



U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

7.2 REACTOR TRIP SYSTEM

REVIEW RESPONSIBILITIES

Primary - Organization responsible for the review of instrumentation and controls

Secondary - None

Review Note: The revision numbers of Regulatory Guides (RG) and the years of endorsed industry standards referenced in this Standard Review Plan (SRP) section are centrally maintained in SRP Section 7.1-T (Table 7-1). Therefore, the individual revision numbers of RGs (except RG 1.97) and years of endorsed industry standards are not shown in this section. References to industry standards incorporated by reference into regulation (IEEE Std 279-1971 and IEEE Std 603-1991) and industry standards that are not endorsed by the agency do include the associated year in this section. See Table 7-1 to ensure that the appropriate RGs and endorsed industry standards are used for the review.

I. AREAS OF REVIEW

The objectives of the review are to confirm that the reactor trip system (RTS): (1) satisfies the

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USNRC STANDARD REVIEW PLAN

This Standard Review Plan (SRP), NUREG-0800, has been prepared to establish criteria that the U.S. Nuclear Regulatory Commission (NRC) staff responsible for the review of applications to construct and operate nuclear power plants intends to use in evaluating whether an applicant or licensee meets the NRC's regulations. 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 an acceptable method of complying with the NRC regulations.

The standard review plan sections are numbered in accordance with corresponding sections in Regulatory Guide (RG) 1.70, "Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants (LWR Edition)." Not all sections of RG 1.70 have a corresponding review plan section. The SRP sections applicable to a combined license application for a new light-water reactor (LWR) are based on RG 1.206, "Combined License Applications for Nuclear Power Plants (LWR Edition)."

These documents are made available to the public as part of the NRC's policy to inform the nuclear industry and the general public of regulatory procedures and policies. Individual sections of NUREG-0800 will be revised periodically, as appropriate, to accommodate comments and to reflect new information and experience. Comments may be submitted electronically by email to NRO_SRP@nrc.gov

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requirements of the acceptance criteria and guidelines applicable to the protection system and (2) performs its safety functions for all plant conditions under which the safety functions are required.

1. This SRP section describes the review process and acceptance criteria for the RTS, which is part of the reactor protection system. The review process and acceptance criteria apply to all RTS equipment, including hardware, software, and firmware, from sensors to actuation devices (e.g., power sources, sensors, signal conditioners, initiation circuits, logic, bypasses, interlocks, racks, panels, control boards, interconnections, and actuation devices) that are required to initiate reactor shutdown, and auxiliary supporting features and other auxiliary features. The RTS is designed to initiate the reactivity control system (control rods) automatically to ensure that specified acceptable fuel design limits are not exceeded. The controls, inhibits, and interlocks for the withdrawal, insertion, and sequence of control rods are described in the safety analysis report (SAR) Sections 7.6 and 7.7.
2. 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.
3. 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. SRP Section 7.0 describes the coordination of reviews, including the information to be reviewed and the scope required for each of the different types of applications that the staff may review. Refer to that section for information regarding how the areas of review are affected by the type of application under consideration and for a description of coordination between the organization responsible for the review of instrumentation and control systems and other organizations.

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

II. ACCEPTANCE CRITERIA

Requirements

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

1. Title 10 of the *Code of Federal Regulations* (10 CFR) 50.54(jj) and 10 CFR 50.55(i).
2. Regulations in 10 CFR 50.55a(h), "Protection and Safety Systems," require compliance with the Institute of Electrical and Electronics Engineers (IEEE) Standard (Std) 603-1991, "IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations," and the correction sheet dated January 30, 1995. For nuclear power plants with construction permits issued before January 1, 1971, the applicant or licensee may elect to comply instead with their plant specific licensing basis. For nuclear power plants with construction permits issued between January 1, 1971, and May 13, 1999, the applicant or licensee may elect to comply instead with the requirements stated in IEEE Std 279-1971, "Criteria for Protection Systems for Nuclear Power Generating Stations."
3. 10 CFR 50.34(f), "Additional TMI-Related Requirements," or equivalent TMI action requirements imposed by Generic Letters.

