



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

15.6.5 RADIOLOGICAL CONSEQUENCES OF A DESIGN BASIS LOSS-OF-COOLANT
Appendix D ACCIDENT: LEAKAGE FROM MAIN STEAM ISOLATION VALVE
LEAKAGE CONTROL SYSTEM (BWR)¹

REVIEW RESPONSIBILITIES

Primary - Accident Evaluation Branch (AEB) Emergency Preparedness and Radiation
Protection Branch (PERB)²

Secondary - None

I. AREAS OF REVIEW

Postulated radiological consequences from a loss-of-coolant accident (LOCA), assuming contributions from various release paths to the atmosphere, are treated in separate appendices to Standard Review Plan (SRP) Section 15.6.5, as follows:

Appendix A: Containment leakage, including the contribution from containment purge valves during closure.

Appendix B: Post-LOCA leakage from engineering safety feature (ESF) systems outside containment.

Appendix C: Post-LOCA hydrogen purge from containment. This appendix has been deleted.

Appendix D: Main steam isolation valve leakage (for boiling water reactor plants only).³

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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.

A potential source of fission product leakage following a ~~loss-of-coolant accident (LOCA)~~⁴ is the leakage past the main steam isolation valves in a boiling water reactor (BWR).⁵ This leakage is controlled by a main steam isolation valve leakage control system (MSIVLCS). This system may be a positive sealing system or a vacuum-type system which collects leakage between the closed isolation valves and releases it to the atmosphere through a filter system. The ~~AEBPERB~~⁶ reviews the method of operation, time of operation, and release paths associated with operation of the MSIVLCS to calculate the fission product releases and their contributions to the doses following a LOCA at the exclusion area and low population zone boundary.

As an alternative, the applicant may use a passive method of controlling offsite doses from LOCA-incurred leakage past the steam line isolation valves by taking credit for fission product plateout and holdup in the large volume and surface area of the main steam piping, main steam drain lines, turbine bypass line, turbine, and main condenser. Whether this alternative is acceptable depends on the integrity of the main steam system and condenser after a safe shutdown earthquake (SSE). Staff review of the acceptability of the seismic classification of this system is addressed in SRP Sections 3.2.1 and 3.2.2.⁷

Review Interfaces⁸

The ~~AEBPERB~~⁹ coordinates its evaluation with other branches that interface with the overall evaluation of the LOCA radiological consequence analysis, as follows:¹⁰

1. The ~~Auxiliary Plant Systems Branch (ASBSPLB)~~¹¹ reviews the design of the MSIVLCS and essential subsystems in accordance with Regulatory Guide 1.96 (~~Ref. 1~~)¹² as part of its primary review responsibility for SRP Section 6.7 to ~~assure~~¹³ the systems' ability to function following a ~~postulated~~¹⁴ LOCA, including the loss of offsite power.
2. The Containment Systems and Severe Accident Branch (~~CSBSCSB~~)¹⁵ will verify, upon request by ~~AEBPERB~~,¹⁶ that for a vacuum-type system, the operation of the MSIVLCS does not produce an adverse pressure transient in the secondary containment.
3. If an MSIVLCS is not utilized and the design takes credit for fission product plateout and holdup in the main steam system and main condenser, the Mechanical Engineering Branch (EMEB) will verify, upon request by PERB, the ability of the steam system and main condenser to maintain integrity during a seismic event as part of its primary review responsibility for SRP Sections 3.2.1 and 3.2.2.¹⁷

The acceptance criteria necessary for the review of these areas and their methods of application are contained in the above-referenced SRP section of the corresponding primary branch.

II. ACCEPTANCE CRITERIA

The ~~postulated~~ radiological consequences associated with the operation of the MSIVLCS leakage after ~~following a postulated~~ LOCA are combined; (under SRP Section 15.6.5, Appendix A)¹⁸ with the consequences from other LOCA fission product release paths to determine the total calculated radiological consequences from the hypothetical LOCA. The acceptability of the site, with respect to the total radiological consequences, is determined by the

adequacy of the exclusion area and low population zone boundary distances in conjunction with the operation of dose mitigating ESF systems. For operating license (OL),¹⁹ combined license (COL), or early site permit²⁰ applications, the total doses should be within the exposure guidelines of 10 CFR Part 100, paragraph 1100.11(a)²¹ (Ref. 2)²², and for²³ a construction permit application, the total doses should be within the guideline values of Regulatory Guide 1.3 (Ref. 3).²⁴ staff applies exposure guideline values of 1.5 Sv (150 rem) to the thyroid and 0.2 Sv (20 rem) to the whole body in accordance with Regulatory Guide 1.3, and SRP Section 2.3.4.²⁴ The acceptability is determined under SRP Section 15.6.5, Appendix A.

