



DANU-ISG-2022-06

Advanced Reactor Content of Application Project

**Chapter 12 “Post-manufacturing and construction
Inspection, Testing, and Analysis Program”**

Interim Staff Guidance

March 2024

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ADAMS Accession No.: Package - ML23277A105; ISG – ML23277A144; Enclosure – ML23277A153; FRN – ML23277A230; CRA Summary – ML23277A272

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|---------------|-----------------------|--------------------|--------------------|---------------------|
| OFFICE | OCIO/GEMSD/FLICB /ICT | QTE | NRR/DRO/IRAB (PM) | NRR/DANU/UTB1 (BC) |
| NAME | DCullison | KAzaria-Kribbs | CCauffman | GOberson |
| DATE | 2/9/2024 | 3/14/2022 | 3/12/2024 | 11/16/2023 |
| OFFICE | NRR/DANU/UTB2 (BC) | NRR/DANU/UARP (PM) | NRR/DANU/UARP (BC) | OGC/GCHA/AGCNRP/NLO |
| NAME | CdeMessieres | JSebrosky | SLynch | RWeisman |
| DATE | 12/28/2023 | 10/26/2023 | 12/3/2023 | 3/22/2024 |
| OFFICE | NRR/DANU (D) | | | |
| NAME | MShams | | | |
| DATE | 2/23/2024 | | | |

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INTERIM STAFF GUIDANCE
ADVANCED REACTOR CONTENT OF APPLICATION PROJECT
**CHAPTER 12 “POST-MANUFACTURING AND CONSTRUCTION INSPECTION,
TESTING, AND ANALYSIS PROGRAM”**

DANU-ISG-2022-06

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PURPOSE

The U.S. Nuclear Regulatory Commission (NRC or Commission) staff is providing this interim staff guidance (ISG) for two reasons. First, this ISG provides guidance on the contents of applications to an applicant submitting a risk-informed, performance-based application for a construction permit (CP) or operating license (OL) under Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, “Domestic Licensing of Production and Utilization Facilities” (Ref. 1), or for a combined license (COL), a manufacturing license (ML), or a design certification (DC) under 10 CFR Part 52, “Licenses, Certifications, and Approvals for Nuclear Power Plants” (Ref. 2), for a non-light-water reactor (non-LWR). The application guidance found in this ISG supports the development of the portion of a non-LWR application associated with an applicant’s “Post-manufacturing and construction Inspection, Testing and Analysis Program.”¹ Second, this ISG provides guidance to NRC staff on how to review such an application.

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As of the date of this ISG, the NRC is developing a rule to amend 10 CFR Parts 50 and 52 (RIN 3150-AI66). The NRC staff notes this guidance may need to be updated to conform to changes to 10 CFR Parts 50 and 52, if any, adopted through that rulemaking. Further, as of the date of this ISG, the NRC is developing an optional performance-based, technology-inclusive regulatory framework for licensing nuclear power plants designated as 10 CFR Part 53, “Licensing and Regulation of Advanced Nuclear Reactors,” (RIN 3150-AK31). After promulgation of those regulations, the NRC staff anticipates that this guidance will be updated and incorporated into the NRC’s Regulatory Guide (RG) series or a NUREG series document to address content of application considerations specific to the licensing processes in this document.

BACKGROUND

This ISG is based on the advanced reactor content of application project (ARCAP), whose purpose is to develop technology-inclusive, risk-informed, and performance-based application guidance. The ARCAP is broader than, and encompasses, the industry-led technology-inclusive content of application project (TICAP). The guidance in this ISG supplements the guidance found in Division of Advanced Reactors and Non-power Production and Utilization Facilities (DANU)-ISG-2022-01, “Review of Risk-Informed, Technology-Inclusive Advanced Reactor Applications – Roadmap,” issued in May 2023 (Ref. 3), which provides a roadmap for

¹ The NRC is issuing this ISG to describe methods that are acceptable to the NRC staff for implementing specific parts of the agency’s regulations, to explain techniques that the NRC staff uses in evaluating specific issues or postulated events, and to describe information that the NRC staff needs in its review of applications for permits and licenses. The guidance in this ISG that pertains to applicants is not an NRC regulation and compliance with it is not required. Methods and solutions that differ from those set forth in this ISG are acceptable if supported by a basis for the issuance or continuance of a permit or license by the Commission.

developing all portions of an application. The guidance in this ISG is limited to the portion of a non-LWR application associated with the development of a risk-informed post-construction (or post-manufacturing for an ML application) inspection, testing, and analysis program (PITAP) and the NRC staff review of that portion of the application.

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Among other things, this ISG includes PITAP guidance to address, in part, the regulatory requirements for applicants to describe their post-construction quality assurance activities, as required by 10 CFR Part 50, Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants." The NRC includes these quality assurance requirements in 10 CFR 50.34(a)(7) for CP applicants and in 10 CFR 50.34(b)(6) for OL applicants. In addition, 10 CFR 52.79(a)(25) contains similar requirements associated with quality assurance for COL applicants and 10 CFR 52.157(f)(17) states similar requirements for quality assurance with respect to a manufactured reactor. The PITAP also consists of preoperational and initial startup tests.

