Surry Power Station
Resolution of Tornado Wind Nonconformances
Proposed License Amendment Request

NRC Pre-Submittal Meeting

May 20, 2021

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Nuclear Engineering and Fuel

Agenda

- Purpose of Submittal
- Current Licensing Basis
- Identified Analyses Deficiencies
- Basis for Current Operability
- License Amendment Request
  - Turbine Building
  - Fuel-Handling Trolley Support Structure
- Scope of LAR Implementation
- Milestones
- Acronyms

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Purpose of Submittal

- To modify the Surry Licensing Basis to affirm the technical adequacy of the current designs for two civil structures for protection against tornado winds
  - Turbine Building Steel Superstructure
  - Fuel Building – Fuel Handling Trolley Support Structure (FHTSS)

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Current Licensing Basis

- **Tornado wind speed**
  - UFSAR Section 15.2.3
  - 360 mph (300 mph rotational speed + 60 translational speed)
  - Pressure drop 3 psi in 3 seconds
  - 1200 ft diameter with radius of max winds = 200 ft
- **Turbine Building**
  - UFSAR Ch. 15, Table 15.2-1
    - Not a Tornado Criterion "T" structure, but…
      "By design, building collapse will not damage any Class I structures and components during earthquake, or tornado-resistant structures and components during tornado"
- **FHTSS**
  - UFSAR Ch. 15, Table 15.2-1
    - Structure is designated Tornado Criterion "T" for protection against tornado winds

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Identified Analyses Deficiencies

- The Turbine Building steel superstructure cannot be demonstrated by analysis to provide adequate protection against collapse under UFSAR tornado wind speeds, which could impact safety-related equipment in the basement
  - Existing design calculation for 300 mph tornado wind speed vs 360 mph in UFSAR
- FHTSS cannot be demonstrated by analysis to be acceptable for UFSAR tornado wind speeds
  - Calculation of FB steel structure addresses 360 mph for low-bay portion of the structure, but calculation did not consider high-bay portion, which is the FHTSS (Structural Bents 3 & 4)

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Basis for Current Operability

- Turbine Building (Operable but Not Fully Qualified)
  - Credit existing 2D analysis by plant A/E for 300 mph winds
  - Reasonable expectation that structural collapse from excessive story drift is impeded by interaction of steel superstructure with Turbine pedestals
- FHTSS (Operable but Not Fully Qualified)
  - Consequences of postulated collapse of the structure concluded to be bounded by design basis fuel handling accident (UFSAR Section 14.4.1.3, *Fuel-Handling Accident in the Spent-Fuel Pool*)
  - Reasonable expectation that structure could sustain an EF3 tornado without collapse

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License Amendment Request
Turbine Building

- Reason for License Amendment
  - To reduce UFSAR tornado wind speed from 360 mph to 250 mph based on crediting more recent meteorological / climate data for purposes of affirming license basis requirement for protection against collapse under tornado winds
  - NRC approval required per 10 CFR50.59(c)(2)(viii) for change in an element of a method of evaluation used to establish that the structure will satisfy its design requirement (tornado wind speed)
- Analytical Approach
  - Apply wind loads based on 250-mph tornado wind speeds
  - Analyze the structure for protection against collapse of the turbine deck

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License Amendment Request
Turbine Building

- Details of Analysis Performed
  - Reviewed updated tornado data in the most recent reports / studies endorsed by NRC (e.g., NUREG/CR-4461, Rev. 1 and 2, RG. 1.76, Rev. 1) and justified reducing the UFSAR tornado wind speed from 360 mph to 250 mph for Surry Power Station
  - Developed three-dimensional finite element model of the Turbine Building steel superstructure to evaluate the effects of 250-mph tornado wind loads along the four cardinal directions in order to address the concerns related to collapse of the steel superstructure and the resulting damage to safety-related equipment in the Turbine Building

