Nuclear Data in the Regulatory Framework

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Nuclear Data in the Regulatory Framework

Where does Nuclear Data Fit within the NRC's Regulatory Framework?
Nuclear data is used throughout the NRC's regulatory framework. Nuclear data support licensing activities in the Office of Nuclear Reactor Regulation (NRR) and Office of Nuclear Materials Safety and Safeguards (NMSS). Some activities include review of consolidated interim storage facilities, analyses of spent fuel pool criticality, and reactor physics analyses. All of these rely on quality nuclear data (e.g., ENDF/B), utilized through the neutronics computer code package SCALE.
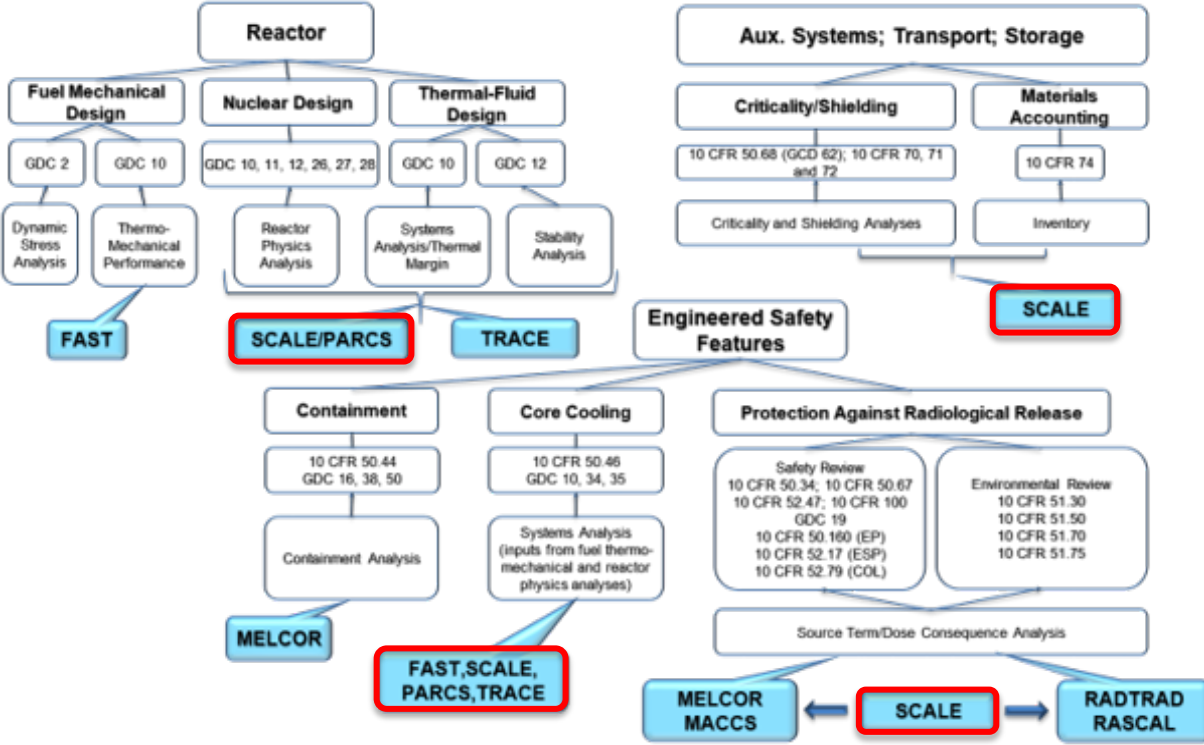
At the NRC, <u>nuclear data supports key current regulatory decision-making activities</u>, such as reactor power uprates, new fuel designs, new transportation package designs, and advanced reactor designs.

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NRC's Computational Tools for Regulatory Decision-Making
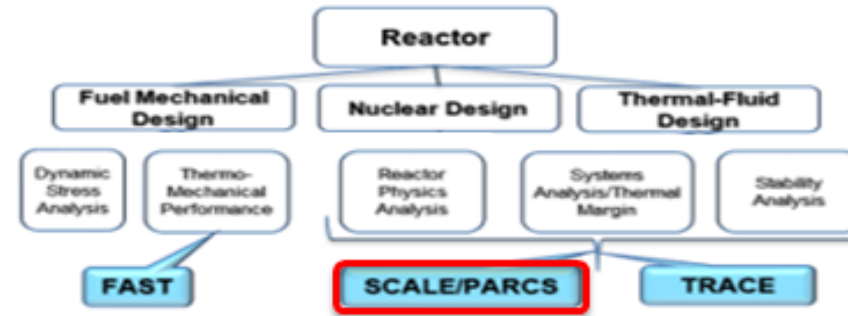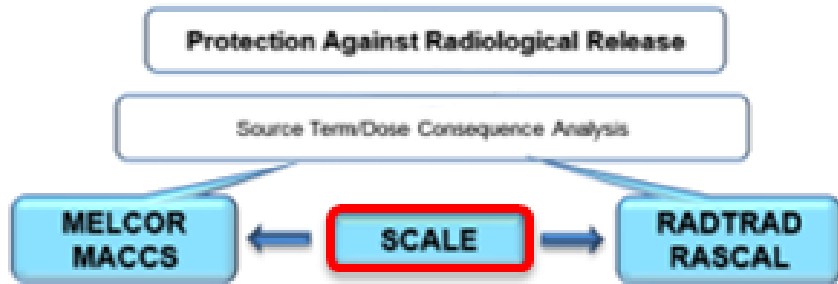
scale
- Nuclear data & cross-section processing
- Decay heat, criticality safety, radiation shielding
- Radionuclide inventory & depletion generation
- Reactor core physics

