19.55 Seismic Margin Analysis

19.55.1 Introduction

In accordance with Section II.N, Site-Specific Probabilistic Risk Assessments and Analysis of External Events, of SECY-93-087 (Reference 19.55-1), the U.S. Nuclear Regulatory Commission (NRC) approved the following staff recommendations:

> "PRA insights will be used to support a margins-type assessment of seismic events. A PRA-based seismic margin analysis will consider sequence-level High Confidence, Low Probability of Failures (HCLPFs) and fragilities for all sequences leading to core damage or containment failures up to approximately one and two-thirds the ground motion acceleration of the Design Basis SSE."

The AP1000 risk-based seismic margin analysis (SMA) satisfies this recommendation of SECY-93-087.

Since the AP1000 nonsafety-related components are not Seismic Category I, it is conservatively assumed for the risk-based seismic margin analysis that no credit is taken for the mitigation functions of the nonsafety-related components and systems. For this risk-based seismic margin analysis, HCLPFs are calculated and reported for systems at the sequence level.

The seismic margin analysis is made based on established criteria, design specifications, existing qualification test reports, established basic design characteristics and configurations, and public domain generic data.

Seismic margins methodology is employed to identify potential vulnerabilities and demonstrate seismic margin beyond the design-level safe shutdown earthquake (SSE). The capacity of those components required to bring the plant to a safe, stable condition is assessed. The structures, systems, and components identified as important to seismic risk are addressed.

19.55.2 Calculation of HCLPF Values

19.55.2.1 Seismic Margin HCLPF Methodology

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19.55.2.2 Calculation of HCLPF Values

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19.55.2.2.1 Review of Plant Information

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19.55.2.2.2 System Analysis

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19.55.2.2.3 Analysis of Structure Response

Relay Chatter

Solid-state switching devices and electromechanical relays will be used in the AP1000 protection and control systems. Solid-state switching devices are inherently immune to mechanical switching discontinuities such as contact chatter. Robust electromechanical relays are selected for AP1000 applications such that inherent mechanical contact chatter is within the required system performance criteria.

19.55.2.2.4 Evaluation of Seismic Capacities of Components and Plant

Table 19.55-1 provides the HCLPF values for the equipment, structures, and systems considered in the seismic margin evaluation. The evaluation considers the effect of uplift of the nuclear island basemat from the hard rock foundation. All of the HCLPF values are above the review level earthquake.

In the design of the AP1000, careful consideration is given to those areas that are recognized as important to plant seismic risk. In addition to paying special attention to those critical components that have HCLPF values close to the review level earthquake, the design process considers potential interaction with both safety-related and nonsafety-related systems or structures, as well as adequate anchorage load transfer and structural ductility.

19.55.2.2.5 Verification of Equipment Fragility Data

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19.55.2.2.6 Turbine Building Seismic Interaction

As part of the seismic margin assessment, the seismic interaction between the Turbine Building and the Nuclear Island was evaluated. The Turbine Building is designed to the Uniform Building Code requirements. It is taller than the Auxiliary Building, which is a Seismic Category I structure. The Auxiliary Building contains important safety-related equipment. The Turbine Building is adjacent to the north-end wing of the Auxiliary Building, the wing containing the main control room and the shutdown panel, as well as I&C rooms and I&C penetration rooms. The main structure of the Turbine Building is separated from the Nuclear Island by an access bay. The consequences of the potential Turbine Building collapse onto and falling debris penetrating the Auxiliary Building was evaluated and it was determined that:

- The adjacent Auxiliary Building structural integrity will not be lost with the failure of the Turbine Building.

- It is not likely that the size and energy of debris from the Turbine Building will be large enough to result in penetration through the Auxiliary Building roof structure.

19.55.3 Seismic Margin Model

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19.55.4 Calculation of Plant HCLPF

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19.55.5 Sensitivity Analyses

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19.55.6 Results and Insights

The AP1000 seismic margin analysis has demonstrated that for structures, systems, and components required for safe shutdown, the high confidence of low probability of failures magnitudes are equal to or greater than the review level earthquake.

19.55.7 References

19.55-1 "SECY-93-087 - Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light-Water Reactor (ALWR) Designs," USNRC Memorandum, July 21, 1993, Chilk to Taylor.

