State-of-the-Art Reactor Consequence Analyses (SOARCA)

Regulatory Information Conference
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Agenda

- Opening Remarks and Overview
- Sequence Selection
- Accident Mitigation
- Accident Analysis
- Emergency Preparedness
- Comments

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OPENING REMARKS

Dr. Farouk Eltawila, Director
Division of System Analysis
Office of Nuclear Regulatory Research

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Overview

- State-of-the-art more realistic evaluation of severe accident progression, radiological releases and offsite consequences
- Integrated and consistent analysis of pilot plants (Peach Bottom, Surry) for important sequences (e.g., SBO, ISLOCA) subject to probabilistic considerations
- Account for plant design and operational improvements, credit existing and newly developed mitigative measures and site specific emergency plans

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Motivation

	Plant Design and Operations	Severe Accident Phenomenology	Emergency Planning
1982 Sandia Siting Study	Total CDF: $1x10^{-4}$/yr to $1x10^{-5}$/yr	Alpha Mode Failure Direct Containment Heating Conservative Accident Progression - Large and fast radiological release	Generic (including bounding) EP modeling
2008 SOARCA	Improved Plant Performance Total CDF: $1x10^{-5}$/yr to $1x10^{-6}$/yr Additional Mitigative Measures	Alpha Mode Failure is remote & speculative DCH resolved Realistic accident progression analysis	Improved Site Specific EP Modeling

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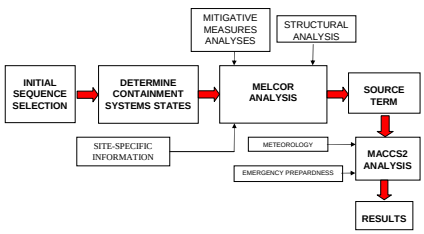
SOARCA PROCESS



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SEQUENCE SELECTION

Richard Sherry, Senior Risk Analyst
Division of Risk Analysis
Office of Nuclear Regulatory Research

Sequence Selection Process

- Full Power Operation
- Internal Initiated Events
  - SPAR model results
  - Comparison with licensee PRA
  - Discussions with licensee staff
- External Initiated Events
  - Review of prior analyses
    - IPEEE
    - NUREG-1150
  - Discussions with licensee staff

Sequence Groups

- Group core damage sequences that have similar initiating events, Sequence timing and equipment unavailability
- Initial Screening
  - CDF Initiating Events CDF $\geq$ 1E-7
  - Sequences with CDF $\geq$ 1E-8
- Sequences Evolution – Identify and evaluate dominant cutsets (~90% of CDF)
- Scenario grouping
- Sequences refined by external events and mitigative measures

Final Sequence Groups

- Screen in sequence groups with group CDF ≥ 10-6/RY

- or -

- Containment bypass sequence groups with group CDF ≥ 10-7/RY

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Containment Systems Availability

- Availability of engineered systems that can impact post-core damage containment accident progression, containment failure and radionuclide release and not considered in Level 1 core damage SPAR model
- Surry and Peach Bottom
  - Availability of containment systems based on support system status
- Sequoyah
  - Availability of containment systems determined using extended Level 1 SPAR model

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Sequence Groups
Peach Bottom Atomic Power Station

- Peach Bottom Internal Events
  - None (Dominant below the screening threshold was SBO)
- Peach Bottom External Events (Seismic)
  - Long Term SBO (RCIC available early) ($1x10^{-6}$ to $5x10^{-6}$ /yr)

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Sequence Groups
Surry Power Station

- Surry Internal Events
  - ISLOCA (7×10^{-7}/yr)
  - SGTR (5×10^{-7}/yr)
- Surry External Events (Seismic)
  - Long-term SBO (TD-AFW available early) (1×10^{-5} to 2×10^{-5}/yr)
  - Short-term SBO (TD-AFW failed) (1×10^{-6} to 2×10^{-6}/yr)

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MITIGATIVE MEASURES

Robert Prato, Senior Program Manager
Division of System Analysis
Office of Nuclear Regulatory Research

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Mitigative Measures Analysis

- Qualitative, sequence-specific systems and operational analyses
  - Licensee identified mitigative measures from EOPs, SAMGs
  - Other applicable severe accident guidelines
- Input into the MELCOR analyses

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Mitigative Measures Analysis Process

- Consider all mitigative measures
- Conduct sensitivity analyses to assess the effectiveness of different mitigative measures

