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 AP600 risk-based seismic margin analysis (SMA) satisfies this recommendation of SECY-93-087.

Since the AP600 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 AP600 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 AP600 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. All of the HCLPF values are above the review level earthquake.

In the design of the AP600, 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 Sequence and Plant HCLPF

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19.55.5 Sensitivity Analyses

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19.55.6 SMA Results and Insights

The core damage sequence HCLPFs are given in Table 19.55-10. The large release HCLPFs are provided in Table 19.55-12.

The AP600 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 5)

SEISMIC MARGIN HCLPF VALUES

Description	HCLPF Value pga [1]
Buildings/Structures	
Shield Building Roof - Tension Ring	1.34 g
Shield Building Roof - at PCS Tank	2.45g
Shield Building Roof - PCS Tank Wall	3. 26g
Shield Building Roof - Columns	0.58g
Containment Vessel - Buckling	0.70g
Containment Vessel - Overturning	0.98g
Containment Baffle Support Failure	1.5g
Interior Containment Structure & IRWST	0.60g
Primary Components	
Reactor Pressure Vessel and Support	0.77g
Reactor Internals and Core Assembly (Includes Fuel)	0.5g
CRDM and Hydraulic Drive Units	0.7g
Pressurizer and Support	0.67g
Steam Generator and Support	0.65g
Reactor Coolant Pump	0.7g
Mechanical Equipment	
Polar Crane	0.89g
Piping Support Controlled	0.81g
Cable Trays Support Controlled	0.54g
Heat Exchanger (PRHR)	0.81g

Table19. 55-1 (Sheet 2 of 5)

SEISMIC MARGIN HCLPF VALUES

Description	HCLPF Value [1]
Tank PXS-MT 1A/B (Accumulator)	0.76g
Tank PXS 2A/B (CMT)	0.63g
Valves	
Room Number 11202	0.96g
Room Number 11206	0.96g
Room Number 11207	0.96g
Room Number 11208	0.96g
Room Number 11300	0.96g
Room Number 11301	0.83g
Room Number 11302	0.96g
Room Number 11304	0.83g
Room Number 11400	0.81g
Room Number 11403	0.81g
Room Number 11500	0.81g
Room Number 11601	0.81g
Room Number 11603	0.81g
Room Number 11703	0.81g
Room Number 12244	0.92g
Room Number 12254	0.92g
Room Number 12255	0.92g
Room Number 12256	0.92g
Room Number 12306	0.86g
Room Number 12362	0.81g

Table 19.55-1 (Sheet 3 of 5)

SEISMIC MARGIN HCLPF VALUES

Description	HCLPF Value [1]
Room Number 12401	0.81g
Room Number 12404	0.81g
Room Number 12405	0.81g
Room Number 12406	0.81g
Room Number 12452	0.81g
Room Number 12454	0.81g
Room Number 12555	0.81g
Room Number 12701	0.81g
Electrical Equipment	
Battery	1.04g
Battery Racks	1.14g
Battery Chargers	0.98g
125 VDC Distribution Panel	0.5lg
120 VAC Distribution Panel	0.51g
Transfer Switches	0.51g
125 VDC MCC	0.93g
125 VDC Switchboard	0.5lg
Regulating Transformer	1.03g
Inverter	0.65g
4.16 kV Switchgear	0.86g
Reactor Trip Switchgear	0.81g

Table19. 55-1 (Sheet 4 of 5)

SEISMIC MARGIN HCLPF VALUES

Description	HCLPF Value [1]
Hydrogen Monitor	1.19g
CMT Level Switch	1.09g
Neutron Detector	0.51g
Radiation Monitor	0.64g
RTD	3.75g
Speed Sensors	2. 17g
Incore Thermocouple	3 .94g
RCP Bearing Water Temp Thermocouple	3 .94g
PCS Water Flow Transmitter (el. 135.3')	0.93g
PCS Water Flow Transmitter (el. 261')	0.61g
PRHR HX Flow Transmitter	1.55g
RCS Flow Transmitter	1.55g
SG Feed Transmitter	1.16g
IRWST Level Transmitter	1.27g
PZR Level Transmitter	1.27g
SG Narrow-Range Transmitter	0.85g
SG Wide-Range Transmitter	0.85g
Air Storage Tank Pressurizer Transmitter	0.99g
Containment Pressurizer Sensor & Transmitter	1. 27g
RCS Wide-Range Pressure Transmitter	1. 27g
PRZ Pressure Sensor	1. 27g

Table19. 55-1 (Sheet 5 of 5)

SEISMIC MARGIN HCLPF VALUES

Description	HCLPF Value [1]
Main Steam Line Pressure Transmitter	0.99g
ESFAC Cabinet	0.74g
Protection Logic Cabinet	0.74g
Integrated Protection Cabinet SWGR	0.74g
Multiplex Cabinet	0.74g
Qualified Data Processing System (QDPS) Cabinet	1.94g
MCR SUPR OPER Station	0.97g
MCR Switch Station	0.97g
QDPS and MCR Display	1.98g
MCR Isolation Dampers	0.80g
Power and Control Panels	1. 14g
Ceramic Insulators (assumed to fail with loss of offsite power)	0.09g

Table Notes:

[1] pga is the free-field peak ground acceleration level for the seismic event

TABLES 55-2 THROUGH 55-9 ARE NOT INCLUDED IN THE DCD.

Table 19.55-10 (Sheet 1 of 2)

SEQUENCE HCLPFs

Sequence Name	HCLPF Value
EQSTR-02	0.58g
EQRVF-02	0.50g
EQLLO-02	0.96g
EQLLO-03	0.81g
EQLLO-05	0.96g
EQLLO-06	0.81g
EQLLO-08	0.96g
EQLLO-09	0.81g
EQLLO-10	0.81g
EQLLO-11	0.81g
EQSLO-02	0.96g
EQSLO-03	0.81g
EQSLO-04	0.81g
EQSLO-05	0.81g
EQSGT-02	0.96g
EQSGT-03	0.65g
EQSGT-04	0.65g
EQSGT-05	0.65g
EQSLB-02	0.96g
EQSLB-03	0.81g
EQSLB-04	0.81g
EQSLB-05	0.81g
EQATW-02	0.96g
EQATW-03	0.96g
EQATW-04	0.51g

Table 19.55-10 (Sheet 2 of 2)

SEQUENCE HCLPFs

Sequence Name	HCLPF Value
EQATW-05	0.63g
EQATW-06	0.81g
EQATW-07	0.60g
EQLSP-03	0.96g
EQLSP-04	0.60g
EQLSP-05	0.60g
EQLSP-10	0.63g
EQLSP-11	0.60g (goes to SLOCA)
EQLSP-12	(goes to SLOCA)

TABLE 19.55-11

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Table 19.55-12

LARGE RELEASE HCLPFs

	Core Damage (CD) and Cont. Structure Failure	CD and Containment Isolation Failure	CD and Containment Cooling Function Failure	CD and Containment Other Issues[1]
Large Release HCLPF by Category	0.58g	0.81g	0.60g	0.50g

Note:

1. "Containment Other Issues" includes failure of the reactor vessel and steam generator tube rupture resulting in containment bypass.

TABLES 19.55-13 AND 19.55-14 ARE 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

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