Table 19.55-1 (Sheet 1 of 4)

SEISMIC MARGIN HCLPF VALUES

Description	Median pga [8]	βc	HCLPF Value [8]	Basis
Buildings/Structures				
Shield Building Roof – Tension Ring	-	-	0.74g	[5]
Shield Building Roof – Columns	-	-	0.60g	[5]
Containment Vessel – Buckling	1.57g	0.41	0.61g	[3]
Containment Vessel – Overturning	5.74g	0.62	1.38g	[3]
Containment Baffle Support Failure	-	-	1.4g	[4]
Interior Containment Structure & IRWST Tank	-	-	0.75g	[4]
Primary Components				
Reactor Pressure Vessel	-	-	0.74g	[4]
Reactor Pressure Vessel Supports	1.59g	0.36	0.69g	[3]
Reactor Internals and Core Assembly (includes fuel)	1.5g	0.51	0.5g	[1]
Control Rod Drive Mechanism (CRDM) and Hydraulic Drive Units	2.2g	0.51	0.7g	[1]
Pressurizer	-	-	0.59g	[4]
Pressurizer Support	1.04g	0.29	0.53g	[3]
Steam Generator	-	-	0.61g	[4]
Steam Generator Supports	1.03g	0.22	0.62g	[3]
Reactor Coolant Pump & Supports	2.2g	0.51	0.68g	[1]
Mechanical Equipment				
Polar Crane	-	-	0.94g	[4]
Piping – Support Controlled	3.3g	0.61	0.81g	[1]
Cable Trays – Support Controlled	2.2g	0.61	0.54g	[1]
Heat Exchanger (PRHR)	-	-	0.93g	[4]
Accumulator Tank	2.2g	0.46	0.76g	[1]
Core Makeup Tank	-	-	0.72g	[4]

Table 19.55-1 (Sheet 2 of 4)

SEISMIC MARGIN HCLPF VALUES

Description	Median pga [8]	βc	HCLPF Value [8]	Basis
Valves				
Room Number 11202	-	-	0.86g	[4]
Room Number 11206	-	-	0.86g	[4]
Room Number 11207	-	-	0.86g	[4]
Room Number 11208	-	-	0.86g	[4]
Room Number 11300	-	-	0.86g	[4]
Room Number 11301	-	-	0.86g	[4]
Room Number 11302	-	-	0.86g	[4]
Room Number 11304	-	-	0.86g	[4]
Room Number 11400	3.3g	0.61	0.81g	[1]
Room Number 11403	3.3g	0.61	0.81g	[1]
Room Number 11500	3.3g	0.61	0.81g	[1]
Room Number 11601	3.3g	0.61	0.81g	[1]
Room Number 11603	3.3g	0.61	0.81g	[1]
Room Number 11703	3.3g	0.61	0.81g	[1]
Room Number 12244	-	-	1.10g	[4]
Room Number 12254	-	-	0.86g	[4]
Room Number 12255	-	-	0.86g	[4]
Room Number 12256	-	-	0.86g	[4]
Room Number 12306	-	-	0.86g	[4]
Room Number 12362	3.3g	0.61	0.81g	[1]
Room Number 12401	3.3g	0.61	0.81g	[1]
Room Number 12404	3.3g	0.61	0.81g	[1]
Room Number 12405	3.3g	0.61	0.81g	[1]
Room Number 12406	3.3g	0.61	0.81g	[1]
Room Number 12452	3.3g	0.61	0.81g	[1]
Room Number 12454	3.3g	0.61	0.81g	[1]
Room Number 12555	3.3g	0.61	0.81g	[1]
Room Number 12701	3.3g	0.61	0.81g	[1]

Table 19.55-1 (Sheet 3 of 4)

SEISMIC MARGIN HCLPF VALUES

Description	Median pga [8]	βc	HCLPF Value [8]	Basis
Passive Containment Cooling System	-	-	0.60g	[5]
Electrical Equipment				
Battery	-	-	0.79g	[6]
Battery Racks	3.3g	0.46	1.14g	[1]
Battery Chargers	-	-	0.81g	[6]
125 DC Distribution Panel	-	-	0.58g	[6]
120 VAC Distribution Panel	-	-	0.58g	[6]
Transfer Switches	-	-	0.58g	[6]
125 VDC MCC	-	-	0.86g	[6]
125 VDC Switchboard	-	-	0.58g	[6]
Regulating Transformer	-	-	0.95g	[6]
Inverter	-	-	0.60g	[6]
4.16 KV Switchgear	-	-	0.69g	[6]
Reactor Trip Switchgear	-	-	0.60g	[6]
Hydrogen Monitor	-	-	1.03g	[6]
CMT Level Switch	-	-	0.83g	[6]
Neutron Detector	-	-	0.56g	[6]
Radiation Monitor	-	-	0.61g	[6]
RTD	-	-	3.54g	[6]
Speed Sensors	-	-	2.89g	[6]
Incore Thermocouple	-	-	3.71g	[6]
RCP Bearing Water Temperature Thermocouple	-	-	5.25g	[6]
PCS Water Flow Transmitter (el. 135.3′)	-	-	0.80g	[6]
PCS Water Flow Transmitter (el. 261′)	-	-	0.56g	[6]
PRHR HX Flow Transmitter	-	-	0.93g	[6]
RCS Flow Transmitter	-	-	0.93g	[6]
SG Start Up Flow Transmitter	-	-	0.61g	[6]
IRWST Level Transmitter	-	-	0.76g	[6]
PZR Level Transmitter	-	-	0.76g	[6]

