC),ISP=1,NSP),L=1,10),IC=1,2)
        IF(DIAG)WRITE(IPRINT,2046)(((FLATE(L,ISP,IC),ISP=1,NSP),
     $     L=1,10),IC=1,2)
 2046   FORMAT(/5X,'FLATE:'/(9(1PE10.1)))
C       BLOCK 11: FOR DIRECT HEATING
C       FDCH=FRACTION OF FPME RELEASED FROM CONTAINMENT (FOR EARLY CF
C       ONLY)
          READ(ISTDAT,*)((FDCHL(L,ISP,1),ISP=1,NSP),L=1,10)
        IF(DIAG)WRITE(IPRINT,2051)((FDCHL(L,ISP,1),ISP=1,NSP),L=1,10)
2051      FORMAT(/5X,'FDCHL: HI PRESSURE'/(9(1PE10.1)))
          READ(ISTDAT,*)((FDCHL(L,ISP,2),ISP=1,NSP),L=1,10)
        IF(DIAG)WRITE(IPRINT,2052)((FDCHL(L,ISP,2),ISP=1,NSP),L=1,10)
2052      FORMAT(/5X,'FDCHL: INT PRESSURE'/(9(1PE10.1)))
C       BLOCK 12:  DF FOR POOL SCRUBBING.
C       CASE 1: ACCUMULATOR WATER ONLY
C       CASE 2: FULL CAVITY
       READ(ISTDAT,*)(((VPSL(L,ISP,IC),ISP=1,NSP),L=1,10),IC=1,2)
        IF(DIAG)WRITE(IPRINT,2056)(((VPSL(L,ISP,IC),ISP=1,NSP),
     $          L=1,10),IC=1,2)
 2056   FORMAT(/5X,'VPSL:'/(9(1PE10.1)))
C       BLOCK 13: FRACTIONS OF CORE IN HPME (HIGH, MODERATE, LOW)
       READ(ISTDAT,*)(FPMEL(L),L=1,3)
       FPMEL(4)=0.0
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       IF(DIAG)WRITE(IPRINT,20566)(FPMEL(L),L=1,3)
20566  FORMAT(5X,'FRACTION OF CORE IN HPME:'/5X,'HIGH      ',F8.3/
     $    5X,'MODERATE ',F8.3/5X,'LOW       ',F8.3)
C      BLOCK 14:
C      DATA FOR ICE CONDENSER DECONTAMINATION FACTOR FOR RCS RELEASE
C      FOUR CASES--
C      CASE 1: FANS OPERATING, NO CF
C      CASE 2: FANS OPERATING, CONTAINMENT FAILED
C      CASE 3: FANS NOT OPERATING,DEFAULT CASE
C      CASE 4: HPME OR DCH EVENT
       READ(ISTDAT,*)((DFICVI(L,IC),L=1,10),IC=1,4)
       IF(DIAG)THEN
         DO 16456 IC=1,4
           WRITE(IPRINT,16457)IC,(DFICVI(L,IC),L=1,10)
16456    CONTINUE
       END IF
16457 FORMAT(/5X,'DFICV, CASE ',I2/2X,(10(1PE8.1)))
C      BLOCK 15
C      DATA FOR ICE CONDENSER DECONTAMINATION FACTOR FOR CCI RELEASE
C      THREE CASES--
C      CASE 1: FANS OPERATING, NO CF
C      CASE 2: FANS OPERATING, CONTAINMENT FAILED
C      CASE 3: FANS NOT OPERATING, DEFAULT CASE
       READ(ISTDAT,*)((DFICCI(L,IC),L=1,10),IC=1,3)
       IF(DIAG)THEN
         DO 16458 IC=1,3
           WRITE(IPRINT,16459)IC,(DFICCI(L,IC),L=1,10)
16458    CONTINUE
       END IF
16459 FORMAT(/5X,'DFICC, CASE ',I2/1X,(10(1PE9.1)))
C       THIS IS THE END OF THE DATA INPUT.
 8550 CONTINUE
       IF(I2CALL) THEN
          DO 10 ISS=1,NISS
            ISSUE=ISSST(ISS)
             LVL(ISS)=XNDX(ISSUE)
 10       CONTINUE
       END IF
       CHH=BIN(1:1)
       EARLY=.FALSE.
       IF(CHH.LE.'D'.OR.BIN(6:6).LT.'C')EARLY=.TRUE.
       IF(DIAG)WRITE(IPRINT,1009)BIN,ISAM,(LVL(ISS),ISS=1,NISS)
 1009 FORMAT(///5X,'DIAGNOSTIC OUTPUT FOR BIN ',A20,
     $  ' SAMPLE MEMBER ',I4/
     $ 5X,'ST LEVELS = ',4(5F5.1,3X))
C      MAIN CALCULATION
C
C      SET UP SPRAY INDICES
C      "TRUE" INDICATES SPRAY IS OPERATING DURING THE FOLLOWING TIME
C      PERIODS.
C      PERIOD 1:  UP TO VESSEL BREACH (EARLY)
C      PERIOD 2:  VESSEL BREACH TO START OF CCI (INTERMEDIATE)
C      PERIOD 3:  DURING CCI (LATE)
C      PERIOD 4:  AFTER CCI (VERY LATE)
       CALL SPRAY(BIN,ISPR)
        IF(DIAG)WRITE(IPRINT,1010)(ISPR(L),L=1,4)
1010    FORMAT(5X,'"SPRAY" CALLED; ISPR = ',4L1)
C      SET UP FAN INDICES
C      PERIOD 1: UP TO VESSEL BREACH
C      PERIOD 2: AFTER VESSEL BREACH
       CALL FAN(BIN,IFAN)
       IF(DIAG)WRITE(IPRINT,1011)(IFAN(L),L=1,2)
 1011 FORMAT(5X,'"FAN" CALLED; IFAN = ',2L1)
C      RELEASE CHARACTERISTICS
         CALL RELCHAR(BIN,TW,T1,DT1,E1,T2,DT2,E2,ELEV,ISPR)
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        DTW=T1-TW
        IF(DIAG)WRITE(IPRINT,2145)TW,DTW,T1,DT1,E1,T2,DT2,E2,ELEV
2145    FORMAT(5X,'"RELCHAR" CALLED; RELEASE CHARACTERISTICS:'/
   $          9X,'TW',7X,'DTW',6X,'T1',7X,'DT1',6X,'E1',7X,'T2',
   $          7X,'DT2',6X,'E2',7X,'ELEV'/5X,9(1PE9.1)/5X,
   $          'TIMES IN SEC.--REL. RATES IN WATTS--ELEV. IN METERS')
C     IN VESSEL RELEASE FOR EACH GROUP (FCOR)
      CALL CORER(BIN,NSP,FCOR,FCORL,LVL(1))
       IF(DIAG)WRITE(IPRINT,1014)(FCOR(IS),IS=1,NSP)
 1014  FORMAT(5X,'"CORER" CALLED'/5X,'FCOR = ',9(1PE9.1))
C     IN-VESSEL RETENTION
      CALL VESREL(BIN,FVES,FVHH,FVHP,FVIP,FVLP,FVV,
    $     FVSG,NSP,LVL(2))
       IF(DIAG)WRITE(IPRINT,1016)(FVES(IS),IS=1,NSP)
 1016  FORMAT(5X,'"VESREL" CALLED'/5X,'FVES = ',9(1PE9.1))
C      CALCULATE FISSION PRODUCTS ENTERING STEAM GENERATOR
C      (FOR SGTR ONLY)
      DO 195 ISP=1,NSP
         XSG(ISP)=0.
         XOSG(ISP)=0.
        IF(BIN(5:6).EQ.'C')GOTO 195
        ICASE=1
        IF(BIN(6:6).EQ.'B')ICASE=2
        XSG(ISP)=XINTERPLSC(LVL(12),FISG,ISP,ICASE,ILOG)
        XOSG(ISP)=XINTERPLSC(LVL(12),FOSG,ISP,ICASE,ILOG)
 195  CONTINUE
      IF(DIAG)WRITE(IPRINT,2076)(XSG(ISP),ISP=1,NSP)
2076  FORMAT(5X,'RELEASE TO SG-S:'/5X,9(1PE9.1))
      IF(DIAG)WRITE(IPRINT,20781)(XOSG(ISP),ISP=1,NSP)
20781 FORMAT(5X,'RELEASE FROM SG-S:'/5X,9(1PE9.1))
      ILOG=1
      VDF=1.0
      IF(CHH.EQ.'B')VDF=XINTERPL(LVL(3),VDFL,ILOG)
      IF(DIAG)WRITE(IPRINT,20791)VDF
20791 FORMAT(5X,'VDF = ',1PE10.1)
C     RELEASE OF MATERIAL FROM CONTAINMENT(FCONV AND FCONC)
      CALL FCONVC(BIN,ISPR,FCONVI,FCONV,FCONCI,
     $     FCONC,LVL(4),LVL(6),NSP)
       IF(DIAG)WRITE(IPRINT,1018)FCONV,(FCONC(IS),IS=1,NSP)
1018   FORMAT(5X,'"FCONVC" CALLED'/5X,'FCONV = ',1PE10.1/
     $           5X,'FCONC = ',9(1PE10.1))
C     CCI RELEASE
      CALL CCIREL(BIN,NSP,CCI,FCCI,LVL(5))
       IF(DIAG)WRITE(IPRINT,1020)(FCCI(IS),IS=1,NSP)
1020   FORMAT(5X'"CCIREL" CALLED'/5X,'FCCI = ',9(1PE9.1))
C      DCH RELEASE
       IDCH=ICHAR(BIN(9:9))-64
       FPME=FPMEL(IDCH)*(1.-FREM)
       IF(DIAG)WRITE(IPRINT,20777)FPME
20777  FORMAT(5X,'FRACTION OF CORE IN HPME = ',F8.4)
C      FRACTION OF CORE PARTICIPATING IN CCI
       ICCI=ICHAR(BIN(7:7))-64
C     MATERIAL REMAINING IN VESSEL, AND MATERIAL INVOLVED IN HIGH
C     PRESSURE MELT EJECTION, CANNOT PARTICIPATE IN CCI
       FPART=FPARTL(ICCI)*(1.-FREM-FPME)
        IF(DIAG)WRITE(IPRINT,10200)FPART
10200   FORMAT(5X,'FRACTION OF CORE IN CCI = ',F8.3)
C     EFFECTS OF SPRAYS
      CALL SPRDF(BIN,ISPR,DFSPR1,DFSPR2,DFSPV,DFSPRC,DFSPC,
     $LVL(7))
       IF(DIAG)WRITE(IPRINT,1022)DFSPV,DFSPC
 1022  FORMAT(5X,'"SPRDF" CALLED; DFSPV = ',F7.1,' DFSPC = ',F7.1)
C     POOL SCRUBBING DF
C      FIND CASE (SHALLOW OR DEEP)
       ICASE=3
```

```
        ILOG=1
        IF(BIN(3:3).EQ.'B')ICASE=1
        IF(BIN(3:3).EQ.'D')ICASE=2
        DO 185 ISP=1,NSP
          IF(ICASE.EQ.3)THEN
            VPS(ISP)=1.
          ELSE
            VPS(ISP)=XINTERPLSC(LVL(13),VPSL,ISP,ICASE,ILOG)
          END IF
185     CONTINUE
       IF(DIAG)WRITE(IPRINT,2077)(VPS(ISP),ISP=1,NSP)
2077   FORMAT(5X,'DF(POOL SCRUB):'/5X,9F7.1)
C      FIND EFFECTS OF ICE CONDENSER
       CALL ICE(BIN,IFAN,DFICVI,DFICCI,DFICV,DFICC,DFICDH,FBYPV,
     $  FBYPC,LVL(11))
       IF(DIAG)WRITE(IPRINT,20877)DFICV,FBYPV,DFICC,FBYPC
20877  FORMAT(5X,'ICE CONDENSER DFS:'/5X,'RCS: ',1PE10.1,
     $  ' BYPASS FRACTION: ',1PE10.1/
     $  5X,'CCI: ',1PE10.1,' BYPASS FRACTION: ',1PE10.1)
C      FIND OVERALL DF
         ILOG=1
         DFE=1.0
        DO 22620 ISP=1,NSP
                 DFL(ISP)=1.0
22620   CONTINUE
C      FOR V-SEQUENCE WITH WATER:
       IF(CHH.EQ.'B')THEN
         DFE=VDF
        DO 22621 ISP=2,NSP
                 DFL(ISP)=AMAX1(VDF,VPS(ISP))
22621   CONTINUE
       ELSE
C      FOR ALL OTHERS:
C      OVERALL DF IS SET EQUAL TO THE LARGEST FOR ALL OPERATIVE
C      MECHANISMS.  FOR EARLY CF (BEFORE CCI) DFL CANNOT BE GREATER
C      THAN WHAT THE SPRAY DF WOULD BE, IF SPRAYS WERE OPERATING.
         DFE=DFSPV
        DFE=DFE/((1.-FBYPV)/DFICV+FBYPV)
        ILOG=1
        DO 22622 ISP=2,NSP
                 DFL(ISP)=AMAX1(VPS(ISP),DFSPC)
                 IF((BIN(1:1).EQ.'D'.OR.BIN(1:1).EQ.'C')
     $              .AND.DFL(ISP).GT.1.)DFL(ISP)=
     $              AMIN1(DFL(ISP),XINTERPL(LVL(7),DFSPRC,ILOG))
        DFL(ISP)=DFL(ISP)/((1.-FBYPC)/DFICC+FBYPC)
22622   CONTINUE
       END IF
C      DO NOT ALLOW OVERALL DF-S TO EXCEED 10,000.
         DFE=AMIN1(DFE,1.E4)
         DO 11211 ISP=2,NSP
           DFL(ISP)=AMIN1(DFL(ISP),1.E4)
11211
                    T"(IPRINT,1026)DFE,(DFL(ISP),ISP=1,NSP)
 1026                  = ',F7.1/5X,'DFL:'/4X,(9(1PE10.1)))
      (                /DCJL,LVL(10),NSP,DST,FCOR,DIAG,IPRINT,
     $
                     .(IPRINT,17775)(DST(ISP),ISP=1,NSP)
1777.                DCH RELEASE TO CONTAINMENT:'/9(1PE10.1))

C                  RE OR LARGE LEAK, NO EFFECT OF SPRAYS ON DCH RELEASE.
        DO 176 ISP=2,NSP
          DST(ISP)=DST(ISP)*FCONV
176     CONTINUE
        IF(BIN(1:1).EQ.'G')DST(1)=.005*DST(1)
        IF(DIAG)WRITE(IPRINT,17776)(DST(ISP),ISP=1,NSP)
```

```
17776  FORMAT(5X,'SCH RELEASE FROM CONTAINMENT:'/9(1PE10.1))
C      CALCULATE SOURCE TERMS
       FCNG=1.
       IF(BIN(1:1).EQ.'G')FCNG=.005
       ST(1)=FCOR(1)*(XSG(1)*XOSG(1)+(1.-XSG(1))*FVES(1)*FCNG)+DST(1)
       STL(1)=FPART*(1.-FCOR(1))*FCCI(1)*FCNG
       GRCS=ST(1)
       GCCI=STL(1)
       DO 200 ISP=2,NSP
          ST(ISP)=FCOR(ISP)*(XSG(ISP)*XOSG(ISP)+(1.-XSG(ISP))*
     $   FVES(ISP)*FCONV/DFE)+DST(ISP)
       STL(ISP)=(1.-FCOR(ISP))*FPART*FCCI(ISP)*FCONC(ISP)/
     $           DFL(ISP)
 200   CONTINUE
C      "LATE" RELEASES OF GROUPS 1-3 ARE TRANSFERRED TO EARLY
C      RELEASES, IF CCI IS PROMPT AND CONTAINMENT FAILURE IS EARLY
C      IF SGTR OCCURS NOBLE GAS RELEASE IS TERMED EARLY
       IF((BIN(1:1).GT.'D'.OR.BIN(3:3).EQ.'F').AND.BIN(6:6).EQ.'C')
     $     GOTO 2333
          DO 230 ISP=1,3
          ST(ISP)=ST(ISP)+STL(ISP)
          STL(ISP)=0.
 230   CONTINUE
C      LATE REVOLATILIZATION FROM THE RCS. RELEASE FRACTIONS FROM
C      CONTAINMENT ARE SET EQUAL TO THOSE FOR "LATE" (CCI) Te.
2333   ILOG=0
       FCONRLX(1)=1.
       FLATEX(1)=1.
C       NOBLE GASES RELEASED IN VESSEL, NOT YET RELEASED TO CONTAINMENT
        SGQ1=FCNG
        IF(BIN(6:6).EQ.'B')SGQ1=1.
        DL1=FCOR(1)*(XSG(1)*(1.-XOSG(1))*SGQ1+(1.-XSG(1))*
     $   (1.-FVES(1))*FCNG)
C       NOBLE GASES NOT YET RELEASED, FROM MATERIAL REMAINING IN RCS
        DL2=(1.-FCOR(1))*FREM*FCNG
C       NOBLE GASES IN MATERIAL LEAVING VESSEL BUT NOT IN CCI
        DL3=(1.-FCOR(1))*(1.-FPART-FREM-FPME)*FCNG
C       REVOLATILIZED NOBLE GASES
        DLATE(1)=(DL1+DL2+DL3)
        GTOT=GRCS+GCCI+DLATE(1)
        IF(DIAG)WRITE(IPRINT,7763)GRCS,GCCI,DL1,DL2,DL3,GTOT
7763    FORMAT(//5X,'NOBLE GASES:'/5X,'FROM RCS: ',1PE12.3/
     $    5X,'FROM CCI: ',1PE12.3/5X,'LATE RCS: ',1PE12.3/
     $    5X,'LATE REM: ',1PE12.3/5X,'LATE NCC: ',1PE12.3/
     $    5X,'TOTAL     ',1PE12.3)
C       NO REVOLATILIZATION IF NO VESSEL BREACH
        IF(BIN(5:5).EQ.'F')THEN
          DO 99570 ISP=1,NSP
             DLATE(ISP)=0.
99570     CONTINUE
        ELSE
       ICASE = ICHAR(BIN(11:11))-64
       DO 9957 ISP=2,NSP
        DFLX=DFSPC
        IF(.NOT.ISPR(4))DFLX=1.
         FCONRLX(ISP)=FCONC(4)
         FLATEX(ISP)=XINTERPLSC(LVL(9),FLATE,ISP,ICASE,ILOG)
        SGQ=0.
        IF(BIN(6:6).EQ.'B')SGQ=FCOR(ISP)*XSG(ISP)
     $     *(1.-XOSG(ISP))
         DLATE(ISP)=FLATEX(ISP)*(FCOR(ISP)*(1.-XSG(ISP))*
     $   (1.-FVES(ISP))+FREM*(1.-FCOR(ISP)))*FCONRLX(ISP)/DFLX
     $   +FLATEX(ISP)*SGQ
         STL(ISP)=STL(ISP)+DLATE(ISP)
9957   CONTINUE
```

```
       END IF
       STL(1)=STL(1)+DLATE(1)
       IF(DIAG)WRITE(IPRINT,1050)(FLATEX(ISP),ISP=1,NSP),
     $    (DLATE(ISP),ISP=1,NSP)
 1050  FORMAT(5X,'LATE REVOLATILIZATION: FLATE = ',9(1PE10.1)/
     $       5X,'DLATE = ',9(1PE10.1))
C     MISCELLANEOUS LATE SOURCES OF IODINE
      XLATE=XINTERPL(LVL(8),LATEIL,ILOG)
      CALL CLATEI2(FCOR(2),FVES(2),FCCI(2),
     $   FLATEX(2),XLATE,DIAG,IPRINT,BIN,FPART,
     $   ST(2),STL(2),DI2,DLATE(2),XSG(2),XOSG(2))
C       IF EARLY RELEASE OVERLAPS LATE RELEASE, A FRACTION OF THE EARLY
C      RELEASE IS PUT INTO THE LATE RELEASE.
       IF(T1+DT1.GT.T2) THEN
         OVERLAP=(T1+DT1-T2)/(T1+DT1)
         DT1=AMAX1(T2-T1,0.)
         DO 7772 ISP=1,NSP
           FRACT=OVERLAP*ST(ISP)
           ST(ISP)=ST(ISP)-FRACT
           STL(ISP)=STL(ISP)+FRACT
7772     CONTINUE
       ENDIF
C      MASS BALANCE OF CORE MATERIAL
       IF(DIAG)THEN
         FM1=FREM
         FM2=FPME
         FM3=FPART
         FM4=(1.-FREM-FPME)-FPART
         SUM=FM1+FM2+FM3+FM4
         WRITE(IPRINT,1058),FM1,FM2,FM3,FM4,SUM
1058   FORMAT(/5X,'CORE DISTRIBUTION:'/
     $          10X,'IN RCS      ',F7.3/
     $          10X,'HPME        ',F7.3/
     $          10X,'CCI         ',F7.3/
     $          10X,'OTHER       ',F7.3/
     $          10X,'             -------'/
     $          10X,'TOTAL       ',F7.3)
       WRITE(IPRINT,1032)(ST(IS),IS=1,NSP),
     $          (STL(IS),IS=1,NSP)
 1032  FORMAT(5X,'SOURCE TERMS:'/5X,'RCS: ',9(1PE9.1)/
     $          5X,'CCI: ',9(1PE9.1))
       END IF
C     TEST THAT RELEASES FOR ALL SPECIES DO NOT EXCEED 1.0
      TEST=.FALSE.
      DO 300 ISP=1,NSP
         IF(ST(ISP)+STL(ISP)-1..GT.1.E-3)THEN
            TEST=.TRUE.
            BAD=ST(ISP)+STL(ISP)
            WRITE (IPRINT,5000)BIN,ISP,BAD
          END IF
 300  CONTINUE
      IF(TEST)STOP0999
 5000 FORMAT('   BIN ',A20,' GROUP ',I1,
     $' ERROR IN SOURCE TERM; TOTAL RELEASE = ',E15.7)
C     NOBLE GAS RELEASE SHOULD EQUAL 1.0, EXCEPT FOP MELTTHROUGH OR NO
C     CONTAINMENT FAILURE.
      RNG=ST(1)+STL(1)
      IF(CHH.LT.'G'.AND.ABS(1.-RNG).GE.1.E-2.AND.BIN(5:5).NE.'F')THEN
         WRITE(IPRINT,5010)BIN,RNG
         STOP 9998
      END IF
 5010 FORMAT('   BIN ',A20,' GROUP 1 ',
     $  ' TOTAL RELEASE = ',E15.7,' SHOULD BE 1.0')
      RETURN
      END
```

```
      SUBROUTINE RELCHAR ( BIN, TW,T1,DT1,E1, T2,DT2,E2, ELEV,ISPR )
C
C                                             Original by WBM, Autumn 1988
C                                             Revised by RJB, 11 Feb 1989
C
      LOGICAL  ISPR(4)
      CHARACTER*20  BIN
      CHARACTER  CHH1, CHH3, CHH6, CHH10
C
C  THIS SUBROUTINE COMPUTES THE RELEASE CHARACTERISTICS --
C    WARNING TIME, RELEASE TIMES, AND ENERGY OF THE RELEASE
C    ALL TIMES ARE IN SECONDS
C  TW = WARNING TIME -- USUALLY THE TIME OF CORE COLLAPSE, BUT
C    THE TIME THE CORE UNCOVERED (TAF) FOR V OR CF BEFORE CM
C    NOTE: TW IS NOT THE WARNING INTERVAL, BUT TIME SINCE THE
C    START OF THE ACCIDENT
C
C  T1 = TIME OF START OF THE FIRST OR EARLY RELEASE
C    ( T1 IS THE SAME AS T2, IF THERE IS NO EARLY RELEASE)
C  DTW = WARNING INTERVAL = T1 - TW
C  DT1 = DURATION OF THE EARLY RELEASE
C  E1 = ENERGY RELEASE RATE OF THE EARLY RELEASE ( WATTS )
C
C  T2 = TIME OF START OF THE SECOND OR LATE RELEASE.
C  DT2 = DURATION OF THE LATE RELEASE
C  E2 = ENERGY RELEASE RATE OF THE LATE RELEASE ( WATTS )
C
C  ELEV = ELEVATION OF THE RELEASE ( METERS )
C
C  GET THE LETTER FOR FOUR CHARACTERISTICS OF THE BIN:
C         CHARACTERISTIC  1 - CF TIME
C         CHARACTERISTIC  3 - CCI
C         CHARACTERISTIC  6 - SGTR
C         CHARACTERISTIC 10 - CF SIZE
      CHH1  = BIN(1:1)
      CHH3  = BIN(3:3)
      CHH6  = BIN(6:6)
      CHH10 = BIN(10:10)
C
C  SET THE DEFAULT CORE UNCOVERY TIME TO 300 MINUTES = 5 HOURS
      TCU = 18000.
C
C  SET DEFAULT RELEASE DURATIONS --
C         CHH10 = A FOR CATASTROPHIC RUPTURE ( 10 SECONDS )
C         CHH10 = B FOR RUPTURE ( 3.3 MINUTES )
C         CHH10 = C FOR LEAK OR BASEMAT MELT-THRU ( 3 HOURS )
C         CHH10 = D FOR NO CF OR BYPASS ONLY ( 24 HOURS )
      IF ( CHH10 .EQ. 'A' )  THEN
       DT1 = 10.
       DT2 = 10.
      ELSEIF ( CHH10 .EQ. 'B' )  THEN
       DT1 = 200.
       DT2 = 200.
      ELSEIF ( CHH10 .EQ. 'C' )  THEN
       DT1 = 10800.
       DT2 = 10800.
      ELSEIF ( CHH10 .EQ. 'D' )  THEN
       DT1 = 86400.
       DT2 = 86400.
      ENDIF
C
C  SET DEFAULT ENERGIES AND ELEVATION
      E1 = 0.
      E2 = 0.
      ELEV = 10.
```

```
C
C  FIRST CONSIDER THE SGTRS
      IF ( CHH6 .NE. 'C' )   GO TO 70
C
C  NEXT CONSIDER THE V's, AND THEN SORT ON CF TIME
      IF ( CHH1 .LE. 'B' )   GO TO 10
      IF ( CHH1 .LE. 'D' )   GO TO 30
      IF ( CHH1 .EQ. 'E' )   GO TO 40
      IF ( CHH1 .EQ. 'F' )   GO TO 50
      IF ( CHH1 .EQ. 'G' )   GO TO 60
C
C  V-SEQUENCE -- CHH1 = A FOR V-DRY, CHH1 = B FOR V-WET
10    TCU = 1250.
      TW = TCU
      T1 = 2400. + TCU
      DT1 = 1800.
      E1 = 3.7E6
      IF ( CHH1 .EQ. 'B' )  E1 = E1 / 2.
      T2 = 9000. + TCU
      DT2 = 21600.
      E2 = 1.7E5
      ELEV = 0.
      RETURN
C
C  CF AT OR BEFORE VB -- CHH1 = C FOR CF BEFORE VB, = D FOR CF AT VB
30    TW =  4300. + TCU
      T1 = 10000. + TCU
      E1 = 5.6E9 / DT1
      IF ( ISPR(1) .OR. ISPR(2) )  E1 = E1 / 10.
      DT2 = 21600.
      E2 = 1.6E6
      IF ( ISPR(3) )  E2 = E2 / 10.
C
C  DETERMINE IF CCI WILL BE PROMPT OR DELAYED --
C     CHH3 = A FOR PROMPT - DRY          CHH3 = B FOR PROMPT - SHALLOW
C     CHH3 = C FOR NO CCI                CHH3 = D FOR PROMPT - DEEP
C     CHH3 = E FOR SHORT DELAY - DRY     CHH3 = F FOR LONG DELAY - DRY
C
      IF ( CHH3 .EQ. 'C' )  GO TO 34
C  PROMPT CCI -- CHH3 = A, B, OR D
      IF ( CHH3 .LE. 'D' )  T2 = 11000. + TCU
C  SHORT DELAYED CCI -- CHH3 = E
      IF ( CHH3 .EQ. 'E' )  T2 = 16000. + TCU
C  LONG DELAYED CCI -- CHH3 = F
      IF ( CHH3 .EQ. 'F' )  T2 = 28000. + TCU
      RETURN
C
C  NO CCI -- CHH3 = C
34    T2 = 1.E6
      DT2 = 1.E6
      RETURN
C
C  LATE OR VERY LATE FAILURE -- CHH1 = E
40    TW =  4300. + TCU
      T1 = 29000. + TCU
      DT1 = 0.
      T2 = 29000. + TCU
      E2 = 7.E9 / DT2
      IF ( ISPR(3) )  E2 = E2 / 10.
      RETURN
C
C  FAILURE IN THE FINAL PERIOD ( AFTER 24 HOURS ) -- CHH1 = F
50    TW =  4300. + TCU
      T1 = 29000. + TCU
      DT1 = 0.
```

```
      T2 = 86400. + T1
      E2 = 7.E8 / DT2
      IF ( ISPR(4) )  E2 = E2 / 10.
      RETURN
C
C  NO CONTAINMENT FAILURE -- CHH1 = G
60    TW =  4300. + TCU
      T1 = 29000. + TCU
      DT1 = 0.
      T2 = T1
      DT2 = 86400.
      ELEV = 0.
      RETURN
C
C  STEAM GENERATOR TUBE RUPTURES -- SGTRs
70    E1 = 1.0E6
C  USE THE DEFAULT VALUES FOR DT2 UNLESS THERE IS NO CF,
C          THEN USE 6 HOURS
      IF ( CHH10 .EQ. 'D' )   DT2 = 21600.
C  SGTRs -- SEPARATE THE "H" SGTRs FROM THE "G" SGTRs
      IF ( CHH6 .EQ. 'A' )   GO TO 80
C
C  SGTRs WITH THE SECONDARY SRVs STUCK OPEN -- HINY-NXY
C          TW = 10 HOURS, T1 = 14.2 HOURS, DT1 = 1 HOUR
      TW = 36000.
      T1 = 51000.
      DT1 = 3600.
      GO TO 83
C
C  SGTRs WITH THE SECONDARY SRVs RECLOSING -- GLYY-YsY
C          TW = 3.5 HOURS, T1 = 5.5 HOURS, DT1 = 1 HOUR
80    TW = 12600.
      T1 = 19800.
      DT1 = 3600.
C
C  NOW SORT OUT THE CCI RELEASES
83    IF ( CHH3 .EQ. 'C' )  GO TO 88
C  PROMPT CCI -- CHH3 = A, B, OR D -- ADD 16.7 MINUTES
      IF ( CHH3 .LE. 'D' )  T2 = T1 + 1000.
C  SHORT DELAYED CCI -- CHH3 = E -- ADD 1.67 HOURS
      IF ( CHH3 .EQ. 'E' )  T2 = T1 + 6000.
C  LONG DELAYED CCI -- CHH3 = F -- ADD 5.0 HOURS
      IF ( CHH3 .EQ. 'F' )  T2 = T1 + 18000.
      RETURN
C
C  NO CCI -- CHH3 = C
88    T2 = 1.0E6
      DT2 = 1.0E6
      RETURN
      END
          SUBROUTINE CORER(BIN.NSP,FCOR,FCORL,LVL)
           REAL LVL
          CHARACTER*20 BIN
C      RELEASE OF RADIONUCLIDES FROM THE CORE.
          DIMENSION FCOR(9),FCORL(10,9,4)
          IC=ICHAR(BIN(6:6))-64
           ILOG=1
          DO 10 ISP=1,NSP
                FCOR(ISP)=XINTERPLSC(LVL,FCORL,ISP,IC,ILOG)
10        CONTINUE
          RETURN
          END
          SUBROUTINE CCIREL(BIN,NSP,CCI,FCCI,LVL)
          DIMENSION CCI(10,9,4),FCCI(9)
           REAL LVL
```

```
         CHARACTER*20 BIN
C      DEGREE OF ZR OXIDATION
         IC=ICHAR(BIN(6:6))-64
C      IS WATER PRESENT?
         IF(BIN(3:3).EQ.'B'.OR.BIN(3:3).EQ.'D')IC=IC+2
          ILOG=1
         FCCI(1)=1.0
C      CALCULATE RELEASE DURING CORE-CONCRETE INTERACTION.
         IF(BIN(3:3).EQ.'C') GOTO 20
C      NON-COOLABLE BED; CCI OCCURS.
         DO 10 ISP=2,NSP
               FCCI(ISP)=XINTERPLSC(LVL,CCI,ISP,IC,ILOG)
10       CONTINUE
         RETURN
C      PERMANENTLY COOLABLE DEBRIS BED; NO CCI OCCURS.
20       DO 30 ISP=2,NSP
               FCCI(ISP)=0.
30       CONTINUE
         RETURN
         END
         SUBROUTINE SPRAY (BIN,ISPR)
         LOGICAL ISPR(4)
         CHARACTER*20 BIN
         CHARACTER CHSP
C      SETS UP THE "ISPR" MATRIX.
C      ISPR(1)  =  .TRUE. : SPRAYS BEFORE VESSEL BREACH.
C      ISPR(2)  =  .TRUE. : SPRAYS AFTER VESSEL BREACK BUT BEFORE CCI
C      ISPR(3)  =  .TRUE. : SPRAYS DURING CCI.
C      ISPR(4) = .TRUE. : SPRAYS AFTER CCI.
C
         CHSP=BIN(2:2)
         DO 10 ISP=1,4
               ISPR(ISP)=.FALSE.
10       CONTINUE
         IF(CHSP.LE.'D')ISPR(1)=.TRUE.
         IF(CHSP.GE.'B'.AND.CHSP.LE.'D')ISPR(2)=.TRUE.
         IF(CHSP.GE.'C'.AND.CHSP.LE.'F')ISPR(3)=.TRUE.
         IF(CHSP.EQ.'D'.OR.CHSP.EQ.'F'.OR.CHSP.EQ.'G')ISPR(4)=.TRUE.
         RETURN
         END
      SUBROUTINE FAN(BIN,IFAN)
      CHARACTER*20 BIN
      LOGICAL IFAN(2)
C     SET UP FAN INDICES
      IFAN(1)=.FALSE.
      IF(BIN(14:14).LE.'B')IFAN(1)=.TRUE.
      IFAN(2)=.FALSE.
      IF(BIN(14:14).EQ.'B'.OR.BIN(14:14).EQ.'C')IFAN(2)=.TRUE.
      RETURN
      END
      SUBROUTINE ICE(BIN,IFAN,DFICVI,DFICCI,DFICV,DFICC,DFICDH,
     $    FBYPV,FBYPC,LVL)
C     FIND DF-S FOR ICE CONDENSER.  DFICV APPLIES TO RCS RELEASE.
C     DFICC APPLIES TO CCI RELEASE.
      DIMENSION DFICVI(10,5),DFICCI(10,5)
      CHARACTER*20 BIN
      REAL LVL
      LOGICAL IFAN(2)
      DATA FBYPV0,FBYPC0/.1,.1/
C       FOR V-SEQUENCE, ICE IS INEFFECTIVE
      IF(BIN(1:1).LE.'B')THEN
      DFICV=1
      DFICC=1.
      FBYPV=1.
      FBYPC=1.
```

```
      DFICDH=1.
      RETURN
      END IF
      ILOG=1
C     FIND CASE FOR RCS RELEASE
C     CASE 3 IS THE DEFAULT
      ICASV=3
      IF(.NOT.IFAN(1))GOTO 100
      IF(BIN(1:1).EQ.'C'.OR.BIN(1:1).EQ.'D')THEN
        ICASV=2
      ELSE
        ICASV=1
      END IF
C     FIND CASE FOR CCI RELEASE
C     CASE 3 IS DEFAULT
100   ICASC=3
      IF(.NOT.IFAN(2))GOTO 200
      IF(BIN(1:1).EQ.'C'.OR.BIN(1:1).EQ.'D'.OR.(BIN(1:1).EQ.'E' .
     &    .AND.BIN(3:3).EQ.'F'))THEN
        ICASC=2
      ELSE
        ICASC=1
      END IF
200   DFICV=XINTERPLC(LVL,DFICVI,ICASV,ILOG)
      DFICC=XINTERPLC(LVL,DFICCI,ICASC,ILOG)
      ICASDH=4
      DFICDH=XINTERPLC(LVL,DFICVI,ICASDH,ILOG)
C     FIND WHETHER ICE CONDENSER IS BYPASSED DURING RCS RELEASE
      FBYPV=0.
C     PARTIAL BYPASS ONLY IF ICE CONDENSER WALL IS BREACHED
      IF(BIN(12:12).EQ.'B'.AND.BIN(1:1).EQ.'C')FBYPV=FBYPV0
      IF(BIN(12:12).EQ.'C')FBYPV=1.
C     IF FANS OPERATE, ICE CONDENSER IS PARTIALLY EFFECTIVE, EVEN IF
C     ALL ICE IS MELTED
      IF(IFAN(1).AND.BIN(12:12).EQ.'C'.AND.BIN(1:1).NE.'C')FBYPV=.8
C     FIND WHETHER ICE CONDENSER IS BYPASSED DURING CCI RELEASE
      FBYPC=0.
      IF(BIN(13:13).EQ.'B'.AND.(BIN(1:1).EQ.'C'.OR.BIN(1:1).EQ.'D'))
     $ FBYPC=FBYPC0
      IF(BIN(13:13).EQ.'C')FBYPC=1.
      IF(IFAN(2).AND.BIN(13:13).EQ.'C'.AND.BIN(1:1).GT.'D')FBYPC=.8
      RETURN
      END
        SUBROUTINE CLATEI2(FCOR,FVES,FCCI,FLATE,XLATE,
     $        DIAG,IPRINT,BIN,FPART,ST,STL,DI2,DLATE,XISG,XOSG)
       LOGICAL DIAG
       CHARACTER*20 BIN
       CHARACTER CHH
       CHH=BIN(1:1)
C      CONTRIBUTION OF MISCELLANEOUS LATE SOURCES OF IODINE,
C      INCLUDING (BUT NOT LIMITED TO) ORGANIC IODIDES.
C
C      RELRCS   =  FRACTION RELEASED FROM THE RCS AND CCI.
C      CONTI2   =  FRACTION REMAINING IN CONTAINMENT.
C      RELI     =  FRACTION RELEASED TO THE ENVIRONMENT, FROM CONTAINMENT.
C
C      REVOLATILIZATION AND I FROM SG'S IS NOT INCLUDED
C
          DSG=FCOR*XISG*XOSG
          RELI=ST+STL-DLATE-DSG
          FRCS=FVES*(1.-XISG)
          RELRCS=FCOR*FRCS+(1.-FCOR)*FPART*FCCI+DI2
          CONTI2=RELRCS-RELI
C      IF 50% OR MORE HAS ALREADY BEEN RELEASED, REDUCE ADDED
C      AMOUNT.
```

```
      ADDI2=CONTI2*XLATE
      IF(RELI.GT.0.5) ADDI2=ADDI2*2.*(1.-AMAX1(0.5,RELI))
       IF(CHH.EQ.'G') ADDI2=ADDI2*.005
      STL=STL+ADDI2
      IF(DIAG)WRITE(IPRINT,1000)XLATE,RELRCS,RELI,CONTI2,ADDI2
1000        FORMAT(/5X,'XLATE = ',F8.4/
     $      5X,'REL. TO CONT. = ',1PE10.1,'REL. FROM CONT. = ',
     $      1PE10.1,' REM. IN CONT. = ',1PE10.1/5X,
     $      'ADDED IODINE = ',1PE10.1)
      RETURN
      END
      SUBROUTINE VESREL(BIN,FVES,FVHH,FVHP,
     $       FVIP,FVLP,FVV,FVSG,NSP,LVL)
      DIMENSION FVES(9),FVHH(10,9),FVHP(10,9',FVIP(10,9),FVLP(10,9),
     $       FVV(10,9),FVSG(10,9)
       REAL LVL
      CHARACTER CHH
       CHARACTER*20 BIN
      CHH=BIN(1:1)
       ILOG=1
C    RELEASE OF RADIONUCLIDES FROM THE VESSEL
C
C    V-SEQUENCE HAS SPECIAL TREATMENT
C
      IF(CHH.LE.'B')GOTO 100
      IF(BIN(6:6).LE.'B')GOTO 200
      IGO=ICHAR(BIN(4:4))-64
      DO 10 ISP=1,NSP
            GOTO (11,12,13,14),IGO
11                   FVES(ISP)=XINTERPLS(LVL,FVHH,ISP,ILOG)
                     GOTO 10
12                   FVES(ISP)=XINTERPLS(LVL,FVHP,ISP,ILOG)
                     GOTO10
13                   FVES(ISP)=XINTERPLS(LVL,FVIP,ISP,ILOG)
                     GOTO10
14                   FVES(ISP)=XINTERPLS(LVL,FVLP,ISP,ILOG)
10    CONTINUE
C    IF NO VESSEL BREACH, REDUCE RELEASE (EXCEPT NG) BY 2.0
      IF(BIN(5:5).EQ.'F')THEN
         DO 17 ISP=2,NSP
            FVES(ISP)=FVES(ISP)/2.
17       CONTINUE
      END IF
      RETURN
100   DO 40 ISP=1,NSP
            FVES(ISP)=XINTERPLS(LVL,FVV,ISP,ILOG)
40    CONTINUE
      RETURN
200   DO 50 ISP=1,NSP
       IF(BIN(6:6).EQ.'A')THEN
         FVES(ISP)=XINTERPLS(LVL,FVSG,ISP,ILOG)
       ELSE
         FVES(ISP)=XINTERPLS(LVL,FVV,ISP,ILOG)
       END IF
50    CONTINUE
      RETURN
      END
      SUBROUTINE FCONVC(BIN,ISPR,FCONVI,FCONV,FCONCI,
     $     FCONC,LVL4,LVL6,NSP)
      DIMENSION FCONVI(10,6)
      DIMENSION FCONCI(10,9,6),FCONC(9)
       REAL LVL4,LVL6
      CHARACTER*20 BIN
      LOGICAL ISPR(4)
      CHARACTER CHH1,CHH10
```

```
            CHH1=BIN(1:1)
            CHH10=BIN(10:10)
             ILOG=1
C        RELEASE OF MATERIAL  FROM CONTAINMENT.
C        FCONV:  RELEASE OF MATERIAL FROM RCS
C        FCONC:  RELEASE OF MATERIAL FROM CCI
C
C        CASE 1 = EARLY SMALL LEAK, DRY CONTAINMENT.
C         CASE 2 = EARLY SMALL LEAK, WET CONTAINMENT.
C        CASE 3 = EARLY RUPTURE OR LARGE LEAK, UPPER COMP.
C         CASE 4 = EARLY RUPTURE OR LARGE LEAK, LOWER COMP.
C        CASE 5 = LATE RUPTURE OR LARGE LEAK
C        CASE 6 = V-SEQUENCE
C
         IF(CHH1.LE.'B')GOTO 100
         IF(CHH1.EQ.'C')GOTO 110
         IF(CHH1.EQ.'D')IJ1=1
         IF(CHH1.EQ.'E')IJ1=2
         IF(CHH1.EQ.'F')IJ1=3
          IF(CHH1.EQ.'G')IJ1=4
         IJ2=ICHAR(CHH10)-64
         IF(IJ1.EQ.4.OR.IJ2.EQ.4)GOTO 120
         IGO=(IJ1-1)*3+IJ2
         GOTO(10,20,30,40,40,60,80,80,80),IGO
C        CATASTROPHIC RUPTURE AT VESSEL BREACH; USE LARGE FCONV & FCONC
10       FM=FCONVI(5,3)
         FI=XINTERPLC(LVL4,FCONVI,3,ILOG)
C        USE 95-TH PERCENTILE OF CASE 3 AS MEDIAN
         FX=FCONVI(7,3)
         IF(FI.EQ.1..OR.FM.EQ.1..OR.FX.EQ.1.)THEN
           FCONV=1.
         ELSE
           YI=FI/(1.-FI)
           YM=FM/(1.-FM)
           YS=FX/(1.-FX)
           PHI=YS/YM
           FCONV=PHI*YI/(1.+PHI*YI)
         END IF
         DO 11 ISP=2,NSP
           FM=FCONCI(5,ISP,3)
           FI=XINTERPLSC(LVL6,FCONCI,ISP,3,ILOG)
           FX=FCONCI(7,ISP,3)
           IF(FI.EQ.1..OR.FM.EQ.1..OR.FX.EQ.1.)THEN
             FCONC(ISP)=1.
           ELSE
             YI=FI/(1.-FI)
             YM=FM/(1.-FM)
             YS=FX/(1.-FX)
             PHI=YS/YM
             FCONC(ISP)=PHI*YI/(1.+PHI*YI)
           END IF
11       CONTINUE
         FCONC(1)=1.
         RETURN
C        LARGE BREAK AT VESSEL BREACH
20       ICASV=3
         ICASC=3
C         LARGE BREAK IN LOWER COMPARTMENT
         IF(BIN(12:12).EQ.'B'.AND.BIN(1:1).EQ.'C'.AND.
      &   BIN(10:10).LE.'B')THEN
           ICASV=4
           ICASC=4
         END IF
         GOTO 150
C        SMALL LEAK AT VESSEL BREACH
```

```
30    ICASV=1
      IF(ISPR(1))ICASV=2
      ICASC=1
      IF(ISPR(1).OR.ISPR(2).OR.ISPR(3))ICASC=2
      GOTO 150
C     CATASTROPHIC RUPTURE OR RUPTURE LATE
40    IF(ISPR(2).OR.ISPR(3))THEN
        FACTV=XINTERPLC(LVL4,FCONVI,5,ILOG)/FCONVI(5,5)
        FCONV=.01*FACTV
        ICASC=5
C     FOR DELAYED CCI, A LATE CF IS THE SAME AS EARLY CF
        IF(BIN(3:3).EQ.'F')ICASC=3
        DO 41 ISP=2,NSP
          FCONC(ISP)=XINTERPLSC(LVL6,FCONCI,ISP,ICASC,ILOG)
41      CONTINUE
        FCONC(1)=1.
        RETURN
      ELSE
        ICASV=5
        ICASC=5
        IF(BIN(3:3).EQ.'F')ICASC=3
        GOTO 150
      END IF
C     LATE LEAK
60    IF(ISPR(2).OR.ISPR(3))GOTO 65
C     NO SPRAYS AFTER VB
        FACTV=XINTERPLC(LVL4,FCONVI,1,ILOG)/FCONVI(5,1)
        FCONV=5.E-3*FACTV
        FCONC(1)=1.
        DO 61 ISP=2,NSP
C     IF CCI IS LONG DELAYED, "LATE" LEAK IS SAME AS EARLY
C     USE EARLY FOR TE AND RU
          IF(BIN(3:3).EQ.'F'.OR.ISP.EQ.4.OR.ISP.EQ.6)THEN
            FCONC(ISP)=XINTERPLSC(LVL6,FCONCI,ISP,1,ILOG)
          ELSE
            FACTC=XINTERPLSC(LVL6,FCONCI,ISP,1,ILOG)/FCONCI(5,ISP,1)
            FCONC(ISP)=1.E-2*FACTC
          END IF
61      CONTINUE
        RETURN
C     SPRAYS OPERATE AFTER VB; REMOVE RCS RELEASE
65    FACTV=XINTERPLC(LVL4,FCONVI,2,ILOG)/FCONVI(5,2)
      FCONV=.001*FACTV
      DO 67 ISP=2,NSP
       IF(BIN(3:3).EQ.'F'.OR.ISP.EQ.4.OR.ISP.EQ.6)THEN
         FCONC(ISP)=XINTERPLSC(LVL6,FCONCI,ISP,2,ILOG)
       ELSE
         FACTC=XINTERPLSC(LVL6,FCONCI,ISP,2,ILOG)/FCONCI(5,ISP,2)
          IF(ISPR(3))THEN
           FCONC(ISP)=.005*FACTC
         ELSE
          FCONC(ISP)=1.E-2*FACTC
          IF(BIN(3:3).EQ.'F'.OR.ISP.EQ.4.OR.ISP.EQ.6)
     $      FCONC(ISP)=XINTERPLSC(LVL6,FCONCI,ISP,2,ILOG)
         END IF
       END IF
67    CONTINUE
      FCONC(1)=1.
      RETURN
C     VERY LATE (24 HRS) RUPTURE OR LEAK
80    FCONV=1.E-6
      DO 85 ISP=2,NSP
        FACTC=XINTERPLSC(LVL6,FCONCI,ISP,3,ILOG)/FCONCI(5,ISP,3)
        FCONC(ISP)=1.E-4*FACTC
85    CONTINUE
```

```
      FCONC(1)=1.
      RETURN
C     V SEQUENCE (CASE 6)
100   ICASV=6
      ICASC=6
      GOTO 150
C     CONTAINMENT FAILURE BEFORE VESSEL BREACH OR ISOLATION FAILURE
110   IF(CHR10.LE.'B')THEN
C     CATASTROPHIC RUPTURE OR RUPTURE BEFORE VESSEL BREACH
         FM=FCONVI(5,3)
        FI=XINTERPLC(LVL4,FCONVI,3,ILOG)
C     ORDINARY RUPTURE USES 75-TH PERCENTILE AS MEDIAN
        FX=FCONVI(6,3)
C     CATASTROPHIC RUPTURE USES 99-TH PERCENTILE
        IF(CHR10.EQ.'A')FX=FCONVI(8,3)
        IF(FI.EQ.1..OR.FM.EQ.1..OR.FX.EQ.1.)THEN
          FCONV=1.
        ELSE
          YI=FI/(1.-FI)
          YM=FM/(1.-FM)
          YS=FX/(1.-FX)
          PHI=YS/YM
          FCONV=PHI*YI/(1.+PHI*YI)
        END IF
        DO 111 ISP=2,NSP
          IF(CHR10.EQ.'A')THEN
            FM=FCONCI(5,ISP,3)
            FI=XINTERPLSC(LVL6,FCONCI,ISP,3,ILOG)
            FX=FCONCI(8,ISP,3)
            IF(FI.EQ.1..OR.FM.EQ.1..OR.FX.EQ.1.)THEN
              FCONC(ISP)=1.
            ELSE
              YI=FI/(1.-FI)
              YM=FM/(1.-FM)
              YS=FX/(1.-FX)
              PHI=YS/YM
              FCONC(ISP)=PHI*YI/(1.+PHI*YI)
            END IF
          ELSE
            FCONC(ISP)=XINTERPLSC(LVL6,FCONCI,ISP,3,ILOG)
          END IF
111     CONTINUE
        FCONC(1)=1.
        RETURN
C     LEAK OR SMALL ISOLATION FAILURE BEFORE VESSEL BREACH
C     USE AVERAGE OF CASES 1 OR 2 AND 3
      ELSE
        IIFC=1
        IF(ISPR(1))IIFC=2
        F1=XINTERPLC(LVL4,FCONVI,IIFC,ILOG)
        F2=XINTERPLC(LVL4,FCONVI,3,ILOG)
        FCONV=(F1+F2)/2.
        DO 114 IS=2,NSP
          FCONC(IS)=XINTERPLSC(LVL6,FCONCI,IS,IIFC,ILOG)
114     CONTINUE
        FCONC(1)=1.
      END IF
      RETURN
C     NO FAILURE
120   FCONV=1.E-6
      FCONC(1)=.005
      DO 121 ISP=2,NSP
        FCONC(ISP)=1.E-6
121   CONTINUE
      RETURN
```

```
C     CALCULATE FCONV AND FCONC FROM GIVEN CASE
150   FCONV=XINTERPLC(LVL4,FCONVI,ICASV,ILOG)
      DO 151 ISP=2,NSP
        FCONC(ISP)=XINTERPLSC(LVL6,FCONCI,ISP,ICASC,ILOG)
151   CONTINUE
      FCONC(1)=1.
      RETURN
       END
         SUBROUTINE SPRDF(BIN,ISPR,DFSPR1,DFSPR2,DFSPV,DFSPRC,DFSPC,
     $ LVL)
         DIMENSION DFSPR1(10),DFSPR2(10),DFSPRC(10)
         LOGICAL ISPR(4)
          REAL LVL
         CHARACTER*20 BIN
         CHARACTER CHH1,CHH10
         CHH1=BIN(1:1)
         CHH10=BIN(10:10)
          ILOG=1
C     DF FOR SPRAYS.
C     DFSPV IS THE DF FOR VESSEL RELEASE.  DFSPC IS
C     THE DF FOR CCI RELEASE.  NO CREDIT FOR SPRAYS (EARLY OR LATE)
C     FOR V-SEQUENCE OR LARGE CF BEFORE MELT.
C     DEFAULT IS NO SPRAYS.
         DFSPV=1.
         DFSPC=1.
         IF(CHH1.LE.'B'.OR.(CHH1.EQ.'C'.AND.CHH10.LE.'B'))RETURN
C     EARLY FAILURE
         IF(CHH1.GT.'D')GOTO 100
         IF(ISPR(3))DFSPC=XINTERPL(LVL,DFSPRC,ILOG)
         IF(BIN(4:4).LE.'B'.AND.CHH10.LE.'B')THEN
           IF(ISPR(1))DFSPV=XINTERPL(LVL,DFSPR1,ILOG)
         ELSE
           IF(ISPR(1))DFSPV=XINTERPL(LVL,DFSPR2,ILOG)
         END IF
C      SPRAY DF SHOULD NOT BE GREATER THAN 10,000.
          DFSPC=AMIN1(DFSPC,1.E4)
          DFSPV=AMIN1(DFSPV,1.E4)
         RETURN
100      IF(CHH1.GT.'E')GOTO 110
           IF(ISPR(1).OR.ISPR(2).OR.ISPR(3))DFSPV=
     $          10.*XINTERPL(LVL,DFSPR2,ILOG)
           IF(ISPR(3))DFSPC=XINTERPL(LVL,DFSPRC,ILOG)
C      SPRAY DF SHOULD NOT BE GREATER THAN 10,000.
            DFSPC=AMIN1(DFSPC,1.E4)
            DFSPV=AMIN1(DFSPV,1.E4)
           RETURN
110      IF(ISPR(1).OR.ISPR(2).OR.ISPR(3).OR.ISPR(4))
     $          DFSPV=10.*XINTERPL(LVL,DFSPR2,ILOG)
         IF(ISPR(3).OR.ISPR(4))DFSPC=10.*XINTERPL(LVL,DFSPRC,ILOG)
C      SPRAY DF SHOULD NOT BE GREATER THAN 10,000.
          DFSPC=AMIN1(DFSPC,1.E4)
          DFSPV=AMIN1(DFSPV,1.E4)
         RETURN
         END
      SUBROUTINE DHEAT(BIN,FDCHL,LDCH,NSP,DST,FCOR,DIAG,IPRINT,FPME,ISPR)
C
C     MODEL DEVELOPED BY D. A. POWERS
C     DCH RELEASE OF NUCLIDE "I": (ADDITION TO ST "I")
C     DST(I)=(1.-FCOR(I))*FPME*FDCH(I)
C     FPME=FRACTION OF CORE PARTICIPATING IN PRESSURIZED MELT EJECTION
C     FPME ASSUMED NOT TO PARTICIPATE IN CCI
C     FDCH(I)=FRACTION OF EJECTED MELT RELEASED TO CONTAINMENT
      DIMENSION FDCHL(10,9,2),DST(9),FCOR(9),FDCH(9)
      LOGICAL DIAG,ISPR(4)
      REAL LDCH
```

