Spent Fuel Pool Modeling and Analyses

Ex 5 portions

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Spent Fuel Pool Analyses

- **Evaluate Response to Initiating Events in Terms of Heatup and Source Term Generation**
  - Partial Pool Drainage
  - Complete Pool Drainage (Air Natural Circulation)

[ ] Ex. 5

- **FLUENT and FLOW-3D Used to Evaluate**
  - Details of Single Assembly in Air Circulation and Heat Flows

[ ] Ex 5

  - Flow and Mixing Behavior in Pool and Building
  - Provide Boundary Conditions for MELCOR Analyses
- **MELCOR Will Analyze**
  - Global Response of Pool and Assemblies,
  - Fuel Damage, Steam and Air Oxidation
  - Fission Product Source Term
  - Mitigation or Recovery Actions

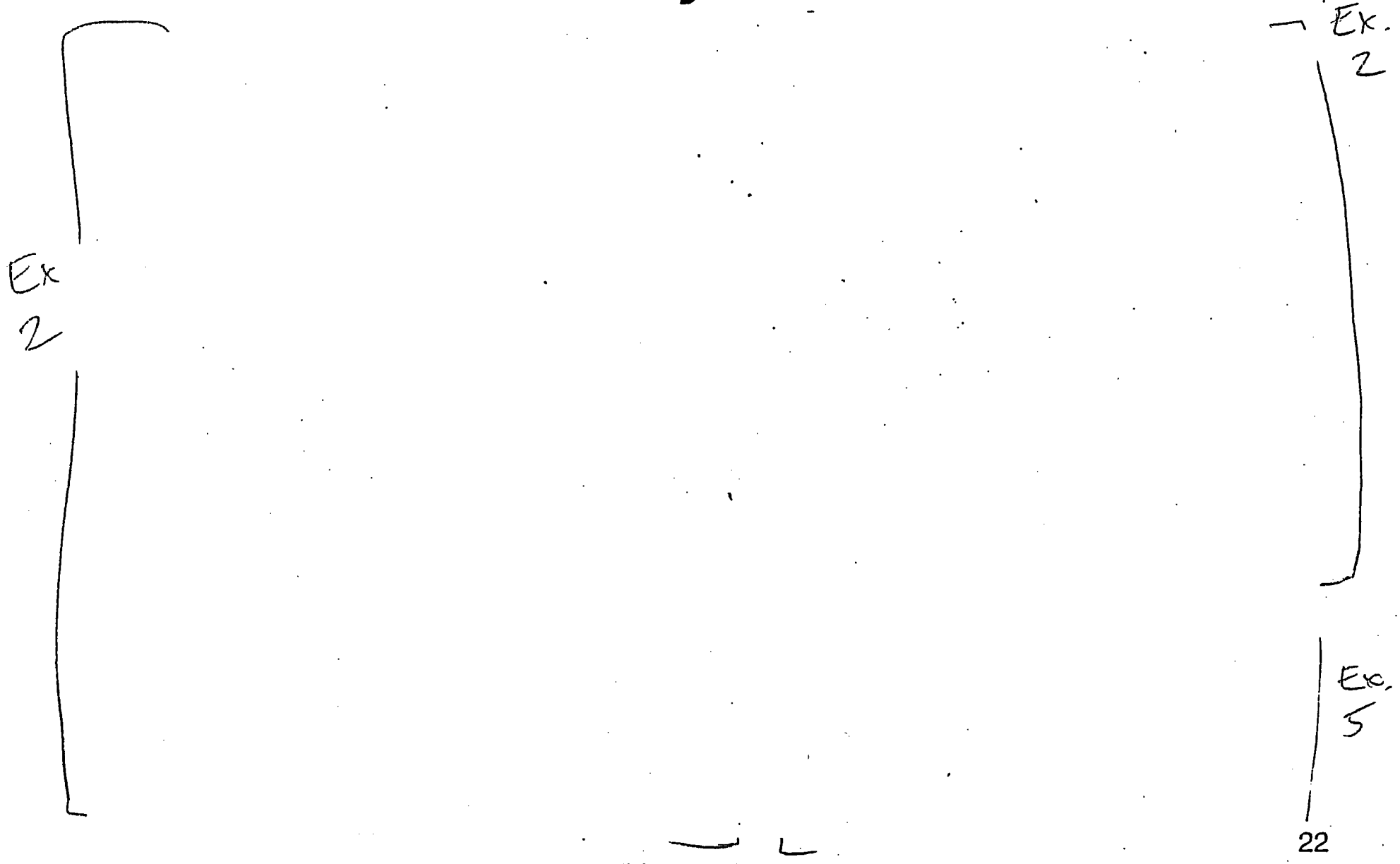
Overview of CFD Analyses

- **Intent is to analyze flow details of individual assemblies to provide input and boundary conditions for MELCOR models of SFP**
  - Detailed flow and pressure drops → loss coefficients
- **Full pool and building analysis using porous media approximation will provide additional flow boundary conditions for MELCOR**
  - Principal flow patterns → MELCOR volume/flow path nodalization
  - Room air mixing → correct return air temperatures
  - Underfloor pressure drops → [redacted] Ex. 5

MELCOR SFP Modeling Approach

- **2 Model Approach - Separate Effects and Whole Pool/Building Models**
  - Subdivided into 2 Types of Scenarios
    - **Complete Loss-of-Inventory**
    - **Partial Loss-of Inventory**
- **Separate Effects Model**
  -
  - **Developed to Guide Full SFP Model Development**
    - **Identify Sensitivities and Uncertainties**
    - **Use Separate Effects Model to Develop Appropriate Modeling Approach and Code Improvements**
  - **Full SFP + Building Model**
  - **Integral Effects**
  - **Whole SFP Source Term**

Geometry of Fuel Racks



SFP Geometry/Inputs

- **Scoping Study Data Obtained from Utility Submittal for Conversion to High Density Racking**
  - Complete Holtec Licensing Analysis
  - Detailed Geometry

[-

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[

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MELCOR SFP Separate Effects Model Calculations

- >50 Calculations Completed in Preliminary Matrix
- Considerable Effort to Develop Robust Model
  - Model Includes

[redacted] Ex. 5

- Parametric Calculations Performed on Both Scenarios
  - Complete Loss-of-Water Inventory
  - Partial Loss-of-Water Inventory

Fission Product Modeling

Fission Product Modeling

Objective: Reflect Best-Estimate Fission Product Release, Transport and Deposition