Table 19.55-1 (Sheet 4 of 4)

SEISMIC MARGIN HCLPF VALUES

Description	Median pga [8]	βc	HCLPF Value [8]	Basis
SG Narrow Range Transmitter	-	-	0.77g	[6]
SG Wide Range Transmitter	-	-	0.77g	[6]
Air Storage Tank Pressurizer Transmitter	-	-	0.65g	[6]
Containment Pressurizer Sensor & Transmitter	-	-	0.82g	[6]
RCS Wide Range Pressure Transmitter	-	-	0.76g	[6]
PRZ Pressure Sensor	-	-	0.76g	[6]
MSL Pressure Transmitter	-	-	0.65g	[6]
ESFAC Cabinet	-	-	0.82g	[6]
Protection Logic Cabinet	-	-	0.82g	[6]
Integrated Protection Cabinet SWGR	-	-	0.82g	[6]
Multiplex Cabinet	-	-	0.82g	[6]
QDPS Cabinet	-	-	1.32g	[6]
MCR Support Operation Station	2.8g	0.46	0.97g	[1]
MCR Switch Station	2.8g	0.46	0.97g	[1]
QDPS and MCR Display	-	-	1.08g	[6]
MCR Isolation Damper	-	-	0.61g	[6]
Hydrogen Recombiner	-	-	1.03g	[6]
Power and Control Panels	-	-	1.03g	[6]
Ceramic Insulators	0.2g	0.35	0.09g	[2]

Notes:
1. HCLPF based on URD recommended generic fragility data
2. HCLPF based on recognized generic fragility data
3. HCLPF based probabilistic fragility analysis
4. HCLPF based on deterministic approach
5. HCLPF based on conservative deterministic fragility margin approach
6. HCLPF based on design margin as defined from test data
7. Component support will control HCLPF value
8. pga is the free field peak ground acceleration level for the seismic event

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TABLES 19.55-2 THROUGH 19.55-7 ARE NOT INCLUDED IN THE DCD.
FIGURE 19.55-1 IS NOT INCLUDED IN THE DCD.

19.56 PRA Internal Flooding Analysis

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19.57 Internal Fire Analysis

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19.58 Winds, Floods, and Other External Events

19.58.1 Introduction

External events considered in the AP1000 PRA are those events whose cause is external to all systems associated with normal and emergency operations situations. Some external events may not pose a significant threat of a severe accident. Some external events are considered at the design stage and have a sufficiently low contribution to core damage frequency or plant risk.

Based upon the guidelines provided in References 19.58-1 and 19.58-2, the following is a list of five external events that are included for AP1000 analysis:

- High winds and tornadoes
- External floods
- Transportation and nearby facility accidents
- Seismic events
- Internal fires

The first three external events are addressed in this section. Seismic events and internal fires are addressed in the AP1000 PRA.

Chapter 2 defines the site characteristics for which the AP1000 is designed. A site is acceptable if the site characteristics fall within the AP1000 site interface parameters.

19.58.2 External Events Analysis

19.58.2.1 Severe Winds and Tornadoes

The overall methodology recommended by NUREG-1407 for analyzing plant risk due to high winds and tornados is a progressive screening approach. This approach is modified to consider determining the acceptability of hazard frequency and risk. High winds (including tornadoes) can affect plant structures in at least two ways: (1) if wind forces exceed the load capacity of a building or other external facility, the walls or framing might collapse or the structure might overturn from the excessive loading; and (2) if the wind is strong enough, as in a tornado or hurricane, it may be capable of lifting materials and thrusting them as missiles against the plant structures that house safety-related equipment. Critical components or other contents of plant structures not designed to resist missile penetration might be damaged and lose their function.