```
      CHARACTER*20 BIN
C     CONTRIBUTION DUE TO AEROSOLIZATION IS ONLY CALCULATED FOR
C     CONTAINMENT FAILURE AT VESSEL BREACH.
C     NOT CALCULATED FOR LOW PRESSURE SEQUENCES
       DO 1 ISP=1,NSP
         DST(ISP)=0.
1      CONTINUE
      IF(FPME.EQ.0..OR.BIN(4:4).GT.'C')RETURN
C     CASE 1: HIGH PRESSURE
C     CASE 2: INTERMEDIATE PRESSURE
      IC=1
      IF(BIN(4:4).GT.'B')IC=2
C     CONTAINMENT FAILURE LATE: DO NOT CALCULATE DCH RELEASE
C     EARLY LEAK AND SPRAYS OPERATE: DO NOT CALCULATE DCH RELEASE
      IF((BIN(1:1).EQ.'D'.OR.BIN(1:1).EQ.'C')
     $      .AND.(BIN(10:10).LE.'B'.OR.BIN(10:10).
     $      EQ.'C'.AND..NOT.ISPR(1))) GOTO 5
      IF(DIAG)WRITE(IPRINT,950)
950   FORMAT(5X,'DCH RELEASE NOT CALCULATED')
      DST(1)=(1.-FCOR(1))*FPME
      RETURN
5     ILOG=1
      DO 10 ISP=1,NSP
        FDCH(ISP)=XINTERPLSC(LDCH,FDCHL,ISP,IC,ILOG)
        DST(ISP)=(1.-FCOR(ISP))*FPME*FDCH(ISP)
10    CONTINUE
      IF (DIAG)WRITE(IPRINT,1000)(FDCH(ISP),ISP=1,NSP)
1000  FORMAT(5X,'FDCH = ',9(1PE8.1))
      RETURN
      END
      SUBROUTINE WEIGHT (NSP,ST,WE,WL)
      DIMENSION ST(9),WFE(9),WFL(9)
      DATA (WFE(I),I=1,9)/.06,1.,.12,.78,.8,2.13,8.31,5.,.55/
      DATA (WFL(I),I=1,9)/.0011,.1,1.,.104,.7,1.19,2.62,5.4,.2/
      WE=0.
      WL=0.
      DO 10 ISP=1,NSP
              WE=WE+ST(ISP)*WFE(ISP)
              WL=WL+ST(ISP)*WFL(ISP)
 10   CONTINUE
      RETURN
      END
      REAL FUNCTION XINTERPL(LEVEL,PARAM,ILOG)
       DIMENSION PARAM(10),CDF(9),PARAMX(10)
      REAL LEVEL
      DATA CDF /0.,.01,.05,.25,.5,.75,.95,.99,1./
      IF(LEVEL.LT.0.)THEN
        XINTERPL=PARAM(10)
        RETURN
       ELSE IF(LEVEL.GE.1.)THEN
                      XINTERPL=PARAM(9)
              RETURN
      ELSE IF(LEVEL.EQ.0.)THEN
              XINTERPL=PARAM(1)
              RETURN
      ELSE
              IF(ILOG.EQ.0)THEN
              DO 2 L=1,9
                PARAMX(L)=PARAM(L)
2             CONTINUE
              ELSE
              DO 4 L=1,9
                PARAMX(L)=LOG(PARAM(L))
4             CONTINUE
              END IF
```

```
               DO 6 L=2,9
                 IF(CDF(L).LE.LEVEL)GOTO 6
                 FR=(LEVEL-CDF(L-1))/(CDF(L)-CDF(L-1))
                 GOTO 8
6              CONTINUE
               L=9
               FR=1.
8              XINTERPL=PARAMX(L-1)+FR*(PARAMX(L)-PARAMX(L-1))
               IF(ILOG.GT.0)XINTERPL=EXP(XINTERPL)
               RETURN
      END IF
      END
      REAL FUNCTION XINTERPLS(LEVEL,PARAM,ISP,ILOG)
      DIMENSION PARAM(10,9),PARAMX(10),CDF(9)
      REAL LEVEL
      DATA CDF /0.,.01,.05,.25,.5,.75,.95,.99,1./
      IF(LEVEL.LT.0.)THEN
        XINTERPLS=PARAM(10,ISP)
        RETURN
       ELSE IF(LEVEL.GE.1.)THEN
                       XINTERPLS=PARAM(9,ISP)
               RETURN
      ELSE IF(LEVEL.EQ.0.)THEN
               XINTERPLS=PARAM(1,ISP)
               RETURN
      ELSE
               IF(ILOG.EQ.0)THEN
               DO 2 L=1,9
                 PARAMX(L)=PARAM(L,ISP)
2              CONTINUE
               ELSE
               DO 4 L=1,9
                 PARAMX(L)=LOG(PARAM(L,ISP))
4              CONTINUE
               END IF
               DO 6 L=2,9
                 IF(CDF(L).LE.LEVEL)GOTO 6
                 FR=(LEVEL-CDF(L-1))/(CDF(L)-CDF(L-1))
                 GOTO 8
6              CONTINUE
               L=9
               FR=1.
8              XINTERPLS=PARAMX(L-1)+FR*(PARAMX(L)-PARAMX(L-1))
               IF(ILOG.GT.0)XINTERPLS=EXP(XINTERPLS)
               RETURN
      END IF
      END
      REAL FUNCTION XINTERPLSC(LEVEL,PARAM,ISP,ICASE,ILOG)
      DIMENSION PARAM(10,9,5),PARAMX(9),CDF(9)
      REAL LEVEL
      DATA CDF /0.,.01,.05,.25,.5,.75,.95,.99,1./
      IF(LEVEL.LT.0.)THEN
        XINTERPLSC=PARAM(10,ISP,ICASE)
        RETURN
       ELSE IF(LEVEL.GE.1.)THEN
                       XINTERPLSC=PARAM(9,ISP,ICASE)
               RETURN
      ELSE IF (LEVEL.EQ.0.) THEN
               XINTERPLSC=PARAM(1,ISP,ICASE)
               RETURN
      ELSE
               IF(ILOG.EQ.0)THEN
               DO 2 L=1,9
                 PARAMX(L)=PARAM(L,ISP,ICASE)
2              CONTINUE
```

```
         ELSE
         DO 4 L=1,9
           PARAMX(L)=LOG(PARAM(L,ISP,ICASE))
4        CONTINUE
         END IF
         DO 6 L=2,9
           IF(CDF(L).LE.LEVEL)GOTO 6
           FR=(LEVEL-CDF(L-1))/(CDF(L)-CDF(L-1))
           GOTO 8
6        CONTINUE
         L=9
         FR=1.
8        XINTERPLSC=PARAMX(L-1)+FR*(PARAMX(L)-PARAMX(L-1))
         IF(ILOG.GT.0)XINTERPLSC=EXP(XINTERPLSC)
         RETURN
    END IF
    END
    REAL FUNCTION XINTERPLC(LEVEL,PARAM,ICASE,ILOG)
    DIMENSION PARAM(10,4),PARAMX(9),CDF(9)
    REAL LEVEL
    DATA CDF /0.,.01,.05,.25,.5,.75,.95,.99,1./
    IF(LEVEL.LT.0.)THEN
      XINTERPLC=PARAM(10,ICASE)
      RETURN
    ELSE IF(LEVEL.GE.1.)THEN
      XINTERPLC=PARAM(9,ICASE)
      RETURN
    ELSE IF (LEVEL.EQ.0.) THEN
      XINTERPLC=PARAM(1,ICASE)
      RETURN
    ELSE
         IF(ILOG.EQ.0)THEN
         DO 2 L=1,9
           PARAMX(L)=PARAM(L,ICASE)
2        CONTINUE
         ELSE
         DO 4 L=1,9
           PARAMX(L)=LOG(PARAM(L,ICASE))
4        CONTINUE
         END IF
         DO 6 L=2,9
           IF(CDF(L).LE.LEVEL)GOTO 6
           FR=(LEVEL-CDF(L-1))/(CDF(L)-CDF(L-1))
           GOTO 8
6        CONTINUE
         L=9
         FR=1.
8        XINTERPLC=PARAMX(L-1)+FR*(PARAMX(L)-PARAMX(L-1))
         IF(ILOG.GT.0)XINTERPLC=EXP(XINTERPLC)
      RETURN
    END IF
    END
```

B.2 SEQSOR DATA FILE

This section contains the data file read by SEQSOR when it begins execution. Most blocks of data contain separate distributions for each radionuclide class. In these blocks, the nine columns give the distributions for the nine radionuclide classes:

Column	Radionculide Class
1	Noble Gas
2	Iodine
3	Cesium
4	Tellurium
5	Barium
6	Strontium
7	Ruthenium
8	Lanthanum
9	Cerium

In the blocks of data containing separate distributions for each radionuclide class, each line contains the values for a given percentile of the distribution. These values are:

Line	1	2	3	4	5	6	7	8	9
Percentile	0	1	5	25	50	75	95	99	100

The tenth line contains a nominal value used for running SEQSOR in a non-sampling mode for checkout. For the data blocks that do not contain separate distributions for each radionuclide class, each entry is the percentile value in the order given above and the tenth entry is a nominal value. The comment lines starting with $s have been added for listing in this appendix to explain each block of data.

Listing of SEQSOR Data File

```
$ FCOR distributions for low Zr oxidation in-vessel
 8.0E-02 2.0E-02 1.0E-02 1.0E-09 1.0E-09 1.0E-09 1.0E-09 1.0E-09 1.0E-09
 9.9E-02 3.3E-02 2.4E-02 2.3E-03 3.0E-05 1.0E-09 1.0E-09 1.0E-09 1.1E-04
 1.6E-01 8.4E-02 6.7E-02 1.3E-02 1.5E-04 1.0E-09 1.0E-09 1.0E-09 2.2E-04
 8.0E-01 3.7E-01 3.0E-01 7.6E-02 7.6E-04 5.0E-05 2.0E-05 2.0E-05 1.7E-03
 9.0E-01 6.9E-01 5.9E-01 2.0E-01 4.0E-03 2.0E-03 1.0E-04 1.5E-04 6.4E-03
 1.0E+00 9.1E-01 8.3E-01 4.6E-01 1.3E-02 1.2E-02 9.5E-04 2.5E-03 2.7E-02
 1.0E+00 1.0E+00 1.0E+00 8.9E-01 5.2E-01 5.8E-02 2.1E-02 '.5E-02 5.2E-01
 1.0E+00 1.0E+00 1.0E+00 9.8E-01 1.0E+00 1.4E-01 1.0E-01 5.1E-01 1.0E+00
 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 2.7E-01 1.1E-01 1.0E+00 1.0E+00
 1.0E+00 9.9E-01 9.9E-01 2.7E-01 1.3E-01 1.0E-06 1.0E-07 1.0E-07 1.3E-01

$ FCOR distributions for high Zr oxidation in-vessel
 9.9E-02 9.9E-02 3.5E-02 1.0E-09 1.0E-09 1.0E-09 1.0E-09 1.0E-09 1.0E-09
 1.6E-01 1.4E-01 8.1E-02 3.0E-03 1.0E-09 1.0E-09 1.0E-09 1.0E-09 2.2E-04
 4.2E-01 2.8E-01 1.7E-01 1.8E-02 2.5E-04 1.0E-09 1.0E-09 1.0E-09 1.2E-03
 8.0E-01 5.6E-01 4.2E-01 9.7E-02 2.1E-03 5.0E-05 2.0E-05 2.0E-05 4.2E-03
 9.2E-01 7.5E-01 6.2E-01 3.3E-01 6.4E-03 4.6E-03 1.0E-04 1.5E-04 8.6E-03
 1.0E+00 9.6E-01 8.9E-01 5.9E-01 1.8E-02 2.0E-02 1.2E-03 3.0E-03 3.0E-02
 1.0E+00 1.0E+00 1.0E+00 9.1E-01 5.1E-01 6.1E-02 2.1E-02 8.5E-02 5.2E-01
 1.0E+00 1.0E+00 1.0E+00 9.9E-01 1.0E+00 1.4E-01 1.0E-01 5.1E-01 1.0E+00
 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 2.9E-01 1.1E-01 1.0E+00 1.0E+00
 1.0E+00 9.9E-01 9.9E-01 6.4E-01 1.3E-01 1.0E-06 1.0E-07 1.0E-07 1.3E-01 FCOR*

$ FVES distributions for VB with the RCS at system setpoint pressure
 1.0E+00 1.0E-09 1.0E-09 1.0E-09 1.0E-09 1.0E-09 1.0E-09 1.0E-09 1.0E-09
 1.0E+00 1.0E-05 1.0E-05 1.0E-05 1.0E-05 1.0E-05 1.0E-05 1.0E-05 1.0E-05
 1.0E+00 1.0E-05 1.0E-05 1.0E-05 1.0E-05 1.0E-05 1.0E-05 1.0E-05 1.0E-05
 1.0E+00 9.3E-03 5.1E-03 1.8E-03 1.8E-03 1.8E-03 1.8E-03 1.8E-03 1.8E-03
 1.0E+00 8.6E-02 4.2E-02 2.8E-02 2.8E-02 2.8E-02 2.8E-02 2.8E-02 2.8E-02
 1.0E+00 3.5E-01 3.5E-01 1.8E-01 1.8E-01 1.8E-01 1.8E-01 1.8E-01 1.8E-01
 1.0E+00 7.7E-01 7.7E-01 7.6E-01 7.6E-01 7.6E-01 7.6E-01 7.6E-01 7.6E-01
 1.0E+00 9.6E-01 9.6E-01 9.6E-01 9.6E-01 9.6E-01 9.6E-01 9.6E-01 9.6E-01
 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00
 1.0E+00 2.4E-01 2.0E-01 1.5E-01 1.1E-01 1.0E-01 1.0E-01 1.0E-01 1.1E-01 FVHH*

$ FVES distributions for VB with the RCS at high pressure
 1.0E+00 1.0E-09 1.0E-09 1.0E-09 1.0E-09 1.0E-09 1.0E-09 1.0E-09 1.0E-09
 1.0E+00 1.0E-05 1.0E-05 1.0E-05 1.0E-05 1.0E-05 1.0E-05 1.0E-05 1.0E-05
 1.0E+00 1.0E-05 1.0E-05 1.0E-05 1.0E-05 1.0E-05 1.0E-05 1.0E-05 1.0E-05
 1.0E+00 9.3E-03 5.1E-03 1.8E-03 1.8E-03 1.8E-03 1.8E-03 1.8E-03 1.8E-03
 1.0E+00 8.6E-02 4.2E-02 2.8E-02 2.8E-02 2.8E-02 2.8E-02 2.8E-02 2.8E-02
 1.0E+00 3.5E-01 3.5E-01 1.8E-01 1.8E-01 1.8E-01 1.8E-01 1.8E-01 1.8E-01
 1.0E+00 7.7E-01 7.7E-01 7.6E-01 7.6E-01 7.6E-01 7.6E-01 7.6E-01 7.6E-01
 1.0E+00 9.6E-01 9.6E-01 9.6E-01 9.6E-01 9.6E-01 9.6E-01 9.6E-01 9.6E-01
 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00
 1.0E+00 2.8E-01 2.8E-01 9.0E-02 2.7E-01 2.7E-01 2.7E-01 2.7E-01 2.7E-01 FVHP*

$ FVES distributions for VB with the RCS at intermediate pressure
 1.0E+00 1.0E-09 1.0E-09 1.0E-09 1.0E-09 1.0E-09 1.0E-09 1.0E-09 1.0E-09
 1.0E+00 3.0E-05 3.0E-05 3.0E-05 3.0E-05 3.0E-05 3.0E-05 3.0E-05 3.0E-05
 1.0E+00 1.1E-02 9.0E-03 8.0E-03 8.6E-03 8.6E-03 8.6E-03 8.6E-03 8.6E-03
 1.0E+00 2.0E-01 1.3E-01 1.2E-01 1.3E-01 1.3E-01 1.3E-01 1.3E-01 1.3E-01
 1.0E+00 4.1E-01 2.9E-01 2.5E-01 2.4E-01 2.4E-01 2.4E-01 2.4E-01 2.4E-01
 1.0E+00 6.1E-01 5.9E-01 4.3E-01 3.7E-01 3.7E-01 3.7E-01 3.7E-01 3.7E-01
 1.0E+00 8.9E-01 8.9E-01 8.9E-01 8.7E-01 8.7E-01 8.7E-01 8.7E-01 8.7E-01
 1.0E+00 9.9E-01 9.9E-01 9.9E-01 9.9E-01 9.9E-01 9.9E-01 9.9E-01 9.9E-01
 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00
 1.0E+00 5.0E-01 5.0E-01 2.0E-02 3.4E-01 3.4E-01 3.4E-01 3.4E-01 3.4E-01 FVIP*

$ FVES distributions for VB with the RCS at low pressure
 1.0E+00 1.0E-09 1.0E-09 1.0E-09 1.0E-09 1.0E-09 1.0E-09 1.0E-09 1.0E-09
 1.0E+00 2.5E-02 1.1E-02 5.9E-0  5.9E-03 5.9E-03 5.9E-03 5.9E-03 5.9E-03
 1.0E+00 1.2E-01 7.2E-02 4.0E-02 4.0E-02 4.0E-02 4.0E-02 4.0E-02 4.0E-02
 1.0E+00 3.1E-01 2.0E-01 1.7E-01 1.7E-01 1.7E-01 1.7E-01 1.7E-01 1.7E-01
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 1.0E+00 5.2E-01 4.0E-01 3.3E-01 3.3E-01 3.3E-01 3.3E-01 3.3E-01 3.3E-01
 1.0E+00 8.7E-01 8.7E-01 6.7E-01 6.2E-01 6.2E-01 6.2E-01 6.2E-01 6.2E-01
 1.0E+00 9.9E-01 9.9E-01 9.9E-01 9.9E-01 9.9E-01 9.9E-01 9.9E-01 9.9E-01
 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00
 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00
 1.0E+00 8.7E-01 8.7E-01 8.3E-01 7.7E-01 7.7E-01 7.7E-01 7.7E-01 7.7E-01 FVLP*

$ FVES distributions for Event V
   1.0E+00 6.5E-02 6.2E-02 5.1E-02 8.1E-02 8.1E-02 8.1E-02 8.1E-02 8.1E-02
   1.0E+00 7.9E-02 1.4E-01 5.3E-02 8.5E-02 8.5E-02 8.5E-02 8.5E-02 8.5E-02
   1.0E+00 1.6E-01 1.5E-01 6.4E-02 1.0E-01 1.0E-01 1.0E-01 1.0E-01 1.0E-01
   1.0E+00 4.1E-01 4.0E-01 1.1E-01 1.7E-01 1.7E-01 1.7E-01 1.7E-01 1.7E-01
   1.0E+00 6.1E-01 6.0E-01 2.5E-01 3.5E-01 3.5E-01 3.5E-01 3.5E-01 3.5E-01
   1.0E+00 7.8E-01 7.8E-01 5.5E-01 6.7E-01 6.7E-01 6.7E-01 6.7E-01 6.7E-01
   1.0E+00 9.8E-01 9.7E-01 9.3E-01 9.6E-01 9.6E-01 9.6E-01 9.6E-01 9.6E-01
   1.0E+00 9.9E-01 9.9E-01 9.8E-01 9.9E-01 9.9E-01 9.9E-01 9.9E-01 9.9E-01
   1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00
   1.0E+00 2.0E-01 2.0E-01 1.0E-01 1.0E-01 1.0E-01 1.0E-01 1.0E-01 1.0E-01 FVV*

$ FVES distributions for SGTRs
   1.0E+00 9.0E-03 8.9E-03 7.1E-02 1.0E-02 7.5E-03 1.0E-02 1.0E-02 1.0E-01
   1.0E+00 1.1E-02 2.2E-02 7.3E-02 2.2E-02 7.9E-03 1.1E-02 1.1E-02 1.1E-02
   1.0E+00 2.4E-02 2.4E-02 8.8E-02 1.3E-02 9.4E-03 1.3E-02 1.3E-02 1.3E-02
   1.0E+00 8.3E-02 8.3E-02 1.5E-01 2.3E-02 1.7E-02 2.3E-02 2.3E-02 2.3E-02
   1.0E+00 1.7E-01 1.7E-01 3.2E-01 5.8E-02 4.4E-02 5.8E-02 5.8E-02 5.8E-02
   1.0E+00 3.3E-01 3.3E-01 6.3E-01 1.9E-01 1.5E-01 1.9E-01 1.9E-01 1.9E-01
   1.0E+00 6.7E-01 6.2E-01 9.5E-01 7.3E-01 6.7E-01 7.3E-01 7.3E-01 7.3E-01
   1.0E+00 9.3E-01 9.3E-01 9.9E-01 9.2E-01 8.9E-01 9.2E-01 9.2E-01 9.2E-01
   1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00
   1.0E+00 1.7E-01 1.7E-01 3.2E-01 5.8E-02 4.4E-02 5.8E-02 5.8E-02 5.8E-02 FVSO*

$ FISG distributions for SGTRs with the secondary SRVs reclosing
   1.5E-01 6.6E-02 6.4E-02 2.6E-01 1.4E-01 1.5E-01 1.5E-01 1.5E-01 1.4E-01
   1.7E-01 7.3E-02 9.9E-02 2.6E-01 1.5E-01 1.5E-01 1.5E-01 1.5E-01 1.5E-01
   2.5E-01 1.1E-01 1.0E-01 2.9E-01 1.6E-01 1.7E-01 1.7E-01 1.7E-01 1.6E-01
   4.4E-01 2.0E-01 2.0E-01 3.8E-01 2.2E-01 2.2E-01 2.2E-01 2.2E-01 2.2E-01
   5.8E-01 2.9E-01 2.8E-01 5.6E-01 3.3E-01 3.4E-01 3.4E-01 3.4E-01 3.3E-01
   7.2E-01 4.1E-01 3.9E-01 8.5E-01 5.3E-01 5.4E-01 5.4E-01 5.4E-01 5.3E-01
   9.5E-01 8.5E-01 7.7E-01 1.0E+00 9.0E-01 9.0E-01 9.0E-01 9.0E-01 9.0E-01
   9.8E-01 9.2E-01 9.2E-01 1.0E+00 9.7E-01 9.8E-01 9.8E-01 9.8E-01 9.8E-01
   1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00
   5.9E-01 2.9E-01 2.8E-01 5.6E-01 3.3E-01 3.4E-01 3.4E-01 3.4E-01 3.3E-01

$ FISG distributions for SGTRs with the secondary SRVs stuck open
  1.0E+00 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
  1.0E+00 4.9E-07 4.9E-07 5.2E-07 5.2E-07 5.2E-07 5.2E-07 5.2E-07 5.2E-07
  1.0E+00 2.8E-05 2.8E-07 3.8E-05 3.8E-05 3.8E-05 3.8E-05 3.8E-05 3.8E-05
  1.0E+00 7.3E-02 6.2E-02 4.0E-02 3.0E-02 3.0E-02 3.0E-02 3.0E-02 3.0E-02
  1.0E+00 2.7E-01 2.6E-01 1.7E-01 2.4E-01 2.4E-01 2.4E-01 2.4E-01 2.4E-01
  1.0E+00 5.6E-01 5.5E-01 4.3E-01 5.5E-01 5.5E-01 5.5E-01 5.5E-01 5.5E-01
  1.0E+00 8.0E-01 7.8E-01 7.7E-01 7.6E-01 7.6E-01 7.6E-01 7.6E-01 7.6E-01
  1.0E+00 9.6E-01 9.5E-01 9.4E-01 9.1E-01 9.1E-01 9.1E-01 9.1E-01 9.1E-01
  1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00
  1.0E+00 2.7E-01 2.6E-01 1.7E-01 2.4E-01 2.4E-01 2.4E-01 2.4E-01 2.4E-01 FISG*

$ FOSG distributions for SGTRs with the secondary SRVs reclosing
   1.8E-01 1.2E-01 1.2E-01 2.3E-01 2.2E-01 2.3E-01 2.3E-01 2.3E-01 2.3E-01
   2.0E-01 1.3E-01 1.9E-01 2.3E-01 2.4E-01 2.3E-01 2.4E-01 2.4E-01 2.4E-01
   2.9E-01 2.0E-01 2.0E-01 2.6E-01 2.6E-01 2.5E-01 2.5E-01 2.6E-01 2.6E-01
   5.0E-01 3.7E-01 3.8E-01 3.4E-01 3.5E-01 3.4E-01 3.5E-01 3.5E-01 3.5E-01
   6.7E-01 5.3E-01 5.4E-01 5.0E-01 5.2E-01 5.3E-01 5.3E-01 5.3E-01 5.3E-01
   8.4E-01 7.4E-01 7.6E-01 7.2E-01 8.4E-01 8.3E-01 8.4E-01 8.4E-01 8.4E-01
   1.0E+00 1.0E+00 1.0E+00 9.3E-01 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00
   1.0E+00 1.0E+00 1.0E+00 9.8E-01 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00
   1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00
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    6.7E-01 5.3E-01 5.4E-01 5.0E-01 5.2E-01 5.3E-01 5.3E-01 5.3E-01 5.3E-01

$ FOSG distributions for SGTRs with the secondary SRVs stuck open
   1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00
   1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00
   1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00
   1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00
   1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00
   1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00
   1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00
   1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00
   1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00
   1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 FOSG*

$ Decontaimination factor distribution for pool scrubbing for Event V
    5.1E+03 4.5E+03 4.1E+03 1.3E+02 6.2E+00 3.0E+00 1.8E+00 1.7E+00 1.6E+00 5.0E+00  VDF*

$ FCONV distribution for early leak - dry containment
    1.0E-03 2.0E-03 8.0E-03 8.8E-02 1.9E-01 4.2E-01 6.9E-01 7.9E-01 9.1E-01 1.0E-01
$ FCONV distribution for early leak - wet containment
    1.0E-03 3.0E-03 9.0E-03 1.1E-01 2.3E-01 4.7E-01 7.4E-01 8.7E-01 9.5E-01 1.0E-01
$ FCONV distribution for early rupture in upper part of containment
    1.0E-02 8.9E-02 2.0E-01 4.6E-01 6.8E-01 8.0E-01 8.9E-01 9.4E-01 9.9E-01 6.4E-01
$ FCONV distribution for early rupture in lower part of containment
    4.6E-02 1.6E-01 2.7E-01 5.0E-01 7.3E-01 8.8E-01 9.8E-01 1.0E+00 1.0E+00 9.8E-01
$ FCONV distribution for late rupture
    1.0E-05 1.0E-04 1.0E-03 3.0E-03 3.5E-02 1.5E-01 5.8E-01 6.7E-01 7.4E-01 1.0E-01
$ FCONV distribution for Event V
    1.3E-02 5.9E-02 1.6E-01 3.4E-01 5.0E-01 7.0E-01 8.6E-01 9.5E-01 9.7E-01 8.0E-01 FCONV*

$ FCONC distributions for early leak - dry containment
    1.0E+00 1.0E-03 1.0E-03 2.0E-03 2.0E-03 2.0E-03 2.0E-03 2.0E-03 2.0E-03
    1.0E+00 2.0E-03 2.0E-03 6.0E-03 6.0E-03 6.0E-03 6.0E-03 6.0E-03 6.0E-03
    1.0E+00 8.0E-03 8.0E-03 1.7E-01 1.7E-01 1.7E-01 1.7E-01 1.7E-01 1.7E-01
    1.0E+00 8.6E-02 8.6E-02 9.4E-02 9.4E-02 9.4E-02 9.4E-02 9.4E-02 9.4E-02
    1.0E+00 2.0E-01 2.0E-01 2.1E-01 2.1E-01 2.1E-01 2.1E-01 2.1E-01 2.1E-01
    1.0E+00 4.1E-01 4.1E-01 4.1E-01 4.1E-01 4.1E-01 4.1E-01 4.1E-01 4.1E-01
    1.0E+00 6.8E-01 6.8E-01 6.8E-01 6.8E-01 6.8E-01 6.8E-01 6.8E-01 6.8E-01
    1.0E+00 7.8E-01 7.8E-01 7.8E-01 7.8E-01 7.8E-01 7.8E-01 7.8E-01 7.8E-01
    1.0E+00 8.8E-01 8.8E-01 8.8E-01 8.8E-01 8.8E-01 8.8E-01 8.8E-01 8.8E-01
    1.0E+00 1.5E-01 1.5E-01 1.5E-01 1.5E-01 1.5E-01 1.5E-01 1.5E-01 1.5E-01

$ FCONC distributions for early leak - wet containment
   1.0E+00 1.0E-03 1.0E-03 4.0E-03 4.0E-03 4.0E-03 4.0E-03 4.0E-03 4.0E-03
    1.0E+00 3.0E-03 3.0E-03 9.0E-03 9.0E-03 9.0E-03 9.0E-03 9.0E-03 9.0E-03
    1.0E+00 9.0E-03 9.0E-03 2.4E-02 2.4E-02 2.4E-02 2.4E-02 2.4E-02 2.4E-02
    1.0E+00 1.1E-01 1.1E-01 1.2E-01 1.2E-01 1.2E-01 1.2E-01 1.2E-01 1.2E-01
    1.0E+00 2.3E-01 2.3E-01 2.4E-01 2.4E-01 2.4E-01 2.4E-01 2.4E-01 2.4E-01
    1.0E+00 4.6E-01 4.6E-01 4.6E-01 4.6E-01 4.6E-01 4.6E-01 4.6E-01 4.6E-01
    1.0E+00 7.3E-01 7.3E-01 7.3E-01 7.3E-01 7.3E-01 7.3E-01 7.3E-01 7.3E-01
    1.0E+00 8.6E-01 8.6E-01 8.6E-01 8.6E-01 8.6E-01 8.6E-01 8.6E-01 8.6E-01
    1.0E+00 9.5E-01 9.5E-01 9.5E-01 9.5E-01 9.5E-01 9.5E-01 9.5E-01 9.5E-01
    1.0E+00 1.5E-01 1.5E-01 1.5E-01 1.5E-01 1.5E-01 1.5E-01 1.5E-01 1.5E-01

$ FCONC distributions for early rupture in upper part of containment
    1.0E+00 1.0E-02 1.0E-02 1.0E-02 1.0E-02 1.0E-02 1.0E-02 1.0E-02 1.0E-02
    1.0E+00 8.9E-02 8.9E-02 8.8E-02 8.8E-02 8.8E-02 8.8E-02 8.8E-02 8.8E-02
    1.0E+00 1.9E-01 1.9E-01 1.6E-01 1.6E-01 1.6E-01 1.6E-01 1.6E-01 1.6E-01
    1.0E+00 4.5E-01 4.5E-01 4.1E-01 4.1E-01 4.1E-01 4.1E-01 4.1E-01 4.1E-01
    1.0E+00 6.3E-01 6.3E-01 6.0E-01 6.0E-01 6.0E-01 6.0E-01 6.0E-01 6.0E-01
    1.0E+00 7.5E-01 7.5E-01 7.3E-01 7.3E-01 7.3E-01 7.3E-01 7.3E-01 7.3E-01
    1.0E+00 8.8E-01 8.8E-01 8.5E-01 8.5E-01 8.5E-01 8.5E-01 8.5E-01 8.5E-01
    1.0E+00 9.1E-01 9.1E-01 9.0E-01 9.0E-01 9.0E-01 9.0E-01 9.0E-01 9.0E-01
    1.0E+00 9.9E-01 9.9E-01 9.9E-01 9.9E-01 9.9E-01 9.9E-01 9.9E-01 9.9E-01
    1.0E-01 4.3E-01 4.3E-01 4.3E-01 4.3E-01 4.3E-01 4.3E-01 4.3E-01 4.3E-01
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$ FCONC distributions for early rupture in lower part of containment
   1.0E+00 2.5E-02 2.5E-02 2.5E-02 2.5E-02 2.5E-02 2.5E-02 2.5E-02 2.5E-02
   1.0E+00 1.6E-01 1.6E-01 1.2E-01 1.2E-01 1.2E-01 1.2E-01 1.2E-01 1.2E-01
   1.0E+00 2.6E-01 2.6E-01 2.0E-01 2.0E-01 2.0E-01 2.0E-01 2.0E-01 2.0E-01
   1.0E+00 5.2E-01 5.2E-01 4.7E-01 4.7E-01 4.7E-01 4.7E-01 4.7E-01 4.7E-01
   1.0E+00 7.3E-01 7.3E-01 7.0E-01 7.0E-01 7.0E-01 7.0E-01 7.0E-01 7.0E-01
   1.0E+00 8.5E-01 8.5E-01 8.4E-01 8.4E-01 8.4E-01 8.4E-01 8.4E-01 8.4E-01
   1.0E+00 9.4E-01 9.4E-01 9.4E-01 9.4E-01 9.4E-01 9.4E-01 9.4E-01 9.4E-01
   1.0E+00 9.6E-01 9.6E-01 9.6E-01 9.6E-01 9.6E-01 9.6E-01 9.6E-01 9.6E-01
   1.0E+00 9.8E-01 9.8E-01 9.8E-01 9.8E-01 9.8E-01 9.8E-01 9.8E-01 9.8E-01
   1.0E+00 4.3E-01 4.3E-01 4.3E-01 4.3E-01 4.3E-01 4.3E-01 4.3E-01 4.3E-01

$ FCONC distributions for late rupture
   1.0E+00 1.0E-03 1.0E-03 1.0E-03 1.0E-03 1.0E-03 1.0E-03 1.0E-03 1.0E-03
   1.0E+00 1.0E-03 1.0E-03 1.0E-03 1.0E-03 1.0E-03 1.0E-03 1.0E-03 1.0E-03
   1.0E+00 1.0E-03 1.0E-03 3.0E-03 3.0E-03 3.0E-03 3.0E-03 3.0E-03 3.0E-03
   1.0E+00 1.4E-02 1.4E-02 3.6E-02 2.0E-02 3.6E-02 2.0E-02 2.0E-02 2.0E-02
   1.0E+00 6.7E-02 6.7E-02 1.1E-01 8.0E-02 1.1E-01 8.0E-02 8.0E-02 8.0E-02
   1.0E+00 1.9E-01 1.9E-01 3.2E-01 2.1E-01 3.2E-01 2.1E-01 2.1E-01 2.1E-01
   1.0E+00 6.2E-01 6.2E-01 6.4E-01 6.2E-01 6.4E-01 6.2E-01 6.2E-01 6.2E-01
   1.0E+00 7.2E-01 7.2E-01 7.4E-01 7.2E-01 7.4E-01 7.2E-01 7.2E-01 7.2E-01
   1.0E+00 7.5E-01 7.5E-01 8.5E-01 7.5E-01 8.5E-01 7.5E-01 7.5E-01 7.5E-01
   1.0E+00 1.0E-01 1.0E-01 3.7E-01 1.6E-01 3.7E-01 1.6E-01 1.6E-01 1.6E-01

$ FCONC distributions for Event V
   1.0E+00 5.3E-03 5.3E-03 5.3E-03 5.3E-03 5.3E-03 5.3E-03 5.3E-03 5.3E-03
   1.0E+00 2.4E-02 2.4E-02 2.4E-02 2.4E-02 2.4E-02 2.4E-02 2.4E-02 2.4E-02
   1.0E+00 1.1E-01 1.1E-01 9.3E-02 9.3E-02 9.3E-02 9.3E-02 9.3E-02 9.3E-02
   1.0E+00 3.1E-01 3.1E-01 2.7E-01 2.7E-01 2.7E-01 2.7E-01 2.7E-01 2.7E-01
   1.0E+00 5.0E-01 5.0E-01 4.7E-01 4.7E-01 4.7E-01 4.7E-01 4.7E-01 4.7E-01
   1.0E+00 6.6E-01 6.6E-01 6.5E-01 6.5E-01 6.5E-01 6.5E-01 6.5E-01 6.5E-01
   1.0E+00 7.7E-01 7.7E-01 7.7E-01 7.7E-01 7.7E-01 7.7E-01 7.7E-01 7.7E-01
   1.0E+00 8.4E-01 8.4E-01 8.4E-01 8.4E-01 8.4E-01 8.4E-01 8.4E-01 8.4E-01
   1.0E+00 9.2E-01 9.2E-01 9.2E-01 9.2E-01 9.2E-01 9.2E-01 9.2E-01 9.2E-01
   1.0E+00 4.3E-01 4.3E-01 4.3E-01 4.3E-01 4.3E-01 4.3E-01 4.3E-01 4.3E-01 FCONC*

$ FCCI distributions for low Zr oxidation in-vessel and dry containment
   1.0E+00 1.0E+00 1.0E+00 1.1E-02 1.0E-09 1.0E-09 1.0E-09 1.0E-09 1.0E-09
   1.0E+00 1.0E+00 1.0E+00 2.4E-02 2.0E-05 1.0E-09 1.0E-09 1.0E-09 9.0E-05
   1.0E+00 1.0E+00 1.0E+00 1.0E-01 3.2E-04 1.0E-09 1.0E-09 2.0E-05 4.3E-04
   1.0E+00 1.0E+00 1.0E+00 3.6E-01 1.9E-03 1.0E-06 2.4E-04 2.9E-04 2.7E-03
   1.0E+00 1.0E+00 1.0E+00 5.7E-01 5.0E-02 2.3E-05 8.6E-04 1.2E-03 4.5E-02
   1.0E+00 1.0E+00 1.0E+00 6.7E-01 2.3E-01 3.3E-04 2.2E-02 2.7E-02 1.9E-01
   1.0E+00 1.0E+00 1.0E+00 9.5E-01 6.4E-01 1.7E-02 9.6E-02 9.8E-02 5.2E-01
   1.0E+00 1.0E+00 1.0E+00 9.8E-01 9.4E-01 8.3E-02 1.8E-02 1.9E-01 9.0E-01
   1.0E+00 1.0E+00 1.0E+00 9.9E-01 1.0E+00 1.2E-01 2.6E-01 2.3E-01 1.0E+00
   1.0E+00 1.0E+00 1.0E+00 4.5E-01 1.7E-01 3.8E-06 8.7E-03 6.5E-03 1.0E-01

$ FCCI distributions for high Zr oxidation in-vessel and dry containment
   1.0E+00 1.0E+00 1.0E+00 7.2E-03 1.0E-09 1.0E-09 1.0E-09 1.0E-09 1.0E-09
   1.0E+00 1.0E+00 1.0E+00 1.6E-02 2.0E-05 1.0E-09 1.0E-09 1.0E-09 5.0E-05
   1.0E+00 1.0E+00 1.0E+00 5.9E-02 2.7E-04 1.0E-09 1.0E-09 1.0E-05 3.4E-04
   1.0E+00 1.0E+00 1.0E+00 2.3E-01 1.6E-03 1.0E-09 2.2E-04 2.3E-04 1.9E-03
   1.0E+00 1.0E+00 1.0E+00 4.9E-01 5.7E-02 2.3E-05 7.0E-04 9.5E-04 3.1E-02
   1.0E+00 1.0E+00 1.0E+00 6.3E-01 2.1E-01 3.3E-04 8.8E-03 1.1E-03 1.7E-01
   1.0E+00 1.0E+00 1.0E+00 9.0E-01 4.8E-01 1.7E-02 8.6E-02 9.3E-02 4.4E-01
   1.0E+00 1.0E+00 1.0E+00 9.7E-01 8.7E-01 8.3E-02 1.8E-01 1.8E-01 8.5E-01
   1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.0E+00 1.2E-01 2.4E-01 2.5E-01 1.0E+00
   1.0E+00 1.0E+00 1.0E+00 4.5E-01 1.7E-01 3.8E-06 8.7E-03 6.5E-03 1.0E-01

$ FCCI distributions for low Zr oxidation in-vessel and wet containment
   1.0E+00 1.0E+00 1.0E+00 2.5E-03 1.0E-09 1.0E-09 1.0E-09 1.0E-09 1.0E-09
   1.0E+00 1.0E+00 1.0E+00 7.2E-03 2.0E-05 1.0E-09 1.0E-09 1.0E-09 2.0E-05
   1.0E+00 1.0E+00 1.0E+00 2.8E-02 1.4E-04 1.0E-09 1.0E-09 1.0E-05 5.0E-05
   1.0E+00 1.0E+00 1.0E+00 1.3E-01 8.4E-04 1.0E-09 9.0E-05 1.1E-04 9.7E-04
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    1.0E+00 1.0E+00 1.0E+00 2.4E-01 2.0E-02 4.0E-06 3.9E-04 4.7E-04 2.0E-02
    1.0E+00 1.0E+00 1.0E+00 3.6E-01 2.0E-01 6.6E-05 5.0E-03 8.1E-03 1.6E-01
    1.0E+00 1.0E+00 1.0E+00 9.1E-01 4.1E-01 1.0E-02 7.4E-02 8.3E-02 3.4E-01
    1.0E+00 1.0E+00 1.0E+00 9.8E-01 8.1E-01 5.0E-02 9.8E-02 1.3E-01 7.5E-01
    1.0E+00 1.0E+00 1.0E+00 1.0E+00 9.6E-01 6.9E-02 1.1E-01 1.6E-01 9.2E-01
    1.0E+00 1.0E+00 1.0E+00 4.5E-01 1.7E-01 3.8E-06 8.7E-03 6.5E-03 1.0E-01

$ FCCI distributions for high Zr oxidation in-vessel and wet containment
    1.0E+00 1.0E+00 1.0E+00 1.7E-03 1.0E-09 1.0E-09 1.0E-09 1.0E-09 1.0E-09
    1.0E+00 1.0E+00 1.0E+00 5.2E-03 1.0E-05 1.0E-09 1.0E-09 1.0E-09 2.0E-05
    1.0E+00 1.0E+00 1.0E+00 2.2E-02 1.1E-04 1.0E-09 1.0E-09 1.0E-09 5.0E-05
    1.0E+00 1.0E+00 1.0E+00 1.2E-01 5.1E-04 1.0E-09 9.0E-05 1.0E-04 7.5E-04
    1.0E+00 1.0E+00 1.0E+00 2.3E-01 1.0E-02 4.0E-06 3.1E-04 4.3E-04 1.1E-02
    1.0E+00 1.0E+00 1.0E+00 3.4E-01 1.8E-01 6.6E-05 4.2E-03 6.6E-03 1.4E-01
    1.0E+00 1.0E+00 1.0E+00 8.6E-01 3.0E-01 1.0E-02 7.3E-02 7.9E-02 2.5E-01
    1.0E+00 1.0E+00 1.0E+00 9.6E-01 7.0E-01 5.0E-02 9.8E-02 1.0E-01 8.1E-01
    1.0E+00 1.0E+00 1.0E+00 9.9E-01 8.8E-01 6.9E-02 1.0E-01 1.2E-01 7.7E-01
    1.0E+00 1.0E+00 1.0E+00 4.5E-01 1.7E-01 3.8E-06 8.7E-03 6.5E-03 1.0E-01 FCCI*

$ Spray DF distribution for RCS release, CF at VB, RCS at high pressure
    2.8E+00 2.6E+00 2.2E+00 2.0E+00 1.8E+00 1.7E+00 1.6E+00 1.4E+00 1.0E+00 2.6E+00  DFSPR1*

$ Spray DF distribution for RCS release, all cases not included above
    2.6E+03 2.6E+03 1.8E+3  7.4E+01 4.0E+01 9.4E+00 3.0E+00 2.4E+00 2.3E+00 4.5E+01  DFSPR2*

$ Spray DF distribution for CCI release
    3.2E+03 2.9E+03 2.0E+03 2.8E+02 2.8E+01 1.4E+01 7.7E+00 6.8E+00 6.7E+00 3.0E+01  DFSPRC*

$ Distribution for the late iodine release
    0.0E+00 1.0E-03 5.0E-03 1.0E-02 5.0E-02 8.0E-02 1.0E-01 1.0E-01 1.0E-01 0.0E+00  LATEIL*

$ Distribtion for the revolatilization release from the RCS, one hole in RCS
    1.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
    1.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
    1.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
    1.0E+00 1.1E-02 1.0E-03 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
    1.0E+00 4.5E-02 2.3E-02 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
    1.0E+00 1.0E-01 7.2E-02 2.4E-02 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
    1.0E+00 4.4E-01 1.7E-01 2.1E-01 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
    1.0E+00 8.0E-01 2.5E-01 4.1E-01 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
    1.0E+00 1.0E+00 7.5E-01 8.0E-01 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
    0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00

$ Distribution for the revolatilization release from the RCS, two holes in the RCS
    1.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
    1.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
    1.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
    1.0E+00 3.6E-02 2.7E-02 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
    1.0E+00 1.3E-01 9.5E-02 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
    1.0E+00 3.0E-01 2.7E-01 7.7E-02 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
    1.0E+00 7.2E-01 7.0E-01 6.3E-01 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
    1.0E+00 9.2E-01 9.1E-01 8.9E-01 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
    1.0E+00 1.0E+00 1.0E+00 1.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00
    0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 0.0E+00 FLATE*

$ Distribution for the DCH release - RCS at high pressure
   1.0E+00 6.7E-01 6.7E-01 2.3E-03 5.2E-05 5.0E-05 5.2E-05 5.2E-05 5.2E-05
   1.0E+00 6.7E-01 6.7E-01 3.4E-03 7.0E-05 7.3E-05 7.0E-05 7.0E-05 7.0E-05
   1.0E+00 6.8E-01 6.8E-01 1.7E-02 2.3E-04 3.3E-04 2.3E-04 2.3E-04 2.3E-04
   1.0E+00 7.5E-01 7.5E-01 6.8E-02 1.3E-03 7.7E-03 1.3E-03 1.3E-03 1.3E-03
   1.0E+00 9.2E-01 9.2E-01 2.0E-01 6.0E-03 2.2E-02 6.0E-03 6.0E-03 9.0E-03
   1.0E+00 9.7E-01 9.7E-01 2.8E-01 2.5E-02 8.2E-02 1.8E-02 1.8E-02 4.3E-02
   1.0E+00 1.0E+00 1.0E+00 3.6E-01 2.3E-01 2.1E-01 6.3E-02 6.3E-02 2.9E-01
   1.0E+00 1.0E+00 1.0E+00 4.0E-01 3.9E-01 3.6E-01 1.3E-01 1.6E-01 3.9E-01
   1.0E+00 1.0E+00 1.0E+00 4.0E-01 4.4E-01 4.2E-01 1.6E-01 2.0E-01 4.2E-01
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  1.0E+00 9.2E-01 9.2E-01 2.0E-01 6.0E-03 2.2E-02 6.0E-03 6.0E-03 9.0E-03 FDCHL-HP*

$ Distribution for the DCH release - RCS at intermediate pressure
  1.0E+00 6.7E-01 6.7E-01 2.3E-03 5.5E-05 5.2E-05 5.5E-05 5.5E-05 5.5E-05
  1.0E+00 6.7E-01 6.7E-01 3.4E-03 7.0E-05 7.3E-05 7.0E-05 7.0E-05 7.0E-05
  1.0E+00 6.8E-01 6.8E-01 1.7E-02 1.8E-04 2.8E-04 1.8E-04 1.8E-04 1.8E-04
  1.0E+00 7.5E-01 7.5E-01 5.7E-02 7.7E-04 7.1E-03 7.7E-04 7.7E-04 7.7E-04
  1.0E+00 9.2E-01 9.2E-01 2.0E-01 4.7E-03 2.0E-02 4.7E-03 4.7E-03 7.7E-03
  1.0E+00 9.7E-01 9.7E-01 2.8E-01 2.1E-02 7.8E-02 1.5E-02 1.5E-02 3.9E-02
  1.0E+00 1.0E+00 1.0E+00 3.3E-01 2.2E-01 2.0E-01 5.0E-02 5.0E-02 2.8E-01
  1.0E+00 1.0E+00 1.0E+00 3.6E-01 3.7E-01 3.4E-01 1.1E-01 1.4E-01 3.7E-01
  1.0E+00 1.0E+00 1.0E+00 3.6E-01 4.2E-01 3.9E-01 1.3E-01 1.8E-01 4.0E-01
  1.0E+00 9.2E-01 9.2E-01 2.0E-01 4.7E-03 2.0E-02 4.7E-03 4.7E-03 7.7E-03 FDCHL-IP*

$ DF distribution for pool scrubbing of CCI release - partially full cavity
   1.0E+00 4.1E+03 4.1E+03 1.6E+03 4.1E+03 1.6E+03 4.1E+03 4.1E+03 4.1E+03
   1.0E+00 3.6E+03 3.6E+03 1.5E+03 3.6E+03 1.5E+03 3.6E+03 3.6E+03 3.6E+03
   1.0E+00 3.3E+03 3.3E+03 1.3E+03 3.3E+03 1.3E+03 3.3E+03 3.3E+03 3.3E+03
   1.0E+00 1.0E+02 1.0E+02 4.2E+01 1.0E+02 4.2E+01 1.0E+02 1.0E+02 1.0E+02
   1.0E+00 5.0E+00 5.0E+00 2.0E+00 5.0E+00 2.0E+00 5.0E+00 5.0E+00 5.0E+00
   1.0E+00 2.4E+00 2.4E+00 1.0E+00 2.4E+00 1.0E+00 2.4E+00 2.4E+00 2.4E+00
   1.0E+00 1.4E+00 1.4E+00 1.0E+00 1.4E+00 1.0E+00 1.4E+00 1.4E+00 1.4E+00
   1.0E+00 1.4E+00 1.4E+00 1.0E+00 1.4E+00 1.0E+00 1.4E+00 1.4E+00 1.4E+00
   1.0E+00 1.3E+00 1.3E+00 1.0E+00 1.3E+00 1.0E+00 1.3E+00 1.3E+00 1.3E+00
   1.0E+00 5.0E+00 5.0E+00 2.0E+00 5.0E+00 2.0E+00 5.0E+00 5.0E+00 5.0E+00

$ DF distribution for pool scrubbing of CCI release - full cavity
   1.0E+00 2.1E+04 2.1E+04 1.1E+04 2.1E+04 1.1E+04 2.1E+04 2.1E+04 2.1E+04
   1.0E+00 1.8E+04 1.8E+04 9.4E+03 1.8E+04 9.4E+03 1.8E+04 1.8E+04 1.8E+04
   1.0E+00 1.7E+04 1.7E+04 8.6E+03 1.7E+04 8.6E+03 1.7E+04 1.7E+04 1.7E+04
   1.0E+00 5.2E+02 5.2E+02 2.7E+02 5.2E+02 2.7E+02 5.2E+02 5.2E+02 5.2E+02
   1.0E+00 2.5E+01 2.5E+01 1.3E+01 2.5E+01 2.5E+01 1.3E+01 2.5E+01 2.5E+01
   1.0E+00 1.2E+01 1.2E+01 6.3E+00 1.2E+01 6.3E+00 1.2E+01 1.2E+01 1.2E+01
   1.0E+00 7.2E+00 7.2E+00 3.8E+00 7.2E+00 3.8E+00 7.2E+00 7.2E+00 7.2E+00
   1.0E+00 6.9E+00 6.9E+00 3.6E+00 6.9E+00 3.6E+00 6.9E+00 6.9E+00 6.9E+00
   1.0E+00 6.4E+00 6.4E+00 3.4E+00 6.4E+00 3.4E+00 6.4E+00 6.4E+00 6.4E+00
   1.0E+00 2.5E+01 2.5E+01 1.3E+01 2.5E+01 1.3E+01 2.5E+01 2.5E+01 2.5E+01 VPSL*

$ Fraction of core in HPME for high, moderate, and low ranges of fraction ejected
   .396  .265  .185 FPME*

$ Ice condenser DF distribution for RCS release, fans operating, no prior CF
   3.0E+01 2.8E+01 1.6E+01 6.0E+00 2.8E+00 1.6E+00 1.2E+00 1.1E+00 1.0E+00 4.0E+00

$ Ice condenser DF distribution for RCS release, fans operating, prior CF
   1.0E+01 9.7E+00 8.2E+00 4.0E+00 1.9E+00 1.2E+00 1.0E+00 1.0E+00 1.0E+00 3.0E+00

$ Ice condenser DF distribution for RCS release, fans not operating
   4.3E+01 4.1E+01 3.5E+01 2.4E+01 7.0E+00 2.3E+00 1.3E+00 1.1E+00 1.0E+00 7.0E+00

$ Ice condenser DF distribution for RCS release, HPME or DCH event
   8.1E+01 6.5E+01 3.2E+01 6.7E+00 3.9E+00 2.4E+00 1.4E+00 1.1E+00 1.0E+00 7.0E+00 DFICV*

$ Ice condenser DF distribution for CCI release, fans operating, no prior CF
   3.0E+01 2.8E+01 1.6E+01 6.0E+00 2.8E+00 1.6E+00 1.2E+00 1.1E+00 1.0E+00 7.0E+00

$ Ice condenser DF distribution for CCI release, fans operating, prior CF
   1.0E+01 9.7E+00 8.2E+00 4.0E+00 2.0E+00 1.2E+00 1.1E+00 1.0E+00 1.0E+00 3.0E+00

