



U.S. NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

7.6 INTERLOCK SYSTEMS IMPORTANT TO SAFETY

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, "Regulatory Requirements, Acceptance Criteria, and Guidelines for Instrumentation and Control Systems Important to Safety," (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.

Revision 6 - August 2016

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 Standard Review Plan 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 SRP 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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I. AREAS OF REVIEW

The objective of the review is to confirm that design considerations such as redundancy, independence, single failures, qualification, bypasses, status indication, and testing are consistent with the design bases of these systems and commensurate with the importance of the safety functions to be performed.

1. This SRP section describes the review process and acceptance criteria for those interlock systems important to safety that operates to reduce the probability of occurrence of specific events, or to maintain safety systems in a state that assures their availability in an accident. These systems include:
 - Interlock systems to prevent over-pressurization of low-pressure systems (e.g., residual heat removal) when these systems are connected to high-pressure systems (e.g., primary coolant).
 - Interlocks to prevent over-pressurization of the primary coolant system during low-temperature operation of the reactor vessel.
 - Valve interlocks to assure the availability of emergency core cooling system (ECCS) accumulators.
 - Interlocks to isolate safety systems from nonsafety systems (e.g., seismic and non-seismic portions of auxiliary supporting systems), and interlocks to preclude inadvertent inter-ties between redundant or diverse safety systems where such inter-ties exist for the purposes of testing or maintenance.
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, "Instrumentation and Controls - Overview of Review Process," 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 controls and other organizations.

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

II. ACCEPTANCE CRITERIA

Requirements

Acceptance criteria 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 50.55(i).
2. 10 CFR 50.55a(h), "Protection and Safety Systems," requires 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 after January 1, 1971, and before 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." For interlock systems that are not safety systems as defined by IEEE Std 603-1991 and isolated from the safety systems, the applicable requirements of 10 CFR 50.55a(h) are IEEE Std 279-1971, Clause 4.7, "Control and Protection System Interaction," IEEE Std 603-1991, Clause 5.6.3, "Independence Between Safety Systems and Other Systems," and IEEE Std 603-1991, Clause 6.3, "Interaction Between the Sense and Command Features and Other Systems."
3. 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."
4. GDC 2, "Design Bases for Protection against Natural Phenomena."
5. GDC 4, "Environmental and Dynamic Effects Design Bases."

6. GDC 13, "Instrumentation and Control."
7. GDC 19, "Control Room."
8. GDC 24, "Separation of Protection and Control Systems."
9. 10 CFR 50.34(f)(2)(v), "Additional TMI-Related Requirements, Bypass and Inoperable Status Indication," or equivalent Three Mile Island Action Plan requirements imposed by Generic Letters (GL).
10. 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 design certification, the provisions of the Atomic Energy Act of 1954 (AEA), and the U.S. Nuclear Regulatory Commission (NRC's) regulations.
11. 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 AEA, and the NRC's regulations.

Additional requirements applicable to safety systems with which interlock systems may interact. These criteria are used as guidelines, when applicable, in establishing the functions important to safety performed by interlock systems:

1. GDC 10, "Reactor Design."
2. GDC 15, "Reactor Coolant System Design."
3. GDC 16, "Containment Design."
4. GDC 28, "Reactivity Limits."
5. GDC 33, "Reactor Coolant Makeup."
6. GDC 34, "Residual Heat Removal."
7. GDC 35, "Emergency Core Cooling."
8. GDC 38, "Containment Heat Removal."
9. GDC 41, "Containment Atmosphere Cleanup."
10. GDC 44, "Cooling Water."

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, "Instrumentation and Controls – Introduction," SRP Table 7-1, and SRP Appendix 7.1-A, "Acceptance Criteria and Guidelines for Instrumentation and Control Systems Important to Safety," 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's regulations.

