



U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

10.2 TURBINE GENERATOR

REVIEW RESPONSIBILITIES

Primary - ~~Power Systems Branch (PSB)~~ Plant Systems Branch (SPLB)¹

Secondary - None

I. AREAS OF REVIEW

Nuclear reactor plants include a turbine generator system (TGS) to convert the energy in steam from the nuclear steam supply system into electrical energy. The TGS consists essentially of the turbine unit and the automatic devices, alarms, and trips which control and regulate turbine action, and the generator unit and its controls. The turbine control system, the steam inlet stop and control valves, the low pressure turbine steam intercept and inlet control valves, and the extraction steam control valves, control the speed of the turbine under normal and abnormal conditions, and are thus related to the overall safe operation of the plant.

The turbine generator system installed in a nuclear plant is typically equipped with redundant overspeed protection instrumentation and controls. The main steam and reheat steam control and stop valving arrangements typically provide redundancy in the valves essential for overspeed protection. The intent of the review under this Standard Review Plan (SRP)² section is to verify that such redundancy, in conjunction with inservice inspection and testing of the essential valves, makes a turbine overspeed condition above the design overspeed very unlikely and to ~~assure~~ ensure³ conformance with General Design Criterion 4. Assessment of the risk to essential plant systems and structures from potential turbine missiles is reviewed under SRP Section 3.5.1.3.

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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.

1. The ~~PSB~~ SPLB⁴ reviews the turbine generator system and the components and subsystems normally provided with this equipment with respect to the following considerations:
 - a. The general arrangement of the turbine and associated equipment with respect to safety-related structures and systems and balance of plant.
 - b. The types and locations of main steam stop and control valves, reheat stop and intercept valves, and associated piping arrangements.
 - c. The capability of the turbine generator control and overspeed protection systems to detect a turbine overspeed condition and to actuate appropriate system valves or other protective devices to preclude an overspeed condition above the design overspeed.
 - d. The overspeed protection instrumentation and controls with respect to redundancy, testability, and reliability.
2. The ~~PSB~~ SPLB⁵ reviews the inservice inspection and operability assurance program for valves essential for overspeed protection.
3. The ~~Auxiliary Systems Branch (ASB)~~ SPLB⁶ determines that the TGS is in accordance with Branch Technical Positions ASB 3-1 and MEB 3-1 as related to pipe cracks or breaks in high- and moderate-energy piping systems outside of containment as part of its primary review responsibility for SRP Section 3.6.1.
4. The review for fire protection is performed by SPLB as part of its primary review responsibility for SRP Section 9.5.1.⁷

Review Interfaces⁸

In the review of the turbine generator, the ~~PSB~~ SPLB⁹ will coordinate with other branches for their evaluations that interface with the overall review of the system, as follows:

1. Consideration of turbine orientation as related to turbine missiles is reviewed by ~~Auxiliary Systems Branch~~ Materials and Chemical Engineering Branch (EMCB)¹⁰ as part of its primary review responsibility for SRP Section 3.5.1.3.
2. The Mechanical Engineering Branch (~~MEB~~) (EMEB)¹¹ determines the acceptability of the seismic and quality group classifications for system components as part of its primary review responsibility for SRP Sections 3.2.1 and 3.2.2.
3. The ~~MEB~~ EMEB¹² determines that the components, piping, and structures are designed in accordance with applicable codes and standards as part of its primary review responsibility for SRP Sections 3.9.1 through 3.9.3.

4. ~~The Materials Engineering Branch (MTEB)~~ Materials and Chemical Engineering Branch (EMCB)¹³ verifies, upon request of ~~PSB~~ SPLB,¹⁴ the compatibility of the materials of construction with service conditions.
5. ~~The Radiological Assessment Branch (RAB)~~ Emergency Preparedness and Radiation Protection Branch (PERB)¹⁵ determines if any radiation shielding is necessary to ~~assure~~ ensure safe access to turbine equipment as part of its primary review responsibility for SRP Section 12.0.
6. ~~The Procedures and Test Review Branch~~ Quality Assurance and Maintenance Branch (HQMB)¹⁶ determines the acceptability of the preoperational and startup tests as part of its primary review responsibility for SRP Section 14.0.

~~The reviews for fire protection, technical specifications, and quality assurance are coordinated and performed by the Chemical Engineering Branch, Licensing Guidance Branch, and Quality Assurance Branch as part of their primary review responsibility for SRP Sections 9.5.1, 16.0, and 17.0, respectively.~~¹⁷

7. The review of quality assurance is performed by the HQMB as part of its primary review responsibility for SRP Chapter 17.¹⁸
8. The review of technical specifications is performed by the Technical Specifications Branch (TSB) as part of its primary review responsibility for SRP Section 16.0.¹⁹

For those areas of review identified above as ~~being~~ part of the primary review responsibility of ~~the~~ other branches, the acceptance criteria ~~necessary for the review~~ and their methods of application are contained in the referenced SRP section ~~of the corresponding primary branches.~~²⁰

II. ACCEPTANCE CRITERIA

Acceptability of the design of the turbine generator system, as described in the applicant's safety analysis report (SAR), is based on the General Design Criteria and the other specific criteria listed below, and on the similarity of the design to that of plants previously reviewed and found acceptable.