10 CFR 50.34(f)(2)(v), "Bypass and Inoperable Status Indication."

10 CFR 50.34(f)(2)(xxiii), "Anticipatory Trip on Loss of Main Feedwater or Turbine Trip."
4. 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," Appendix A, "General Design Criteria for Nuclear Power Plants," General Design Criterion (GDC) 1, "Quality Standards and Records."
5. GDC 2, "Design Basis for Protection against Natural Phenomena."
6. GDC 4, "Environmental and Dynamic Effects Design Basis."
7. GDC 10, "Reactor Design."
8. GDC 13, "Instrumentation and Control."
9. GDC 15, "Reactor Coolant System Design."
10. GDC 19, "Control Room."
11. GDC 20, "Protection System Functions."
12. GDC 21, "Protection System Reliability and Testability."
13. GDC 22, "Protective System Independence."
14. GDC 23, "Protection System Failure Modes."
15. GDC 24, "Separation of Protection and Control Systems."

16. GDC 25, "Protection System Requirements for Reactivity Control Malfunctions."
17. GDC 29, "Protection against Anticipated Operational Occurrences."
18. 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 plant that incorporates the design certification is built and will operate in accordance with the DC, the provisions of the Atomic Energy Act, and the U.S. Nuclear Regulatory Commission's (NRC's) regulations.
19. 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 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 contained in SRP Section 7.1, SRP Table 7-1, and SRP Appendix 7.1-A, which list standards, RGs, and branch technical positions (BTPs). 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. SRP Appendix 7.1-B provides guidance for evaluating conformance to the requirements of IEEE Std 279-1971.
2. SRP Appendix 7.1-C provides guidance for evaluating conformance to IEEE Std 603 1991.
3. SRP Appendix 7.1-D provides guidance for evaluating conformance to the acceptance criteria contained in RG 1.152, "Criteria for Digital Computers in Safety Systems of Nuclear Power Plants," which endorses IEEE Std 7-4.3.2, "IEEE Standard Criteria for Digital Computers in Safety Systems of Nuclear Power Generating Stations."
4. Item II.Q, "Defense against Common-Mode Failures in Digital Instrument and Control Systems," of the Staff Requirements Memorandum (SRM) on SECY-93-087, "Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light Water Reactor (ALWR) Designs," provides guidance on Diversity and Defense-in-Depth. SRP BTP 7-19 provides additional guidance.

REVIEW PROCEDURES

The reviewer will select material from the procedures described below, as may be appropriate for a particular case. Typical reasons for a non-uniform emphasis are the introduction of new design features or the utilization in the design of features previously reviewed and found acceptable.

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

SRP Section 7.1 describes the general procedures to be followed in reviewing any instrumentation and control system. This part of SRP Section 7.2 highlights specific topics that should be emphasized in the RTS review.

1. The review should include an evaluation of the RTS design against the requirements of IEEE Std 603-1991 or IEEE Std 279-1971, depending upon the applicant or licensee's commitment regarding design criteria. For computer-based RTSs, guidance is provided by RG 1.152.

SRP Appendices 7.1-B and 7.1-C discuss the requirements of IEEE Std 279-1971 and IEEE Std 603-1991, respectively, and how the requirements are used in the review of the RTS. SRP Appendix 7.1-D discusses the criteria of IEEE Std 7-4.3.2 and how the criteria are used in the review of the RTS. Although the primary emphasis is on the equipment comprising the RTS, the reviewer must consider the overall protective functions at the system level. The RTS design should be compatible with the accident analysis. It is not sufficient to evaluate the adequacy of the RTS only on the basis that the design meets the specific requirements of IEEE Std 279-1971 or IEEE Std 603-1991.