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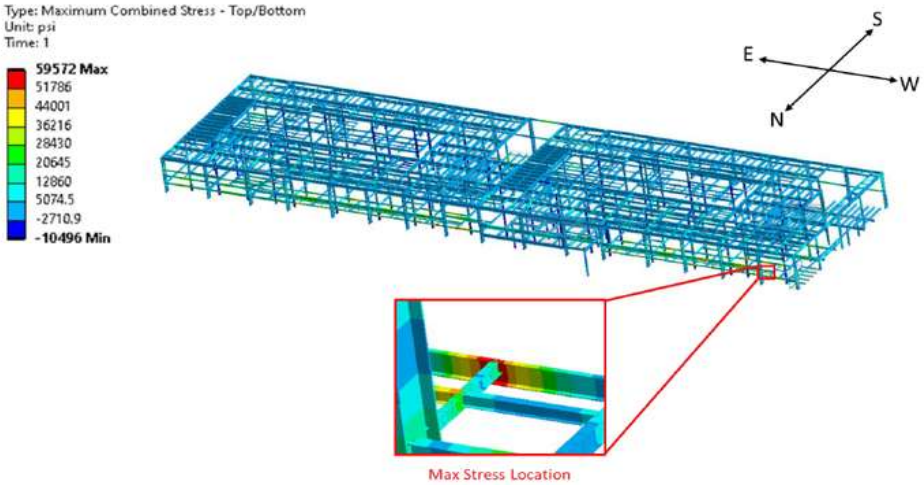
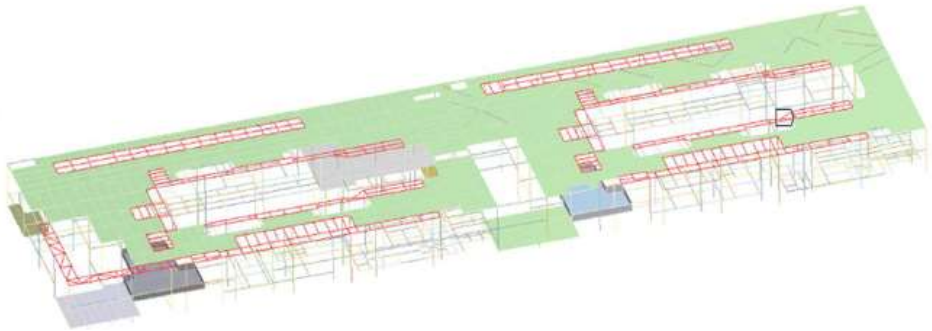
License Amendment Request

Turbine Building





- Results
  - Under the effect of the 250-mph tornado wind speed:
    - The lateral drift ratio of the operating floor remained under 1%.
    - The stress level in all steel members and RC slab and wall elements remained below the acceptable stress limits.
    - All girder-to-column and girder-to-girder connections are acceptable based on AISC 15th edition combined stress criteria.
  - This assessment confirmed that the safety-related equipment in the TB will not be damaged if the TB is subjected to a tornado with sustained winds up to 250 mph in any of the four cardinal directions.

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License Amendment Request
Fuel Handling Trolley Support Structure

- Reason for License Amendment
  - To change the licensing basis for the structure to apply a risk-informed approach that shows acceptable levels of risk in terms of damage to spent fuel assemblies
  - NRC approval required for change in method used to affirm acceptability of the structure to satisfy licensing requirements for protection against tornado winds
- Analytical Approach
  - Risk-informed approach to demonstrate minimal risk of fuel damage in SFP due to possible collapse of the FHTSS under tornado winds
  - Follows RG 1.174 approach to demonstrate acceptably small change in risk

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License Amendment Request

Fuel Handling Trolley Support Structure

- Details of Analysis Performed
  - Developed 3-D FEA model of the FHTSS
  - Constructed a mean fragility curve for failure of the FHTSS as a function of wind speed
    - Calculated tornado wind speed corresponding to 50% probability of failure
      - Open-frame analysis of FHTSS framing following ASCE guidance to characterize drag coefficients and estimate the total applied wind force
      - Estimate nominal (un-factored) member strength based on AISC 15th Ed. and using median material properties
      - Determine the wind speed that results in the maximum interaction (demand to capacity) ratio of 1.0 (or slightly less)
    - Justify use of generic composite variability (0.175) based on industry research
  - Convolved the mean fragility curve with the NUREG/CR-4661, Rev. 2 wind hazard (initiating event probabilities) in order to calculate a risk of damage to fuel in the Spent Fuel Pool
  - Demonstrated that the risk is within acceptable thresholds consistent with RG 1.174

