



U.S. NUCLEAR REGULATORY COMMISSION  
**STANDARD REVIEW PLAN**  
OFFICE OF NUCLEAR REACTOR REGULATION

15.4.1 UNCONTROLLED CONTROL ROD ASSEMBLY WITHDRAWAL FROM A SUBCRITICAL OR LOW POWER STARTUP CONDITION

REVIEW RESPONSIBILITIES

Primary - Core Performance Branch (CPB)

Secondary - None

I. AREAS OF REVIEW

The CPB evaluates the effects and consequences of an uncontrolled control rod assembly withdrawal (a bank for a pressurized water reactor; and a single rod, with current control modes, for a boiling water reactor\*) from a subcritical or low-power (e.g., startup-range) condition to assure conformance with the requirements of General Design Criteria 10, 20, and 25 under this SRP section. The review under this SRP section covers the description of the causes of the transient and the transient itself, the initial conditions, the reactor parameters used in the analysis, the analytical methods and computer codes used, and the consequences of the transient as compared with the acceptance criteria. The reactivity coefficients and control rod worths utilized in this review are also evaluated by the CPB under SRP Section 4.3.

II. ACCEPTANCE CRITERIA

1. The following General Design Criteria (Ref. 1) apply:

- a. Criterion 10, which requires that specified acceptable fuel design limits are not to be exceeded during normal operation, including the effects of anticipated operational occurrences.
- b. Criterion 20, which requires that the protection system initiate automatically appropriate systems to assure that specified acceptable fuel design limits are not exceeded as a result of anticipated operational occurrences.

\*If a single-failure proof system prevents the uncontrolled withdrawal of a control rod, this transient need not be considered for BWRs.

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USNRC STANDARD REVIEW PLAN

Standard review plans are prepared for the guidance of the Office of Nuclear Reactor Regulation staff responsible for the review of applications to construct and operate nuclear power plants. These documents are made available to the public as part of the Commission's policy to inform the nuclear industry and the general public of regulatory procedures and policies. Standard review plans are not substitutes for regulatory guides or the Commission's regulations and compliance with them is not required. The standard review plan sections are keyed to the Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants. Not all sections of the Standard Format have a corresponding review plan.

Published standard review plans will be revised periodically, as appropriate, to accommodate comments and to reflect new information and experience.

Comments and suggestions for improvement will be considered and should be sent to the U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Washington, D.C. 20555.

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- c. Criterion 25, which requires that the reactor protection system be designed to assure that specified acceptable fuel design limits are not exceeded in the event of a single malfunction of the reactivity control system.
2. The requirements of GDC 10, 20, and 25 concerning the specified acceptable fuel design limits are assumed to be met for this event when:
    - a. The thermal margin limits (DNBR for PWRs and MCPR for BWRs) as specified in SRP Section 4.4, subsection II.1 are met.
    - b. Fuel centerline temperatures (for PWRs) as specified in SRP Section 4.2, subsection II.A.2(a) and (b) do not exceed the melting point.
    - c. Uniform cladding strain (for BWRs) as specified in SRP Section 4.2, subsection II.A.2(b) do not exceed 1%.

### III. REVIEW PROCEDURES

The reviewer, in determining whether the acceptance criteria are met, considers the following:

1. Peak conditions for the transient are maximized by low initial power; thus, the power level of the reactor should be at the lowest possible value compatible with the control rod configuration used for the accident. The postulated initial reactor coolant flow, pressure and inlet temperature (i.e., the extremes of postulated conditions) should be consistent with the rod and power configuration to give minimum DNBR, or CPR conditions.
2. Peak conditions for the transient are maximized by large reactivity addition rates near prompt critical; thus, the control rod configurations for the assumed withdrawal must be examined to confirm that such a maximized state has been included in the calculations. For a PWR, control bank withdrawal should be used. For a BWR, with the present control rod withdrawal procedures, a single rod of maximum worth available in a normal configuration should be used. In many cases this will be a rod near the 50% rod density configuration. (More recent modes of BWR control such as group withdrawal may require that other configurations be examined.)
3. The exact analysis of the transient would ideally involve a three-dimensional, coupled neutron kinetics-thermal hydraulics calculation. However, acceptable results may be obtained with a neutron point-kinetics analysis and a coupled or separate hot fuel rod thermal analysis, if conservative input data are used. The reviewer determines whether the applicant's analytical methods are acceptable by using one or more of the following procedures:
  - a. Determine whether the method has been reviewed and approved previously, by considering past safety evaluation reports and reports prepared in response to technical assistance requests:
  - b. Perform a de novo review of the method (usually described in a separate licensing topical report, and frequently handled outside the scope of the review for a particular facility).