$ Ice condenser DF distribution for CCI release, fans not operating
   2.0E+01 1.9E+01 1.3E+01 3.5E+00 2.5E+00 1.7E+00 1.1E+00 1.0E+00 1.0E+00 7.0E+00 DFICC*
```
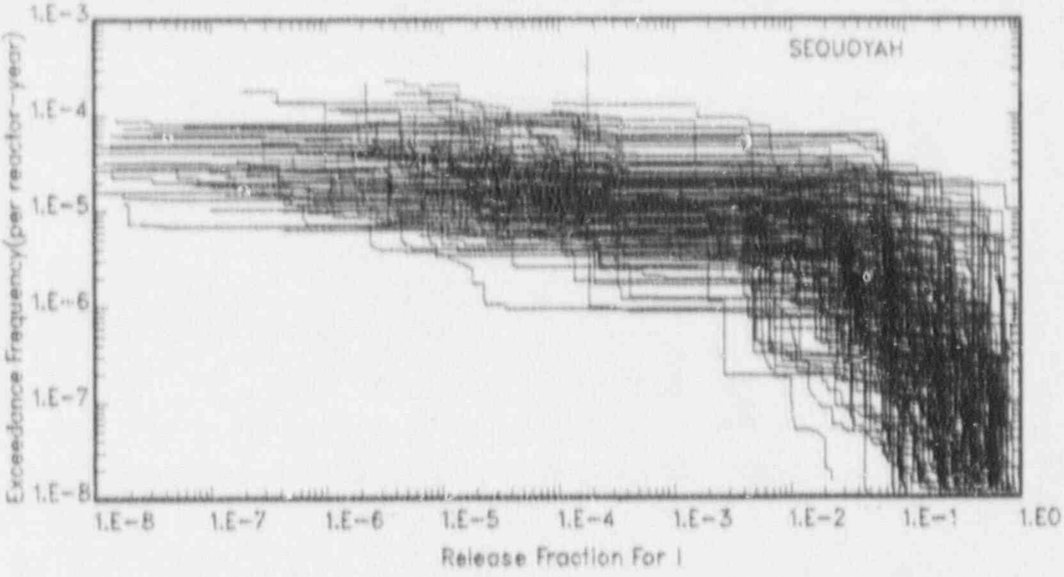

B.3 SOURCE TERM RESULTS

This section contains examples of additional source term results for internal initiators. Figure B.3-1 presents the complementary cumulative distribution functions (CCDFs) for release fractions for the iodine, cesium, strontium, and lanthanum radionuclide classes. The CCDF for noble gases is not particularly interesting since almost all the noble gases that escape from the fuel are eventually released to the environment; 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 200 observations in the sample for Sequoyah.

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 there is early failure of the containment (Summary accident progression bins (APBs) 1 through 4). Figure B.3-3 provides the same type of information for accidents in which there is late failure of the containment (Summary APB 5). 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 early containment failure, for example, all the iodine release fractions for source terms resulting from early containment failure are simply averaged. That is, all the iodine total release fractions 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.



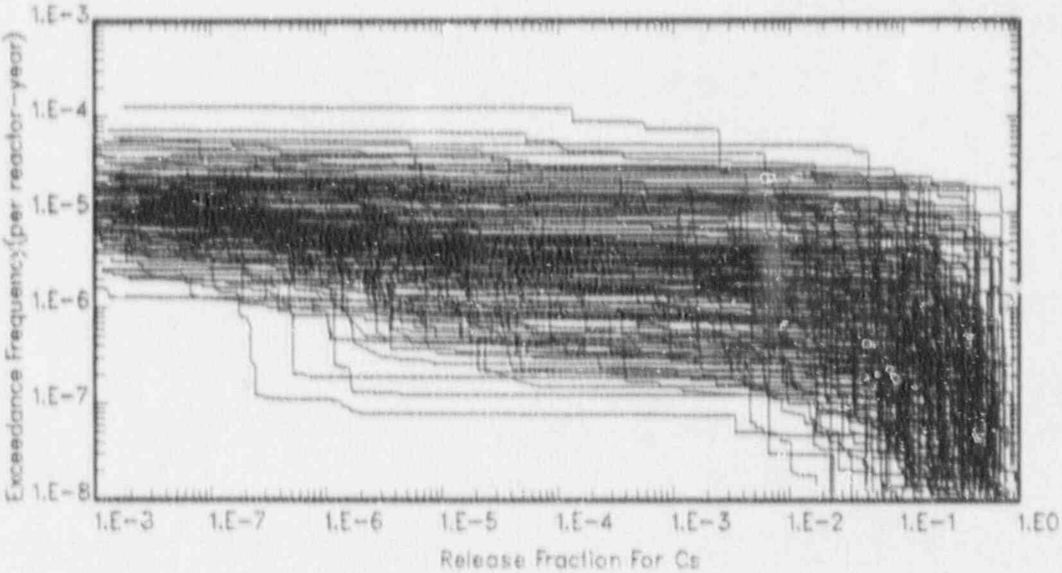


Figure B.3-1. Exceedance Frequencies for Release Fractions (iodine, cesium, strontium, lanthanum)

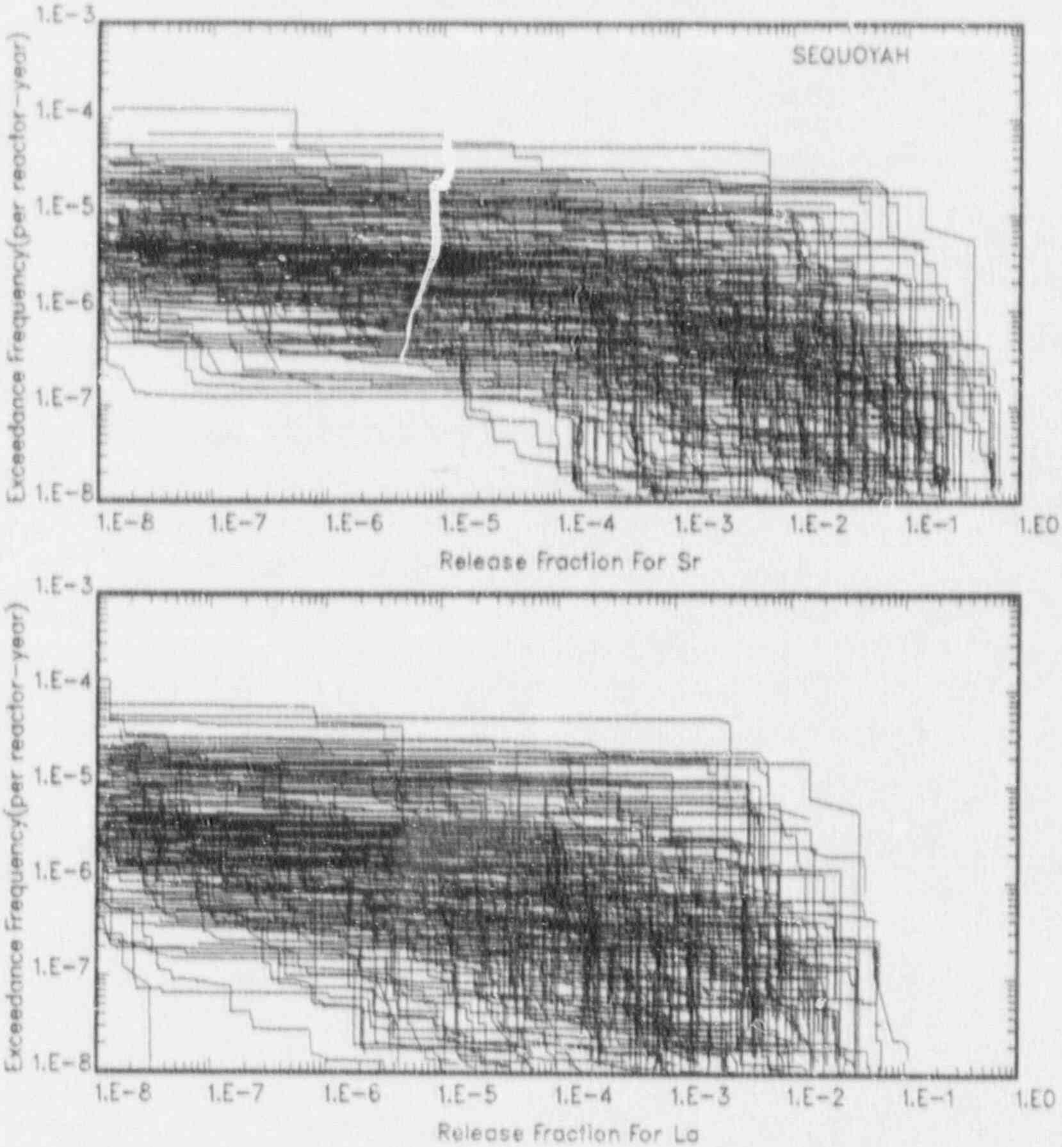


Figure B.3-1. (Continued)

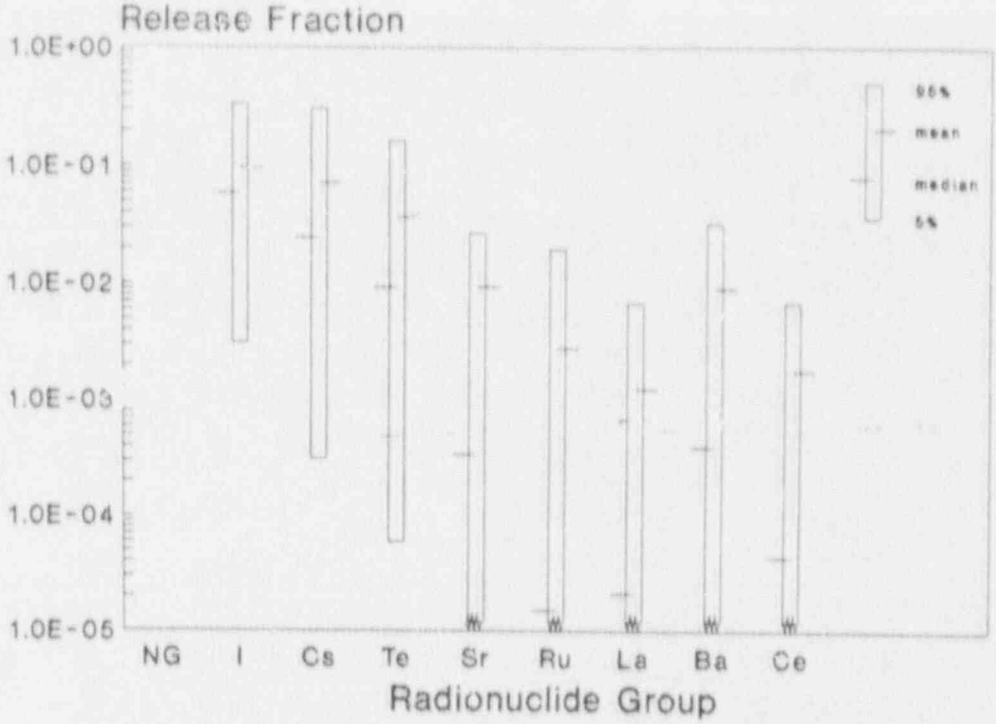


Figure B.3-2. Total Release Fractions for Early Containment Failure

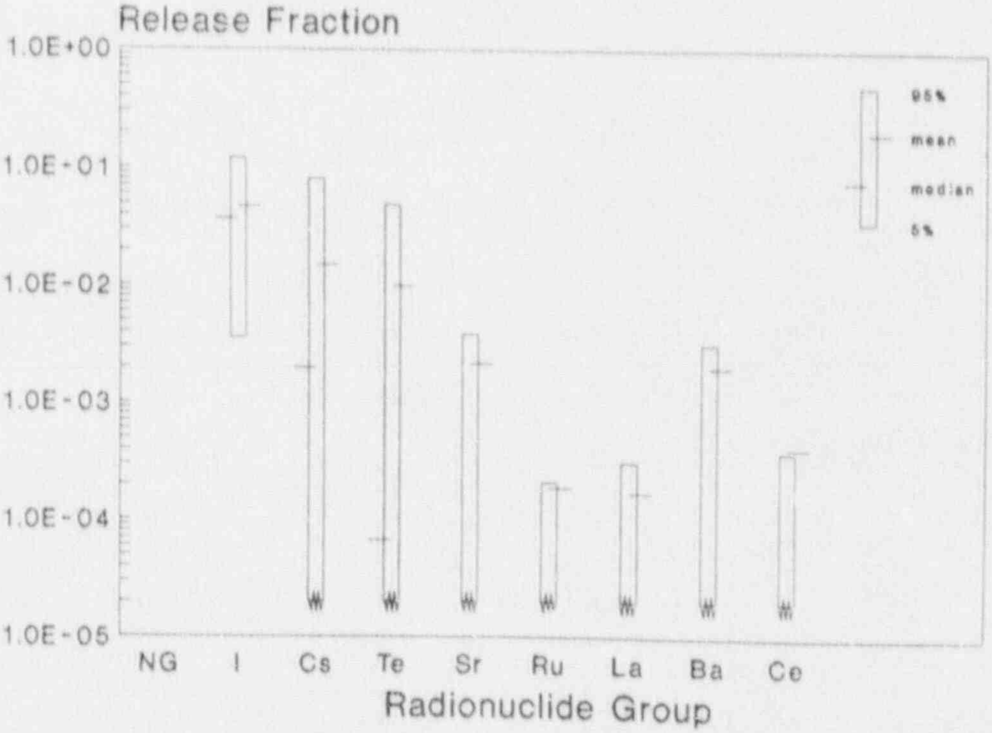


Figure B.3-3. Total Release Fractions for Late Containment Failure

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 Sequoyah. Specifically, Figure B.4-1 and Table B.4-1 present the results of site-specific MACCS calculations for Sequoyah 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-5253.[B.4-1] Table B.4-2 lists the PARTITION input file for the Sequoyah 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.

The curve shown in Figure B.4-1 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 and data used in the calculation are the same as those described in Sprung et al. (1989).

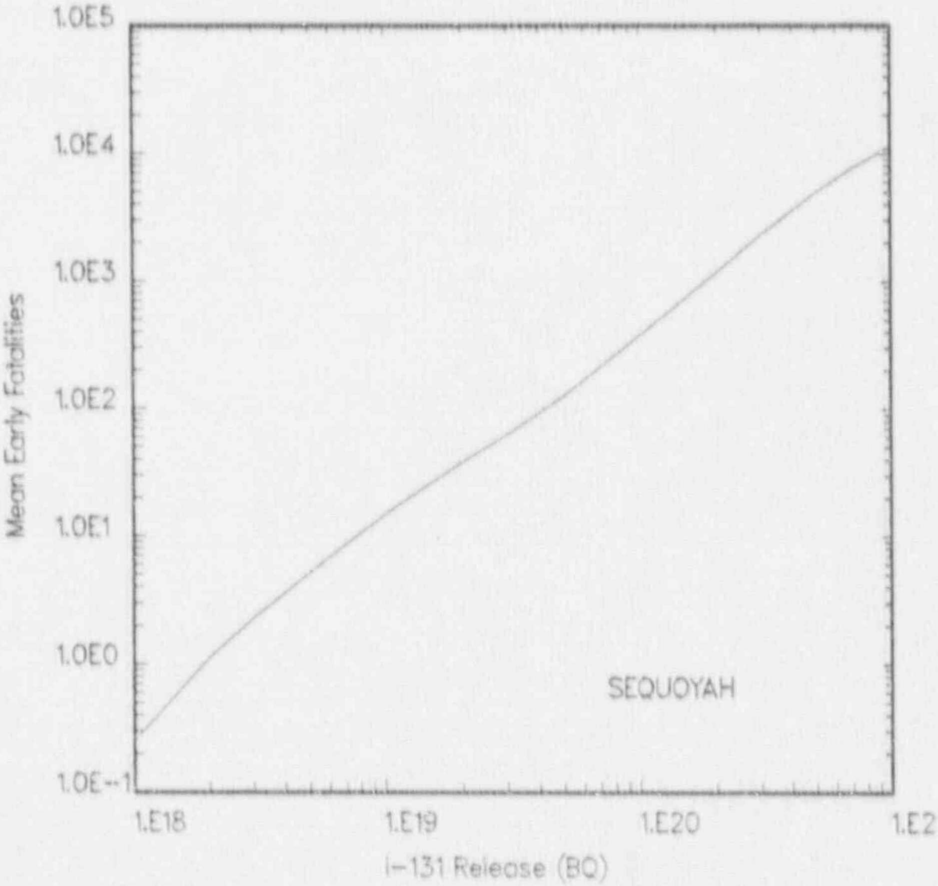


Figure B.4-1. Mean Early Fatalities vs. Released Activity for Sequoyah

Selected MACCS Mean Results for Single Isotope Releases for Sequoyah Table B.4-1 presents the results of a full MACCS calculation for each isotope. Each calculation assumes the indicated inventory 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 Sequoyah

Release[1] Class	Element[2]	Isotope	Half-life (Days)	Inventory (bq)	Early[3] Fetalities	Early[4] Injuries	E.L.C.F.[5]	C.L.C.F.[6]
1					0.00E+00	8.61E-03	1.14E+00	0.00E+00
	KR				0.00E+00	8.61E-03	9.56E-01	0.00E+00
		KR-85	3.919E+03	2.475E+15	0.00E+00	0.00E+00	8.09E-05	0.00E+00
		KR-85M	1.867E-01	1.159E+17	0.00E+00	0.00E+00	2.38E-02	0.00E+00
		KR-87	5.278E-02	2.118E+17	0.00E+00	0.00E+00	9.53E-02	0.00E+00
		KR-88	1.167E-01	2.864E+17	0.00E+00	8.61E-03	8.37E-01	0.00E+00
	XE				0.00E+00	0.00E+00	1.84E-01	0.00E+00
		XE-133	5.291E+00	6.782E+17	0.00E+00	0.00E+00	1.28E-01	0.00E+00
		XE-135	3.821E-01	1.273E+17	0.00E+00	0.00E+00	5.59E-02	0.00E+00
2					9.35E-01	5.58E+00	4.69E+01	1.69E+02
	I				9.35E-01	5.58E+00	4.69E+01	1.69E+02
		I-131	8.041E+00	3.206E+17	3.21E-03	1.13E-01	2.37E+01	1.69E+02
		I-132	9.521E-02	4.725E+17	1.19E-01	9.45E-01	2.07E+00	0.00E+00
		I-133	8.667E-01	6.77[illegible]E+17	1.82E-01	1.13E+00	1.26E+01	4.01E-04
		I-134	3.653E-02	7.440E+17	5.42E-02	7.20E-01	1.09E+00	0.00E+00
		I-135	2.744E-01	6.392E+17	5.77E-01	2.67E+00	7.47E+00	2.21E-15
3					6.43E-04	2.41E-02	2.36E+01	9.75E+03
	RB				0.00E+00	0.00E+00	5.70E-03	5.51E-03
		RB-86	1.865E+01	1.888E+14	0.00E+00	0.00E+00	5.70E-03	5.51E-03
	CS				6.43E-04	2.41E-02	2.36E+01	9.75E+03
		CS-134	7.524E+02	4.324E+16	6.43E-04	2.35E-02	1.57E+01	5.65E+03
		CS-136	1.300E+01	1.316E+16	0.00E+00	6.37E-04	3.43E+00	4.79E+00
		CS-137	1.099E+04	2.417E+16	0.00E+00	0.00E+00	4.47E+00	4.10E+03
4					1.06E+00	3.91E+00	7.81E+01	1.13E+01
	SB				1.42E-05	1.98E-02	3.39E+00	1.54E-01
		SB-127	3.800E+00	2.787E+16	0.00E+00	6.86E-05	2.72E+00	1.54E-01
		SB-129	1.808E-01	9.872E+16	1.42E-05	1.97E-02	6.67E-01	2.01E-24
	TE				1.06E+00	3.89E+00	7.47E+01	1.11E+01
		TE-127	3.896E-01	2.692E+16	0.00E+00	0.00E+00	3.11E-02	1.79E-14
		TE-127M	1.090E+02	3.564E+15	0.00E+00	0.00E+00	2.97E-01	2.43E-01
		TE-129	4.861E-02	9.267E+16	0.00E+00	0.00E+00	8.27E-03	0.00E+00
		TE-129M	3.340E+01	2.443E+16	0.00E+00	0.00E+00	3.27E+00	1.21E+00
		TE-131M	1.250E+00	4.680E+16	1.28E-05	1.48E-02	3.58E+00	4.41E+00
		TE-132	3.250E+00	4.6[illegible]8E+17	1.06E+00	3.88E+00	6.75E+01	5.28E+00
5					3.14E-01	1.57E+00	2.97E+01	4.69E+03
	SR				3.14E-01	1.57E+00	2.97E+01	4.69E+03
		SR-89	5.200E+01	3.590E+17	1.10E-01	1.41E-02	1.21E+01	1.06E+03
		SR-90	1.026E+04	1.938E+16	0.00E+00	0.00E+00	9.09E+00	3.63E+03
		SR-91	3.950E-01	4.616E+17	1.51E-01	1.02E+00	5.98E+00	2.60E-01
		SR-92	1.129E-01	4.803E+17	5.32E-02	5.39E-01	2.51E+00	2.12E-29

Table B.4-1 (continued)

6					2.20E+00	1.03E+00	3.87E+02	7.08E+02
	CO				0.00E+00	0.00E+00	2.89E+00	1.71E+02
		CO-58	7.130E+01	3.223E+15	0.00E+00	0.00E+00	5.53E-01	4.99E+00
		CO-60	1.921E+03	2.465E+15	0.00E+00	0.00E+00	2.34E+00	1.66E+02
	MO				2.77E-01	3.61E-01	3.40E+01	4.33E-01
		MO-99	2.751E+00	6.098E+17	2.77E-01	3.61E-01	3.40E+01	4.33E-01
	TC				0.00E+00	2.57E-03	4.23E-01	5.35E-18
		TC-99M	2.508E-01	5.263E+17	0.00E+00	2.57E-03	4.23E-01	5.36E-18
	RU				1.92E+00	6.64E-01	3.47E+02	5.37E+02
		RU-103	3.959E+01	4.542E+17	1.13E-01	5.24E-01	4.67E+01	1.90E+02
		RU-105	1.850E-01	2.954E+17	1.20E-03	1.03E-01	1.52E+00	1.90E-04
		RU-106	3.690E+02	1.032E+17	1.81E+00	3.66E-02	2.99E+02	3.47E+02
	RH				0.00E+00	2.94E-04	2.17E+00	9.20E-04
		RH-105	1.479E+00	2.046E+17	0.00E+00	2.94E-04	2.17E+00	9.20E-04
7					8.36E+00	1.80E+01	7.06E+02	1.79E+03
	Y				1.98E+00	3.79E-01	1.49E+02	3.65E+01
		Y-90	2.670E+00	2.079E+16	0.00E+00	0.00E+00	1.56E+00	1.09E-03
		Y-91	5.880E+01	4.374E+17	1.69E+00	8.02E-02	1.40E+02	3.65E+01
		Y-92	1.475E-01	4.821E+17	3.76E-02	8.35E-02	1.04E+00	6.52E-30
		Y-93	4.208E-01	5.454E+17	2.50E-01	2.15E-01	6.43E+00	4.02E-11
	ZR				1.75E+00	6.18E+00	1.11E+02	1.27E+03
		ZR-95	6.550E+01	5.526E+17	4.92E-01	1.61E+00	8.01E+01	1.27E+03
		ZR-97	7.000E-01	5.759E+17	1.27E+00	4.57E+00	3.12E+01	1.32E-05
	NB				3.04E-01	1.45E+00	5.48E+01	2.89E+02
		NB-95	3.510E+01	5.224E+17	3.04E-01	1.45E+00	5.48E+01	2.89E+02
	LA				2.62E+00	9.93E+00	7.03E+01	3.71E-01
		LA-140	1.676E+00	6.352E+17	2.49E+00	9.00E+00	6.76E+01	1.75E-01
		LA-141	1.641E-01	5.826E+17	1.29E-02	1.16E-02	8.27E-01	1.96E-01
		LA-142	6.625E-02	5.616E+17	1.17E-01	9.17E-01	1.85E+00	0.00E+00
	PR				2.55E-01	1.96E-02	3.60E+01	1.81E+00
		PR-143	1.358E+01	5.395E+17	2.55E-01	1.96E-02	3.60E+01	1.81E+00
	ND				1.66E-02	1.14E-02	1.62E+01	4.91E+00
		ND-147	1.099E+01	2.412E+17	1.66E-02	1.14E-02	1.62E+01	4.91E+00
	AM				0.00E+00	0.00E+00	4.08E+00	6.48E+00
		AM-241	1.581E+05	1.159E+13	0.00E+00	0.00E+00	4.08E+00	6.48E+00
	CM				1.42E+00	0.00E+00	2.64E+02	1.85E+02
		CM-242	1.630E+02	4.436E+15	1.42E+00	0.00E+00	1.97E+02	1.06E+02
		CM-244	6.611E+03	2.596E+14	0.00E+00	0.00E+00	6.70E+01	7.87E+01
8					1.71E+01	1.14E+01	1.73E+03	1.38E+03
	CE				9.56E+00	7.16E-01	8.39E+02	5.90E+02
		CE-141	3.253E+01	5.651E+17	1.39E-01	3.63E-02	3.78E+01	3.74E+01
		CE-143	1.375E+00	5.494E+17	1.69E-01	3.51E-01	2.13E+01	2.12E-01
		CE-144	2.844E+02	3.405E+17	9.25E+00	3.29E-01	7.80E+02	5.52E+02
	NP				7.55E+00	1.07E+01	2.02E+02	3.04E+00
		NP-239	2.350E+00	6.464E+18	7.55E+00	1.07E+01	2.02E+02	3.04E+00
	PU				2.31E-02	0.00E+00	6.85E+02	7.88E+02
		PU-238	3.251E+04	3.664E+14	2.31E-02	0.00E+00	3.46E+02	3.63E+02
		PU-239	8.912E+06	8.263E+13	0.00E+00	0.00E+00	6.63E+01	8.55E+01
		PU-240	2.469E+06	1.042E+14	0.00E+00	0.00E+00	8.63E+01	1.08E+02

Table B.4-1 (continued)

		PU-241	5.333E+03	1.755E+16	0.00E+00	0.00E+00	1.86E+02	2.31E+02
9					3.42E-01	6.28E-01	9.32E+01	2.75E+02
	BA				3.42E-01	6.28E-01	9.32E+01	2.75E+02
		BA-139	5.771E-02	6.282E+17	0.00E+00	5.60E-03	1.02E-01	0.00E+00
		BA-140	1.279E+01	6.216E+17	3.42E-01	6.22E-01	9.31E+01	2.75E+02

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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 seven days of the accident).

[6] Mean number of latent cancer fatalities due to chronic exposure.

Table B.4-2
PARTITION Input File for Sequoyah Analysis (Containing Dose Factors, Reactor Inventory, Site-Specific MACCS Results, and Other Information Needed to Define the Early and Chronic Health Effect Weights)

```
SEQUOYAH:  (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:  MCD SER #32,  1-NOV-88, 10:20:02  (RED MARROW ONLY)
         CLOUDSHINE  GROUND     GROUND     GROUND    INHALED   INHALED  INGESTION
                    SHINE 8HR SHINE 7DAY SHINE RATE ACUTE      CHRONIC
60
CO-58       3.869E-14 2.179E-11 4.430E-10 7.579E-16 1.577E-10 9.228E-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       6.562E-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 3.682E-11 6.913E-17 8.078E-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 6.562E-12
Y-92        1.012E-14 2.708E-12 3.425E-12 1.861E-16 2.061E-12 2.079E-12 4.930E-12
Y-93        3.710E-15 1.448E-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       6.084E-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 3.096E-11 5.074E-11 7.972E-11
TC-99M      4.217E-15 1.755E-12 2.915E-12 9.323E-17 2.296E-12 2.389E-12 6.273E-12
RU-103      1.849E-14 1.093E-11 2.166E-10 3.806E-16 8.176E-11 3.163E-10 1.666E-10
RU-105      3.076E-14 1.021E-11 1.558E-11 6.152E-16 7.221E-12 7.688E-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 5.385E-12 7.746E-12 1.463E-11
SB-127      2.584E-14 1.456E-11 1.799E-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 2.668E-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     6.026E-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 2.500E-10 3.951E-10 4.064E-10
I-131       1.449E-14 8.678E-12 1.363E-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       6.658E-14 2.377E-11 4.582E-11 1.165E-15 2.194E-11 2.231E-11 3.638E-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 4.653E-11 8.245E-10 1.620E-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 6.525E-10 1.471E-16 4.739E-10 1.221E-09 4.219E-10
LA-140      9.481E-14 4.419E-11 3.242E-10 1.843E-15 1.440E-10 2.124E-10 2.816E-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 1.569E-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 8.613E-13 2.070E-11 3.457E-17 4.025E-11 2.786E-09 8.660E-11
PR-143      3.552E-22 1.983E-19 3.531E-18 6.944E-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)

```
PU-238     4.535E-19 1.113E-15 2.340E-14 3.869E-20 2.552E-09 5.785E-05 1.266E-08
PU-239     1.671E-18 1.379E-15 2.665E-14 4.788E-20 2.400E-09 6.568E-05 1.405E-08
PU-240     4.661E-19 1.095E-15 2.301E-14 3.805E-20 2.400E-09 6.562E-05 1.405E-08
PU-241     0.000E+00 8.539E-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 7.766E-07
I-131 EARLY FATALITIES VS INVENTORY RELEASED
INVENTORY   # EARLY FATALITIES
  (BQ)
16
 1.000E+18   2.54E-01
 2.000E+18   1.12E+00
 3.000E+18   2.28E+00
 5.000E+18   5.18E+00
 7.000E+18   8.77E+00
 1.000E+19   1.47E+01
 2.000E+19   3.80E+01
 3.000E+19   6.25E+01
 5.000E+19   1.26E+02
 7.000E+19   2.12E+02
 1.000E+20   3.74E+02
 2.000E+20   1.16E+03
 3.000E+20   2.29E+03
 5.000E+20   4.95E+03
 7.000E+20   7.65E+03
 1.000E+21   1.14E+04
 ISOTOPE    HALF-LIFE   INVENTORY    EARLY      EARLY     E.L.C.F.  C.L.C.F.
             (DAYS)       (BQ)     FATALITIES INJURIES
CO-58       7.130E+01   3.223E+15   0.00E+00   0.00E+00   5.53E-01  4.99E+00
CO-60       1.921E+03   2.465E+15   0.00E+00   0.00E+00   2.34E+00  1.66E+02
KR-85       3.919E+03   2.475E+15   0.00E+00   0.00E+00   8.09E-05  0.00E+00
KR-85M      1.867E-01   1.159E+17   0.00E+00   0.00E+00   2.38E-02  0.00E+00
KR-87       5.278E-02   2.118E+17   0.00E+00   0.00E+00   9.53E-02  0.00E+00
KR-88       1.167E-01   2.864E+17   0.00E+00   8.61E-03   8.37E-01  0.00E+00
RB-86       1.865E+01   1.888E+14   0.00E+00   0.00E+00   5.70E-03  5.51E-03
SR-89       5.200E+01   3.590E+17   1.10E-01   1.41E-02   1.21E+01  1.06E+03
SR-90       1.026E+04   1.938E+16   0.00E+00   0.00E+00   9.09E+00  3.63E+03
SR-91       3.950E-01   4.616E+17   1.51E-01   1.02E+00   5.98E+00  2.60E-01
SR-92       1.129E-01   4.803E+17   5.32E-02   5.39E-01   2.51E+00  2.12E-29
Y-90        2.670E+00   2.079E+16   0.00E+00   0.00E+00   1.56E+00  1.09E-03
Y-91        5.880E+01   4.374E+17   1.69E+00   8.02E-02   1.40E+02  3.65E+01
Y-92        1.475E-01   4.621E+17   3.76E-02   8.35E-02   1.04E+00  6.52E-30
Y-93        4.208E-01   5.454E+17   2.50E-01   2.15E-01   6.43E+00  4.02E-11
ZR-95       6.550E+01   5.026E+17   4.92E-01   1.61E+00   8.01E+01  1.27E+03
ZR-97       7.000E-01   5.759E+17   1.27E+00   4.57E+00   3.12E+01  1.32E-05
NB-95       3.510E+01   5.224E+17   3.04E-01   1.45E+00   5.48E+01  2.89E+02
MO-99       2.751E+00   6.098E+17   2.77E-01   3.61E-01   3.40E+01  4.33E-01
TC-99M      2.508E-01   5.263E+17   0.00E+00   2.57E-03   4.23E-01  5.36E-18
RU-103      3.959E+01   4.542E+17   1.13E-01   5.24E-01   4.67E+01  1.90E+02
RU-105      1.850E-01   2.954E+17   1.20E-03   1.03E-01   1.52E+00  1.90E-04
RU-106      3.690E+02   1.032E+17   1.81E+00   3.66E-02   2.99E+02  3.47E+02
RH-105      1.479E+00   2.046E+17   0.00E+00   2.94E-04   2.17E+00  9.20E-04
SB-127      3.800E+00   2.787E+16   0.00E+00   6.86E-05   2.72E+00  1.54E-01
SB-129      1.808E-01   9.872E+16   1.42E-05   1.97E-02   6.67E-01  2.01E-24
TE-127      3.896E-01   2.692E+16   0.00E+00   0.00E+00   3.11E-02  1.79E-14
TE-127M     1.090E+02   3.564E+15   0.00E+00   0.00E+00   2.97E-01  2.43E-01
TE-129      4.861E-02   9.267E+16   0.00E+00   0.00E+00   8.27E-03  0.00E+00
TE-129M     3.340E+01   2.443E+16   0.00E+00   0.00E+00   3.27E+00  1.21E+00
TE-131M     1.250E+00   4.680E+16   1.28E-05   1.48E-02   3.58E+00  4.41E+00
TE-132      3.250E+00   4.658E+17   1.06E+00   3.88E+00   6.75E+01  5.28E+00
I-131       8.041E+00   3.206E+17   3.21E-03   1.13E-01   2.37E+01  1.69E+02
```

Table B.4-2 (continue.

```
I-132      9.521E-02   4.725E+17   1.19E-01  9.45E-01  2.07E+00  0.00E+00
I-133      8.667E-01   6.779E+17   1.82E-01  1.13E+00  1.26E+01  4.01E-04
I-134      3.653E-02   7.440E+17   5.42E-02  7.20E-01  1.09E+00  0.00E+00
I-135      2.744E-01   6.392E+17   5.77E-01  2.67E+00  7.47E+00  2.21E-15
XE-133     5.281E+00   6.782E+17   0.00E+00  0.00E+00  1.28E-01  0.00E+00
XE-135     3.821E-01   1.273E+17   0.00E+00  0.00E+00  5.59E-02  0.00E+00
CS-134     7.524E+02   4.324E+16   6.43E-04  2.35E-02  1.57E+01  5.65E+03
CS-136     1.300E+01   1.316E+16   0.00E+00  6.37E-04  3.43E+00  4.79E+00
CS-137     1.099E+04   2.417E+16   0.00E+00  0.00E+00  4.47E+00  4.10E+03
BA-139     5.771E-02   6.282E+17   0.00E+00  5.60E-03  1.02E-01  0.00E+00
BA-140     1.279E+01   6.216E+17   3.42E-01  6.22E-01  9.31E+01  2.75E+02
LA-140     1.676E+00   6.352E+17   2.49E+00  9.00E+00  6.76E+01  1.75E-01
LA-141     1.641E-01   5.826E+17   1.29E-02  1.16E-02  8.27E-01  1.96E-01
LA-142     6.625E-02   5.616E+17   1.17E-01  9.17E-01  1.85E+00  0.00E+00
CE-141     3.253E+01   5.651E+17   1.39E-01  3.63E-02  3.78E+01  3.74E+01
CE-143     1.375E+00   5.494E+17   1.69E-01  3.51E-01  2.13E+01  2.12E-01
CE-144     2.844E+02   3.405E+17   9.25E+00  3.29E-01  7.80E+02  5.52E+02
PR-143     1.358E+01   5.395E+17   2.55E-01  1.96E-02  3.60E+01  1.81E+00
ND-147     1.099E+01   2.412E+17   1.66E-02  1.14E-02  1.62E+01  4.91E+00
NP-239     2.350E+00   6.464E+18   7.55E+00  1.07E+01  2.02E+02  3.04E+00
PU-238     3.251E+04   3.664E+14   2.31E-02  0.00E+00  3.46E+02  3.63E+02
PU-239     8.912E+06   8.263E+13   0.00E+00  0.00E+00  6.63E+01  8.55E+01
PU-240     2.469E+06   1.042E+14   0.00E+00  0.00E+00  8.63E+01  1.08E+02
PU-241     5.333E+03   1.755E+16   0.00E+00  0.00E+00  1.86E+02  2.31E+02
AM-241     1.581E+05   1.159E+13   0.00E+00  0.00E+00  4.08E+00  6.48E+00
CM-242     1.630E+02   4.436E+15   1.42E+00  0.00E+00  1.97E+02  1.06E+02
CM-244     6.611E+03   2.596E+14   0.00E+00  0.00E+00  6.70E+01  7.87E+01
1.003         POWER LEVEL FOR SEQUOYAH (PWR INVENTORY)
NUCNAM   IGROUP       HAFLIF       ACTIVITY
                       (S)           (BQ)
CO-58       6        6.160E+06  3.223E+16
CO-60       6        1.660E+08  2.465E+16
KR-85       1        3.386E+08  2.475E+16
KR-85M      1        1.613E+04  1.159E+18
KR-87       1        4.560E+03  2.118E+18
KR-88       1        1.008E+04  2.864E+18
RB-86       3        1.611E+06  1.888E+15
SR-89       5        4.493E+06  3.590E+18
SR-90       5        8.865E+08  1.938E+17
SR-91       5        3.413E+04  4.616E+18
SR-92       5        9.756E+03  4.803E+18
Y-90        7        2.307E+05  2.079E+17
Y-91        7        5.080E+06  4.374E+18
Y-92        7        1.274E+04  4.821E+18
Y-93        7        3.636E+04  5.454E+18
ZR-95       7        5.659E+06  5.526E+18
ZR-97       7        6.048E+04  5.759E+18
NB-95       7        3.033E+06  5.224E+18
MO-99       6        2.377E+05  6.098E+18
TC-99M      6        2.167E+04  5.263E+18
RU-103      6        3.421E+06  4.542E+18
RU-105      6        1.598E+04  2.954E+18
RU-106      6        3.188E+07  1.032E+18
RH-105      6        1.278E+05  2.046E+18
SB-127      4        3.283E+05  2.787E+17
SB-129      4        1.562E+04  9.872E+17
TE-127      4        3.366E+04  2.692E+17
TE-127M     4        6.418E+06  3.564E+16
TE-129      4        4.200E+03  1.002E+18
TE-129M     4        2.886E+06  9.267E+17
TE-131M     4        1.080E+05  4.680E+17
TE-132      4        2.808E+05  4.658E+18
I-131       2        6.947E+05  3.206E+18
```

Table B.4-2 (continued)

I-132	2	8.226E+03	4.725E+18
I-133	2	7.488E+04	6.779E+18
I-134	2	3.156E+03	7.440E+18
I-135	2	2.371E+04	6.362E+18
XE-133	1	4.571E+05	6.782E+18
XE-135	1	3.301E+04	1.273E+18
CS-134	3	6.501E+07	4.324E+17
CS-136	3	1.123E+06	1.316E+17
CS-137	3	9.495E+08	2.417E+17
BA-139	9	4.986E+03	6.282E+18
BA-140	9	1.105E+06	6.216E+18
LA-140	7	1.448E+05	6.352E+18
LA-141	7	1.418E+04	5.826E+18
LA-142	7	5.724E+03	5.616E+18
CE-141	8	2.811E+06	5.651E+18
CE-143	8	1.188E+05	5.494E+18
CE-144	8	2.457E+07	3.405E+18
PR-143	7	1.173E+06	5.395E+18
ND-147	7	9.495E+05	2.412E+18
NP-239	8	2.030E+05	6.464E+19
PU-238	8	2.809E+09	3.664E+15
PU-239	8	7.700E+11	8.263E+14
PU-240	8	2.133E+11	1.042E+15
PU-241	8	4.808E+08	1.755E+17
AM-241	7	1.366E+10	1.159E+14
CM-242	7	1.408E+07	4.436E+16
CM-244	7	5.712E+08	2.596E+15

References

B.4-1 R.L. Iman, J.C. Helton, J.D. Johnson, "A User's Guide for PARTITION: A Program 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

TABLE

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 Sequoyah than is given in Table 4.3-1. Table C.1 shows mean results for the population within 10 mi of the plant under the assumptions that everyone evacuates, everyone continues normal activity, and everyone takes shelter. Further, divisions of results between within 10 mi and beyond 10 mi 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 mi with the results for evacuation, normal activity, and sheltering within 10 mi) 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 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 mi of the reactor due to radiation exposure within 7 days of the accident under the assumption that everyone within 10 mi evacuates 2.3 h after the warning time. For the two population dose consequence measures, the results are only for the part of the population initially within 10 mi. (The results for the population initially beyond 10 mi 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 mi 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 mi of the reactor due to radiation exposure within 7 days of the accident under the assumption that everyone within 10 mi continues their normal activities after the accident. For the two population dose consequence measures, the results are only for the part of the population initially within 10 mi. (The results for the population initially beyond 10 mi are in the column labeled 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 mi 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 mi of the reactor due to radiation exposure within 7 days of the accident under the assumption that everyone within 10 mi takes shelter 45 min after the warning time. For the two population dose consequence measures, the results are only for the part of the population initially within 10 mi. (The results for the population initially beyond 10 mi 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 mi 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 mi from the reactor due to radiation exposure within 7 days of the accident under the assumption that everyone beyond 10 mi continues their normal activities. For the two population dose consequence measures, the results are only for the part of the population initially beyond 10 mi. The value 1.000 in the row labeled WEIGHT at the top of the column indicates that everyone beyond 10 mi continues normal activities; the results in this column are multiplied by 1.000 in the generation of the mean results in the columns labeled TOTAL EARLY and TOTAL.

The column labeled TOTAL EARLY contains the total mean effects incurred by the entire population due to radiation exposure within 7 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 7 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

SOURCE TERM SEQ-01-1, MEAN FREQUENCY = 0.00E+00 /YR

SOURCE TERM SEQ-01-2, MEAN FREQUENCY = 7.82E-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	1.08E-03	0.00E+00	0.00E+00	0.00E+00	1.07E-03	----	1.07E-03
PRODROM VOMITING	4.58E-01	1.69E-02	9.21E-03	0.00E+00	4.56E-01	----	4.56E-01
EF RISK, 1 MI	1.57E-06	0.00E+00	0.00E+00	----	1.56E-06	----	1.56E-06
CANCER FATALITIES	1.75E+00	5.16E-01	3.82E-01	2.36E+00	4.11E+00	7.83E+00	1.19E+01
POP DOSE, 0-50 MI	7.40E+01	2.68E+01	1.74E+01	7.62E+01	1.50E+02	2.08E+02	3.58E+02
POP DOSE, 0-1000 MI	7.40E+01	2.68E+01	1.74E+01	1.35E+02	2.09E+02	5.12E+02	7.21E+02
ECONOMIC COSTS ($)	----	----	----	----	----	2.94E+06	2.94E+06
POP EF RISK, 0-1 MI	2.43E-06	0.00E+00	0.00E+00	----	2.42E-06	----	2.42E-06
POP CF RISK, 0-10 MI	4.49E-05	1.32E-05	9.79E-06	----	4.47E-05	1.20E-05	5.67E-05

SOURCE TERM SEQ-01-3, MEAN FREQUENCY = 0.00E+00 /YR

SOURCE TERM SEQ-02-1, MEAN FREQUENCY = 2.19E-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	2.89E-02	1.53E-04	0.00E+00	1.44E-04	----	1.44E-04
PRODROM VOMITING	0.00E+00	4.31E-01	5.27E-02	0.00E+00	2.16E-03	----	2.16E-03
EF RISK, 1 MI	0.00E+00	3.72E-06	0.00E+00	----	1.86E-08	----	1.86E-08
CANCER FATALITIES	2.86E-03	2.89E+00	1.65E+00	1.86E+01	1.86E+01	2.62E+01	4.49E+01
POP DOSE, 0-50 MI	3.10E-01	2.56E+02	1.67E+02	9.89E+02	9.91E+02	4.37E+02	1.43E+03
POP DOSE, 0-1000 MI	3.10E-01	2.56E+02	1.67E+02	1.57E+03	1.57E+03	2.40E+03	3.97E+03
ECONOMIC COSTS ($)	----	----	----	----	----	3.87E+07	3.87E+07
POP EF RISK, 0-1 MI	0.00E+00	7.27E-05	3.85E-07	----	3.64E-07	----	3.64E-07
POP CF RISK, 0-10 MI	7.33E-08	7.41E-05	4.23E-05	----	4.44E-07	1.93E-05	1.98E-05

SOURCE TERM SEQ-02-2, MEAN FREQUENCY = 1.27E-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	1.69E-03	0.00E+00	0.00E+00	0.00E+00	1.68E-03	----	1.68E-03
PRODROM VOMITING	4.40E-01	2.19E-02	1.09E-02	0.00E+00	4.37E-01	----	4.37E-01
EF RISK, 1 MI	1.16E-06	0.00E+00	0.00E+00	----	1.16E-06	----	1.16E-06
CANCER FATALITIES	1.87E+00	1.14E+00	4.21E-01	4.85E+00	6.71E+00	5.01E+01	5.68E+01
POP DOSE, 0-50 MI	8.35E+01	7.81E+01	2.03E+01	2.14E+02	2.97E+02	1.00E+03	1.30E+03
POP DOSE, 0-1000 MI	8.35E+01	7.81E+01	2.03E+01	3.42E+02	4.25E+02	3.12E+03	3.54E+03
ECONOMIC COSTS ($)	----	----	----	----	----	3.95E+07	3.95E+07
POP EF RISK, 0-1 MI	4.06E-06	0.00E+00	0.00E+00	----	4.04E-06	----	4.04E-06
POP CF RISK, 0-10 MI	4.81E-05	2.84E-05	1.08E-05	----	4.80E-05	5.07E-05	9.87E-05

SOURCE TERM SEQ-02-3, MEAN FREQUENCY = 7.44E-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	8.17E-01	4.48E-01	2.64E-01	0.00E+00	8.15E-01	----	8.15E-01
PRODROM VOMITING	1.21E+01	3.51E+00	2.57E+00	0.00E+00	1.21E+01	----	1.21E+01

Table C.1 (continued)

EF RISK, 1 MI	8.06E-04	4.14E-04	2.12E-04	----	8.04E-04	----	8.04E-04
CANCER FATALITIES	8.03E+00	3.33E+00	2.57E+00	7.84E+00	1.58E+01	1.96E+01	3.55E+01
POP DOSE, 0-50 MI	2.51E+02	1.42E+02	1.05E+02	3.22E+02	5.72E+02	4.83E+02	1.06E+03
POP DOSE, 0-1000 MI	2.51E+02	1.42E+02	1.05E+02	4.34E+02	6.84E+02	1.26E+03	1.94E+03
ECONOMIC COSTS ($)	----	----	----	----	----	1.03E+07	1.03E+07
POP EF RISK, 0-1 MI	1.37E-03	1.05E-03	6.35E-04	----	1.37E-03	----	1.37E-03
POP CF RISK, 0-10 MI	2.06E-04	8.54E-05	6.59E-05	----	2.05E-04	3.00E-05	2.35E-04

SOURCE TERM SEQ-03-1, MEAN FREQUENCY = 2.28E-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	3.85E-02	3.80E-04	0.00E+00	1.92E-04	----	1.92E-04
PRODROM VOMITING	0.00E+00	4.54E-01	5.63E-02	0.00E+00	2.27E-03	----	2.27E-03
EF RISK, 1 MI	0.00E+00	8.20E-06	0.00E+00	----	4.10E-08	----	4.10E-08
CANCER FATALITIES	3.89E-03	3.16E+00	1.82E+00	2.24E+01	2.24E+01	1.44E+02	1.66E+02
POP DOSE, 0-50 MI	4.14E-01	2.73E+02	1.79E+02	1.13E+03	1.13E+03	1.83E+03	2.96E+03
POP DOSE, 0-1000 MI	4.14E-01	2.73E+02	1.79E+02	1.86E+03	1.86E+03	9.00E+03	1.09E+04
ECONOMIC COSTS ($)	----	----	----	----	----	1.76E+08	1.76E+08
POP EF RISK, 0-1 MI	0.00E+00	9.68E-05	9.57E-07	----	4.84E-07	----	4.84E-07
POP CF RISK, 0-10 MI	9.98E-08	8.12E-05	4.67E-05	----	5.05E-07	3.74E-05	3.79E-05

SOURCE TERM SEQ-03-2, MEAN FREQUENCY = 3.29E-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	9.79E-05	0.00E+00	0.00E+00	0.00E+00	9.74E-05	----	9.74E-05
PRODROM VOMITING	1.18E-01	6.34E-03	1.63E-03	0.00E+00	1.17E-01	----	1.17E-01
EF RISK, 1 MI	8.43E-08	0.00E+00	0.00E+00	----	8.39E-08	----	8.39E-08
CANCER FATALITIES	1.83E+00	1.52E+00	4.30E-01	8.23E+00	1.01E+01	2.62E+02	2.72E+02
POP DOSE, 0-50 MI	1.04E+02	1.06E+02	2.58E+01	3.57E+02	4.61E+02	3.28E+03	3.75E+03
POP DOSE, 0-1000 MI	1.04E+02	1.06E+02	2.58E+01	5.92E+02	6.96E+02	1.51E+04	1.58E+04
ECONOMIC COSTS ($)	----	----	----	----	----	2.57E+08	2.57E+08
POP EF RISK, 0-1 MI	2.47E-07	0.00E+00	0.00E+00	----	2.45E-07	----	2.45E-07
POP CF RISK, 0-10 MI	4.71E-05	3.90E-05	1.10E-05	----	4.70E-05	1.00E-04	1.47E-04

SOURCE TERM SEQ-03-3, MEAN FREQUENCY = 0.00E+00 /YR

SOURCE TERM SEQ-04-1, MEAN FREQUENCY = 2.90E-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	0.00E+00	5.74E+00	1.04E+00	0.00E+00	2.87E-02	----	2.87E-02
PRODROM VOMITING	0.00E+00	1.80E+01	4.27E+00	0.00E+00	9.00E-02	----	9.00E-02
EF RISK, 1 MI	0.00E+00	5.66E-03	4.54E-04	----	2.83E-05	----	2.83E-05
CANCER FATALITIES	8.58E-04	4.43E+01	3.08E+01	1.80E+02	1.80E+02	3.14E+02	4.94E+02
POP DOSE, 0-50 MI	4.38E-02	1.30E+03	8.08E+02	4.68E+03	4.69E+03	3.02E+03	7.71E+03
POP DOSE, 0-1000 MI	4.38E-02	1.30E+03	8.08E+02	9.32E+03	9.32E+03	1.99E+04	2.92E+04
ECONOMIC COSTS ($)	----	----	----	----	----	3.99E+09	3.99E+09
POP EF RISK, 0-1 MI	0.00E+00	1.12E-02	2.52E-03	----	5.62E-05	----	5.62E-05
POP CF RISK, 0-10 MI	2.20E-08	1.14E-03	7.91E-04	----	5.71E-06	8.55E-05	9.12E-05

Table C.1 (continued)

SOURCE TERM SEQ-04-2, MEAN FREQUENCY = 2.65E-13 /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	8.60E-01	1.37E+00	5.77E-01	0.00E+00	8.62E-01	----	8.62E-01
PRODROM VOMITING	5.16E+00	5.25E+00	2.87E+00	0.00E+00	5.16E+00	----	5.16E+00
EF RISK, 1 MI	8.98E-04	1.19E-03	3.32E-04	----	8.99E-04	----	8.99E-04
CANCER FATALITIES	9.46E+00	5.65E+00	3.94E+00	2.57E+01	3.51E+01	1.56E+02	1.91E+02
POP DOSE, 0-50 MI	7.91E+02	4.39E+02	3.16E+02	1.38E+03	2.17E+03	2.43E+03	4.60E+03
POP DOSE, 0-1000 MI	7.91E+02	4.39E+02	3.16E+02	2.03E+03	2.82E+03	9.42E+03	1.22E+04
ECONOMIC COSTS ($)	----	----	----	----	----	1.98E+08	1.98E+08
POP EF RISK, 0-1 MI	2.08E-03	3.25E-03	1.43E-03	----	2.09E-03	----	2.09E-03
POP CF RISK, 0-10 MI	2.43E-04	1.45E-04	1.01E-04	----	2.42E-04	4.71E-05	2.89E-04

SOURCE TERM SEQ-04-3, MEAN FREQUENCY = 1.28E-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	8.41E-01	7.73E-01	4.18E-01	0.00E+00	8.41E-01	----	8.41E-01
PRODROM VOMITING	1.21E+01	5.09E+00	3.41E+00	0.00E+00	1.21E+01	----	1.21E+01
EF RISK, 1 MI	8.30E-04	7.86E-04	3.41E-04	----	8.30E-04	----	8.30E-04
CANCER FATALITIES	9.26E+00	7.96E+00	5.03E+00	2.80E+01	3.72E+01	3.34E+02	3.71E+02
POP DOSE, 0-50 MI	3.26E+02	4.92E+02	3.14E+02	1.33E+03	1.66E+03	4.66E+03	6.32E+03
POP DOSE, 0-1000 MI	3.26E+02	4.92E+02	3.14E+02	1.98E+03	2.30E+03	1.94E+04	2.17E+04
ECONOMIC COSTS ($)	----	----	----	----	----	4.96E+08	4.96E+08
POP EF RISK, 0-1 MI	1.42E-03	1.83E-03	1.01E-03	----	1.43E-03	----	1.43E-03
POP CF RISK, 0-10 MI	2.38E-04	2.04E-04	1.29E-04	----	2.37E-04	1.15E-04	3.53E-04