The NUREG-1407 criterion for high winds and tornados states that "these events pose no significant threat of a severe accident because the current design criteria for wind are dominated by tornadoes having an annual frequency of exceedance of about 10^{-7}." This is interpreted to mean that events with an annual frequency of exceedance less than 10^{-7} may be removed from further consideration and events with an annual frequency of exceedance greater than 10^{-7} must be further evaluated. However, the NUREG-1407 criterion was developed for currently operating plants.

High winds and tornados tend to behave as a loss of offsite power (LOSP) since the site switchyard is unprotected and not designed against high winds velocities. For wind velocities greater than the design basis, additional structures, systems, and components (SSC) may also fail. Therefore, two analyses are performed, one considering only a LOSP, and another considering a LOSP with failure of the standby nonsafety systems. This analysis considers not only excessive wind forces, but also missile generation. A conditional core damage probability will be calculated for each of those scenarios. Risk due to the event can be estimated using the following equation:

CDF = IEF * CCDP (Equation 19.58-1)

Where CDF is annual core damage frequency, IEF is the initiating event frequency, and CCDP is the conditional core damage probability. If this evaluation indicates an acceptably small contribution to risk (e.g., less than 10% of the total plant CDF), then the progressive screening is complete and no detailed PRA will be necessary.

A sensitivity study is be performed for the above two cases with a loss of component cooling water/service water considered also because those systems may not be available following above design basis winds.

The analysis for winds and tornadoes is site-specific. It is anticipated that a high wind or tornado event would result in a loss of offsite power because the switchyard is likely to become unavailable during the event.

The analysis for high winds and tornados begins with an examination of the design basis for the plant, which is documented in Chapter 2.

The AP1000 design basis wind speed for tornados is 300 mph as discussed in Chapter 2 . This value is assumed to be the maximum wind speed that will not challenge the safety-related structures. The AP1000 operating basis wind speed is 145 mph as discussed in Chapter 2. This value is assumed to be the maximum wind speed that will not challenge the nonsafety-related structures.

The structures protecting safety-related features of the AP1000 are designed for extreme winds and missiles associated with these winds. As long as the external event winds are less than these design basis winds, the safety features of the AP1000 will be unaffected. If the winds exceed the design values, then the integrity of the safety relates structures may be compromised.

The structures protecting nonsafety-related features of the AP1000 are designed according to uniform building code and have some level of protection against seismic and high wind events. As long as the external event winds are less than the operating basis winds (145 mph, per Chapter 2), the nonsafety features of the AP1000 will be unaffected. If the winds exceed the operating basis values, then the integrity of the nonsafety relates structures may be compromised.

In summary of the design against high winds, the plant is designed against 300 miles per hour (mph) winds. The operating basis of the plant is winds up to 145 mph. This means that the safety structures are protected against winds up to 300 mph and nonsafety system (NSS) structures are protected against winds up to 145 mph. Per the Enhanced Fujita Scale for Tornados (Table 19.58-1), no tornados are expected to exceed 300 mph; however, EF3, EF4, and EF5 tornados do exceed the operating basis of the AP1000. Per the Saffir-Simpson Scale for

Hurricanes (Table 19.58-2), no hurricanes are expected to reach 300 mph winds; however, Category 4 and Category 5 hurricane winds do exceed the operating basis of the AP1000.

Three studies are performed to evaluate the high wind events. The Case 1 study is a LOSP induced by each of the events, with no other equipment unavailable. A conditional core damage probability (CCDP) is developed for this scenario, which may be multiplied by the high wind event frequency. All tornados and hurricanes are considered in this Case 1 as they may challenge the AP1000 switchyard. Extratropical cyclones are normal storms and thunderstorms with winds expected to fall below the operating basis for the AP1000. They are also included in the Case 1 analysis.

As stated above, the EF3, EF4, and EF5 tornados and Category 4 and Category 5 hurricanes may challenge the nonsafety-related structures in the AP1000. Therefore, these events will be evaluated with the loss of additional SSCs. The Case 2 study is created by modifying the Case 1 analysis for the EF3, EF4, and EF5 tornados, and Category 4 and Category 5 hurricanes to have a LOSP with additional failures of nonsafety systems unavailable. A CCDP is developed for this scenario, which may be multiplied by the high wind event frequency.

The final Case 3 is a conservative study where all high wind events are evaluated as a LOSP with failure of the nonsafety systems. This case is created to represent the worst case scenario unavailable. In this analysis, events are considered of low risk importance if their initiating event frequency is less than 10^{-7} or if their estimated CDF is less than 10% of the total plant CDF. Therefore, the CDF screening values is 5.08E-08/yr.