1. SRP Appendix 7.1-B, "Guidance for Evaluation of Conformance to IEEE Std 279," provides guidance for evaluating conformance to the requirements of IEEE Std 279-1971.
2. SRP Appendix 7.1-C, "Guidance for Evaluation of Conformance to IEEE Std 603," provides guidance for evaluating conformance to IEEE Std 603-1991.
3. SRP Appendix 7.1-D, "Guidance for Evaluation of The Application of IEEE Std 7-4.3.2," provides guidance for evaluating conformance to the acceptance criteria contained in RG 1.152, "Criteria for Use of 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."

III. REVIEW PROCEDURES

The reviewer will select material from the procedures described below, as may be appropriate for a particular case. Typical reasons for such a nonuniform 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 7.6 highlights specific topics that should be emphasized in the interlock systems review.

1. The review should include an evaluation of the interlock system design against the guidance of IEEE Std 603-1991 or IEEE Std 279-1971, depending on the applicant or licensee's commitment regarding these design criteria. For computer-based interlock systems, the guidance is provided by RG 1.152, which endorses IEEE Std 7-4.3.2. These procedures are detailed in SRP Appendix 7.1-B for IEEE Std 279-1971, SRP Appendix 7.1-C for IEEE Std 603-1991, and SRP Appendix 7.1-D for IEEE Std 7-4.3.2.

SRP Appendices 7.1-B and 7.1-C discuss IEEE Std 279-1971 and IEEE Std 603-1991, respectively, and how they are used in the review of the interlock systems. SRP Appendix 7.1-D discusses the criteria of IEEE Std 7-4.3.2 and how they are used in the review of interlocks. Although the primary emphasis is on the equipment comprising the interlock systems, the reviewer should consider the interlock functions at the system level. The interlock systems design should be compatible with the SAR Chapter 15 design bases accident analyses. It is not sufficient to evaluate the adequacy of the interlock systems only on the basis of the design's meeting the specific requirements of IEEE Std 279-1971 or IEEE Std 603-1991.

The interlock systems review should address the applicable topics identified 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 review of the interlock systems are identified below.

- A. Single-failure criterion - See SRP Appendix 7.1-B, Subsection 4.2 or SRP Appendix 7.1-C, Subsection 5.1.
- B. Quality of components and modules - See SRP Appendix 7.1-B, Subsection 4.3 or SRP Appendix 7.1-C, Subsection 5.3.
- C. 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.
- D. System testing and inoperable surveillance - See SRP Appendix 7.1-B, Subsections 4.9, 4.10, and 4.13 or SRP Appendix 7.1-C, Subsections 5.7, 5.8, and 6.5.
- E. Use of digital systems - See SRP Appendix 7.0-A, "Review Process for Digital Instrumentation and Control Systems," and SRP Appendix 7.1-D.
- F. Interlocks to prevent over-pressurization of low-pressure systems - See SRP BTP 7-1, "Guidance on Isolation of Low-Pressure Systems from the High-Pressure Reactor Coolant System."
- G. Interlocks to prevent over-pressurization of the primary coolant system during low-temperature operations of the reactor vessel - See SRP BTP 5-2,

“Overpressurization Protection of Pressurized-Water Reactors While Operating at Low Temperatures.”

- H. Interlocks for ECCS accumulator valves - See SRP BTP 7-2, “Guidance on Requirements of Motor--Operated Valves in the Emergency Core Cooling System Accumulator Lines.”
 - I. Interlocks required to isolate safety systems from nonsafety systems.
 - J. Interlocks required to preclude inadvertent inter-ties between redundant or diverse safety systems.
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.

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 (SER). The reviewer also states the following for those conclusions:

1. The NRC staff concludes that the design of the interlock systems is established in accordance with its safety function, is acceptable, and meets the relevant requirements of General Design Criteria 1, 2, 4, 10, 13, 15, 16, 19, 24, 28, 33, 34, 35, 38, 41 and 44, 10 CFR 50.54(jj) and 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 concludes that the applicant or licensee adequately identified the guidelines applicable to these systems and has properly classified them. 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 General Design

Criteria 1, 15, 16, 33, 34, 35, 38, 41, and 44, and 10 CFR 50.54(jj) and 50.55(i) have been met.

