

Proposed - For Interim Use and Comment



U.S. NUCLEAR REGULATORY COMMISSION DESIGN-SPECIFIC REVIEW STANDARD FOR mPOWER™ iPWR DESIGN

10.4.4 TURBINE BYPASS SYSTEM

REVIEW RESPONSIBILITIES

Primary - Organization responsible for the review of power conversion systems.

Secondary - None

I. AREAS OF REVIEW

The turbine bypass system (TBS) is designed to discharge a stated percentage of rated main steam flow directly to the main condensers, bypassing the turbine. This steam bypass enables the plant to take step load reductions up to the TBS capacity without the reactor or turbine tripping. The system is also used during startup and shutdown to control steam generator pressure. The TBS is not required for safe shutdown, as the relief and safety valves are operated under emergency conditions. The system is not required to function as a heat sink for the prevention or mitigation of postulated accidents. Failure of the TBS during a load reduction or turbine trip would result in the actuation of the relief valves and possibly the safety valves.

The specific areas of review are as follows:

1. Review of the system from the branch connection at the main steam system to the main condensers.
2. Review of the TBS to determine that a failure of the system or system components will not have an adverse effect on essential equipment.
3. Review of the TBS functional requirements for both normal and abnormal operating conditions, and with respect to the following: (1) capability to isolate those portions of the system that could leak or malfunction; (2) capability to perform adequate operational testing and inservice inspection; (3) to ensure there are no adverse effects of postulated system piping failures on safety-related equipment; and (4) to reduce the possibility of reactor transients due to inadvertent operation of the TBS from faults in the TBS instrumentation and control.
4. 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 design-specific review standard (DSRS) section in accordance with Standard Review Plan (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 DSRS 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 DSRS Sections 14.2 and 14.3.7.

5. 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 DSRS/SRP sections interface with this section as follows:

1. Review to ensure conformance to SRP Branch Technical Position (BTP) 3-3, "Protection Against Postulated Piping Failures in Fluid Systems Outside Containment," concerning cracks and breaks in high- and moderate-energy piping outside containment is performed under SRP Section 3.6.1.
2. Review of the fire protection program is performed under SRP Section 9.5.1.
3. Review of the seismic and quality group classifications is performed under DSRS Sections 3.2.1 and 3.2.2.
4. Review to ensure conformance to BTP 3-4, "Postulated Break and Leakage Locations in Fluid System Piping Outside Containment," concerning cracks and breaks in high- and moderate-energy piping outside containment.
5. Review to ensure the steam bypass capacity is consistent with reactor transient analysis is performed under DSRS Section 4.4.
6. Acceptability of the preoperational and startup tests is performed under DSRS Section 14.2.
7. Review of technical specifications is performed under DSRS Section 16.0.
8. Review of quality assurance programs is performed under SRP Chapter 17.
9. Review of the probabilistic risk assessment performed under SRP Chapter 19.0 for potential risk significance of TBS elements.

For those areas of review identified above as part of the primary review responsibility of other staff, the acceptance criteria necessary for the review and their methods of application are contained in the referenced DSRS/SRP sections of the corresponding primary reviewers.

II. ACCEPTANCE CRITERIA

Requirements

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

1. General Design Criterion 4 (GDC) 4, "Environmental and Dynamic Effects Design

Basis,” in that failure of the TBS due to a pipe break, steam hammer, or malfunction of the TBS should not adversely affect essential systems or components (i.e., those necessary for safe shutdown or accident prevention or mitigation).

2. GDC 34, “Residual Heat Removal,” as related to the ability to use the system for shutting down plant during normal operation. The operation of the TBS eliminates the need to rely solely on safety systems or components, which are required to meet the redundancy and power source requirements of this criterion.
3. 10 CFR 52.47(b)(1), which requires that a DC application contain the proposed 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 facility that incorporates the DC has been constructed and will be operated in conformity with the DC, the provisions of the Atomic Energy Act (AEA), and the U.S. Nuclear Regulatory Commission’s (NRC’s) regulations.
4. 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 COL, the provisions of the AEA, and the NRC’s regulations.

DSRS Acceptance Criteria

Specific DSRS acceptance criteria acceptable to meet the relevant requirements of the NRC’s regulations identified above are set forth below. The DSRS is not a substitute for the NRC’s regulations, and compliance with it is not required. Identifying the differences between this DSRS section and the design features, analytical techniques, and procedural measures proposed for the facility, and discussing how the proposed alternative provides an acceptable method of complying with the regulations that underlie the DSRS acceptance criteria, is sufficient to meet the intent of 10 CFR 52.47(a)(9), “Contents of applications; technical information.” The same approach may be used to meet the requirements of 10 CFR 52.79(a)(41) for COL applications.