The results of the CDF calculation are shown in Table 19.58-3. Equation 19.58-1 was used to determine the resultant CDF.

In that table, none of the initiating event frequencies were sufficiently low to be removed from further consideration. Therefore, the CDF calculation was performed. In each case, the resultant CDF is less than 10% of the total plant CDF, 5.08E-08/yr. The Category 4 and Category 5 hurricane frequency is considered to be extremely conservative at 1.00E-02/yr. An event with the conservative initiating event frequency, and the worst case sensitivity study (Case 3), the resultant CDF is still less than the CDF criterion of 5.08E-08/yr. Furthermore, the sum of the estimated CDF for each case falls below the CDF criterion of 5.08E-08/yr. Therefore, no further detailed PRA is necessary for the AP1000 high winds and tornados analysis.

19.58.2.2 External Floods

An external flooding analysis is performed to verify that any significant contribution to core damage frequency – resulting from plant damage caused by storms, dam failure, and flash floods – is accounted for as follows:

> The analysis for external floods begins with an examination of the design basis for the plant, which is documented in Chapter 2. The AP1000 is designed against flood levels less than plant elevation 100 feet.

The basic steps involved in an external flooding analysis are similar to those followed for internal flooding in the individual plant examination. However, the focus of attention is on areas, which due to their location and grading, may be susceptible to external flood damage. This requires information on such items as dikes, surface grading, locations of structures, and locations of equipment within the structures. Information such as meteorological data for the site, historical flood height, and frequency data, is also needed.

Category 5 hurricanes, per the Saffir-Simpson scale, are capable of storm surges greater than 18 feet. However, the probability of generating a storm surge of 18 feet, combined with the frequency of a Category 5 hurricane, results in a small event frequency. Even conservatively assuming a storm surge of 18 feet, the frequency of an event capable of generating this storm surge is small. Engineering judgment is used to establish that the frequency of this type of flood is significantly less than the 10^{-7} per year criterion for initiating event frequency.

As a sensitivity study, the 10^{-7}/yr initiating event frequency is taken as the frequency of an event that may challenge the nonsafety structures in the plant. This sensitivity study also considers failure of the switchyard due to flooding. LOSP with failure of the nonsafety systems CCDP was developed. Equation 1 was used to determine the resultant CDF.

As expected, the risk due to a flooding event is low for the AP1000. The resultant CDF of 5.85E-15/yr is an insignificant contribution to total plant CDF.

For other sites, the AP1000 is designed to site characteristics described in Chapter 2. The site selection criterion provides that for an accident that has potential consequences serious enough to affect the safety of the plant to the extent that 10 CFR 100 guidelines are exceeded, the annual frequency of occurrence is less than 10^{-6} per year. To consider the already low risk of the AP1000 design, this criterion should be extended to an annual frequency of occurrence less than 10^{-7} per year.

19.58.2.3 Transportation and Nearby Facility Accidents

These events consist of accidents related to transportation near the nuclear power plant and accidents at industrial and military facilities in the vicinity. The following modes of transportation are considered:

- Aviation (commercial/general/military)
- Marine (ship/barge)
- Pipeline (gas/oil)
- Railroad
- Truck

19.58.2.3.1 Aviation Accidents

For limiting event frequency of 1.21E-06/year with most of that frequency for small aircraft, and with commercial aircraft contribution 9.40E-09/year, then the following discussion is applicable.

A conservative analysis was performed to evaluate the risk due to small aircraft accidents onsite. This analysis assumes a LOSP and loss of component cooling water/service water event, and conservatively fail a set of standby nonsafety systems. This is acceptable because it is unlikely that a small aircraft accident would challenge the passive safety systems inside containment. This leaves only the nonsafety systems outside containment as vulnerable. However, this evaluation is conservative because it is unlikely that a small aircraft would have the capacity to fail such a large area of the AP1000.

Equation 19.58-1 is used to determine the resultant CDF. A CDF of 7.08E-14/yr is calculated and is an insignificant contribution to total plant CDF of approximately 5.08E-07/yr. Therefore, sites that can demonstrate an aviation event frequency less than or equal to 1.21E-06/yr for small aircraft accidents are bounded by this evaluation.

Larger commercial aircraft may have the capacity to challenge SSCs within the AP1000 containment. However, the containment structure and safety systems are designed to withstand various earthquake levels so that many of the safety system SSCs will still be available following the accident. To consider the already low risk of the AP1000 design, the 10^{-7}/yr criterion for event frequency is applicable for larger commercial aircraft. Sites that can demonstrate a commercial aircraft aviation event frequency less than the 10^{-7}/yr criterion are also bounded by this analysis.

