



# Advanced Reactor Fuel Qualification Framework

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# Agenda

- ▶ NEA/CNRA Guidance on Fuel Qualification
- ▶ US NRC Guidance on Fuel Qualification
- ▶ Application of a Fuel Qualification Framework to Different Fuel Types
- ▶ Fuel Qualification Reviews Currently Underway

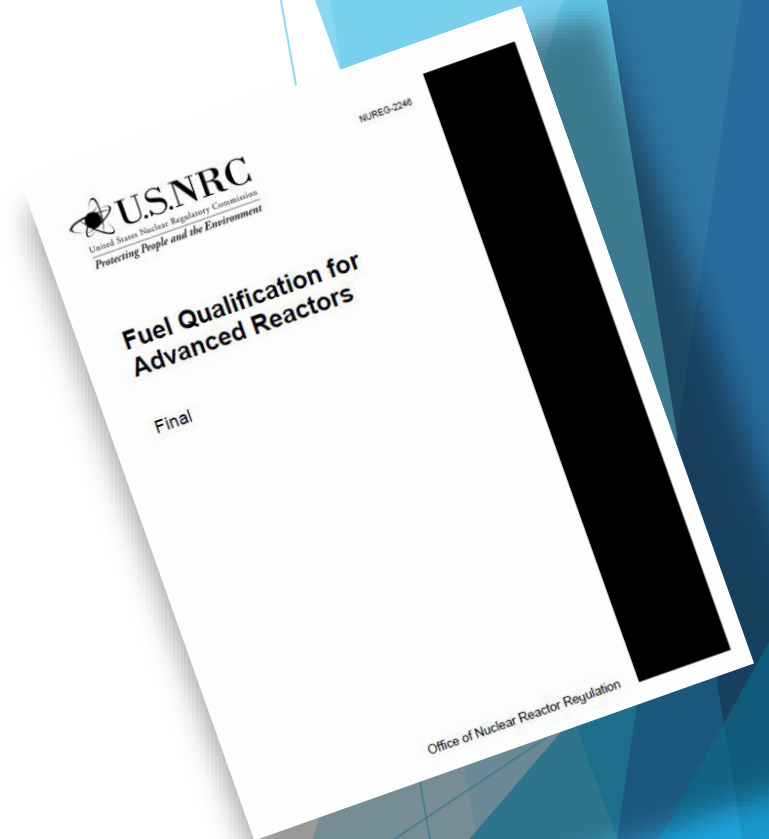
# NEA/CNRA Guidance on Fuel Qualification

- ▶ In December 2020, NEA/CNRA approved “Regulatory Perspectives on Nuclear Fuel Qualification for Advanced Reactors (NRC participated)
- Describes the regulatory perspectives on nuclear fuel qualification for advanced reactors and identifies topics that should be investigated in the frame of regulation, potentially involving additional research and development needs
- Based on input from Working Group on the Safety of Advanced Reactors (WGSAR) members and international experts from their respective organization
- ▶ The scope as defined by this report focuses on the identification and understanding of fuel life limiting failure and degradation mechanisms that occur as a result of irradiation during reactor operation.