The RTS review should address all topics identified as applicable in SRP Table 7-1. SRP Appendix 7.1-A describes review methods for each topic. Major design considerations that should be emphasized in the RTS review are identified below.

- A. Design basis - See SRP Appendix 7.1-B, Subsection 3 or SRP Appendix 7.1-C, Subsection 4.
- B. Single-failure criterion - See SRP Appendix 7.1-B, Subsection 4.2 or SRP Appendix 7.1-C, Subsection 5.1.
- C. Quality of components and modules - See SRP Appendix 7.1-B, Subsection 4.3 or SRP Appendix 7.1-C, Subsection 5.3.
- D. Independence - See SRP Appendix 7.1-B Subsections 4.6 and 4.7 or SRP Appendix 7.1-C, Subsections 5.6 and 6.3.
- E. Diversity and defense-in-depth - RTSs should incorporate multiple means for responding to each event discussed in the SAR Chapter 15, "Transient and Accident Analyses." At least one pair of these means for each event should have the property of signal diversity, i.e., the use of different sensed parameters to initiate protective action, in which any of the parameters may independently

indicate an abnormal condition, even if the other parameters are sensed incorrectly (see NUREG/CR-6303, "Method for Performing Diversity and Defense-in-Depth Analyses of Reactor Protection Systems"). The diverse means may actuate the same protective function or different protective functions, and may be automatically or manually activated, consistent with the response time requirements of the function. For digital computer-based RTSs, the applicant or licensee should have performed a defense-in-depth and diversity analysis. Additionally, for advanced reactor design under 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants," the design should provide for manual, system-level actuation of critical safety functions. SRP BTP 7-19 provides guidance for the review of diversity and defense-in-depth.

- F. System testing and inoperable surveillance - See Appendix SRP 7.1-B, Subsections 4.9 and 4.10 or SRP Appendix 7.1-C, Subsections 5.7, 5.8, and 6.5.
 - G. Use of digital systems - See SRP Appendix 7.0-A and SRP Appendix 7.1-D.
 - H. Setpoint determination - See RG 1.105, "Setpoints for Safety-Related Instrumentation," and SRP BTP 7-12.
2. 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. 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 or other NRC approvals (e.g., manufacturing license, site suitability report or topical report).

3. 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.

III. 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 (SER). The reviewer also states the bases for those conclusions.

1. The NRC staff concludes that the design of the RTS and RTS initiation of auxiliary supporting features and other auxiliary features are acceptable and meet the relevant requirements of General Design Criteria 1, 2, 4, 10, 13, 15, 19-25, and 29, and 10 CFR 50.34(f), 10 CFR 50.54(jj) and 10 CFR 50.55(i), and 10 CFR 50.55a(h). The staff conducted a review of these systems for conformance to the guidelines in the RGs and industry codes and standards applicable to these systems. The staff concluded that the applicant or licensee identified the guidelines applicable to these

systems adequately. Based upon the review of the system design for conformance to the guidelines, the staff finds that there is reasonable assurance that the systems fully conform to the guidelines applicable to these systems. Therefore the staff finds that the requirements of GDC 1, 10 CFR 50.54(jj) and 10 CFR 50.55(i) have been met.

The review included the identification of those systems and components for the RTS designed to survive the effects of earthquakes, other natural phenomena, abnormal environments and missiles. Based upon the review, the staff concludes that the applicant or licensee has identified those systems and components consistent with the design bases for those systems. Sections 3.10 and 3.11 of the SER address the qualification programs to demonstrate the capability of these systems and components to survive these events. Therefore, the staff finds that the identification of these systems and components satisfies the requirements of General Design Criteria 2 and 4.

Based on the review of RTS status information, manual initiation capabilities, and provisions to support safe shutdown, the staff concludes that information is provided to monitor the RTS over the anticipated ranges for normal operation, for the anticipated operational occurrences, and for the accident conditions as appropriate to assure adequate safety. Appropriate controls are provided for manual initiation of reactor trip. The RTS appropriately supports actions to operate the nuclear power unit safety under normal conditions and to maintain it in a safe condition under accident conditions. Therefore, the staff finds that the RTS design satisfies the requirements of General Design Criteria 13 and 19.

