U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

15.4.7 INADVERTENT LOADING AND OPERATION OF A FUEL ASSEMBLY IN AN IMPROPER POSITION

REVIEW RESPONSIBILITIES

Primary - ~~Core Performance Branch (CPB)~~ Reactor Systems Branch (SRXB)[1]

Secondary - None

I. AREAS OF REVIEW

The review of fuel-loading errors considers:

1. The spectrum of misloading events analyzed. A sufficient number of fuel-loading errors must be studied by the applicant and presented to show that the worst situation undetectable by incore instrumentation has been identified. The kinds of errors considered should include loading of one or more fuel assemblies into improper locations and, where physically possible, with incorrect orientation. For those reactors in which burnable poison or fuel rods are added to or removed from fuel assemblies at the plant, errors in these processes must be considered.

2. Changes in the power distribution and increased local power density.

3. The provisions made to search for loading errors at the beginning of each fuel cycle.

~~CPB~~SRXB[2] also reviews the effect of misloaded fuel on nuclear design parameters, the detection of fuel-loading errors, and any operational restrictions that would assist in staying within fuel rod failure limits.

Review Interfaces[3]

On request, the ~~appropriate technical review branch~~Emergency Preparedness and Radiation Protection Branch (PERB)[4] reviews the radiological implications of misloaded fuel or the measures provided to minimize the probability of a fuel misloading.

II. ACCEPTANCE CRITERIA

The acceptance criteria for this SRP section are as follows:

1. General Design Criterion 13 ~~(Ref. 1)~~ (GDC 13)[5] as it relates to instrumentation and controls provided to monitor variables over anticipated ranges for normal operations, anticipated operational occurrences, and for accident conditions.

2. 10 CFR Part 100 ~~(Ref. 2)~~[6] as it relates to offsite consequences resulting from reactor operations with an undetected misloaded fuel assembly.

The primary safeguards against fuel-loading errors are procedures and design features to minimize the likelihood of the event. Additional safeguards include incore instrumentation systems which would detect errors. However, should an error be made and go undetected, it is possible in some reactor designs for fuel rod failure limits to be exceeded. Therefore, the following acceptance criteria are necessary to cover the event of operation with misloaded fuel caused by loading errors:

a. To meet the requirements of GDC 13, plant operating procedures should include a provision requiring that reactor instrumentation be used to search for potential fuel-loading errors after fueling operations.

b. In the event the error is not detectable by the instrumentation system and fuel rod failure limits could be exceeded during normal operation, the offsite consequences should be a small fraction of the 10 CFR Part 100 guidelines.

Technical Rationale[7]

The technical rationale for application of these acceptance criteria to reviewing the applicant's analysis of potential fuel-loading errors is discussed in the following paragraphs:[8]

1. Compliance with GDC 13 requires that instrumentation be provided to monitor variables and systems (including those that can affect the fission process, the integrity of the reactor core, the reactor coolant pressure boundary, and the containment and its associated systems) over their anticipated ranges for normal operation, for anticipated operational occurrences, and for accident conditions.

   GDC 13 is applicable to this section because the reviewer evaluates the potential for fuel-loading errors that could adversely affect the fission process (power distribution), the integrity of the reactor core, and the reactor coolant pressure boundary. Each of these concerns is specifically addressed in GDC 13. In addition, ensuring the appropriate use

of instrumentation (e.g., the incore instruments used to detect fuel-loading errors after fueling operations) is a principal objective of GDC 13.

Meeting the requirements of GDC 13 provides assurance that fuel-loading errors will be detected before they can affect power distribution or core integrity or could produce unacceptable stress on the reactor coolant pressure boundary.[9]

2. To establish the suitability of a nuclear power plant site, 10 CFR Part 100, specifies how the exclusion area, low population zone, and population center distance should be determined. Further, radiation exposure criteria stipulated in 10 CFR Part 100 provide reference values to be used in the site suitability determination based on postulated fission product releases associated with accidental events.

10 CFR Part 100 is applicable to SRP Section 15.4.7 because it specifies the methodology for calculating radiation exposures at the site boundary for postulated accidents or events that might be caused by a fuel-loading error. For events having a moderate-frequency of occurrence, any release of radioactive material must be such that the calculated doses at the site boundary are a small fraction of the 10 CFR Part 100 guidelines. A small fraction is interpreted to be less than 10% of the 10 CFR Part 100 reference values. For the purpose of this review, the radiological consequences of any fuel-loading error must include consideration of the containment, confinement, and filtering systems. The applicant's source terms and methodologies with respect to gap release fractions, iodine chemical form, and fission product release timing should reflect NRC-approved source terms and methodologies.

Meeting this requirement provides assurance that, in the event of an undetected fuel-loading error, radiation exposures at the site boundary will not exceed a small fraction of the reference values specified in 10 CFR Part 100.[10]

III. REVIEW PROCEDURES

The review procedures for fuel-loading errors are as follows:

1. The reviewer verifies that the various cases of misloaded fuel assemblies outlined in subsection I above have been analyzed by the applicant and the worst case determined. For each case, the effect on the reactor power distribution should be given.

2. The reviewer determines that the effect each postulated error has on reactor instrumentation has been ascertained. For limiting events (where fuel rod failure limits are exceeded), the reviewer verifies that acceptable techniques (see SRP Section 4.4) have been used to calculate the fuel temperature conditions.

3. The reviewer ~~assures~~ensures[11] compliance with acceptance criterion a of subsection II above by reviewing the plant operating procedures to verify that they contain provisions requiring that incore instrumentation be used to search for misloaded fuel after each fueling operation. Since low-power mapping is typically done, searching for misloading can be accomplished by the usual low-power maps.