The design of the turbine generator system is acceptable if the integrated design of the system meets the requirement of General Design Criterion 4 (GDC 4)²¹ as related to the protection of structures, systems, and components important to safety from the effects of turbine missiles by providing a turbine overspeed protection system (with suitable redundancy) to minimize the probability of generation of turbine missiles. Specific criteria necessary to meet the requirements of GDC 4 are as follows:

1. A turbine control and overspeed protection system should be provided to control turbine action under all normal or abnormal operating conditions, and to ~~assure~~ ensure that a full load turbine trip will not cause the turbine to overspeed beyond acceptable limits. Under these conditions, the control and protection system should permit an orderly reactor shutdown either by use of the turbine bypass system and main steam relief system or

other engineered safety systems. The overspeed protection system should meet the single failure criterion and should be testable when the turbine is in operation.

2. Turbine main steam stop and control valves and reheat steam stop and intercept valves should be provided to protect the turbine from exceeding set speeds and to protect the reactor system from abnormal surges. The reheat stop and intercept valves should be capable of closure concurrent with the main steam stop valves, or of sequential closure within an appropriate time limit, to ~~assure~~ ensure that turbine overspeed is controlled within acceptable limits. The valve arrangements and valve closure times should be such that a failure of any single valve to close will not result in excessive turbine overspeed in the event of a TGS trip signal.
3. The extraction steam check valves provided at extraction connections shall be capable of closing within an appropriate time limit to maintain stable turbine speeds in the event of a TGS trip signal.
4. The TGS should be provided with the capability to permit periodic testing of components important to safety while the unit is operating at rated load.
5. An inservice inspection program for main steam and reheat valves should be provided and it should include the following provisions:
 - a. At approximately 3 $\frac{1}{3}$ -year intervals, during refueling or maintenance shutdowns coinciding with the inservice inspection schedule required by Section XI of the ASME Code for reactor components, at least one main steam stop valve, one main steam control valve, one reheat stop valve, and one reheat intercept valve should be dismantled and visual and surface examinations conducted of valve seats, disks, and stems. If unacceptable flaws or excessive corrosion are found in a valve, all other valves of that type should be dismantled and inspected. Valve bushings should be inspected and cleaned, and bore diameters should be checked for proper clearance.
 - b. Main steam stop and control valves and reheat stop and intercept valves should be exercised at least once a week by closing each valve and observing by the valve position indicator that it moves smoothly to a fully closed position. At least once a month, this examination should be made by direct observation of the valve motion.
6. Unlimited access to all levels of the turbine area under all operating conditions should be provided. Radiation shielding should be provided as necessary to permit access.
7. Connection joints between the low pressure turbine exhaust and the main condenser should be arranged to prevent adverse effects on any safety-related equipment in the turbine room in the event of rupture (it is preferable not to locate safety-related equipment in the turbine room).

Technical Rationale²²

The technical rationale for application of the above acceptance criterion is discussed in the following paragraphs:²³

Compliance with GDC 4 requires, in part, that structures, systems, and components important to safety be appropriately protected against dynamic effects, including missiles.

GDC 4 applies to this SRP section because the reviewer evaluates the turbine generator system to ensure that it is unlikely to be a source of missiles. Missiles resulting from a failure of the turbine generator system have the potential to cause the loss of function of safety-related structures or components, thus compromising the safety of the nuclear power plant. Specifically, turbine overspeed is a potential initiating event that could become a source of missiles. Implementation of a turbine overspeed protection system serves to control turbine action under all operating conditions, thereby ensuring that a full-load turbine trip will not cause the turbine to overspeed beyond acceptable limits.

Meeting this requirement provides assurance that missiles resulting from failure of the turbine generator system will not result in loss of function of safety-related portions of the nuclear power plant.²⁴

III. REVIEW PROCEDURES

The procedures below are used during the construction permit (CP) review to determine that the design criteria and bases and preliminary design as set forth in the Preliminary Safety Analysis Report meet the acceptance criteria given in subsection II. For review of design certification or²⁵ operating license (OL) applications, the procedures are utilized to verify that the initial design criteria and bases have been appropriately implemented in the final design as set forth in the final safety analysis report.