1. Piping Failures. The requirements of GDC 4 related to the ability of safety-related or risk-significant SSCs to meet environmental conditions associated with normal operation, maintenance, testing, and postulated accident conditions is met by demonstrating that failure of the TBS due to a pipe break or malfunction of the TBS will not adversely affect essential systems or components (i.e., those necessary for safe shutdown or accident prevention or mitigation).
2. Residual Heat Removal. The requirements of GDC 34 related to providing a reliable system that removes residual heat during normal plant shutdown is met by demonstrating the ability to use the turbine bypass system for shutting down the plant during normal operations. The operation of the TBS eliminates the need to rely solely on safety systems, which are required to meet the redundancy and power source requirements of this criterion.

Technical Rationale

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

1. GDC 4 requires that safety-related or risk-significant SSCs be designed to meet environmental conditions associated with normal operation, maintenance, testing, and postulated accident. However, dynamic effects associated with postulated pipe ruptures in nuclear power plants may be excluded from the design basis when analyses reviewed and approved by the Commission demonstrate that the probability of a rupture in the fluid system piping is extremely low under conditions consistent with the design basis for the piping.

Although the turbine bypass system is not classified as a system important to safety, GDC 4 applies to this DSRS section because a failure of the TBS or one of its components could have an adverse impact on a safety-related or risk-significant structure, system, or component.

Meeting the requirements of this criterion provides a level of assurance that SSCs will not be adversely affected by a failure of the turbine bypass system.

2. GDC 34 requires that the applicant provide a system to remove residual heat, and it establishes specific requirements related to performance, redundancy, and reliability.

Although the TBS is not the residual heat removal system specified in GDC 34, it can perform that function. GDC 34 applies to this SRP section because using the TBS during normal plant shutdown reduces demands on systems important to safety.

Meeting the requirements of this criterion provides a level of assurance that the residual heat removal system will remain operable and that safety systems will have the capability to transfer residual heat from the reactor core at a rate that does not exceed specified fuel design limits or the design conditions of the reactor pressure boundary.

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 DSRS 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 procedures for review of COL 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 technical specifications review, as indicated in Subsection I of this DSRS section.

Upon request from the reviewer, the interface reviewers will provide input for the areas of review stated in Subsection I. The reviewer obtains and uses such input as required to ensure that this review procedure is complete.

1. Programmatic Requirements — In accordance with the guidance in NUREG-0800 "Introduction," Part 2 as applied to this DSRS Section, the staff will review the programs proposed by the applicant to satisfy the following programmatic requirements. If any of

the proposed programs satisfies the acceptance criteria described in Subsection II, it can be used to augment or replace some of the review procedures. It should be noted that the wording of “to augment or replace” applies to nonsafety-related risk-significant SSCs, but “to replace” applies to nonsafety-related nonrisk-significant SSCs according to the “graded approach” discussion in NUREG-0800 “Introduction,” Part 2. Commission regulations and policy mandate programs applicable to SSCs that include:

- A. Maintenance rule, SRP Section 17.6 (DSRS Section 13.4, Table 13.4, Item 17, Regulatory Guide (RG) 1.160, “Monitoring the Effectiveness of Maintenance at Nuclear Power Plants,” and RG 1.18, “Assessing and Managing Risk Before Maintenance Activities at Nuclear Power Plants.”
 - B. Quality Assurance Program, SRP Sections 17.3 and 17.5 (DSRS Section 13.4, Table 13.4, Item 16).
 - C. Technical Specifications (DSRS Section 16.0 and SRP Section 16.1) – including brackets value for DC and COL. Brackets are used to identify information or characteristics that are plant specific or are based on preliminary design information.
 - D. Reliability Assurance Program (SRP Section 17.4).
 - E. Initial Plant Test Program (RG 1.68, “Initial Test Programs for Water-Cooled Nuclear Power Plants,” DSRS Section 14.2, and DSRS Section 13.4, Table 13.4, Item 19).
 - F. ITAAC (DSRS Chapter 14).
2. In accordance with 10 CFR 52.47(a)(8),(21), and (22), for new reactor license applications submitted under Part 52, the applicant is required to (1) address the proposed technical resolution of unresolved safety issues and medium- and high-priority generic safety issues that are identified in the version of NUREG-0933 current on the date 6 months before application and that are technically relevant to the design; (2) demonstrate how the operating experience insights have been incorporated into the plant design; and, (3) provide information necessary to demonstrate compliance with any technically relevant portions of the Three Mile Island requirements set forth in 10 CFR 50.34(f), except paragraphs (f)(1)(xii), (f)(2)(ix), and (f)(3)(v). These cross-cutting review areas should be addressed by the reviewer for each technical subsection and relevant conclusions documented in the corresponding safety evaluation report (SER) section.
 3. The application is reviewed to determine that the system description and schematics and piping and instrumentation diagrams (P&IDs) delineate the system and components.
 4. The safety analysis report (SAR) is reviewed to verify that the system design bases and an evaluation of the system capacity are provided, including valve capacity in terms of percentage of rated main steam flow, the maximum reactor power step change the system is designed to accommodate without a reactor or turbine trip, and the maximum electric load step change the reactor is designed to accommodate without reactor control rod motion or steam bypassing.
 5. The reviewer uses engineering judgment and the results of failure modes and effects analyses to determine that:

- A. Failure of the TBS to operate will not preclude operation of any essential systems. Statements in the SAR that confirm the above are acceptable.
- B. Failure of the TBS high energy piping will not have adverse effects on any safety-related systems or components that may be located close to the system.

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 DCD.

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 technical review and analysis 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.

The TBS includes all components and piping from the branch connection at the main steam system to the main condensers. The scope of review of the turbine bypass system included layout drawings, P&IDs, and descriptive information for the TBS and auxiliary supporting systems that are essential to its operation.

The basis for acceptance of the TBS in the staff's review was conformance of the designs, design criteria, and design bases to the Commission's regulations as set forth in GDC 4 and GDC 34 of Appendix A to 10 CFR Part 50.

1. The applicant has met the requirements of GDC 4, "Environmental and Dynamic Effects Design Bases," with respect to the system being designed such that a safe shutdown will not be precluded as a result of the TBS failure and the programmatic requirements will provide assurance that the TBS will be designed, installed, and tested as described in the DCD or the FSAR.
2. The applicant has met the requirements of GDC 34, "Residual Heat Removal," with respect to the ability to use the turbine bypass system for shutting down the plant during normal operations. The turbine bypass system is designed such that sufficient steam can be bypassed to the main condenser so that the plant can be shutdown during normal operations without using the turbine generator.

The staff concludes that the design of the turbine bypass system conforms to all applicable GDCs, staff positions and industry standards 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 DSRS 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 acceptance criteria, as applicable.

V. IMPLEMENTATION

The staff will use this DSRS section in performing safety evaluations of mPower™-specific DC, or COL applications submitted by applicants pursuant to 10 CFR Part 52. The staff will use the method described herein to evaluate conformance with Commission regulations.

Because of the numerous design differences between the mPower™ and large light-water nuclear reactor power plants, and in accordance with the direction given by the Commission in SRM-COMGBJ-10-0004/COMGEA-10-0001, "Use of Risk Insights to Enhance the Safety Focus of Small Modular Reactor Reviews," dated August 31, 2010 (Agencywide Documents Access and Management System Accession No. ML102510405), to develop risk-informed licensing review plans for each of the small modular reactor reviews, including the associated pre-application activities, the staff has developed the content of this DSRS section as an alternative method for mPower™-specific DC, COL, or ESP application submitted pursuant to 10 CFR Part 52 to comply with 10 CFR 52.47(a)(9), "Contents of applications; technical information."

This regulation states, in part, that the application must contain "an evaluation of the standard plant design against the Standard Review Plan (SRP) revision in effect 6 months before the docket date of the application." The content of this DSRS section has been accepted as an alternative method for complying with 10 CFR 52.47(a)(9), as long as the mPower™ DCD FSAR does not deviate significantly from the design assumptions made by the NRC staff while preparing this DSRS section. The application must identify and describe all differences between the standard plant design and this DSRS section, and discuss how the proposed alternative provides an acceptable method of complying with the regulations that underlie the DSRS acceptance criteria. If the design assumptions in the DC application deviate significantly from the DSRS, the staff will use the SRP as specified in 10 CFR 52.47 (a)(9). Alternatively, the staff may supplement the DSRS section by adding the appropriate criteria in order to address new design assumptions. The same approach may be used to meet the requirements of 10 CFR 52.79 (a)(41), for COL applications.

VI. REFERENCES

1. 10 CFR Part 50, Appendix A, GDC 4, "Environmental and Dynamic Effects Design Bases."
2. 10 CFR Part 50, Appendix A, GDC 34, "Residual Heat Removal."
3. 10 CFR 52.47, "Contents of applications."
4. 10 CFR 52.80(A), "Issuance of combined licenses."