

CHAPTER 15 ACCIDENT ANALYSES

15.1	Selection of Accidents.....	15-1
15.2	Evaluation Methodology.....	15-1
15.3	Source Terms.....	15-2
15.4	Radiological Consequences.....	15-2
	Chapter 15 References.....	15-23

Page intentionally left blank.

Chapter 15 Accident Analyses

This chapter presents the required 10 CFR 52.17(a)(1), “Contents of Applications,” early site permit (ESP) application analysis and evaluation of the major structures, systems, and components of the facility that bear significantly on the acceptability of the site with respect to the radiological consequence evaluation factors identified in 10 CFR 50.34(a)(1).

15.1 Selection of Accidents

The *AP1000 Design Control Document (DCD)* design bases accidents are considered in this chapter (**Westinghouse 2005**). Table 15-1 shows the NUREG-0800 Standard Review Plan (SRP) section numbers and accident descriptions, as well as the corresponding accidents as defined in the AP1000 DCD. Although only those accidents identified in Regulatory Guide 1.183, *Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors*, July 2000 (RG 1.183), are required to be evaluated, the radiological consequences of all the accidents listed in Table 15-1 are assessed to demonstrate that new units could be sited at the VEGP site without undue risk to the health and safety of the public.

15.2 Evaluation Methodology

The AP1000 DCD presents the radiological consequences for the accidents identified in Table 15-1. The DCD design basis analyses are updated with VEGP site data to demonstrate that the DCD analyses are bounding for the VEGP site. The basic scenario for each accident is that some quantity of activity is released at the accident location inside a building and this activity is eventually released to the environment. The transport of activity within the plant is independent of the site and specific to the AP1000 design. Details about the methodologies and assumptions pertaining to each of the accidents, such as activity release pathways and credited mitigation features, are provided in the DCD.

The dose to an individual located at the exclusion area boundary (EAB) or the low population zone (LPZ) is calculated based on the amount of activity released to the environment, the atmospheric dispersion of the activity during the transport from the release point to the offsite location, the breathing rate of the individual at the offsite location, and activity-to-dose conversion factors. The only site-specific parameter is atmospheric dispersion. Site-specific doses are obtained by adjusting the DCD doses to reflect site-specific atmospheric dispersion factors (χ/Q values). Since the site-specific χ/Q values are bounded by the DCD χ/Q values, this approach demonstrates that the site-specific doses are within those calculated in the DCD.

Short-term accident χ/Q values are calculated using the methodology of Regulatory Guide 1.145, *Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants*, Revision 1 (RG 1.145) with site-specific meteorological data. As indicated in Section 2.3.4, the RG 1.145 methodology is implemented in the NRC-sponsored PAVAN computer program. This program computes χ/Q values at the EAB and the LPZ for each

combination of wind speed and atmospheric stability for each of 16 downwind direction sectors and then calculates overall (non direction-specific) χ/Q values. For a given location, either the EAB or the LPZ, the 0 – 2 hour χ/Q value is the top 5th percentile overall value calculated by PAVAN, meaning that conditions would be more favorable for dispersion 95% of the time. For the LPZ, the χ/Q values for all subsequent times are calculated by logarithmic interpolation between the top 5th percentile χ/Q value and the annual average χ/Q value. Releases are assumed to be at ground level, and the shortest distances between the power block and the offsite locations are selected to conservatively maximize the χ/Q values.

The accident doses are expressed as total effective dose equivalent (TEDE), consistent with 10 CFR 50.34. The TEDE consists of the sum of the committed effective dose equivalent (CEDE) from inhalation and the effective dose equivalent (EDE) from external exposure. The CEDE is determined using the dose conversion factors in Federal Guidance Report 11 (**EPA 1988**), while the EDE is based on the dose conversion factors in Federal Guidance Report 12 (**EPA 1993**). Appendix 15A of the AP1000 DCD provides information on the methodologies used to calculate CEDE and EDE values. As indicated in RG 1.183, the dose conversion factors in Federal Guidance Reports 11 and 12 are acceptable to the NRC staff.

15.3 Source Terms

The design basis accident source terms in the AP1000 DCD are calculated in accordance with RG 1.183, based on 102 percent of rated core thermal power of 3400 MW. The time-dependent isotopic activities released to the environment from each of the evaluated accidents are presented in Tables 15-2 to 15-10.

15.4 Radiological Consequences

For each of the accidents identified in Table 15-1, the site-specific dose for a given time interval is calculated by multiplying the AP1000 DCD dose by the ratio of the site χ/Q value, developed in Section 2.3.4.2, to the DCD χ/Q value as indicated in *AP1000 Accident Releases and Doses as Function of Time (Westinghouse 2006b)*. The time-dependent DCD χ/Q values and the time-dependent site χ/Q values and their ratios are shown in Table 15-11. As all site χ/Q values are bounded by DCD χ/Q values, site-specific doses for all accidents are also bounded by DCD doses. The total doses are summarized in Table 15-12, based on the individual accident doses presented in Tables 15-13 to 15-22. For each accident, the EAB dose shown is for the two-hour period that yields the maximum dose, in accordance with RG 1.183.

The results of the VEGP site analysis contained in the referenced tables demonstrate that all accident doses meet the site acceptance criteria of 10 CFR 50.34. The acceptance criteria in 10 CFR 50.34 apply to accidents of exceedingly low probability of occurrence and low risk of public exposure to radiation. For events with a higher probability of occurrence, more restrictive dose limits are specified in RG 1.183. Where applied, the more restrictive dose limit is either 10 or 25 percent of the 10 CFR 50.34 limit of 25 rem TEDE.