SOURCE TERM SEQ-05-1, MEAN FREQUENCY = 9.54E-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	2.77E-01	1.53E-02	0.00E+00	1.38E-03	----	1.38E-03
PRODROM VOMITING	0.00E+00	1.84E+00	2.85E-01	0.00E+00	9.20E-03	----	9.20E-03
EF RISK, 1 MI	0.00E+00	2.69E-04	1.62E-06	----	1.34E-06	----	1.34E-06
CANCER FATALITIES	6.20E-03	5.97E+00	3.55E+00	4.54E+01	4.54E+01	6.77E+02	7.22E+02
POP DOSE, 0-50 MI	5.46E-01	3.96E+02	2.65E+02	1.82E+03	1.82E+03	3.73E+03	5.55E+03
POP DOSE, 0-1000 MI	5.46E-01	3.96E+02	2.65E+02	3.21E+03	3.22E+03	3.86E+04	4.18E+04
ECONOMIC COSTS ($)	----	----	----	----	----	1.44E+09	1.44E+09
POP EF RISK, 0-1 MI	0.00E+00	6.79E-04	3.86E-05	----	3.39E-06	----	3.39E-06
POP CF RISK, 0-10 MI	1.59E-07	1.53E-04	9.10E-05	----	9.24E-07	7.17E-05	7.26E-05

SOURCE TERM SEQ-05-2, MEAN FREQUENCY = 1.95E-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	2.86E-03	1.02E-02	6.75E-04	0.00E+00	2.89E-03	----	2.89E-03
PRODROM VOMITING	3.50E-01	2.38E-01	7.71E-02	0.00E+00	3.49E-01	----	3.49E-01
EF RISK, 1 MI	9.31E-07	7.65E-07	0.00E+00	----	9.31E-07	----	9.31E-07
CANCER FATALITIES	2.00E+01	8.19E+00	4.31E+00	4.82E+01	6.82E+01	6.39E+02	7.07E+02
POP DOSE, 0-50 MI	6.48E+02	3.74E+02	1.70E+02	1.75E+03	2.39E+03	5.37E+03	7.76E+03
POP DOSE, 0-1000 MI	6.48E+02	3.74E+02	1.70E+02	3.07E+03	3.71E+03	3.76E+04	4.13E+04
ECONOMIC COSTS ($)	----	----	----	----	----	2.29E+09	2.29E+09
POP EF RISK, 0-1 MI	7.04E-06	2.57E-05	1.70E-06	----	7.13E-06	----	7.13E-06
POP CF RISK, 0-10 MI	5.14E-04	2.10E-04	1.10E-04	----	5.13E-04	1.43E-04	6.56E-04

Table C.1 (continued)

SOURCE TERM SEQ-05-3, MEAN FREQUENCY = 0.00E+00 /YR

SOURCE TERM SEQ-06-1, MEAN FREQUENCY = 3.55E-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	3.66E-02	2.74E-04	0.00E+00	1.83E-04	----	1.83E-04
PRODROM VOMITING	0.00E+00	4.73E-01	5.37E-02	0.00E+00	2.37E-03	----	2.37E-03
EF RISK, 1 MI	0.00E+00	6.60E-06	0.00E+00	----	3.30E-08	----	3.30E-08
CANCER FATALITIES	5.75E-03	3.68E+00	2.06E+00	2.84E+01	2.84E+01	3.98E+02	4.27E+02
POP DOSE, 0-50 MI	5.60E-01	2.86E+02	1.83E+02	1.29E+03	1.29E+03	3.22E+03	4.51E+03
POP DOSE, 0-1000 MI	5.60E-01	2.86E+02	1.83E+02	2.17E+03	2.17E+03	2.30E+04	2.52E+04
ECONOMIC COSTS ($)	----	----	----	----	----	7.16E+08	7.16E+08
POP EF RISK, 0-1 MI	0.00E+00	9.21E-05	6.91E-07	----	4.60E-07	----	4.60E-07
POP CF RISK, 0-10 MI	1.47E-07	9.44E-05	5.28E-05	----	6.19E-07	5.73E-05	5.79E-05

SOURCE TERM SEQ-06-2, MEAN FREQUENCY = 5.52E-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	1.54E-03	1.54E-03	1.22E-04	0.00E+00	1.54E-03	----	1.54E-03
PRODROM VOMITING	2.94E-01	1.06E-01	3.51E-02	0.00E+00	2.93E-01	----	2.93E-01
EF RISK, 1 MI	1.80E-07	0.00E+00	0.00E+00	----	1.79E-07	----	1.79E-07
CANCER FATALITIES	3.84E+00	2.55E+00	1.02E+00	1.43E+01	1.82E+01	5.79E+02	5.97E+02
POP DOSE, 0-50 MI	2.47E+02	1.67E+02	6.91E+01	6.06E+02	8.52E+02	5.25E+03	6.11E+03
POP DOSE, 0-1000 MI	2.47E+02	1.67E+02	6.91E+01	9.87E+02	1.23E+03	3.28E+04	3.40E+04
ECONOMIC COSTS ($)	----	----	----	----	----	8.72E+08	8.72E+08
POP EF RISK, 0-1 MI	3.87E-06	3.89E-06	3.08E-07	----	3.87E-06	----	3.87E-06
POP CF RISK, 0-10 MI	9.86E-05	6.53E-05	2.62E-05	----	9.84E-05	1.38E-04	2.37E-04

SOURCE TERM SEQ-06-3, MEAN FREQUENCY = 0.00E+00 /YR

SOURCE TERM SEQ-07-1, MEAN FREQUENCY = 0.00E+00 /YR

SOURCE TERM SEQ-07-2, MEAN FREQUENCY = 0.00E+00 /YR

SOURCE TERM SEQ-07-3, MEAN FREQUENCY = 9.70E-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	1.93E+00	4.97E+00	2.57E+00	0.00E+00	1.95E+00	----	1.95E+00
PRODROM VOMITING	1.94E+01	1.84E+01	1.12E+01	1.05E-01	1.95E+01	----	1.95E+01
EF RISK, 1 MI	1.73E-03	4.84E-03	2.39E-03	----	1.75E-03	----	1.75E-03
CANCER FATALITIES	1.92E+01	3.22E+01	2.36E+01	1.32E+02	1.51E+02	1.54E+03	1.69E+03
POP DOSE, 0-50 MI	9.13E+02	1.59E+03	1.17E+03	5.11E+03	6.02E+03	8.88E+03	1.49E+04
POP DOSE, 0-1000 MI	9.13E+02	1.59E+03	1.17E+03	8.70E+03	9.61E+03	8.97E+04	9.93E+04
ECONOMIC COSTS ($)	----	----	----	----	----	7.04E+09	7.04E+09
POP EF RISK, 0-1 MI	3.02E-03	1.06E-02	5.81E-03	----	3.06E-03	----	3.06E-03
POP CF RISK, 0-10 MI	4.93E-04	8.25E-04	6.06E-04	----	4.95E-04	2.09E-04	7.04E-04

Table C.1 (continued)

SOURCE TERM SEQ-08-1, MEAN FREQUENCY = 1.27E-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	2.72E+00	9.09E-01	0.00E+00	1.36E-02	----	1.36E-02
PRODROM VOMITING	0.00E+00	9.09E+00	2.68E+00	0.00E+00	4.55E-02	----	4.55E-02
EF RISK, 1 MI	0.00E+00	1.95E-03	4.51E-04	----	9.76E-06	----	9.76E-06
CANCER FATALITIES	1.31E+00	8.65E+01	6.47E+01	3.19E+02	3.21E+02	1.08E+03	1.40E+03
POP DOSE, 0-50 MI	8.01E+01	2.56E+03	1.89E+03	8.11E+03	8.20E+03	7.58E+03	1.58E+04
POP DOSE, 0-1000 MI	8.01E+01	2.56E+03	1.89E+03	1.73E+04	1.74E+04	6.86E+04	8.60E+04
ECONOMIC COSTS ($)	----	----	----	----	----	1.75E+10	1.75E+10
POP EF RISK, 0-1 MI	0.00E+00	5.52E-03	2.06E-03	----	2.76E-05	----	2.76E-05
POP CF RISK, 0-10 MI	3.37E-05	2.22E-03	1.66E-03	----	4.47E-05	1.18E-04	1.62E-04

SOURCE TERM SEQ-08-2, MEAN FREQUENCY = 2.24E-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	5.68E-02	2.37E-01	6.23E-02	0.00E+00	5.77E-02	----	5.77E-02
PRODROM VOMITING	1.74E+00	1.65E+00	6.12E-01	0.00E+00	1.74E+00	----	1.74E+00
EF RISK, 1 MI	5.07E-05	2.06E-04	2.25E-05	----	5.15E-05	----	5.15E-05
CANCER FATALITIES	4.70E+01	1.66E+01	1.01E+01	1.19E+02	1.65E+02	1.51E+03	1.68E+03
POP DOSE, 0-50 MI	1.54E+03	6.92E+02	3.94E+02	3.89E+03	5.43E+03	8.11E+03	1.35E+04
POP DOSE, 0-1000 MI	1.54E+03	6.92E+02	3.94E+02	7.31E+03	8.85E+03	8.90E+04	9.78E+04
ECONOMIC COSTS ($)	----	----	----	----	----	6.87E+09	6.87E+09
POP EF RISK, 0-1 MI	9.08E-05	5.74E-04	1.56E-04	----	9.32E-05	----	9.32E-05
POP CF RISK, 0-10 MI	1.21E-03	4.25E-04	2.59E-04	----	1.20E-03	1.88E-04	1.39E-03

SOURCE TERM SEQ-08-3, MEAN FREQUENCY = 1.25E-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	1.61E+00	2.87E+00	1.53E+00	0.00E+00	1.61E+00	----	1.61E+00
PRODROM VOMITING	1.75E+01	1.18E+01	7.41E+00	9.19E-02	1.75E+01	----	1.75E+01
EF RISK, 1 MI	1.48E-03	2.91E-03	1.58E-03	----	1.49E-03	----	1.49E-03
CANCER FATALITIES	1.67E+01	2.89E+01	2.09E+01	1.07E+02	1.24E+02	9.25E+02	1.05E+03
POP DOSE, 0-50 MI	7.63E+02	1.18E+03	8.50E+02	4.02E+03	4.78E+03	5.88E+03	1.07E+04
POP DOSE, 0-1000 MI	7.63E+02	1.18E+03	8.50E+02	6.77E+03	7.53E+03	5.50E+04	6.25E+04
ECONOMIC COSTS ($)	----	----	----	----	----	7.48E+09	7.48E+09
POP EF RISK, 0-1 MI	2.59E-03	6.23E-03	3.56E-03	----	[illegible]	----	2.61E-03
POP CF RISK, 0-10 MI	4.29E-04	7.41E-04	5.37E-04	----	[illegible]	1.22E-04	[illegible]

SOURCE TERM SEQ-09-1, MEAN FREQUENCY = 2.39E-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	6.12E-01	6.76E-02	0.00E+00	3.06E-03	----	3.06E-03
PRODROM VOMITING	0.00E+00	3.09E+00	8.13E-01	0.00E+00	1.54E-02	----	1.54E-02
EF RISK, 1 MI	0.00E+00	4.40E-04	1.14E-05	----	2.20E-06	----	2.20E-06
CANCER FATALITIES	4.38E-01	1.20E+01	7.75E+00	6.49E+01	6.54E+01	1.37E+03	1.44E+03
POP DOSE, 0-50 MI	3.56E+01	7.24E+02	4.92E+02	2.82E+03	2.86E+03	7.45E+03	1.03E+04
POP DOSE, 0-1000 MI	3.56E+01	7.24E+02	4.92E+02	4.57E+03	4.61E+03	7.84E+04	8.31E+04
ECONOMIC COSTS ($)	----	----	----	----	----	3.61E+09	3.61E+09
POP EF RISK, 0-1 MI	0.00E+00	1.51E-03	1.70E-04	----	7.55E-06	----	7.55E-06
POP CF RISK, 0-10 MI	1.13E-05	3.08E-04	1.99E-04	----	1.27E-05	1.73E-04	1.86E-04

Table C.1 (continued)

SOURCE TERM SEQ-09-2, MEAN FREQUENCY = 7.38E-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	8.08E-02	1.85E-01	3.88E-02	0.00E+00	8.13E-02	----	8.13E-02
PRODROM VOMITING	1.51E+00	1.40E+00	5.31E-01	0.00E+00	1.51E+00	----	1.51E+00
EF RISK, 1 MI	7.91E-05	8.52E-05	5.12E-06	----	7.92E-05	----	7.92E-05
CANCER FATALITIES	4.23E+01	1.39E+01	9.28E+00	7.49E+01	1.17E+02	1.14E+03	1.26E+03
POP DOSE, 0-50 MI	1.37E+03	5.57E+02	3.57E+02	2.44E+03	3.81E+03	6.74E+03	1.05E+04
POP DOSE, 0-1000 MI	1.37E+03	5.57E+02	3.57E+02	4.59E+03	5.96E+03	6.63E+04	7.23E+04
ECONOMIC COSTS ($)	----	----	----	----	----	4.00E+09	4.00E+09
POP EF RISK, 0-1 MI	1.23E-04	4.60E-04	9.76E-05	----	1.25E-04	----	1.25E-04
POP CF RISK, 0-10 MI	1.08E-03	3.57E-04	2.38E-04	----	1.08E-03	1.67E-04	1.25E-03

SOURCE TERM SEQ-09-3, MEAN FREQUENCY = 0.00E+00 /YR

SOURCE TERM SEQ-10-1, MEAN FREQUENCY = 5.04E-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	1.21E-01	4.78E-03	0.00E+00	6.03E-04	----	6.03E-04
PRODROM VOMITING	0.00E+00	1.15E+00	2.30E-01	0.00E+00	5.77E-03	----	5.77E-03
EF RISK, 1 MI	0.00E+00	2.16E-05	0.00E+00	----	1.08E-07	----	1.08E-07
CANCER FATALITIES	1.65E-01	5.97E+00	3.20E+00	3.82E+01	3.84E+01	1.08E+03	1.12E+03
POP DOSE, 0-50 MI	1.46E+01	4.01E+02	2.39E+02	1.68E+03	1.70E+03	6.26E+03	7.96E+03
POP DOSE, 0-1000 MI	1.46E+01	4.01E+02	2.39E+02	2.64E+03	2.66E+03	6.13E+04	6.39E+04
ECONOMIC COSTS ($)	----	----	----	----	----	2.18E+09	2.18E+09
POP EF RISK, 0-1 MI	0.00E+00	3.04E-04	1.20E-05	----	1.52E-06	----	1.52E-06
POP CF RISK, 0-10 MI	4.23E-06	1.53E-04	8.21E-05	----	4.98E-06	1.67E-04	1.72E-04

SOURCE TERM SEQ-10-2, MEAN FREQUENCY = 2.25E-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	3.45E-04	0.00E+00	0.00E+00	1.73E-06	----	1.73E-06
PRODROM VOMITING	2.64E-02	6.11E-02	1.64E-02	0.00E+00	2.66E-02	----	2.66E-02
EF RISK, 1 MI	0.00E+00	0.00E+00	0.00E+00	----	0.00E+00	----	0.00E+00
CANCER FATALITIES	2.79E+00	4.24E+00	9.95E-01	2.83E+01	3.11E+01	1.19E+03	1.22E+03
POP DOSE, 0-50 MI	1.92E+02	3.00E+02	6.98E+01	1.33E+03	1.52E+03	9.34E+03	1.09E+04
POP DOSE, 0-1000 MI	1.92E+02	3.00E+02	6.98E+01	2.06E+03	2.25E+03	6.75E+04	6.98E+04
ECONOMIC COSTS ($)	----	----	----	----	----	2.37E+09	2.37E+09
POP EF RISK, 0-1 MI	0.00E+00	8.70E-07	0.00E+00	----	4.35E-09	----	4.35E-09
POP CF RISK, 0-10 MI	7.16E-05	1.09E-04	2.55E-05	----	7.18E-05	2.41E-04	3.13E-04

SOURCE TERM SEQ-10-3, MEAN FREQUENCY = 0.00E+00 /YR

SOURCE TERM SEQ-11-1, MEAN FREQUENCY = 1.10E-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	1.98E+01	8.80E+00	0.00E+00	9.90E-02	----	9.90E-02
PRODROM VOMITING	3.12E-04	5.07E+01	2.03E+01	1.17E+00	1.42E+00	----	1.42E+00
EF RISK, 1 MI	0.00E+00	2.05E-02	1.10E-02	----	1.02E-04	----	1.02E-04
CANCER FATALITIES	2.14E+01	1.41E+02	1.11E+02	5.70E+02	5.92E+02	2.47E+03	3.07E+03
POP DOSE, 0-50 MI	6.73E+02	5.04E+03	3.72E+03	1.29E+04	1.36E+04	1.29E+04	2.65E+04

Table C.1 (continued)

POP DOSE, 0-1000 MI	6.73E+02	5.04E+03	3.72E+03	2.87E+04	2.94E+04	1.51E+05	1.80E+05
ECONOMIC COSTS ($)	----	----	----	----	----	2.60E+10	2.60E+10
POP EF RISK, 0-1 MI	0.00E+00	2.14E-02	1.43E-02	----	1.07E-04	----	1.07E-04
POP CF RISK, 0-10 MI	5.50E-04	3.62E-03	2.86E-03	----	5.65E-04	8.65E-05	6.52E-04

SOURCE TERM SEQ-11-2, MEAN FREQUENCY = 2.92E-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	2.60E+00	3.24E+00	1.29E+00	0.00E+00	2.60E+00	----	2.60E+00
PRODROM VOMITING	1.26E+01	1.65E+01	6.38E+00	9.85E-01	1.36E+01	----	1.36E+01
EF RISK, 1 MI	2.55E-03	3.15E-03	9.75E-04	----	2.55E-03	----	2.55E-03
CANCER FATALITIES	9.21E+01	3.47E+01	2.37E+01	3.07E+02	3.99E+02	3.00E+03	3.40E+03
POP DOSE, 0-50 MI	3.65E+03	1.47E+03	1.03E+03	8.50E+03	1.21E+04	1.27E+04	2.48E+04
POP DOSE, 0-1000 MI	3.65E+03	1.47E+03	1.03E+03	1.90E+04	2.27E+04	1.80E+05	2.02E+05
ECONOMIC COSTS ($)	----	----	----	----	----	2.25E+10	2.25E+10
POP EF RISK, 0-1 MI	2.20E-03	6.25E-03	2.96E-03	----	2.22E-03	----	2.22E-03
POP CF RISK, 0-10 MI	2.36E-03	8.90E-04	6.09E-04	----	2.36E-03	1.17E-04	2.47E-03

SOURCE TERM SEQ-11-3, MEAN FREQUENCY = 2.09E-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	2.81E+01	1.94E+01	1.17E+01	0.00E+00	2.81E+01	----	2.81E+01
PRODROM VOMITING	6.31E+01	5.44E+01	3.23E+01	1.44E+00	6.45E+01	----	6.45E+01
EF RISK, 1 MI	1.35E-02	2.03E-02	1.40E-02	----	1.36E-02	----	1.36E-02
CANCER FATALITIES	2.85E+02	1.62E+02	1.31E+02	6.22E+02	9.06E+02	1.81E+03	2.72E+03
POP DOSE, 0-50 MI	9.04E+03	5.48E+03	4.23E+03	1.44E+04	2.35E+04	1.02E+04	3.36E+04
POP DOSE, 0-1000 MI	9.04E+03	5.48E+03	4.23E+03	2.97E+04	3.87E+04	1.13E+05	1.52E+05
ECONOMIC COSTS ($)	----	----	----	----	----	2.08E+10	2.08E+10
POP EF RISK, 0-1 MI	1.57E-02	2.26E-02	1.71E-02	----	1.57E-02	----	1.57E-02
POP CF RISK, 0-10 MI	7.32E-03	4.16E-03	3.37E-03	----	7.30E-03	7.24E-05	7.37E-03

SOURCE TERM SEQ-12-1, MEAN FREQUENCY = 3.03E-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	6.13E+00	1.90E+00	0.00E+00	3.06E-02	----	3.06E-02
PRODROM VOMITING	0.00E+00	1.88E+01	6.91E+00	0.00E+00	9.42E-02	----	9.42E-02
EF RISK, 1 MI	0.00E+00	8.77E-03	1.92E-03	----	4.38E-05	----	4.38E-05
CANCER FATALITIES	2.95E+00	3.53E+01	2.51E+01	1.55E+02	1.58E+02	2.30E+03	2.45E+03
POP DOSE, 0-50 MI	1.98E+02	1.88E+03	1.33E+03	5.49E+03	5.69E+03	1.13E+04	1.70E+04
POP DOSE, 0-1000 MI	1.98E+02	1.88E+03	1.33E+03	1.03E+04	1.05E+04	1.34E+05	1.44E+05
ECONOMIC COSTS ($)	----	----	----	----	----	1.03E+10	1.03E+10
POP EF RISK, 0-1 MI	0.00E+00	1.12E-02	4.34E-03	----	5.61E-05	----	5.61E-05
POP CF RISK, 0-10 MI	7.57E-05	9.05E-04	6.43E-04	----	7.98E-05	1.17E-04	1.97E-04

SOURCE TERM SEQ-12-2, MEAN FREQUENCY = 1.07E-06 /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	9.47E-01	1.38E+00	4.76E-01	0.00E+00	9.49E-01	----	9.49E-01
PRODROM VOMITING	6.12E+00	7.14E+00	2.77E+00	1.36E-01	6.26E+00	----	6.26E+00
EF RISK, 1 MI	6.69E-04	1.09E-03	3.07E-04	----	6.71E-04	----	6.71E-04
CANCER FATALITIES	6.48E+01	2.48E+01	1.56E+01	1.59E+02	2.24E+02	2.43E+03	2.65E+03
POP DOSE, 0-50 MI	2.51E+03	1.09E+03	6.77E+02	5.01E+03	7.52E+03	1.05E+04	1.80E+04

Table C.1 (continued)

POP DOSE, 0-1000 MI	2.51E+03	1.09E+03	6.77E+02	9.93E+03	1.24E+04	1.42E+05	1.55E+05
ECONOMIC COSTS ($)	----	----	----	----	----	1.20E+10	1.20E+10
POP EF RISK, 0-1 MI	9.35E-04	3.07E-03	1.16E-03	----	9.46E-04	----	9.46E-04
POP CF RISK, 0-10 MI	1.66E-03	6.38E-04	3.99E-04	----	1.66E-03	1.57E-04	1.82E-03

SOURCE TERM SEQ-12-3, MEAN FREQUENCY = 1.16E-11 /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	2.49E+00	4.28E+00	2.14E+00	0.00E+00	2.50E+00	----	2.50E+00
PRODROM VOMITING	2.34E+01	1.70E+01	1.02E+01	1.76E-01	2.35E+01	----	2.35E+01
EF RISK, 1 MI	2.06E-03	5.34E-03	2.33E-03	----	2.07E-03	----	2.07E-03
CANCER FATALITIES	2.65E+01	1.55E+01	1.09E+01	7.27E+01	9.92E+01	1.72E+03	1.82E+03
POP DOSE, 0-50 MI	1.32E+03	8.83E+02	6.24E+02	2.99E+03	4.30E+03	6.62E+03	1.09E+04
POP DOSE, 0-1000 MI	1.32E+03	8.83E+02	6.24E+02	4.93E+03	6.25E+03	9.84E+04	1.05E+05
ECONOMIC COSTS ($)	----	----	----	----	----	4.70E+09	4.70E+09
POP EF RISK, 0-1 MI	3.52E-03	8.05E-03	4.52E-03	----	3.55E-03	----	3.55E-03
POP CF RISK, 0-10 MI	6.81E-04	3.99E-04	2.79E-04	----	6.79E-04	7.23E-05	7.52E-04

SOURCE TERM SEQ-13-1, MEAN FREQUENCY = 1.02E-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	2.25E+00	6.40E-01	0.00E+00	1.13E-02	----	1.13E-02
PRODROM VOMITING	0.00E+00	8.01E+00	2.78E+00	0.00E+00	4.01E-02	----	4.01E-02
EF RISK, 1 MI	0.00E+00	2.56E-03	4.92E-04	----	1.28E-05	----	1.28E-05
CANCER FATALITIES	3.00E+00	2.53E+01	1.79E+01	1.06E+02	1.09E+02	1.46E+03	1.57E+03
POP DOSE, 0-50 MI	1.77E+02	1.15E+03	8.08E+02	3.73E+03	3.92E+03	8.30E+03	1.22E+04
POP DOSE, 0-1000 MI	1.77E+02	1.15E+03	8.08E+02	6.82E+03	7.00E+03	8.52E+04	9.22E+04
ECONOMIC COSTS ($)	----	----	----	----	----	7.80E+09	7.80E+09
POP EF RISK, 0-1 MI	0.00E+00	4.93E-03	1.58E-03	----	2.47E-05	----	2.47E-05
POP CF RISK, 0-10 MI	7.71E-05	6.49E-04	4.59E-04	----	8.00E-05	1.19E-04	1.99E-04

SOURCE TERM SEQ-13-2, MEAN FREQUENCY = 7.49E-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	4.64E-02	1.98E-01	4.37E-02	0.00E+00	4.72E-02	----	4.72E-02
PRODROM VOMITING	1.56E+00	1.46E+00	5.58E-01	0.00E+00	1.56E+00	----	1.56E+00
EF RISK, 1 MI	4.32E-05	1.29E-04	1.00E-05	----	4.37E-05	----	4.37E-05
CANCER FATALITIES	1.57E+01	7.19E+00	4.02E+00	5.11E+01	6.67E+01	2.13E+03	2.20E+03
POP DOSE, 0-50 MI	1.03E+03	4.86E+02	2.81E+02	2.13E+03	3.16E+03	1.03E+04	1.34E+04
POP DOSE, 0-1000 MI	1.03E+03	4.86E+02	2.81E+02	3.71E+03	4.74E+03	1.21E+05	1.26E+05
ECONOMIC COSTS ($)	----	----	----	----	----	4.88E+09	4.88E+09
POP EF RISK, 0-1 MI	4.77E-05	4.88E-04	1.10E-04	----	4.99E-05	----	4.99E-05
POP CF RISK, 0-10 MI	4.03E-04	1.85E-04	1.03E-04	----	4.02E-04	2.28E-04	6.29E-04

SOURCE TERM SEQ-13-3, MEAN FREQUENCY = 0.00E+00 /YR

SOURCE TERM SEQ-14-1, MEAN FREQUENCY = 5.23E-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	1.17E+00	1.57E+02	9.94E+01	1.10E+01	1.29E+01	----	1.29E+01
PRODROM VOMITING	1.16E+00	2.54E+02	1.16E+02	8.09E+01	8.33E+01	----	8.33E+01

Table C.1 (continued)

EF RISK, 1 MI	1.43E-03	5.30E-02	4.68E-02	----	1.69E-03	----	1.69E-03
CANCER FATALITIES	3.14E+02	7.74E+02	6.92E+02	5.01E+03	5.32E+03	3.48E+03	8.80E+03
POP DOSE, 0-50 MI	7.18E+03	3.72E+04	2.87E+04	8.64E+04	9.37E+04	1.95E+04	1.13E+05
POP DOSE, 0-1000 MI	7.18E+03	3.72E+04	2.87E+04	1.72E+05	1.80E+05	2.21E+05	4.01E+05
ECONOMIC COSTS ($)	----	----	----	----	----	5.17E+10	5.17E+10
POP EF RISK, 0-1 MI	1.19E-03	4.98E-02	4.38E-02	----	1.44E-03	----	1.44E-03
POP CF RISK, 0-10 MI	8.05E-03	1.99E-02	1.77E-02	----	8.11E-03	7.23E-05	8.19E-03

SOURCE TERM SEQ-14-2, MEAN FREQUENCY = 4.75E-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	4.99E+01	3.19E+01	1.04E+01	3.35E+00	5.31E+01	----	5.31E+01
PRODROM VOMITING	1.02E+02	1.14E+02	5.03E+01	7.28E+01	1.74E+02	----	1.74E+02
EF RISK, 1 MI	1.30E-02	1.62E-02	1.17E-02	----	1.30E-02	----	1.30E-02
CANCER FATALITIES	4.12E+02	1.39E+02	1.14E+02	1.19E+03	1.60E+03	4.79E+03	6.40E+03
POP DOSE, 0-50 MI	1.65E+04	5.34E+03	4.01E+03	2.42E+04	4.07E+04	1.47E+04	5.54E+04
POP DOSE, 0-1000 MI	1.65E+04	5.34E+03	4.01E+03	6.13E+04	7.77E+04	2.93E+05	3.71E+05
ECONOMIC COSTS ($)	----	----	----	----	----	5.24E+10	5.24E+10
POP EF RISK, 0-1 MI	1.26E-02	1.39E-02	1.09E-02	----	1.26E-02	----	1.26E-02
POP CF RISK, 0-10 MI	1.06E-02	3.56E-03	2.91E-03	----	1.05E-02	8.50E-05	1.06E-02

SOURCE TERM SEQ-14-3, MEAN FREQUENCY = 7.98E-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	1.40E+02	7.83E+01	4.73E+01	4.34E-01	1.40E+02	----	1.40E+02
PRODROM VOMITING	1.79E+02	1.84E+02	1.08E+02	3.35E+01	2.12E+02	----	2.12E+02
EF RISK, 1 MI	3.39E-02	4.47E-02	3.58E-02	----	3.40E-02	----	3.40E-02
CANCER FATALITIES	5.78E+02	4.06E+02	3.49E+02	2.12E+03	2.70E+03	3.20E+03	5.90E+03
POP DOSE, 0-50 MI	2.81E+04	1.56E+04	1.21E+04	4.03E+04	6.83E+04	1.37E+04	8.20E+04
POP DOSE, 0-1000 MI	2.81E+04	1.56E+04	1.21E+04	8.63E+04	1.14E+05	2.01E+05	3.16E+05
ECONOMIC COSTS ($)	----	----	----	----	----	4.21E+10	4.21E+10
POP EF RISK, 0-1 MI	2.91E-02	4.28E-02	3.50E-02	----	2.92E-02	----	2.92E-02
POP CF RISK, 0-10 MI	1.48E-02	1.04E-02	8.94E-03	----	1.48E-02	4.88E-05	1.49E-02

SOURCE TERM SEQ-15-1, MEAN FREQUENCY = 5.87E-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	2.19E+01	8.64E+00	0.00E+00	1.09E-01	----	1.09E-01
PRODROM VOMITING	1.87E-03	6.01E+01	2.41E+01	1.76E+00	2.06E+00	----	2.06E+00
EF RISK, 1 MI	0.00E+00	2.15E-02	1.18E-02	----	1.07E-04	----	1.07E-04
CANCER FATALITIES	1.40E+01	8.12E+01	6.17E+01	3.58E+02	3.72E+02	3.06E+03	3.43E+03
POP DOSE, 0-50 MI	6.91E+02	4.08E+03	2.93E+03	1.03E+04	1.10E+04	1.16E+04	2.26E+04
POP DOSE, 0-1000 MI	6.91E+02	4.08E+03	2.93E+03	2.17E+04	2.24E+04	1.81E+05	2.03E+05
ECONOMIC COSTS ($)	----	----	----	----	----	2.11E+10	2.11E+10
POP EF RISK, 0-1 MI	0.00E+00	2.25E-02	1.40E-02	----	1.13E-04	----	1.13E-04
POP CF RISK, 0-10 MI	3.59E-04	2.08E-03	1.58E-03	----	3.67E-04	1.06E-04	4.73E-04

SOURCE TERM SEQ-15-2, MEAN FREQUENCY = 3.69E-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	1.03E+01	7.19E+00	2.75E+00	4.24E-02	1.03E+01	----	1.03E+01
PRODROM VOMITING	3.56E+01	3.75E+01	1.44E+01	9.66E+00	4.53E+01	----	4.53E+01

EF RISK, 1 MI	2.26E-03	8.61E-03	2.76E-03	----	2.29E-03	----	2.29E-03
CANCER FATALITIES	1.31E+02	4.58E+01	3.17E+01	4.02E+02	5.32E+02	4.16E+03	4.70E+03
POP DOSE, 0-50 MI	6.59E+03	2.24E+03	1.60E+03	1.15E+04	1.81E+04	1.26E+04	3.07E+04
POP DOSE, 0-1000 MI	6.59E+03	2.24E+03	1.60E+03	2.54E+04	3.20E+04	2.47E+05	2.79E+05
ECONOMIC COSTS ($)	----	----	----	----	----	2.80E+10	2.80E+10
POP EF RISK, 0-1 MI	4.15E-03	9.04E-03	5.44E-03	----	4.18E-03	----	4.18E-03
POP CF RISK, 0-10 MI	3.36E-03	1.17E-03	8.13E-04	----	3.35E-03	1.43E-04	3.49E-03

SOURCE TERM SEQ-15-3, MEAN FREQUENCY = 5.42E-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	1.60E+01	2.72E+01	1.47E+01	0.00E+00	1.61E+01	----	1.61E+01
PRODROM VOMITING	7.63E+01	8.12E+01	4.70E+01	3.49E+00	7.98E+01	----	7.98E+01
EF RISK, 1 MI	1.14E-02	2.67E-02	1.79E-02	----	1.14E-02	----	1.14E-02
CANCER FATALITIES	7.53E+01	6.26E+01	4.66E+01	2.98E+02	3.73E+02	3.13E+03	3.50E+03
POP DOSE, 0-50 MI	4.47E+03	3.40E+03	2.51E+03	1.01E+04	1.46E+04	1.08E+04	2.53E+04
POP DOSE, 0-1000 MI	4.47E+03	3.40E+03	2.51E+03	1.94E+04	2.38E+04	1.85E+05	2.09E+05
ECONOMIC COSTS ($)	----	----	----	----	----	1.89E+10	1.89E+10
POP EF RISK, 0-1 MI	1.37E-02	2.87E-02	2.08E-02	----	1.38E-02	----	1.38E-02
POP CF RISK, 0-10 MI	1.93E-03	1.61E-03	1.20E-03	----	1.93E-03	7.09E-05	2.00E-03

SOURCE TERM SEQ-16-1, MEAN FREQUENCY = 2.24E-05 /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	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	6.58E-09	1.52E-03	1.38E-04	6.86E-03	6.87E-03	1.55E-02	2.24E-02
POP DOSE, 0-50 MI	5.29E-07	1.20E-01	1.23E-02	2.14E-01	2.15E-01	1.17E+00	1.39E+00
POP DOSE, 0-1000 MI	5.29E-07	1.20E-01	1.23E-02	4.87E-01	4.87E-01	1.85E+00	2.34E+00
ECONOMIC COSTS ($)	----	----	----	----	----	4.36E+05	4.36E+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	1.69E-13	3.89E-08	3.55E-09	----	1.95E-10	7.10E-09	7.30E-09

SOURCE TERM SEQ-16-2, MEAN FREQUENCY = 1.53E-12 /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	0.00E+00	0.00E+00	0.00E+00	0.00E+00	----	0.00E+00
PRODROM VOMITING	0.00E+00	1.04E-03	4.23E-04	0.00E+00	5.20E-06	----	5.20E-06
EF RISK, 1 MI	0.00E+00	0.00E+00	0.00E+00	----	0.00E+00	----	0.00E+00
CANCER FATALITIES	1.18E-01	1.30E-01	1.12E-01	4.82E-01	6.00E-01	1.84E-03	6.02E-01
POP DOSE, 0-50 MI	5.74E+00	6.18E+00	5.35E+00	1.39E+01	1.97E+01	7.10E-02	1.97E+01
POP DOSE, 0-1000 MI	5.74E+00	6.18E+00	5.35E+00	2.63E+01	3.20E+01	1.11E-01	3.21E+01
ECONOMIC COSTS ($)	----	----	----	----	----	5.56E+05	5.56E+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	3.03E-06	3.35E-06	2.89E-06	----	3.03E-06	2.64E-09	3.03E-06

SOURCE TERM SEQ-16-3, MEAN FREQUENCY = 0.00E+00 /YR

Table C.1 (continued)

SOURCE TERM SEQ-17-1, MEAN FREQUENCY = 1.49E-05 /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	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	1.96E-07	1.91E-02	1.49E-03	7.48E-02	7.49E-02	1.56E-01	2.31E-01
POP DOSE, 0-50 MI	1.04E-05	1.56E+00	1.38E-01	2.70E+00	2.71E+00	8.62E+00	1.13E+01
POP DOSE, 0-1000 MI	1.04E-05	1.56E+00	1.38E-01	5.52E+00	5.53E+00	1.81E+01	2.36E+01
ECONOMIC COSTS ($)	----	----	----	----	----	5.10E+05	5.10E+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	5.03E-12	4.91E-07	3.81E-08	----	2.46E-09	1.04E-07	1.07E-07

SOURCE TERM SEQ-17-2, MEAN FREQUENCY = 1.09E-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	0.00E+00	0.00E+00	0.00E+00	0.00E+00	----	0.00E+00
PRODROM VOMITING	0.00E+00	3.75E-03	1.26E-03	0.00E+00	1.88E-05	----	1.88E-05
EF RISK, 1 MI	0.00E+00	0.00E+00	0.00E+00	----	0.00E+00	----	0.00E+00
CANCER FATALITIES	2.78E-01	3.02E-01	2.29E-01	1.19E+00	1.47E+00	1.14E+00	2.61E+00
POP DOSE, 0-50 MI	1.34E+01	1.57E+01	1.07E+01	3.52E+01	4.86E+01	3.91E+01	8.76E+01
POP DOSE, 0-1000 MI	1.34E+01	1.57E+01	1.07E+01	6.84E+01	8.18E+01	1.03E+02	1.85E+02
ECONOMIC COSTS ($)	----	----	----	----	----	9.74E+05	9.74E+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	7.14E-06	7.75E-06	5.87E-06	----	7.14E-06	1.36E-06	8.50E-06

SOURCE TERM SEQ-17-3, MEAN FREQUENCY = 0.00E+00 /YR

SOURCE TERM SEQ-18-1, MEAN FREQUENCY = 9.22E-06 /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	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	2.28E-05	9.76E-01	9.83E-03	6.72E+00	6.73E+00	3.31E+01	3.99E+01
POP DOSE, 0-50 MI	1.95E-03	8.77E+01	8.20E-01	3.28E+02	3.28E+02	7.03E+02	1.03E+03
POP DOSE, 0-1000 MI	1.95E-03	8.77E+01	8.20E-01	5.69E+02	5.69E+02	2.33E+03	2.89E+03
ECONOMIC COSTS ($)	----	----	----	----	----	2.62E+07	2.62E+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	5.85E-10	2.50E-05	2.52E-07	----	1.26E-07	3.92E-05	3.94E-05

SOURCE TERM SEQ-18-2, MEAN FREQUENCY = 1.16E-06 /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	0.00E+00	0.00E+00	0.00E+00	0.00E+00	----	0.00E+00
PRODROM VOMITING	8.17E-03	1.77E-02	6.86E-03	0.00E+00	8.22E-03	----	8.22E-03
EF RISK, 1 MI	0.00E+00	0.00E+00	0.00E+00	----	0.00E+00	----	0.00E+00
CANCER FATALITIES	8.39E-01	1.02E+00	4.37E-01	4.02E+00	4.86E+00	1.63E+02	1.68E+02
POP DOSE, 0-50 MI	4.58E+01	6.68E+01	2.46E+01	1.68E+02	2.14E+02	2.92E+03	3.14E+03
POP DOSE, 0-1000 MI	4.58E+01	6.68E+01	2.46E+01	2.72E+02	3.18E+02	9.33E+03	9.65E+03
ECONOMIC COSTS ($)	----	----	----	----	----	9.73E+07	9.73E+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	2.15E-05	2.62E-05	1.12E-05	----	2.15E-05	1.20E-04	1.41E-04

SOURCE TERM SEQ-18-3, MEAN FREQUENCY = 0.00E+00 /YR

SOURCE TERM SEQ-19 , MEAN FREQUENCY = 0.00E+00 /YR

APPENDIX D

RISK RESULTS

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Appendix D

RISK RESULTS

This appendix presents detailed risk results for Sequoyah for internal initiators. Figures D.1 through D.6 contain the complementary cumulative distribution functions (CDDFs) for early fatalities, latent with cancer fatalities, population dose within 50 mi, population dose within the entire region, individual risk of early fatality within 1 mi of the site boundary, and individual risk of latent cancer fatality within 10 mi of the plant. Each plot displays 200 CCDFs; each individual curve results from one observation in the Latin hypercube sampling (LHS) sample for Sequoyah. These families of curves are the most basic risk results generated in this probabilistic risk assessment.

Tables D.1 and D.2 present the PRAMIS output for internal initiators in slightly edited form. The PRAMIS output uses plant damage state (PDS) as an abbreviation for PDS group. The 7 PDS groups for internal initiators at Sequoyah are:

PDS Group 1	Slow SBO
PDS Group 2	Fast SBO
PDS Group 3	Loss of Coolant Accidents
PDS Group 4	Event V
PDS Group 5	Transients
PDS Group 6	ATWS
PDS Group 7	SGTR

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 mi
4. Latent Cancer Fatalities
5. Population Dose - 10 mi (Sv)
6. Population Dose - Entire Region (Sv)
7. Economic Cost ($)
8. Individual Early Fatality Risk within 1 mi
9. Individual Latent Cancer Fatality Risk within 10 mi

PRAMIS uses PAR as an abbreviation for the partitioned source term groups. The source term groups are defined in Section 3.4. PRAMIS uses AFB 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 5.1.3. The lists of the fractional contributions of individual APBs have been truncated to show only the top 60 contributors.

Table D.1
PRAMIS Results for Sequoyah
Internal Initiators

```
                                        CSQ
           1       2       3       4       5       6       7       8       9
MEAN RISK= 2.6E-05 7.6E-05 9.2E-09 1.4E-02 1.2E-01 8.0E-01 6.7E+04 1.1E-08 1.0E-08


MFCR - FRACTIONAL CONTRIBUTIONS OF PDS TO CSQ, NORMALIZED ON A SAMPLE BASIS
                                       CSQ
          1       2       3       4       5       6       7       8       9
PDS
 1     0.06655 0.07273 0.06904 0.08378 0.07953 0.08339 0.08012 0.07047 0.08159
 2     0.18174 0.20016 0.18216 0.25395 0.24331 0.25416 0.24331 0.18981 0.239.9
 3     0.13031 0.14634 0.12310 0.20899 0.28092 0.22055 0.15036 0.12843 0.25695
 4     0.40545 0.32948 0.38918 0.10045 0.10413 0.09675 0.14036 0.37683 0.16175
 5     0.01313 0.01426 0.01395 0.01387 0.01344 0.01367 0.01293 0.01376 0.01684
 6     0.06811 0.07860 0.07330 0.05747 0.05286 0.05642 0.06141 0.07205 0.07492
 7     0.13471 0.15843 0.14927 0.28146 0.22582 0.27507 0.31152 0.14866 0.16876


FCMR - FRACTIONAL CONTRIBUTIONS OF PDS TO CSQ, NORMALIZED ON A GLOBAL BASIS
                                       CSQ
          1       2       3       4       5       6       7       8       9
PDS
 1     0.06940 0.11228 0.06569 0.12450 0.11098 0.12504 0.12356 0.08542 0.11757
 2     0.16013 0.23963 0.16201 0.28627 0.26542 0.28681 0.27232 0.17669 0.28250
 3     0.01720 0.04044 0.02544 0.14238 0.18613 0.14553 0.08807 0.03162 0.14866
 4     0.67953 0.48205 0.66286 0.10330 0.14922 0.09830 0.14284 0.61835 0.29196
 5     0.00145 0.00248 0.00209 0.00452 0.00479 0.00455 0.00395 0.00213 0.00474
 6     0.01919 0.02910 0.02178 0.03830 0.03682 0.03828 0.03562 0.02221 0.04134
 7     0.05306 0.09401 0.06012 0.30074 0.24655 0.30148 0.33365 0.06359 0.11324
```

Table D.1 (continued)

MFCR - FRACTIONAL CONTRIBUTIONS OF PAR TO CSQ, NORMALIZED ON A SAMPLE BASIS

PAR	CSQ 1	2	3	4	5	6	7	8	9
1	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
2	0.00013	0.00275	0.00026	0.00007	0.00021	0.00008	0.00001	0.00025	0.00059
3	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
4	0.00009	0.00013	0.00001	0.00366	0.00803	0.00499	0.00122	0.00019	0.00236
5	0.00077	0.00619	0.00088	0.00079	0.00152	0.00082	0.00028	0.00136	0.00192
6	0.00069	0.00150	0.00098	0.00001	0.00003	0.00001	0.00000	0.00123	0.00009
7	0.00004	0.00006	0.00001	0.00728	0.00674	0.00764	0.00344	0.00012	0.00243
8	0.00032	0.00599	0.00061	0.01130	0.01264	0.01093	0.00551	0.00044	0.00905
9	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
10	0.00000	0.00000	0.00001	0.00002	0.00002	0.00002	0.00004	0.00001	0.00000
11	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
12	0.02063	0.04597	0.03181	0.00737	0.00967	0.00716	0.00317	0.04012	0.00860
13	0.00010	0.00013	0.00024	0.00458	0.00355	0.00446	0.00391	0.00039	0.00145
14	0.00078	0.00956	0.00034	0.02235	0.02212	0.02176	0.02265	0.00180	0.02753
15	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
16	0.00072	0.00112	0.00015	0.02989	0.02496	0.02851	0.02437	0.00142	0.00977
17	0.00370	0.01372	0.00096	0.03055	0.02873	0.02914	0.01824	0.00504	0.01884
18	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
19	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
20	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
21	0.00710	0.01353	0.01029	0.01033	0.00849	0.01014	0.01049	0.01288	0.00561
22	0.00001	0.00001	0.00002	0.00098	0.00121	0.00101	0.00264	0.00005	0.00025
23	0.00910	0.02915	0.01243	0.03291	0.02640	0.03206	0.03945	0.01578	0.03824
24	0.02270	0.03938	0.03163	0.01233	0.01159	0.01234	0.01990	0.03926	0.00837
25	0.00281	0.00166	0.00346	0.04754	0.03516	0.04594	0.04159	0.00633	0.01533
26	0.05433	0.09125	0.07259	0.08750	0.07326	0.08421	0.08796	0.07505	0.12124
27	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
28	0.00013	0.00013	0.00003	0.01789	0.01117	0.01692	0.01437	0.00032	0.00475
29	0.00000	0.00005	0.00000	0.00557	0.00447	0.00523	0.00368	0.00000	0.00196
30	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
31	0.00100	0.00160	0.00141	0.00313	0.00304	0.00312	0.00494	0.00113	0.00152
32	0.09226	0.08473	0.12545	0.05763	0.04765	0.05736	0.07794	0.10108	0.06729
33	0.20282	0.12588	0.18816	0.03717	0.03982	0.03553	0.06167	0.17620	0.08573
34	0.00956	0.00469	0.01667	0.06445	0.04854	0.06327	0.07315	0.01567	0.01525
35	0.15039	0.14972	0.16858	0.12655	0.09753	0.12381	0.14420	0.17373	0.13320
36	0.00001	0.00001	0.00002	0.00000	0.00000	0.00000	0.00000	0.00002	0.00000
37	0.00105	0.00042	0.00161	0.01869	0.01462	0.01833	0.02468	0.00209	0.00454
38	0.00116	0.00360	0.00160	0.00632	0.00447	0.00612	0.00465	0.00128	0.00324
39	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
40	0.00915	0.01196	0.00599	0.00860	0.00833	0.00754	0.01112	0.00528	0.00850
41	0.07462	0.06750	0.06586	0.01757	0.01689	0.01718	0.02834	0.06097	0.03635
42	0.12630	0.08019	0.09772	0.02884	0.03155	0.02723	0.03791	0.08138	0.04902
43	0.01118	0.02707	0.01761	0.07227	0.05796	0.07151	0.08433	0.01595	0.02714
44	0.17114	0.15610	0.11402	0.06964	0.05448	0.06922	0.09133	0.13746	0.07344
45	0.02521	0.02302	0.02856	0.00440	0.00298	0.00433	0.00723	0.02574	0.00433
46	0.00000	0.00000	0.00000	0.00016	0.00078	0.00028	0.00129	0.00000	0.00008
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	0.00106	0.00397	0.00173	0.00102	0.00000	0.00069
50	0.00000	0.00000	0.00000	0.00001	0.00004	0.00002	0.00000	0.00000	0.00007
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	0.13056	0.24595	0.15087	0.03740	0.00000	0.18746
53	0.00000	0.00132	0.00000	0.02002	0.02842	0.01818	0.00587	0.00000	0.02376
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	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Table D.1 (continued)

FCMR - FRACTIONAL CONTRIBUTIONS OF PAR TO CSQ, NORMALIZED ON A GLOBAL BASIS

PAR	CSQ 1	2	3	4	5	6	7	8	9
1	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
2	0.00000	0.00047	0.00001	0.00007	0.00024	0.00007	0.00000	0.00002	0.00044
3	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
4	0.00000	0.00001	0.00000	0.00072	0.00269	0.00109	0.00013	0.00001	0.00043
5	0.00001	0.00073	0.00002	0.00053	0.00142	0.00057	0.00008	0.00005	0.00125
6	0.00023	0.00119	0.00065	0.00002	0.00007	0.00002	0.00000	0.00097	0.00017
7	0.00000	0.00001	0.00000	0.00278	0.00580	0.00311	0.00060	0.00001	0.00086
8	0.00000	0.00051	0.00000	0.00660	0.01060	0.00653	0.00127	0.00001	0.00484
9	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
10	0.00000	0.00000	0.00000	0.00001	0.00002	0.00001	0.00002	0.00000	0.00000
11	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
12	0.00412	0.02036	0.01157	0.00349	0.00695	0.00348	0.00095	0.01723	0.00450
13	0.00001	0.00001	0.00001	0.00508	0.00456	0.00501	0.00207	0.00003	0.00069
14	0.00002	0.00090	0.00002	0.01016	0.01305	0.01011	0.00672	0.00013	0.01277
15	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
16	0.00000	0.00001	0.00000	0.01113	0.01377	0.01122	0.00382	0.00002	0.00205
17	0.00003	0.00213	0.00001	0.02428	0.02898	0.02355	0.00724	0.00020	0.01302
18	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
19	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
20	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
21	0.00725	0.02492	0.01853	0.01207	0.01244	[illegible]	0.01027	0.02820	0.00682
22	0.00001	0.00001	0.00001	0.00131	0.00173	[illegible]	0.00334	0.00003	0.00021
23	0.00049	0.00513	0.00126	0.02769	0.02600	0.02748	0.02311	0.00198	0.03108
24	0.00778	0.02904	0.02038	0.00969	0.01153	0.00982	0.01409	[illegible]	0.00692
25	0.00003	0.00005	0.00006	0.02537	0.02121	0.02491	0.01298	0.00017	0.00445
26	0.00230	0.01469	0.00638	0.06853	0.06672	0.06698	0.04441	0.00877	0.09150
27	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
28	0.00000	0.00000	0.00000	0.00416	0.00345	0.00405	0.00165	0.00001	0.00087
29	0.00000	0.00001	0.00000	0.00202	0.00211	0.00197	0.00080	0.00000	0.00070
30	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
31	0.00004	0.00021	0.00012	0.00248	0.00250	0.00248	0.00429	0.00011	0.00072
32	0.02910	0.05232	0.08129	0.07312	0.06257	0.07437	0.09877	0.06159	0.07207
33	0.22548	0.17791	0.30659	0.04194	0.06072	0.03993	0.06547	0.31231	0.15440
34	0.00036	0.00038	0.00145	0.05490	0.04433	0.05512	0.04692	0.00161	0.00596
35	0.03888	0.08817	0.07832	0.20867	0.16560	0.20657	0.19288	0.09609	0.19336
36	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
37	0.00004	0.00005	0.00014	0.01176	0.01068	0.01177	0.01193	0.00024	0.00202
38	0.00014	0.00154	0.00036	0.01215	0.00871	0.01185	0.00550	0.00036	0.00472
39	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
40	0.00258	0.00574	0.00096	0.00339	0.00508	0.00262	0.00406	0.00071	0.00427
41	0.09675	0.10898	0.06748	0.02241	0.02266	0.02213	0.03745	0.05691	0.05035
42	0.43138	0.22295	0.29633	0.03469	0.05633	0.03155	0.05053	0.22147	0.11806
43	0.00245	0.01592	0.00692	0.14819	0.11408	0.14940	0.18608	0.00630	0.02778
44	0.14717	0.21987	0.09231	0.12754	0.09755	0.12025	0.15543	0.14629	0.12876
45	0.00334	0.00569	0.00680	0.00140	0.00118	0.00142	0.00154	0.00711	0.00108
46	0.00000	0.00000	0.00000	0.00004	0.00027	0.00007	0.00015	0.00000	0.00002
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	0.00025	0.00145	0.00044	0.00011	0.00000	0.00016
50	0.00000	0.00000	0.00000	0.00000	0.00001	0.00000	0.00000	0.00000	0.00001
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	0.02703	0.08174	0.03356	0.00363	0.00000	0.03622
53	0.00000	0.00013	0.00000	0.01434	0.03123	0.01404	0.00170	0.00000	0.01645
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	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Table D.1 (continued)

MFCR - 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	10	11	12	13	14
A	0.26488	0.07845	0.61972	0.00429	0.10174	0.17931	0.80688	0.51412	0.02759	0.15982	0.55912	0.88368	0.73362	0.27431
B	0.14057	0.00000	0.01047	0.05299	0.67931	0.03111	0.00000	0.48587	0.03300	0.20274	0.44088	0.05176	0.04607	0.53158
C	0.11969	0.00833	0.18562	0.10271	0.01816	0.78956	0.00749		0.01062	0.22667		0.06456	0.22031	0.10789
D	0.27335	0.17375	0.11332	0.84000	0.04461		0.18562		0.92879	0.41077				0.08621
E	0.00507	0.00270	0.00000		0.00197									
F	0.02266	0.02098	0.07087		0.15421									
G	0.17378	0.02122												
H		0.69456												

MFCR - 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	10	11	12	13	14
A	0.15570	0.09238	0.56552	0.00578	0.12775	0.19757	0.76897	0.50719	0.03528	0.17388	0.53790	0.88238	0.71570	0.26140
B	0.17378	0.00000	0.01823	0.07153	0.62614	0.04545	0.00000	0.49280	0.04404	0.21464	0.46209	0.05667	0.05047	0.52934
C	0.13267	0.00999	0.22068	0.12841	0.02314	0.75697	0.01035		0.01380	0.22259		0.06094	0.23383	0.11670
D	0.30934	0.20494	0.13562	0.79426	0.03884		0.22068		0.90688	0.38889				0.09256
E	0.00391	0.00316	0.00000		0.00195									
F	0.02846	0.03110	0.05995		0.18218									
G	0.19614	0.02143												
H		0.63700												