Technical Rationale²⁵

The technical rationale for application of these acceptance criteria is discussed in the following paragraphs:²⁶

Compliance with 10 CFR 100.11(a) requires that radiation dose calculations be performed at the exclusion area and low population zone. These calculations shall assume a given fission product release from the core, an expected leak rate from the MSIVLCS, and meteorological conditions pertinent to the site.

The identification of an exclusion area, a low population zone, and a population center distance is an integral part of the site criteria for new nuclear power plants. Radiation dose guidelines of 0.25 Sv (25 rem) to the whole body or 3 Sv (300 rem) to the thyroid from iodine exposure are associated with the exclusion area (2-hour exposure) and the low population zone (30-day exposure). Expected offsite radiation doses calculated to verify that the proposed plant design meets established guidelines uses a radioactive source term that, in turn, is based on reactor parameters immediately preceding the LOCA, the leakage rate of the containment and ESF components, and site-specific atmospheric dispersion characteristics.

Meeting the requirements of 10 CFR 100.11(a) provides assurance that offsite radiation doses from postulated accidents will not result in undue risk to the health and safety of the public.²⁷

III. REVIEW PROCEDURES

The reviewer selects and emphasizes aspects covered by this SRP section which are appropriate for a particular case. The judgment of which areas need to be given attention and emphasis in the review is based on a determination if the material presented is similar to that recently reviewed on other plants or that items of special safety significance are involved.

The applicant's description of the method used to address MSIV leakage~~MSIVLCS~~ is reviewed with respect to the system performance and to obtain the information needed to perform the dose calculation.²⁸

For a positive sealing system, verification of the system operability, assuming a single active failure, actuation time, and identification of any potential release paths, is obtained from the ASBSPLB.²⁹ If the reviewer finds that no release paths exist and that the system can be actuated prior to the steam line pressure decreasing below the drywell pressure, no further review is required.

For a vacuum-type system, which processes rather than seals the leakage, the AEBPERB³⁰ reviewer obtains the following information, assuming the most adverse single failure of an active component:

1. Release paths and fractions of the leakage through these paths, as a function of time, e.g., steam leakage, releases through a depressurization line, releases through drain lines, etc.;
2. System actuation time;
3. Flow rates as a function of time; and
4. Release points.

This information should be verified by the ASBSPLB³¹ (and documented by buckslip to the AEB).³² Interaction with systems used to mitigate the consequences of containment leakage should be noted. The AEBPERB³³ reviewer should consult with the CSBSCSB³⁴ to assure³⁵ that the operation of the MSIVLCS does not adversely affect pressure transients in secondary containment regions.

The system is then modeled using the computer code Pipe Model³⁶ (Ref. 4).³⁷ The source assumed is the same as that used to estimate the containment leakage dose calculated in SRP Section 15.6.5, Appendix A, but it is assumed to be instantaneously distributed in the drywell free volume at the time of the accident. No credit for leakage of activity from the drywell to the containment (Mark III) or to the suppression pool region (Mark I and II) is assumed, but credit can be taken for radioactive decay of the fission products in the drywell prior to operation of the MSIVLCS. The main steam isolation valves are assumed to leak at the technical specification limit. No release of activity from the MSIVLCS is assumed up to the time of system actuation. Leakage through valve stems or drain lines to an untreated region is assumed to be released to the atmosphere. Releases through the MSIVLCS which are directed to treated regions are assumed to be direct to the filter intake unless the MSIVLCS flow is mechanically directed to a distribution header. If the latter is the case, then credit for mixing is given on the same basis as for other leakage to this system (see SRP Section 6.5.3).

If the design does not incorporate an MSIVLCS and if credit is taken for fission product holdup and retention in the main steam system and main condenser, the reviewer verifies that a suitable analysis has been performed to demonstrate that adequate fission product holdup and plateout will take place in these systems such that 10 CFR 100 limits are met during a LOCA. In the ABWR FSER the staff found the guidance of GE reports NEDO-31643P and NEDO-31858P, both titled "Increasing Main Steam Isolation Valve Leakage Rate Limits and Elimination of Leakage Control Systems," acceptable for addressing this issue (References 6 and 7).

The reviewer verifies the applicant's method of modeling iodine removal in BWR main steam lines and the main condenser after a LOCA by plateout of the various forms of iodine by performing independent calculations using the code developed by J. E. Cline and Associates, Inc. (Reference 5) or by other suitable analyses.³⁸

The resulting doses at the exclusion area and the LPZ boundaries are calculated using the dose model described in Regulatory Guide 1.3 (Ref. 3)³⁹. The χ/Q values to be used for this evaluation are the accident χ/Q 's used in Section 15.6.5, Appendix A. For systems which are designed for initial releases at significantly later times into the accident, application of worst meteorology at the time of release may have to be considered; this will be handled on a case-by-case basis.

