U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

10.2 TURBINE GENERATOR

REVIEW RESPONSIBILITIES

Primary - Organization responsible for the review of power conversion systems

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 (1) the turbine unit and the automatic devices, alarms, and trips that control and regulate turbine action and (2) the generator unit and its controls. The turbine control system, steam inlet stop and control valves, low-pressure turbine steam intercept and inlet control valves, and 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 TGS 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 SRP section is to verify that such redundancy, in conjunction with inservice inspection and testing of the essential valves, makes a turbine overspeed condition that exceeds the design overspeed very unlikely and to ensure conformance with General Design Criterion (GDC) 4.

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The specific areas of review are as follows:

1. The TGS and the components and subsystems are normally provided with 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 that exceeds the design overspeed

   D. The overspeed protection instrumentation and controls with respect to redundancy, testability, and reliability

2. A review is conducted of the inservice inspection and operability assurance program for valves essential for overspeed protection.

3. Inspections, Tests, Analyses, and Acceptance Criteria (ITAAC). For design certification (DC) and combined license (COL) reviews, the staff reviews the applicant's proposed ITAAC associated with the structures, systems, and components (SSCs) related to this SRP section in accordance with SRP Section 14.3, "Inspections, Tests, Analyses, and Acceptance Criteria." The staff recognizes that the review of ITAAC cannot be completed until after the rest of this portion of the application has been reviewed against acceptance criteria contained in this SRP section. Furthermore, the staff reviews the ITAAC to ensure that all SSCs in this area of review are identified and addressed as appropriate in accordance with SRP Section 14.3.

4. COL Action Items and Certification Requirements and Restrictions. For a DC application, the review will also address COL action items and requirements and restrictions (e.g., interface requirements and site parameters).

   For a COL application referencing a DC, a COL applicant must address COL action items (referred to as COL license information in certain DCs) included in the referenced DC. Additionally, a COL applicant must address requirements and restrictions (e.g., interface requirements and site parameters) included in the referenced DC.

Review Interfaces

Other SRP sections interface with this section as follows:

1. Acceptability of the seismic and quality group classifications for system components is reviewed under SRP Sections 3.2.1 and 3.2.2.

2. Review of the assessment of the risk to essential plant systems and structures and consideration of turbine orientation as related to turbine missiles is performed under SRP Section 3.5.1.3.

3. Review of high- and moderate-energy pipe breaks is performed under SRP Section 3.6.1. If safety-related systems or portions of systems are located close to the TGS, the physical layout of the system is reviewed to ensure that protection has been provided from the effects of high- and moderate-energy TGS piping failures or a failure of the connections from the low-pressure turbine section of the main condenser. Section 3.6 of the SAR will note the means of providing such protection, and the corresponding SRP sections will cite procedures for reviewing this information.

4. Review of the components, piping, and structures, which are designed in accordance with applicable codes and standards, is performed under SRP Sections 3.9.1 through 3.9.3.

5. Review of the adequacy of the inservice testing program of the system valves is performed under SRP Section 3.9.6.

6. Review of the compatibility of the materials of construction with service conditions is performed under SRP Sections 5.2.3 and 10.3.6.

7. Review of portions of the Main Steam System with respect to the adequacy of design, installation, inspection, and testing of essential components necessary for instrumentation and control functions is performed under SRP Sections 7.1, 7.4, 7.5, and 7.7.

8. Acceptability of the fire protection system is reviewed under SRP Section 9.5.1.

9. A determination is made whether any radiation shielding is necessary to ensure safe access to turbine equipment under review for SRP Chapter 12.

10. Review of radiation protection design features, expected radiation levels around the TGS and the degree of access to TGS components during operation is performed under SRP Section 12.3.

11. A determination is made of the acceptability of the preoperational and startup tests under review for SRP Chapter 14.

12. Review of technical specifications is performed under SRP Chapter 16.

13. Review of quality assurance is performed under SRP Chapter 17.

The specific acceptance criteria and review procedures are contained in the referenced SRP sections.

II. ACCEPTANCE CRITERIA

Requirements

Acceptance criteria are based on meeting the relevant requirements of the following Commission regulations:

1. General Design Criterion (GDC 4) as it relates to the TGS for the protection of SSCs 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.