MFCR - FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ 3, NORMALIZED ON A SAMPLE BASIS

CSQ 3

APB ATTRIBUTES

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
A	0.21868	0.08211	0.61065	0.00539	0.11413	0.19003	0.79131	0.51381	0.02929	0.16100	0.56204	0.89052	0.74182	0.27434
B	0.17050	0.00000	0.01571	0.05978	0.65413	0.04048	0.00000	0.48618	0.03864	0.19391	0.43796	0.05462	0.04879	0.52848
C	0.11487	0.00891	0.20157	0.11127	0.01785	0.76949	0.00711		0.01360	0.22734		0.05485	0.20939	0.10616
D	0.27260	0.18411	0.11730	0.82355	0.04153		0.20157		0.91847	0.41774				0.09102
E	0.00721	0.00306	0.00000		0.00324									
F	0.02598	0.02274	0.05477		0.16913									
G	0.19016	0.02188												
H		0.67720												

MFCR - 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	10	11	12	13	14
A	0.04012	0.10343	0.49879	0.00823	0.23227	0.12663	0.77688	0.51397	0.05510	0.27847	0.56809	0.88950	0.74676	0.24322
B	0.06033	0.00000	0.07865	0.14652	0.55831	0.20967	0.00000	0.48603	0.07697	0.19724	0.43191	0.06561	0.06110	0.48911
C	0.11448	0.01999	0.19626	0.22904	0.04216	0.66369	0.02684		0.05029	0.24927		0.04489	0.19213	0.15785
D	0.28857	0.17334	0.19619	0.61621	0.01753		0.19626		0.81763	0.27501				0.10982
E	0.09109	0.05479	0.00000		0.00356									
F	0.18913	0.04651	0.03010		0.14616									
G	0.21628	0.01864												
H		0.58329												

MFCR - 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	10	11	12	13	14
A	0.04213	0.10200	0.45698	0.00863	0.23039	0.10460	0.79480	0.51059	0.05034	0.29729	0.57114	0.89816	0.78100	0.24087
B	0.06200	0.00000	0.07141	0.14332	0.58356	0.16644	0.00000	0.48941	0.07118	0.20007	0.42885	0.06350	0.06032	0.50097
C	0.09482	0.02426	0.18161	0.23253	0.04273	0.72896	0.02358		0.04400	0.26205		0.03833	0.15867	0.15511
D	0.25238	0.17803	0.25675	0.61551	0.01367		0.18161		0.83447	0.24058				0.10304
E	0.09715	0.06430	0.00000		0.00294									
F	0.27177	0.05129	0.03325		0.12672									
G	0.17975	0.01648												
H		0.56364												

Table D.1 (continued)

MFCR - 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	10	11	12	13	14
A	0.03775	0.10290	0.46210	0.00825	0.23355	0.12293	0.78131	0.51340	0.05465	0.28323	0.56626	0.88998	0.75154	0.24173
B	0.03900	0.00000	0.07760	0.14680	0.56133	0.20514	0.00000	0.48660	0.07637	0.19914	0.43373	0.06562	0.06133	0.4897'
C	0.11110	0.02072	0.19206	0.23056	0.04239	0.67192	0.02662		0.05004	0.24941		0.04439	0.18712	0.15861
D	0.28307	0.17274	0.20665	0.61439	0.01703		0.19206		0.81894	0.26822				0.10992
E	0.09286	0.05680	0.00000		0.00350									
F	0.20456	0.04709	0.03121		0.14220									
G	0.21166	0.01862												
H		0.58114												

MFCR - 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	10	11	12	13	14
A	0.06611	0.09257	0.55104	0.00685	0.21505	0.14773	0.78190	0.51891	0.05511	0.23975	0.57011	0.88575	0.72159	0.25170
B	0.07425	0.00000	0.07635	0.13461	0.56607	0.22726	0.00000	0.48108	0.07375	0.19837	0.42988	0.06484	0.05909	0.48814
C	0.12067	0.01466	0.19207	0.21051	0.03719	0.62500	0.02602		0.04822	0.24085		0.04939	0.21932	0.14880
D	0.31287	0.16530	0.14502	0.64793	0.02494		0.19207		0.82291	0.32103				0.11136
E	0.07006	0.03489	0.00000		0.00375									
F	0.11710	0.03732	0.03552		0.15299									
G	0.23894	0.02112												
H		0.63414												

MFCR - 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	10	11	12	13	14
A	0.16820	0.08542	0.60263	0.00543	0.11742	0.18698	0.78597	0.51036	0.03030	0.16796	0.55742	0.88798	0.73970	0.27092
B	0.16862	0.00000	0.01668	0.06018	0.64876	0.04108	0.00000	0.45963	0.04002	0.19860	0.44258	0.05583	0.05014	0.52720
C	0.12105	0.00913	0.20502	0.11743	0.01989	0.77193	0.00900		0.01495	0.22518		0.05618	0.21016	0.11121
D	0.27893	0.18420	0.11904	0.81626	0.03966		0.20502		0.91471	0.40826				0.09067
E	0.00833	0.00398	0.00000		0.00204									
F	0.02695	0.02435	0.05663		0.17131									
G	0.18791	0.02157												
H		0.67135												

MFCR - 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	10	11	12	13	14
A	0.08545	0.11634	0.43657	0.00997	0.18974	0.16707	0.74723	0.49706	0.04256	0.26605	0.51817	0.88904	0.75110	0.23482
B	0.07630	0.00000	0.04458	0.11068	0.57125	0.07445	0.00000	0.50294	0.05786	0.21281	0.48183	0.06618	0.06178	0.51790
C	0.12240	0.02047	0.23692	0.19850	0.03345	0.75847	0.01583		0.02773	0.23770		0.04477	0.18711	0.14308
D	0.28339	0.22023	0.24366	0.68284	0.02241		0.23692		0.87184	0.28344				0.10419
E	0.04968	0.03577	0.00000		0.00319									
F	0.19389	0.05084	0.03627		0.17995									
G	0.18889	0.02027												
H		0.53607												

Table D.1 (continued)

MFCR - 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	0.26488	0.15570	0.21866	0.04012	0.04213	0.03775	0.06611	0.18820	0.08545
B	0.14057	0.17378	0.17050	0.06033	0.06200	0.05900	0.07425	0.16662	0.07630
C	0.11969	0.13267	0.11487	0.11448	0.09482	0.11110	0.12067	0.12105	0.12240
D	0.27335	0.30934	0.27260	0.28857	0.25238	0.28307	0.31287	0.27893	0.28339
E	0.00507	0.00391	0.00721	0.09109	0.09715	0.09286	0.07006	[illegible]	[illegible]
F	0.02266	0.02646	0.02598	0.18013	0.27177	0.20456	0.11710	0.02695	0.16369
G	0.17378	0.19614	0.19016	0.21626	0.17975	0.21166	0.23894	0.18791	0.18889

MFCR - 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	0.07845	0.09238	0.08211	0.10343	0.10200	0.10290	0.09257	0.08542	0.11634
B	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
C	0.00833	0.00999	0.00891	0.01999	0.02426	0.02072	0.01466	0.00915	0.02047
D	0.17375	0.20494	0.18411	0.17334	0.17803	0.17274	0.16530	0.18420	0.22023
E	0.00270	0.00316	0.00306	0.05479	0.06430	0.05680	0.03489	0.00398	0.03577
F	0.02098	0.03110	0.02274	[illegible]	0.05129	0.04709	0.03732	0.02435	0.05084
G	0.02122	0.02143	0.02188	0.01364	0.01648	0.01862	0.02112	0.02157	0.02027
H	0.69456	0.63700	0.67720	0.56329	0.56364	0.58114	0.63414	0.67135	0.53607

MFCR - 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	0.61972	0.56552	0.61065	0.49879	0.45698	0.49210	0.55104	0.60263	0.43857
B	0.01047	0.01823	0.01571	0.07865	0.07141	0.07798	0.07635	0.01668	0.04458
C	0.18562	0.22068	0.20157	0.19626	0.18161	0.19205	0.19207	0.20502	0.23692
D	0.11332	0.13562	0.11730	0.19619	0.25675	0.20665	0.14502	0.11904	0.24366
E	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
F	0.07087	0.05995	0.05477	0.03010	0.03325	0.03121	0.03552	0.05663	0.03627

MFCR - 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	0.00429	0.00576	0.00539	0.00823	0.00863	0.00825	0.00665	0.00543	0.00997
B	0.05299	0.07153	0.05978	0.14652	0.14332	0.14680	0.13461	0.06018	0.11068
C	0.10271	0.12641	0.11127	0.22904	0.23253	0.23056	0.21061	0.11743	0.19650
D	0.84000	0.79428	0.82355	0.61621	0.61551	0.61439	0.64793	0.81696	0.68284

MFCR - 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	0.10174	0.12775	0.11413	0.23227	0.23039	0.23355	0.21505	0.11742	0.18974
B	0.67931	0.62614	0.65413	0.55831	0.58356	0.56133	0.56607	0.64976	0.57125
C	0.01816	0.02314	0.01785	0.04216	0.04273	0.04239	0.03719	0.01980	0.03345
D	0.04461	0.03884	0.04153	0.01753	0.01367	0.01703	0.02494	0.03966	0.02241
E	0.00197	0.00195	0.00324	0.00356	0.00294	0.00350	0.00375	0.00204	0.00319
F	0.15421	0.18216	0.16913	0.14616	0.12672	0.14220	0.15299	0.17131	0.17995

MFCR - 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	0.17931	0.19757	0.19003	0.12663	0.10460	0.12293	0.14773	0.18696	0.16707
B	0.03111	0.04545	0.04048	0.20967	0.16644	0.20514	0.22726	0.04108	0.07445
C	0.78956	0.75697	0.76949	0.66369	0.72896	0.67192	0.62500	0.77193	0.75847

Table D.1 (continued)

MFCR - 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	0.80688	0.76897	0.79131	0.77688	0.79480	0.78131	0.78190	0.78597	0.74723
B	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
C	0.00749	0.01035	0.00711	0.02684	0.02358	0.02662	0.02602	0.00900	0.01583
D	0.18562	0.22068	0.20157	0.19626	0.18161	0.19206	0.19207	0.20502	0.23692

MFCR - 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	0.51412	0.50719	0.51381	0.51397	0.51059	0.51340	0.51891	0.51036	0.49706
B	0.48587	0.49280	0.48618	0.48603	0.48941	0.48660	0.48108	0.48963	0.50294

MFCR - 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	0.02759	0.03528	0.02929	0.05510	0.05034	0.05465	0.05511	0.03030	0.04256
B	0.03500	0.04404	0.03864	0.07697	0.07118	0.07637	0.07375	0.04002	0.05786
C	0.01062	0.01380	0.01360	0.05029	0.04400	0.05004	0.04822	0.01495	0.02773
D	0.92679	0.90688	0.91847	0.81763	0.83447	0.81894	0.82291	0.91471	0.87184

MFCR - FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ, NORMALIZED ON A SAMPLE BASIS
APB ATTRIBUTE 10
CSQ

	1	2	3	4	5	6	7	8	9
A	0.15982	0.17388	0.16100	0.27847	0.29729	0.28323	0.23975	0.16796	0.26605
B	0.20274	0.21464	0.19391	0.19724	0.20007	0.19914	0.19837	0.19860	0.21281
C	0.22667	0.22259	0.22734	0.24927	0.26205	0.24941	0.24085	0.22518	0.23770
D	0.41077	0.38889	0.41774	0.27501	0.24058	0.26822	0.32103	0.40826	0.28344

MFCR - FRACTIONAL CONTRIBUTIOKS OF APB ATTRIBUTES TO CSQ, NORMALIZED ON A SAMPLE BASIS
APB ATTRIBUTE 11
CSQ

	1	2	3	4	5	6	7	8	9
A	0.55912	0.53790	0.56204	0.56809	0.57114	0.56626	0.57011	0.55742	0.51817
B	0.44088	0.46209	0.43796	0.43191	0.42885	0.43373	0.42988	0.44258	0.48183

MFCR FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ, NORMALIZED ON A SAMPLE BASIS
APB ATTRIBUTE 12
CSQ

	1	2	3	4	5	6	7	8	9
A	0.88368	0.88238	0.89052	0.88950	0.89816	0.88998	0.88575	0.88798	0.88904
B	0.05176	0.05667	0.05462	0.06561	0.06350	0.06562	0.06484	0.05583	0.06618
C	0.06456	0.06094	0.05485	0.04489	0.03833	0.04439	0.04939	0.05618	0.04477

MFCR - FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ, NORMALIZED ON A SAMPLE BASIS
APB ATTRIBUTE 13
CSQ

	1	2	3	4	5	6	7	8	9
A	0.73362	0.71570	0.74182	0.74676	0.78100	0.75154	0.72159	0.73970	0.75110
B	0.04607	0.05047	0.04879	0.06110	0.06032	0.06133	0.05909	0.05014	0.06178
C	0.22031	0.23383	0.20939	0.19213	0.15867	0.18712	0.21932	0.21016	0.18711

MFCR - FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ, NORMALIZED ON A SAMPLE BASIS
APB ATTRIBUTE 14
CSQ

	1	2	3	4	5	6	7	8	9
A	0.27431	0.26140	0.27434	0.24322	0.24087	0.24173	0.25170	0.27092	0.23482
B	0.53158	0.52934	0.52848	0.48911	0.50097	0.48974	0.48814	0.52720	0.51790
C	0.10789	0.11670	0.10616	0.15785	0.15511	0.15861	0.14880	0.11121	0.14308
D	0.08621	0.09256	0.09102	0.10982	0.10304	0.10992	0.11136	0.09067	0.10419

Table D.1 (continued)

FCMR - FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ 1, NORMALIZED ON A GLOBAL BASIS
CSQ 1
APB ATTRIBUTES

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
A	0.43454	0.02238	0.80428	0.00169	0.10321	0.06772	0.94790	0.53378	0.01572	0.16374	0.78480	0.89881	0.87205	0.32386
B	0.24503	0.00000	0.00692	0.06486	0.84970	0.00545	0.00000	0.46621	0.06723	0.08316	0.21529	0.02600	0.02439	0.45927
C	0.02485	0.00307	0.05138	0.05939	0.00368	0.92682	0.00070		0.00017	0.30877		0.07518	0.10355	0.12058
D	0.23962	0.06302	0.03951	0.87405	0.01046		0.05138		0.91686	0.44433				0.09628
E	0.00013	0.00070	0.00000		0.00013									
F	0.00827	0.01036	0.00790		0.03282									
G	0.04755	0.01528												
H		0.88518												

FCMR - FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ 2, NORMALIZED ON A GLOBAL BASIS
CSQ 2
APB ATTRIBUTES

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
A	0.24377	0.04717	0.81139	0.00372	0.16485	0.10202	0.90576	0.53574	0.03174	0.24331	0.69220	0.87017	0.82464	0.26540
B	0.23626	0.00000	0.01754	0.11983	0.74056	0.02224	0.00000	0.46426	0.12018	0.13003	0.30779	0.03960	0.03676	0.40943
C	0.04657	0.00484	0.09269	0.09866	0.00522	0.87573	0.00153		0.00072	0.26724		0.09022	0.13860	0.17756
D	0.37446	0.09858	0.06557	0.77779	0.01101		0.09269		0.84734	0.35941				0.14761
E	0.00027	0.00152	0.00000		0.00025									
F	0.01632	0.02398	0.01281		0.05810									
G	0.07633	0.02553												
H		0.79837												

FCMR - FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ 3, NORMALIZED ON A GLOBAL BASIS
CSQ 3
APB ATTRIBUTES

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
A	0.33772	0.03297	0.86556	0.00223	0.11700	0.07366	0.92754	0.52379	0.01911	0.15163	0.79394	0.91342	0.87164	0.32366
B	0.32514	0.00000	0.01550	0.07574	0.81674	0.00943	0.00000	0.47620	0.07701	0.08398	0.20605	0.03049	0.02827	0.46655
C	0.03356	0.00341	0.07136	0.05770	0.00318	0.91668	0.00108		0.00046	0.31775		0.05609	0.09969	0.11111
D	0.23262	0.06954	0.03880	0.86433	0.01212		0.07136		0.90340	0.44643				0.09845
E	0.00032	0.00156	0.00000		0.00019									
F	0.00993	0.01639	0.00867		0.05076									
G	0.06072	0.01878												
H		0.85533												

FCMR - FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ 4, NORMALIZED ON A GLOBAL BASIS
CSQ 4
APB ATTRIBUTES

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
A	0.04193	0.11908	0.60424	0.00929	0.37077	0.10071	0.80671	0.56855	0.06802	0.31393	0.68224	0.89287	0.79248	0.23859
B	0.06137	0.00000	0.08232	0.25392	0.49690	0.23640	0.00000	0.43143	0.22040	0.17342	0.31775	0.06823	0.06362	0.41417
C	0.09743	0.01045	0.18200	0.20117	0.01705	0.66287	0.01128		0.02210	0.26162		0.03888	0.14390	0.19300
D	0.46100	0.12773	0.11408	0.53561	0.00941		0.18200		[illegible]	0.25103				0.15424
E	0.03950	0.03010	0.00000		0.00104									
F	0.10793	0.06670	0.01736		0.10482									
G	0.19083	0.02963												
H		0.61631												

FCMR - FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ 5, NORMALIZED ON A GLOBAL BASIS
CSQ 5
APB ATTRIBUTES

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
A	0.06509	0.11755	0.57982	0.0088[illegible]	0.32999	0.08611	0.80883	0.56278	0.07441	0.29442	0.69114	0.90120	0.80601	0.24822
B	0.08413	0.00000	0.07465	0.23064	0.54204	0.19208	0.00000	0.43721	0.18648	0.17893	0.30885	0.06274	0.05887	0.43821
C	0.08927	0.01391	0.17938	0.19975	0.02072	0.72180	0.01178		0.02089	0.27919		0.03605	0.13512	0.17756
D	0.41150	0.13864	0.14799	0.56077	0.00906		0.17938		0.71621	0.24746				0.13601
E	0.04992	0.03661	0.00000		0.00115									
F	0.13957	0.06453	0.01615		0.09705									
G	0.16053	0.02506												
H		0.60370												

Table D.1 (continued)

FCMR - FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ 6, NORMALIZED ON A GLOBAL BASIS

CSQ 6

APB ATTRIBUTES

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
A	0.03875	0.11822	0.60119	0.00926	0.37276	0.10078	0.80832	0.56850	0.08930	0.31511	0.67961	0.89307	0.79336	0.23715
B	0.05955	0.00000	0.08238	0.25415	0.49565	0.23684	0.00000	0.43149	0.22040	0.17546	0.32038	0.06821	0.06364	0.41405
C	0.09643	0.01086	0.18046	0.20319	0.01715	0.66237	0.01121		0.02210	0.26099		0.03871	0.14299	0.19363
D	0.45956	0.12876	0.11821	0.53339	0.00934		0.18046		0.66820	0.24843				0.15516
E	0.04086	0.03092	0.00000		0.00103									
F	0.11371	0.06654	0.01777		0.10407									
G	0.19114	0.02982												
H		0.61487												

FCMR - FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ 7, NORMALIZED ON A GLOBAL BASIS

CSQ 7

APB ATTRIBUTES

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
A	0.06153	0.08986	0.66707	0.00775	0.38870	0.11019	0.84224	0.57417	0.09813	0.29403	0.68969	0.88982	0.79622	0.24567
B	0.08131	0.00000	0.08208	0.24338	0.51456	0.25988	0.00000	0.42582	0.22048	0.15688	0.31030	0.06264	0.05796	0.40750
C	0.08247	0.00728	0.14999	0.18974	0.01059	0.62991	0.00775		0.01425	0.26145		0.04752	0.14580	0.18554
D	0.45670	0.11457	0.08490	0.55913	0.00991		0.14999		0.66712	0.28764				0.16129
E	0.01938	0.01506	0.00000		0.00071									
F	0.09409	0.05318	0.01596		0.07551									
G	0.20451	0.03233												
H		0.68772												

FCMR - FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ 8, NORMALIZED ON A GLOBAL BASIS

CSQ 8

APB ATTRIBUTES

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
A	0.27344	0.03947	0.85159	0.00293	0.14240	0.07801	0.92154	0.51421	0.02392	0.17083	0.77685	0.91341	0.87194	0.30886
B	0.34491	0.00000	0.01442	0.09032	0.79112	0.00889	0.00000	0.48578	0.09354	0.10401	0.22314	0.03499	0.03260	0.45171
C	0.04188	0.00372	0.07739	0.07068	0.00289	0.91309	0.00105		0.00056	0.30654		0.05159	0.09546	0.12676
D	0.27015	0.07504	0.04634	0.83606	0.01189		0.07739		0.88197	0.41861				0.11266
E	0.00043	0.00168	0.00000		0.00018									
F	0.01001	0.02281	0.01024		0.05152									
G	0.05919	0.02149												
H		0.83579												

FCMR - FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ 9, NORMALIZED ON A GLOBAL BASIS

CSQ 9

APB ATTRIBUTES

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
A	0.13972	0.11976	0.63214	0.00974	0.26835	0.10832	0.80895	0.52886	0.04941	0.29083	0.66798	0.88426	0.79771	0.24007
B	0.15224	0.00000	0.04295	0.18839	0.59920	0.04464	0.00000	0.47113	0.17038	0.16969	0.33200	0.06053	0.05645	0.42102
C	0.09535	0.00913	0.18554	0.14093	0.01169	0.84703	0.00550		0.00626	0.26491		0.05520	0.14583	0.18713
D	0.44170	0.13479	0.12192	0.66094	0.01228		0.18554		0.77394	0.27457				0.15177
E	0.01095	0.01025	0.00000		0.00086									
F	0.05509	0.06365	0.01744		0.10761									
G	0.10494	0.02928												
H		0.63312												

Table D.1 (continued)

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FCMR - FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ, NORMALIZED ON A GLOBAL BASIS
                                   APB ATTRIBUTE  1
                                          CSQ
           1       2       3       4       5       6       7       8       9
A     0.43454 0.24377 0.33772 0.04193 0.06509 0.03875 0.06153 0.27344 0.13972
B     0.24503 0.23828 0.32514 0.06137 0.08413 0.05955 0.08131 0.34491 0.15224
C     0.02485 0.04857 0.03356 0.09743 0.08927 0.09643 0.08247 0.04188 0.09535
D     0.23962 0.37446 0.23262 0.46100 0.41150 0.45956 0.45670 0.27015 0.44170
E     0.00013 0.00027 0.00032 0.03950 0.04992 0.04086 0.01938 0.00043 0.01095
F     0.00827 0.01632 0.00993 0.10793 0.13957 0.11371 0.09409 0.01001 0.05509
G     0.04755 0.07833 0.06072 0.19083 0.18053 0.19114 0.20451 0.05919 0.10494

FCMR - FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ, NORMALIZED ON A GLOBAL BASIS
                                   APB ATTRIBUTE  2
                                          CSQ
           1       2       3       4       5       6       7       8       9
A     0.02238 0.04717 0.03297 0.11908 0.11755 0.11822 0.08986 0.03947 0.11976
B     0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
C     0.00307 0.00484 0.00341 0.01045 0.01391 0.01086 0.00728 0.00372 0.00913
D     0.06302 0.09858 0.06954 0.12773 0.13864 0.12876 0.11457 0.07504 0.13479
E     0.00070 0.00152 0.00156 0.03010 0.02661 0.03092 0.01506 0.00188 0.01025
F     0.01036 0.02398 0.01839 0.06670 0.06453 0.08654 0.05318 0.02281 0.06365
G     0.01528 0.02553 0.01878 0.02963 0.02506 0.02982 0.03232 0.02149 0.02928
H     0.88518 0.79837 0.85533 0.61631 0.60370 0.61487 0.68772 0.83579 0.63312

FCMR - FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ, NORMALIZED ON A GLOBAL BASIS
                                   APB ATTRIBUTE  3
                                          CSQ
           1       2       3       4       5       6       7       8       9
A     0.89428 0.81139 0.86566 0.60424 0.57982 0.60119 0.66707 0.85159 0.63214
B     0.00692 0.01754 0.01550 0.08232 0.07465 0.08238 0.06208 0.01442 0.04295
C     0.05138 0.09269 0.07138 0.18200 0.17938 0.18046 0.14999 0.07739 0.18554
D     0.03951 0.06557 0.03880 0.11408 0.14799 0.11821 0.08490 0.04634 0.12192
E     0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
F     0.00790 0.01281 0.00867 0.01736 0.01815 0.01777 0.01596 0.01024 0.01744

FCMR - FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ, NORMALIZED ON A GLOBAL BASIS
                                   APB ATTRIBUTE  4
                                          CSQ
           1       2       3       4       5       6       7       8       9
A     0.00169 0.00372 0.00223 0.00829 0.00884 0.00926 0.00775 0.00293 0.00974
B     0.06486 0.11983 0.07574 0.25392 0.23064 0.25415 0.24338 0.09032 0.18839
C     0.05939 0.09866 0.05770 0.20117 0.19975 0.20319 0.18974 0.07068 0.14093
D     0.87405 0.77778 0.86433 0.53561 0.56077 0.53339 0.55913 0.83606 0.66094

FCMR - FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ, NORMALIZED ON A GLOBAL BASIS
                                   APB ATTRIBUTE  5
                                          CSQ
           1       2       3       4       5       6       7       8       9
A     0.10321 0.18485 0.11700 0.37077 0.32999 0.37276 0.36870 0.14240 0.26835
B     0.84970 0.74056 0.81674 0.49690 0.54204 0.49565 0.51456 0.79112 0.59920
C     0.00368 0.00522 0.00318 0.01705 0.02072 0.01715 0.01059 0.00289 0.01169
D     0.01046 0.01101 0.01212 0.00941 0.00906 0.00934 0.00991 0.01189 0.01228
E     0.00013 0.00025 0.00019 0.00104 0.00115 0.00103 0.00071 0.00019 0.00086
F     0.03282 0.05810 0.05076 0.10482 0.09705 0.10407 0.09551 0.05152 0.10761

FCMR - FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ, NORMALIZED ON A GLOBAL BASIS
                                   APB ATTRIBUTE  6
                                          CSQ
           1       2       3       4       5       6       7       8       9
A     0.06772 0.10202 0.07366 0.10071 0.08611 0.10078 0.11019 0.07801 0.10832
B     0.00545 0.02224 0.00943 0.23640 0.19208 0.23684 0.25988 0.00889 0.04464
C     0.92682 0.87573 0.91688 0.66287 0.72180 0.66237 0.62991 0.91309 0.84703
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Table D.1 (continued)

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FCMR - FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ, NORMALIZED ON A GLOBAL BASIS
                                    APB ATTRIBUTE  7
                                          CSQ
            1       2       3       4       5       6       7       8       9
   A    0.94790 0.90578 0.92754 0.80671 0.80883 0.80832 0.84224 0.92154 0.80895
   B    0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000 0.00000
   C    0.00070 0.00153 0.00108 0.01128 0.01178 0.01121 0.00775 0.00105 0.00550
   D    0.05138 0.09269 0.07136 0.18200 0.17938 0.18046 0.14999 0.07739 0.18554

FCMR - FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ, NORMALIZED ON A GLOBAL BASIS
                                    APB ATTRIBUTE  8
                                          CSQ
            1       2       3       4       5       6       7       8       9
   A    0.53378 0.53574 0.52378 0.56855 0.56278 0.56850 0.57417 0.51421 0.52886
   B    0.46621 0.46426 0.47620 0.43143 0.43721 0.43149 0.42582 0.48578 0.47113

FCMR - FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ, NORMALIZED ON A GLOBAL BASIS
                                    APB ATTRIBUTE  9
                                          CSQ
            1       2       3       4       5       6       7       8       9
   A    0.01572 0.03174 0.01911 0.08902 0.07441 0.08930 0.09813 0.02392 0.04941
   B    0.06723 0.12018 0.07701 0.22040 0.18648 0.22040 0.22048 0.09354 0.17038
   C    0.00017 0.00072 0.00046 0.02210 0.02089 0.02210 0.01425 0.00056 0.00626
   D    0.91686 0.84734 0.90340 0.66848 0.71821 0.66820 0.66712 0.88197 0.77394

FCMR - FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ, NORMALIZED ON A GLOBAL BASIS
                                    APB ATTRIBUTE 10
                                          CSQ
            1       2       3       4       5       6       7       8       9
   A    0.16374 0.24331 0.15183 0.31393 0.29442 0.31511 0.29403 0.17083 0.29083
   B    0.08316 0.13003 0.08398 0.17342 0.17893 0.17546 0.15688 0.10401 0.16969
   C    0.30877 0.26724 0.31775 0.26162 0.27919 0.26099 0.26145 0.30654 0.26491
   D    0.44433 0.35941 0.44643 0.25103 0.24746 0.24843 0.28764 0.41861 0.27457

FCMR - FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ, NORMALIZED ON A GLOBAL BASIS
                                    APB ATTRIBUTE 11
                                          CSQ
            1       2       3       4       5       6       7       8       9
   A    0.78469 0.69220 0.79394 0.68224 0.69114 0.67961 0.68969 0.77685 0.66798
   B    0.21529 0.30779 0.20605 0.31775 0.30885 0.32038 0.31030 0.22314 0.33200

FCMR - FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ, NORMALIZED ON A GLOBAL BASIS
                                    APB ATTRIBUTE 12
                                          CSQ
            1       2       3       4       5       6       7       8       9
   A    0.89881 0.87017 0.91342 0.89287 0.90120 0.89307 0.88982 0.91341 0.88426
   B    0.02600 0.03960 0.03049 0.06823 0.06274 0.06821 0.06264 0.03499 0.06053
   C    0.07518 0.09022 0.05609 0.03888 0.03605 0.03871 0.04752 0.05159 0.05520

FCMR - FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ, NORMALIZED ON A GLOBAL BASIS
                                    APB ATTRIBUTE 13
                                          CSQ
            1       2       3       4       5       6       7       8       9
   A    0.87205 0.82464 0.87184 0.79248 0.80601 0.79336 0.79622 0.87194 0.79771
   B    0.02439 0.03676 0.02827 0.06362 0.05887 0.06364 0.05796 0.03260 0.05845
   C    0.10355 0.13860 0.09989 0.14390 0.13512 0.14299 0.14580 0.09546 0.14583