19.58.2.3.2 Marine Accidents

Only sites with large waterways with ship and/or barge traffic that goes through or near the site need to consider marine accidents.

Marine accidents involving ship or barge accidents pose a potential hazard to a nuclear power plant due to two possibilities:

1. Release of hazardous material towards the plant
2. Explosion with resulting damage to the plant

The potential exists for a marine accident that leads to a release of toxic materials into the atmosphere. This type of event may compromise the safety of the plant operators, resulting in reduced operator reliability. However, the toxic release does not directly lead to any failure of plant equipment. To evaluate the risk impact of this scenario, a CCDP is developed that models a reactor trip followed by the guaranteed failure of all PRA credited operator actions. The resulting CCDP is 6.26E-08. The bounding initiating event frequency is 1.0E-06/yr.

Equation 19.58-1 is used to determine the resultant CDF. The resultant CDF is 6.26E-14/yr. The results indicate a low estimated CDF contribution due to toxic releases from a marine accident.

The above analysis is conservative. The AP1000 has an additional level of defense against toxic airborne material. With advanced warning, the operators may actuate passive control room habitability. This system isolates the control room from normal HVAC and actuates a separate system supplied from compressed air containers. The compressed air slightly pressurizes the control room above atmospheric pressure, preventing the entrance of toxic material in the control room. This system is available for 72 hours, which is adequate time to withstand the event.

There is also a potential for marine explosion accidents. The AP1000 is not designed with a service water intake structure. Therefore, loss of service water events as a consequence of marine explosions are not a concern for the AP1000 design. As long as Regulatory Guide 1.91 acceptance criterion is met, marine explosion accidents do not need to be considered further for the AP1000 PRA.

19.58.2.3.3 Pipeline Accidents

Pipeline accidents could pose a hazard to the AP1000 due to the release of hazardous material or the possibility of an explosion and resulting damage to the plant. For a site with a 30-inch gas line approximately 5800 feet away, a semi-quantitative evaluation is performed.

Considerations for the evaluation are as follows:

- Gas pipe rupture frequency
- Gas cloud formation probability
- Gas cloud transportation and nondispersion probability
- Gas cloud ignition probability onsite

Figure 19.58-1 is considered to further evaluate the probability of this accident. When then considering the probability of forming a dense gas cloud, and the probability of the wind speed and direction to be in the ranges necessary to transport the gas cloud 5800 feet to the site, without dispersing the gas, including ignition of the gas cloud onsite in a location that may challenge the plant, this probability becomes very low.

Site habitability is also a concern for toxic materials. However, the AP1000 has an additional level of defense against toxic airborne material. With advanced warning, the operators may actuate passive control room habitability. This system isolates the control room from normal HVAC and actuates a separate system supplied from compressed air containers. The compressed air slightly pressurizes the control room above atmospheric pressure, preventing the entrance of toxic material in the control room. This system is available for 72 hours, which is adequate time to withstand the event. The expected frequency value is expected to be below the initiating event criterion of 10^{-7} events/year. Therefore, no further quantitative evaluation is necessary.

19.58.2.3.4 Railroad and Truck Accidents

Railroad accidents could pose a hazard to the AP1000 due to the release of hazardous material or the possibility of an explosion and resulting damage to the plant. Toxic material releases were evaluated in the marine accident evaluation as to not be important to AP1000 plant risk. Significant damage to the AP1000 plant was evaluated in the aviation accident evaluation. No railroad accidents are expected to result in the amount of damage that may be seen from an aviation accident. This is especially true considering the increased security barriers established at U.S. nuclear power plants.

The AP1000 is designed to site characteristics described in Chapter 2. The site selection criterion provides that, for an accident that has potential consequences serious enough to affect the safety of the plant to the extent that 10 CFR 100 guidelines are exceeded, the annual frequency of occurrence is less than 10^{-6} per year. As explained in Chapter 2, this criterion should be extended to an annual frequency of occurrence less than 10^{-7} per year.

19.58.3 Conclusion

The risk due to external hazards is low for the AP1000 design for the participating sites listed in Section 3.2. The AP1000 design is shown to be highly robust against the external events discussed in this section. The design is resilient against high winds, external floods, and other external events that challenge various equipment in the plant.

The following conclusions and insights are derived from the AP1000 external events assessment for events at power:

1. High winds and tornados were quantitative evaluated to be of low risk to the AP1000 design for each of the participating sites. A bounding assessment is provided to show that the expected CDF due to any one of these events exceeds 10% of the total plant CDF (5.08E-08 events/year). The same is true for the aggregate results. Sensitivity studies were performed to determine that there is low risk for more limiting scenarios. No further analysis is suggested.

