

Task 1: 10 CFR Parts 50, 52, and 100 Regulatory Framework, In-reactor Performance

Accident tolerant fuel (ATF) presents new and unique technical issues that may not be readily addressed with the current guidance, review plans, and regulatory criteria for zirconium/UF₆-based nuclear fuel. To prepare the agency to conduct meaningful and timely licensing reviews of ATF designs, well-developed and vetted positions on potential policy issues that may arise during ATF licensing are needed. These positions must be communicated to stakeholders clearly and early.

There are two distinct ATF activities contemplated by this plan that may require changes to the regulatory framework: (1) batch loading of ATF into NRC regulated power plants and (2) crediting the safety enhancements of ATF in the licensing basis of NRC regulated power plants. The regulatory framework changes that may be necessary for each of these activities are likely to be different and the staff anticipates that the changes to address batch loading will need to be completed ahead of changes that may be necessary for crediting the safety enhancements of ATF in the licensing basis.

The degree to which existing regulations and guidance are impacted and need to be revised, or new regulatory requirements established and new guidance developed, depends on the level of departure from existing fuel designs. The regulation at Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50 Appendix A, "General Design Criteria for Nuclear Power Plants," provides principle design and performance requirements. The following general design criterion (GDC) relate to fuel design and overall fuel performance under normal and accident conditions. Additional GDC may be impacted if ATF performance becomes more challenging for the control or protection systems that ensure acceptable consequences under accident conditions. For each ATF design, the staff plans to map the hazards and failure mechanisms to the design and performance criteria of the GDC to determine the appropriate applicability and potential need for additional criteria.

GDC #	Title
1	Quality standards and records
2	Design bases for protection against natural phenomena
10	Reactor design
11	Reactor inherent protection
12	Suppression of reactor power oscillations
13	Instrumentation and control
20	Protection system functions
25	Protection system requirements for reactivity control malfunctions
26	Reactivity control system redundancy and capability
27	Combined reactivity control systems capability
28	Reactivity limits

34	Residual heat removal
35	Emergency core cooling
61	Fuel storage and handling and radioactivity control
62	Prevention of criticality in fuel storage and handling

Even if a particular ATF design is unable to demonstrate verbatim compliance, the intent of these principle design and performance requirements must be satisfied or new requirements developed.

In addition to the GDC, there are a number of other regulations related to fuel design and performance that may be impacted by ATF and are listed below. For each ATF design, the staff plans to map the hazards and failure mechanisms to the below requirements to determine if any changes are necessary.

Regulation	Title
50.34	Contents of applications; technical information
50.46	Acceptance criteria for emergency core cooling systems
50.67	Accident source term
50.68	Criticality accident requirements
Part 50 Appendix B	Quality assurance criteria
Part 50 Appendix K	ECCS evaluation models
Part 50 Appendix S	Earthquake engineering criteria
Part 100	Reactor site criteria

The following regulatory guidance documents contain fuel related information. For each ATF design the staff plans to map the hazards and failure mechanisms to the guidance documents to determine what if any changes are necessary.

Guidance Document	Title
NUREG-0630	Cladding Swelling and Rupture Models for LOCA Analysis
NUREG-0800	Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition
RG 1.157	Best-Estimate Calculations of Emergency Core Cooling System Performance
RG 1.183	Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors

RG 1.195	Methods and Assumptions for Evaluating Radiological Consequences of Design Basis Accidents at Light-Water Nuclear Power Reactors
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Potential Challenges

Certain aspects of ATF designs and/or implementation strategy could expand the scope, level of complexity, and schedule of the staff's review. These aspects include the following:

- Increase in U235 enrichment, U235 density, and/or fuel burnup beyond current limits for batch loading of ATF
- Characterization of fission product release (e.g., chemical forms and release kinetics), core melt progression, core relocation, and mechanical and chemical interactions under severe accidents for non-UO2 ceramic pellet fuel designs for batch loading of ATF

Lead Test Assemblies

Lead test assemblies (LTA) programs provide pool-side, post-irradiation examination data collection, irradiated material for subsequent hot-cell examination and research, and demonstration of in-reactor performance. This characterization of irradiated material properties and performance is essential for qualifying analytical codes and methods and developing the safety design bases for new design features and/or new fuel designs. Plant Technical Specifications (TS) may allow for a limited number of LTAs to be loaded in non-limiting core locations. An NRC steering committee has been formed to produce additional clarification and guidance to support future LTA irradiation programs.

Initiating Activity

The staff expenditures associated with developing regulatory strategies and the framework for design-independent ATF licensing began in FY2017 and will continue as long as Department of Energy and industry are actively pursuing ATF development. The staff expenditures to support design-specific regulatory hurdles will begin with the receipt of an applicant's letter of intent (LOI) authorizing fee-based pre-application activities.

Deliverables

Title	Due Date (evolutionary/revolutionary)
Map of hazards and failure mechanism to GDC, regulations, and guidance documents	6-12 months from budget allocation or LOI
Rulemaking to address any identified necessary changes	24-48/36-60 months from budget allocation or LOI
Guidance development or revisions to address any identified necessary changes	24-48/36-60 months from budget allocation or LOI

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