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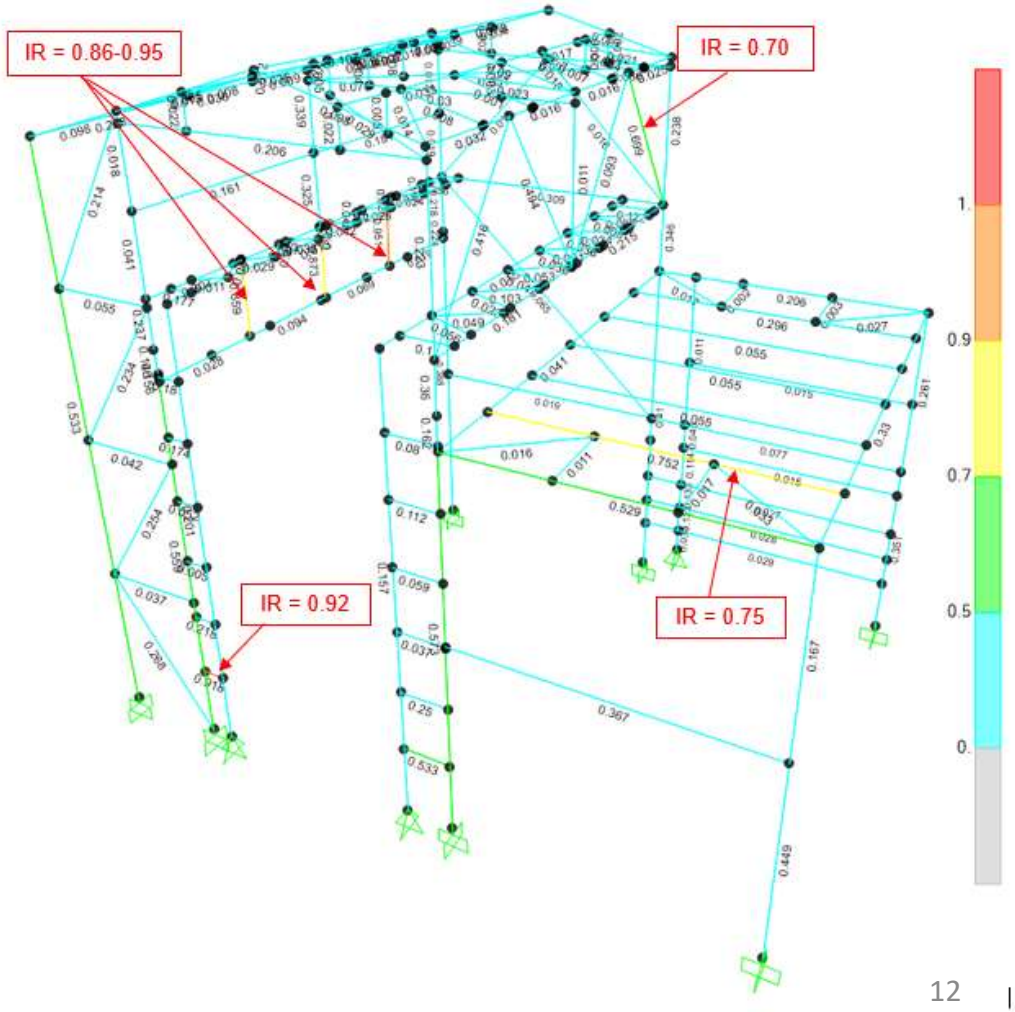
License Amendment Request

Fuel Handling Trolley Support Structure

- Structural Fragility Results
  - Median-based Tornado Wind Speed Capacity = **210 mph**
  - Composite variability = **0.175**
  - The maximum interaction ratio under 210 mph wind speed is **0.95.**