2. 10 CFR 52.47(b)(1), which requires that a DC application contain the proposed inspections, tests, analyses, and acceptance criteria (ITAAC) that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, a plant that incorporates the design certification is built and will operate in accordance with the design certification, the provisions of the Atomic Energy Act, and the NRC's regulations;

3. 10 CFR 52.80(a), which requires that a COL application contain the proposed inspections, tests, and analyses, including those applicable to emergency planning, that the licensee shall perform, and the acceptance criteria that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, the facility has been constructed and will operate in conformity with the combined license, the provisions of the Atomic Energy Act, and the NRC's regulations.

SRP Acceptance Criteria

Specific SRP acceptance criteria acceptable to meet the relevant requirements of the NRC's regulations identified above are as follows for the review described in this SRP section. The SRP is not a substitute for the NRC's regulations, and compliance with it is not required. However, an applicant is required to identify differences between the design features, analytical techniques, and procedural measures proposed for its facility and the SRP acceptance criteria and evaluate how the proposed alternatives to the SRP acceptance criteria provide acceptable methods of compliance with the NRC regulations.

1. Specific criteria necessary to meet the requirements of GDC 4 are as follows:

   A. A turbine control and overspeed protection system should control turbine action under all normal or abnormal operating conditions and should 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 by use of either 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.

   B. The turbine main steam stop and control valves and the reheat steam stop and intercept valves should protect the turbine from exceeding set speeds and should 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 ensure that turbine overspeed is controlled within acceptable limits. The valve arrangements and valve closure times should be structured so that a failure of any single valve to close will not result in excessive turbine overspeed in the event of a TGS trip signal.

   C. The TGS should have the capability to permit periodic testing of components important to safety while the unit is operating at rated load.

2. An inservice inspection program for main steam and reheat valves should be established and should include the following provisions:

A. At intervals of approximately 3-1/3 years, during refueling or maintenance shutdowns coinciding with the inservice inspection schedule required by Section XI of the American Society of Mechanical Engineers (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 should be conducted of valve seats, disks, and stems. If this process detects unacceptable flaws or excessive corrosion 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 should be exercised at a frequency recommended by the turbine vendor or valve manufacturer.

3. The arrangement of connection joints between the low-pressure turbine exhaust and the main condenser should prevent adverse effects on any safety-related equipment in the turbine room in the event of a rupture (it is preferable not to locate safety-related equipment in the turbine room).

Technical Rationale

The technical rationale for application of these acceptance criteria to the areas of review addressed by this SRP section is discussed in the following paragraphs:

1. Compliance with GDC 4 requires, in part, that SSCs important to safety are appropriately protected against dynamic effects, including missiles.

   GDC 4 applies to this SRP section because missiles resulting from a failure of the TGS can potentially cause a 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 cause turbine blades to fail and 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 a TGS failure will not result in a loss of function of safety-related portions of the nuclear power plant.

III. REVIEW PROCEDURES

The reviewer will select material from the procedures described below, as may be appropriate for a particular case.

These review procedures are based on the identified SRP acceptance criteria. For deviations from these acceptance criteria, the staff should review the applicant's evaluation of how the proposed alternatives provide an acceptable method of complying with the relevant NRC requirements identified in Subsection II.

The NRC staff uses the procedures below during the construction permit review to determine whether the design criteria and bases and preliminary design in the preliminary safety analysis report (SAR) meet the acceptance criteria in subsection II. For review of operating license (OL) applications, the procedures verify that the initial design criteria and bases have been

appropriately implemented in the final design detailed in the final SAR. These procedures should be followed for review of a DC or COL application.

The review procedures for COL, DC, or OL applications determine that the content and intent of the applicant's technical specifications agree with the requirements for system testing, minimum performance, and surveillance developed as a result of the staff's review.

The specified review procedures are for a typical TGS. Any variance in the review to account for a proposed unique design will 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.

1. The reviewer confirms that the system description and the piping and instrumentation diagrams (P&IDs) provided in the SAR show the TGS. The general arrangement of the TGS and associated equipment with respect to safety-related SSCs is noted.