The TEDE dose limits shown in Tables 15-12 to 15-22 are from RG 1.183, Table 6, for all accidents except Reactor Coolant Pump Shaft Break (SRP Section 15.3.4) and Failure of Small Lines Carrying Primary Coolant Outside Containment (SRP Section 15.6.2). Although RG 1.183 does not address these two accidents, NUREG-0800 indicates a dose limit of 2.5 rem for these accidents. All doses are within the acceptance criteria.

Table 15-1 Selection of Accidents

SRP/DCD		Identified in		
Section	SRP Description	DCD Description	RG 1.183	Comment
15.1.5	Steam System Piping Failures Inside and Outside of Containment (PWR)	Steam System Piping Failure	Yes	
15.2.8	Feedwater System Pipe Breaks Inside and Outside Containment	Feedwater System Pipe Break	No	In the DCD, this is bounded by Section 15.1.5 accident
15.3.3	Reactor Coolant Pump Rotor Seizure	Reactor Coolant Pump Shaft Seizure (Locked Rotor)	Yes	
15.3.4	Reactor Coolant Pump Shaft Break	Reactor Coolant Pump Shaft Break	No	In the DCD, this is bounded by Section 15.3.3 accident
15.4.8	Spectrum of Rod Ejection Accidents (PWR)	Spectrum of Rod Cluster Control Assembly Ejection Accidents	Yes	
15.6.2	Radiological Consequences of the Failure of Small Lines Carrying Primary Coolant Outside Containment	Failure of Small Lines Carrying Primary Coolant Outside Containment	No	
15.6.3	Radiological Consequences of Steam Generator Tube Failure	Steam Generator Tube Rupture	Yes	
15.6.5A	Radiological Consequences of a Design Basis Loss of Coolant Accident Including Containment Leakage Contribution	Loss-of-Coolant Accident Resulting from a Spectrum of Postulated Piping Breaks Within the Reactor Coolant Pressure Boundary	Yes	Addressed in DCD Section 15.6.5
15.6.5B	Radiological Consequences of a Design Basis Loss of Coolant Accident: Leakage From Engineered Safety Feature Components Outside Containment	Loss-of-Coolant Accident Resulting from a Spectrum of Postulated Piping Breaks Within the Reactor Coolant Pressure Boundary	Yes	Addressed in DCD Section 15.6.5
15.7.4	Radiological Consequences of Fuel Handling Accidents	Fuel Handling Accident	Yes	

Table 15-2 Activity Releases for Steam System Piping Failure with Pre-Existing Iodine Spike

Isotope	Activity Release (Ci)				
	0-2 hr	2-8 hr	8-24 hr	24-72 hr	Total
Kr-85m	6.86E-02	1.14E-01	6.80E-02	6.18E-03	2.57E-01
Kr-85	2.82E-01	8.46E-01	2.25E+00	6.69E+00	1.01E+01
Kr-87	2.76E-02	1.34E-02	5.29E-04	8.60E-08	4.15E-02
Kr-88	1.12E-01	1.37E-01	4.04E-02	8.27E-04	2.91E-01
Xe-131m	1.28E-01	3.79E-01	9.81E-01	2.70E+00	4.19E+00
Xe-133m	1.59E-01	4.51E-01	1.04E+00	2.05E+00	3.70E+00
Xe-133	1.18E+01	3.45E+01	8.64E+01	2.16E+02	3.49E+02
Xe-135m	3.04E-03	1.33E-05	0.00E+00	0.00E+00	3.06E-03
Xe-135	3.10E-01	6.90E-01	8.35E-01	3.38E-01	2.17E+00
Xe-138	3.99E-03	1.14E-05	0.00E+00	0.00E+00	4.00E-03
I-130	3.59E-01	1.42E-01	2.09E-01	1.33E-01	8.44E-01
I-131	2.40E+01	1.21E+01	3.10E+01	8.22E+01	1.49E+02
I-132	3.05E+01	4.14E+00	8.06E-01	6.55E-03	3.55E+01
I-133	4.34E+01	1.90E+01	3.53E+01	3.98E+01	1.37E+02
I-134	6.74E+00	1.63E-01	1.43E-03	4.54E-09	6.91E+00
I-135	2.60E+01	8.16E+00	7.54E+00	1.71E+00	4.34E+01
Cs-134	1.90E+01	1.95E-01	5.19E-01	1.54E+00	2.12E+01
Cs-136	2.82E+01	2.86E-01	7.43E-01	2.06E+00	3.13E+01
Cs-137	1.37E+01	1.41E-01	3.74E-01	1.11E+00	1.53E+01
Cs-138	1.01E+01	1.02E-03	4.42E-07	0.00E+00	1.01E+01
Total	2.15E+02	8.15E+01	1.68E+02	3.56E+02	8.21E+02

Table 15-3 Activity Releases for Steam System Piping Failure with Accident-Initiated Iodine Spike