FCMR - FRACTIONAL CONTRIBUTIONS OF APB ATTRIBUTES TO CSQ, NORMALIZED ON A GLOBAL BASIS
                                    APB ATTRIBUTE 14
                                          CSQ
            1       2       3       4       5       6       7       8       9
   A    0.32386 0.26540 0.32388 0.23859 0.24822 0.23715 0.24567 0.30886 0.24007
   B    0.45927 0.40943 0.46655 0.41417 0.43821 0.41405 0.40750 0.45171 0.42102
   C    0.12058 0.17756 0.11111 0.19300 0.17756 0.19363 0.18554 0.12676 0.18713
   D    0.09628 0.14761 0.09845 0.15424 0.13601 0.15516 0.16129 0.11266 0.15177
```

Table D.1 (continued)

MFCR - FRACTIONAL CONTRIBUTIONS OF APB TO CSQ, NORMALIZED ON A SAMPLE BASIS

CSQ 1			CSQ 2			CSQ 3		
AHADBCAADDAAAB	0.05054	0.05054	GDCDFADADDBAAB	0.04158	0.04158	AHADBCAADDAAAB	0.04165	0.04165
AHADBCAADDAAAA	0.03931	0.08985	GDCDFADBDDBAAB	0.03554	0.07712	GDCDFADADDBAAB	0.04061	0.08227
GDCDFADADDBAAB	0.03747	0.12732	BHADBCAADDAAAB	0.03214	0.10826	GDCDFADBDDBAAB	0.03301	0.11527
AHADBCABDDAAAB	0.03630	0.16362	AHADBCAADDAAAB	0.02935	0.13861	AHADBCAADDAAAA	0.03240	0.14768
AHADBCAADCAAAB	0.03404	0.19766	BHADBCAADDAAAA	0.,2500	0.16361	BHADBCAADDAAAB	0.03108	0.17876
GDCDFADBDDBAAB	0.03018	0.22783	BHADBCABDDAAAB	0.02401	0.18762	AHADBCABDDAAAB	0.03010	0.20885
AHADBCABDDAAAA	0.02823	0.25606	AHADBCAADDAAAA	0.02283	0.21045	AHADBCAADCAAAB	0.02805	0.23690
AHADBCAADCAAAA	0.02647	0.28253	BHADBCAADCAAAB	0.02186	0.23231	BHADBCAADDAAAA	0.02417	0.26108
BHADBCAADDAAAB	0.02524	0.30777	AHADBCABDDAAAB	0.02174	0.25405	BHADBCABDDAAAB	0.02378	0.28486
AHADBCABDCAAAB	0.02451	0.33228	AHADBCAADCAAAB	0.01977	0.27382	AHADBCABDDAAAA	0.02340	0.30826
BHADBCABDDAAAB	0.01977	0.35206	BHADBCABDDAAAA	0.01868	0.29250	AHADBCAADCAAAA	0.02181	0.33008
BHADBCAADDAAAA	0.01963	0.37169	BHADBCAADCAAAA	0.01701	0.30951	BHADBCAADCAAAB	0.02115	0.35123
AHADBCABDCAAAA	0.01906	0.39075	AHADBCABDDAAAA	0.01690	0.32642	AHADBCABDCAAAB	0.02030	0.37153
BHADBCAADCAAAB	0.01723	0.40798	BHADBCABDCAAAB	0.01625	0.34266	BHADBCABDDAAAA	0.01850	0.39004
BHADBCABDDAAAA	0.01538	0.42336	AHADBCAADCAAAA	0.01538	0.35804	BHADBCAADCAAAA	0.01647	0.40650
BHADBCAADCAAAA	0.01341	0.43677	AHADBCABDCAAAB	0.01466	0.37270	BHADBCABDCAAAB	0.01610	0.42261
BHADBCABDCAAAB	0.01339	0.45016	DHADBCABDABAAC	0.01402	0.38672	AHADBCABDCAAAA	0.01579	0.43839
DHADBCABDABAAC	0.01272	0.46289	GDCDFADADDBAAA	0.01369	0.40041	GDCDFADADDBAAA	0.01336	0.45175
GDCDFADADDBAAA	0.01232	0.47521	BHADBCABDCAAAA	0.01264	0.41305	BHADBCABDCAAAA	0.01253	0.46428
DHFDBCAADBBACB	0.01100	0.48621	GDCDFADBDDBAAA	0.01162	0.42467	DHADBCABDABAAC	0.01091	0.47519
BHADBCABDCAAAA	0.01042	0.49663	CACDFCDBDABAAB	0.01161	0.43628	GDCDFADBDDBAAA	0.01079	0.48598
GDCDFADBDDBAAA	0.00983	0.50647	AHADBCABDCAAAA	0.01139	0.44767	DHADBCAADABAAC	0.00956	0.49555
DHADBCAADABAAC	0.00978	0.51625	DHADBCAADABAAC	0.01000	0.45767	CACDFCDBDABAAB	0.00945	0.50500
CACDFCDBDABAAB	0.00846	0.52471	DHFDBCAADBBACB	0.00981	0.46748	DHFDBCAADBBACB	0.00783	0.51283
DHADDCAADBBACC	0.00797	0.53269	DHADBCABDABAAD	0.00751	0.47499	DHADDCAADBBACC	0.00738	0.52021
DHADBCABDABAAD	0.00679	0.53947	DHDDBCAADBBACB	0.00726	0.48225	DHADBCABDABAAD	0.00701	0.52722
CADDBCABDABAAB	0.00661	0.54608	DHADDCAADBBACC	0.00624	0.48849	DHDDBCAADBBACB	0.00696	0.53418
DHDDBCAADBBACB	0.00610	0.55218	CADDBCABDABAAB	0.00570	0.49419	CADDBCABDABAAB	0.00562	0.53981
CDCDFCDBDBBCCB	0.00505	0.55723	CDCDFCDBDBBCCB	0.00562	0.49981	CDCDFCDBDBBCCB	0.00468	0.54448
CHDDBCABDABAAB	0.00501	0.56223	GACDFADADDBAAB	0.00459	0.50440	DHDDBCABDBBACB	0.00457	0.54906
DHADDCAADBBACD	0.00439	0.56662	CHDDBCABDABAAB	0.00415	0.50855	GACDFADADDBAAB	0.00446	0.55352
GDDCAAABDDBAAB	0.00431	0.57093	DHADBCABDAAAAC	0.00412	0.51267	GDDCAAABDDBAAB	0.00428	0.55780
DHFDDCAADBBACB	0.00425	0.57517	DHDDBCABDBBACB	0.00405	0.51672	CHDDBCABDABAAB	0.00415	0.56195
GDDCBAABDDBAAB	0.00417	0.57934	GDDCBAABDDBAAB	0.00396	0.52068	DHADBCAADABAAD	0.00411	0.56606
GACDFADADDBAAB	0.00412	0.58346	DHADBCABDABCCC	0.00385	0.52454	DHADBCABDABCCC	0.00395	0.57001
DHDDBCABDBBACB	0.00409	0.58755	GACDFADBDDBAAB	0.00382	0.52836	DHADBCABDAAAAC	0.00389	0.57390
DHADBCABDABCCC	0.00401	0.59156	CACDFCDBDABAAA	0.00370	0.53206	DHADDCAADBBACD	0.00389	0.57779
DHADBCABDAAAAC	0.00388	0.59544	GHADBBAADDAAAB	0.00365	0.53572	GDDCBAABDDBAAB	0.00354	0.58133
CAFDBCABDABAAB	0.00353	0.39897	GDCDFADADDBBBB	0.00364	0.53935	GDCDFADADDBBBB	0.00354	0.58487
DHFDBCABDBBACB	0.00352	0.60249	DHADBCAADABAAD	0.00361	0.54296	GACDFADBDDBAAB	0.00354	0.58841
GDCDFADADDBBBB	0.00327	0.60576	GDDCAAABDDBAAB	0.00352	0.54649	GHADBBAADDAAAB	0.00345	0.59186
GACDFADBDDBAAB	0.00322	0.60898	DHADDCAADBBACD	0.00332	0.54981	CHADBCABDBBBBC	0.00334	0.59520
DHADBCAADABAAD	0.00313	0.61211	CHADBCABDBBBBC	0.00314	0.55295	DHFDBCABDBBACB	0.00323	0.59843
CHADBCABDBBBBC	0.00312	0.61524	GDCDFADBDDBBBB	0.00309	0.55604	CACDFCDBDABCCB	0.00320	0.60163
DHADBCAADAAAAC	0.00299	0.61823	CAFDBCABDABAAB	0.00302	0.55906	DHADBCABDAAAAD	0.00310	0.60473
DHFDDCABDBBACB	0.00296	0.62119	DHFDDCAADBBACB	0.00299	0.56205	DHADBCAADAAAAD	0.00305	0.60778
GDCBFADBDDAAAB	0.00296	0.62415	DHADBCAADAAAAC	0.00297	0.56502	CACDFCDBDABAAA	0.00300	0.61078
GHADBBAADDAAAB	0.00274	0.62689	DHADBCABDAAAAD	0.00289	0.56791	GDDCAAAADDBAAB	0.00297	0.61375
DHACACAAAAAAAC	0.00273	0.62962	GHADBBAADDAAAA	0.00284	0.57075	DHADDCABDBBACC	0.00297	0.61671
CACDFCDBDABAAA	0.00270	0.63232	DHFDBCABDBBACB	0.00284	0.57359	GDCDFADBDDBBBB	0.00288	0.61959
CFADBCABDBBBBC	0.00268	0.63499	DHACACAAAAAAAC	0.00275	0.57634	CFADBCABDBBBBC	0.00286	0.62245
CFADBCABDBBCCC	0.00266	0.63765	GDCBFADBDDAAAB	0.00272	0.57906	DHFDDCAADBBACB	0.00271	0.62516
DHADDCABDBBACC	0.00263	0.64028	CFADBCABDBBBBC	0.00269	0.58175	GHADBBAADDAAAA	0.00268	0.62784
DHADBCABDAAAAD	0.00263	0.64291	FHADBBAADCAAAB	0.00261	0.58436	DHADBCAADAAAAC	0.00266	0.63050
GDCDFADBDDBBBB	0.00262	0.64553	DHADBCAADABCCC	0.00261	0.58697	DGACACAABCAACD	0.00263	0.63313
CHADBCABDBBCCC	0.00259	0.64812	CACDFCDBDABCCB	0.00260	0.58957	GDCBFADBDDAAAB	0.00257	0.63570
DHDDBCAADBBCCB	0.00259	0.65071	DHFDDCABDBBACB	0.00255	0.59213	DHADBCABDABCCD	0.00249	0.63819
DHFDBCAADBBACA	0.00258	0.65329	DHDDBCAADBAACB	0.00249	0.59461	CAFDBCABDABAAB	0.00242	0.64061
DHADBCAADABCCC	0.00253	0.65583	GDDCAAAADDBAAB	0.00247	0.59708	FHADBBAADCAAAB	0.00234	0.64295
DHADBCABDABCCD	0.00250	0.65833	CFADBCABDBBCCC	0.00245	0.59954	DHACACAAAAAAAC	0.00233	0.64528
DGACACAABCAACD	0.00248	0.66082	CHADBCABDBBCCC	0.00242	0.60195	DACCACDAAAAAAB	0.00226	0.64755
GDDCAAAADDBAAB	0.00243	0.66325	DHADBCABDABCCD	0.00239	0.60435	DHFDDCABDBBACB	0.00226	0.64980

Table D.1 (continued)

MFCR - FRACTIONAL CONTRIBUTIONS OF APB TO CSQ, NORMALIZED ON A SAMPLE BASIS

CSQ 4			CSQ 5			CSQ 6		
GDCDFADBDDBAAB	0.02515	0.02515	GDCDFADBDDBAAB	0.02044	0.02044	GDCDFADBDDBAAB	0.02435	0.02435
GDCDFADADDBAAB	0.02431	0.04945	GDCDFADADDBAAB	0.02007	0.04051	GDCDFADADDBAAB	0.02356	0.04790
GHADBBAADDAAAB	0.01308	0.06254	GHADBBAADDAAAB	0.01114	0.05165	GHADBBAADDAAAB	0.01287	0.06077
CACDFCDBDABAAB	0.01295	0.07549	CACDFCDBDABAAB	0.01071	0.06237	DHADBCABDABAAC	0.01280	0.07357
DHADBCABDABAAC	0.01292	0.08840	DHADBCABDABAAC	0.01064	0.07301	CACDFCDBDABAAB	0.01256	0.08612
FHADBBAADCAAAB	0.01079	0.09919	BHADBCAADDAAAB	0.01052	0.08354	FHADBBAADCAAAB	0.01049	0.09661
BHADBCAADDAAAB	0.01027	0.10946	BHADBCABDDAAAB	0.00949	0.09303	GHADBBAADDAAAA	0.01002	0.10663
GHADBBAADDAAAA	0.01018	0.11965	FHADBBAADCAAAB	0.00870	0.10173	BHADBCAADDAAAB	0.01000	0.11664
BHADBCABDDAAAB	0.00924	0.12889	GHADBBAADDAAAA	0.00867	0.11040	BHADBCABDDAAAB	0.00908	0.12571
FHADBBAADCAAAA	0.00839	0.13728	FHDDBCAADBBAAB	0.00841	0.11881	FHADBBAADCAAAA	0.00816	0.13388
GDCDFADBDDBAAA	0.00831	0.14559	BHADBCAADDAAAA	0.00819	0.12700	GDCDFADBDDBAAA	0.00805	0.14193
GDCDFADADDBAAA	0.00802	0.15361	FHDDBCAADABAAB	0.00800	0.13499	BHADBCAADDAAAA	0.00778	0.14971
BHADBCAADDAAAA	0.00799	0.16160	BHADBCABDDAAAA	0.00739	0.14238	GDCDFADADDBAAA	0.00777	0.15748
DHADBCAADABAAC	0.00766	0.16926	EEADBCAADABAAC	0.00735	0.14973	DHADBCAADABAAC	0.00765	0.16513
BHADBCABDDAAAA	0.00718	0.17645	BHADBCAADCAAAB	0.00717	0.15690	DHADBCABDABAAD	0.00708	0.17221
DHADBCABDABAAD	0.00714	0.18359	FHDDBCABDABAAB	0.00713	0.16403	BHADBCABDDAAAA	0.00706	0.17927
BHADBCAADCAAAB	0.00698	0.19057	DHADBCAADABAAC	0.00703	0.17106	BHADBCAADCAAAB	0.00680	0.18607
GHADBBABDDAAAB	0.00690	0.19747	AHADBCABDDAAAB	0.00698	0.17804	EEADBCAADABAAC	0.00675	0.19282
AHADBCABDDAAAB	0.00667	0.20414	FHDDBCABDBBAAB	0.00695	0.18498	GHADBBABDDAAAB	0.00669	0.19951
AHADBCAADDAAAB	0.00650	0.21063	AHADBCAADDAAAB	0.00685	0.19183	AHADBCABDDAAAB	0.00634	0.20585
EEADBCAADABAAC	0.00648	0.21712	FHADBBAADCAAAA	0.00677	0.19860	BHADBCABDCAAAB	0.00617	0.21202
BHADBCABDCAAAB	0.00628	0.22339	GDCDFADBDDBAAA	0.00677	0.20537	AHADBCAADDAAAB	0.00605	0.21807
BHADBCAADCAAAA	0.00544	0.22883	GDCDFADADDBAAA	0.00663	0.21200	BHADBCAADCAAAA	0.00529	0.22336
GHADBBABDDAAAA	0.00538	0.23421	BHADBCABDCAAAB	0.00645	0.21845	EEADBCABDABAAC	0.00523	0.22859
CDCDFCDBDBBCCB	0.00520	0.23941	EEADBCABDABAAC	0.00640	0.22485	GHADBBABDDAAAA	0.00521	0.23380
FHADBBABDCAAAB	0.00519	0.24460	DHADBCABDABAAD	0.00610	0.23096	FHDDBCAADABAAB	0.00517	0.23897
AHADBCABDDAAAA	0.00519	0.24978	BHADBCAADCAAAA	0.00558	0.23654	CDCDFCDBDBBCCB	0.00514	0.24411
AHADBCAADDAAAA	0.00505	0.25484	AHADBCABDDAAAA	0.00543	0.24197	FHADBBABDCAAAB	0.00504	0.24915
EEADBCABDABAAC	0.00492	0.25975	AHADBCAADDAAAA	0.00533	0.24729	FHDDBCAADBBAAB	0.00494	0.25409
BHADBCABDCAAAA	0.00489	0.26464	BHADBCABDCAAAA	0.00502	0.25232	AHADBCABDDAAAA	0.00493	0.25902
FHDDBCAADABAAB	0.00455	0.26919	GHADBBABDDAAAB	0.00485	0.25717	BHADBCABDCAAAA	0.00480	0.26382
AHADBCABDCAAAB	0.00449	0.27367	AHADBCABDCAAAB	0.00470	0.26186	AHADBCAADDAAAA	0.00470	0.26852
AHADBCAADCAAAB	0.00440	0.27807	AHADBCAADCAAAB	0.00463	0.26649	AHADBCABDCAAAB	0.00426	0.27279
GHACABABBDAAAB	0.00419	0.28226	CDCDFCDBDBBCCB	0.00424	0.27073	AHADBCAADCAAAB	0.00410	0.27689
FHDDBCAADBBAAB	0.00417	0.28642	EEADBCABDABAAD	0.00413	0.27485	DHADBCAADABAAD	0.00409	0.28098
CACDFCDBDABAAA	0.00416	0.29059	DHADBCABDAAAAC	0.00379	0.27865	GHACABABBDAAAB	0.00409	0.28506
DHADBCAADABAAD	0.00407	0.29466	GHADBBABDDAAAA	0.00378	0.28243	FHDDBCABDABAAB	0.00406	0.28912
FHADBBABDCAAAA	0.00405	0.29871	EEADBCAADABAAD	0.00378	0.28621	CACDFCDBDABAAA	0.00404	0.29316
DHADBCABDAAAAC	0.00397	0.30268	FHADBBABDCAAAB	0.00367	0.28988	DHADBCABDAAAAC	0.00397	0.29713
GHABABAACDAAAB	0.00396	0.30663	AHADBCABDCAAAA	0.00365	0.29353	EEADBCABDABAAD	0.00395	0.30108
EEADBCABDABAAD	0.00391	0.31054	AHADBCAADCAAAA	0.00360	0.29713	FHADBBABDCAAAA	0.00393	0.30501
AHADBCABDCAAAA	0.00349	0.31403	DHADBCAADABAAD	0.00355	0.30068	GHABABAACDAAAB	0.00389	0.30890
FHDDBCABDABAAB	0.00347	0.31750	CACDFCDBDABAAA	0.00345	0.30413	FHDDBCABDBBAAB	0.00384	0.31273
AHADBCAADCAAAA	0.00342	0.32092	GHACABABBDAAAB	0.00337	0.30750	EEADBCAADABAAD	0.00352	0.31625
EEADBCAADABAAD	0.00342	0.32434	FDDDBCABDCBAAB	0.00331	0.31081	AHADBCABDCAAAA	0.00332	0.31957
GHBCBBAADDAAAB	0.00341	0.32775	FDDDBCAADCBAAB	0.00328	0.31409	GHBCBBAADDAAAB	0.00330	0.32286
EEADBCAADABCCC	0.00336	0.33111	FDDCACAADCAAAB	0.00320	0.31729	AHADBCAADCAAAA	0.00319	0.32605
GHACABABBDAAAA	0.00325	0.33437	GHABABAACDAAAB	0.00297	0.32027	EEADBCAADABCCC	0.00318	0.32924
FHDDBCABDBBAAB	0.00324	0.33761	DHADBBAADAAAAB	0.00295	0.32322	GHACABABBDAAAA	0.00318	0.33241
DHDDBCAADBBACB	0.00324	0.34086	DHADBCABDAAAAD	0.00294	0.32616	DHADBBAADAAAAB	0.00316	0.33557
DHADBBAADAAAAB	0.00315	0.34401	FHADBBABDCAAAA	0.00286	0.32902	DHDDBCAADBBACB	0.00304	0.33861
GHABABAACDAAAA	0.00308	0.34709	FHDDBCAADBBAAA	0.00278	0.33180	GHABABAACDAAAA	0.00303	0.34164
DHADBCABDAAAAD	0.00303	0.35012	FHDDBCAADAAAAB	0.00274	0.33455	DHADBCABDAAAAD	0.00303	0.34467
DHDDBCABDBBACB	0.00289	0.35301	FDDCBCAADCAAAB	0.00272	0.33726	CACDFCDBDABCCB	0.00283	0.34749
CACDFCDBDABCCB	0.00288	0.35589	FHDDBCAADABAAA	0.00265	0.33992	CHADBCABDBBBBC	0.00280	0.35030
GHBBBBAADDAAAB	0.00287	0.35877	GHACABABBDAAAA	0.00262	0.34253	FHACABABBCAAAB	0.00278	0.35308
FHACABABBCAAAB	0.00285	0.36162	FHFDBCAADBBAAB	0.00259	0.34512	DHDDBCABDBBACB	0.00276	0.35585
CHADBCABDBBBBC	0.00284	0.36445	GHBCBBAADDAAAB	0.00256	0.34768	GHBBBBAADDAAAB	0.00276	0.35861
CADDBCABDABAAB	0.00280	0.36725	EEBCBCAADAAAAC	0.00254	0.35022	CADDBCABDABAAB	0.00272	0.36132
GACDFADBDDBAAB	0.00277	0.37002	FHFDBCAADABAAB	0.00249	0.35271	GACDFADBDDBAAB	0.00268	0.36401
EHADBCAADABAAC	0.00271	0.37273	FHDDBCABDAAAAB	0.00248	0.35519	GACDFADADDBAAB	0.00262	0.36663
GACDFADADDBAAB	0.00270	0.37543	EEADBCAADABCCC	0.00246	0.35765	FHABABAACCAAAB	0.00260	0.36923

Table D.1 (continued)

MFCR - FRACTIONAL CONTRIBUTIONS OF APB TO CSQ, NORMALIZED ON A SAMPLE BASIS

CSQ 7			CSQ 8			CSQ 9		
GDCDFADBDDBAAB	0.02945	0.02945	GDCDFADADDBAAB	0.04013	0.04013	GDCDFADADDBAAB	0.03467	0.03467
GDCDFADADDBAAB	0.02859	0.05805	AHADBCAADDAAAB	0.03539	0.07552	GDCDFADBDDBAAB	0.03185	0.06652
GHADBBAADDAAAB	0.01389	0.07193	BHADBCAADDAAAB	0.03469	0.11021	AHADBCAADDAAAB	0.01481	0.08132
DHADBCABDABAAC	0.01368	0.08561	GDCDFADBDDBAAB	0.03246	0.14267	CACDFCDBDABAAB	0.01466	0.09598
BHADBCAADDAAAB	0.01277	0.09837	AHADBCAADDAAAA	0.02753	0.17020	AHADBCABDDAAAB	0.01328	0.10927
FHADBBAADCAAAB	0.01164	0.11001	BHADBCAADDAAAA	0.02698	0.19718	BHADBCAADDAAAB	0.01300	0.12227
CACDFCDBDABAAB	0.01162	0.12163	AHADBCABDDAAAB	0.02637	0.22354	DHADBCABDABAAC	0.01230	0.13456
BHADBCABDDAAAB	0.01121	0.13284	BHADBCABDDAAAB	0.02615	0.24970	BHADBCABDDAAAB	0.01152	0.14608
AHADBCAADDAAAB	0.01110	0.14395	AHADBCAADCAAAB	0.02384	0.27354	AHADBCAADDAAAA	0.01152	0.15760
GHADBBAADDAAAA	0.01081	0.15475	BHADBCAADCAAAB	0.02359	0.29713	GDCDFADADDBAAA	0.01143	0.16903
AHADBCABDDAAAB	0.01060	0.16535	AHADBCABDDAAAA	0.02050	0.31763	GDCDFADBDDBAAA	0.01053	0.17956
BHADBCAADDAAAA	0.00993	0.17528	BHADBCABDDAAAA	0.02035	0.33797	AHADBCABDDAAAA	0.01033	0.18989
GDCDFADBDDBAAA	0.00970	0.18498	AHADBCAADCAAAA	0.01854	0.35651	BHADBCAADDAAAA	0.01011	0.20000
GDCDFADADDBAAA	0.00943	0.19441	BHADBCAADCAAAA	0.01836	0.37488	AHADBCAADCAAAB	0.00997	0.20997
FHADBBAADCAAAA	0.00905	0.20346	AHADBCABDCAAAB	0.01778	0.39265	BHADBCABDDAAAA	0.00896	0.21892
BHADBCABDDAAAA	0.00872	0.21218	BHADBCABDCAAAB	0.01770	0.41036	AHADBCABDCAAAB	0.00893	0.22785
DHADBCAADABAAC	0.00870	0.22088	AHADBCABDCAAAA	0.01382	0.42418	BHADBCAADCAAAB	0.00884	0.23669
BHADBCAADCAAAB	0.00864	0.22952	BHADBCABDCAAAA	0.01378	0.43795	DHADBCAADABAAC	0.00851	0.24520
AHADBCAADDAAAA	0.00864	0.23815	GDCDFADADDBAAA	0.01320	0.45115	BHADBCABDCAAAB	0.00784	0.25304
AHADBCABDDAAAA	0.00824	0.24639	DHADBCABDABAAC	0.01238	0.46353	AHADBCAADCAAAA	0.00775	0.26079
DHADBCABDABAAD	0.00793	0.25432	GDCDFADBDDBAAA	0.01062	0.47415	DHADBCABDABAAD	0.00744	0.26823
BHADBCABDCAAAB	0.00762	0.26194	CACDFCDBDABAAB	0.01059	0.48474	AHADBCABDCAAAA	0.00694	0.27517
AHADBCAADCAAAB	0.00754	0.26948	DHADBCAADABAAC	0.00992	0.49466	BHADBCAADCAAAA	0.00688	0.28205
GHADBBABDDAAAB	0.00722	0.27670	DHFDBCAADBBACB	0.00853	0.50319	GHADBBAADDAAAB	0.00666	0.28871
AHADBCABDCAAAB	0.00712	0.28382	DHADBCABDABAAD	0.00721	0.51040	FHDDBCAADABAAB	0.00635	0.29506
BHADBCAADCAAAA	0.00673	0.29055	DHADDCAADBBACC	0.00689	0.51729	BHADBCABDCAAAA	0.00610	0.30116
BHADBCABDCAAAA	0.00593	0.29649	DHDDBCAADBBACB	0.00681	0.52410	FHDDBCAADBBAAB	0.00601	0.30716
AHADBCAADCAAAA	0.00587	0.30235	CADDBCABDABAAB	0.00584	0.52994	CDCDFCDBDBBCCB	0.00531	0.31247
GHADBBABDDAAAA	0.00563	0.30798	CDCDFCDBDBBCCB	0.00563	0.53557	GHADBBAADDAAAA	0.00518	0.31765
AHADBCABDCAAAA	0.00554	0.31352	DHDDBCABDBBACB	0.00467	0.54023	FHDDBCABDABAAB	0.00515	0.32280
FHADBBABDCAAAB	0.00541	0.31893	GACDFADADDBAAB	0.00440	0.54464	CACDFCDBDABAAA	0.00471	0.32751
CDCDFCDBDBBCCB	0.00526	0.32419	DHADBCAADABAAD	0.00413	0.54877	FHADBBAADCAAAB	0.00468	0.33218
DHDDBCAADBBACB	0.00483	0.32901	DHADBCABDAAAAC	0.00408	0.55285	FHDDBCABDBBAAB	0.00464	0.33682
DHADBCAADABAAD	0.00437	0.33339	GDDCAAABDDBAAB	0.00404	0.55689	DHDDBCAADBBACB	0.00412	0.34094
DHFDBCAADBBACB	0.00436	0.33775	CHDDBCABDABAAB	0.00398	0.56087	DHADBCABDAAAAC	0.00398	0.34492
GHACABABBDAAAB	0.00426	0.34201	GDDCBAABDDBAAB	0.00366	0.56453	EEADBCAADABAAC	0.00394	0.34886
FHADBBABDCAAAA	0.00422	0.34623	GDCDFADADDBBBB	0.00350	0.56803	GACDFADADDBAAB	0.00385	0.35271
EEADBCAADABAAC	0.00407	0.35030	GACDFADBDDBAAB	0.00349	0.57152	DHADBCAADABAAD	0.00385	0.35655
DHADBCABDAAAAC	0.00405	0.35435	DHADDCAADBBACD	0.00347	0.57499	EEADBCABDABAAC	0.00366	0.36022
GHBCBBAADDAAAB	0.00394	0.35829	GHADBBAADDAAAB	0.00340	0.57839	FHADBBAADCAAAA	0.00364	0.36385
CADDBCABDABAAB	0.00392	0.36221	CACDFCDBDABAAA	0.00337	0.58176	GACDFADBDDBAAB	0.00352	0.36737
CACDFCDBDABAAA	0.00372	0.36593	DHADBCABDABCCC	0.00334	0.58510	CADDBCABDABAAB	0.00347	0.37084
DHDDBCABDBBACB	0.00362	0.36955	CHADBCABDBBBBC	0.00331	0.58841	DHDDBCABDBBACB	0.00338	0.37422
GHBBBBAADDAAAB	0.00362	0.37317	CACDFCDBDABCCB	0.00313	0.59154	GDCDFADADDBBBB	0.00304	0.37726
GHABABAACDAAAB	0.00354	0.37672	DHADBCABDAAAAD	0.00299	0.59454	DHADBCABDAAAAD	0.00302	0.38029
DHADBBAADAAAAB	0.00351	0.38022	DHFDBCABDBBACB	0.00296	0.59750	DHADBCABDABCCC	0.00300	0.38329
GHACABABBDAAAA	0.00331	0.38354	DHADBCAADAAAAC	0.00291	0.60041	CHADBCABDBBBBC	0.00293	0.38622
CHADBCABDBBBBC	0.00330	0.38684	DHFDDCAADBBACB	0.00285	0.60326	GDDCBAABDDBAAB	0.00288	0.38909
EHADBCAADABAAC	0.00328	0.39012	CFADBCABDBBBBC	0.00284	0.60610	GDCDFADBDDBBBB	0.00284	0.39193
EEADBCABDABAAC	0.00328	0.39340	GDCDFADBDDBBBB	0.00283	0.60893	GDDCAAABDDBAAB	0.00281	0.39475
GACDFADBDDBAAB	0.00322	0.39662	GDDCAAAADDBAAB	0.00269	0.61162	FDDCBCAADCAAAB	0.00260	0.39735
GACDFADADDBAAB	0.00317	0.39979	DHADBCAADAAAAD	0.00268	0.61430	CACDFCDBDABCCB	0.00257	0.39992
EEADBCABDABAAD	0.00316	0.40295	GDCBFADBDDAAAB	0.00267	0.61697	FDDCACAADCAAAB	0.00252	0.40243
DHADBCABDAAAAD	0.00311	0.40606	GHADBBAADDAAAA	0.00264	0.61961	DACCACDAAAAAAB	0.00252	0.40495
GHBCBBAADDAAAA	0.00307	0.40913	DHACACAAAAAAAC	0.00263	0.62224	FDDDBCAADCBAAB	0.00252	0.40746
GHACABAACDAAAB	0.00298	0.41211	FHADBBAADCAAAB	0.00262	0.62486	CFADBCABDBBBBC	0.00251	0.40997
CACDFCDBDABCCB	0.00295	0.41506	CAFDBCABDABAAB	0.00258	0.62744	DHACACAAAAAAAC	0.00240	0.41237
FHACABABBCAAAB	0.00293	0.41799	DGACACAABCAACD	0.00256	0.63000	CHADBCABDBBBBD	0.00238	0.41476
CFADBCABDBBBBC	0.00283	0.42082	DHADDCABDBBACC	0.00249	0.63249	FHDDBCAADAAAAB	0.00230	0.41706
GHBBBBAADDAAAA	0.00282	0.42364	DHFDDCABDBBACB	0.00237	0.63486	GDCCFADBDDAAAB	0.00226	0.41931
GHABABAACDAAAA	0.00276	0.42641	DACCACDAAAAAAB	0.00236	0.63722	DHADBCAADAAAAC	0.00224	0.42155
DHADBBAADAAAAA	0.00271	0.42911	DHADBCAADBBACD	0.00213	0.63936	FDDDBCABDCBAAB	0.00223	0.42378

Table D.1 (continued)

FCMR - FRACTIONAL CONTRIBUTIONS OF APB TO CSQ, NORMALIZED ON A GLOBAL BASIS

CSQ 1			CSQ 2			CSQ 3		
AHADBCABDDAAAB	0.07516	0.07516	AHADBCABDDAAAB	0.04251	0.04251	AHADBCABDDAAAB	0.05984	0.05984
AHADBCAADDAAAB	0.06706	0.14222	BHADBCAADDAAAB	0.04074	0.08325	BHADBCAADDAAAB	[illegible]	0.11531
AHADBCABDDAAAA	0.05852	0.20074	DHADBCAADABCCC	0.03739	0.12064	AHADBCAADDAAAB	0.05073	0.16603
AHADBCAADDAAAA	0.05214	0.25288	AHADBCAADDAAAB	0.03727	0.15791	BHADBCABDDAAAB	0.04855	0.21458
AHADBCABDCAAAB	0.05095	0.30383	BHADBCABDDAAAB	0.03584	0.19376	AHADBCABDDAAAA	0.04659	0.26117
BHADBCAADDAAAB	0.04616	0.35000	AHADBCABDDAAAA	0.03310	0.22685	BHADBCAADDAAAA	0.04313	0.30430
AHADBCAADCAAAB	0.04518	0.39518	BHADBCAADDAAAA	0.03168	0.25854	AHADBCABDCAAAB	0.04050	0.34480
AHADBCABDCAAAA	0.03967	0.43485	DHABACAABBAAAD	0.02983	0.28837	AHADBCAADDAAAA	0.03944	0.38424
BHADBCAADDAAAA	0.03590	0.47074	AHADBCAADDAAAA	0.02898	0.31735	BHADBCABDDAAAA	0.03775	0.42199
AHADBCAADCAAAA	0.03529	0.50603	AHADBCABDCAAAB	0.02879	0.34613	BHADBCAADCAAAB	0.03753	0.45952
DHADBCAADABCCC	0.03319	0.53923	BHADBCABDDAAAA	0.02787	0.37401	BHADBCABDCAAAB	0.03472	0.49423
BHADBCABDDAAAB	0.03234	0.57157	BHADBCAADCAAAB	0.02776	0.40176	AHADBCAADCAAAB	0.03424	0.52847
BHADBCAADCAAAB	0.03112	0.60269	BHADBCABDCAAAB	0.02527	0.42703	AHADBCABDCAAAA	0.03153	0.56000
BHADBCABDDAAAA	0.02515	0.62784	AHADBCAADCAAAB	0.02518	0.45221	BHADBCAADCAAAA	0.02931	0.58930
BHADBCAADCAAAA	0.02431	0.65214	AHADBCABDCAAAA	0.02241	0.47462	BHADBCABDCAAAA	0.02701	0.61631
BHADBCABDCAAAB	0.02327	0.67541	DHADBCABDABAAC	0.02176	0.49638	AHADBCAADCAAAA	0.02673	0.64304
DHABACAABBAAAD	0.01997	0.69538	BHADBCAADCAAAA	0.02166	0.51804	DHADBCAADABCCC	0.02315	0.66619
BHADBCABDCAAAA	0.01811	0.71349	BHADBCABDCAAAA	0.01966	0.53770	DHABACAABBAAAD	0.01253	0.67872
DHADBCABDABAAC	0.01433	0.72782	AHADBCAADCAAAA	0.01965	0.55735	DHADBCAADABAAC	0.01135	0.69006
DHADBCAADABCCD	0.01419	0.74201	DHADBCAADABAAC	0.01907	0.57642	GDCDFADADDBAAB	0.01082	0.70088
DHADBCAADABAAC	0.01249	0.75450	DHABACAABBAAAC	0.01845	0.59488	GDCDFADBDDBAAB	0.00990	0.71078
DHABACAABBAAAC	0.01235	0.76685	DHADBCAADABCCD	0.01598	0.61086	DHADBCAADABCCD	0.00990	0.72068
DHADBCABDABCCC	0.01050	0.77736	DGABACAABBAAAD	0.01349	0.62435	DHADBCABDABAAC	0.00984	0.73052
GDCDFADADDBAAB	0.00947	0.78683	GDCDFADADDBAAB	0.01332	0.63767	DHABACAABBAAAC	0.00775	0.73827
DGABACAABBAAAD	0.00903	0.79586	DHADBCABDABAAD	0.01217	0.64984	DHADBCABDABCCC	0.00758	0.74585
DHADBCABDABAAD	0.00793	0.80379	DHADBCABDABCCC	0.01200	0.66184	DHADBCABDABAAD	[illegible]	0.75208
DHADBCABDABCCD	0.00701	0.81080	DHADBCABDAAAAC	0.01048	0.67232	DHAB[illegible]ABCAAAD	0.00593	0.75801
DDDCAAABDCBAAB	0.00681	0.81761	DDDCAAABDCBAAB	0.01017	0.68249	DGAB[illegible]AABBAAAD	0.00566	0.76367
DHADBCABDAAAAC	0.00661	0.82422	GDCDFADBDDBAAB	0.00881	0.69130	DHADBCABDAAAAC	0.00523	0.76890
DHACACAAAAAAAC	0.00541	0.82963	DHACACAAAAAAAC	0.00810	0.69940	DHADBCABDABCCD	0.00504	0.77394
GDDCBAABDDBAAB	0.00476	0.83438	DHADBCABDABCCD	0.00799	0.70739	DHADBCAADABAAD	0.00504	0.77898
DHADBCAADABAAD	0.00466	0.83904	DHADBCAADABAAD	0.00785	0.71525	DFABACAABCAAAC	0.00484	0.78382
GDCDFADBDDBAAB	0.00452	0.84357	DHADBCABDAAAAD	0.00723	0.72248	DGABACAABCAAAD	0.00436	0.78818
DHADBCABDAAAAD	0.00443	0.84800	GDDCBAABDDBAAB	0.00632	0.72880	DDDCAAABDCBAAB	0.00427	0.79245
DHACACAAAAAAAD	0.00413	0.85213	DHACACAAAAAAAD	0.00618	0.73498	DHADBCABDAAAAD	0.00404	0.79649
GDCDFADADDBAAA	0.00312	0.85524	DFABACAABCAAAC	0.00545	0.74043	GDCDFADADDBAAA	0.00357	0.80006
GDCCBADBDDBAAB	0.00257	0.85781	GDCDFADADDBAAA	0.00439	0.74482	GDDCAAABDDBAAB	0.00355	0.80361
DFABACAABCAAAC	0.00240	0.86022	CACDFCDBDABAAB	0.00433	0.74914	CACDFCDBDABAAB	0.00353	0.80714
DDDCAAABDCBAAA	0.00227	0.86248	DHABACAABCAAAD	0.00381	0.75296	DHACACAAAAAAAC	0.00344	0.81058
DHABACAABCAAAD	0.00212	0.86461	DDDCAAABDCBAAA	0.00339	0.75635	DHBBACAABBAAAD	0.00338	0.81397
CACDFCDBDABAAB	0.00184	0.86644	GDCCBADBDDBAAB	0.00339	0.75974	GDCDFADBDDBAAA	0.00328	0.81725
BHADDCABDBBACB	0.00175	0.86819	DACCACDAAAAA[illegible]	0.00327	0.76301	DHADBCAADAAACC	0.00326	0.82051
GDDCAAABDDBAAB	0.00162	0.86981	GDCDFADBDDBAAA	0.00292	0.76593	GDDCBAABDDBAAB	0.00313	0.82364
DHADBCABDABBBC	0.00161	0.87142	DGABACAABCAAAD	0.00281	0.76873	DHADBCAADABACC	0.00307	0.82670
DGABACAABCAAAD	0.00156	0.87298	GDDCAAABDDBAAB	0.00278	0.77151	DACCACDAAAAAAB	0.00291	0.82961
GDDCBAABDDBAAA	0.00155	0.87453	CDCDFCDBDBBCCB	0.00269	0.77420	DHACACAAAAAAAD	0.00261	0.83222
FDDCBAABDCBAAB	0.00154	0.87607	CHADBCABDBABBC	0.00258	0.77678	DHADBCAADAAAAD	0.00243	0.83466
GDCDFADBDDBAAA	0.00149	0.87757	DACCACDAAAAAAA	0.00246	0.77924	BHADDCABDBBACB	0.00240	0.83706
AHADBCABDAAAAB	0.00149	0.87906	DHADBCABDABBBC	0.00244	0.78168	DACCACDAAAAAAA	0.00218	0.83924
CDCDFCDBDBBCCB	0.00147	0.88053	CFADBCABDBABBC	0.00221	0.78389	CHADBCABDBABBC	0.00215	0.84140
DACCACDAAAAAAB	0.00144	0.88197	DFABACAABBAAAC	0.00220	0.78609	DHBBACAABBAAAC	0.00214	0.84354
BHADDCABDBBACA	0.00135	0.88332	DHBBACAABBAAAD	0.00218	0.78827	DHADBCAADAAACD	0.00209	0.84563
DDCCAADBDCBAAB	0.00130	0.88462	DHADBCAADAAACC	0.00210	0.79036	DHABACAABCAAAC	0.00208	0.84771
GDCCAADBBDBAAB	0.00128	0.88590	GDDCBAABDDBAAA	0.00207	0.79243	DHADBCAADAAAAC	0.00201	0.84972
DHBBACAABBAAAD	0.00121	0.88712	DHADBCAADAAAAC	0.00206	0.79449	DFABACAABBAAAC	0.00195	0.85167
DHADBCABDABACC	0.00120	0.88832	FDDCBAABDCBAAB	0.00205	0.79655	DHADBCAADABACD	0.00188	0.85355
DHADBCAADAAAAC	0.00120	0.88952	DHADBCAADABACC	0.00199	0.79854	BHADDCABDBBACA	0.00185	0.85541
DHADBCAADABBBC	0.00118	0.89071	DDCCAADBDCBAAB	0.00194	0.80048	CFADBCABDBABBC	0.00185	0.85725
CHADBCABDBABBC	0.00118	0.89189	GDCCAADBBDBAAB	0.00188	0.80236	CDCDFCDBDBBCCB	0.00171	0.85896
DHADBCAADAAACC	0.00117	0.89306	DGADBCAADCAACD	0.00188	0.80423	GDCCBADBDDBAAB	0.00170	0.86066
DHADBCAADABACC	0.00111	0.89417	DHADBCAADABBBC	0.00186	0.80610	DGADBCAADCAACD	0.00167	0.86282
DACCACDAAAAAAA	0.00108	0.89525	DFABACAABCAAAD	0.00182	0.80792	DFABACAABCAAAD	0.00162	0.86394

Table D.1 (continued)

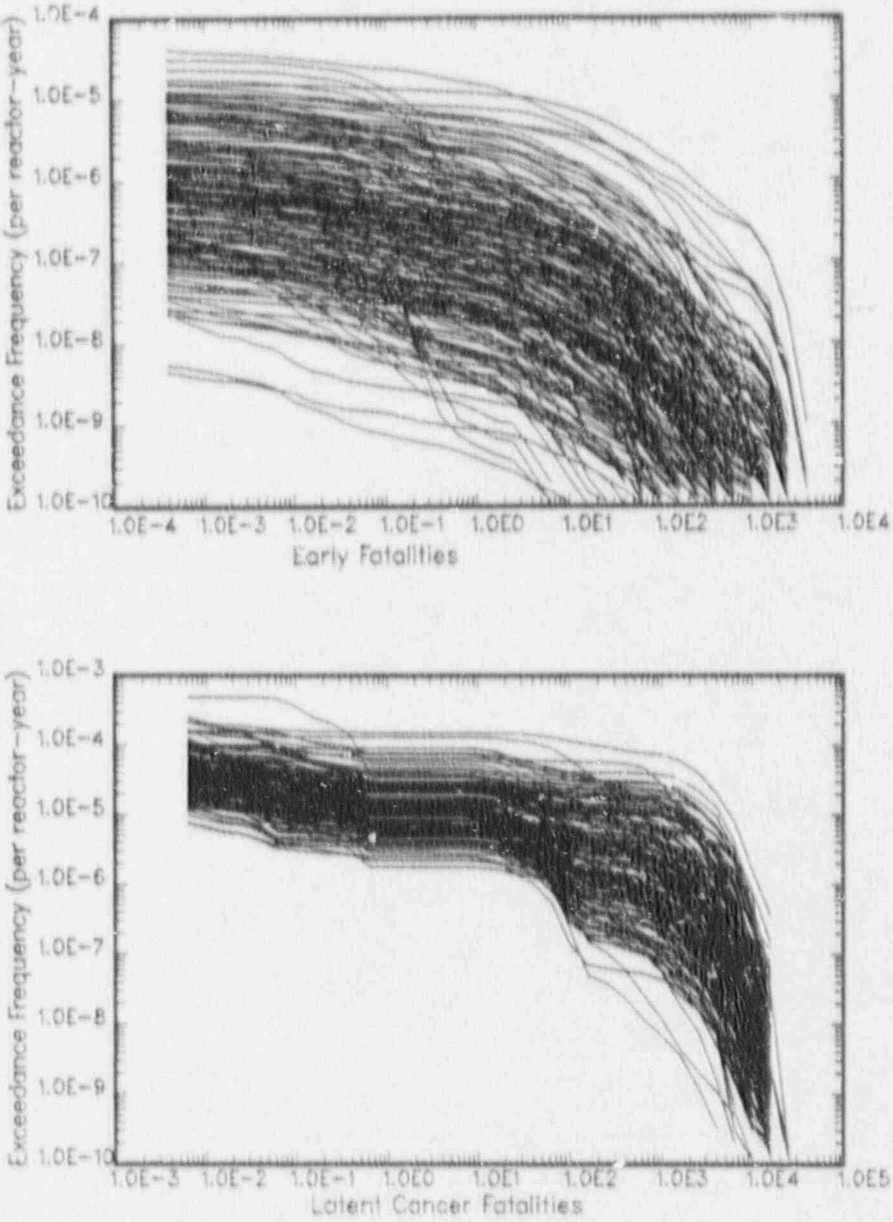
FCMR - FRACTIONAL CONTRIBUTIONS OF APB TO CSQ, NORMALIZED ON A GLOBAL BASIS

CSQ 4			CSQ 5			CSQ 6		
DHADBCAADABAAC	0.01890	0.01890	DHADBCAADABAAC	0.01534	0.01534	DHADBCAADABAAC	0.01884	0.01884
DHABACAABBAAAD	0.01731	0.03621	GDCDFADBDDBAAB	0.01409	0.02943	DHABACAABBAAAD	0.01754	0.03638
GDCDFADBDDBAAB	0.01666	0.05288	BHADBCAADDAAAB	0.01380	0.04323	GDCDFADBDDBAAB	0.01664	0.05301
DHADBCABDABAAC	0.01468	0.06756	BHADBCABDDAAAB	0.01326	0.05649	DHADBCABDABAAC	0.01482	0.06783
GHADBBAADDAAAB	0.01432	0.08188	DHABACAABBAAAD	0.01324	0.06973	GHADBBAADDAAAB	0.01435	0.08218
GDCDFADADDBAAB	0.01350	0.09538	GDCDFADADDBAAB	0.01225	0.08198	GDCDFADADDBAAB	0.01344	0.09562
DHADBBAADAAAAB	0.01320	0.10858	GHADBBAADDAAAB	0.01173	0.09371	DHADBBAADAAAAB	0.01331	0.10894
DFABACAABCAAAC	0.01290	0.12148	AHADBCABDDAAAB	0.01146	0.10517	DFABACAABCAAAC	0.01277	0.12171
GHACABABBDAAAB	0.01222	0.13371	DHADBCABDABAAC	0.01135	0.11651	GHACABABBDAAAB	0.01230	0.13401
GHABABAAADAAAB	0.01117	0.14487	BHADBCAADDAAAA	0.01073	0.12724	GHABABAAADAAAB	0.01126	0.14527
GHADBBAADDAAAA	0.01114	0.15602	BHADBCABDDAAAA	0.01031	0.13756	GHADBBAADDAAAA	0.01116	0.15643
CACDFCDBDABAAB	0.01106	0.16707	DFABACAABCAAAC	0.01024	0.14779	CACDFCDBDABAAB	0.01092	0.16735
DHABACAABBAAAC	0.01070	0.17778	DHADBBAADAAAAB	0.01017	0.15796	DHABACAABBAAAC	0.01085	0.17820
DHADBBAADAAAAA	0.01019	0.18797	AHADBCAADDAAAB	0.00985	0.16780	DHADBBAADAAAAA	0.01028	0.18848
FHADBBAADCAAAB	0.01003	0.19800	GHACABABBDAAAB	0.00953	0.17733	FHADBBAADCAAAB	0.01004	0.19852
BHADBCABDDAAAB	0.01003	0.20802	BHADBCAADCAAAB	0.00941	0.18674	BHADBCABDDAAAB	0.00979	0.20830
BHADBCAADDAAAB	0.00974	0.21776	BHADBCABDCAAAB	0.00931	0.19605	GHACABABBDAAAA	0.00957	0.21787
GHACABABBDAAAA	0.00950	0.22727	CACDFCDBDABAAB	0.00930	0.20535	BHADBCAADDAAAB	0.00940	0.22728
DHADBCABDAAAAC	0.00925	0.23651	GHADBBAADDAAAA	0.00913	0.21448	DHADBCABDAAAAC	0.00927	0.23655
DHADBCAADABAAD	0.00918	0.24570	AHADBCABDDAAAA	0.00892	0.22340	DHADBCAADABAAD	0.00918	0.24573
GHABABAAADAAAA	0.00868	0.25438	GHABABAAADAAAB	0.00862	0.23202	DHADBCABDABAAD	0.00876	0.25449
DHADBCABDABAAD	0.00867	0.26306	FHADBBAADCAAAB	0.00832	0.24034	GHABABAAADAAAA	0.00875	0.26324
FHACABABBCAAAB	0.00815	0.27121	DHABACAABBAAAC	0.00819	0.24853	FHACABABBCAAAB	0.00821	0.27145
DACBACDBBAAAAB	0.00791	0.27912	DHADBBAADAAAAA	0.00785	0.25638	DGABACAABBAAAD	0.00793	0.27938
DGABACAABBAAAD	0.00783	0.28694	DHADBCAADABCCC	0.00778	0.26415	FHADBBAADCAAAA	0.00781	0.28719
FHADBBAADCAAAA	0.00780	0.29475	AHADBCABDCAAAB	0.00775	0.27190	DACBACDBBAAAAB	0.00773	0.29492
BHADBCABDDAAAA	0.00780	0.30254	DACBACDBBAAAAB	0.00770	0.27961	DACCACDAAAAAAB	0.00767	0.30259
DACCACDAAAAAAB	0.00775	0.31029	AHADBCAADDAAAA	0.00766	0.28726	BHADBCABDDAAAA	0.00761	0.31020
DHADBCAADABCCC	0.00769	0.31798	GHACABABBDAAAA	0.00741	0.29467	DHADBCAADABCCC	0.00759	0.31780
BHADBCAADDAAAA	0.00758	0.32556	DHADBCAADABAAD	0.00740	0.30207	FHABABAAACAAAB	0.00751	0.32530
FHABABAAACAAAB	0.00745	0.33300	BHADBCAADCAAAA	0.00734	0.30941	DHADBCABDAAAAD	0.00738	0.33268
AHADBCABDDAAAB	0.00739	0.34039	[illegible]HADBCABDCAAAA	0.00725	0.31666	BHADBCAADDAAAA	0.00731	0.34000
DHADBCABDAAAAD	0.00738	0.34777	DHADBCABDAAAAC	0.00719	0.32385	AHADBCABDDAAAB	0.00684	0.34683
BHADBCABDCAAAB	0.00701	0.35478	[illegible]HADBCABDABAAD	0.00683	0.33069	BHADBCABDCAAAB	0.00684	0.35367
BHADBCAADCAAAB	0.00664	0.36142	GHABABAAADAAAA	0.00671	0.33739	BHADBCAADCAAAB	0.00641	0.36008
FHACABABBCAAAA	0.00634	0.36776	AHADBCAADCAAAB	0.00666	0.34405	FHACABABBCAAAA	0.00638	0.36646
AHADBCAADDAAAB	0.00633	0.37409	FHADBBAADCAAAA	0.00648	0.35053	DACBACDBBAAAAA	0.00600	0.37245
DACBACDBBAAAAA	0.00613	0.38022	FHACABABBCAAAB	0.00636	0.35689	DDDCAAABDCBAAB	0.00598	0.37843
DDDCAAABDCBAAB	0.00590	0.38612	DACCACDAAAAAAB	0.00615	0.36304	AHADBCAADDAAAB	0.00584	0.38428
DACCACDAAAAAAA	0.00581	0.39193	AHADBCABDCAAAA	0.00603	0.36907	FHABABAAACAAAA	0.00583	0.39011
FHABABAAACAAAA	0.00579	0.39772	DGABACAABBAAAD	0.00598	0.37506	DACCACDAAAAAAA	0.00576	0.39587
AHADBCABDDAAAA	0.00576	0.40348	DACBACDBBAAAAA	0.00597	0.38103	CHADBCABDBABBC	0.00568	0.40155
CHADBCABDBABBC	0.00574	0.40921	DHADBCABDAAAAD	0.00578	0.38681	GDCDFADBDDBAAA	0.00552	0.40707
GDCDFADBDDBAAA	0.00553	0.41475	FHABABAAACAAAB	0.00575	0.39256	DHABACAABCAAAD	0.00542	0.41249
BHADBCABDCAAAA	0.00545	0.42020	AHADBCAADCAAAA	0.00520	0.39776	AHADBCABDDAAAA	0.00532	0.41781
DHABACAABCAAAD	0.00533	0.42553	FHACABABBCAAAA	0.00494	0.40270	BHADBCABDCAAAA	0.00532	0.42313
DFABACAABBAAAC	0.00520	0.43072	EEADBCAADABAAC	0.00490	0.40760	DFABACAABBAAAC	0.00514	0.42828
BHADBCAADCAAAA	0.00518	0.43590	GDCDFADBDDBAAA	0.00468	0.41228	BHADBCAADCAAAA	0.00500	0.43327
AHADBCABDCAAAB	0.00500	0.44090	DACCACDAAAAAAA	0.00461	0.41689	CFADBCABDBABBC	0.00488	0.43815
CFADBCABDBABBC	0.00492	0.44583	CHADBCABDBABBC	0.00457	0.42146	DHACACAAAAAAAC	0.00487	0.44302
AHADBCAADDAAAA	0.00492	0.45075	DHABACAABCAAAD	0.00456	0.42602	AHADBCABDCAAAB	0.00462	0.44764
DHACACAAAAAAAC	0.00481	0.45555	DDDCAAABDCBAAB	0.00451	0.43054	AHADBCAADDAAAA	0.00454	0.45219
GDCDFADADDBAAA	0.00446	0.46001	FHABABAAACAAAA	0.00447	0.43501	GDCDFADADDBAAA	0.00444	0.45663
DGADBCAADCAACD	0.00444	0.46445	DFABACAABBAAAC	0.00412	0.43913	DGADBCAADCAACD	0.00440	0.46102
EEADBCAADABAAC	0.00431	0.46876	GDCDFADADDBAAA	0.00405	0.44318	EEADBCAADABAAC	0.00439	0.46541
DFABACAABCAAAD	0.00431	0.47307	CFADBCABDBABBC	0.00393	0.44710	DFABACAABCAAAD	0.00427	0.46968
AHADBCAADCAAAB	0.00429	0.47736	DHDDBCAADAAAAB	0.00375	0.45085	CDCDFCDBDBBCCB	0.00418	0.47386
CDCDFCDBDBBCCB	0.00421	0.48158	DHACACAAAAAAAC	0.00368	0.45454	DGABACAABCAAAD	0.00399	0.47785
GDDCAAABDDBAAB	0.00396	0.48553	EEADBCAADAAAAC	0.00353	0.45807	GDDCAAABDDBAAB	0.00398	0.48183
DHDDBCAADAAAAB	0.00393	0.48946	DGADBCAADCAACD	0.00352	0.46159	AHADBCAADCAAAB	0.00396	0.48579
DGABACAABCAAAD	0.00392	0.49339	CDCDFCDBDBBCCB	0.00344	0.46503	DHDDBCAADAAAAB	0.00391	0.48970
AHADBCABDCAAAA	0.00389	0.49728	DFABACAABCAAAD	0.00342	0.46845	DACBACDABAAAAB	0.00378	0.49349

Table D.1 (continued)

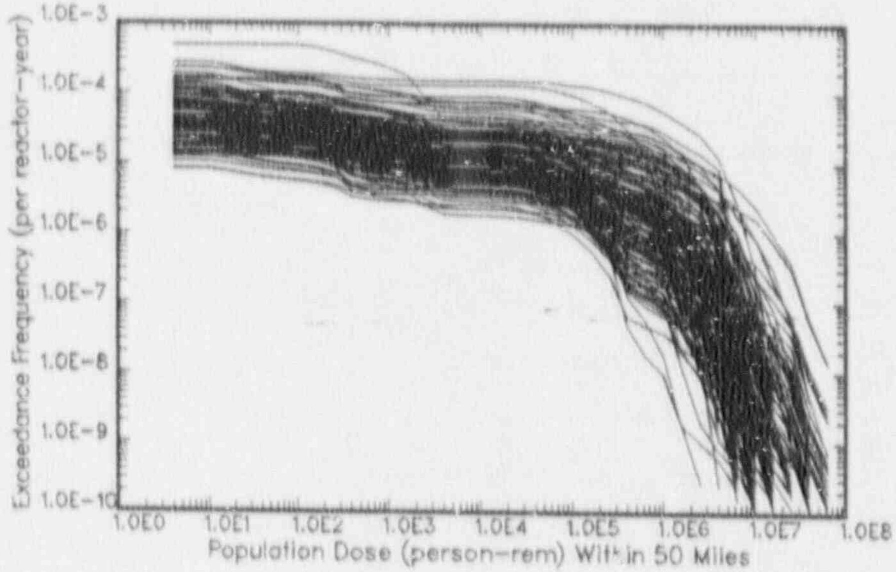
FCMR - FRACTIONAL CONTRIBUTIONS OF APB TO CSQ, NORMALIZED ON A GLOBAL BASIS

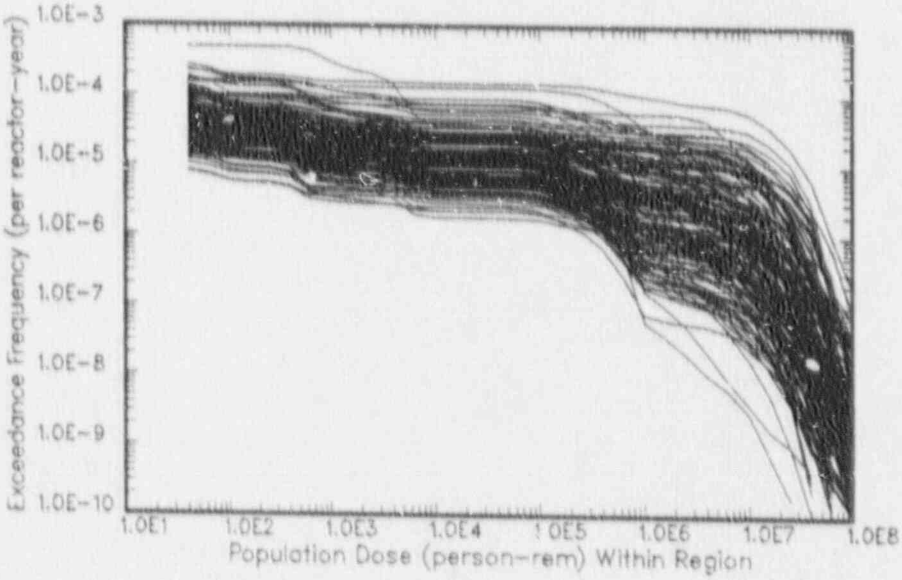
CSQ 7			CSQ 8			CSQ 9		
DHABACAABBAAAD	0.02109	0.02109	BHADBCAADDAAAB	0.05679	0.05679	BHADBCAADDAAAB	0.02558	0.02558
DHADBCAADABAAC	0.01960	0.04069	BHADBCABDDAAAB	0.05364	0.11043	AHADBCABDDAAAB	0.02507	0.05065
GDCDFADBDDBAAB	0.01729	0.05798	AHADBCABDDAAAB	0.04903	0.15946	BHADBCABDDAAAB	0.02304	0.07369
DHADBCABDABAAC	0.01700	0.07497	BHADBCAADDAAAA	0.04416	0.20362	AHADBCAADDAAAB	0.02068	0.09437
DHADBBAADAAAAB	0.01658	0.09156	BHADBCABDDAAAA	0.04171	0.24532	BHADBCAADDAAAA	0.01989	0.11426
GHADBBAADDAAAB	0.01448	0.10604	AHADBCAADDAAAB	0.04051	0.28583	DHADBCAADABAAC	0.01980	0.13406
GDCDFADADDBAAB	0.01427	0.12031	BHADBCAADCAAAB	0.03854	0.32437	AHADBCABDDAAAA	0.01952	0.15357
GHACABABBDAAAB	0.01407	0.13438	AHADBCABDDAAAA	0.03816	0.36253	BHADBCABDDAAAA	0.01791	0.17149
GHABABAAADAAAB	0.01398	0.14836	BHADBCABDCAAAB	0.03815	0.40068	DHABACAABBAAAD	0.01747	0.18896
BHADBCAADDAAAB	0.01323	0.16158	AHADBCABDCAAAB	0.03315	0.43382	BHADBCAADCAAAB	0.01729	0.20625
DHABACAABBAAAC	0.01305	0.17463	AHADBCAADDAAAA	0.03150	0.46532	DHADBCAADABCCC	0.01728	0.22353
BHADBCABDDAAAB	0.01288	0.18751	BHADBCAADCAAAA	0.03008	0.49540	AHADBCABDCAAAB	0.01695	0.24048
DHADBCAADABCCC	0.01285	0.20036	BHADBCABDCAAAA	0.02968	0.52508	BHADBCABDCAAAB	0.01653	0.25701
DHADBBAADAAAAA	0.01280	0.21316	AHADBCAADCAAAB	0.02739	0.55248	GDCDFADBDDBAAB	0.01630	0.27331
DFABACAABCAAAC	0.01192	0.22508	AHADBCABDCAAAA	0.02580	0.57827	AHADBCAADDAAAA	0.01608	0.28939
GHADBBAADDAAAA	0.01127	0.23635	AHADBCAADCAAAA	0.02137	0.59965	GDCDFADADDBAAB	0.01576	0.30515
GHACABABBDAAAA	0.01094	0.24729	DHABACAABBAAAD	0.01985	0.61949	DHADBCABDABAAC	0.01442	0.31958
AHADBCABDDAAAB	0.01089	0.25819	DHADBCAADABCCC	0.01953	0.63902	AHADBCAADCAAAB	0.01397	0.33354
GHABABAAADAAAA	0.01087	0.26905	DHADBCABDABAAC	0.01487	0.65390	BHADBCAADCAAAA	0.01350	0.34705
DHADBCABDABAAD	0.01029	0.27935	DHADBCAADABAAC	0.01411	0.66800	AHADBCABDCAAAA	0.01320	0.36024
BHADBCAADDAAAA	0.01029	0.28963	DHABACAABBAAAC	0.01228	0.68028	BHADBCABDCAAAA	0.01286	0.37311
DHADBCABDAAAAC	0.01003	0.29966	GDCDFADADDBAAB	0.00991	0.69019	DFABACAABCAAAC	0.01195	0.38506
BHADBCABDDAAAA	0.01002	0.30968	GDCDFADBDDBAAB	0.00930	0.69949	AHADBCAADCAAAA	0.01090	0.39596
FHADBBAADCAAAB	0.00985	0.31953	DGABACAABBAAAD	0.00898	0.70846	CACDFCDBDABAAB	0.01085	0.40681
DHADBCAADABAAD	0.00960	0.32912	DHADBCABDABAAD	0.00867	0.71714	DHABACAABBAAAC	0.01081	0.41762
DGABACAABBAAAD	0.00954	0.33866	DHADBCAADABCCD	0.00835	0.72549	DACBACDBBAAAAB	0.01056	0.42818
CACDFCDBDABAAB	0.00954	0.34820	DHADBCABDAAAAC	0.00772	0.73321	DHADBCAADABAAD	0.00912	0.43730
FHACABABBCAAAB	0.00939	0.35758	DDDCAAABDCBAAB	0.00677	0.73998	DHADBCABDAAAAC	0.00899	0.44628
FHABABAAACAAAB	0.00932	0.36690	DHADBCABDABCCC	0.00647	0.74644	DHADBCABDABAAD	0.00877	0.45505
AHADBCAADDAAAB	0.00925	0.37615	DHADBCAADABAAD	0.00640	0.75284	DACBACDBBAAAAA	0.00819	0.46324
BHADBCABDCAAAB	0.00909	0.38524	DFABACAABCAAAC	0.00594	0.75878	DGABACAABBAAAD	0.00790	0.47114
BHADBCAADCAAAB	0.00898	0.39422	DHADBCABDAAAAD	0.00563	0.76441	DHADBCAADABCCD	0.00739	0.47852
AHADBCABDDAAAA	0.00848	0.40270	DHACACAAAAAAAC	0.00542	0.76983	DACCACDAAAAAAB	0.00718	0.48571
DHADBCABDAAAAD	0.00784	0.41054	DHABACAABCAAAD	0.00449	0.77432	DHADBCABDAAAAD	0.00711	0.49281
FHADBBAADCAAAA	0.00766	0.41820	CACDFCDBDABAAB	0.00439	0.77871	DDDCAAABDCBAAB	0.00596	0.49877
AHADBCABDCAAAB	0.00737	0.42556	DHADBCABDABCCD	0.00429	0.78300	DHADBCABDABCCC	0.00580	0.50457
FHACABABBCAAAA	0.00730	0.43286	DHACACAAAAAAAD	0.00413	0.78713	GDCDFADBDDBAAA	0.00541	0.50997
FHABABAAACAAAA	0.00724	0.44010	GDDCBAABDDBAAB	0.00386	0.79098	DACCACDAAAAAAA	0.00539	0.51536
DHABACAABCAAAD	0.00720	0.44730	DACCACDAAAAAAB	0.00357	0.79455	CHADBCABDBABBC	0.00537	0.52073
DDDCAAABDCBAAB	0.00719	0.45449	DGABACAABCAAAD	0.00330	0.79786	DHABACAABCAAAD	0.00525	0.52598
AHADBCAADDAAAA	0.00719	0.46168	GDCDFADADDBAAA	0.00327	0.80112	GDCDFADADDBAAA	0.00520	0.53119
DACCACDAAAAAAB	0.00716	0.46885	GDCDFADBDDBAAA	0.00308	0.80421	DHACACAAAAAAAC	0.00484	0.53603
BHADBCABDCAAAA	0.00707	0.47592	GDDCAAABDDBAAB	0.00293	0.80714	DFABACAABBAAAC	0.00481	0.54084
BHADBCAADCAAAA	0.00701	0.48293	CHADBCABDBABDC	0.00268	0.80982	CFADBCABDBABBC	0.00461	0.54545
AHADBCAADCAAAB	0.00627	0.48919	DACCACDAAAAAAA	0.00268	0.81250	DHDDBCAADAAAAB	0.00443	0.54988
DHACACAAAAAAAC	0.00582	0.49502	DHBBACAABBAAAD	0.00256	0.81506	DGADBCAADCAACD	0.00412	0.55399
GDCDFADBDDBAAA	0.00574	0.50076	DHADBCAADAAACC	0.00247	0.81753	CDCDFCDBDBBCCB	0.00411	0.55810
AHADBCABDCAAAA	0.00573	0.50649	BHADDCABDBBACB	0.00244	0.81997	DFABACAABCAAAD	0.00399	0.56210
DHADBCAADABCCD	0.00549	0.51198	DFABACAABBAAAC	0.00239	0.82236	GDDCAAABDDBAAB	0.00398	0.56608
DACCACDAAAAAAA	0.00537	0.51736	DHADBCAADABACC	0.00233	0.82469	DGABACAABCAAAD	0.00386	0.56995
CHADBCABDBABBC	0.00532	0.52268	CDCDFCDBDBBCCB	0.00230	0.82699	DHADBCABDABCCD	0.00384	0.57379
DGABACAABCAAAD	0.00530	0.52798	CFADBCABDBABBC	0.00230	0.82930	CACBFCDBDAAAAB	0.00376	0.57755
DACBACDBBAAAAB	0.00513	0.53310	DDDCAAABDCBAAA	0.00226	0.83155	DHACACAAAAAAAD	0.00368	0.58123
AHADBCAADCAAAA	0.00489	0.53799	GDCCBADBDDBAAB	0.00206	0.83361	CACDFCDBDABAAA	0.00355	0.58478
DFABACAABBAAAC	0.00480	0.54280	DGADBCAADCAACD	0.00204	0.83566	GDDCBAABDDBAAB	0.00340	0.58818
GDDCAAABDDBAAB	0.00475	0.54755	DFABACAABCAAAD	0.00198	0.83764	DHBABCAADAAAAC	0.00305	0.59122
GDCDFADADDBAAA	0.00471	0.55226	DHADBCAADAAAAD	0.00198	0.83962	DHBBACAABBAAAD	0.00300	0.59423
DHADBCABDABCCC	0.00460	0.55686	DHADBCAADAAAAC	0.00191	0.84153	DFBBACAABCAAAC	0.00298	0.59721
CFADBCABDBABBC	0.00457	0.56143	BHADDCABDBBACA	0.00188	0.84341	DFACACAABCAACC	0.00294	0.60015
DHACACAAAAAAAD	0.00443	0.56585	DHADBCABDABBBC	0.00171	0.84512	DHADBCAADAAACC	0.00289	0.60303
DHBBACAABBAAAD	0.00411	0.56997	DHBBACAABBAAAC	0.00162	0.84674	DHADBCAADAAAAD	0.00282	0.60585
DGADBCAADCAACD	0.00411	0.57407	DHADBCAADAAACD	0.00158	0.84833	CHADBCABDBABBD	0.00274	0.60859



SEQUOYAH BaseCase

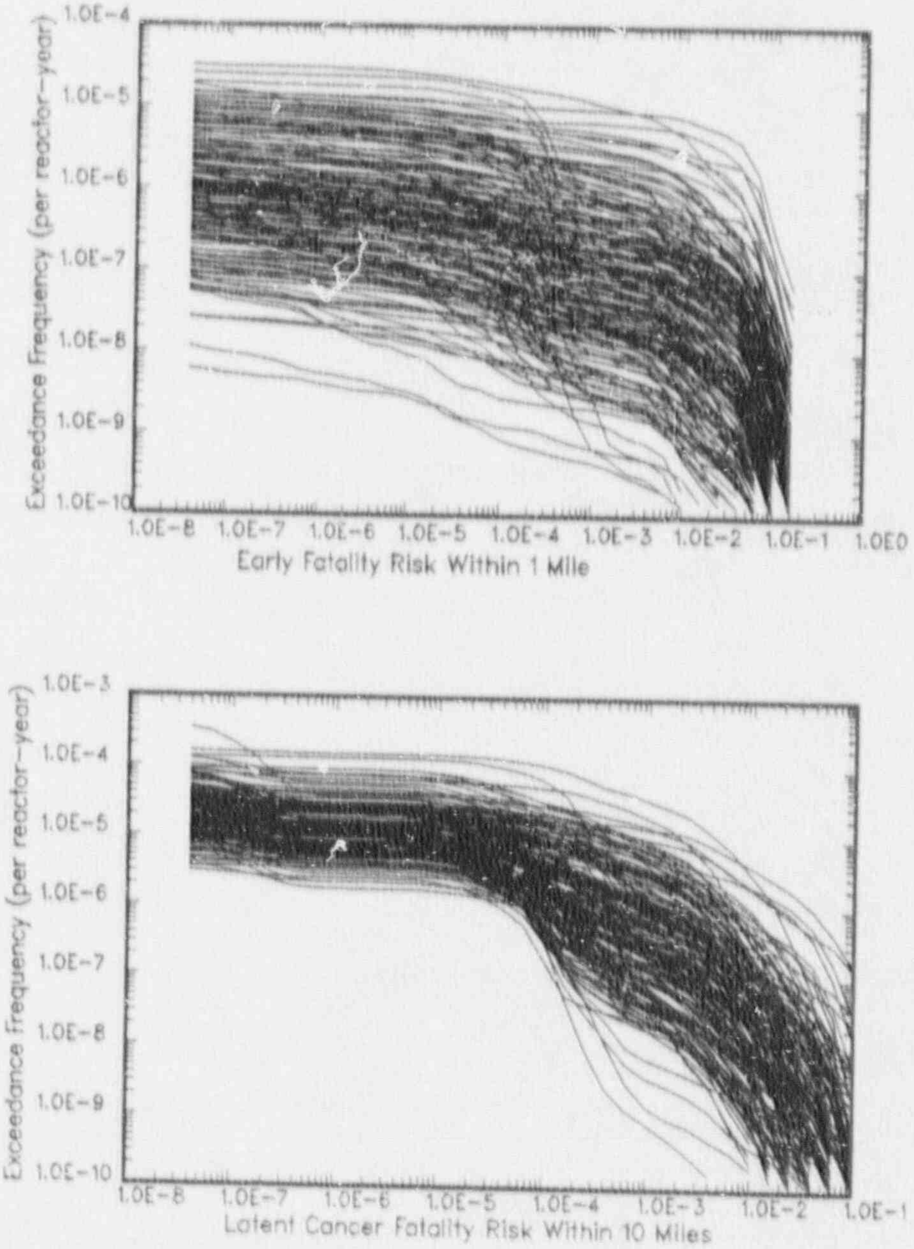
Figure D.1. Exceedance Frequencies for Risk; Sequoyah: All Internal Initiators





SEQUOYAH BaseCase

Figure D.1. (continued)



SEQUOYAH BaseCase

Figure D.1. (continued)

APPENDIX E

SAMPLING INFORMATION

CONTENTS

FIGURE

APPENDIX E

SAMPLING INFORMATION

INTRODUCTION

The Sequoyah analysis uses Latin Hypercube Sampling (LHS)[E.1] as implemented by the LHS program[E.2] in the propagation of uncertainties. The variables sampled in the analysis for Sequoyah 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 Sequoyah. The relationship between these files and programs is depicted in Figure E.1. These files were used to generate a sample of size 200 for Sequoyah.

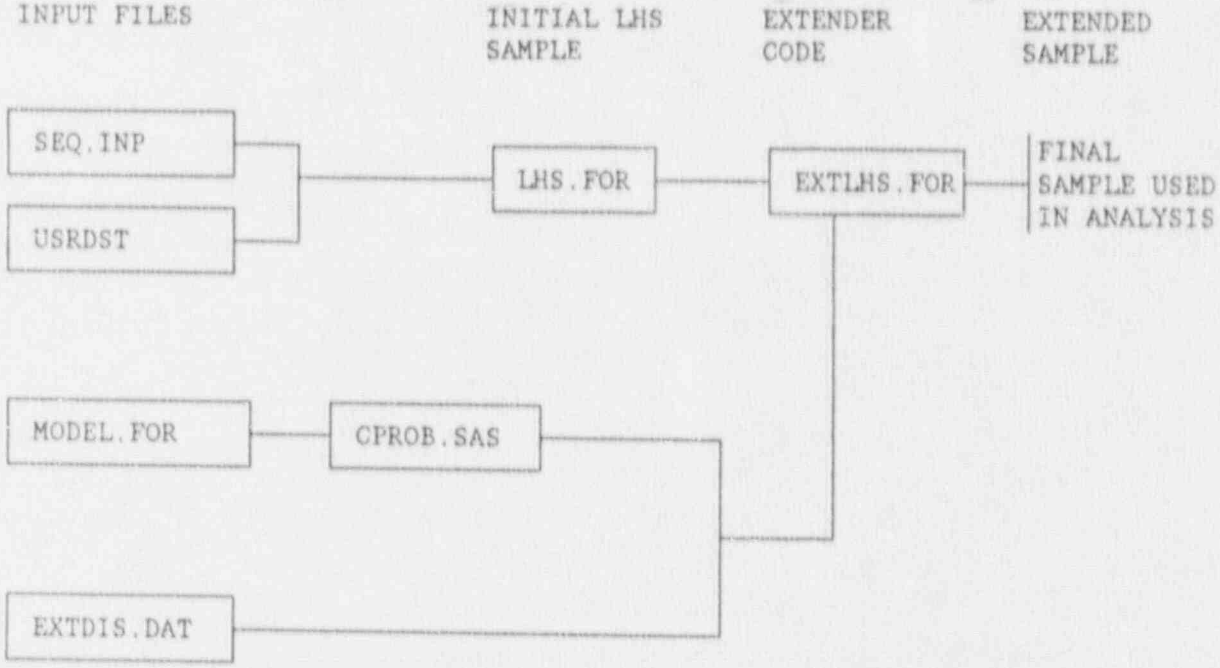


Figure E.1. File Structure Used to Generate Final LHS Sample for Sequoyah

The input to the LHS program, SEQ.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 Section 3.2.3). As indicated at the end of the LHS input in Subsection E.1, this file also contains 35 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. These user-defined distributions are defined in several ways. The input to LHS for such distributions contains an integer flag which 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 an LHS of size 200 from 108 variables. However, this is not the sample that is actually used as input to the integrated analysis for Sequoyah. Rather, certain variables are converted into a format that is easier to use in the integrated analysis or were expanded in additional variables with the "extender" code EXTLHS, which is shows in Subsection E.3. Five types of conversions occur and are listed below.

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 LHS input shown in Subsection E.1. The sub-routine USRDST shown in Subsection E.2 recognizes such variables by the integer flag just indicated and outputs a section of FORTRAN code which 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 Sequoyah 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 frequency of Alpha mode failure is modified to incorporate a reduced frequency of occurrence for conditions involving high pressure in the reactor coolant system (RCS). The Alpha mode frequency sampled in the original LHS is assumed to be for events occurring when the RCS is at low pressure. Alpha mode failures are believed to be less likely when the RCS is at high pressure. This is implemented by introducing a second variable into the sample which is one-tenth the original Alpha mode frequency. This new frequency for Alpha mode failure is used when the RCS is at high pressure.

3. The probability of offsite power recovery is generated from and indicator variable included in the original sample. This variable is identified by the subroutine USRDST by the integer flag 3. This variable is then used in EXTLHS to select 200 sequences of power recovery probabilities from a set of 500 sequences of power recovery probabilities. These recovery probabilities are defined by a model for offsite power recovery developed by Iman and Hora.[E.4] The actual calculation of power recovery curves is performed by the program MODEL presented in Subsection E.4. In turn, the output of MODEL is post-processed by an SAS program to

generate conditional probabilities of power recovery for specified time intervals given that power has not been recovered in a previous time interval; this program is given in Subsection E.5. The result of the operation of the programs in Subsection E.4 and E.5 is the 500 sequences (i.e., rows) of power recovery probabilities given in Subsection E.6. Each row in Appendix E.6 consists of 12 conditional probabilities for power recovery defined as follows:

Col. 1	Prob. of Recovery Between	Given No Recovery By
1	1 and 2.5 h	1 h
2	1 and 4.5 h	1 h
3	4 and 6 h	4 h
4	4 and 10.5 h	4 h
5	7 and 12.5 h	7 h
6	2.5 and 9 h	2.5 h
7	4.5 and 9 h	4.5 h
8	6 and 9 h	6 h
9	10.5 and 17 h	10.5 h
10	12.5 and 17 h	12.5 h
11	9 and 24 h	9 h
12	17 and 24 h	17 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 12 power recovery probabilities from Subsection E.6 is inserted in its place.

4. EXTLHS also generates variables for all of the correlated variables that were 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 are handled in EXTLHS. From this single variable a group of correlated variables is obtained. For example, the amount of hydrogen that is generated in-vessel is correlated for the 7 different cases in Question 38 in the APET, as well as being correlated with the occurrence of temperature-induced hot leg failure and temperature-induced steam generator tube rupture (SGTR). In the LHS input, SEQ.INP, a single variable appears for these distributions. For each observation, the single variable from the original sample is used to obtain values for each of the other variables from the distributions in Subsection E.7. In the extended LHS, the original single variable is dropped and the new correlated variables are added.

5. In addition, EXTLHS also generates and appends to the end of the extended LHS eight "0-1" variables for reactor coolant pump (RCP) seal loss-of-coolant accidents (LOCA) for use in the accident frequency analysis. These variables and their mean probabilities are listed below:

RCP-LOCA-240GPM	240 gpm RCP SEAL LOCA at 90 min	5.0E-2
RCP-LOCA-620AVG	240 to 1000 gpm RCP seal LOCA at 150 min	1.25E-1
RCP-LOCA-433GPM	433 gpm RCP seal LOCA at 90 min	5.0E-3
RCP-LOCA-717AVG	433 to 1000 gpm RCP seal LOCA at 210 min	5.0E-3
RCP-LOCA-1000GPM	1440 gpm RCP seal LOCA at 90 min	5.25E-1
RCP-LOCA-1920GPM	183 gpm RCP seal LOCA at 90 min	5.0E-3
NORMAL	No failure	2.7E-1

The original LHS that contained 108 variables was extended to include 225 variables that were used in the integrated analysis.

References

E.1. M.D. McKay, 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, 239-45, 1979.

E.2. R.L. Iman 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," NUREG/CR-3624, SAND83-2365, Sandia National Laboratories, March 1984.

E.3. R.L. Iman 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. R.L. Iman 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, 1988.

SUBSECTION E.1