- c. Perform auditing-type calculations with methods available to the staff.
  - d. Require additional, bounding calculations by the applicant to cover portions of the applicant's analytical methods that have not been fully reviewed or approved.
4. The input to the neutron kinetics analysis model should be examined to assure that the input is appropriately conservative both for the state of the reactor and for the particular way it is used in the analysis. The power distribution or peaking factors used in the neutron kinetics and hot pin thermal calculations must provide a conservative representation of the control rod configuration under consideration. The Doppler feedback coefficient should be related conservatively to the values accepted in the review under SRP Section 4.3, considering the time in cycle and temperature conditions of the fuel. Non-weighting of the coefficients is conservative, but weighting factors for the particular flux distribution shapes involved in the transients may be used if fully explored and justified. The moderator coefficients used should also be conservatively related to the values accepted in the review under SRP Section 4.3. The most positive or least negative values should be used and for a PWR this occurs at BOL. If the coefficient is negative, it may be conservatively taken as zero.
  5. The analysis should consider the relationships between the particular spatial flux shapes for the transient and the nuclear instrument response to assure that scrams occur at the times used in the analysis, that valid scram power levels are assumed, and that conservative scram delays and reactivity functions are used.
  6. The significant results of the analysis should be presented and should include maximum power levels reached for the reactor and the peak fuel rod, reactor temperatures and pressures, maximum heat flux levels, and the related fuel duty (operating conditions and performance). The latter are compared with the acceptance criteria in subsection II of this SRP.

#### IV. EVALUATION FINDINGS

If the staff, on completion of the review finds the applicant's analysis acceptable, conclusions of the following type should be included in the staff's safety evaluation report:

The possibilities for single failures of the reactor control system which could result in uncontrolled withdrawal of control rods under low power startup conditions have been reviewed. The scope of the review has included investigations of initial conditions and control rod reactivity worths, the course of the resulting transients or steady-state conditions, and the instrument response to the transient or power maldistribution. The methods used to determine the peak fuel rod response, and the input into that analysis, such as power distributions and reactivity feedback effects due to moderator and fuel temperature changes, have been examined. (If audit calculations have been done, they should be summarized.)

The staff concludes that the requirements of General Design Criteria 10, 20, and 25 have been met. This conclusion is based on the following:

The applicant has met the requirement of GDC 10 that the specified acceptable fuel design limits are not exceeded, GDC 20 that the reactivity control systems are automatically initiated so that specified acceptable fuel design limits are not exceeded, and GDC 25 that single malfunctions in the reactivity control system will not cause the specified acceptable fuel design limits to be exceeded. These requirements have been met by comparing the resulting extreme operating conditions and response for the fuel (i.e., fuel duty) with the acceptance criteria for fuel damage (e.g., critical heat flux, fuel temperatures, and clad strain limits should not be exceeded), to assure that fuel rod failure will be precluded for this event. The basis for acceptance in the staff review is that the applicant's analyses of the maximum transients for single error control rod withdrawal from a subcritical or low-power condition have been confirmed, that the analytical methods and input data are reasonably conservative and that specified acceptable fuel design limits will not be exceeded.

#### For BWR/6 Designs

The possibilities for single failures of the reactor control system which could result in uncontrolled withdrawal of control rods under low power startup conditions have been reviewed.

The staff concludes that the requirements of General Design Criteria 10, 20, and 25 have been met. This conclusion is based on the following:

The applicant has met the requirements of GDC 10 that the specified acceptable fuel design limits are not exceeded, GDC 20 that the reactivity control systems are automatically initiated so that specified acceptable fuel design limits are not exceeded, and GDC 25 that single malfunctions in the reactivity control system will not cause the specified acceptable fuel design limits to be exceeded. These requirements have been met since the system design contains a Rod Pattern Control System. This system has been reviewed and found acceptable because single failures in the reactor control system which could result in uncontrolled withdrawal of control rods under low-power conditions have been precluded. The scope of the review has included the design features, which act to prevent such withdrawals. This review has shown that no single failure will permit an uncontrolled rod withdrawal that could lead to reactivity insertions greater than those routinely encountered during operation.

#### V. IMPLEMENTATION

The following is intended to provide guidance to applicants and licensees regarding the NRC staff's plans for using this SRP section.

Except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein will be used by the staff in its evaluation of conformance with Commission regulations.

VI. REFERENCES.

1. 10 CFR Part 50, Appendix A, General Design Criterion 10, "Reactor Design," General Design Criterion 20, "Protection System Functions," and General Design Criterion 25, "Protection System Requirements for Reactivity Control Malfunctions." |