Based on the review of interlock system functions, the staff concludes that appropriate interlocks are provided to maintain an appropriate design margin to assure that acceptable fuel design limits are not exceeded during any condition of normal operation, including the effects of anticipated operational occurrences. Therefore, the staff finds that the interlock systems satisfy the requirements of General Design Criteria 10, 15, 16, 28, 33, 34, 35, 38, 41, and 44.

Based on the review of interlock system status information, initiation capabilities, and provisions to support safe shutdown, the staff concludes that information is provided to monitor interlocks over the anticipated ranges for normal operation, for anticipated operational occurrences, and for accident conditions as appropriate to assure adequate safety. Appropriate controls are provided for interlock initiation and bypass. The interlocks appropriately support actions to operate the nuclear power unit safely under normal conditions and to maintain it in a safe condition under accident conditions. Therefore, the staff finds that the interlock systems satisfy the requirements of GDC 13 and 19.

The staff conducted a review of these systems and finds that they comply with the reliability guidance of (IEEE Std 279-1971 or IEEE Std 603-1991). Based on this review, the staff finds that the redundancy requirements of General Design Criteria 34, 35, 38, 41, and 44 have been met.

The review included the identification of those systems and components for the interlock systems that are designed to survive the effects of earthquakes, other natural phenomena, abnormal environments, and missiles. Based on 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.

The staff reviewed the bypassed or inoperable status indication of safety interlocks. The staff finds that appropriate bypass indications are provided to give the operators timely information and status reports so the operators can mitigate the effects of unexpected system unavailability. The bypass indications satisfy the guidelines of RG 1.47, "Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems." Therefore, the staff concludes that the safety interlock systems satisfy the applicable requirements of 10 CFR 50.55a(h) and 10 CFR 50.34(f)(2)(v).

The nonsafety interlock systems are appropriately isolated from safety systems. Therefore, the staff concludes that the isolation of these systems from safety systems satisfies the requirements of 10 CFR 50.55a(h) and the requirements of GDC 24.

Based on the review of interlock safety system design, the staff concludes that the safety portions of the interlock systems comply with the requirements of (IEEE Std 279-1971 or

IEEE Std 603-1991). Therefore, the staff finds that the interlock safety systems satisfy the requirements of 10 CFR 50.55a(h).

In the review of the interlock systems, the staff examined the dependence of this system on the availability of auxiliary supporting features and other auxiliary features. 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 interlock systems is compatible with the functional requirements of auxiliary supporting features and other auxiliary features.

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

Based on the review of software development plans and the inspections of the computer 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 interlock systems satisfy the requirements of 10 CFR 50.54(jj) and 50.55(i), and General Design Criteria 1, 13, and 19.

3. For DC and COL reviews, the findings will also summarize the staff's evaluation of the 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 interlock systems 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].

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, "Licenses, Certifications, and Approvals for Nuclear Power Plants." 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 6 months or more after the date of issuance of this SRP section, unless superseded by a later revision.

VI. REFERENCES

1. Institute of Electrical and Electronics Engineers, IEEE Std 279-1971, "Criteria for Protection Systems for Nuclear Power Generating Stations," Piscataway, NJ.
2. Institute of Electrical and Electronics Engineers, IEEE Std 603-1991, "IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations," Piscataway, NJ.
3. Institute of Electrical and Electronics Engineers, IEEE Std 7-4.3.2, "IEEE Standard Criteria for Digital Computers in Safety Systems of Nuclear Power Generating Stations," Piscataway, NJ.
4. U.S. Nuclear Regulatory Commission, "Criteria for Use of Computers in Safety Systems of Nuclear Power Plants," Regulatory Guide 1.152.
5. U.S. Nuclear Regulatory Commission, "Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems," Regulatory Guide 1.47.

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 7.6
Description of Changes**

SRP Section 7.6, “Interlock Systems Important to Safety”

This SRP Section affirms the technical accuracy and adequacy of the guidance previously provided in SRP Section 7.6, Revision 5, dated March 2007. See ADAMS Accession No. ML070460348.

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).