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License Amendment Request

Fuel Handling Trolley Support Structure

- Risk Results
  - Fuel damage was assumed for any plastic deformation of the FHTSS that occurs
  - Overall risk associated with the wind speed effecting the FHTSS that will cause fuel damage is **1.97E-06** / reactor year based on conservative analysis
  - This risk fell into the Region II of R.G. 1.174, where the application needs to show that the total CDF is <1.0E-4 per reactor year to be considered reasonable
  - NRC study* corroborates that the base risk is in the range of applicability of RG 1.174

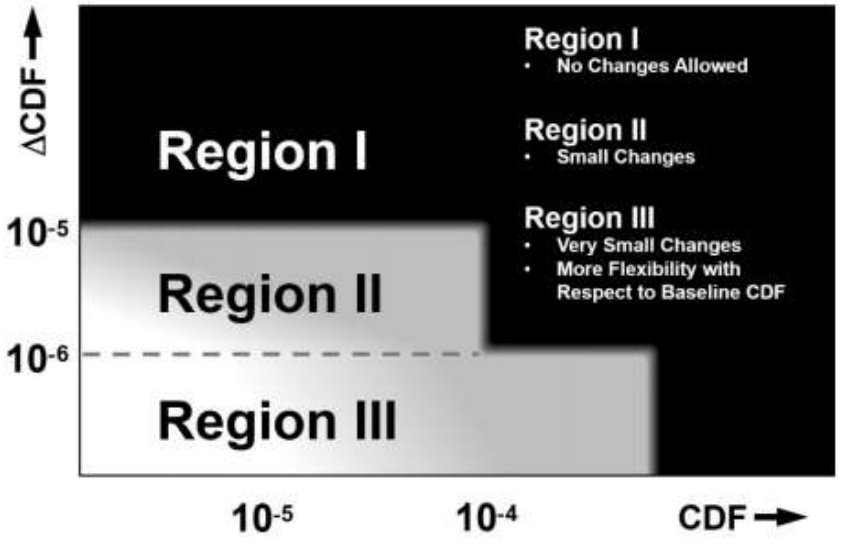

Figure 4. Acceptance guidelines* for core damage frequency

Risk Criteria		
Risk Metric	Value	R.G. 1.174 criteria
FDF due to Wind Speed	**1.97E-06**	**1.0E-6 to 1.0E-5**
Total Fuel Risk	**1.97E-06**	**<1.0E-4**

*Kelly, G., Palla, R., Cheok, M., & Parry, G., "Insights from a comprehensive evaluation of risk at spent fuel pools at decommissioning nuclear power plants in the US. 9 international conference on nuclear engineering", France, 2001

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Scope of LAR Implementation

- Conforming Changes to UFSAR
  - Descriptions of TB and FHTSS analyses performed to be inserted within Chapter 15.2, “Structural Design Criteria,” **Sections 15.2.3**, “Tornado Criteria” to clarify the bases for structural acceptability of the existing designs with respect to tornado wind design
  - Edits to **Table 15.2-1**, “Structures, Systems, and Components Designed for Seismic and Tornado Criteria” to clarify bases for classifications as denoted within Section 15.2.3 for each respective structure

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Proposed Milestones

- Submit LAR to NRC — July 30, 2021
- Requested approval — July 2022
- Implement amendment — 60 days after approval

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Acronyms / References

Acronym	Definition	Acronym	Definition
A/E	Architect / Engineer	IR	Interaction Ratio
AISC	American Institute of Steel Construction	LAR	License Amendment Request
ASCE	American Society of Civil Engineers	mph	miles per hour
CDF	Core Damage Frequency	NRC	Nuclear Regulatory Commission
CE	Civil Engineering	psi	pounds per square inch
ETE	Engineering Technical Evaluation	RG	Regulatory Guide
FEA	Finite Element Analysis	SFP	Spent Fuel Pool
FDF	Fuel Damage Frequency	TB	Turbine Building
FHTSS	Fuel-Handling Trolley Support Structure	UCR	UFSAR Change Request
ft	foot / feet	UFSAR	Updated Final Safety Analysis Report

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