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Transient Fuel Performance and Testing

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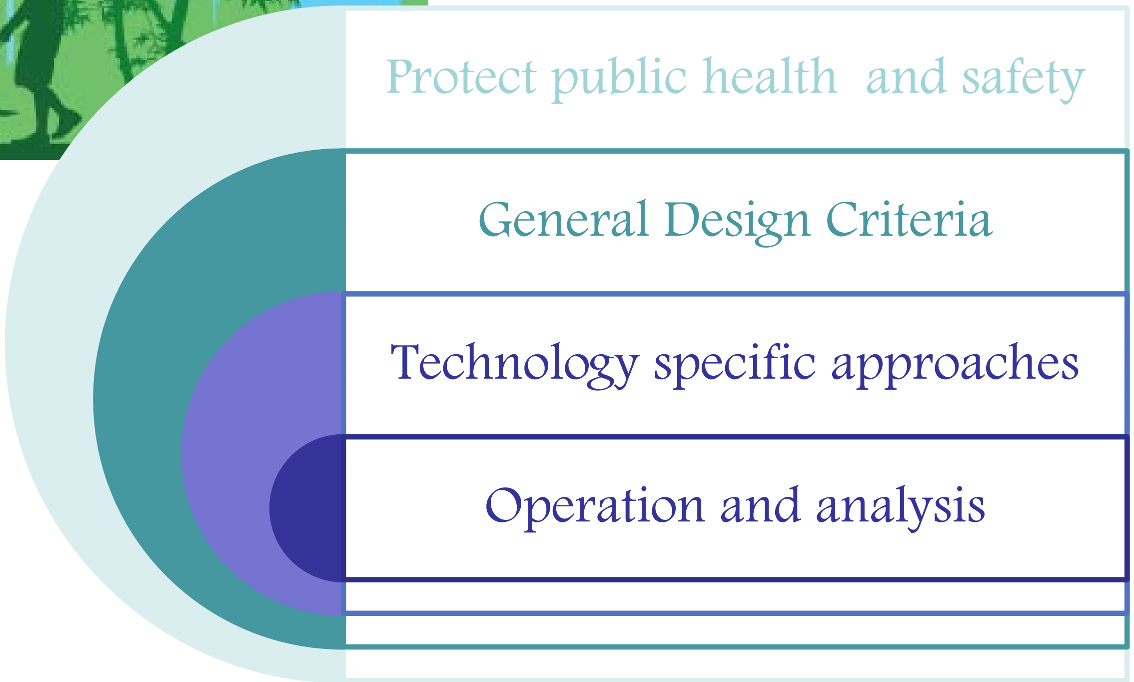
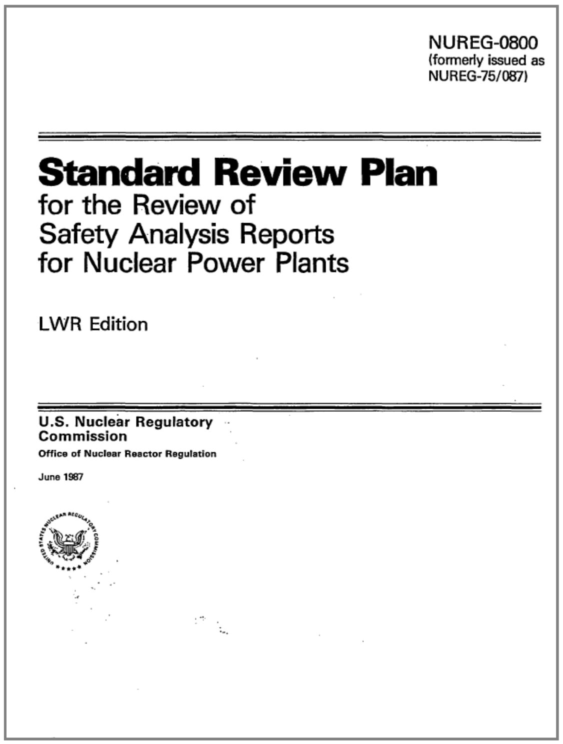


Ensuring that the technology specific approaches are acceptable, that the operation limits are adequate and analysis results are valid requires an extensive amount of data.