Isotope	Activity Release (Ci)				
	0-2 hr	2-8 hr	8-24 hr	24-72 hr	Total
Kr-85m	6.86E-02	1.14E-01	6.80E-02	6.18E-03	2.57E-01
Kr-85	2.82E-01	8.46E-01	2.25E+00	6.69E+00	1.01E+01
Kr-87	2.76E-02	1.34E-02	5.29E-04	8.60E-08	4.15E-02
Kr-88	1.12E-01	1.37E-01	4.04E-02	8.27E-04	2.91E-01
Xe-131m	1.28E-01	3.79E-01	9.81E-01	2.70E+00	4.19E+00
Xe-133m	1.59E-01	4.51E-01	1.04E+00	2.05E+00	3.70E+00
Xe-133	1.18E+01	3.45E+01	8.64E+01	2.16E+02	3.49E+02
Xe-135m	3.04E-03	1.33E-05	0.00E+00	0.00E+00	3.06E-03
Xe-135	3.10E-01	6.90E-01	8.35E-01	3.38E-01	2.17E+00
Xe-138	3.99E-03	1.14E-05	0.00E+00	0.00E+00	4.00E-03
I-130	4.20E-01	9.95E-01	1.58E+00	1.01E+00	4.01E+00
I-131	2.60E+01	5.73E+01	1.56E+02	4.13E+02	6.53E+02
I-132	4.62E+01	9.74E+01	2.24E+01	1.82E-01	1.66E+02
I-133	4.91E+01	1.14E+02	2.27E+02	2.55E+02	6.45E+02
I-134	1.34E+01	1.86E+01	2.65E-01	8.42E-07	3.23E+01
I-135	3.24E+01	7.74E+01	7.83E+01	1.77E+01	2.06E+02
Cs-134	1.90E+01	1.95E-01	5.19E-01	1.54E+00	2.12E+01
Cs-136	2.82E+01	2.86E-01	7.43E-01	2.06E+00	3.13E+01
Cs-137	1.37E+01	1.41E-01	3.74E-01	1.11E+00	1.53E+01
Cs-138	1.01E+01	1.02E-03	4.42E-07	0.00E+00	1.01E+01
Total	2.51E+02	4.03E+02	5.78E+02	9.20E+02	2.15E+03

Table 15-4 Activity Releases for Reactor Coolant Pump Shaft Seizure

Isotope	Activity Release (Ci)				
	No Feedwater	Feedwater Available			
	0-1.5 hr	0-2 hr	2-8 hr	6-8 hr	Total
Kr-85m	8.16E+01	1.05E+02	1.74E+02	4.13E+01	2.79E+02
Kr-85	7.58E+00	1.01E+01	3.03E+01	1.01E+01	4.04E+01
Kr-87	1.20E+02	1.43E+02	6.97E+01	5.43E+00	2.13E+02
Kr-88	2.08E+02	2.62E+02	3.20E+02	6.05E+01	5.82E+02
Xe-131m	3.77E+00	5.03E+00	1.49E+01	4.95E+00	1.99E+01
Xe-133m	2.02E+01	2.69E+01	7.64E+01	2.48E+01	1.03E+02
Xe-133	6.66E+02	8.87E+02	2.60E+03	8.57E+02	3.49E+03
Xe-135m	3.24E+01	3.28E+01	1.43E-01	2.68E-06	3.30E+01
Xe-135	1.59E+02	2.08E+02	4.64E+02	1.32E+02	6.72E+02
Xe-138	1.29E+02	1.30E+02	3.72E-01	3.01E-06	1.30E+02
I-130	8.45E-01	1.17E-01	1.33E+00	5.65E-01	1.45E+00
I-131	3.77E+01	5.39E+00	7.51E+01	3.46E+01	8.05E+01
I-132	2.79E+01	3.45E+00	1.48E+01	3.95E+00	1.83E+01
I-133	4.86E+01	6.86E+00	8.29E+01	3.64E+01	8.98E+01
I-134	2.88E+01	2.76E+00	2.98E+00	2.09E-01	5.74E+00
I-135	4.19E+01	5.68E+00	5.22E+01	2.05E+01	5.79E+01
Cs-134	1.29E+00	1.82E-01	2.40E+00	1.11E+00	2.59E+00
Cs-136	5.63E-01	8.45E-02	7.79E-01	3.47E-01	8.63E-01
Cs-137	7.74E-01	1.10E-01	1.41E+00	6.51E-01	1.52E+00
Cs-138	6.08E+00	7.29E-01	3.35E+00	1.13E+00	4.08E+00
Rb-86	1.33E-02	1.83E-03	2.73E-02	1.27E-02	2.91E-02
Total	1.62E+03	1.84E+03	3.99E+03	1.23E+03	5.82E+03

Note: The release period of 6-8 hr yields the maximum 2-hr EAB dose with feedwater available.

Table 15-5 Activity Releases for Spectrum of Rod Cluster Control Assembly Ejection Accidents