2. The reviewer verifies the adequacy of the control and overspeed protection system and determines the following:

   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 design of the in-depth defense provided by the turbine generator protection system to preclude excessive overspeeds should include 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 percent of rated turbine speed by closing the control and intercept valves.

   C. A mechanical overspeed trip device will actuate the control, stop, and intercept valves at approximately 111 percent of rated speed.

   D. An independent and redundant backup electrical overspeed trip circuit senses the turbine speed by magnetic pickup and closes all valves associated with speed control at approximately 112 percent of rated speed. This backup electrical overspeed trip system may use the same sensing techniques as the electrohydraulic control system. However, the circuitry is reviewed to confirm that the control signals from the two systems are isolated from, and independent of, each other.

3. The main steam stop, control, reheat stop, and intercept valving arrangements and the valve closure times are reviewed to ensure that no single valve failure can disable or otherwise compromise the overspeed control function.

4. The capability to test essential components during TGS operation is reviewed.

5. The proposed inservice inspection program for essential speed control valves is reviewed to verify that it includes the provisions of subsection I of this SRP section.

6. For review of a DC application, the reviewer should follow the above procedures to verify that the design, including requirements and restrictions (e.g., interface requirements and site parameters), set forth in the final safety analysis report (FSAR) meets the acceptance criteria. DCs have referred to the FSAR as the design control document

(DCD). The reviewer should also consider the appropriateness of identified COL action items. The reviewer may identify additional COL action items; however, to ensure these COL action items are addressed during a COL application, they should be added to the DC FSAR.

For review of a COL application, the scope of the review is dependent on whether the COL applicant references a DC, an early site permit (ESP) or other NRC approvals (e.g., manufacturing license, site suitability report or topical report).

For review of both DC and COL applications, SRP Section 14.3 should be followed for the review of ITAAC. The review of ITAAC cannot be completed until after the completion of this section.

IV. EVALUATION FINDINGS

The reviewer verifies that the applicant has provided sufficient information and that the review and calculations (if applicable) support conclusions of the following type to be included in the staff's safety evaluation report. The reviewer also states the bases for those conclusions.

1. The TGS includes all components and equipment normally provided, such as turbine main steam stop and control valves and reheat steam stop and intercept valves. The scope of review of the TGS for the plant includes layout drawings, P&IDs, and descriptive information for the system and for control and supporting systems that are essential to its operation.

2. The basis for acceptance of the TGS in the NRC review was conformance of the designs, design criteria, and design bases to the Commission's regulations, as cited in the GDC 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 SSCs 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, which ensures that a full-load turbine trip will not cause the turbine to overspeed beyond acceptable limits and will not result in turbine missiles.

3. The staff concludes that the TGS design conforms to all applicable GDC, staff positions, and industry standards and that it can perform its designed safety functions and is therefore acceptable.

For DC and COL reviews, the findings will also summarize the staff's evaluation of requirements and restrictions (e.g., interface requirements and site parameters) and COL action items relevant to this SRP section.

In addition, to the extent that the review is not discussed in other SER sections, the findings will summarize the staff's evaluation of the ITAAC, including design acceptance criteria, as applicable.

V. IMPLEMENTATION

The staff will use this SRP section in performing safety evaluations of DC applications and license applications submitted by applicants pursuant to 10 CFR Part 50 or 10 CFR Part 52. Except when the applicant proposes an acceptable alternative method for complying with

specified portions of the Commission's regulations, the staff will use the method described herein to evaluate conformance with Commission regulations.

The provisions of this SRP section apply to reviews of applications submitted six months or more after the date of issuance of this SRP section, unless superseded by a later revision.

VI. REFERENCES

1. 10 CFR Part 50, Appendix A, General Design Criterion 4, "Environmental and Dynamic Effects Design Bases."

2. Regulatory Guide 1.68, "Initial Test Programs for Water-Cooled Reactor Power Plants."

3. Branch Technical Position 3-3, "Protection Against Postulated Piping Failures in Fluid Systems Outside Containment."

4. Branch Technical Position 3-4, "Postulated Rupture Locations in Fluid System Piping Inside and Outside Containment."

5. American Society of Mechanical Engineers. Boiler and Pressure Code. Section XI, "Rules for Inservice Inspection of Nuclear Power Plants Components."