REVISION AND EXPANSION OF ASME/ANS EXTERNAL FLOODING PRA STANDARD

PSA 2017

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Introduction

Current version of XFPRA standard (Part 8) is limited

- External flooding judged to be low significance
- Allowed aggressive screening

Significant effort undertaken to revise Part 8

- Significantly more detailed
- Reflects recent lessons-learned
  - Understanding of external flood phenomena and its complexities
  - The diversity of plant response strategies that may be employed

Recognizes limitations in current state of practice

- Uses many non-prescriptive requirements
- Provides significant flexibility in addressing requirements

*XFPRA: External flood probabilistic risk assessment

Presentation Overview

Structure of revised standard

Key challenges associated with XFPRA

- Challenges from the nature of flooding hazards
- Challenges from the plant impacts of flooding events

Overview of technical element requirements

- Hazard
- Fragility
- Plant response

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Structure of XFPRA Standard

Part 8 of the Level I, At-power PRA standard

- Plant is at-power when flood conditions begin at site or when warning is received of potential impending floods
- Plants may change the mode or configuration of the plant prior to onset of flooding conditions
  - Availability of significant warning time (in some cases)
  - Unique compared to most hazard groups

Uses three technical elements (like other external hazard groups)

1. Hazard Analysis Technical Element
2. Fragility Technical Element
3. Plant Response Technical Element

Includes two different categories of analysis (capability categories)

- Selected category based on intended application of PRA

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Key Challenges

Nature of flooding hazards

- Diverse flooding hazards that may affect nuclear power plant sites
- Diverse characteristics of flooding events

Plant Impacts From Flooding Hazards

- Diverse ways flood hazards may affect a nuclear power plant site in a consequential manner
- Diverse strategies that may be employed to protect against or mitigate the associated plant impacts

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Challenges: Nature Of Flooding Hazards

Broad range of phenomena may lead to flooding at NPP sites

- Natural (e.g., weather-induced)
- Man-made (e.g., caused by operational releases from dams)

Combinations of flood-causing mechanisms may also lead to site flooding

- Common cause events
  - Example: Hurricane event that causes both storm surge and river flooding NPP sites located on estuaries or tidal rivers
- Independent events
  - Perhaps each of moderate severity
  - May occur coincidentally (and with non-negligible probability) and cause consequential site flooding

Challenges: Nature Of Flooding Hazards

Coexistent hazards

- Flooding events may also occur as a result of (secondary to) or along with (concurrent with) hazards associated other PRA hazard groups

Flooding events are complex

- Temporally and spatially dynamic characteristics
  - Cannot easily capture all characteristics in PRA
- Captured in Standard as
  - Flood height
  - Associated effects
  - Flood event duration

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Challenges: Plant Impacts From Flooding Hazards

Plant response strategies differ across sites and mechanisms
- Depends on:
  - Site characteristics
  - Flood mechanisms affecting a site
- May lead to conflicting objectives
  - Example: Flood wall to protect against surge creates “bathtub” for precipitation during hurricane

Some sites were not initially designed to withstand low probability but potentially consequential large flood events
- May instead rely on mitigation approaches
  - Unconventional strategies
  - Significant manual actions
  - Equipment that are not modeled in the baseline PRA

Warning time may be available
- Sites may take actions to change the operating mode of the plant or re-configure the plant prior to or following the onset of site flooding

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Hazard Analysis Technical Element: Overview

Purpose

- Addresses the systematic evaluation of the frequency that a specified parameter or set of parameters representing flood severity (e.g., flood elevations at locations around the site) will be exceeded at a site based on a site-specific probabilistic evaluation

Hazard Analysis Technical Element: Key Components

1. **Screening**
   - Determines which external flood mechanisms can pose external flood challenges to the site
     - Individual mechanisms
     - Combinations of mechanisms
   - Includes flood specific-considerations (no longer in Part 6)
2. **Development of the aleatory models**
3. **Treatment of epistemic uncertainties**
4. **Suite of hazard curves**
   - mean, median, fractiles

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Fragility Technical element: Overview

Purpose

- Identify SSCs that are susceptible to the effects of external floods and evaluate their failure probability as a function of flood severity (e.g., flood height or velocities)

Main outcome

- Development of fragility functions
- Usually with respect to one parameter with others addressed implicitly

Fragility Technical element: Key Components

1. **Development of a list of SSCs for which a fragility analysis is needed**
2. **Incorporation of walkdown findings into the SSC evaluation**
   - Condition and configuration of SSCs
   - External flood failure mechanisms for relevant failure modes of the plant response model
   - Potential physical interactions between SSCs
3. **Evaluation of potential impacts from (time-varying) flood heights and associated effects during the flood event duration**
4. **Development of a fragility function**
   - For the failure modes of the relevant SSCs in the plant response model
5. **Evaluation of potential impacts from relevant coexistent hazards**

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Plant Response Technical Element: Overview

Purpose

- Development of a plant response model that includes the initiating events and other failures resulting from the effects of external flood that can lead to core damage or large early release

May be based on:

- Internal events PRA with modifications
- Ad hoc (flood-specific) model

Plant Response Technical Element: Key Components

Scenario identification

- characteristics of the flood event
- effects on the plant

Development of timelines

- warning time
- period of inundation or other defined mission time
- water surface elevations that are relevant to plant response
- the expected plant mode(s) during the entire flood event duration
- necessary human actions, including cues, indications, and notifications

Development of logic structures

Quantification

Conclusions

Revision of Part 8 …

- Is significantly expanded and more detailed that previous version
- Recognizes that external flooding is a potentially significant risk contributor
- Includes a large number of new requirements due to terseness of previous version
- Affords significant flexibility is addressing most requirements
- Includes a detailed non-mandatory appendix (companion document)

Questions?