Objective of transient fuel performance and testing research is to provide data needed to fully characterize fuel system performance and demonstrate fuel system safety under transient conditions.

Demonstrating Safety



NUREG-0800
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Standard Review Plan
for the Review of
Safety Analysis Reports
for Nuclear Power Plants

LWR Edition

U.S. Nuclear Regulatory
Commission
Office of Nuclear Reactor Regulation

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The objectives of the fuel system safety review outlined in Chapter 4.2 are to provide assurance that:

1. the fuel system is not damaged as a result of normal operation and anticipated operational occurrences (AOOs)
2. fuel system damage is never so severe as to prevent control rod insertion when it is required
3. the number of fuel rod failures is not underestimated for postulated accidents,
4. coolability is always maintained.

Characterization of Fuel System

Identify all degradation mechanisms and failure modes

Define failure thresholds corresponding to each degradation mechanism

Establish fuel design analytical limits and requirements

Fuel System Damage

- Applies to normal operation
- Fuel system damage criteria should be included for all known damage mechanisms to meet the requirements of **GCD 10**.

Fuel Rod Failure

- Applies to normal operation, AOOs and postulated accidents
- Fuel rod failure criteria should be provided for all known fuel rod failure mechanisms to meeting the requirements of **GDC 10 and 10 CFR Part 100**.

Fuel Coolability

- Applies to postulated accidents.
- Control rod insertability and core coolability for postulated accidents, fuel coolability criteria should be provided for all severe damage mechanisms to meet the requirements of **GCD 27 and 35**.

Characterization of Fuel System

Fuel System Damage

- Fretting wear should be limited
- Oxidation, hydriding and the buildup of corrosion products should be limited
- Dimensional changes should be limited

Fuel Rod Failure

- Centerline melt should be presumed to lead to failure
- Exceeding DNBR or CPR should be presumed to lead to failure
- Strain >1% should be presumed to lead to failure

Fuel Coolability

- Cladding embrittlement criteria must be met
- Violent expulsion of fuel in RIA should be considered
- Generalized cladding melting should be avoided

Transient fuel performance and testing experimental capabilities are critical to the nuclear industry

- Characterization of fuel system performance and demonstration of fuel system safety under transient conditions requires an extensive amount of data
- New fuel designs will always require new experimental data to support licensing.
- As industry seeks new licensing conditions (e.g., higher burnup, power up rates), new experimental data may be required to demonstrate acceptable performance.
- Developing a domestic capability to test fuel designs under transient and accident conditions is an initiative with clear benefit
- As experts in the nuclear industry retire, a new workforce will need hands-on research experience to develop knowledge and facility in the area of fuel behavior.

Backup Slides

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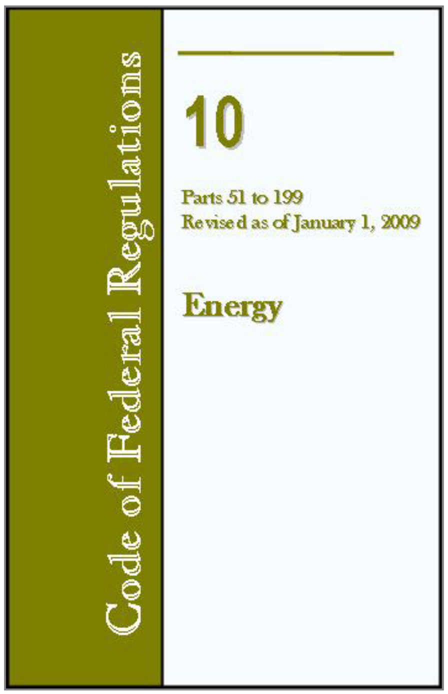

The main regulations in 10 CFR that pertain to fuel design are:

- **GDC 10** - Establish specified acceptable fuel design limits (SAFDLs) to ensure the reactor core and associated coolant, control, and protection systems are designed with appropriate margin.
- **GDC 11** - Requires that, in the power operating range, the prompt inherent nuclear feedback characteristics tend to compensate for a rapid increase in reactivity.
- **GDC 12** - Requires that power oscillations that could result in conditions exceeding specified acceptable fuel design limits are not possible or can be reliably and readily detected and suppressed
- **GDC 20** - Requires automatic initiation of the reactivity control systems (RCSs) to assure that acceptable fuel design limits are not exceeded as a result of anticipated operational occurrences and to assure automatic operation of systems and components important to safety occurs under accident conditions. There are usually primary and secondary independent RCSs

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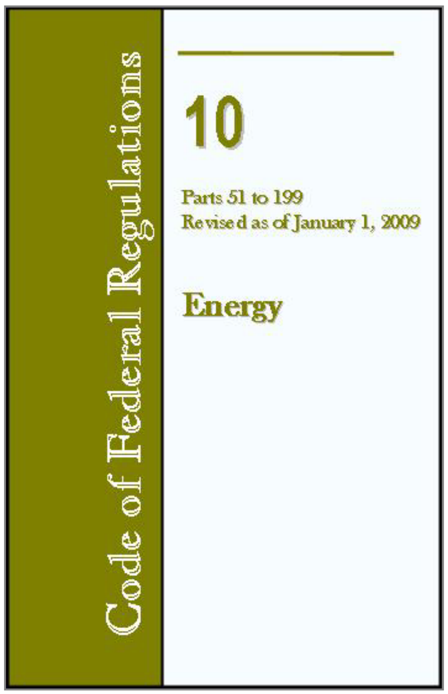
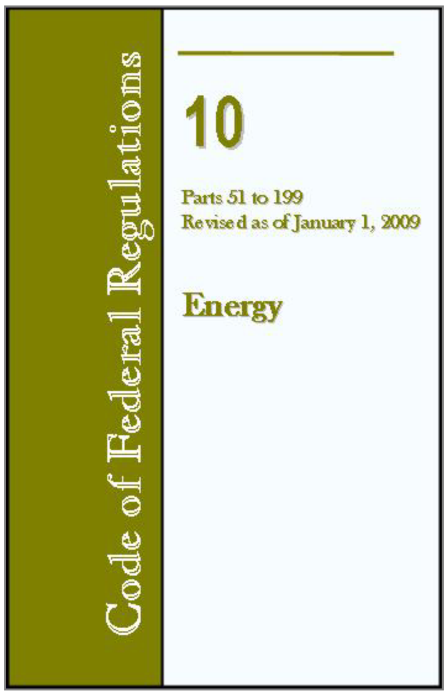


- **GDC 25** - Requires that no single malfunction of the RCSs (this does not include rod ejection or dropout) causes violation of the acceptable fuel design limits.
- **GDC 26** - Requires that two independent RCSs of different design be provided, and that each system have the capability to control the rate of reactivity changes resulting from planned, normal power changes. One of the systems must be capable of reliably controlling anticipated operational occurrences. In addition, one of the systems must be capable of holding the reactor core subcritical under cold conditions.
- **GDC 27** - Requires that the RCSs have a combined capability, in conjunction with poison addition by the emergency core cooling system, of reliably controlling reactivity changes under postulated accident conditions, with appropriate margin for stuck rods.



The main regulations in 10 CFR that pertain to fuel design are:

- **GDC 28** - Requires that the effects of postulated reactivity accidents neither result in damage to the reactor coolant pressure boundary greater than limited local yielding, nor cause sufficient damage to impair significantly the capability to cool the core.
- **GDC 35** - Ensure emergency core cooling is adequate to prevent fuel and clad damage that could interfere with continued effective core cooling and limit clad metal-water reaction to negligible amounts.
  - **50.46 / 50.46c** – ECCS performance requirements and fuel specific analytical limits and requirements
- **50.67** – Accident source term. EAB and LPZ radiological limits for accident analysis.
- **Part 20** – Occupation dose limits
- **Part 100** – Reactor siting criteria