```
TITLE   SEQUOYAH   2/11/89
RANDOM SEED -652448715
NOBS 200
LOGNORMAL     ACT-FA
           0.4823E-04           0.2038E-01
LOGNORMAL     AOV-FT
           0.1016E-03           0.6301E-02
LOGNORMAL     DGN-FR-1HR
           0.9935E-05           0.5675E-01
LOGNORMAL     DGN-FR-1AA6
           0.5961E-04           0.3405E+00
LOGNORMAL     DGN-FS
           0.3048E-02           0.1890E+00
LOGNORMAL     DGN-MA
           0.2980E-04           0.1703E+00
USER DISTRIBUTION     ACP-DGN-RC-U2
5  3
           0.5600E-01           0.2610E+00           0.1000E+01
LOGNORMAL     STEAM-BINDING
           0.1982E-08           0.7020E-03
LOGNORMAL     MDP-FR-6HR
           0.8941E-06           0.5108E-02
LOGNORMAL     MDP-FS
           0.1490E-04           0.8513E-01
LOGNORMAL     MDP-TM
           0.9935E-05           0.5675E-01
LOGNORMAL     MOV-CC
           0.1490E-04           0.8513E-01
LOGNORMAL     PPS-MOV-FT
           0.1490E-04           0.8513E+01
LOGNORMAL     MOV-OO
           0.1490E-04           0.8513E-01
LOGNORMAL     PPS-SOV-FT
           0.3129E-04           0.1788E+00
USER DISTRIBUTION     TDP-FR-6HR
5  3
           0.3000E-02           0.3000E-01           0.3000E+00
USER DISTRIBUTION     TDP-FS
5  3
           0.3000E-02           0.3000E-01           0.3000E+00
LOGNORMAL     TDP-TM
           0.4967E-04           0.2838E+00
USER DISTRIBUTION     XHE-DPRZT7
5  3
           0.2900E-02           0.2900E-01           0.2900E+00
LOGNORMAL     HPR-XHE-FO
           0.1018E-04           0.5817E-01
LOGNORMAL     HRP-XHE-FO-SIMIN
           0.1416E-04           0.8087E-01
LOGNORMAL     HPR-XHE-FO-SIMN1
           0.1247E-04           0.7123E-01
LOGNORMAL     MSS-XHE-FO
           0.1689E-04           0.9648E-01
USER DISTRIBUTION     HPI-XHE-FO
5  3
           0.2200E-02           0.2200E-01           0.2200E+00
USER DISTRIBUTION     MSS-XHE-FO-ADV
5  3
           0.1000E-01           0.1000E+00           0.1000E+01
USER DISTRIBUTION     AFW-XHE-OPNVALVE
5  3
           0.6400E-02           0.6400E-01           0.6400E+00
LOGNORMAL     IE-T7
           0.4967E-04           0.2838E+00
USER DISTRIBUTION     RA3
5  3
           0.1120E-01           0.1120E+00           0.1000E+01
```

```
LOGNORMAL     IE-S3
          0.1321E-02          0.8191E-01
LOGNORMAL     RA14
          0.6954E-04          0.3973E+00
LOGNORMAL     Z
          0.1795E-03          0.2690E+00
LOGNORMAL     RA11
          0.6954E-04          0.3973E+00
USER DISTRIBUTION    R
5  3
          0.3400E-01          0.3400E+00          0.1000E+01
LOGNORMAL     IE-TDCI
          0.2484E-04          0.1419E+00
LOGNORMAL     A
          0.5080E-04          0.3150E-02
LOGNORMAL     K
          0.1809E-05          0.7643E-03
LOGNORMAL     IE-T3
          0.1568E+01          0.2120E+02
LOGNORMAL     IE-TZ
          0.1195E+01          0.1615E+02
LOGNORMAL     IE-T
          0.1314E+01          0.1776E+02
LOGNORMAL     IE-T2
          0.1797E+00          0.2429E+01
LOGNORMAL     BETA-2DG
          0.3861E-02          0.2394E+00
LOGNORMAL     BETA-8AOV
          0.3475E-02          0.2155E+00
LOGNORMAL     IAS-PTF-LF-AOV
          0.4967E-06          0.2838E-02
USER DISTRIBUTION    INTERFACING SYSTEM FOR LOCA
1  21
1.83E-13  0.00
1.26E-11  0.05
4.82E-11  0.10
1.74E-10  0.15
4.77E-10  0.20
1.10E-09  0.25
2.10E-09  0.30
4.13E-09  0.35
6.94E-09  0.40
1.10E-08  0.45
1.63E-08  0.50
2.43E-08  0.55
3.72E-08  0.60
5.23E-08  0.65
8.20E-08  0.70
1.24E-07  0.75
1.94E-07  0.80
3.30E-07  0.85
6.78E-07  0.90
1.72E-06  0.95
1.50E-05  1.00
USER DISTRIBUTION    LOSS OF OFFSITE POWER
6  1000
LOGNORMAL     Q12C1 LEAK OR ISOLATION FAILURE
2.48E-5  0.142
UNIFORM       Q15C1 EVENT V - BREAK LOC. UNDER WATER
.6   1.0
UNIFORM       Q17C2  PORVS STICK OPEN
0.0  1.0
USER DISTRIBUTION  Q18C2  RCP SEAL FAILURE
2  2
1  .71
2  .29
```

```
USER DISTRIBUTION  Q18C3  RCP SEAL FAILURE
2  2
1  .65
2  .35
USER DISTRIBUTION  Q18C4  RCP SEAL FAILURE
2  2
1  .60
2  .40
USER DISTRIBUTION  Q25C2  VESSEL PRES. BEFORE VB
2  2
1  .2
2  .8
USER DISTRIBUTION  Q25C3  VESSEL PRES. BEFORE VB
2  3
1  .333
2  .334
3  .333
UNIFORM       Q26C2  CORE DAMAGE ARREST-NO VB
.9   1.
UNIFORM       Q26C3  CORE DAMAGE ARREST-NO VB
.8   1.
UNIFORM       Q26C6  CORE DAMAGE ARREST-NO VB
.56   1.
UNIFORM       Q26C7  CORE DAMAGE ARREST-NO VB
.34   1.
USER DISTRIBUTION  Q31C2  H2 IGNITION ON RECOVERED SBO'S
1  20
   0.000E+00   0.0
   3.100E-02   1.055E-01
   4.800E-02   1.546E-01
   6.300E-02   1.974E-01
   8.000E-02   2.870E-01
   1.000E-01   4.080E-01
   1.500E-01   5.454E-01
   2.000E-01   6.946E-01
   2.500E-01   7.930E-01
   3.000E-01   8.733E-01
   4.000E-01   9.156E-01
   5.000E-01   9.501E-01
   5.270E-01   9.564E-01
   5.500E-01   9.616E-01
   6.000E-01   9.930E-01
   7.000E-01   9.947E-01
   7.500E-01   9.957E-01
   8.000E-01   9.962E-01
   8.500E-01   9.972E-01
   9.000E-01   1.000E+00
USER DISTRIBUTION  Q32C1  LC TO UC VIA FLOOR DRAIN
2  2
1  .25
2  .75
USER DISTRIBUTION Q20,21,38 T-I INDUCED FAIL/IN-V H2
8  10
USER DISTRIBUTION   Q40C1P9 FRAC. H2 RELEASED FROM RCS
1  7
0.25  0.0
0.30  0.01
0.55  0.25
0.70  0.50
0.75  0.75
0.80  0.99
0.85  1.00
USER DISTRIBUTION   Q40C2P9 FRAC. H2 RELEASED FROM RCS
1  7
0.35  0.0
0.40  0.01
```

```
0.60  0.25
0.70  0.50
0.75  0.75
0.80  0.99
0.85  1.00
USER DISTRIBUTION   Q40C3P9 FRAC. H2 RELEASED FROM RCS
1  7
0.55  0.0
0.60  0.01
0.65  0.25
0.70  0.50
0.75  0.75
0.80  0.99
0.85  1.00
USER DISTRIBUTION   Q40C4P9 FRAC. H2 RELEASED FROM RCS
1  7
0.65  0.0
0.70  0.01
0.75  0.25
0.85  0.50
0.95  0.75
1.00  0.99
1.00  1.00
USER DISTRIBUTION   Q41C2  HYDROGEN MIXTURE IN UPPER COMP.
2  3
1  .446
2  .45
3  .104
USER DISTRIBUTION  Q49,50,51 H2 IGNITION FOR SBO
8  9
USER DISTRIBUTION  C52C1-C3 DENONATION TRANSITION
8  3
USER DISTRIBUTION    Q55C1P1   IMPULSE FROM DET.
1  19
 0.000E+00   0.000E+00
 1.960E+00   4.573E-03
 2.000E+00   8.000E-03
 3.000E+00   9.033E-02
 4.000E+00   1.751E-01
 5.000E+00   2.598E-01
 6.000E+00   2.693E-01
 8.000E+00   3.716E-01
 1.100E+01   5.666E-01
 1.200E+01   6.927E-01
 1.300E+01   7.899E-01
 1.400E+01   8.538E-01
 1.450E+01   8.774E-01
 1.500E+01   9.010E-01
 1.540E+01   9.067E-01
 2.400E+01   9.575E-01
 3.600E+01   9.857E-01
 4.800E+01   9.930E-01
 5.940E+01   1.000E+00
USER DISTRIBUTION    Q57C1P1  FAILURE FOR PRESS
  1  20
 273.70 0.000
 308.17 0.016
 342.64 0.038
 377.12 0.060
 411.59 0.083
 446.07 0.124
 480.54 0.197
 515.01 0.395
 549.49 0.527
 583.96 0.706
 618.43 0.780
```

```
 652.81 0.833
 687.38 0.878
 721.86 0.922
 756.33 0.948
 790.81 0.975
 825.28 0.987
 859.75 0.994
 894.23 0.997
 928.70 1.00
UNIFOPM              Q57C1P2  FAILURE MODE
0.0   1.0
USER DISTRIBUTION Q57C1P3,C1P4 IMPULSIVE FAILURE CRITERION
8  2
USER DISTRIBUTION Q63C2  LEVEL OF CAVITY FLOOD A/ VB
2  2
1  .5
2  .5
USER DISTRIBUTION Q64C1  ALPHA MODE EVENT
4  6000
USER DISTRIBUTION Q65C2  TYPE OF VB
2  3
1  .79
2  .08
3  .13
USER DISTRIBUTION Q65C3  TYPE OF VB-(Q62C4-CET PNTR TO 3)
2  3
1   6
2  .27
3  .13
USER DISTRIBUTION Q66C1  FRAC. OF CORE IN HPME
1  5
0.  0.
.13  .08
.27  .5
.4   .73
.6   1.0
USER DISTRIBUTION Q68C2-C8, FRAC.OF CORE AT VB DIVERTED SEAL TABLE
8  7
USER DISTRIBUTION Q71C4 EX-VESSEL STEAM EXPLOSION AT VF
7  2
.001  .01  .1
USER DISTRIBUTION Q72C1 SIZE OF HOLE IN VESSEL
2  2
1  .1
2  .9
USER DISTRIBUTION       Q73C3-C7  PRESSURE RISE AT VB -NO HPME
8  10
USER DISTRIBUTION Q74,Q75 PRESSURE RISE AT VB-HPME
   43
USER DISTRIBUTION Q78C2    CF IMPINGEMENT ON WALL
2  2
1  .01
2  .99
USER DISTRIBUTION Q78C3    CF IMPINGEMENT ON WALL
2  2
1  .31
2  .69
USER DISTRIBUTION Q78C4    CF IMPINGEMENT ON WALL
2  2
1  .53
2  .47
USER DISTRIBUTION Q78C5    CF IMPINGEMENT ON WALL
2  2
1  .60
2  .40
```

```
USER DISTRIBUTION Q79C1P1 FRAC. METAL OXIDIZED AT VB
1  3
0.0   0.0
0.05  0.5
0.2   1.0
UNIFORM           Q79C2P1   FRAC. METAL OXIDIZED AT VB
0.5  1.0
USER DISTRIBUTION Q81C1  H2 CONSUMED AT VB
1  3
0.7   0.0
0.75  0.5
0.9   1.0
UNIFORM           Q94C4P1B1  LATE BASELINE PRESSURE
206.8   275.8
UNIFORM           Q94C5P1B1  LATE BASELINE PRESSURE
241.3   310.3
UNIFORM           Q94C4P1B1      LATE BASELINE PRESSURE
172.4   241.3
UNIFORM           Q108C4  VERY LATE PRESSURE
137.9  241.3
UNIFORM           Q108C5  VERY LATE PRESSURE
137.9  344.7
USER DISTRIBUTION Q111C4  VERY LATE CCI
2  2
1  .75
2  .25
UNIFORM    IN-VESSEL RELEASE FROM FUEL (FCOR)
0.0   1.0
UNIFORM    RELEASE FROM VESSEL (FVES)
0.0   1.0
UNIFORM    V-SEQ. DF WITH SUBMERGED RELEASE (VDF)
0.0   1.0
UNIFORM   RELEASE OF RCS SPECIES FROM CONT.(FCONV)
0.0   1.0
UNIFORM   RELEASES FROM MELT IN CCI (FCCI)
0.0   1.0
UNIFORM   RELEASE OF CCI SPECIES FROM CONT.(FCONC)
0.0   1.0
UNIFORM   SPRAY DF'S (SPRDF)
0.0   1.0
UNIFORM         LATE IODINE RELEASES FROM CONTAINMENT (XLATE)
0.0   1.0
UNIFORM         LATE REVOLATILIZATION (FLATE)
0.0   1.0
UNIFORM         RELEASE DUE TO DIRECT HEATING (FDCH)
0.0   1.0
UNIFORM         DECONT. FACTOR FOR ICE CONDENSER(ICDF)
0.0   1.0
UNIFORM         STEAM GENERATOR TUBE RUPTURE FISG & FOSG
0.0   1.0
UNIFORM         POOL SCRUBBING OF CCI
0.0   1.0
USER DISTRIBUTION  LOSP   Q22C3-7,Q90C3-7,Q105C3,4
3  0
CORRELATION MATRIX
35
2  3  .999
12 13 .999
12 14 .999
13 14 .999
20 21 .999
20 22 .999
21 22 .999
49 50 .999
49 51 .999
50 51 .999
```

```
52 53 .999
54 55 .999
54 56 .999
54 57 .999
55 56 .999
55 57 .999
56 57 .999
61 62 .999
61 63 .999
61 64 .999
62 63 .999
62 64 .999
63 64  999
73 74 .999
81 82 .999
81 83 .999
81 84 .999
82 83 .999
82 84 .999
83 84 .999
85 86 .999
88 89 .999
88 90 .999
89 90 .999
91 92 .999
```

SUBSECTION E.2

```
C*****************************************************************
      SUBROUTINE USRDST(J)
C
C  FOR SEQUOYAH LHS
C
C  THE SUBROUTINE HAS BEEN WRITTEN TO READ A FLAG, IFL, TO INDICATE
C  WHICH OF THE 5 SECTIONS OF THE SUBROUTINE IS TO BE IMPLEMENTED.
C  THE FIRST LINE OF INPUT IS 'IFL,NP' WHERE NP IS THE NUMBER OF PAIRS
C  TO BE READ IN FOR IFL=1 AND IFL=2. NP IS 500 FOR IFL=3. FOR IFL=4
C  AND 5, NP IS A DUMMY VARIABLE BUT MUST BE PRESENT.
C
C  FOR IFL=1
C   GENERATE A DISCRETE DISTRIBUTION FUNCTION WITH INPUT OF X VALUES
C       AND CUMULATIVE PROBABILITIES.
C
C  FOR IFL=2
C   GENERATE A DISCRETE DISTRIBUTION FUNCTION OF INTEGERS AS SPECIFIED
C       IN THE INPUT. THESE INTEGERS ARE REPRESENTATIONS OF A 0-1
C       SAMPLING SCHEME AND WILL BE DECODED OUTSIDE OF LHS. THE
C       VARIABLE NUMBER J AND THE NUMBER OF BRANCHES NP IS WRITTEN TO
C       UNIT 30. THIS INFORMATION IS EDITED INTO SEQEXT.FOR. THE VARIABLE
C       NUMBER FOR ALPHA MODE (IFL=4) IS ADDED AT EDIT TIME WITH NP=2.
C
C  FOR IFL=3
C   GENERATE A DISCRETE DISTRIBUTION FUNCTION FOR LOSP.
C   AN ADDITIONAL INPUT FILE IS REQUIRED ASSIGNED TO UNIT 27.
C   THE FILE NAME IS 'DISCRETE.DAT'.
C
C  FOR IFL=4
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'.
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 MAXIMUM ENTROPY DISTRIBUTION FUNCTION FOR THE
C   VARIABLE AND INDICATE THAT A VARIABLE WILL BE ADDED.
C   AN ADDITIONAL LINE OF INPUT IS REQUIRED GIVING THE LOWER
C   END OF THE RANGE, A , THE MEAN, RMU,AND THE UPPER END OF
C   THE RANGE, B .***NOTE*** FOR THIS CASE A LINK TO
C   IMSLIBS/LIB IS REQUIRED.
C
C  FOR IFL=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 THE FOLLOWING SIX LINES OF CODE ARE REQUIRED BY USRDST
C
      PARAMETER (NMAX=1000)
      PARAMETER (NVAR=205)
      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 STATEMENTS ARE NEEDED FOR ***IFL=1***
C XVAL AND CP MUST BE DIMENSIONED TO THE MAXIMUM NUMBER PAIRS
C TO BE READ.
C
      PARAMETER(NCP=50)
      DIMENSION XVAL(NCP),CP(NCP)

C
C  THE FOLLOWING STATEMENTS ARE NEEDED FOR ****IFL=2  AND IFL=3****
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
      PARAMETEP(MAXNP=500)
      DIMENSION IVAL(MAXNP),FREQ(MAXNP),CDF(MAXNP+1)
C
C  THE FOLLOWING STATEMENTS ARE NEEDED FOR ****IFL=4****
C
C DVAL(K) IS THE DISTRIBUTION FOR THE ALPHA MODE VB CASE.
C
      PARAMETER(MAXDIS=5500)
      DIMENSION DVAL(MAXDIS)
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 FUNCTION DEFINITION IS REQUIRED BY USRDST.
C
      LOC(I,J) = (J-1) * N + I
C
C
C  READ IFL AND NP (NP IS A DUMMY PARAMETER FOR IFL=4,5 AND 6)
C
      READ(7,*)IFL,NP
      IF(IFL.EQ.2.OR.IFL.EQ.3)GO TO 98
      IF(IFL.EQ.4)GO TO 200
      IF(IFL.EQ.5)GO TO 300
      IF(IFL.EQ.6)GO TO 405
      IF(IFL.EQ.7)THEN
       WRITE(30,99)J,NP
       WRITE(30,196)J
196    FORMAT(7X,'JME =',I3)
       GO TO 300
      ENDIF
      IF(IFL.EQ.8)THEN
           WRITE(30,197)J,NP
197        FORMAT(7X,'ID8(',I3,') = ',I2)
```

```
           GO TO 6
      ENDIF
C
C FOR IFL=1
C
C READ IN THE NP VALUES FOR THE CONTINUOUS PROBABILITY CURVE
C
      DO 1 K=1,NP
    1 READ(7,*)XVAL(K),CP(K)
C
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 SAMPLE SIZE
C
6     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 4 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    FOR IFL=8********NEED ONLY R
        IF(IFL.EQ.8)THEN
         X(LOC(I,J)) = R
         GO TO 25
        ENDIF
C
C THIS LOOP WILL SELECT THE SPECIFIC VALUE OF THE RANDOM VARIABLE
C CORRESPONDING TO R BY LINEAR INTERPOLATION. THE VALUE IS STORED BY
C USE OF THE LOC FUNCTION
C
C  THIS LOOP WILL OBTAIN THE N SAMPLES
C
        DO 3 K=1,NP-1
         IF(R.GT.CP(K).AND.R.LT.CP(K+1)) X(LOC(I,J))=
     1     ((R-CP(K))/(CP(K+1)-CP(K)))*
     2     (XVAL(K+1)-XVAL(K))+XVAL(K)
   3    CONTINUE
C
C RESET THE STARTING POINT TO THE BEGINNING OF THE NEXT SUBINTERVAL
C UNLESS A RANDOM SAMPLE HAS BEEN SPECIFIED
C
25       IF(IRS.NE.1)STRTPT=STRTPT+PROBINC
    4 CONTINUE
      RETURN
C
C  IFL=2
C
98   IF(IFL.EQ.2)THEN
C THIS SECTION OF THE SUBROUTINE CONSTRUCTS THE SAMPLE
C VARIABLES BASED FOR THE ZERO-ONE CASES, IFL=2,
C  AND THE VARIABLES FOR LOSP, IFL=3
C
        DO 100,K=1,NP
        READ(7,*)IVAL(K),FREQ(K)
```

```
100    CONTINUE
       WRITE(30,99)J,NP
99     FORMAT(7X,'ID (',I3,') = ',I2)
      ELSE
C
C  IFL=3
C
       REWIND 27
       READ(27,*)NP
       DO 110 K = 1,NP
       READ(27,*)IVAL(K),FREQ(K)
110    CONTINUE
      ENDIF
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
        STRTPT  = 0.0
        PROBINC = 1.0 / FLOAT(N)
        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
       IF(IFL.EQ.2)GO TO 140
C
C  IFL=3; THE "DO 135" LOOP CHECKS TO MAKE SURE THAT THE INTEGERS
C  BEING SAMPLED FOR THE LOSP 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
C
140     IF(IRS.NE.1)STRTPT=STRTPT+PROBINC
150   CONTINUE
```

```
      RETURN
C
C  FOR IFL = 4
C
200    REWIND 28
       READ(28,*)(DVAL(I),I=1,MAXDIS)
       NAM=2
       WRITE(30,99)J,NAM
       WRITE(30,199)J
199    FORMAT(7X,'JAM =',I5)
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
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*NP+1)
          IF (IRS .NE. 1) STRTPT = STRTPT + PROBINC
   51   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

```
      PROGRAM EXTSEQ8
C***********************************************************************
C                                                                      *
C  MODIFIED FROM NEXTLHS TO INCLUDE COMPUTING SAMPLES FOR FLAGGED
C  DISTRIBUTIONS-2/10/89 (AWS)
C  ADDED COMPUTATION FOR IFL=7 2/11/89
C  COMPUTE SAMPLES FOR GIVEN NUMBER OF DISTRIBUTIONS
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.  A SEPARATE 0-1 SAMPLING SCHEME         *
C  CONSISTING OF ONE EIGHT-LEVEL 0-1 VARIABLE IS CREATED AND MERGED    *
C  ONTO THE END OF THE MATRIX                                          *
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            *
C  NLOSP IS THE NUMBER OF ROWS IN THE LOSP DATA                        *
C  NVONE IS THE NUMBER OF VARIABLES (CONSISTING OF ONE MULTI-LEVEL     *
C       0-1 VARIABLE) THAT ARE MERGED ONTO THE END OF THE EXTENDED     *
C       LHS DATA MATRIX.                                               *
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=200,NVAR=108,MADD=200,NTIME=12,NLOSP=500,NVONE=7)
      DIMENSION X(NLHS,NVAR+MADD), ID(NVAR), CPROB(NLOSP,NTIME),
     &          CPROBSAM(NLHS,NTIME), IDVAR(NVONE), CUMPROB(NVONE),
     &          PROBINT(NVONE,NVONE), XONE(NLHS*NVONE),ID8(NVAR),
     &          XVAL(100),CP(100)
      OPEN(5,FILE='LHS.DAT',STATUS='OLD')
      OPEN(6,FILE='CPROB.DAT',STATUS='OLD')
      OPEN(7,FILE='EXTLHS.DAT',STATUS='NEW')
      OPEN(8,FILE='ONES.DAT',STATUS='OLD')
      OPEN(20,FILE='DISTR.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
        ID ( 49) =  2
        ID ( 50) =  2
        ID ( 51) =  2
        ID ( 52) =  2
        ID ( 53) =  3
        ID ( 59) =  2
```

```
      ID8( 60) = 10
      ID ( 65) =  3
      ID8( 66) =  9
      ID8( 67) =  3
      ID8( 71) =  2
      ID ( 72) =  2
      ID ( 73) =  2
      JAM = 73
      ID ( 74) =  3
      ID ( 75) =  3
      ID8( 77) =  7
      ID ( 78) =  2
      JME = 78
      ID ( 79) =  2
      ID8( 80) = 10
      ID8( 81) = 43
      ID ( 82) =  2
      ID ( 83) =  2
      ID ( 84) =  2
      ID ( 85) =  2
      ID ( 94) =  2
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 VB VARIABLE - ID(JAM) WILL BE 2
              IF(J.EQ.JAM)THEN
                X(K,LOC+1)=.1*X(K,LOC)
                LOC=LOC+1
                GO TO 30
              ENDIF
C  CHECK FOR MAX. ENT.VARIABLE - ID(JME) WILL BE 2
              IF(J.EQ.JME)THEN
                X(K,LOC+1)=.86/(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
            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
          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
 25     IF(ID8(J).EQ.0)GO TO 30
            NOD=ID8(J)
            R = X(K,LOC)
            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
           DO 5 KK=1,NP
            READ(20,*) XVAL(KK), CP(KK)
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)
             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,R,X(K,LOC+ND-1)
6        CONTINUE
       LOC = LOC + NOD-1
30      CONTINUE
20      CONTINUE
CC
C  READ IN THE MATRIX OF CONDITIONAL PROBABILITIES FOR LOSP
CC
      DO 70 I=1,NLOSP
        READ(6,*)(CPROB(I,J),J=1,NTIME)
  70  CONTINUE
CC
C  SAMPLE THE CONDITIONAL PROBABILITIES FOR LOSP
CC
      DO 80 I=1,NLHS
        DO 90 J=1,NTIME
          CPROBSAM(I,J) = CPROB(X(I,NTVAR),J)
  90    CONTINUE
  80  CONTINUE
CC
C  I2 IS THE NUMBER OF VARIABLES AFTER THE 0-1 VARIABLES
C  HAVE BEEN EXTENDED AND AFTER THE LOSP VARIABLES HAVE BEEN
C  SAMPLED.
CC
       I2 = NTVAR - 1 + NTIME
CC
C  II2 IS THE NUMBER OF EXTENDED LHS VARIABLES MINUS THE LOSP VARIABLES
CC
       II2 = I2 - NTIME
CC
C   ERROR MESSAGE
CC
       IF(I2.GT.NVAR+MADD) STOP ' I2 EXCEEDS DIMENSIONS '
C
C READ IN THE VALUES FOR THE DISCRETE PROBABILITY FUNCTION
C
C  FRONT END VAR
       DO 100 K=1,NVONE
         READ(6,101)IDVAR(K),CUMPROB(K)
101      FORMAT(I2,40X,E13.5)
  100  CONTINUE
C
C   FIND THE CUMULATIVE PROBABILITIES
```

```
C
      DO 110 K = 2,NVONE
        CUMPROB(K) = CUMPROB(K) + CUMPROB(K-1)
  110 CONTINUE
C
C   SET UP THE DESIRED PROBABILITY INTERVALS
C
      DO 120 K = 1,NVONE
        IF(K.EQ.1)THEN
          PROBINT(1,1) = 0.
          PROBINT(1,2)=CUMPROB(1)
        ELSE
          PROBINT(K,1)=CUMPROB(K-1)
          PROBINT(K,2)=CUMPROB(K)
        ENDIF
  120 CONTINUE
C
      STRTPT=0.0
      PROBINC=1.0/FLOAT(NLHS)
C
C   SET ALL ELEMENTS IN THE MATRIX TO ZERO INITIALLY
C
      DO 130 I=1,NLHS
        DO 130 L=1,NVONE
  130     XONE((L-1)*NLHS+I) = 0.
C
      KTEMP = 1
      DO 140 I=1,NLHS
        R=STRTPT+PROBINC*RAN(ISEED)
        DO 150 K=KTEMP,NVONE
          IF(R.GE.PROBINT(K,1).AND.R.LT.PROBINT(K,2))THEN
            XONE((IDVAR(K)-1)*NLHS+I)= 1.
            KTEMP = K
          ENDIF
  150   CONTINUE
        STRTPT=STRTPT+PROBINC
  140 CONTINUE
CC
C  I2 IS THE TOTAL NUMBER OF VARIABLES IN THE EXTENDED MATRIX
CC
       I2 = I2 + NVONE
CC
C   ERROR MESSAGE
CC
500    I1 = 0
      DO 160 I=1,NLHS
        I1 = I1 + 1
        IF(I2.GT.NVAR+MADD) STOP ' I2 EXCEEDS DIMENSIONS '
        WRITE(7,*)I1,I2,(X(I,J),J=1,II2),(CPROBSAM(I,J),J=1,NTIME),
     1             (XONE((L-1)*NLHS+I),L=1,NVONE)
  160 CONTINUE
      STOP 'NORMAL TERMINATION'
999   TYPE*,IFL,NP
      TYPE *,'  EOF'
      END
```

SUBSECTION E.4

```
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/LIB
C
      PROGRAM MODEL
      PARAMETER(NREP=500,NPLANT=70,K=3,NX=136,NTIME=11)
C NOTE:WHEN NTIME CHANGES, THE NUMBER IN FORMATS 8000 AND 8001 CHANGES.
      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),
     2REQTIM(NTIME)
      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
      DATA REQTIM/1.,2.5,4.,4.5,6.0,7.,9.,10.5,12.5,17.,24./
C
C     NX TIME STEPS ARE USED TO GENERATE A GRAPH OF THE RECOVERY CURVE.
C     THE TIME STEPS CORRESPOND TO TIMES OF .05, .10,...,(.05), ..., 2.50,
C     2.75, ...,(.25),... 24.00.  NX=136.
C
C     THE VECTOR IDT IS COMPUTED TO INDEX THE TIMES FOR WHICH THE UNCERTAINTY
C     DISTRIBUTION WILL BE SAVED IN A FILE.
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 CAUSAL 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 .05 FROM .05 TO 2.5 FOR THE RECOVERY CURVE
C
      DO 15 I=1,50
      X(I)=.05*I
   15 CONTINUE
C
C     GENERATE THE TIME IN STEPS OF .25 FROM 2.75 TO 24.0 FOR THE RECOVERY CURVE
C
      DO 16 I=51,136
      X(I) = 0.25 * I - 10.0
   16 CONTINUE
C
C    DETERMINE THE INDICES FOR THE TIMES REQUESTED
```

```
C
      DO 20 I=1,NTIME
      DO 19 J=1,136
      IF(REQTIM(I).EQ.X(J))THEN
      IDT(I)=J
      GO TO 20
      ENDIF
19    CONTINUE
      PRINT *,'   REQUESTED TIME NOT IN LIST',REQTIM
      STOP 20
20    CONTINUE
C
C  PRINT THE TIMES REQUESTED
C
      PRINT 8000,(X(IDT(I)),I=1,NTIME)
8000  FORMAT(2X,'THE COLUMNS WRITTEN TO THE FILE ARE FOR THE TIMES:',/,
     12X,11(F6.2))
      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     OPTAIN 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 (11,8001) (RESULTS(I,IDT(J)),J=1,NTIME)
8001  FORMAT(11E12.5)
 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 PROBLEMS.
C
      IF (AA.LT.(5.0E-3)) GOTO 300
      IF(AA.GT..999999) GOTO 300
      F1=F(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/S
  330 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),N(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=106)
      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,,8.5,0.5,11,2,0')
105 FORMAT ('&I.35>RECOVERY CURVE FOR ',A,/,'RETURN')
106 FORMAT ('*LOWER*',
107 FORMAT ('*MEDIAN*')
108 FORMAT ('*UPPER*')
    RETURN
    END
```

SUBSECTION E.5

```
*      L O S P  FOR   SEQUOYAH;
* THIS PROGRAM GENERATES THE CONDITIONAL PROBABILITY;
* P(t1<T<t2/T>t1) AND SORTS THEM SO THAT THE DESIRED;
* QUANTILES MAY BE PICKED OFF;
* THE PROBABILITY IS (A - B)/A WHERE B = P(T>B) = 1-F(B);
* AND A = P(T>A) = 1-F(A);
*;
DATA A;
  INFILE RECSEQ;
  INPUT  T1HR T2_5HR T4HR T4_5HR T6HR T7HR T9HR T10_5HR T12_5HR T17HR T24HR;
  P1  = (T1HR - T2_5HR) / T1HR;
  DROP  T1HR T2_5HR T4HR T4_5HR T6HR T7HR T9HR T10_5HR T12_5HR T17HR T24HR;
PROC SORT;
 BY P1;
DATA B;
  INFILE RECSEQ;
  INPUT  T1HR T2_5HR T4HR T4_5HR T6HR T7HR T9HR T10_5HR T12_5HR T17HR T24HR;
  P2  = (T1HR - T4_5HR) / T1HR;
  DROP  T1HR T2_5HR T4HR T4_5HR T6HR T7HR T9HR T10_5HR T12_5HR T17HR T24HR;
PROC SORT;
 BY P2;
DATA C;
  INFILE RECSEQ;
  INPUT  T1HR T2_5HR T4HR T4_5HR T6HR T7HR T9HR T10_5HR T12_5HR T17HR T24HR;
  P3  = (T4HR - T6HR) / T4HR;
  DROP  T1HR T2_5HR T4HR T4_5HR T6HR T7HR T9HR T10_5HR T12_5HR T17HR T24HR;
PROC SORT;
 BY P3;
DATA D;
  INFILE RECSEQ;
  INPUT  T1HR T2_5HR T4HR T4_5HR T6HR T7HR T9HR T10_5HR T12_5HR T17HR T24HR;
  P4  = (T4HR - T10_5HR) / T4HR;
  DROP  T1HR T2_5HR T4HR T4_5HR T6HR T7HR T9HR T10_5HR T12_5HR T17HR T24HR;
PROC SORT;
 BY P4;
DATA E;
  INFILE RECSEQ;
  INPUT  T1HR T2_5HR T4HR T4_5HR T6HR T7HR T9HR T10_5HR T12_5HR T17HR T24HR;
  P5  = (T7HR - T12_5HR) / T7HR;
  DROP  T1HR T2_5HR T4HR T4_5HR T6HR T7HR T9HR T10_5HR T12_5HR T17HR T24HR;
PROC SORT;
 BY P5;
DATA F;
  INFILE RECSEQ;
  INPUT  T1HR T2_5HR T4HR T4_5HR T6HR T7HR T9HR T10_5HR T12_5HR T17HR T24HR;
  P6  = (T2_5HR - T9HR) / T2_5HR;
  DROP  T1HR T2_5HR T4HR T4_5HR T6HR T7HR T9HR T10_5HR T12_5HR T17HR T24HR;
PROC SORT;
 BY P6;
DATA G;
  INFILE RECSEQ;
  INPUT  T1HR T2_5HR T4HR T4_5HR T6HR T7HR T9HR T10_5HR T12_5HR T17HR T24HR;
  P7  = (T4_5HR - T9HR) / T4_5HR;
  DROP  T1HR T2_5HR T4HR T4_5HR T6HR T7HR T9HR T10_5HR T12_5HR T17HR T24HR;
PROC SORT;
 BY P7;
DATA H;
  INFILE RECSEQ;
  INPUT  T1HR T2_5HR T4HR T4_5HR T6HR T7HR T9HR T10_5HR T12_5HR T17HR T24HR;
  P8  = (T6HR - T9HR) / T6HR;
  DROP  T1HR T2_5HR T4HR T4_5HR T6HR T7HR T9HR T10_5HR T12_5HR T17HR T24HR;
PROC SORT;
 BY P8;
DATA I;
  INFILE RECSEQ;
```

```
  INPUT  T1HR T2_5HR T4HR T4_5HR T6HR T7HR T9HR T10_5HR T12_5HR T17HR T24HR;
  P9  = (T10_5HR - T17HR) / T10_5HR;
  DROP  T1HR T2_5HR T4HR T4_5HR T6HR T7HR T9HR T10_5HR T12_5HR T17HR T24HR;
PROC SORT;
 BY P9;
DATA J;
  INFILE RECSEQ;
  INPUT  T1HR T2_5HR T4HR T4_5HR T6HR T7HR T9HR T10_5HR T12_5HR T17HR T24HR;
  P10 = (T12_5HR - T17HR) / T12_5HR;
  DROP  T1HR T2_5HR T4HR T4_5HR T6HR T7HR T9HR T10_5HR T12_5HR T17HR T24HR;
PROC SORT;
 BY P10;
DATA K;
  INFILE RECSEQ;
  INPUT  T1HR T2_5HR T4HR T4_5HR T6HR T7HR T9HR T10_5HR T12_5HR T17HR T24HR;
  P11 = (T9HR - T24HR) / T9HR;
  DROP  T1HR T2_5HR T4HR T4_5HR T6HR T7HR T9HR T10_5HR T12_5HR T17HR T24HR;
PROC SORT;
 BY P11;
DATA L;
  INFILE RECSEQ;
  INPUT  T1HR T2_5HR T4HR T4_5HR T6HR T7HR T9HR T10_5HR T12_5HR T17HR T24HR;
  P12 = (T17HR - T24HR) / T17HR;
  DROP  T1HR T2_5HR T4HR T4_5HR T6HR T7HR T9HR T10_5HR T12_5HR T17HR T24HR;
PROC SORT;
 BY P12;
DATA MERGE1;
  MERGE A B C D E F;
DATA MERGE2;
  MERGE G H I J K L;
DATA MERGE3;
  MERGE MERGE1 MERGE2;
PROC PRINT DATA = MERGE3 NOOBS;
```

SUBSECTION E.6

0.237208	0.429430	0.111497	0.300822	0.202531	0.416051	0.269125	0.177409	0.105264	0.038505	0.366909	0.070385
0.262195	0.497656	0.154871	0.379167	0.251669	0.567303	0.342965	0.222562	0.227164	0.102406	0.371261	0.178082
0.265871	0.498244	0.156892	0.446862	0.296113	0.618126	0.387810	0.257609	0.284218	0.205980	0.409365	0.191035
0.289646	0.501586	0.169194	0.451276	0.297681	0.624351	0.394417	0.260835	0.326801	0.237098	0.525569	0.201110
0.289775	0.512706	0.171033	0.451732	0.304834	0.624818	0.397454	0.274745	0.337433	0.237408	0.530979	0.205904
0.352724	0.544346	0.175381	0.451784	0.314416	0.625854	0.405457	0.276533	0.353232	0.249524	0.535026	0.213238
0.357061	0.592756	0.180720	0.455095	0.318103	0.627111	0.416113	0.28[illegible]72	0.357697	0.256425	0.553304	0.243956
0.359105	0.593570	0.194741	0.466513	0.325133	0.629619	0.423417	0.289572	0.358070	0.258102	0.576582	0.299909
0.360245	0.609438	0.195665	0.472340	0.327930	0.632775	0.439559	0.290863	0.359632	0.260894	0.588326	0.317156
0.360250	0.614981	0.200550	0.474360	0.329799	0.646226	0.443435	0.291402	0.360631	0.264278	0.603734	0.317192
0.360493	0.617080	0.201742	0.475434	0.332481	0.646392	0.446370	0.293144	0.371475	0.267244	0.615891	0.332958
0.360660	0.619588	0.203026	0.489995	0.334137	0.651053	0.447571	0.295646	0.373791	0.267269	0.622518	0.360606
0.361318	0.619700	0.206397	0.492802	0.335568	0.656452	0.449930	0.302451	0.379797	0.267948	0.630862	0.360827
0.361464	0.621283	0.213222	0.498053	0.340522	0.659565	0.453755	0.302508	0.383216	0.274567	0.633448	0.364781
0.361548	0.625465	0.214130	0.505433	0.347007	0.667241	0.460413	0.302619	0.387041	0.276714	0.640877	0.370279
0.362021	0.625891	0.214378	0.507497	0.349253	0.669429	0.460459	0.302706	0.390684	0.283164	0.643084	0.370839
0.362381	0.626068	0.216226	0.507996	0.352265	0.670594	0.463134	0.303897	0.392583	0.289353	0.656406	0.372247
0.363275	0.627136	0.217719	0.510409	0.353187	0.671223	0.464930	0.304136	0.405689	0.315087	0.659242	0.372537
0.363386	0.627771	0.218064	0.510547	0.355134	0.679305	0.464993	0.305354	0.407536	0.328725	0.660240	0.375299
0.363583	0.628485	0.218803	0.511031	0.357643	0.679722	0.466374	0.306350	0.410421	0.329045	0.669937	0.380212
0.363861	0.628598	0.220709	0.512262	0.361920	0.679853	0.470269	0.308637	0.437528	0.330254	0.674523	0.380634
0.364534	0.629712	0.220882	0.513985	0.364626	0.680830	0.471095	0.312719	0.442156	0.331561	0.696124	0.390383
0.365016	0.629861	0.221536	0.514239	0.365732	0.681136	0.471224	0.325847	0.443535	0.332166	0.699021	0.393501
0.366049	0.629926	0.223629	0.514591	0.366181	0.681171	0.472087	0.330984	0.447280	0.333278	0.699312	0.397248
0.366062	0.630323	0.224310	0.516822	0.369695	0.681649	0.476873	0.332509	0.450393	0.334703	0.703763	0.400826
0.366139	0.630387	0.224580	0.520001	0.373216	0.683015	0.478426	0.343463	0.450768	0.335829	0.704066	0.403477
0.366216	0.631101	0.226027	0.523499	0.374215	0.692684	0.483451	0.343666	0.451819	0.337318	0.704225	0.408447
0.366259	0.631537	0.226327	0.525222	0.377254	0.695637	0.484621	0.345775	0.455359	0.338434	0.707754	0.409972
0.366665	0.631745	0.226333	0.525844	0.380833	0.703016	0.486027	0.348406	0.458241	0.340547	0.710364	0.419078
0.367223	0.632115	0.229119	0.541468	0.384893	0.703508	0.487931	0.351461	0.459831	0.341974	0.711820	0.423530
0.367358	0.632709	0.229263	0.543444	0.385134	0.705385	0.491693	0.354370	0.460652	0.343098	0.712114	0.425558
0.367515	0.632752	0.229722	0.550039	0.398983	0.707749	0.497789	0.358017	0.462847	0.343314	0.712694	0.426211
0.367551	0.632871	0.229972	0.553176	0.403212	0.708899	0.505715	0.360367	0.466391	0.345688	0.714405	0.428044
0.367929	0.633016	0.230627	0.554661	0.414560	0.709414	0.506026	0.361586	0.466622	0.347078	0.716982	0.428183
0.368116	0.633262	0.232956	0.556108	0.429708	0.710471	0.507950	0.362360	0.467254	0.348833	0.721751	0.429041
0.368328	0.633513	0.235810	0.562147	0.434348	0.710815	0.509264	0.363579	0.467284	0.349232	0.731118	0.434322
0.368575	0.633635	0.236805	0.564277	0.438678	0.710825	0.512416	0.367273	0.469275	0.349935	0.740639	0.434637
0.368670	0.634074	0.237145	0.564941	0.439995	0.712624	0.515085	0.368020	0.470690	0.361065	0.740730	0.440503
0.368933	0.634352	0.237226	0.569833	0.440858	0.712773	0.516866	0.368284	0.470728	0.362070	0.744725	0.440612
0.368964	0.634520	0.237713	0.576856	0.446004	0.714833	0.519696	0.369611	0.472657	0.363291	0.745428	0.441064
0.368981	0.634704	0.238715	0.577096	0.446418	0.715581	0.519831	0.370262	0.473605	0.363425	0.745859	0.448990
0.369142	0.634847	0.238737	0.578760	0.446566	0.716355	0.520133	0.370564	0.473674	0.365856	0.747079	0.451475
0.369148	0.635053	0.239048	0.579937	0.446883	0.720832	0.527059	0.379431	0.475076	0.365910	0.747822	0.451591
0.369631	0.635068	0.240002	0.582295	0.448087	0.724040	0.527584	0.380444	0.476703	0.368176	0.748652	0.452690
0.369633	0.635125	0.240066	0.584106	0.448210	0.724456	0.528162	0.380793	0.479148	0.371774	0.749508	0.456105
0.369735	0.635132	0.240304	0.584413	0.450050	0.725317	0.529065	0.381121	0.482209	0.374172	0.749646	0.456752
0.369782	0.635224	0.240375	0.584505	0.451245	0.726035	0.530327	0.381786	0.496208	0.387703	0.752463	0.464557
0.369817	0.635588	0.241361	0.584753	0.452623	0.726902	0.530330	0.381958	0.511693	0.399750	0.752883	0.466765
0.370077	0.635717	0.241766	0.584790	0.453099	0.727118	0.531430	0.382601	0.524424	0.399817	0.760255	0.473307
0.370183	0.635777	0.241826	0.585867	0.453235	0.728015	0.531951	0.383042	0.526462	0.405637	0.760931	0.474529
0.370466	0.635844	0.242310	0.586564	0.453739	0.728327	0.536843	0.383052	0.530266	0.407305	0.779527	0.475354
0.370528	0.635854	0.243125	0.587185	0.453749	0.728365	0.537933	0.383164	0.533997	0.407973	0.781891	0.475557
0.370541	0.636074	0.243225	0.588030	0.456659	0.728839	0.538095	0.383409	0.536855	0.408906	0.793944	0.496230
0.370697	0.636116	0.244109	0.588422	0.457147	0.729070	0.539230	0.383623	0.537522	0.411409	0.797501	0.498230
0.370709	0.636130	0.244894	0.588675	0.457312	0.729484	0.539422	0.384[illegible]32	0.538376	0.419285	0.798647	0.499874
0.370782	0.636193	0.246042	0.589097	0.460387	0.729528	0.539427	0.387[illegible]57	0.5395[illegible]8	0.419513	0.800617	0.500768
0.370871	0.636265	0.246046	0.591382	0.460483	0.729575	0.539637	0.387484	0.540152	0.419765	0.801729	0.503152
0.370896	0.636368	0.247161	0.592865	0.460856	0.730474	0.541262	0.388067	0.540296	0.419967	0.802426	0.508451
0.371016	0.636392	0.247565	0.594629	0.460994	0.731343	0.543443	0.391560	0.540623	0.421927	0.802528	0.509473
0.371018	0.636399	0.247742	0.599219	0.464065	0.738012	0.544135	0.398733	0.543420	0.422703	0.802798	0.513281
0.371046	0.636503	0.248318	0.599826	0.464901	0.741019	0.549141	0.399991	0.544294	0.423364	0.803293	0.513805
0.371451	0.636600	0.248723	0.606740	0.467740	0.741054	0.549227	0.400200	0.544653	0.425613	0.803772	0.514939
0.371538	0.636775	0.249773	0.608757	0.472738	0.745169	0.554426	0.404562	0.545365	0.427707	0.806498	0.515696
0.371661	0.636996	0.250610	0.609225	0.474391	0.745373	0.555472	0.404565	0.545623	0.428001	0.807594	0.515830
0.371698	0.637042	0.250732	0.610235	0.474816	0.745640	0.555923	0.404801	0.547539	0.428049	0.807728	0.516927