2. The AP1000 is designed to flooding levels described in Chapter 2. The site selection criterion provides that, for an accident that has potential consequences serious enough to affect the safety of the plant to the extent that 10 CFR 100 guidelines are exceeded, the annual frequency of occurrence is less than 10^{-6} per year. As explained in Section 4.1, this criterion can be extended to an annual frequency of occurrence less than 10^{-7} per year. No further analysis is suggested.

3. Transportation and nearby facilities accidents are qualitatively evaluated to be of low risk importance and do not warrant further evaluation.

19.58.4 References

19.58-1 "Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities - 10 CFR 50.54(f)," Generic Letter 88-20, Supplement 4, June 28, 1991.

19.58-2 NUREG-1407, "Procedural and Submittal Guidance for the Individual Plant Examination of External Events (IPEEE) for Severe Accident Vulnerabilities," June 1991.

19.58-3 National Weather Service, "The Enhanced Fujita Scale," February 2, 2007, http://www.spc.noaa.gov/efscale/.

19.58-4 National Weather Service, "The Saffir-Simpson Hurricane Scale," June 22, 2006, http://www.nhc.noaa.gov/aboutsshs.shtml.

19.58-5 U.S. Nuclear Regulatory Commission Regulatory Guide 1.91, "Evaluation of Explosions Postulated to Occur on Transportation Routes Near Nuclear Power Plants," Revision 1, February 1978.

Table 19.58-1

DESCRIPTION OF THE ENHANCED FUJITA SCALE (TORNADOS)
(Reference 19.58-3)

Scale Number	Intensity Phrase	Wind Speed	Type of Damage Done
EF0	Gale tornado	65-85 mph	Some damage to chimneys; breaks branches off trees; pushes over shallow-rooted trees; Some damage to chimneys; branches broken off trees; shallow-rooted trees pushed over; sign boards damaged.
EF1	Moderate tornado	86-110 mph	Peels surface off roofs; mobile homes pushed off foundations or overturned; moving autos blown off roads.
EF2	Significant tornado	111-135 mph	Roofs torn off frame houses; mobile homes demolished; boxcars overturned; large trees snapped or uprooted; light-object missiles generated; cars lifted off ground.
EF3	Severe tornado	136 - 165 mph	Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; heavy cars lifted off the ground and thrown.
EF4	Devastating tornado	166-200 mph	Well-constructed houses leveled; structures with weak foundations blown away some distance; cars thrown and large missiles generated.
EF5	Incredible tornado	>200 mph	Strong frame houses leveled off foundations and swept away; automobile-sized missiles fly through the air in excess of 100 meters (109 yds); trees debarked; incredible phenomena will occur.

Table 19.58-2

DESCRIPTION OF SAFFIR-SIMPSON SCALE (HURRICANES)
(Reference 19.58-4)

Category Number	Wind Speed	Category Description
1	74-95 mph	Storm surge generally 4-5 ft above normal. No real damage to building structures. Damage primarily to unanchored mobile homes, shrubbery, and trees. Some damage to poorly constructed signs. Also, some coastal road flooding and minor pier damage.
2	96-110 mph	Storm surge generally 6-8 feet above normal. Some roofing material, door, and window damage of buildings. Considerable damage to shrubbery and trees with some trees blown down. Considerable damage to mobile homes, poorly constructed signs, and piers. Coastal and low-lying escape routes flood 2-4 hours before arrival of the hurricane center. Small craft in unprotected anchorages break moorings.
3	111-130 mph	Storm surge generally 9-12 ft above normal. Some structural damage to small residences and utility buildings with a minor amount of curtain wall failures. Damage to shrubbery and trees with foliage blown off trees and large trees blown down. Mobile homes and poorly constructed signs are destroyed. Low-lying escape routes are cut by rising water 3-5 hours before arrival of the center of the hurricane. Flooding near the coast destroys smaller structures with larger structures damaged by battering from floating debris. Terrain continuously lower than 5 ft above mean sea level may be flooded inland 8 miles (13 km) or more. Evacuation of low-lying residences with several blocks of the shoreline may be required.
4	131-155 mph	Storm surge generally 13-18 ft above normal. More extensive curtain wall failures with some complete roof structure failures on small residences. Shrubs, trees, and all signs are blown down. Complete destruction of mobile homes. Extensive damage to doors and windows. Low-lying escape routes may be cut by rising water 3-5 hours before arrival of the center of the hurricane. Major damage to lower floors of structures near the shore. Terrain lower than 10 ft above sea level may be flooded requiring massive evacuation of residential areas as far inland as 6 miles (10 km).
5	>155 mph	Storm surge generally greater than 18 ft above normal. Complete roof failure on many residences and industrial buildings. Some complete building failures with small utility buildings blown over or away. All shrubs, trees, and signs blown down. Complete destruction of mobile homes. Severe and extensive window and door damage. Low-lying escape routes are cut by rising water 3-5 hours before arrival of the center of the hurricane. Major damage to lower floors of all structures located less than 15 ft above sea level and within 500 yards of the shoreline. Massive evacuation of residential areas on low ground within 5-10 miles (8-16 km) of the shoreline may be required.

