OAK RIDGE National Laboratory

A Method of Performing k_{eff} Validation of As-loaded Criticality Calculations using UNF-ST&DARDS

Justin Clarity

B. J. Marshall

Kaushik Banerjee

John Scaglione

Oak Ridge National Laboratory

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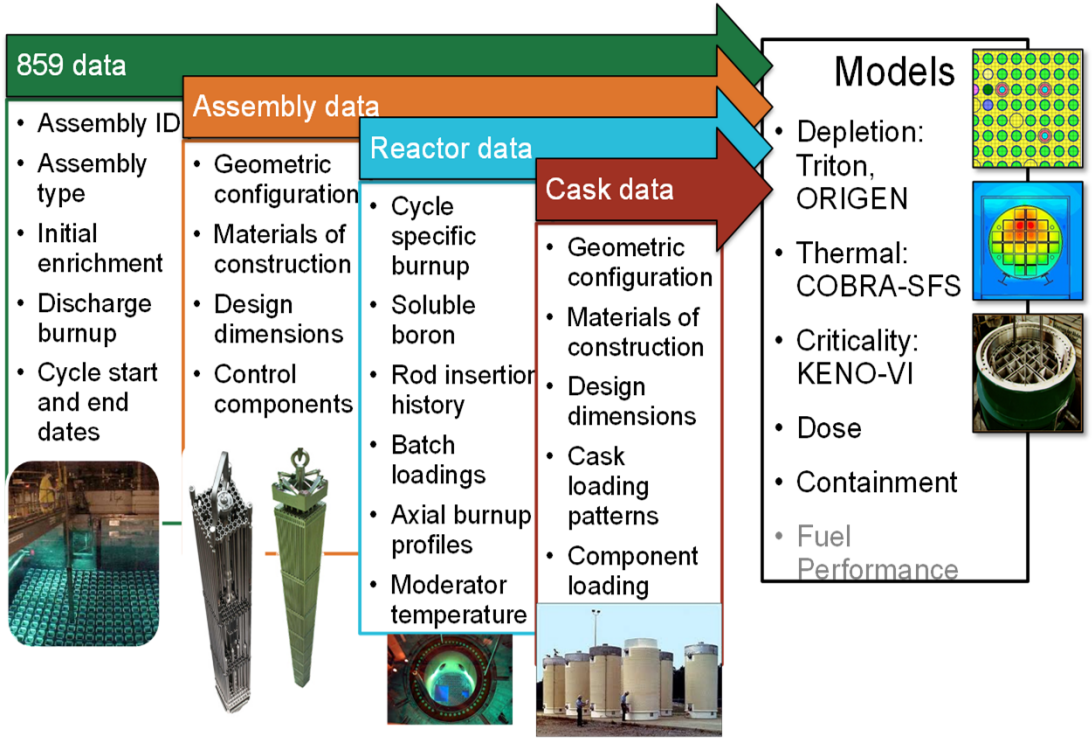
Overview

- UNF-ST&DARDS
- Criticality calculations within UNF-ST&DARDS
- S/U based k_{eff} validation
- S/U based k_{eff} validation for UNF-ST&DARDS

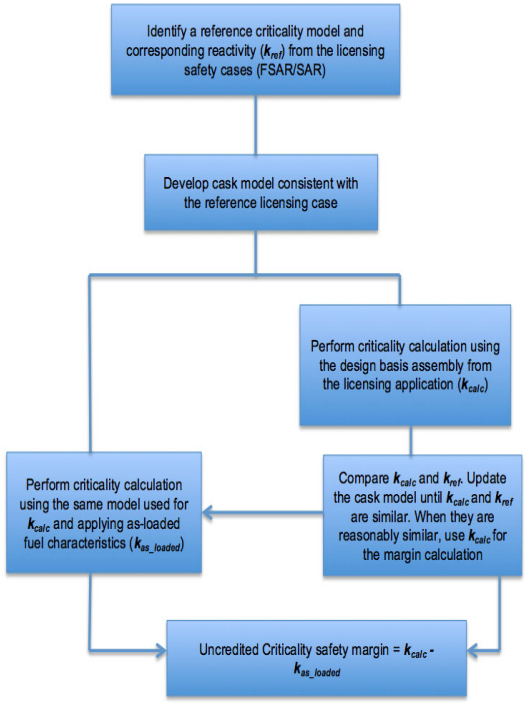
UNF-ST&DARDS provides a means to integrate data and analysis tools to estimate safety margins

- A Unified tool that contains modeling information in a database integrated with analysis codes
- Database contains GC-859 collected fuel, irradiation information, and cask loading maps
- The tool also contains
  - templates for a number of canisters and fuel assemblies
  - ORIGEN libraries for a diverse set of fuel assembly types
- Criticality calculations are performed for storage /transportation and disposal