Isotope	Activity Release (Ci)					
	0-2 hr	2-8 hr	8-24 hr	24-96 hr	96-720 hr	Total
Kr-85m	1.12E+02	6.48E+01	3.87E+01	1.77E+00	2.51E-05	2.18E+02
Kr-85	5.01E+00	5.60E+00	1.49E+01	3.35E+01	2.88E+02	3.47E+02
Kr-87	1.82E+02	2.60E+01	1.03E+00	8.37E-05	0.00E+00	2.09E+02
Kr-88	2.91E+02	1.18E+02	3.49E+01	3.59E-01	8.41E-09	4.45E+02
Xe-131m	4.94E+00	5.46E+00	1.42E+01	2.86E+01	1.16E+02	1.69E+02
Xe-133m	2.67E+01	2.81E+01	6.49E+01	8.45E+01	5.31E+01	2.57E+02
Xe-133	8.79E+02	9.58E+02	2.40E+03	4.27E+03	8.45E+03	1.70E+04
Xe-135m	7.34E+01	5.30E-02	4.33E-09	0.00E+00	0.00E+00	7.35E+01
Xe-135	2.15E+02	1.72E+02	2.09E+02	4.35E+01	1.79E-01	6.39E+02
Xe-138	2.99E+02	1.38E-01	3.19E-09	0.00E+00	0.00E+00	2.99E+02
I-130	4.90E+00	7.28E+00	4.32E+00	2.03E-01	2.95E-04	1.67E+01
I-131	1.36E+02	2.45E+02	2.31E+02	3.10E+01	1.68E+01	6.60E+02
I-132	1.53E+02	9.94E+01	9.85E+00	8.24E-03	0.00E+00	2.62E+02
I-133	2.72E+02	4.40E+02	3.18E+02	2.28E+01	2.41E-01	1.05E+03
I-134	1.66E+02	2.85E+01	1.37E-01	4.48E-08	0.00E+00	1.95E+02
I-135	2.39E+02	2.97E+02	1.19E+02	2.39E+00	7.32E-05	6.57E+02
Cs-134	3.08E+01	6.22E+01	6.03E+01	7.76E+00	5.16E+00	1.66E+02
Cs-136	8.79E+00	1.75E+01	1.67E+01	2.05E+00	6.58E-01	4.57E+01
Cs-137	1.79E+01	3.62E+01	3.51E+01	4.52E+00	3.05E+00	9.68E+01
Cs-138	1.09E+02	7.05E+00	1.68E-03	0.00E+00	0.00E+00	1.16E+02
Rb-86	3.62E-01	7.27E-01	6.96E-01	8.67E-02	3.42E-02	1.91E+00
Total	3.23E+03	2.62E+03	3.58E+03	4.53E+03	8.93E+03	2.29E+04

Table 15-6 Activity Releases for Failure of Small Lines Carrying Primary Coolant Outside Containment

Isotope	Activity Release (Ci)
	0-2 hr
Kr-85m	1.24E+01
Kr-85	4.40E+01
Kr-87	7.05E+00
Kr-88	2.21E+01
Xe-131m	1.99E+01
Xe-133m	2.50E+01
Xe-133	1.84E+03
Xe-135m	2.59E+00
Xe-135	5.20E+01
Xe-138	3.65E+00
I-130	1.89E+00
I-131	9.26E+01
I-132	3.49E+02
I-133	2.01E+02
I-134	1.58E+02
I-135	1.68E+02
Cs-134	4.16E+00
Cs-136	6.16E+00
Cs-137	3.00E+00
Cs-138	2.21E+00
Total	3.02E+03

Table 15-7 Activity Releases for Steam Generator Tube Rupture with Pre-Existing Iodine Spike

Isotope	Activity Release (Ci)			
	0-2 hr	2-8 hr	8-24 hr	Total
Kr-85m	5.53E+01	1.93E+01	7.53E-03	7.46E+01
Kr-85	2.20E+02	1.09E+02	1.34E-01	3.29E+02
Kr-87	2.39E+01	3.61E+00	9.12E-05	2.75E+01
Kr-88	9.22E+01	2.65E+01	5.43E-03	1.19E+02
Xe-131m	9.96E+01	4.88E+01	5.91E-02	1.48E+02
Xe-133m	1.24E+02	5.91E+01	6.61E-02	1.83E+02
Xe-133	9.19E+03	4.47E+03	5.29E+00	1.37E+04
Xe-135m	3.44E+00	5.86E-03	0.00E+00	3.45E+00
Xe-135	2.46E+02	1.02E+02	7.10E-02	3.47E+02
Xe-138	4.56E+00	5.07E-03	0.00E+00	4.57E+00
I-130	1.79E+00	5.39E-02	2.68E-01	2.12E+00
I-131	1.21E+02	5.27E+00	3.06E+01	1.56E+02
I-132	1.42E+02	7.43E-01	1.92E+00	1.44E+02
I-133	2.16E+02	7.63E+00	4.06E+01	2.64E+02
I-134	2.74E+01	4.40E-03	4.23E-03	2.74E+01
I-135	1.27E+02	2.70E+00	1.17E+01	1.42E+02
Cs-134	1.63E+00	6.05E-02	2.16E-01	1.90E+00
Cs-136	2.42E+00	8.86E-02	3.14E-01	2.82E+00
Cs-137	1.17E+00	4.37E-02	1.56E-01	1.37E+00
Cs-138	5.64E-01	2.91E-06	5.73E-07	5.64E-01
Total	1.07E+04	4.85E+03	9.14E+01	1.56E+04

Table 15-8 Activity Releases for Steam Generator Tube Rupture with Accident-Initiated Iodine Spike