0.371821	0.637295	0.251864	0.610369	0.474881	0.746086	0.556089	0.405078	0.549476	0.428348	0.808162	0.518504
0.372003	0.637507	0.251890	0.610593	0.476827	0.746239	0.557325	0.407237	0.550137	0.428686	0.809288	0.519443
0.372180	0.637512	0.252237	0.610688	0.477736	0.746489	0.558360	0.407704	0.550275	0.428869	0.811436	0.519620
0.372208	0.637567	0.252766	0.611054	0.479840	0.746629	0.560021	0.407824	0.551514	0.428950	0.811606	0.519752
0.372260	0.637702	0.252924	0.611219	0.480409	0.746701	0.560079	0.408066	0.552207	0.429431	0.812196	0.521086
0.372438	0.637733	0.253670	0.611469	0.481071	0.746717	0.560132	0.408661	0.553185	0.430918	0.812528	0.522026
0.372553	0.637780	0.253761	0.611532	0.481572	0.746726	0.560310	0.409530	0.555533	0.431939	0.812997	0.522968
0.372621	0.637907	0.254466	0.611926	0.483006	0.746762	0.560559	0.410572	0.557990	0.432056	0.814217	0.524458
0.372640	0.638025	0.254687	0.611957	0.483101	0.747426	0.560704	0.410727	0.561743	0.432233	0.815250	0.525417
0.372786	0.638253	0.255642	0.612375	0 483229	0.747520	0.560852	0.411143	0.562472	0.432282	0.817387	0.525461
0.372855	0.638713	0.255962	0.613531	0.483232	0.747631	0.561423	0.411518	0.563795	0.432804	0.818182	0.526325
0.372927	0.638744	0.256189	0.614036	0.484432	0.747904	0.561430	0.411902	0.567519	0.433819	0.818184	0.526523
0.373068	0.638768	0.256236	0.614273	0.484874	0.747940	0.561642	0.411982	0.567995	0.436351	0.818583	0.526944
0.373074	0.639228	0.256443	0.614690	0.485029	0.748439	0.561952	0.412231	0.569159	0.438255	0.820794	0.527031
0.373160	0.639668	0.256839	0.615506	0.485391	0.748937	0.562106	0.412296	0.569473	0.441922	0.821144	0.527669
0.373865	0.640507	0.257410	0.616191	0.485437	0.750232	0.562538	0.412429	0.569553	0.442667	0.821268	0.527726
0.374032	0.640531	0.257615	0.616650	0.485817	0.750375	0.562589	0.412812	0.570747	0.442747	0.821311	0.527758
0.374103	0.642855	0.258096	0.617774	0.486600	0.750550	0.563213	0.413117	0.571066	0.442882	0.821353	0.527919
0.374170	0.643471	0.259073	0.617779	0.486786	0.751858	0.563518	0.413417	0.571664	0.443402	0.824312	0.529672
0.374170	0.644787	0.259229	0.618272	0.486906	0.752125	0.564082	0.413794	0.573317	0.444005	0.824339	0.530058
0.374273	0.644800	0.259287	0.619144	0.487236	0.752230	0.564690	0.414046	0.573353	0.444266	0.825708	0.532417
0.374604	0.644873	0.259409	0.619148	0.487762	0.752253	0.565396	0.414256	0.573400	0.448301	0.826089	0.532639
0.374684	0.645420	0.259531	0.619377	0.488877	0.755735	0.567774	0.414367	0.573444	0.449252	0.826182	0.532840
0.374713	0.645681	0.260269	0.620372	0.489126	0.758123	0.570267	0.414829	0.573663	0.451987	0.827091	0.533009
0.374718	0.645807	0.260587	0.620846	0.489303	0.758381	0.570604	0.418120	0.574440	0.452096	0.827109	0.535095
0.375000	0.645958	0.260656	0.623863	0.489538	0.758597	0.572107	0.418639	0.574518	0.453344	0.827300	0.537891
0.375149	0.646230	0.261267	0.626502	0.489813	0.759546	0.573816	0.419258	0.574756	0.453835	0.827852	0.538068
0.375327	0.646250	0.261270	0.627017	0.490070	0.759784	0.574011	0.419524	0.574975	0.455010	0.828271	0.538458
0.375559	0.646684	0.261368	0.627107	0.490587	0.760445	0.574620	0.422368	0.575191	0.455138	0.828574	0.538494
0.375900	0.647413	0.262425	0.627572	0.492093	0.763045	0.575641	0.425621	0.575296	0.455691	0.829049	0.538495
0.375912	0.647461	0.262810	0.627728	0.492285	0.763968	0.576062	0.427605	0.575687	0.455793	0.829578	0.538771
0.376461	0.647552	0.263089	0.628382	0.492881	0.764347	0.576163	0.427836	0.575937	0.456745	0.829854	0.541243
0.376773	0.648329	0.263570	0.628842	0.493339	0.764441	0.576235	0.428061	0.576222	0.456995	0.830186	0.541347
0.377280	0.648580	0.264322	0.628865	0.494648	0.765106	0.576410	0.428581	0.576273	0.457476	0.830517	0.541498
0.377771	0.648683	0.266150	0.629099	0.494875	0.765526	0.577011	0.429088	0.576513	0.457879	0.830857	0.541660
0.378040	0.648831	0.267255	0.630162	0.495090	0.765698	0.577596	0.429672	0.577282	0.458090	0.830900	0.543306
0.378304	0.648963	0.267574	0.634572	0.495555	0.766028	0.577816	0.430320	0.577890	0.458288	0.835782	0.549495
0.379377	0.648984	0.267745	0.634597	0.496076	0.766126	0.578015	0.431556	0.578297	0.458398	0.836366	0.549593
0.379423	0.649179	0.268627	0.640246	0.496153	0.767884	0.580532	0.431611	0.578627	0.458907	0.836987	0.550363
0.380533	0.649193	0.269281	0.641492	0.496257	0.768059	0.581030	0.432636	0.579430	0.458933	0.837708	0.554322
0.380691	0.649451	0.270814	0.644271	0.496430	0.770553	0.585498	0.432636	0.580057	0.459411	0.839889	0.564846
0.380957	0.649471	0.270967	0.644550	0.496790	0.771989	0.585813	0.432649	0.580320	0.459535	0.840660	0.567469
0.381164	0.649515	0.273775	0.644569	0.498674	0.772066	0.587535	0.434230	0.580470	0.459628	0.848360	0.568743
0.381512	0.649654	0.274977	0.645599	0.499685	0.774433	0.591030	0.435625	0.580536	0.460243	0.849998	0.573465
0.381564	0.649677	0.275359	0.648418	0.507281	0.775112	0.596188	0.440634	0.580554	0.460482	0.850008	0.577758
0.381690	0.649803	0.276555	0.648741	0.508131	0.775403	0.597932	0.441039	0.581168	0.460646	0.850054	0.578275
0.381730	0.649823	0.278393	0.650690	0.517530	0.776384	0.598304	0.442748	0.581524	0.461457	0.850137	0.579052
0.381828	0.649927	0.278403	0.651257	0.519625	0.776565	0.598550	0.443036	0.586456	0.461798	0.850776	0.579481
0.381971	0.650174	0.278481	0.651999	0.521352	0.777040	0.599209	0.444585	0.5[illegible]85	0.461840	0.850868	0.580087
0.382343	0.650305	0.281016	0.652217	0.522795	0.777167	0.599437	0.444894	0.588596	0.462164	0.850980	0.580671
0.382468	0.650798	0.281258	0.653411	0.523555	0.777587	0.599781	0.445085	0.591577	0.462618	0.851265	0.580784
0.382514	0.650807	0.281511	0.654435	0.523722	0.780548	0.608903	0.451638	0.591810	0.462844	0.851388	0.581157
0.382654	0.650882	0.281873	0.655966	0.523755	0.780899	0.609317	0.452381	0.592840	0.463458	0.851701	0.582349
0.382935	0.651623	0.282797	0.657455	0.523877	0.783287	0.609612	0.452942	0.593657	0.464580	0.851930	0.582501
0.382995	0.652766	0.282978	0.657940	0.524564	0.783484	0.609725	0.453038	0.593844	0.467273	0.851931	0.582720
0.383036	0.653107	0.283254	0.659369	0.525354	0.783489	0.609744	0.453164	0.595147	0.467560	0.852438	0.582755
0.383345	0.653232	0.283679	0.659377	0.525950	0.783523	0.610037	0.453824	0.596632	0.468504	0.854297	0.582813
0.383447	0.653508	0.283801	0.662499	0.531015	0.783583	0.610042	0.454256	0.598499	0.469441	0.855631	0.583118
0.383507	0.653612	0.283992	0.668877	0.533931	0.783658	0.610418	0.454770	0.600146	0.470493	0.856069	0.583590
0.383573	0.653859	0.283994	0.669039	0.534434	0.783674	0.610682	0.455117	0.602319	0.470558	0.856881	0.583776
0.383620	0.654282	0.284013	0.669289	0.534633	0.783976	0.611846	0.455167	0.602935	0.471256	0.857448	0.583925
0.383695	0.654320	0.284458	0.669293	0.536277	0.785261	0.612620	0.457232	0.603151	0.471674	0.857592	0.585002
0.383856	0.654540	0.284694	0.669376	0.536809	0.785853	0.612825	0.457730	0.603921	0.473230	0.857736	0.585843
0.384146	0.655063	0.284768	0.669903	0.537943	0.786393	0.616243	0.458156	0.606267	0.475939	0.858090	0.585955
0.384180	0.655418	0.285025	0.669909	0.538355	0.787112	0.616570	0.458515	0.610180	0.481329	0.859001	0.586022
0.384341	0.656200	0.285216	0.671432	0.538357	0.787801	0.616915	0.461763	0.610311	0.482008	0.859614	0.586217

0.384564	0.656281	0.285240	0.671971	0.538534	0.788199	0.616994	0.461870	0.610894	0.484570	0.860312	0.587060
0.384569	0.657724	0.285364	0.672013	0.538717	0.789071	0.617261	0.461930	0.611610	0.484753	0.860501	0.587716
0.384579	0.657735	0.285622	0.672184	0.539336	0.789181	0.617285	0.462030	0.614486	0.485213	0.861424	0.590437
0.384661	0.657918	0.285757	0.672718	0.540481	0.789636	0.617401	0.462219	0.615175	0.486764	0.861632	0.591500
0.384788	0.657936	0.285822	0.674680	0.541020	0.789760	0.617489	0.462416	0.631082	0.499123	0.863938	0.592995
0.384811	0.658010	0.286066	0.675005	0.541573	0.790479	0.618667	0.462479	0.631122	0.502339	0.870290	0.593201
0.384886	0.658228	0.286339	0.675652	0.542094	0.790820	0.618856	0.462744	0.631494	0.502543	0.870477	0.595154
0.384903	0.658467	0.286532	0.675710	0.542606	0.791130	0.618868	0.463458	0.632305	0.504160	0.872253	0.595282
0.385095	0.659381	0.286665	0.675782	0.542977	0.791170	0.618913	0.463789	0.632487	0.505343	0.872660	0.596067
0.385276	0.659942	0.286681	0.675880	0.543240	0.791578	0.619109	0.464306	0.632950	0.506087	0.874461	0.602196
0.385300	0.660320	0.286910	0.675972	0.543403	0.791798	0.619116	0.464308	0.633328	0.506426	0.875479	0.604381
0.385379	0.661867	0.286992	0.676051	0.548345	0.791813	0.619273	0.464407	0.633596	0.507545	0.877331	0.609906
0.385395	0.662094	0.287038	0.676188	0.553587	0.792012	0.619513	0.464453	0.634510	0.507672	0.880712	0.618350
0.385449	0.663399	0.287497	0.676262	0.553730	0.792055	0.619731	0.464782	0.634746	0.509286	0.881976	0.619333
0.385564	0.663740	0.287499	0.676293	0.554343	0.792096	0.619800	0.464796	0.635229	0.509366	0.882181	0.619475
0.385591	0.663956	0.287860	0.676380	0.554361	0.792103	0.620249	0.464928	0.635539	0.510154	0.882501	0.619528
0.385789	0.665005	0.288118	0.676390	0.555021	0.792209	0.620389	0.465282	0.637259	0.510330	0.885000	0.620006
0.385832	0.665160	0.288457	0.676497	0.555023	0.792317	0.620403	0.465315	0.637294	0.510453	0.885289	0.620177
0.385843	0.665188	0.288559	0.676707	0.555176	0.792379	0.620627	0.466200	0.637402	0.510522	0.885412	0.620910
0.385926	0.665277	0.288611	0.676730	0.555531	0.792449	0.620800	0.466364	0.638724	0.511127	0.885611	0.622185
0.385926	0.665329	0.288705	0.676820	0.555862	0.792470	0.620828	0.467334	0.639291	0.511476	0.885617	0.622450
0.385933	0.665353	0.288762	0.676916	0.555867	0.792480	0.621067	0.467487	0.639448	0.511686	0.885656	0.623091
0.386002	0.665606	0.288866	0.677336	0.555980	0.792649	0.621275	0.467682	0.639492	0.511993	0.885733	0.624443
0.386113	0.665668	0.289059	0.677419	0.556046	0.792727	0.621364	0.468187	0.641680	0.513006	0.885775	0.624462
0.386316	0.665784	0.289719	0.677487	0.556148	0.792953	0.621521	0.468269	0.642311	0.513138	0.885871	0.624838
0.386335	0.665807	0.290334	0.677593	0.556225	0.792982	0.622441	0.468440	0.642479	0.513162	0.885908	0.624978
0.386355	0.665813	0.290762	0.677798	0.556259	0.793520	0.623561	0.468451	0.642963	0.513851	0.885975	0.625025
0.386410	0.665851	0.290800	0.678245	0.556752	0.794285	0.624763	0.473353	0.643965	0.513929	0.886068	0.625249
0.386446	0.666681	0.290964	0.679073	0.556831	0.795793	0.627385	0.474477	0.644255	0.514755	0.886094	0.625470
0.386586	0.666959	0.291176	0.681632	0.557187	0.797365	0.629664	0.479113	0.644846	0.515940	0.886283	0.625633
0.386632	0.667037	0.291233	0.682553	0.557453	0.798311	0.630344	0.481112	0.644921	0.516273	0.886623	0.625635
0.386830	0.667135	0.291686	0.682614	0.557470	0.798502	0.630869	0.481530	0.645074	0.517727	0.886846	0.625804
0.386974	0.667315	0.291762	0.682839	0.557656	0.799301	0.630918	0.481901	0.645607	0.518270	0.887237	0.625986
0.386978	0.667441	0.291897	0.683075	0.557774	0.799701	0.631026	0.482350	0.646269	0.518822	0.887534	0.626015
0.387060	0.667447	0.291986	0.683629	0.557883	0.800055	0.631740	0.482670	0.646524	0.518862	0.887770	0.626310
0.387064	0.667701	0.292314	0.685230	0.557933	0.800371	0.631850	0.482945	0.646656	0.519156	0.887975	0.626357
0.387180	0.667863	0.292360	0.685572	0.558291	0.801207	0.632531	0.483495	0.647106	0.519448	0.888089	0.626376
0.387382	0.667941	0.292633	0.685866	0.558575	0.801509	0.632910	0.483690	0.647171	0.519481	0.888108	0.626647
0.387404	0.667994	0.292678	0.686390	0.558584	0.801605	0.633118	0.483725	0.647308	0.519741	0.888163	0.627170
0.387467	0.668159	0.292816	0.691826	0.559219	0.801620	0.633434	0.483877	0.648047	0.520922	0.888593	0.627288
0.387507	0.668228	0.292959	0.692407	0.560117	0.802963	0.636109	0.483971	0.648154	0.521272	0.888765	0.627427
0.387529	0.668297	0.293165	0.694630	0.560139	0.803619	0.637518	0.484014	0.648789	0.521438	0.888983	0.627513
0.387602	0.668535	0.295755	0.694963	0.560160	0.804405	0.639286	0.485901	0.649494	0.521538	0.889080	0.627654
0.387606	0.668643	0.296221	0.695247	0.560556	0.804723	0.639287	0.486025	0.649542	0.521592	0.889095	0.627758
0.387608	0.669168	0.296312	0.695378	0.560788	0.805037	0.639778	0.486086	0.649832	0.522023	0.889299	0.628107
0.387847	0.669196	0.297178	0.695443	0.560906	0.805105	0.640317	0.486360	0.650251	0.522367	0.889375	0.628691
0.387923	0.669331	0.297731	0.695492	0.560961	0.805221	0.640413	0.486554	0.653107	0.522672	0.889657	0.628815
0.387975	0.669359	0.298309	0.695528	0.561385	0.806610	0.641890	0.486976	0.653625	0.525085	0.890215	0.628946
0.388072	0.669403	0.298908	0.695712	0.561679	0.807750	0.642010	0.487044	0.654302	0.525849	0.890473	0.629003
0.388086	0.669439	0.299510	0.696617	0.562756	0.807771	0.642845	0.487701	0.654596	0.527613	0.892792	0.629025
0.388396	0.669517	0.299937	0.697078	0.563116	0.807967	0.642896	0.488771	0.656381	0.528101	0.892936	0.629141
0.388440	0.670416	0.300606	0.697135	0.564452	0.808264	0.643736	0.488876	0.658342	0.528686	0.893047	0.629207
0.388493	0.670571	0.301377	0.697403	0.566285	0.808395	0.643914	0.489664	0.660182	0.529214	0.893089	0.629362
0.388556	0.670692	0.302143	0.697605	0.567192	0.809271	0.644012	0.489829	0.660411	0.529551	0.893252	0.629377
0.388599	0.671036	0.302391	0.697916	0.568102	0.809801	0.644048	0.489897	0.660458	0.529885	0.893370	0.629764
0.388638	0.671179	0.302936	0.697995	0.568774	0.810355	0.644487	0.490048	0.660603	0.530013	0.893494	0.629968
0.388737	0.671200	0.303185	0.698928	0.570100	0.811275	0.646541	0.490305	0.660942	0.530508	0.893523	0.630016
0.388801	0.671319	0.303475	0.698962	0.570263	0.811279	0.646792	0.490574	0.661112	0.530695	0.893827	0.630127
0.388881	0.671530	0.305117	0.699444	0.571673	0.811305	0.646796	0.490639	0.662420	0.530745	0.894130	0.630673
0.389112	0.671698	0.305185	0.702666	0.571764	0.811331	0.646926	0.490688	0.663248	0.530906	0.894222	0.631328
0.389141	0.671822	0.306186	0.702669	0.571856	0.811747	0.646974	0.490991	0.663430	0.530951	0.894440	0.632106
0.389161	0.671943	0.306710	0.703156	0.573273	0.811800	0.647287	0.491284	0.664062	0.530958	0.894582	0.632251
0.389222	0.672133	0.306856	0.703605	0.576501	0.813317	0.650559	0.491485	0.664213	0.531297	0.894630	0.633251
0.389232	0.672197	0.306866	0.705466	0.578240	0.813344	0.650850	0.491892	0.664547	0.531660	0.894695	0.633589
0.389303	0.672401	0.307289	0.705717	0.578962	0.813378	0.651308	0.492073	0.664600	0.531922	0.895014	0.633825
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0.389959	0.678197	0.309078	0.709634	0.592341	0.816016	0.652250	0.493758	0.665737	0.535375	0.900837	0.644121
0.390099	0.678214	0.309215	0.709672	0.592716	0.816159	0.652254	0.494571	0.666234	0.535575	0.900871	0.644313
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0.446981  0.741399  0.376546  0.817930  0.716068  0.894020  0.772779  0.635150  0.817558  0.701396  0.972552  0.815226
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0.447080  0.742198  0.376705  0.818882  0.716719  0.894108  0.773366  0.636266  0.818121  0.706935  0.973628  0.816259
0.447215  0.742667  0.377042  0.822858  0.717721  0.894281  0.773786  0.638073  0.818711  0.710033  0.974031  0.817213
0.447444  0.742842  0.377323  0.822964  0.717883  0.894576  0.773832  0.638295  0.818946  0.710569  0.974051  0.818875
0.447454  0.743193  0.378268  0.823540  0.718180  0.894597  0.773855  0.638718  0.818972  0.711262  0.975294  0.820105
0.447496  0.743682  0.378680  0.823580  0.718628  0.894785  0.773960  0.638741  0.819078  0.711848  0.976664  0.822477
0.447526  0.745995  0.378961  0.824140  0.718944  0.896278  0.773995  0.639656  0.819462  0.712979  0.976854  0.822682
0.447764  0.748349  0.379186  0.825625  0.720567  0.897178  0.774881  0.640276  0.820194  0.713866  0.976882  0.823424
0.447798  0.748416  0.379498  0.825832  0.723062  0.897194  0.775464  0.640417  0.820726  0.714175  0.977088  0.823981
0.447829  0.748694  0.379558  0.826477  0.723777  0.897275  0.775500  0.640632  0.821071  0.714939  0.977112  0.823998
0.447836  0.748776  0.379939  0.828160  0.725825  0.898674  0.776406  0.641381  0.821549  0.715336  0.977204  0.824211
0.447942  0.748909  0.380043  0.831304  0.725963  0.899381  0.778483  0.642283  0.821900  0.715637  0.977222  0.824578
0.447978  0.748993  0.380107  0.832005  0.727199  0.899684  0.778995  0.642633  0.622390  0.718765  0.977321  0.824761
0.448049  0.749433  0.381491  0.832060  0.729333  0.900329  0.780276  0.642689  0.826899  0.718768  0.977329  0.824854
0.448051  0.750979  0.382574  0.832178  0.736439  0.901353  0.780839  0.643657  0.831520  0.719565  0.977331  0.827016
0.448174  0.751254  0.382688  0.832890  0.736962  0.901613  0.781328  0.643863  0.831903  0.719739  0.977340  0.827419
0.448216  0.751488  0.382708  0.833045  0.744811  0.901685  0.781406  0.644136  0.832089  0.720172  0.977491  0.827582
0.448740  0.751779  0.382982  0.833087  0.746544  0.901872  0.781460  0.644230  0.832393  0.720205  0.977502  0.827987
0.449547  0.751860  0.383852  0.833350  0.754281  0.902360  0.781587  0.644287  0.832578  0.720634  0.977684  0.828654
0.449771  0.751978  0.384284  0.833618  0.755072  0.902364  0.781857  0.644383  0.833923  0.720958  0.978292  0.828832
0.449887  0.751997  0.385105  0.833675  0.757469  0.902440  0.781924  0.644400  0.834462  0.723379  0.978507  0.829036
0.449969  0.752227  0.385258  0.835837  0.757866  0.902555  0.782014  0.644476  0.836987  0.724047  0.978509  0.829263
0.450037  0.752671  0.385658  0.836067  0.759471  0.902867  0.782018  0.644590  0.838183  0.725632  0.978582  0.829384
0.450100  0.752948  0.385671  0.836958  0.759866  0.903116  0.782500  0.644747  0.838620  0.725716  0.979563  0.829392
0.450135  0.752954  0.386060  0.837008  0.760717  0.903551  0.782529  0.644919  0.839583  0.726826  0.979598  0.829534
0.450307  0.756157  0.386136  0.837951  0.761437  0.903957  0.782933  0.645145  0.841045  0.729765  0.980204  0.829885
0.450404  0.756224  0.386432  0.838155  0.761729  0.904433  0.783256  0.645215  0.841925  0.729892  0.980295  0.829928
0.450609  0.756466  0.387012  0.838187  0.762027  0.904553  0.783459  0.645519  0.844541  0.730052  0.980420  0.829998
0.450760  0.756532  0.388454  0.838308  0.762097  0.904588  0.783465  0.645575  0.846333  0.730143  0.981060  0.830793
0.450786  0.757195  0.389768  0.838337  0.762443  0.904601  0.783793  0.645861  0.851883  0.735179  0.981318  0.831016
0.451173  0.759429  0.389865  0.838411  0.762483  0.904862  0.783845  0.645963  0.852022  0.736525  0.981360  0.831088
0.451219  0.759631  0.390149  0.838443  0.762727  0.905085  0.784137  0.646124  0.852472  0.738149  0.981377  0.831695
0.451293  0.759681  0.390630  0.838780  0.763384  0.905339  0.784169  0.646314  0.852567  0.738391  0.981425  0.832145
0.451314  0.759809  0.390654  0.839123  0.765006  0.905446  0.784789  0.646580  0.853186  0.739233  0.981551  0.832538
0.451642  0.760160  0.391462  0.839308  0.765113  0.905975  0.784904  0.646625  0.853619  0.739334  0.981556  0.833060
0.453736  0.760184  0.392075  0.839392  0.766357  0.907289  0.789149  0.646717  0.855682  0.739372  0.981821  0.833199
0.454867  0.760279  0.392171  0.839569  0.766881  0.907427  0.789432  0.646733  0.856382  0.739518  0.981891  0.833440
0.455289  0.760519  0.393064  0.839833  0.767056  0.907505  0.789958  0.647186  0.856748  0.740434  0.982145  0.833706
0.455819  0.760715  0.393953  0.841039  0.771606  0.907604  0.789971  0.647730  0.857229  0.741291  0.982247  0.834177
0.457245  0.760728  0.401734  0.843213  0.773531  0.907877  0.791896  0.647838  0.858111  0.741654  0.982402  0.834321
0.457526  0.761452  0.405810  0.844599  0.776607  0.908105  0.792804  0.648253  0.858159  0.745264  0.982488  0.834726
0.460627  0.761520  0.406392  0.847072  0.777204  0.908131  0.793052  0.649063  0.858604  0.745748  0.982820  0.834954
0.465353  0.761708  0.406436  0.847238  0.777291  0.908549  0.796009  0.649957  0.859069  0.745936  0.982865  0.835554
0.465459  0.761828  0.406490  0.848386  0.777889  0.908607  0.796387  0.654308  0.859869  0.746216  0.983002  0.836630
0.468586  0.761999  0.406492  0.853652  0.778239  0.908683  0.797764  0.655526  0.861529  0.746575  0.983476  0.836984
0.469821  0.762076  0.406505  0.855415  0.779261  0.908935  0.798203  0.655626  0.861774  0.748954  0.983983  0.837040
0.470173  0.763381  0.407385  0.856158  0.779297  0.909095  0.798236  0.657270  0.861823  0.749154  0.984140  0.837087
0.470681  0.763420  0.409331  0.856335  0.780959  0.910076  0.801422  0.659067  0.862452  0.749348  0.984172  0.837220
0.470972  0.764101  0.409925  0.857756  0.786867  0.910978  0.802216  0.661409  0.864300  0.751543  0.984220  0.837292
0.471534  0.764736  0.410936  0.858076  0.788158  0.911126  0.802557  0.663004  0.864591  0.752023  0.984319  0.837823
0.471585  0.765505  0.410998  0.858302  0.788172  0.911172  0.803917  0.663185  0.864731  0.752513  0.986053  0.839760
0.471627  0.766787  0.413095  0.859018  0.788423  0.912309  0.804745  0.665168  0.865192  0.753419  0.986083  0.842093
0.471926  0.766814  0.413512  0.859975  0.788868  0.914748  0.804763  0.674183  0.871507  0.760244  0.986295  0.843021
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0.472013	0.767083	0.413518	0.860142	0.789198	0.916268	0.805008	0.675575	0.875690	0.771242	0.986981	0.844686
0.472051	0.767091	0.414016	0.86023.	0.789564	0.916863	0.806163	0.676484	0.875947	0.771520	0.987039	0.845125
0.472066	0.767537	0.414284	0.861017	0.790017	0.917086	0.808073	0.677649	0.876534	0.773923	0.987928	0.845523
0.472165	0.767823	0.415188	0.861199	0.790203	0.917916	0.808995	0.677768	0.884921	0.788342	0.988030	0.846026
0.472690	0.773136	0.415664	0.862142	0.790711	0.918677	0.809660	0.678169	0.885321	0.789997	0.988079	0.847419
0.472822	0.773319	0.416102	0.862174	0.790855	0.919071	0.810851	0.678232	0.885646	0.790245	0.988093	0.853413
0.473302	0.773482	0.416858	0.862247	0.791817	0.919335	0.811023	0.678822	0.888722	[illegible]	0.988187	0.853483
0.473418	0.775590	0.416924	0.862687	0.792775	0.920190	0.811613	0.678867	0.890572	[illegible]	0.988388	0.853878
0.474418	0.775735	0.416971	0.862956	0.793502	0.921509	0.811826	0.679351	0.890677	0.794473	0.990248	0.854543
0.474448	0.775883	0.417240	0.862967	0.793621	0.921566	0.812908	0.679359	0.890751	0.795062	0.990274	0.856171
0.474598	0.776702	0.417831	0.863260	0.793665	0.921592	0.813424	0.680631	0.893113	0.796149	0.990478	0.856419
0.474908	0.778585	0.418760	0.863591	0.796003	0.921734	0.813630	0.680893	0.893902	0.798673	0.990888	0.856481
0.476797	0.783093	0.419389	0.863618	0.796268	0.921955	0.814369	0.681114	0.895779	[illegible]	0.990911	0.856711
0.476906	0.785214	0.420874	0.863988	0.796499	0.922048	0.815178	0.681635	[illegible]	[illegible]	0.990914	0.857398
0.477453	0.790357	0.421475	0.864240	0.797308	0.923891	0.815389	0.682199	[illegible]	[illegible]	0.991238	0.858199
0.477543	0.792753	0.423286	0.864553	0.798277	0.924324	0.815617	0.682617	[illegible]	[illegible]	0.991378	0.858241
0.477884	0.792972	0.424293	0.864663	0.799944	0.924847	0.815896	0.683134	[illegible]	[illegible]	0.991485	0.859495
0.478844	0.793330	0.425916	0.864938	0.801761	0.933582	0.828179	0.706591	0.902657	0.808996	0.991570	0.864779
0.479196	0.793920	0.426645	0.875085	0.803439	0.933360	0.833868	0.707230	0.903536	0.809526	0.991608	0.868223
0.479250	0.794155	0.426704	0.884820	0.808023	0.935790	0.837185	0.713843	0.904721	0.810502	0.991680	0.868888
0.479842	0.794191	0.431030	0.885388	0.828345	0.938789	0.841510	0.718023	0.905906	0.811441	0.991764	0.872878
0.480827	0.795111	0.441562	0.893663	0.832723	0.940177	0.844133	0.718284	0.906026	0.815624	0.991845	0.874695
0.481060	0.795207	0.445031	0.895828	0.833661	0.940178	0.844596	0.725136	0.907329	0.815664	0.991857	0.876085
0.481383	0.798538	0.447729	0.896260	0.834299	0.940254	0.847459	0.725877	0.909556	0.817191	0.991938	0.877667
0.481484	0.803668	0.449016	0.896843	0.834924	0.940261	0.848747	0.729260	0.910278	0.818364	0.991951	0.877984
0.482363	0.805909	0.449860	0.897094	0.842117	0.943189	0.853599	0.732367	0.912316	0.820299	0.992319	0.880140
0.482971	0.807102	0.458515	0.897178	0.842389	0.946603	0.853766	0.733830	0.912946	0.821218	0.992367	0.880242
0.483449	0.815224	0.459834	0.897720	0.845614	0.947075	0.854451	0.734595	0.915202	0.821641	0.992389	0.880912
0.484864	0.816061	0.463099	0.898021	0.847424	0.947434	0.857010	0.734912	0.915446	0.823507	0.992510	0.881294
0.490626	0.816803	0.465723	0.900533	0.854615	0.948110	0.858431	0.739364	0.915464	0.828078	0.992518	0.881714
0.511297	0.821697	0.468127	0.907095	0.858632	0.948537	0.860866	0.743051	0.916350	0.830738	0.992982	0.883090
0.523725	0.827425	0.469015	0.909203	0.860410	0.948595	0.862913	0.745919	0.925199	0.834294	0.993014	0.883597
0.524295	0.829237	0.469195	0.910578	0.867944	0.949444	0.865087	0.750815	0.928709	0.837706	0.993124	0.884781
0.526061	0.832811	0.480007	0.921742	0.869305	0.954260	0.880985	0.771123	0.931481	0.848465	0.993471	0.885316
0.532049	0.841299	0.492672	0.934439	0.871113	0.964474	0.897225	0.788284	0.936180	0.857045	0.993482	0.885779
0.556020	0.845533	0.514561	0.936959	0.872055	0.965799	0.897480	0.797923	0.944176	0.868181	0.993507	0.886327
0.560377	0.849137	0.533005	0.939765	0.888970	0.970908	0.910415	0.808168	0.945905	0.872867	0.993635	0.886676
0.564649	0.853703	0.556159	0.944482	0.889612	0.975111	0.916081	0.810925	0.945944	0.879353	0.993856	0.887893
0.564978	0.879384	0.588545	0.947691	0.902556	0.980129	0.923257	0.813485	0.947463	0.883026	0.994224	0.889732

SUBSECTION E.7

```
USER DISTRIBUTION  Q20C1  T-I SGTR
1  20
0.0    0.0
1.E-5  1.4E-1
9.E-5  2.438E-1
1.4E-4 5.937E-1
4.4E-4 7.254E-1
1.41E-3 7.3E-1
7.03E-3 7.43E-1
8.59E-3 7.5E-1
1.509E-2 7.77E-1
1.715E-2 7.87E-1
1.997E-2 7.97E-1
2.203E-2 8.067E-1
2.356E-2 8.10E-1
2.509E-2 8.167E-1
3.385E-2 8.433E-1
3.982E-2 8.533E-1
4.703E-2 8.667E-1
5.029E-2 8.733E-1
1.111E-1 9.833E-1
1.208E-1 1.0
USER DISTRIBUTION  Q21C1  T-I HOT LEG FAILURE
     1    24
    0.0000     0.0000
    0.0000     0.1400
    0.0439     0.1600
    0.2921     0.1800
    0.4811     0.2000
    0.5809     0.2200
    0.6489     0.2400
    0.7146     0.2600
    0.7830     0.2800
    0.8316     0.3000
    0.8675     0.3200
    0.8947     0.3400
    0.9165     0.3600
    0.9369     0.3800
    0.9625     0.4000
    0.9783     0.4200
    0.9820     0.4400
    0.9853     0.4600
    0.9888     0.4800
    0.9924     0.5001
    0.9966     0.5201
    0.9999     0.5401
    1.0000     0.9801
    1.0000     1.0000
USER DISTRIBUTION  Q21C2  T-I HOT LEG FAILURE
1  5
0.   0.
.0001 .82
.20   .95
.50   .99
1.0   1.0
USER DISTRIBUTION  Q38C1  HYDROGEN RELEASED IN-VESSEL
   1   9
    0.00 0.000
   30.41 0.010
   50.68 0.050
  141.90 0.250
  197.65 0.500
  253.40 0.750
  486.53 0.950
  633.50 0.990
```

```
 658.84 1.000
USER DISTRIBUTION   Q38C2  HYDROGEN RELEASED IN-VESSEL
   1   9
   0.00 0.000
  40.54 0.010
 101.36 0.050
 172.31 0.250
 228.06 0.500
 314.22 0.750
 471.32 0.950
 633.50 0.990
 658.84 1.000
USER DISTRIBUTION   Q38C3  HYDROGEN RELEASED IN-VESSEL
   1   9
   0.00 0.000
  35.48 0.010
  70.95 0.050
 116.56 0.250
 152.04 0.500
 197.65 0.750
 288.88 0.950
 369.96 0.990
 405.44 1.000
USER DISTRIBUTION   Q38C4  HYDROGEN RELEASED IN-VESSEL
   1   9
   0.00 0.000
  40.54 0.010
  86.16 0.050
 136.84 0.250
 182.45 0.500
 238.20 0.750
 324.35 0.950
 395.30 0.990
 430.78 1.000
USER DISTRIBUTION   Q38C5  HYDROGEN RELEASED IN-VESSEL
   1   9
  25.34 0.000
  60.82 0.010
  91.22 0.050
 136.84 0.250
 202.72 0.500
 324.35 0.750
 491.60 0.950
 577.75 0.990
 608.16 1.000
USER DISTRIBUTION   Q38C6  HYDROGEN RELEASED IN-VESSEL
   1   9
  25.34 0.000
  60.82 0.010
 101.36 0.050
 172.31 0.250
 243.26 0.500
 329.42 0.750
 491.60 0.950
 577.75 0.990
 608.16 1.000
USER DISTRIBUTION   Q38C7  HYDROGEN RELEASED IN-VESSEL
   1   9
  25.34 0.000
  55.75 0.010
  76.02 0.050
 121.63 0.250
 167.24 0.500
 319.28 0.750
 491.60 0.950
 577.75 0.990
```

```
 608.16 1.000
USER DISTRIBUTION  Q49C3 IGNITION FREQ.IN ICE CONDENSER
1  33
 0.000E+00   0.000E+00
 1.000E-02   1.060E-02
 3.900E-02   2.249E-02
 5.000E-02   2.802E-02
 7.500E-02   6.127E-02
 9.400E-02   9.812E-02
 1.000E-01   1.108E-01
 1.120E-01   1.375E-01
 1.130E-01   1.415E-01
 1.390E-01   2.742E-01
 1.410E-01   2.893E-01
 1.580E-01   4.335E-01
 1.630E-01   4.650E-01
 1.770E-01   5.499E-01
 1.940E-01   6.091E-01
 1.960E-01   6.160E-01
 2.000E-01   6.290E-01
 2.080E-01   6.575E-01
 2.120E+01   6.713E-01
 2.210E-01   6.947E-01
 2.330E-01   7.187E-01
 2.500E-01   7.398E-01
 2.540E-01   7.602E-01
 2.590E-01   7.858E-01
 3.000E-01   9.687E-01
 4.000E-01   9.693E-01
 5.000E-01   9.707E-01
 5.500E-01   9.713E-01
 6.000E-01   9.720E-01
 7.000E-01   9.740E-01
 8.500F-01   9.807E-01
 9.000E-01   1.000E+00
 1.000E+00   1.000E+00
USER DISTRIBUTION    Q49C4  IGNITION FREQ.IN ICE CONDENSER
 1  32
 0.000E+00   0.000E+00
 8.000E-03   5.947E-03
 1.900E-02   2.255E-02
 3.500E-02   9.477E-02
 3.900F-02   1.157E-01
 5.000E+02   1.742E-01
 5.200E-02   1.850E-01
 7.100E-02   2.777E-01
 7.500E-02   2.892E-01
 9.200E-02   3.484E-01
 9.400E-02   3.528E-01
 1.000E-01   3.672E-01
 1.070E-01   3.854E-01
 1.130E-01   4.000E-01
 1.210E-01   4.279E-01
 1.220E-01   4.338E-01
 1.390E-01   4.769E-01
 1.580E-01   5.719E-01
 1.960E-01   6.785E-01
 2.000E-01   6.890E-01
 2.210E-01   7.743E-01
 2.330E-01   8.158E-01
 2.540E-01   8.724E-01
 2.590E-01   8.861E-01
 3.000E-01   9.707E-01
 4.000E-01   9.723E-01
 5.000E-01   9.743E-01
 5.500E-01   9.757E-01
```

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 6.000E-01   9.773E-01
 8.000E-01   9.877E-01
 9.000E-01   1.000E+00
 1.000E+00   1.000E+00
USER DISTRIBUTION    Q49C5  IGNITION FREQ.IN ICE CONDENSER
1  29
 0.0         0.0
 0.000E+00   3.333E-03
 1.000E-03   1.732E-02
 7.000E-03   1.712E-01
 1.500E-02   2.598E-01
 2.900E-02   3.189E-01
 3.100E-02   3.369E-01
 3.600E-02   3.535E-01
 3.900E-02   3.568E-01
 5.000E-02   3.670E-01
 7.500E-02   3.892E-01
 9.400E-02   4.176E-01
 1.000E-01   4.276E-01
 1.130E-01   4.549E-01
 1.390E-01   5.368E-01
 1.580E-01   6.435E-01
 1.960E-01   7.734E-01
 2.000E-01   7.863E-01
 2.210E-01   8.520E-01
 2.330E-01   8.822E-01
 2.540E-01   9.192E-01
 2.590E-01   9.281E-01
 3.000E-01   9.743E-01
 4.000E-01   9.780E-01
 5.000E-01   9.823E-01
 6.000E-01   9.877E-01
 7.000E-01   9.957E-01
 7.500E-01   1.000E+00
 1.000E+00   1.000E+00
USER DISTRIBUTION   Q50C6  IGNITION FREQ. IN UPPER PLENUM
 1  30
 0.000E+00   0.000E+00
 2.500E-02   1.906E-02
 5.000E-02   3.927E-02
 9.700E-02   4.656E-02
 1.000E-01   4.849E-02
 1.220E-01   6.284E-02
 1.470E-01   8.248E-02
 1.500E-01   8.725E-02
 1.810E-01   1.412E-01
 2.000E-01   1.880E-01
 2.190E-01   2.351E-01
 2.270E-01   2.533E-01
 2.500E-01   3.164E-01
 2.610E-01   3.468E-01
 2.970E-01   4.249E-01
 3.000E-01   4.291E-01
 3.240E-01   4.637E-01
 3.300E-01   4.708E-01
 3.610E-01   5.449E-01
 3.750E-01   5.757E-01
 3.800E-01   5.884E-01
 4.000E-01   6.358E-01
 4.130E-01   6.682E-01
 4.460E-01   7.281E-01
 4.680E-01   7.514E-01
 5.000E-01   7.682E-01
 5.270E-01   7.905E-01
 5.500E-01   8.077E-01
 6.000E-01   1.000E+00
```

```
 1.000E+00   1.000E+00
USER DISTRIBUTION   Q50C7  IGNITION FREQ. IN UPPER PLENUM
1  29
 0.000E+00   0.000E+00
 2.500E-02   2.210E-02
 5.000E-02   4.536E-02
 5.200E-02   4.590E-02
 6.300E-02   6.151E-02
 9.700E-02   1.121E-01
 1.000E-01   1.180E-01
 1.150E-01   1.482E-01
 1.220E-01   1.676E-01
 1.470E-01   2.414E-01
 1.550E-01   2.714E-01
 1.610E-01   3.650E-01
 1.960E-01   4.386E-01
 2.000E-01   4.460E-01
 2.190E-01   5.181E-01
 2.350E-01   5.755E-01
 2.610E-01   6.471E-01
 2.670E-01   6.601E-01
 2.870E-01   7.062E-01
 2.970E-01   7.259E-01
 3.000E-01   7.285E-01
 3.240E-01   7.517E-01
 3.610E-01   7.780E-01
 3.800E-01   7.880E-01
 4.000E-01   7.950E-01
 5.000E-01   8.550E-01
 5.500E-01   9.150E-01
 6.000E-01   1.000E+00
 1.000E+00   1.000E+00
USER DISTRIBUTION   Q50C8  IGNITION FREQ. IN UPPER PLENUM
1  27
 0.000E+00   3.333E-03
 2.000E-03   1.860E-02
 8.000E-03   9.107E-02
 1.700E-02   1.631E-01
 2.500E-02   2.123E-01
 4.800E-02   2.975E-01
 5.000E-02   3.029E-01
 7.700E-02   3.597E-01
 8.400E-02   3.791E-01
 8.900E-02   3.943E-01
 9.000E-02   3.980E-01
 9.700E-02   4.007E-01
 1.000E-01   4.033E-01
 1.220E-01   4.235E-01
 1.470E-01   4.498E-01
 1.610E-01   5.130E-01
 2.000E-01   5.620E-01
 2.190E-01   6.131E-01
 2.610E-01   7.173E-01
 2.970E-01   7.652E-01
 3.000E-01   7.885E-01
 3.240E-01   8.202E-01
 3.610E-01   8.536E-01
 3.800E-01   8.763E-01
 4.000E-01   8.903E-01
 5.000E-01   1.000E+00
 1.000E+00   1.000E+00
USER DISTRIBUTION   Q51C6  IGNITION FREQ. - DOME
 1  22
 0.000E+00   0.000E+00
 1.000E-02   8.500E-03
 2.000E-02   1.800E-02
```

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 3.400E-02   3.690E-02
 4.000E-02   4.750E-02
 4.600E-02   8.000E-02
 5.000E-02   1.047E-01
 6.000E-02   1.310E-01
 6.300E-02   1.401E-01
 7.000E-02   1.749E-01
 7.100E-02   1.807E-01
 7.600E-02   2.669E-01
 8.000E-02   2.974E-01
 9.000E-02   3.870E-01
 1.000E-01   7.321E-01
 1.040E-01   7.500E-01
 1.520E-01   8.750E-01
 1.760E-01   9.500E-01
 1.830E-01   9.750E-01
 2.220E-01   9.950E-01
 2.500E-01   1.000E+00
 1.000E+00   1.000E+00
USER DISTRIBUTION   Q51C7  IGNITION FREQ. - DOME
 1  22
 0.000E+00   0.000E+00
 1.000E-02   1.700E-02
 2.000E-02   3.650E-02
 3.400E-02   7.360E-02
 4.000E-02   9.200E-02
 4.600E-02   1.248E-01
 5.000E-02   1.497E-01
 6.000E-02   1.905E-01
 6.300E-02   2.053E-01
 7.000E-02   2.534E-01
 7.100E-02   2.618E-01
 7.600E-02   3.630E-01
 8.000E-02   4.019E-01
 9.000E-02   5.365E-01
 1.000E-01   7.321E-01
 1.040E-01   7.500E-01
 1.520E-01   8.750E-01
 1.760E-01   9.500E-01
 1.830E-01   9.750E-01
 2.220E-01   9.950E-01
 2.500E-01   1.000E+00
 1.000E+00   1.000E+00
USER DISTRIBUTION   Q51C8  IGNITION FREQ. - DOME
 1  22
 0.000E+00   0.000E+00
 1.000E-02   3.400E-02
 2.000E-02   7.250E-02
 3.400E-02   1.471E-01
 4.000E-02   1.815E-01
 4.600E-02   2.146E-01
 5.000E-02   2.397E-01
 6.000E-02   3.095E-01
 6.300E-02   3.354E-01
 7.000E-02   4.094E-01
 7.100E-02   4.231E-01
 7.600E-02   5.508E-01
 8.000E-02   6.109E-01
 9.000E-02   6.870E-01
 1.000E-01   7.321E-01
 1.040E-01   7.500E-01
 1.520E-01   8.750E-01
 1.760E-01   9.500E-01
 1.830E-01   9.750E-01
 2.220E-01   9.950E-01
 2.500E-01   1.000E+00
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 1.000E+00   1.000E+00
USER DISTRIBUTION    Q52C1  DETONATION TRANSITION
 1   8
 4.940E-01   0.000E+00
 5.000E-01   3.333E-03
 5.010E-01   3.372E-01
 6.500E-01   4.167E-01
 8.000E-01   5.000E-01
 9.000E-01   5.833E-01
 9.010E-01   9.175E-01
 1.000E+00   1.0
USER DISTRIBUTION    Q52C2  DETONATION TRANSITION
1   9
 4.940E-01   0.000E+00
 5.000E-01   3.333E-03
 5.010E-01   3.372E-01
 6.000E-01   3.900E-01
 6.010E-01   7.239E-01
 6.500E-01   7.500E-01
 8.000E-01   8.333E-01
 9.000E-01   9.167E-01
 1.000E+00   1.0
USER DISTRIBUTION    Q52C3  DETONATION TRANSITION
 1   9
 1.000E-01   0.000E+00
 1.010E-01   3.333E-01
 4.940E-01   3.333E-01
 5.000E-01   3.367E-01
 5.010E-01   6.705E-01
 6.500E-01   7.500E-01
 8.000E-01   8.333E-01
 9.000E-01   9.167E-01
 1.000E+00   1.0
USER DISTRIBUTION    Q57C1P3   FAILURE OF UPPER PLEUM IMPULSE
1 19
0.46   0.0
0.69   2.381E-3
1.38   1.286E-2
2.07   7.444E-2
3.45   1.976E-1
3.70   2.099E-1
4.48   2.548E-1
5.65   3.221E-1
6.90   4.00E-1
9.45   5.210E-1
10.34  5.643E-1
12.41  6.450E-1
13.45  6.715E-1
16.07  7.669E-1
18.62  8.287E-1
20.69  8.550E-1
22.76  8.812E-1
44.82  9.833E-1
48.42  1.000
USER DISTRIBUTION     Q57C1P4  FAILURE OF ICE CONDENSER IMPULSE
1   25
0.69        0.0
1.38        3.33E-3
4.83        1.667E-1
5.18        1.763E-1
6.50        2.153E-1
6.90        2.280E-1
7.93        2.642E-1
9.66        3.234E-1
10.07       3.294E-1
12.27       3.681E-1
```

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13.79     3.986E-1
17.24     4.433E-1
20.68     4.912E-1
24.82     5.547E-1
27.58     6.250E-1
30.34     7.000E-1
34.48     7.834E-1
36.54     8.218E-1
40.68     8.627E-1
41.37     8.928E-1
44.82     9.350E-1
48.26     9.633E-1
55.16     9.833E-1
62.06     9.967E-1
63.78     1.0
USER DISTRIBUTION Q68C2 FRAC.OF CORE AT VB DIVERTED SEAL TABLE
1  7
          0.0002  0.00
          0.0190  0.05
          0.0650  0.25
          0.1110  0.50
          0.2030  0.75
          0.3457  0.95
          0.4718  1.00
USER DISTRIBUTION Q68C3 FRAC.OF CORE AT VB DIVERTED SEAL TABLE
1  7
          0.0008  0.00
          0.0859  0.05
          0.1862  0.25
          0.2736  0.50
          0.4192  0.75
          0.7257  0.95
          0.9577  1.00
USER DISTRIBUTION Q68C4 FRAC.OF CORE AT VB DIVERTED SEAL TABLE
1  7
          0.0011  0.00
          0.0935  0.05
          0.1784  0.25
          0.2585  0.50
          0.4057  0.75
          0.7484  0.95
          0.9909  1.00
USER DISTRIBUTION Q68C5 FRAC.OF CORE AT VB DIVERTED SEAL TABLE
1  7
          0.0012  0.00
          0.0653  0.05
          0.1508  0.25
          0.2529  0.50
          0.3896  0.75
          0.7181  0.95
          0.9507  1.00
USER DISTRIBUTION Q68C6 FRAC.OF CORE AT VB DIVERTED SEAL TABLE
1  7
          0.0015  0.00
          0.1690  0.05
          0.2523  0.25
          0.3559  0.50
          0.5319  0.75
          0.8609  0.95
          0.9730  1.00
USER DISTRIBUTION Q68C7 FRAC.OF CORE AT VB DIVERTED SEAL TABLE
1  7
          0.0013  0.00
          0.1665  0.05
          0.2564  0.25
          0.3511  0.50
```

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          0.5330  0.75
          0.8540  0.95
          0.9730  1.00
USER DISTRIBUTION Q68C8 FRAC.OF CORE AT VB DIVERTED REAL TABLE
1  7
          0.0014  0.00
          0.1650  0.05
          0.2495  0.25
          0.3540  0.50
          0.5327  0.75
          0.8657  0.95
          0.9780  1.00
USER DISTRIBUTION       Q73C3P1B1   PRESSURE RISE AT VB - NO HPME
  1  9
    3.80     0.00
   15.00     0.01
   60.00     0.05
  180.00     0.25
  280.00     0.50
  330.00     0.75
  370.00     0.95
  400.00     0.99
  407.50     1.00
USER DISTRIBUTION       Q73C3P2B1   PRESSURE RISE AT VB - NO HPME
  1  9
    3.80     0.00
   15.00     0.01
   60.00     0.05
  205.00     0.25
  330.00     0.50
  405.00     0.75
  470.00     0.95
  525.00     0.99
  536.80     1.00
USER DISTRIBUTION       Q73C4P1B1   PRESSURE RISE AT VB - NO HPME
  1  9
   80.00     0.00
   80.00     0.01
   80.00     0.05
   80.00     0.25
  105.00     0.50
  355.80     0.75
 1240.00     0.95
 1325.00     0.99
 1346.30     1.00
USER DISTRIBUTION       Q73C4P2B1   PRESSURE RISE AT VB - NO HPME
   1   9
  88.00 0.000
  88.00 0.010
  88.00 0.050
  88.00 0.250
 115.50 0.500
 391.38 0.750
1364.00 0.950
1457.50 0.990
1480.93 1.000
USER DISTRIBUTION       Q73C5P1B1   PRESSURE RISE AT VB - NO HPME
  1  9
   12.00     0.00
   16.70     0.01
   35.70     0.05
   50.60     0.25
   74.20     0.50
  238.30     0.75
  806.70     0.95
  927.50     0.99
```

```
  957.70    1.00
USER DISTRIBUTION       Q73C5P2B1   PRESSURE RISE AT VB - NO HPME
  1  9
   10.70    0.00
   16.70    0.01
   40.90    0.05
   60.40    0.25
   75.20    0.50
  311.60    0.75
 1202.50    0.95
 1325.00    0.99
 1355.60    1.00
USER DISTRIBUTION       Q73C6P1B1   PRESSURE RISE AT VB - NO HIME
  1  9
    8.10    0.00
   18.70    0.01
   61.00    0.05
   69.00    0.25
   79.10    0.50
  196.70    0.75
  303.70    0.95
  353.10    0.99
  365.50    1.00
USER DISTRIBUTION       Q73C6P2B1   PRESSURE RISE AT VB - NO HPME
   1   9
   8.91 0.000
  20.57 0.010
  67.10 0.050
  75.80 0.250
  87.01 0.500
 216.37 0.750
 334.07 0.950
 388.41 0.990
 402.05 1.000
USER DISTRIBUTION       Q73C7P1B1   PRESSURE RISE AT VB - NO HPME
  1  9
    4.80    0.00
    6.30    0.01
   12.50    0.05
   30.00    0.25
   64.80    0.50
   74.30    0.75
   93.30    0.95
  122.50    0.99
  129.80    1.00
USER DISTRIBUTION       Q73C7P2B1   PRESSURE RISE AT VB - NO HPME
  1  9
    4.10    0.00
    6.30    0.01
   15.00    0.05
   50.00    0.25
   62.50    0.50
   75.00    0.75
  112.00    0.95
  142.50    0.99
  150.10    1.00
USER DISTRIBUTION       Q74C2P1B1   PRESSURE RISE AT VB - HPME
  1  9
   45.90    0.00
   51.80    0.01
   75.60    0.05
  171.70    0.25
  284.50    0.50
  545.20    0.75
  765.00    0.95
  928.60    0.99
```

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   969.50    1.00
 USER DISTRIBUTION      Q74C2P2B1   PRESSURE RISE AT VB - HPME
   1  9
    50.80    0.00
    72.30    0.01
   158.40    0.05
   341.60    0.25
   597.30    0.50
   764.00    0.75
  1117.60    0.95
  1226.70    0.99
  1254.00    1.00
 USER DISTRIBUTION      Q74C3P1B1   PRESSURE RISE AT VB - HPME
   1  9
    43.50    0.00
    47.60    0.01
    64.10    0.05
   130.20    0.25
   201.80    0.50
   355.80    0.75
   540.40    0.95
   632.10    0.99
   655.00    1.00
 USER DISTRIBUTION      Q74C3P2B1   PRESSURE RISE AT VB - HPME
   1  9
    24.70    0.00
    44.60    0.01
   124.20    0.05
   253.90    0.25
   383.00    0.50
   518.80    0.75
   831.10    0.95
   924.20    0.99
   947.50    1.00
 USER DISTRIBUTION      Q74C4P1B1   PRESSURE RISE AT VB - HPME
   1  9
    25.80    0.00
    33.20    0.01
    62.60    0.05
    89.60    0.25
   140.40    0.50
   276.30    0.75
   422.10    0.95
   492.50    0.99
   510.20    1.00
 USER DISTRIBUTION      Q74C4P2B1   PRESSURE RISE AT VB - HPME
   1  9
    14.40    0.00
    25.50    0.01
    69.60    0.05
   152.00    0.25
   222.80    0.50
   296.90    0.75
   471.60    0.95
   533.40    0.99
   548.80    1.00
 USER DISTRIBUTION      Q74C5P1B1   PRESSURE RISE AT VB - HPME
   1  9
    45.90    0.00
    50.80    0.01
    70.60    0.05
   144.90    0.25
   259.20    0.50
   491.90    0.75
   700.50    0.95
   864.60    0.99
```

```
  905.60    1.00
USER DISTRIBUTION       Q74C5P2B1   PRESSURE RISE AT VB - HPME
  1  9
    81.10     0.00
    98.20     0.01
   166.50     0.05
   345.40     0.25
   562.10     0.50
   710.00     0.75
  1085.50     0.95
  1206.10     0.99
  1236.30     1.00
USER DISTRIBUTION       Q74C8P1B1   PRESSURE RISE AT VB - HPME
  1  9
    45.90     0.00
    50.30     0.01
    67.80     0.05
   135.70     0.25
   227.40     0.50
   485.90     0.75
   698.80     0.95
   847.70     0.99
   884.90     1.00
USER DISTRIBUTION       Q74C8P2B1   PRESSURE RISE AT VB - HPME
  1  9
    32.30     0.00
    54.30     0.01
   142.40     0.05
   313.90     0.25
   502.10     0.50
   689.40     0.75
  1084.30     0.95
  1206.10     0.99
  1236.60     1.00
USER DISTRIBUTION       Q74C11P1B1  PRESSURE RISE AT VB - HPME
  1  9
    95.50     0.00
   106.40     0.01
   150.00     0.05
   299.50     0.25
   412.60     0.50
   532.20     0.75
   728.70     0.95
   954.40     0.99
  1010.80     1.00
USER DISTRIBUTION       Q74C12P1B1  PRESSURE RISE AT VB - HPME
  1  9
    88.70     0.00
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In support of the U.S. Nuclear Regulatory Commission's assessment of the risk from severe accidents at commercial nuclear power plants in the U.S. reported in NUREG-1150, the Severe Accident Risk Reduction Program has completed a revised calculation of the risk to the general public from severe accidents at the Sequoyah Power Station, Unit 1. This power plant, located in southeastern Tennessee, is operated by the Tennessee Valley Authority.

The emphasis in this risk 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 risks from initiating events internal to the power station were assessed.

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