Criticality Analysis

- Model Individual assemblies with nominal assembly enrichments, burnups and cooling times for desired analysis date from GC-859
  - Transportation: In-service date to 2100
  - Disposal: In-service date to 25,000 years
- Transportation
  - Calculation of k_{eff} values for each date
  - Calculation of margin to the licensing basis
- Disposal
  - Degraded Neutron Absorber
    - Neutron absorber was not credited in the analysis
    - Assumed survival of basket structure for SS components but failure of CS components
    - Subcritical limit of 0.98 assumed
- To perform more complete criticality calculations k_{eff} and Isotopic validation are necessary

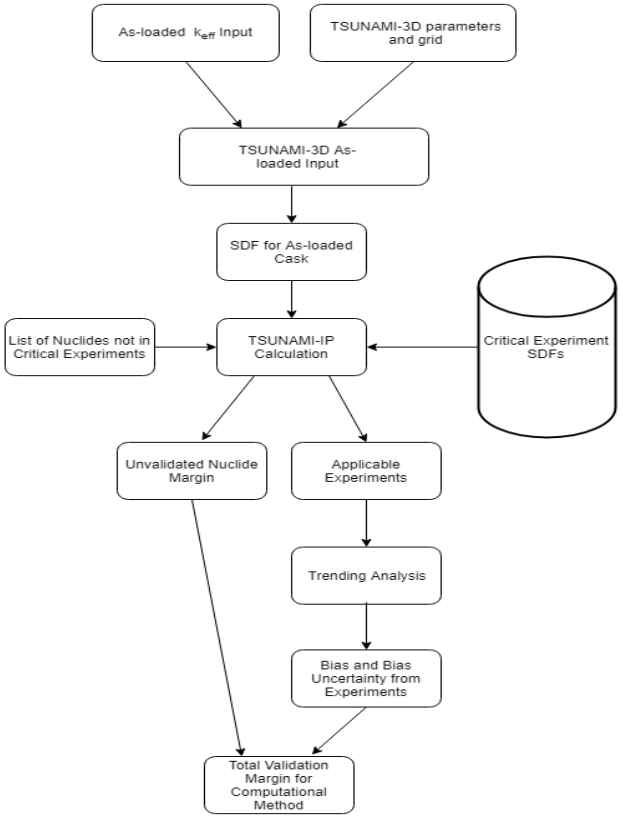


S/U Techniques for Validation

- Typically used for:
  - Judging similarity of safety application model to critical experiment benchmarks (integral indices)
  - Propagating nuclear data uncertainties into uncertainties in k_{eff} – used for penalty for unvalidated minor constituents in model
- Calculate sensitivities of k_{eff} to the underlying nuclear data and propagate
  - $C_{kk} = SC_{\propto\propto}S^T$
- Calculate correlation coefficients for similarity
  - $c_k = \frac{\sigma^2_{appexp}}{\sigma_{app}\sigma_{exp}}$
- Often trend on values of c_k

UNF-ST&DARDS Validation Process

- Convert CSAS model into TSUNAMI-3D model
- Perform TSUNAMI-3D calculation to generate SDF for As-loaded application
- TSUNAMI-IP calculation to generate c_k values for application and exps and FP uncertainties
- Perform USLSTATS calculation to determine validation bias and bias uncertainty



TSUNAMI-3D Calculation

- Most challenging sensitivity calculation to date
  - Unique composition in each axial node of each
- Three methods of performing calculations
  - Multigroup
    - Serial execution only – memory limitations
    - Large memory footprint
    - Over 1 day of cross section processing time alone
  - CLUTCH
    - Allows for parallel execution
    - Requires $F^*(r)$
  - IFP
    - Most accurate but most expensive
- Investigating the use of CLUTCH

TSUNAMI-IP Calculations

- Used to compare the TSUNAMI-3D generated SDFs to calculate c_k values with a predefined set of SDFs for critical experiments.
- Library of pregenerated SDFs for comparison with application cases
  - 1,643 Experiments that have been used in previous burnup credit validation work
    - VALID and NEA SDFs
    - HTC, LCT, MCT, MST Experiment sets
- Also calculate uncertainty due to minor actinides and fission products
  - No publicly available experiments include these nuclides

Bias Assessment

- USLSTATS to calculate bias and bias uncertainty
- Experiments and k_{eff}s filtered according to c_k using cutoff value
- Calculated via a trend on c_k and extrapolation to 1.0
- Combine bias and bias uncertainty with unvalidated nuclide penalty and administrative margin

Questions?