PRA Uncertainty Workshop
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Level 2 Session Summary Presentation

Don Vanover
ERIN Engineering
Tim Wheeler
Sandia National Laboratories

Sources of Level 2 Model Uncertainty

- Presenters
  - Don Helton, NRC Office of Nuclear Regulatory Research
  - Dr. Richard Denning, The Ohio State University
  - Mark Leonard, dycoda LLC
  - Jeff Gabor, ERIN Engineering
  - Ray Schneider, Westinghouse Electric Corporation

Sources of Level 2 Model Uncertainty

- Scope
  - Full Level 2 (Not Just LERF)
  - Consideration of Accident Management Strategy Development
  - Limited to At-power Conditions
  - Attempted to Account for New Reactor Designs

Sources of Level 2 Model Uncertainty

- Technical Elements
  - Level 1 / Level 2 Interface
  - Containment Capacity
  - Severe Accident Progression
  - Probabilistic Treatment
  - Source Term Analysis

Level 1 / Level 2 Interface

- Loss of Information due to PDS simplification
  - Initiator and support system dependencies
  - Prior equipment failures
  - Operator action dependencies (including available time)
  - Functional dependencies (including degraded plant conditions)
  - Common cause dependencies

Level 1 / Level 2 Interface

- Loss of Information due to PDS simplification
  - Are the number of PDS groups sufficient to represent the significant differences among the Level 1 sequences?
  - If fewer PDS groups are used does the "representative" sequence reasonably bound the set of sequences assigned to the PDS and are the intergroup sequence characteristics sufficiently similar such that the representative sequence does not create a overly conservative or non-conservative bias in the modeling?

Level 1 / Level 2 Interface

- Loss of Information due to PDS simplification
  - Model Uncertainty Significance
    - HIGH potential impact on risk insights, but
    - Not a true source of model uncertainty but is a Level of Detail Issue
      - Should be able to address (Peer Review)
    - Potentially addressed with targeted dynamic PRA

Level 1 / Level 2 Interface

- Partial / degraded performance not credited in Level 1
  - Model Uncertainty Significance
    - Potential to be HIGH (Unknown)
    - Need better understanding of impacts of partial injection (below L1 success criteria)
    - May apply to Level 1 data collection (definition of failures) or lower capacity systems
    - Focused investigation may be warranted

Containment Capacity

- Dynamic Load Impacts on Failure Modes
- Methods for Containment Response from Dynamic Loads
  - Dependent on geometry and definition of impulse
  - Model Uncertainty Significance
    - HIGH
    - Typically handled with separate engineering analysis
    - Is there a middle ground between hand calcs and full-blown CFD solutions? (Research and tool development)

Containment Capacity

- Seismic Induced Leakage for Well Beyond Design Basis Earthquakes
  - Model Uncertainty Significance
    - MEDIUM
    - Factor into fragility for containment building

Containment Capacity

- Quasi-steady failure threshold methods and correlation between failure pressure and leak rate
  - Model Uncertainty Significance
    - MEDIUM
    - Handle with sensitivity studies and address in CET structure
    - More of an impact on Level 3 analysis
    - Continued need for ASME / NRC efforts in this area

Containment Capacity

- Ageing Impacts on Threshold Failure
  - Model Uncertainty Significance
    - LOW
    - Revisit fragility curve (NUREG/CR-6920, Risk-Informed Assessment of Degraded Containment Vessels)
      - Showed not big impact on NUREG-1150 results
    - Plant would need to address aging mechanisms

Severe Accident Progression

- Recovery of Degraded Core
  - H2 Production
  - Arrest Core Melt Progression?
  - Re-criticality
  - **Impacts on Accident Management Strategies**
  - Model Uncertainty Significance
    - HIGH
    - Address with focused sensitivity studies
    - Additional research warranted

Severe Accident Progression

- Onset of Fuel Relocation
  - Affects H2 Production and Source Terms
  - Model Uncertainty Significance
    - MEDIUM
    - MAAP / MELCOR codes benchmarked to in-pile experiments
    - Included as part of SOARCA uncertainty analysis

Severe Accident Progression

- Treatment of Natural Circulation
  - Loop Seal Clearing
- Thermally Induced Failures of RCS
  - Creep Rupture
  - SG tube flaw/wear distribution
  - Instrument Tube Failures
  - SRV/MSL Failures
  - Model Uncertainty Significance
    - HIGH
    - Address with focused sensitivity studies (separate effects CFD models or MAAP/MELCOR sequence assumptions)
    - Could be more important to unanalyzed reactor designs

Severe Accident Progression

- Lower Head Failure Modes
  - Creep vs Penetration Failures
  - Timing
- Ex-vessel Cooling
  - Important for new reactor designs
  - Model Uncertainty Significance
    - HIGH
    - Significant Impact on Accident Sequence Progression

Severe Accident Progression

- Energetic Containment Challenges
  - DCH / HPME (adequate technical understanding exists)
  - Cavity Steam Explosion (plant-specific issue)
    - Triggerability
  - H2 Combustion
    - DDT
    - Need for specialized tools (H2 distribution, flame/wave propagation)
  - Model Uncertainty Significance
    - HIGH
    - Ability to Mechanistically Treat Energetic Structure/SSC Challenges for specific containment designs

Severe Accident Progression

- Core Concrete Interactions
  - Consequences of undermining of structures
  - Debris Coolability in wet cavity/sumps
  - Model Uncertainty Significance
    - MEDIUM/HIGH
    - Potential large impact on magnitude of late releases and land contamination issues

Probabilistic Treatment

- Modeling of Operator Actions during Severe Accidents
  - HFE and HEPs
    - Performance Shaping Factors
  - Model Uncertainty Significance
    - HIGH
    - Already Recognized as Source of Model Uncertainty in NUREG-1855 and EPRI 1016737

Probabilistic Treatment

- Equipment / Instrument Survivability for SAMG implementation
  - Aux Building Equipment
  - SRV Failure
  - Random Failure Probabilities of SSCs not covered in Data Collection
  - Model Uncertainty Significance
    - HIGH
    - If credited, could improve risk profile and realism
    - Needs to be considered in Level 2 Model Development

Probabilistic Treatment

- Model and Parameter Physical / Phenomenological Correlation
  - Challenge is translating deterministic relationships to probabilistic models (e.g., H2 generation impacts on multiple other facets of analysis)
  - Model Uncertainty Significance
    - MEDIUM
    - Mostly impacts uncertainty propagation

Probabilistic Treatment

- Passive System Reliability
- Particularly for new reactor designs
  - Model Uncertainty Significance
    - HIGH
    - Should be addressed with focused research and experiments

Source Term Analysis

- Chemical Forms
  - Speciation of volatiles (Cs, I)
  - Release of groups historically considered as lower volatiles (e.g., Cerium, Barium) – Identified in SOARCA
- Release models from CCI
  - Model Uncertainty Significance
    - MEDIUM
    - More of long term health effect issue

Source Term Analysis

- Retention / Re-evolution in RCS
- Plate out in containment / Aux Bldg and re-evolution
  - Re-evolution of Iodine
- Impact from Accident Duration Truncation of Sequence Runs
  - Model Uncertainty Significance
    - MEDIUM/HIGH
    - Some impacts on short term releases, but more important for long term effects