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Dry Cask Storage PRA Peer Review Requirements Workshop

NRC Church Street Building
January 27-30, 2015

Industry Dry Cask PRA Efforts

- In EPRI Report 1003011, “Dry Cask Storage Probabilistic Risk Assessment Scoping Study,” March 2002, the basic approach to performing such a PRA was explored
- This presentation provides some highlights from that document

Historical Perspective

- Dry cask storage was first implemented in the 1980s with a limited term of 20 years
- The licensing period was the time expected for the federal government to dispose of the spent nuclear fuel
- Since that did not occur, the industry and the NRC decided to investigate performance of PRAs of the dry cask storage option

Purpose

- Describe and evaluate the current state of risk assessment methodologies applicable to dry cask storage PRA
- Suggest appropriate approaches for performing the various aspects of a dry cask storage PRA

PRA Technical Elements

- Initiating Events
  - Passive design
  - Human errors and equipment failures
  - External hazards similar to at-power nuclear power plant
- Accident Sequence
  - No active criticality control function
  - Inventory control (water) not a critical safety function
  - Different end states: fuel failure, containment failure, radionuclide release, dose, economic loss

PRA Technical Elements

- Systems Analysis
  - Not a significant portion of a dry cask storage PRA
- Human Error
  - Pre-initiators, Errors causing initiating events, Post-initiators, and Recovery
  - Focus on errors that cause an initiating event (rather than post-initiators)

PRA Technical Elements

- Data
  - Initiating event frequencies; equipment failure rates
  - Not much data available
- Structural Evaluation
  - Containment (cask) structural failure in response to accident loads
  - Generally external loads (e.g., cask drops), rather than internal temperature/pressure

PRA Technical Elements

- Thermal Hydraulic Evaluation
  - Use of codes other than MAAP
- Consequence Evaluation
  - Based on the number of fuel bundles stored for some time
  - Dry cask storage are typically outside with no surrounding structure

Technical Elements for Recommended PRA Approach

- Initiating Events
- Accident Scenarios
- Human Error Interface
- Systems Analysis
- Data Development
- Structural Evaluation
- Thermal Hydraulic Analysis
- Radionuclide Release/Consequence Evaluations
- PRA Computer Modeling/Quantification

Initiating Events

- Cask Tipover
- Cask Drop
- Flood
- Fire
- Explosion
- Lightning
- Earthquake
- Loss of Shielding
- Blockage of All Air Vents
- Tornadoes
- Nearby Facility Accidents

Accident Scenarios

- Event tree headers
  - Initiating Event and Hazard
  - Inner Cask Integrity
  - Fuel Cladding Integrity
  - Building Integrity
  - Recovery and Mitigation
- Endstates
  - Failure of cask containment
  - Failure of retrievability of fuel
  - Release of fission products from cask
  - Dose to onsite workers
  - Dose at site boundary
  - Economic cost

Human Error Interface

- Human errors during:
  - Fuel loading
  - Cask decontamination/closure
  - Transportation inside building
  - Transportation to storage pad
- Human error probabilities (HEP) supported by review of operating history/observation of tasks
- Need to adapt current HEP methodologies; sparse information available

System Analysis

- Use fault trees
  - Component level failure modes
  - Independent and dependent failure events
  - Human error probabilities
  - Developed support system logic (from internal events PRA)

Data Development

- Initiating Event Frequency Data
  - Crane failure rates
  - Aircraft crash rates
  - Onsite vehicle crash rates
  - Natural phenomena occurrence rates (seismic, winds, floods, lightning, forest fires)
  - Other external hazards
- Equipment Failure Rates
  - Random failure rates
  - Dependent failure rates

Structural Evaluation

- Structural fragilities of buildings and casks
- Use of finite elements codes (e.g., ANSYS)
- Use of more simplistic and conservative assumptions (in lieu of structural analysis)

Thermal Hydraulic Analysis

- MAAP has no obvious application
- Thermal heat-up calculations can be performed using ANSYS (steady state and transient calculations)

Radionuclide Release/ Consequence Evaluations

- Calculated consequences should be used as the basis for the definition of the accident sequence end state
- Some industry studies have been performed

- NRC analyses are only Level 1/Level 2 PRAs

PRA Computer Modeling/ Quantification

- Suggests the use of EPRI's Risk & Reliability Workstation codes:
  - ETA (event trees)
  - CAFTA (fault trees)
  - PRAQuant (quantification) (today: using FTREX with PRAQuant)
  - (today: SYSIMP (important measures)
  - (today: UNCERT (uncertainty analysis)