Isotope	Activity Release (Ci)			
	0-2 hr	2-8 hr	8-24 hr	Total
Kr-85m	5.53E+01	1.93E+01	7.53E-03	7.46E+01
Kr-85	2.20E+02	1.09E+02	1.34E-01	3.29E+02
Kr-87	2.39E+01	3.61E+00	9.12E-05	2.75E+01
Kr-88	9.22E+01	2.65E+01	5.43E-03	1.19E+02
Xe-131m	9.96E+01	4.88E+01	5.91E-02	1.48E+02
Xe-133m	1.24E+02	5.91E+01	6.61E-02	1.83E+02
Xe-133	9.19E+03	4.47E+03	5.29E+00	1.37E+04
Xe-135m	3.44E+00	5.86E-03	0.00E+00	3.45E+00
Xe-135	2.46E+02	1.02E+02	7.10E-02	3.47E+02
Xe-138	4.56E+00	5.07E-03	0.00E+00	4.57E+00
I-130	8.87E-01	1.62E-01	8.24E-01	1.87E+00
I-131	4.36E+01	1.14E+01	6.76E+01	1.23E+02
I-132	1.47E+02	4.86E+00	1.29E+01	1.65E+02
I-133	9.33E+01	2.00E+01	1.08E+02	2.22E+02
I-134	5.59E+01	6.04E-02	5.94E-02	5.60E+01
I-135	7.61E+01	9.88E+00	4.38E+01	1.30E+02
Cs-134	1.63E+00	6.05E-02	2.16E-01	1.90E+00
Cs-136	2.42E+00	8.86E-02	3.14E-01	2.82E+00
Cs-137	1.17E+00	4.37E-02	1.56E-01	1.37E+00
Cs-138	5.64E-01	2.91E-06	5.73E-07	5.64E-01
Total	1.05E+04	4.88E+03	2.40E+02	1.56E+04

Table 15-9 Activity Releases for Loss-of-Coolant Accident Resulting from a Spectrum of Postulated Piping Breaks Within the Reactor Coolant Pressure Boundary

Isotope	Activity Release (Ci)					
	1.4-3.4 hr	0-8 hr	8-24 hr	24-96 hr	96-720 hr	Total
I-130	5.64E+01	1.12E+02	5.37E+00	7.10E-01	1.27E-02	1.18E+02
I-131	1.68E+03	3.49E+03	2.66E+02	2.39E+02	7.19E+02	4.71E+03
I-132	1.23E+03	2.14E+03	1.64E+01	1.46E-02	0.00E+00	2.15E+03
I-133	3.23E+03	6.54E+03	3.83E+02	1.04E+02	1.04E+01	7.04E+03
I-134	6.60E+02	1.14E+03	2.96E-01	6.79E-08	0.00E+00	1.14E+03
I-135	2.56E+03	4.89E+03	1.58E+02	6.09E+00	3.16E-03	5.06E+03
Kr-85m	1.42E+03	3.77E+03	1.87E+03	8.56E+01	1.22E-03	5.73E+03
Kr-85	8.31E+01	2.97E+02	7.06E+02	1.59E+03	1.36E+04	1.62E+04
Kr-87	1.10E+03	1.95E+03	4.97E+01	4.05E-03	0.00E+00	1.99E+03
Kr-88	3.11E+03	7.26E+03	1.70E+03	1.75E+01	4.09E-07	8.97E+03
Xe-131m	8.26E+01	2.94E+02	6.79E+02	1.37E+03	5.57E+03	7.91E+03
Xe-133m	4.43E+02	1.54E+03	3.15E+03	4.11E+03	2.58E+03	1.14E+04
Xe-133	1.47E+04	5.19E+04	1.16E+05	2.06E+05	4.07E+05	7.80E+05
Xe-135m	1.06E+01	3.59E+01	2.14E-07	0.00E+00	0.00E+00	3.59E+01
Xe-135	3.15E+03	9.64E+03	1.01E+04	2.11E+03	8.68E+00	2.19E+04
Xe-138	3.11E+01	1.20E+02	1.58E-07	0.00E+00	0.00E+00	1.20E+02
Rb-86	3.04E+00	6.32E+00	2.99E-01	9.83E-02	5.13E-01	7.23E+00
Cs-134	2.58E+02	5.38E+02	2.57E+01	9.11E+00	7.74E+01	6.50E+02
Cs-136	7.33E+01	1.52E+02	7.16E+00	2.28E+00	9.88E+00	1.72E+02
Cs-137	1.51E+02	3.13E+02	1.50E+01	5.32E+00	4.57E+01	3.79E+02
Cs-138	1.50E+02	3.30E+02	2.18E-03	0.00E+00	0.00E+00	3.30E+02
Sb-127	2.42E+01	4.80E+01	2.29E+00	5.67E-01	7.82E-01	5.16E+01
Sb-129	5.10E+01	8.94E+01	1.51E+00	4.95E-03	4.90E-08	9.09E+01
Te-127m	3.15E+00	6.30E+00	3.16E-01	1.11E-01	8.71E-01	7.60E+00
Te-127	2.05E+01	3.83E+01	1.15E+00	2.75E-02	1.33E-04	3.94E+01
Te-129m	1.07E+01	2.15E+01	1.07E+00	3.65E-01	2.36E+00	2.52E+01
Te-129	1.88E+01	2.83E+01	2.69E-02	3.54E-08	0.00E+00	2.84E+01
Te-131m	3.17E+01	6.20E+01	2.64E+00	3.35E-01	7.81E-02	6.50E+01
Te-132	3.23E+02	6.40E+02	3.02E+01	7.04E+00	7.83E+00	6.85E+02
Sr-89	9.23E+01	1.85E+02	9.24E+00	3.19E+00	2.26E+01	2.20E+02
Sr-90	7.95E+00	1.59E+01	7.99E-01	2.84E-01	2.44E+00	1.94E+01

Table 15-9 (cont.) Activity Releases for Loss-of-Coolant Accident Resulting from a Spectrum of Postulated Piping Breaks Within the Reactor Coolant Pressure Boundary