4. When it is determined that fuel rod failure limits can be exceeded, the ~~appropriate technical review branch~~PERB[12] is requested to perform dose calculations to ~~assure~~ensure[13] that acceptable criterion b of subsection II above is met.

For standard design certification reviews under 10 CFR Part 52, the procedures above should be followed, as modified by the procedures in SRP Section 14.3 (proposed), to verify that the design set forth in the standard safety analysis report, including inspections, tests, analysis, and acceptance criteria (ITAAC), site interface requirements and combined license action items, meet the acceptance criteria given in subsection II. SRP Section 14.3 (proposed) contains procedures for the review of certified design material (CDM) for the standard design, including the site parameters, interface criteria, and ITAAC.[14]

IV. EVALUATION FINDINGS

The reviewer verifies that sufficient information has been provided and that the review supports the following kind of statement, to be included in the staff's safety evaluation report:

> The staff has evaluated the consequences of a spectrum of postulated fuel-loading errors. We conclude that the analyses provided by the applicant have shown for each case considered that either the error is detectable by the available instrumentation (and hence remediable) or the error is undetectable but the offsite consequences of any fuel rod failures are a small fraction of 10 CFR Part 100 guidelines. The applicant affirms that the available incore instrumentation will be used before the start of a fuel cycle to search for fuel-loading errors.
>
> The staff concludes that the requirements of General Design Criterion 13 and 10 CFR Part 100 have been met. This conclusion is based on the following:
>
> > The applicant has met the requirements of GDC 13 with respect to providing adequate provisions to minimize the potential of a misloaded fuel assembly going undetected and meets 10 CFR Part 100 with respect to mitigating the consequences of reactor operations with a misloaded fuel assembly. These requirements have been met by providing acceptable procedures and design features that will minimize the likelihood of loading fuel in a location other than its designated place.

For design certification reviews, the findings will also summarize, to the extent that the review is not discussed in other safety evaluation report sections, the staff's evaluation of inspections, tests, analyses, and acceptance criteria (ITAAC), including design acceptance criteria (DAC), site interface requirements, and combined license action items that are relevant to this SRP section.[15]

V. IMPLEMENTATION

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

This SRP section will be used by the staff when performing safety evaluations of license applications submitted by applicants pursuant to 10 CFR 50 or 10 CFR 52.[16] 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.

The provisions of this SRP section apply to reviews of applications docketed six months or more after the date of issuance of this SRP section.[17]

VI. REFERENCES

1. 10 CFR Part 50, Appendix A, ~~"~~General Design ~~Criteria for Nuclear Power Plants~~ Criterion 13, "Instrumentation and Control."[18]

2. 10 CFR Part 100, "Reactor Site Criteria."

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SRP Draft Section 15.4.7
Attachment A - Proposed Changes in Order of Occurrence

Item numbers in the following table correspond to superscript numbers in the redline/strikeout copy of the draft SRP section.

Item	Source	Description
1.	Current PRB name and abbreviation	Changed PRB to Reactor Systems Branch (SRXB).
2.	SRP-UDP format item	Changed CPB to SRXB. The Core Performance Branch has been incorporated into the SRXB.
3.	SRP-UDP format item	Added "Review Interfaces" to AREAS OF REVIEW to describe how SRXB coordinates the review of potential fuel-loading errors with another NRR branch.
4.	SRP-UDP format item	Identified branch responsible for radiological assessment of potential events resulting from fuel-loading errors.
5.	SRP-UDP format item	Added abbreviation for General Design Criterion 13 (GDC 13) and deleted unnecessary reference designation.
6.	SRP-UDP format item	Deleted unnecessary reference designation.
7.	SRP-UDP format item	Added "Technical Rationale" to ACCEPTANCE CRITERIA and presented in paragraph form.
8.	SRP-UDP format item	Added lead-in sentence for "Technical Rationale."
9.	SRP-UDP format item	Added technical rationale for GDC 13.
10.	SRP-UDP format item	Added technical rationale for 10 CFR Part 100.
11.	Editorial modification	Replaced "assure" with "ensure."
12.	SRP-UDP format item	Identified 'appropriate technical review branch' as PERB.
13.	Editorial modification	Replaced "assure" with "ensure."
14.	SRP-UDP Guidance, Implementation of 10 CFR 52	Added standard paragraph to address application of Review Procedures in design certification reviews.
15.	SRP-UDP Format Item, Implement 10 CFR 52 Related Changes	To address design certification reviews a new paragraph was added to the end of the Evaluation Findings. This paragraph addresses design certification specific items including ITAAC, DAC, site interface requirements, and combined license action items.
16.	SRP-UDP Guidance, Implementation of 10 CFR 52	Added standard sentence to address application of the SRP section to reviews of applications filed under 10 CFR Part 52, as well as Part 50.
17.	SRP-UDP Guidance	Added standard paragraph to indicate applicability of this section to reviews of future applications.

Item	Source	Description
18.	Editorial modification	Revised reference to make it specific for GDC 13 and to provide consistency with GDC references in other SRP sections.

SRP Draft Section 15.4.7
Attachment B - Cross Reference of Integrated Impacts

Integrated Impact No.	Issue	SRP Subsections Affected
1376	Consider updating the ACCEPTANCE CRITERIA and related references to reflect staff guidance contained in NUREG-1465 regarding gap fractions of relevant isotopes (noble gases, iodines, cesiums, and rubidiums) and chemical species of iodines to be assumed within the gap for analysis of the radiological consequences of accidents related to fuel-loading errors.	No changes. This issue is addressed generically in SRP Section 15.0.