Table 19.58-3

HIGH WINDS AND TORNADOS RESULTS

Category	Event	Limiting Initiating Event Freq. (/yr)	CDF (/yr)		
			LOSP (Case 1) (/yr)	LOSP with Nonsafety Systems Unavailable for Select Events (Case 2) (/yr)	LOSP with Nonsafety Systems Unavailable for All Events (Case 3) (/yr)
High Winds	EF0 Tornado	8.00E-05	7.85E-13	7.85E-13(1)	4.68E-12
	EF1 Tornado	8.00E-05	7.85E-13	7.85E-13(1)	4.68E-12
	EF2 Tornado	1.60E-04	1.57E-12	1.57E-12(1)	9.36E-12
	EF3 Tornado	8.00E-05	7.85E-13	7.85E-13(1)	4.68E-12
	EF4 Tornado	8.00E-05	7.85E-13	7.85E-13(1)	4.68E-12
	EF5 Tornado	8.00E-05	7.85E-13	4.68E-12	4.68E-12
	Cat. 1 Hurricane	1.00E-01	9.81E-10	9.81E-10(1)	5.85E-09
	Cat. 2 Hurricane	5.00E-02	2.94E-10	2.94E-10(1)	2.93E-09
	Cat. 3 Hurricane	3.00E-02	2.94E-10	2.94E-10(1)	1.76E-09
	Cat. 4 Hurricane	1.00E-02	9.81E-11	5.85E-10	5.85E-10
	Cat. 5 Hurricane	1.00E-02	9.81E-11	5.85E-10	5.85E-10
	Extratropical Cyclones	3.00E-02	2.94E-10	2.94E-10(1)	1.76E-09
Totals			2.07E-09	3.05E-09	1.35E-08

Note:

1. CDF values from Case 1 were used to illustrate the winds from these events will not challenge additional plant SSCs.

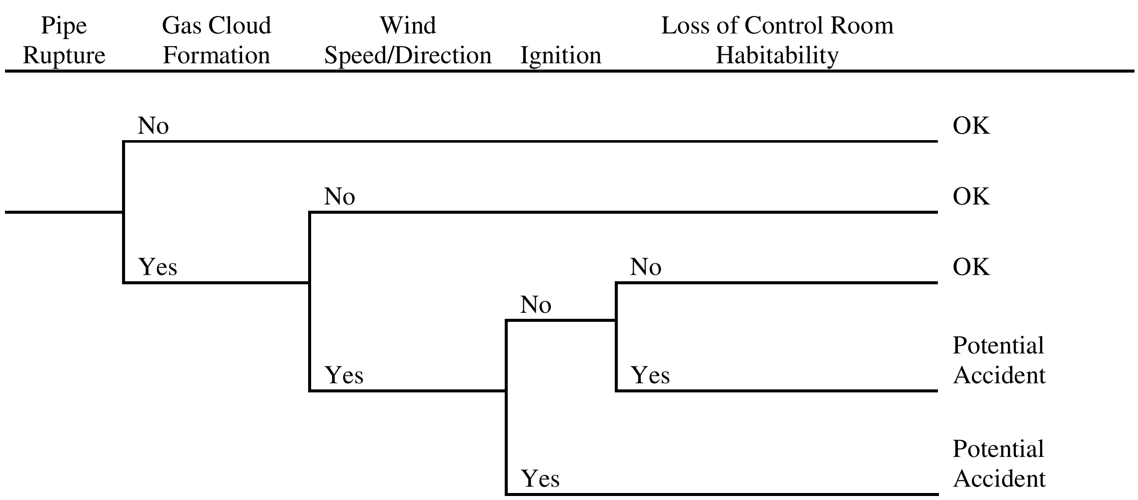

Figure 19.58-1

Pipeline Accident Model