Isotope	Activity Release (Ci)					
	1.4-3.4 hr	0-8 hr	8-24 hr	24-96 hr	96-720 hr	Total
Sr-91	9.68E+01	1.81E+02	5.46E+00	1.35E-01	7.06E-04	1.87E+02
Sr-92	6.83E+01	1.13E+02	1.01E+00	5.15E-04	0.00E+00	1.14E+02
Ba-139	5.44E+01	8.30E+01	1.49E-01	9.91E-07	0.00E+00	8.32E+01
Ba-140	1.63E+02	3.25E+02	1.61E+01	5.11E+00	2.17E+01	3.68E+02
Mo-99	2.15E+01	4.25E+01	1.98E+00	4.29E-01	3.78E-01	4.53E+01
Tc-99m	1.47E+01	2.66E+01	6.05E-01	5.27E-03	1.33E-06	2.72E+01
Ru-103	1.73E+01	3.46E+01	1.73E+00	5.93E-01	3.99E+00	4.09E+01
Ru-105	8.18E+00	1.44E+01	2.48E-01	8.86E-04	1.17E-08	1.46E+01
Ru-106	5.70E+00	1.14E+01	5.73E-01	2.03E-01	1.70E+00	1.39E+01
Rh-105	1.03E+01	2.02E+01	8.81E-01	1.29E-01	4.14E-02	2.12E+01
Ce-141	3.89E+00	7.78E+00	3.88E-01	1.32E-01	8.45E-01	9.15E+00
Ce-143	3.46E+00	6.78E+00	2.93E-01	4.05E-02	1.14E-02	7.13E+00
Ce-144	2.94E+00	5.89E+00	2.96E-01	1.05E-01	8.68E-01	7.15E+00
Pu-238	9.16E-03	1.83E-02	9.21E-04	3.27E-04	2.82E-03	2.24E-02
Pu-239	8.06E-04	1.61E-03	8.10E-05	2.88E-05	2.48E-04	1.97E-03
Pu-240	1.18E-03	2.37E-03	1.19E-04	4.22E-05	3.63E-04	2.89E-03
Pu-241	2.66E-01	5.31E-01	2.67E-02	9.48E-03	8.14E-02	6.49E-01
Np-239	4.48E+01	8.87E+01	4.08E+00	8.15E-01	5.70E-01	9.41E+01
Y-90	8.08E-02	1.60E-01	7.44E-03	1.59E-03	1.35E-03	1.70E-01
Y-91	1.19E+00	2.37E+00	1.19E-01	4.12E-02	3.00E-01	2.83E+00
Y-92	7.89E-01	1.35E+00	1.80E-02	2.86E-05	0.00E+00	1.37E+00
Y-93	1.21E+00	2.28E+00	7.08E-02	1.98E-03	1.42E-05	2.35E+00
Nb-95	1.60E+00	3.19E+00	1.59E-01	5.44E-02	3.55E-01	3.76E+00
Zr-95	1.59E+00	3.18E+00	1.59E-01	5.52E-02	4.08E-01	3.80E+00
Zr-97	1.43E+00	2.74E+00	1.03E-01	6.73E-03	3.71E-04	2.85E+00
La-140	1.67E+00	3.29E+00	1.46E-01	2.36E-02	9.62E-03	3.47E+00
La-141	1.03E+00	1.79E+00	2.71E-02	6.41E-05	2.01E-10	1.81E+00
La-142	5.38E-01	8.31E-01	2.09E-03	3.39E-08	0.00E+00	8.33E-01
Nd-147	6.16E-01	1.23E+00	6.06E-02	1.90E-02	7.29E-02	1.38E+00
Pr-143	1.39E+00	2.78E+00	1.37E-01	4.40E-02	1.94E-01	3.15E+00
Am-241	1.20E-04	2.39E-04	1.20E-05	4.27E-06	3.68E-05	2.92E-04
Cm-242	2.82E-02	5.65E-02	2.83E-03	9.98E-04	8.08E-03	6.84E-02

Table 15-9 (cont.) Activity Releases for Loss-of-Coolant Accident Resulting from a Spectrum of Postulated Piping Breaks Within the Reactor Coolant Pressure Boundary

Isotope	Activity Release (Ci)					Total
	1.4-3.4 hr	0-8 hr	8-24 hr	24-96 hr	96-720 hr	
Cm-244	3.46E-03	6.93E-03	3.48E-04	1.24E-04	1.06E-03	8.47E-03
Total	3.53E+04	9.85E+04	1.35E+05	2.15E+05	4.30E+05	8.79E+05

Table 15-10 Activity Releases for Fuel Handling Accident

Isotope	Activity Release (Ci)
	0-2 hr
Kr-85m	3.42E+02
Kr-85	1.11E+03
Kr-87	6.00E-02
Kr-88	1.07E+02
Xe-131m	5.54E+02
Xe-133m	2.80E+03
Xe-133	9.66E+04
Xe-135m	1.26E+03
Xe-135	2.49E+04
I-130	2.51E+00
I-131	3.76E+02
I-132	3.01E+02
I-133	2.40E+02
I-135	3.94E+01
Total	1.29E+05