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.⁴⁰

IV. EVALUATION FINDINGS

The reviewer verifies that the applicant has provided sufficient information for an independent staff calculation of the potential thyroid and whole-body doses due to ~~MSIV~~ main steam isolation valve⁴¹ leakage and operation of the MSIVLCS as a fission product release path following a ~~postulated~~ LOCA.⁴² The doses are reported in the safety evaluation report (SER) in Table 15.____ under SER Section 15.____, "LOCA Radiological Consequences," in accordance with SRP Section 15.6.5, Appendix A. The same SER section also includes the staff's findings with respect to the total calculated doses from all release paths and with respect to the acceptability of the exclusion area and low population zone boundaries on the basis of the total calculated doses in accordance with the guideline values of 10 CFR ~~Part~~ 100.11(a).⁴³

Following the summary section on the total radiological consequences, separate subsections present the staff's evaluation and findings for each specific fission product release path. For the ~~MSIV leakage and operation of the MSIVLCS~~⁴⁴ reviewed under SRP Section 15.6.5, Appendix D, the staff's review and independent calculations should support a conclusion of the following type:

The staff has reviewed the applicant's analysis and has independently evaluated the ~~postulated~~ radiation doses resulting from main steam isolation valve leakage ~~and operation of the main steam isolation valve leakage control system~~⁴⁵ following a ~~hypothetical~~ ~~postulated~~ LOCA ~~assuming~~ ~~with~~⁴⁶ a single failure that is most adverse from the standpoint of radiological consequences. The analysis included the influence of fission product removal systems, delay times, and various release paths. The results of this calculation are reported in Table 15.____. The review has established that the applicant's design is effective in limiting the radiological consequences due to the main steam isolation valve leakage or due to operation of the MSIVLCS.

The acceptability of the exclusion area and the low population boundaries in meeting the requirements of 10 CFR ~~Part~~ 100.11(a)⁴⁷ for all release paths following a LOCA is discussed in SRP Section 15.6.5, Appendix A, and the staff's recommendations are contained in the "Evaluation Findings" of that SRP section.

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.⁴⁸

V. IMPLEMENTATION

The following provides guidance to applicants and licensees regarding the 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 52.⁴⁹ 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.⁵⁰

Implementation schedules for conformance to parts of the method discussed herein are contained in the referenced regulatory guides.

V. REFERENCES

1. Regulatory Guide 1.96, "Design of Main Steam Isolation Valve Leakage Control Systems for Boiling Water Reactor Nuclear Power Plants."
2. 10 CFR Part 100.11(a), Paragraph 11,⁵¹ "Determination of Exclusion Area, Low Population Zone, and Population Center Distance."
3. Regulatory Guide 1.3, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss-of-Coolant Accident for Boiling Water Reactors," Revision 2.
4. ~~Computer codes are currently under development. Documentation will be published in a NUREG report.⁵²~~
4. J. E. Cline, "MSIV Leakage Iodine Transport Analysis," Science Applications International Corporation, March 26, 1991.⁵³
5. GE report NEDO-31643P, "Increasing Main Steam Isolation Valve Leakage Rate Limits and Elimination of Leakage Control Systems," November 1988.
6. GE report NEDO-31858P, "Increasing Main Steam Isolation Valve Leakage Rate Limits and Elimination of Leakage Control Systems," February 1991.⁵⁴

SRP Draft Section 15.6.5
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.	Integrated Impact 1373	The title was modified to more appropriately categorize the topic of this Section which now includes review of MSIV leakage in designs without an MSIV leakage control system.
2.	Current PRB name and abbreviation	Changed PRB to Emergency Preparedness and Radiation Protection Branch (PERB).
3.	Editorial	Added paragraph on contents of appendices to SRP Section 15.6.5.
4.	Editorial	Defined LOCA in item 2 above.
5.	Editorial	Provided "BWR" as initialism for "boiling water reactor."
6.	Current PRB abbreviation	Changed PRB to PERB.
7.	Integrated Impact 1373	Added reference to an alternative means of controlling fission product leakage following a LOCA.
8.	SRP-UDP format item	Added "Review Interfaces" to AREAS OF REVIEW and put in numbered paragraph form to describe how other branches support the PERB review.
9.	Current PRB abbreviation	Changed PRB to PERB.
10.	SRP-UDP format item	Revised lead-in sentence on PERB coordination with other review branches and put in numbered paragraph form.
11.	Current review branch name and abbreviation	Changed review branch to Plant Systems Branch (SPLB).
12.	SRP-UDP format item	Deleted unnecessary reference callout.
13.	Editorial	Changed "assure" to "ensure."
14.	Editorial	Deleted unnecessary word.
15.	Current review branch name and abbreviation	Changed review branch to Containment Systems and Severe Accident Branch (SCSB).
16.	Current PRB abbreviation	Changed PRB to PERB.
17.	Integrated Impact 1373	Added a Review Procedure for EMEB verifying the integrity of the main steam system during a seismic event if an MSIVLCS is not utilized.
18.	Integrated Impact 1373	Made minor editorial changes for clarity and readability; added reference to radiological consequences, assuming the alternative passive method of controlling offsite doses.