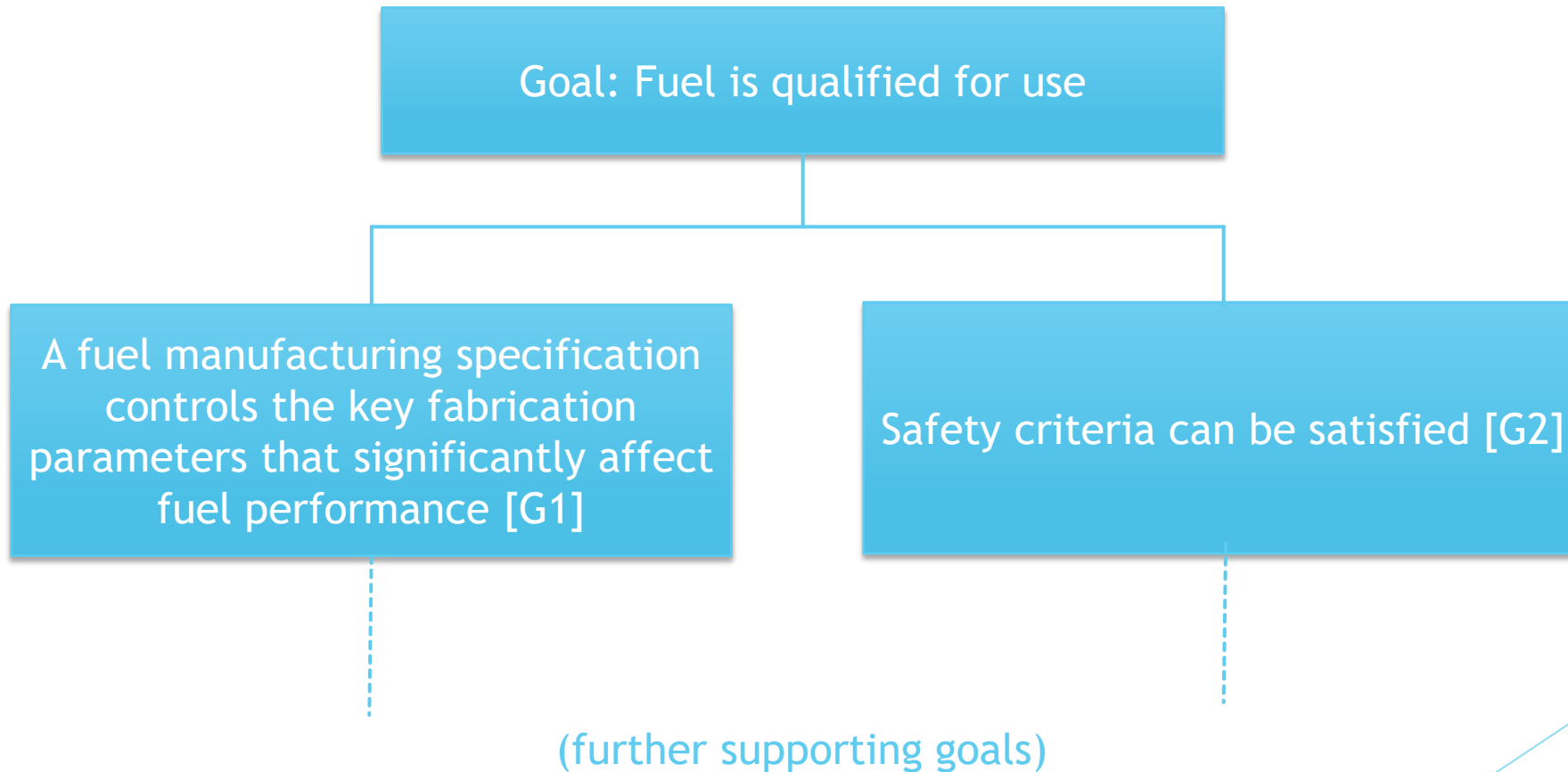
# US NRC Guidance on Fuel Qualification

- ▶ NUREG-2246 provides advanced reactor fuel qualification guidance for US applicants based on NEA/CNRA/2020
- ▶ Considers NRC regulatory guide 1.233 for use of a risk-informed licensing methodology
- ▶ The assessment framework emphasizes:
  1. the identification of key fuel manufacturing parameters,
  2. the specification of a fuel performance envelope to inform testing requirements,
  3. the use of evaluation models in the fuel qualification process, and
  4. the assessment of the experimental data used to develop and validate evaluation models and empirical safety criteria.
- ▶ Two supporting frameworks for assessment:
  - Evaluation model(s)
  - Experimental data



# US NRC Guidance on Fuel Qualification

- ▶ Top-down framework provides a systematic approach to identify high-level goals, and guidance to decompose each goal into supporting goals.



# US NRC Guidance on Fuel Qualification

- ▶ Framework flows down into progressively more detailed supporting goals/attributes, until no further detailed decomposition is needed
- ▶ These goals/attributes are technology-inclusive such that any fuel type should be able to justify meeting them through an appropriate test and analysis program
- ▶ Further guidance in the NUREG links goals/attributes to specific principal design criteria (PDC) corresponding to general or advanced reactor design criteria (GDC and ARDC, respectively), which are required by regulation

# Application of a Fuel Qualification Framework to Different Fuel Types

- ▶ Use of the framework could highlight areas for further development such as:
  1. Specific designs might use new cladding material with no pre-existing data
  2. Historical data might not have been performed under an acceptable QA program
  3. The planned reactor operating envelope might not be supported by existing data
  4. The state of knowledge regarding microstructure impacts might be insufficient
  5. Modifications/improvements in existing evaluation models for new applications or margin reduction
  6. Testing which would support first principal evaluation models to further the state of the art or accelerate fuel qualification.

# Application of a Fuel Qualification Framework to Different Fuel Types

- ▶ The NRC has contracted national laboratories to review the NUREG-2246 qualification framework and to apply the fuel qualification framework to other fuel designs. The goals are:
  1. to identify areas in which NUREG-2246 is insufficient or could be improved
  2. to use the framework to identify fuel data needs that could inform future test plans
- ▶ Idaho National Lab is evaluating applicability to metallic fuel (specifically EBR-II fuel but the results should provide insight for similar metallic fuel designs)
- ▶ Pacific Northwest National Lab is evaluating applicability to TRISO fuel
- ▶ Oak Ridge National Lab is preparing a molten salt specific NUREG/CR
- ▶ These contracts are in progress and expected to be completed in 2023. Results will be made public.



# Fuel Qualification Reviews Currently Underway

- ▶ The NRC has received submittals related to fuel qualification from:
  - ▶ Electric Power Research Institute (generic TRISO fuel qualification)
  - ▶ Kairos Power (TRISO fuel, salt coolant)
  - ▶ X-Energy (TRISO fuel, gas coolant)
  - ▶ Westinghouse (TRISO fuel, heat pipe cooled)
  - ▶ General Atomics (SiC-clad UC fuel, gas coolant)
  - ▶ Natrium (metallic fuel, salt coolant)
- ▶ Pre-application reviews are ongoing with a wide spectrum of other vendors/designers for an array of different fuel types, including:
  - ▶ Fluoride and chloride salt fuel
  - ▶ TRISO-based fuels
  - ▶ Other metallic fuels

# Questions

# References

- ▶ NUREG-2246, “Fuel Qualification for Advanced Reactors,” <https://www.nrc.gov/docs/ML2206/ML22063A131.pdf>
- ▶ Nuclear Energy Agency (NEA), “Regulatory Perspectives on Nuclear Fuel Qualification for Advanced Reactors (DRAFT),” (in press), <https://www.nrc.gov/docs/ML2201/ML22018A099.pdf>