Based on the review of system functions, the staff concludes that the RTS conforms to the design bases requirements of (IEEE Std 279-1971 or IEEE Std 603-1991) and 10 CFR 50.34(f). The RTS conforms to the guidance of RG 1.105. Based upon this review and coordination with those having primary review responsibility for the accident analysis, the staff concludes that the RTS includes the provision to sense accident conditions and anticipated operational occurrences in order to initiate reactor shutdown consistent with the accident analysis presented in Chapter 15 of the SAR and evaluated in the SER. Therefore, the staff finds that the RTS satisfies the requirements of GDC 20.

The RTS conforms to the guidelines for periodic testing in RG 1.22, "Periodic Testing of Protection System Actuation Functions," and RG 1.118, "Periodic Testing of Electric Power and Protection Systems." The bypassed and inoperable status indication conforms to the guidelines of RG 1.47, "Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems." The RTS conforms to the guidelines of the single-failure criterion in RG 1.53, "Application of the Single-Failure Criterion to Safety Systems," which endorses IEEE Std 379, "IEEE Standard Application of the Single-Failure Criterion to Nuclear Power Generating Station Safety Systems." Based on the review, the staff concludes that the RTS satisfies the requirement of (IEEE Std 279-1971 or IEEE Std 603-1991) with regard to the system reliability and testability. Therefore the staff finds that the RTS satisfies these requirements of GDC 21.

The RTS conforms to the guidelines in RG 1.75, "Criteria for Independence of Electrical Safety Systems," for the protection system independence. Based on the review, the staff concludes that the RTS satisfies the requirement of (IEEE Std 279-1971 or IEEE Std 603-1991) with regard to the systems independence. Therefore, the staff finds that the RTS satisfies the requirements of GDC 22.

Based on the review of the failure modes and effects analysis for the RTS, the staff concludes that the system is designed to fail into a safe mode if conditions such as disconnection of the system, loss of energy, or postulated adverse environment are experienced. Therefore, the staff finds that the RTS satisfies the requirements of GDC 23.

Based on the review of the interfaces between the RTS and plant operating control systems, the staff concludes that the system satisfies the requirements of (IEEE Std 279-1971 or IEEE Std 603-1991) with regard to control and protection system interactions. Therefore the staff finds the RTS satisfies the requirements of GDC 24.

Based on the review of the RTS, the staff concludes that the system satisfies the protection system requirements for malfunctions of the reactivity control system such as accidental withdrawal of control rods. Chapter 15 of the SAR and SER address the capability of the system to ensure that fuel design limits are not exceeded for such events. Therefore, the staff finds that the RTS satisfies the requirements of GDC 25.

Based on the review of all the above General Design Criteria, the staff concludes that the RTS satisfies the requirements of GDC 29.

The staff's conclusions noted above are based upon the requirements of (IEEE Std 279-1971 or IEEE Std 603-1991) with respect to the design of the RTS. Therefore, the staff finds that the RTS satisfies the requirement of 10 CFR 50.55a(h).

The applicant or licensee has also incorporated in the system design the recommendations of task action plan items (identify item number and how implemented) that the staff has reviewed and found acceptable.

In the review of the RTS, the staff examined the dependence of the RTS on the availability of essential auxiliary systems. Based on this review and coordination with those having primary review responsibility of auxiliary supporting features and other auxiliary features, the staff concludes that the design of the RTS is compatible with the functional requirements of auxiliary supporting features and auxiliary features.

2. Note: The following finding applies to systems involving computer-based components.

Based on the review of software development plans and the review of the computer software development process and design outputs, the staff concludes that the computer systems meet the guidance of RG 1.152. Therefore, the special characteristics of computer systems have been adequately addressed, and the staff finds that the RTS satisfies the requirements of General Design Criteria 1 and 21.