SRP Draft Section 15.6.5
Attachment A - Proposed Changes in Order of Occurrence

Item	Source	Description
19.	Editorial	Provided "OL" as an abbreviation for "operating license."
20.	SRP-UDP format item	Added COL and early site review applications per 10 CFR Part 52.
21.	Editorial	Corrected citation format for 10 CFR 100.11(a).
22.	SRP-UDP format item	Deleted unnecessary reference callout.
23.	Editorial	Reorganized one complex sentence into two simpler sentences.
24.	Editorial	Revised sentence to conform to a similar sentence in SRP Section 15.6.5, Appendix A.
25.	SRP-UDP format item	Added "Technical Rationale" to ACCEPTANCE CRITERIA to describe the basis for referencing 10 CFR 100.11(a).
26.	SRP-UDP format item	Added lead-in sentence for "Technical Rationale."
27.	SRP-UDP format item	Added technical rationale for 10 CFR 100.11(a).
28.	Integrated Impact 1373	Deleted reference to the MSIVLCS and added a more general reference to MSIV leakage so that coverage of designs without an MSIVLCS is not excluded.
29.	Current review branch abbreviation	Changed review branch to SPLB.
30.	Current PRB abbreviation	Changed PRB to PERB.
31.	Current review branch abbreviation	Changed review branch to SPLB.
32.	Editorial	Deleted reference to informal (buckslip) means of obtaining verification.
33.	Current PRB abbreviation	Changed PRB to PERB.
34.	Current review branch abbreviation	Changed review branch to SCSB.
35.	Editorial	Changed "assure" to "ensure."
36.	Editorial	Identified the computer code Pipe Model as the program currently used for MSIVLCS analysis.
37.	SRP-UDP format item	Deleted unnecessary reference callout.
38.	Integrated Impact 1373	Added a Review Procedure for verifying appropriate analyses of fission product retention in the main steam system and condenser for BWRs that do not utilize an MSIVLCS.
39.	Editorial	Removed ref. 3 callout.
40.	SRP-UDP Guidance, Implementation of 10 CFR 52	Added standard paragraph to address application of Review Procedures in design certification reviews.

SRP Draft Section 15.6.5
Attachment A - Proposed Changes in Order of Occurrence

Item	Source	Description
41.	Editorial	Spelled out "MSIV," which had not been previously defined.
42.	Editorial	Made minor changes for clarity.
43.	Editorial	Corrected citation format for 10 CFR 100.11(a).
44.	Integrated Impact 1373	Deleted reference to the MSIVLCS and added a more general reference to MSIV leakage so that coverage of designs without an MSIVLCS is not excluded.
45.	Integrated Impact 1373	Deleted reference to the MSIVLCS and added a more general reference to MSIV leakage so that coverage of designs without an MSIVLCS is not excluded.
46.	Editorial	Made minor changes for clarity.
47.	Editorial	Corrected citation format for 10 CFR 100.11(a).
48.	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.
49.	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.
50.	SRP-UDP Guidance	Added standard paragraph to indicate applicability of this section to reviews of future applications.
51.	Editorial	Corrected citation format for 10 CFR 100.11.
52.	Editorial	Deleted reference since NUREG has not been prepared.
53.	Integrated Impact 1373	Added report by J. E. Cline to REFERENCES.
54.	Integrated Impact 1373	Added references that provide guidance for analyses of fission product retention in the main steam system and condenser for BWRs that do not utilize an MSIVLCS.

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SRP Draft Section 15.6.5
Attachment B - Cross Reference of Integrated Impacts

Integrated Impact No.	Issue	SRP Subsections Affected
1373	Revise SRP 15.6.5 Appendix D to reflect the alternative passive method of controlling offsite doses from a LOCA.	<p>Section I AREAS OF REVIEW, third paragraph</p> <p>Section I AREAS OF REVIEW, Review Interfaces, paragraph 3</p> <p>Section II, ACCEPTANCE CRITERIA, first paragraph</p> <p>Section III, REVIEW PROCEDURES, second paragraph</p> <p>Section III, REVIEW PROCEDURES, seventh and eighth paragraphs</p> <p>Section IV EVALUATION FINDINGS, second paragraph</p> <p>Section IV EVALUATION FINDINGS, second paragraph</p> <p>Section VI, REFERENCES, Reference 5</p>