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6	6-28	720.024 (R1)
6	6-32 and 6-33	720.024 (R1)
6	6-37 through 6-39	720.024 (R1)
6	6-41	720.024 (R1)
6	6-50 through 6-53	720.024 (R1)
6	6-69	720.029 (R1)
24	24-17	720.046 (R1)
24	24-22 and 24-23	720.046 (R1)
24	24-27	720.046 (R1)
30	30-26a through 30-28	720.029 (R1)
35	35-28	720.043 (R1)
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43	43-9b	Editorial
43	43-10a	720.039 (R2)
43	43-10b	Editorial
43	43-93a through 43-93w	720.039 (R2)
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50	50-1	
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50	50-14	720.039 (R2)
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56	56-36 and 56-37	Editorial
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56	56-38l	Editorial
56	56-47 through 56-49	Editorial
56	56-51	Editorial
56	56-54 and 56-55	720.038 (R1)
57	57-14 and 57-15	280.011 (R1)
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59	59-23 and 59-23a	720.038 (R1)
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Appendix A	A-12	Editorial
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Appendix A	A-26b	Editorial
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Appendix A	A-63	720.012 (R1)
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Appendix A	A-103c and A-103d	720.012 (R1)
Appendix A	A-151 and A-152	720.013 (R1)
Appendix A	A-165 and A-166	720.013 (R1)

REVISION 2 CHANGE ROADMAP (Cont.)

Section	Page No.	Type of Change[1]
Appendix D	D-13 and D-14	720.080 (R1)
Appendix D	D-35 and D-36	720.080 (R1)

1. Changes incorporated as a result of Westinghouse responses to NRC Request for Additional Information (RAI) identified by RAI number.

CHAPTER 50

IMPORTANCE AND SENSITIVITY ANALYSES

Various importance and sensitivity analyses are performed for the AP1000 PRA and are reported in different sections of the report. This section contains the importance and sensitivity analyses for plant CDF for internal events at power. Sensitivity analyses for other subjects are reported in their respective sections. For example:

- LRF sensitivity analyses are found in Section 43
- Dose sensitivity analyses are found in Section 49
- Shutdown sensitivity analyses are found in Section 54
- Internal flooding sensitivity analyses are found in Section 56
- Internal fire sensitivity analyses are found in Section 57

50.1 Introduction

Importance and sensitivity analyses have been performed for the AP1000 at-power PRA. These analyses are chosen among numerous potential candidates to address the following issues:

- Importances of individual basic events in their effect on plant core damage frequency (CDF)
- Importances of safety and non-safety systems in maintaining current plant core damage frequency
- Importances of containment safeguards systems in maintaining current severe release frequency
- Effect of human reliabilities as a group on plant core damage frequency
- Special issues

The importance and sensitivity studies are organized in the following subsections:

- 50.2 Importance analyses for core damage
- 50.3 System importances for core damage
- 50.4 Human error sensitivity analyses
- 50.5 Other sensitivity analyses for core damage

The importance and sensitivity analyses results are summarized in Section 50.6.

50.2 Importance Analyses for Core Damage

The core damage results for internal initiating events at power has 599 basic events (including initiating events, component failures, human error, common cause failures) in over

19,000 core damage cutsets. The importance analysis of these basic events is provided in this section. The results are given in terms of risk decrease (set basic event probability to 0.0) and risk increase (set basic event probability to 1.0) measures.

In this section, the various importances associated with at-power initiating events core damage analysis are discussed in terms of:

- Initiating events
- Accident sequences
- End states
- Common cause

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- Human errors
- Component failures

The relative importance of all basic events appearing in the cutsets for the baseline core damage quantification are presented in Tables 50-22 through 50-25. These tables show risk decrease (i.e., the factor by which the core damage frequency would decrease if the failure probability for a particular basic event were set to zero; also referred to as risk reduction worth) and risk increase (i.e., the factor by which the core damage frequency increases if the failure probability for a given basic event were set to one; also referred to as risk achievement worth), respectively. Risk decrease is a useful measure of the benefit that might be obtained as a result of improved component maintenance or testing, better procedures or operator training, and so forth. Risk increase is a useful measure of which components or actions would most adversely affect the core damage frequency if actual operating practices resulted in higher failure probabilities than assumed.

50.2.1 Initiating Event Importances

The AP1000 plant core damage frequency for internal initiating events at power is calculated to be 2.4E-07 events per year. Twenty-six separate initiating event categories are defined to accurately represent the AP1000 design. Of these categories of events, eleven are LOCAs, twelve are transients, and three are ATWS precursors (that is, initiating events that result in an ATWS sequence as a result of failure to trip the reactor). Where appropriate, plant-specific initiating event categories such as safety injection line breaks, core makeup tank (CMT) line breaks, and passive residual heat removal (passive RHR) tube ruptures have also been defined and evaluated. The resulting core damage frequency is very small; a value of 2.4E-07 means that only one core damage event is expected in approximately four million plant-years of operation.