The review procedures for combined license (COL), design certifications, or²⁶ OL applications include a determination that the content and intent of the technical specifications prepared by the applicant are in agreement with the requirements for system testing, minimum performance, and surveillance developed as a result of the staff's review.

For standard design certification reviews, the above review procedures are used to verify that the design as set forth in the standard SAR (including inspections, tests, analyses, and acceptance criteria (ITAAC); site interface requirements; and COL action items) meets the acceptance criteria given in subsection II.²⁷

The review procedures given are for a typical turbine generator system. Any variance of the review, to take account of a proposed unique design, will be such as to ~~assure~~ ensure that the system meets the criteria of subsection II. The reviewer evaluates the TGS, subsystems, and components of the unit that are considered essential for the safe integrated operation of the reactor facility. The reviewer will select and emphasize material from this review plan, as may be appropriate for a particular case.

The primary reviewer will coordinate this review with other branches for their particular areas of responsibility as stated in subsection I. The primary reviewer obtains and uses such input as required to ~~assure~~ ensure that this review procedure is complete.

1. The SAR is reviewed to determine that the system description and piping and instrumentation diagrams (P&IDs) show the turbine generator system. The general arrangement of the TGS and associated equipment with respect to safety-related structures, systems, and components is noted.
2. The reviewer verifies the adequacy of the control and overspeed protection system and determines that:
 - a. Support systems, subsystems, control systems, and alarms and trips will function for all abnormal conditions, including a single failure of any component or subsystem, and will preclude an unsafe turbine overspeed. The in depth defense that is provided by the turbine generator protection system to preclude excessive overspeeds should be designed with diverse protection means.
 - b. For normal speed-load control, the speed governor action of the electrohydraulic control system fully cuts off steam at approximately 103% of rated turbine speed by closing the control, and intercept valves.
 - c. A mechanical overspeed trip device is provided that will actuate the control, stop, and intercept valves at approximately 111% of rated speed.
 - d. An independent and redundant backup electrical overspeed trip circuit is provided that senses the turbine speed by magnetic pickup and closes all valves associated with speed control at approximately 112% of rated speed. This backup electrical overspeed trip system may utilize the same sensing techniques as the electrohydraulic control system. However, the circuitry is reviewed to determine that the control signals from the two systems are isolated from, and independent of, one another.
3. The main steam stop, control, reheat stop, and intercept valving arrangements and valve closure times are reviewed to ensure that no single valve failure can disable the overspeed control function.
4. The extraction steam valving arrangements and valve closure times are reviewed to see that stable turbine operation will result after a TGS trip.
5. The capability for testing of essential components during TGS operation is reviewed.
6. The proposed inservice inspection program for essential speed control valves is reviewed to verify that it includes the provisions of item 5 of subsection II of this SRP section.

7. The ~~RAB~~ ~~PERB~~²⁸ reviews the expected radiation levels around the TGS and the degree of access to TGS components during operation and the ~~MEB~~ ~~EMEB~~²⁹ reviews the quality and seismic classification as indicated in subsection I of this SRP section.
8. If there are safety-related systems or portions of systems located close to the TGS, the physical layout of the system is reviewed to ~~assure~~ ensure that protection has been provided from the effects of high and moderate energy TGS piping failures or failure of the connections from the low pressure turbine section of the main condenser. The means of providing such protection will be given in Section 3.6 of the SAR, and the procedures for reviewing this information are given in the corresponding SRP Sections.

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.³⁰

IV. EVALUATION FINDINGS

The reviewer verifies that sufficient information has been provided and ~~his~~ that the³¹ review supports conclusions of the following type, to be included in the staff's safety evaluation report (SER).³²

The turbine generator system (TGS) includes all components and equipment normally provided including turbine main steam stop and control valves and reheat steam stop and intercept valves. The scope of review of the turbine generator system for the _____ plant included layout drawings, piping and instrumentation diagrams, and descriptive information for the system and for control and supporting systems that are essential to its operation.

The basis for acceptance of the turbine generator system in our review was conformance of the designs, design criteria, and design bases to the Commission's regulations as set forth in General Design Criteria (~~GDC~~)³³ of Appendix A to 10 CFR Part 50. The staff concludes that the plant design is acceptable and meets the requirements of GDC 4 with respect to the protection of structures, systems, and components important to safety from the effects of turbine missiles. The applicant has met this requirement by providing a turbine overspeed protection system to control the turbine action under all operating conditions and which ~~assures~~ ensures that a full-load turbine trip will not cause the turbine to overspeed beyond acceptable limits and will not result in turbine missiles.

The staff concludes that the design of the turbine generator system conforms to all applicable ~~GDC~~ General Design Criteria,³⁴ staff positions, industry standards, and it can perform its designed safety functions and is therefore acceptable.