Based on the review of the applicant or licensee's diversity and defense-in-depth analysis, the staff concludes that the RTS complies with the criteria for defense against common-cause failure in digital instrumentation and control systems. Therefore, the staff finds that adequate diversity and defense against common-cause failure have been provided to satisfy these requirements of General Design Criteria 21 and 22, and Item II.Q of the Staff Requirements Memorandum on SECY-93-087.

3. 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.

4. Note: The following conclusion is applicable to all applications.

The conclusions noted above for the RTS are applicable to all portions of the systems except for the following, for which acceptance is based upon prior NRC review and approval as noted (list applicable system or topics and identify references).

5. 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.

IV. 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.

REFERENCES

1. IEEE Std 279-1971, "Criteria for Protection Systems for Nuclear Power Generating Stations."
2. IEEE Std 379, "IEEE Standard Application of the Single-Failure Criterion to Nuclear Power Generating Station Safety Systems."
3. IEEE Std 603-1991, "IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations."
4. IEEE Std 7-4.3.2, "IEEE Standard Criteria for Digital Computers in Safety Systems of Nuclear Power Generating Stations."
5. NUREG/CR-6303, "Method for Performing Diversity and Defense-in-Depth Analyses of Reactor Protection Systems," December 1994.
6. RG 1.22, "Periodic Testing of Protection System Actuation Functions."
7. RG 1.47, "Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems."
8. RG 1.53, "Application of the Single-Failure Criterion to Safety Systems."
9. RG 1.75, "Criteria for Independence of Electrical Safety Systems."

10. RG 1.105, "Setpoints for Safety-Related Instrumentation."
11. RG 1.118, "Periodic Testing of Electric Power and Protection Systems."
12. RG 1.152, "Criteria for Use of Computers in Safety Systems of Nuclear Power Plants."
13. SECY-93-087, "Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light Water Reactor (ALWR) Designs," April 2, 1993.
14. Staff Requirements Memorandum on SECY-93-087, "Policy, Technical, and Licensing Issues Pertaining to Evolutionary and Advanced Light Water Reactor (ALWR) Designs," July 15, 1993.

PAPERWORK REDUCTION ACT STATEMENT

The information collections contained in the Standard Review Plan are covered by the requirements of 10 CFR Part 50 and 10 CFR Part 52, and were approved by the Office of Management and Budget, approval number 3150-0011 and 3150-0151.

PUBLIC PROTECTION NOTIFICATION

The NRC may not conduct or sponsor, and a person is not required to respond to, a request for information or an information collection requirement unless the requesting document displays a currently valid OMB control number.

**SRP Section 7.2
Description of Changes**

SRP Section 7.2, “Reactor Trip System”

This SRP Section affirms the technical accuracy and adequacy of the guidance previously provided in SRP Section 7.2, Revision 5, dated March 2007. See ADAMS Accession Number ML070550083.

The main purpose of this update is to incorporate the revised software Regulatory Guides and the associated endorsed standards. For organizational purposes, the revision number of each Regulatory Guide and year of each endorsed standard is now listed in one place, Table 7-1. As a result, revisions of Regulatory Guides and years of endorsed standards were removed from this section, if applicable. For standards that are incorporated by reference into regulation (IEEE Std 279-1971 and IEEE Std 603-1991) and standards that have not been endorsed by the agency, the associated revision number or year is still listed in the discussion. Additional changes were editorial.

Part of 10 CFR was reorganized due to a rulemaking in the fall of 2014. Quality requirement discussions in the former 10 CFR 50.55a(a)(1) were moved to 10 CFR 50.54(jj) and 10 CFR 50.55(i). The incorporation by reference language in the former 10 CFR 50.55a(h)(1) was moved to 10 CFR 50.55a(a)(2). There were no changes either to 10 CFR 50.55a(h)(2) or 10 CFR 50.55a(h)(3).