Table 15-11 Atmospheric Dispersion Factors

Accident	Location	Time (hr)	DCD χ/Q (sec/m ³)	Site χ/Q (sec/m ³)	χ/Q Ratio (Site/DCD)
LOCA	EAB	0 – 2	5.10E-04	3.49E-04	0.684
	LPZ	0 – 8	2.20E-04	7.04E-05	0.320
		8 – 24	1.60E-04	5.25E-05	0.328
		24 – 96	1.00E-04	2.77E-05	0.277
		96 – 720	8.00E-05	1.11E-05	0.139
Other Accidents	EAB	0 – 2	8.00E-04	3.49E-04	0.436
	LPZ	0 – 8	5.00E-04	7.04E-05	0.141
		8 – 24	3.00E-04	5.25E-05	0.175
		24 – 96	1.50E-04	2.77E-05	0.185
		96 – 720	8.00E-05	1.11E-05	0.139

Note: The DCD χ/Q values for LOCA are consistent with AP1000 DCD Table 15A-5. Although not indicated as such in the DCD, a different set of χ/Q values was used by Westinghouse to calculate doses for accidents other than LOCA (**Westinghouse 2006b**). It is seen that the site χ/Q values are bounded by the DCD χ/Q values for all time steps.

Table 15-12 Summary of Design Basis Accident Doses

DCD/SRP Section	Accident	Site Dose (rem TEDE)			Dose Table
		EAB	LPZ	Limit	
15.1.5	Steam System Piping Failure				
	Pre-Existing Iodine Spike	0.35	0.11	25	15-13
	Accident-Initiated Iodine Spike	0.39	0.31	2.5	15-14
15.2.8	Feedwater System Pipe Break	a	a		
15.3.3	Reactor Coolant Pump Shaft Seizure				
	No Feedwater	0.31	0.05	2.5	15-15
	Feedwater Available	0.22	0.11	2.5	15-16
15.3.4	Reactor Coolant Pump Shaft Break	b	b		
15.4.8	Spectrum of Rod Cluster Control Assembly Ejection Accidents	1.3	0.80	6.3	15-17
15.6.2	Failure of Small Lines Carrying Primary Coolant Outside Containment	0.74	0.14	2.5	15-18
15.6.3	Steam Generator Tube Rupture				
	Pre-Existing Iodine Spike	0.79	0.18	25	15-19
	Accident-Initiated Iodine Spike	0.39	0.12	2.5	15-20
15.6.5	Loss-of-Coolant Accident Resulting from a Spectrum of Postulated Piping Breaks Within the Reactor Coolant Pressure Boundary	17	7.4	25	15-21
15.7.4	Fuel Handling Accident	2.4	0.48	6.3	15-22

- a. Feedwater System Pipe Break is bounded by Steam System Piping Failure, as indicated in the AP1000 DCD.
- b. Reactor Coolant Pump Shaft Break is bounded by Reactor Coolant Pump Shaft Seizure, as indicated in the AP1000 DCD.

Table 15-13 Doses for Steam System Piping Failure with Pre-Existing Iodine Spike

Time	DCD Dose (rem TEDE)		χ/Q Ratio (Site/DCD)	Site Dose (rem TEDE)	
	EAB	LPZ		EAB	LPZ
0-2 hr	8.0E-01		4.36E-01	3.49E-01	
0-8 hr		5.81E-01	1.41E-01		8.18E-02
8-24 hr		7.18E-02	1.75E-01		1.26E-02
24-96 hr		1.08E-01	1.85E-01		1.99E-02
96-720 hr		0.00E+00	1.39E-01		0.00E+00
Total	8.0E-01	7.61E-01		3.49E-01	1.14E-01
Limit				25	25

Table 15-14 Doses for Steam System Piping Failure with Accident-Initiated Iodine Spike

Time	DCD Dose (rem TEDE)		χ/Q Ratio (Site/DCD)	Site Dose (rem TEDE)	
	EAB	LPZ		EAB	LPZ
0-2 hr	9.00E-01		4.36E-01	3.93E-01	
0-8 hr		1.02E+00	1.41E-01		1.44E-01
8-24 hr		3.77E-01	1.75E-01		6.60E-02
24-96 hr		5.36E-01	1.85E-01		9.90E-02
96-720 hr		0.00E+00	1.39E-01		0.00E+00
Total	9.00E-01	1.94E+00		3.93E-01	3.09E-01
Limit				2.5	2.5

Table 15-15 Doses for Reactor Coolant Pump Shaft Seizure with No Feedwater

Time	DCD Dose (rem TEDE)		χ/Q Ratio (Site/DCD)	Site Dose (rem TEDE)	
	EAB	LPZ		EAB	LPZ
0-2 hr	7.00E-01		4.36E-01	3.05E-01	
0-8 hr		3.89E-01	1.41E-01		5.48E-02
8-24 hr		0.00E+00	1.75E-01		0.00E+00
24-96 hr		0.00E+00	1.85E-01		0.00E+00
96-720 hr		0.00E+00	1.39E-01		0.00E+00
Total	7.00E-01	3.89E-01		3.05E-01	5.48E-02
Limit				2.5	2.5

Table 15-16 Doses for Reactor Coolant Pump Shaft Seizure with Feedwater Available

Time	DCD Dose (rem TEDE)		χ/Q Ratio (Site/DCD)	Site Dose (rem TEDE)	
	EAB	LPZ		EAB	LPZ
6-8 hr	5.00E-01		4.36E-01	2.18E-01	
0-8 hr		7.94E-01	1.41E-01		1.12E-01
8-24 hr		0.00E+00	1.75E-01		0.00E+00
24-96 hr		0.00E+00	1.85E-01		0.00E+00
96-720 hr		0.00E+00	1.39E-01		0.00E+00
Total	5.00E-01	7.94E-01		2.18E-01	1.12E-01
Limit				2.5	2.5