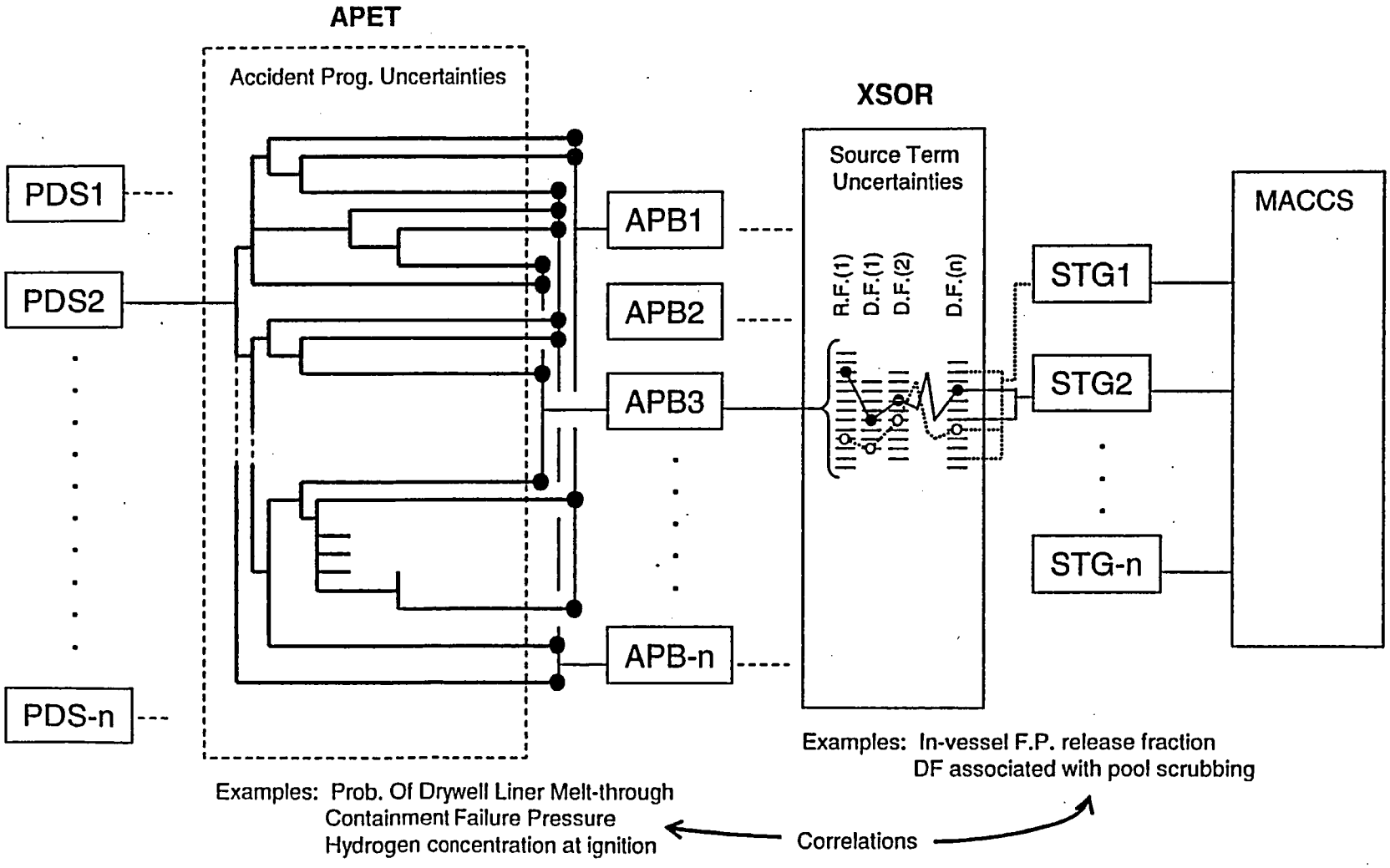
- **Review and assess present MELCOR fission product source term modeling**
- **Update as appropriate for present applications**

[redacted]