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.³⁵

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 52.⁶ 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.³⁷

VI. REFERENCES

1. 10 CFR Part 50, Appendix A, General Design Criterion 4, "Environmental and ~~Missile~~ Dynamic Effects³⁸ Design Bases."
2. Regulatory Guide 1.68, "Initial Test Programs for Water-Cooled Reactor Power Plants."
3. Branch Technical Positions ASB 3-1,³⁹ "Protection Against Postulated Piping Failures in Fluid Systems Outside Containment," attached to SRP Section 3.6.1.
4. Branch Technical Position MEB 3-1,⁴⁰ "Postulated ~~Break and Leakage~~ Rupture⁴¹ Locations in Fluid System Piping Inside and⁴² Outside Containment," attached to SRP Section 3.6.2.

SRP Draft Section 10.2

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 Plant Systems Branch (SPLB).
2.	Editorial	Defined SRP as Standard Review Plan.
3.	Editorial	Replaced "assure" with "ensure" (global change for this section).
4.	Current PRB abbreviation	Changed PRB to SPLB.
5.	Current PRB abbreviation	Changed PRB to SPLB.
6.	Current PRB abbreviation	Changed PRB to SPLB.
7.	Current SPLB review responsibility	Changed to reflect review responsibility for SRP Section 9.5.1.
8.	SRP-UDP format item	Added "Review Interfaces" to AREAS OF REVIEW and organized in numbered paragraph form.
9.	Current PRB abbreviation	Changed PRB to SPLB.
10.	Current SRB name and abbreviation	Changed SRB to Materials and Chemical Engineering Branch (EMCB).
11.	Current SRB abbreviation	Changed SRB to Mechanical Engineering Branch (EMEB).
12.	Current SRB abbreviation	Changed SRB to EMEB.
13.	Current SRB name and abbreviation	Changed SRB to Materials and Chemical Engineering Branch (EMCB).
14.	Current PRB abbreviation	Changed PRB to SPLB.
15.	Current SRB name and abbreviation	Changed SRB to Emergency Preparedness and Radiation Protection Branch (PERB).
16.	Current SRB name and abbreviation	Changed SRB to Quality Assurance and Maintenance Branch (HQMB).

SRP Draft Section 10.2
Attachment A - Proposed Changes in Order of Occurrence

Item	Source	Description
17.	SRP-UDP format item	Each SRB review responsibility presented in numbered paragraph form.
18.	SRP-UDP format item	Each SRB review responsibility presented in numbered paragraph form.
19.	SRP-UDP format item	Each SRB review responsibility presented in numbered paragraph form.
20.	Editorial	Simplified for clarity and readability.
21.	Editorial	Added GDC 4 abbreviation.
22.	SRP-UDP format item	Added "Technical Rationale" to ACCEPTANCE CRITERIA and organized in numbered paragraph form to describe the bases for referencing the GDC and regulations.
23.	SRP-UDP format item	Added lead-in sentence for "Technical Rationale."
24.	SRP-UDP format item	Added technical rationale for GDC 4.
25.	SRP-UDP format item	Added reference to design certification reviews.
26.	SRP-UDP format item	Added reference to combined license and design certification reviews.
27.	SRP-UDP format item	Added reference to design certification reviews.
28.	Current SRB abbreviation	Changed SRB to PERB.
29.	Current SRB abbreviation	Changed SRB to EMEB.
30.	SRP-UDP Guidance, Implementation of 10 CFR 52	Added standard paragraph to address application of Review Procedures in design certification reviews.
31.	Editorial	Modified to eliminate gender-specific pronoun.
32.	Editorial	Provided "SER" as initialism for "safety evaluation report."

SRP Draft Section 10.2
Attachment A - Proposed Changes in Order of Occurrence

Item	Source	Description
33.	Editorial	Eliminated "GDC" as an initialism for "General Design Criteria" because GDC is used in a singular context.
34.	Editorial	Changed "GDC" to "General Design Criteria" to accommodate plural usage.
35.	SRP-UDP format item	Added reference to design certification reviews.
36.	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.
37.	SRP-UDP Guidance	Added standard paragraph to indicate applicability of this section to reviews of future applications.
38.	Editorial	Corrected title of GDC 4.
39.	Action item	Branch Technical Position ASB 3-1 should be revised as a follow on to the SRP-UDP.
40.	Action item	Branch Technical Position MEB 3-1 should be revised as a follow on to the SRP-UDP.
41.	Editorial	Corrected title to MEB 3-1.
42.	Editorial	Corrected title to MEB 3-1.

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SRP Draft Section 10.2
Attachment B - Cross Reference of Integrated Impacts

Integrated Impact No.	Issue	SRP Subsections Affected
	No Integrated Impacts were incorporated in this SRP Section.	