The contribution of initiating events to the total plant core damage frequency is summarized in Table 50-1. This information is equivalent to risk decrease importance of the initiating events. The conditional probability of core damage, given that an initiating event occurs, is given in Table 50-2. These conditional probabilities are related to risk increase importance measure; they can be viewed as indicators of plant's robustness against the initiating events, given that the event has occurred.

From Table 50-1, eight initiating events, all being LOCAs, comprise approximately 93 percent of the total plant core damage frequency. These events are:

- Safety injection line break
- Large LOCA
- Spurious ADS actuation
- Small LOCA
- Medium LOCA
- Reactor vessel rupture
- Steam generation tube rupture (SGTR)
- Core makeup tank line break

RHN-MAN01
RN11MOD3
RN22MOD4
RN23MOD5
RN55MOD1
RNAMOD06
RNAMOD09
RNBMOD07
RNBMOD10
RNNCV013GO
RNNCV056GO
RNX-CV-GO
RNX-KV-GO
RNX-KV1-GO
RNX-PM-ER
RNX-PM-FS
SGX-AV-FA
SWN-MAN03
ZO1DG001TM
ZO1MOD01
ZO1MOD03
ZO1MOD04
ZO2DG002TM
ZO2MOD01
ZO2MOD04
ZOX-BL-ES
ZOX-DG-DR
ZOX-DG-DS
ZOX-PD-ER
ZOX-PD-ES
FSMOD255A
RNAEP01ASA
RNAEP01BSA
RNAEP022SA
RNBEP011SA
RNDEP023SA
SGX-CV-GO
SGX-MV-RP

The failure probabilities of these basic events are set to 1.0 and the drop option of SEN.EXE code is used to process the CDF cutset uncertainty.

Results

The calculations are performed on a personal computer using the SEN code for sensitivity analysis. The input file is taken from the AP1000 PRA CDF analysis. This file is CMTOT.OUT. The results of the sensitivity analysis are given in Tables 50-20 and 50-21.

Table 50-20 shows the contribution of the initiating events when no credit is taken for the above standby systems.

The output file contains 7269 cutsets. The top 50 of these cutsets are shown in Table 50-23.

This sensitivity analysis estimates that the CDF increases from 2.41E-07/year to 7.41E-06/year when no credit is taken for the standby systems CVS, SFS, RNS, DAS, and DGs.

These results are limited by the way the sensitivity analysis is performed. Namely, if a CDF cutset does not appear in the CMTOT.OUT file due to cutoff probability, then it is not resurrected in the present analysis.

50.5.5 Sensitivity to Standby Systems; Manual DAS Credited

This section documents the sensitivity analysis named as case 37, which is similar to case 36, except manual DAS is credited (automatic DAS is assumed failed). This sensitivity analysis is performed on the core damage frequency results of the AP1000 PRA internal events at-power. The objective of this analysis is to estimate the benefit of manual DAS actuation, when other standby nonsafety systems are assumed unavailable. These five standby nonsafety systems (which are taken credit for in the base AP1000 PRA) are:

1. Chemical and Volume Control System (CVS)
2. Startup Feedwater System (SFW)
3. Normal Residual Heat Removal System (RNS)
4. Automatic Diverse Actuation System (DAS) – excludes manual DAS
5. Diesel Generators (DG)

The process is similar to that of case 36, except the following basic events appearing in the plant CDF cutsets are not set to failure: REC-MANDAS, REC-MANDASC, MDAS, ATW-MAN04, ATW-MAN04C, and ATW-MAN06. This allows credit for manual DAS actuation to be retained.

The resulting plant CDF is 2.12E-06/yr. This result shows that crediting manual DAS reduces the case 36 CDF by a factor of 3.5. This is a worthwhile decrease, which justifies the administrative controls placed on manual DAS.

50.6 Results

Importance and sensitivity analyses are performed on the core damage model for internal initiating events at power. The results for individual cases have been discussed in their respective sections, whenever needed.

The major conclusions of the sensitivity analyses are:

- If no credit is taken for operator actions, the plant core damage frequency is 1.37E-05/year (case 29). This compares well with the risk of existing plants where credit is taken for operator actions.

- For system importances the most important systems for core damage prevention are PMS, Class 1E DC, ADS, and IRWST. None of the non-safety systems have high system importance.

- The common cause failure basic events are important individually, as well as a group for plant core damage frequency. This is expected for a plant with highly redundant safety systems.

- There are no operator actions that provide a significant risk decrease if made to be more reliable.

- When no credit is taken for standby systems CVS, SFS, RNS, DAS, and DGs, the plant core damage frequency increased by a factor of 31. While this is a significant increase, the plant core damage frequency is still low (7.41E-06/year). If manual DAS credit is retained in this case, the plant CDF becomes 2.12E-06/yr, which shows the benefit gained by the administrative controls placed on manual DAS.

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