Ex 5

Analysis of Risk and Uncertainty

NUREG-1150 Probabilistic Risk Analysis



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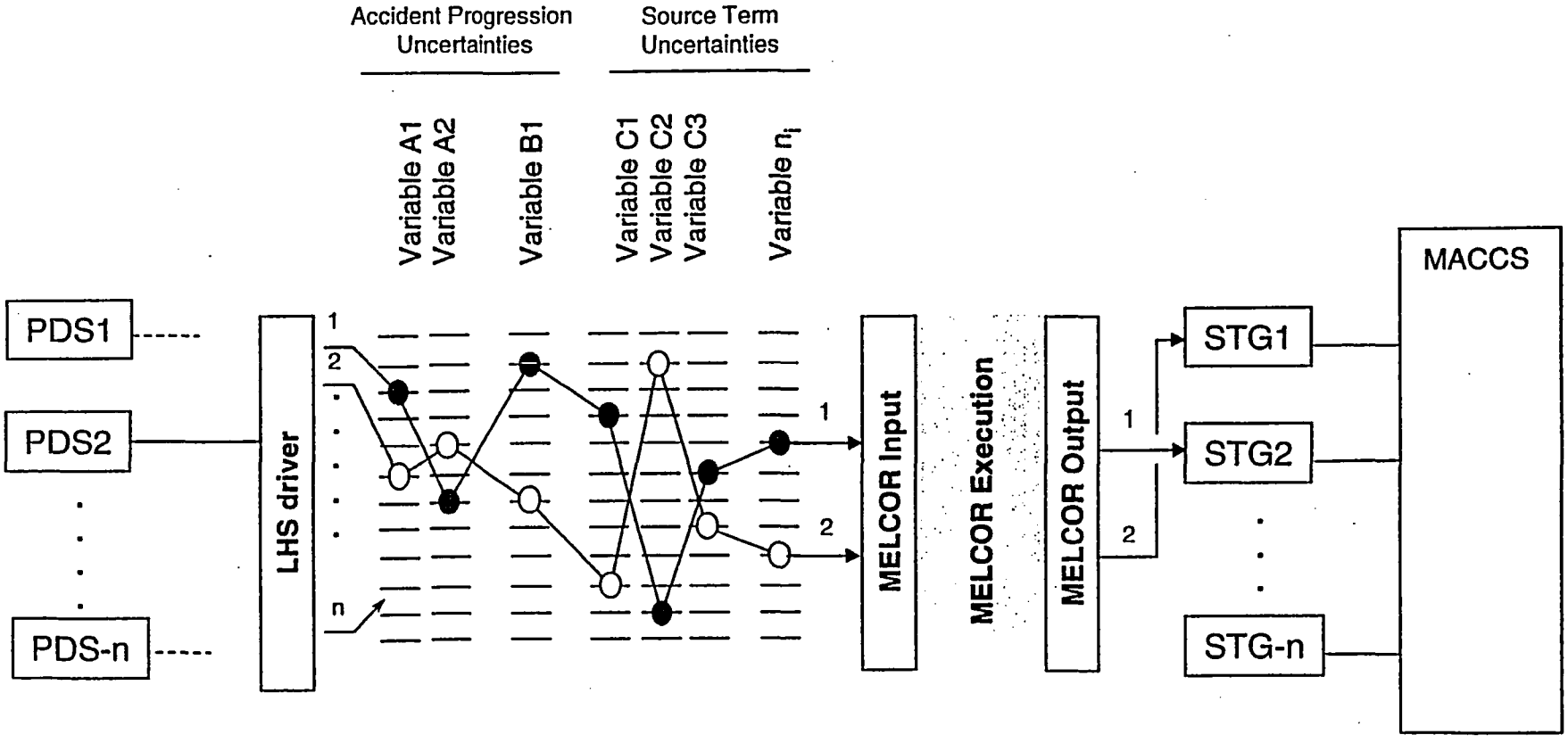
Probabilistic Physical Process Modeling