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Mitigative Measures Analysis Process

- For each sequence grouping, identify the potential failure mechanisms and determine available mitigative measures
- Perform a system and an operational analysis based on the initial conditions and anticipated subsequent failures
- Determine the anticipated availability, capability and the time to implementation (e.g., TSC activation)
- MELCOR used to determine the effectiveness of the mitigative measures based on capability and estimated time of implementation

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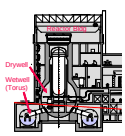
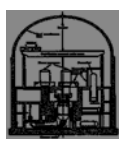
Structural Analyses

Evaluate the behavior of containment structures under unmitigated severe accident conditions to predict the following performance criteria at the selected sites:

- Functional Failure Pressure - Leakage
- Structural Failure Pressure - Rupture
- Develop Leakage Rate and/or Leakage Area as a Function of Internal Pressure



Peach Bottom "Mark I – Steel Containment"



Surry "Reinforced Concrete Containment"

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Peach Bottom LTSBO

- Effectiveness of Mitigative Measures
  - Batteries were available for ~ 4 hours
  - RCIC automatically started and prevented loss of RCS inventory
  - Operator, by procedure, depressurizes at ~ 1 hr
  - Portable power supply ensures long-term DC to hold SRV open and provide level indication (allow management of RCIC)

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Surry LTSBO

- Dominant containment dominant failure mode is leakage from cracking around the Equipment and/or Personnel Hatches
- Effectiveness of Mitigative Measures
  - Batteries were available for ~ 8 hours
  - TDAFW Pump automatically starts to makeup to the SGs
  - SG PORVs operable on DC power for 100 F/hr RCS cooldown
  - Portable power supply ensures long-term DC to provide level indication (allow management of TDAFW)
  - Portable pump provided make up for RCP seal cooling

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Surry STSBO

- Dominant containment dominant failure mode is leakage from cracking (9 in^2) around the Equipment and/or Personnel Hatches
- Effectiveness of Mitigative Measures
  - AC and DC power are unavailable
  - Mechanical failure of TDAFW Pump, fails to start
  - No instrumentation or RCS makeup
  - Portable pump provided containment spray within 8 hours (spray operation terminated @ 15 hours)

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Surry SGTR

- Effectiveness of Mitigative Measures
  - All ac and dc power supplies were available
  - All instrumentation was available
  - Plant response
    - HPI, AFW initiate
    - Turbine stop valves close
    - Steam dump valves throttle and close

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SEQUENCE ANALYSIS

Randall Gauntt, Project Manager
Sandia National Laboratories

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EMERGENCY PREPAREDNESS

Randolph Sullivan, CHP
Office of Nuclear Security and Incident Response

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Objective

- Realistically model emergency response during a severe accident
- Evolutionary improvement over past EP modeling

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Assumptions

- Emergency plans will be implemented
- The public will largely obey direction from officials
- Emergency workers will implement plans

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Technical Basis

- Site, State and local emergency plans
- Site emergency classification procedures
  - Aligned with accident progression from MELCOR
- State/local protective action procedures
  - Precautionary protective actions modeled
- Evacuation Time Estimate (ETE)
- Oak Ridge Evacuation Modeling System for evacuation beyond EPZ (if necessary)

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Identify Cohorts

- ETE data:
  - General public
  - "Tail" of public
  - Special needs
- Precautionary protective actions:
  - Schools
  - Parks, beaches, etc.

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Identify Cohorts

- Non-evacuating (0.5%)
- Shadow evacuation (10%)

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Speed of Travel

- Determined from ETE and OREMS
- Modified in space and time
  - "Bottle necks" identified
  - Free flowing areas identified
  - Road loading timing

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Example ETE

Region	Population	Non-Evacuating	Evacuated	Number of Vehicles
0-10	71,400	400	71,000	41,000

EPZ Evacuation Times

- 6.5 hours (from ETE)

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Speed of Travel

- MACCS2 does not allow input of road loading function
- Median speed of cohort assumed
  - Speeds adjusted for areas of free flow or congestion
- Distance travelled assumed 50% more than radial
- Median speed equals dist/time to clear

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Example Accident

- Long Term Station Blackout scenario
- General Emergency is declared about 2 hours after loss of all A/C power
  - Evacuation starts at General Emergency
  - No precautionary evacuation of schools (Site specific decision)

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Comments and Questions