PARCS
- Advanced core simulator
- Neutron flux solver and depletion for transient

MELCOR
- Accident progression & source term characterization
- Thermal-hydraulic response of the reactor
- Core heat-up, degradation, and relocation
- Fission product release and transport behavior

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Nuclear Data Supporting Regulatory Analyses

Nuclear Data Sources

Activation (JEFF-3.0/A)
Activation reactions

Fusion (FENDL)
Activation reactions

ENDF/B
Physics data
Thermal scattering law
Resonance data
Energy distributions
Fission yields, decay constants, decay energy
Recoverable energy
Delayed neutron data

Includes all applicable uncertainties

scale

PARCS

MELCOR

Reactor & Source Term Analyses
- Radionuclide inventories & source term generation
- Reactor power distribution
- Depletion, eigenvalue, kinetics analyses
- Severe accident radionuclide transport

Dry Storage Systems & Transportation Package Analyses (10 CFR Part 71/72)
- Criticality safety
- Shielding & Dose
- Decay heat

- SCALE is the first step in processing nuclear data for developing problem-specific libraries
  - Confidence in SCALE's predictive solutions rely on quality and complete nuclear data
  - Requires measured mean values and associated uncertainties

LWR Activities at the NRC

Near-term ATF

| Higher burnup & Increased Enrichment | Chromium-doped fuels | Cr-coated Zirconium Cladding Systems | Iron-based claddings (FeCrAl) |

Long-term ATF

| Metallic Fuels | Silicon Carbide Cladding | Uranium Silicide Fuels | Uranium Nitride Fuels |

Does the NRC envision any nuclear data needs for LWRs, including ATF?
Large uncertainties in nuclear data, such as cross-sections, fission yields, and decay data, can propagate into increased uncertainties in key quantities of interests, used to support NRC activities (i.e., k-effective for criticality safety analyses, calculated reactivity coefficients for reactor physics applications). Key nuclear data activities, supporting the NRC, include ensuring nuclear datasets, including uncertainties are complete for the application areas mentioned.

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Non-LWR Activities at the NRC

Technology & Reactor Type	Key Design Characteristics	
High-Temperature Gas-Cooled Reactors (HTGRs)	**Fast Spectrum Systems**** • Uranium carbide fuel • Silicon carbide cladding • Helium-cooled	**Thermal Spectrum Systems**** • TRISO particle (<20 wt.% U-235) fuel • Graphite moderated • Helium-cooled X-Energy Xe-100**
Fluoride salt-cooled Reactors (FHRs)	**Thermal Spectrum Systems***** • TRISO particle (<20 wt.% U-235) fuel • Graphite moderated, • Molten fluoride salt cooled (Flibe) Kairos Power Hermes I & Hermes II***	
Molten Salt-fueled Reactors (MSRs)	**Fast Spectrum Systems** • Uranium-chloride salt fueled	**Thermal Spectrum Systems***** • Molten fluoride salt, fueled with UF_4 • LiF, BeF_2, UF_4 (< 20 wt.% U-235) • Graphite moderated
Sodium-cooled Fast Reactors (SFRs)	**Fast Spectrum Systems*** • High-assay LEU (HALEU) metallic fuels • Sodium coolant TerraPower Natrium*	

* Applications submitted (e.g., construction permit, operating license, etc.)
** Pre-application activities (e.g., topical reports, white papers, etc.)
*** Approved Construction Permit

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Non-LWR Nuclear Data Needs

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NUREG/CR-7289
ORNL/TM-2021/2002

Nuclear Data Assessment for Advanced Reactors

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- ## *NUREG/CR-7289*

  – Assessment on key <u>nuclear data relevant to reactor safety analysis</u> in selected non-LWR technologies

Does the NRC envision any nuclear data needs for non-LWRs?
NUREG/CR-7289 identified many key isotopes for the various types of non-LWR designs on the horizon. This assessment also identified missing nuclear data. Examples include:
- Many non-LWR designs are graphite-rich. Thus, complete nuclear data sets for graphite would be important. One key missing nuclear data identified was missing graphite thermal scattering uncertainty data.
- Nuclear data related to the salts (e.g., Flibe) under consideration. Some salts make use of Lithium-7. Large uncertainty in Li-7(n,γ) has found to be a dominating contributor to impacting reactivity effects.
- Understanding the differences between nuclear data libraries which impact reactivity (ENDF/B VII.1 to VIII.0) (e.g., Cl-35)

DNCSH program will address these identified data needs by generating new graphite scattering and Cl-35 cross-section data, which includes new measurements, evaluations, and validation.

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Summary - Nuclear Data Needs & Interests

Key Data Needs & Interests

- TSL data, including uncertainties
- Fission yields , including uncertainties
- Decay constants & branching ratio, including uncertainties
- Recoverable energy data, including uncertainties

Key data needs & interests revolve around isotopes that support near- and longer-term concepts (ATF/HBU/LEU+, non-LWRs, and fusion).

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Nuclear Data Related Research Activities

- Supported recent efforts to begin assessing ENDF/B-VIII.1 for NRC-applications
  - Understanding changes in k-effective and/or nuclide inventories with different ENDF/B libraries (VII.1, VIII.0, and VIII.1)

- Efforts underway to automate testing of new evaluated nuclear data libraries to support NRC-related assessments within SCALE
  - Quickly assess ENDF/B beta released libraries, allowing for greater opportunities for collaboration

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