Example Use of MELCOR in Uncertainty Analyses: In-Vessel Hydrogen Production

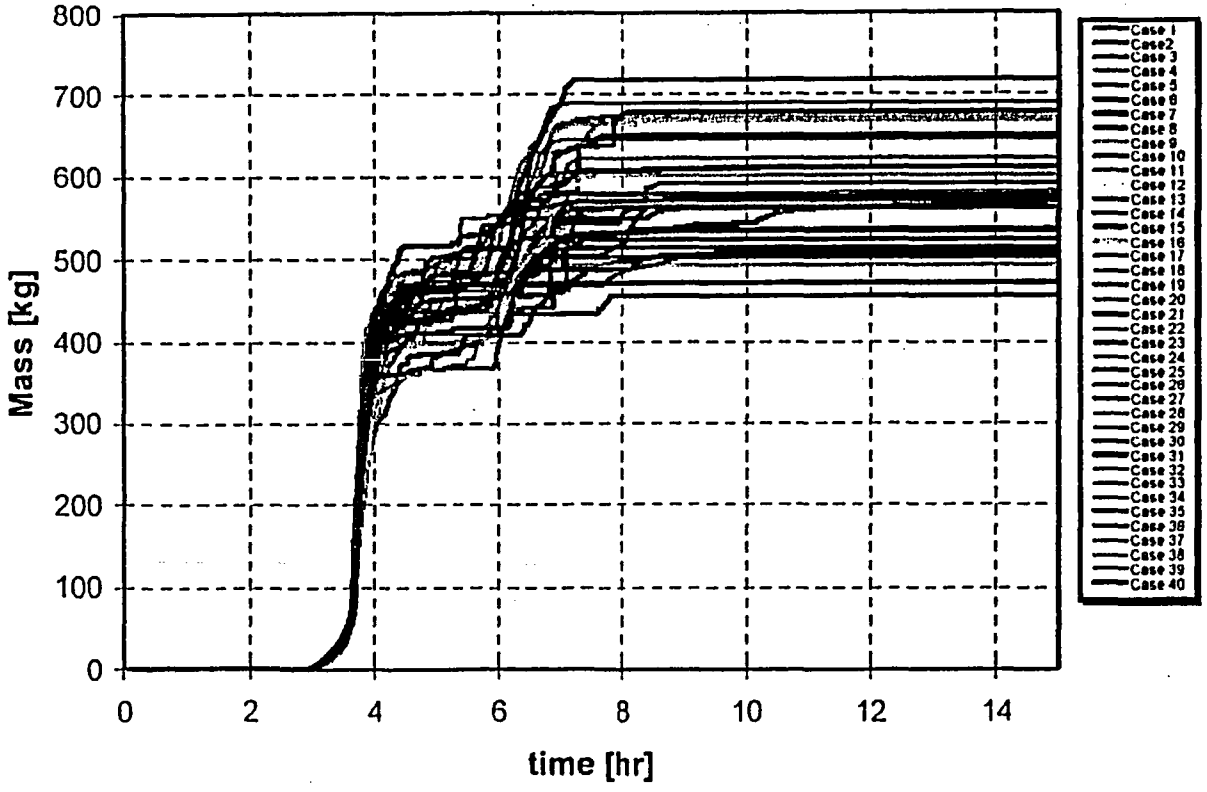


Figure 1 - In-Vessel hydrogen uncertainty range.

- **LHS sampling of 12 uncertain parameters produced 40 MELCOR input files**
- **40 calculations for STSBO produced for Sequoyah**
- **Determination of parameter importance underway**

Testing Activities

ANL Cladding Air Oxidation Experiments

- **Present data base sparse in low temperature regime**
- **Experiments presently underway at ANL**
- **Emphasis on low temperature oxidation in air**
  - Important in predicting thresholds for initiating zirconium fire
- **Will incorporate data in MELCOR as is becomes available**

SFP Thermal Hydraulic Experiments

- Characterize effect of SFP geometry on air thermal-hydraulics and onset of oxidation
  - Grid spacers and end pieces
  - SFP rack construction, flux trap, boral
  - Under-floor details affecting flow and pressure drop
    - Flow paths and Bernoulli effects
- Characterize air oxidation and Zirc Fire Onset
  - Heat generation from oxidation and nitriding combined with decay heat profile
  - Air reactions affecting flow and pressure drop
  - Burn localization, role of radiation heat transfer
    - Rack wall heating, failure (melting and materials interaction)
    - Adjacent assembly heating and zirc-fire propagation
- Model Integral effects
  - Modeling extensions to capture integral behavior of SFP damage progression
- Testing also applicable to Dry Cask Storage analysis

Fission Product Release Experiments

- Data on fission product release from fuel in air-oxidation environment deficient
- Ru release of more volatile oxide expected - data lacking
- UO_2 oxidation to volatile higher oxides also expected
  - Fuel decrepitation observed in Canadian testing
  - Large fuel volatilization can release otherwise low volatile fission products owing to physical stripping of fuel matrix