Table 15-17 Doses for Spectrum of Rod Cluster Control Assembly Ejection Accidents

Time	DCD Dose (rem TEDE)		χ/Q Ratio (Site/DCD)	Site Dose (rem TEDE)	
	EAB	LPZ		EAB	LPZ
0-2 hr	2.90E+00		4.36E-01	1.27E+00	
0-8 hr		4.58E+00	1.41E-01		6.45E-01
8-24 hr		7.84E-01	1.75E-01		1.37E-01
24-96 hr		6.32E-02	1.85E-01		1.17E-02
96-720 hr		2.06E-02	1.39E-01		2.86E-03
Total	2.90E+00	5.45E+00		1.27E+00	7.97E-01
Limit				6.3	6.3

Table 15-18 Doses for Failure of Small Lines Carrying Primary Coolant Outside Containment

Time	DCD Dose (rem TEDE)		χ/Q Ratio (Site/DCD)	Site Dose (rem TEDE)	
	EAB	LPZ		EAB	LPZ
0-2 hr	1.70E+00		4.36E-01	7.42E-01	
0-8 hr		1.02E+00	1.41E-01		1.44E-01
8-24 hr		0.00E+00	1.75E-01		0.00E+00
24-96 hr		0.00E+00	1.85E-01		0.00E+00
96-720 hr		0.00E+00	1.39E-01		0.00E+00
Total	1.70E+00	1.02E+00		7.42E-01	1.44E-01
Limit				2.5	2.5

Table 15-19 Doses for Steam Generator Tube Rupture with Pre-Existing Iodine Spike

Time	DCD Dose (rem TEDE)		χ/Q Ratio (Site/DCD)	Site Dose (rem TEDE)	
	EAB	LPZ		EAB	LPZ
0-2 hr	1.80E+00		4.36E-01	7.85E-01	
0-8 hr		1.16E+00	1.41E-01		1.64E-01
8-24 hr		7.24E-02	1.75E-01		1.27E-02
24-96 hr		0.00E+00	1.85E-01		0.00E+00
96-720 hr		0.00E+00	1.39E-01		0.00E+00
Total	1.80E+00	1.23E+00		7.85E-01	1.76E-01
Limit				25	25

Table 15-20 Doses for Steam Generator Tube Rupture with Accident-Initiated Iodine Spike

Time	DCD Dose (rem TEDE)		χ/Q Ratio (Site/DCD)	Site Dose (rem TEDE)	
	EAB	LPZ		EAB	LPZ
0-2 hr	9.00E-01		4.36E-01	3.93E-01	
0-8 hr		6.27E-01	1.41E-01		8.83E-02
8-24 hr		1.69E-01	1.75E-01		2.96E-02
24-96 hr		0.00E+00	1.85E-01		0.00E+00
96-720 hr		0.00E+00	1.39E-01		0.00E+00
Total	9.00E-01	7.96E-01		3.93E-01	1.18E-01
Limit				2.5	2.5

Table 15-21 Doses for Loss-of-Coolant Accident Resulting from a Spectrum of Postulated Piping Breaks Within the Reactor Coolant Pressure Boundary

Time	DCD Dose (rem TEDE)		χ/Q Ratio (Site/DCD)	Site Dose (rem TEDE)	
	EAB	LPZ		EAB	LPZ
1.4-3.4 hr	2.43E+01		6.84E-01	1.66E+01	
0-8 hr		2.17E+01	3.20E-01		6.94E+00
8-24 hr		7.69E-01	3.28E-01		2.52E-01
24-96 hr		3.71E-01	2.77E-01		1.03E-01
96-720 hr		8.70E-01	1.39E-01		1.21E-01
Total	2.43E+01	2.37E+01		1.66E+01	7.42E+00
Limit				25	25

Table 15-22 Doses for Fuel Handling Accident

Time	DCD Dose (rem TEDE)		χ/Q Ratio (Site/DCD)	Site Dose (rem TEDE)	
	EAB	LPZ		EAB	LPZ
0-2 hr	5.60E+00		4.36E-01	2.44E+00	
0-8 hr		3.44E+00	1.41E-01		4.84E-01
8-24 hr		0.00E+00	1.75E-01		0.00E+00
24-96 hr		0.00E+00	1.85E-01		0.00E+00
96-720 hr		0.00E+00	1.39E-01		0.00E+00
Total	5.60E+00	3.44E+00		2.44E+00	4.84E-01
Limit				6.3	6.3

Chapter 15 References

(EPA 1988) Federal Guidance Report 11, *Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion*, US Environmental Protection Agency, EPA-520/1-88-020, 1988.

(EPA 1993) Federal Guidance Report 12, *External Exposure to Radionuclides in Air, Water, and Soil*, US Environmental Protection Agency, EPA-402-R-93-081, 1993.

(Westinghouse 2005) AP1000 Document APP-GW-GL-700, *AP1000 Design Control Document*, Revision 15, Westinghouse Electric Company, 2005.

(Westinghouse 2006b) Westinghouse Document No. LTR-CRA-06-21, *AP1000 Accident Releases and Doses as Function of Time*, Westinghouse Electric Company, February 1, 2006.

Page intentionally left blank.