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Under 10 CFR 52.47(b)(1), a DC application must propose inspections, tests, analyses, and acceptance criteria (ITAAC) necessary and sufficient to demonstrate that a facility that incorporates the DC has been constructed and will be operated in conformity with the DC, the Act, and NRC regulations. Similarly, 10 CFR 52.158(a) requires an ML application to include ITAAC necessary and sufficient to demonstrate that the manufactured reactor has been manufactured in conformity with the ML, the Atomic Energy Act of 1954, as amended (Act), and NRC regulations, and that the reactor will be operated in conformity with the approved design and any license authorizing operation of the manufactured reactor. Under 10 CFR 52.80(a), a COL application must include the ITAAC necessary and sufficient to demonstrate that the facility has been constructed and will be operated in conformity with the COL, the Act, and NRC regulations. A COL application referencing a DC or an ML must include the ITAAC stated in the DC or ML, except that any particular ITA may be performed and the AC satisfied before COL issuance. ITAAC often include testing requirements that are also considered preoperational tests and are completed as part of the initial test program. In summary, this ISG includes applicant and NRC staff guidance related to the integration of post-manufacturing and post-construction quality assurance, the initial test program, and ITAAC for CP, OL, DC, ML, and COL applications, as applicable. Post fuel load, this ISG is applicable to OLs and COLs

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RATIONALE

The current application guidance related to post construction inspection and testing is directly applicable only to light water reactors (LWRs) and may not fully identify the information to be included in a non-LWR application or efficiently provide a technology-inclusive, risk-informed, and performance-based review approach for non-LWR technologies. This ISG serves as the non-LWR application guidance for PITAP. This ISG provides both applicant content of application and NRC staff review guidance.

APPLICABILITY

This ISG is applicable to applicants for non-LWR² permits and licenses that submit risk-informed, performance-based applications for CPs or OLs under 10 CFR Part 50 or for COLs, DCs, or MLs under 10 CFR Part 52.³ This ISG is also applicable to the NRC staff reviewers of these applications.

PAPERWORK REDUCTION ACT

This ISG provides voluntary guidance for implementing the mandatory information collections in 10 CFR Parts 50 and 52 that are subject to the Paperwork Reduction Act of 1995 (44 U.S.C. 3501 et. seq.). These information collections were approved by the Office of Management and Budget (OMB), approval numbers 3150-0011 and 3150-0151. Send comments regarding this information collection to the FOIA, Library, and Information Collections Branch (T6-A10M), U.S. Nuclear Regulatory Commission, Washington, DC 20555 0001, or by e-mail to Infocollects.Resource@nrc.gov, and to the OMB reviewer at: OMB Office of Information and Regulatory Affairs (3150-0011 and 3150-0151), Attn: Desk Officer for the Nuclear Regulatory Commission, 725 17th Street, NW Washington, DC 20503.

PUBLIC PROTECTION NOTIFICATION

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

GUIDANCE

The ISG consists of guidance related to post-construction (or post-manufacturing, as applicable) inspection, preoperational testing (i.e., tests conducted following construction and construction-related testing but prior to initial fuel load), analysis verification, and initial startup testing (i.e., tests conducted during and after initial fuel load, up to and including initial power ascension). References to "verification" in the below guidance includes verification of the adequacy of the analytical tools used in the analysis. The primary objective of the PITAP is to demonstrate, to the extent possible, that the safety-related (SR) and safety-significant structures, systems, and components (SSCs) were constructed or manufactured, as the case may be, and will operate in accordance with the design and as described in the safety analysis report. For COLs, the ITAAC (which are completed prior to initial fuel loading) include testing requirements that are the same as or similar to the preoperational tests required to be completed as part of the initial test program. In cases in which preoperational tests are performed that demonstrate the acceptance criteria of both the ITP and the ITAAC are met, the test results should be recorded under both programs.

² An applicant desiring to use this ISG for a light water reactor application should contact the NRC staff to hold pre-application discussions on its proposed approach.

³ This ISG does not provide guidance on testing requirements prior to receipt of byproduct, source, or special nuclear material under 10 CFR Parts 30, 40, and 70. For example, an applicant would need a 10 CFR Part 30 license for possession of sources to check radiation detectors and a 10 CFR Part 70 license to possess fission detectors containing special nuclear material. A CP applicant may address these testing requirements with its CP application (in accordance with 10 CFR 50.31, "Combining applications") or separately from the CP application.

Additional objectives of the PITAP include the following:

- providing reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, the plant is built and will operate in accordance with the safety analysis, the associated provisions of the Act, and the applicable NRC regulations (for COLs)
- providing reasonable assurance that the facility exhibits the performance and associated safety margins described in the design (preoperational testing only)
- satisfying any license conditions associated with the PITAP
- obtaining as-built data to verify the analytical assumptions, limits, and models
- familiarizing the plant's operating and technical staff with operation of the facility
- verifying the adequacy of the plant operating and emergency procedures

The PITAP addresses, in part, the implementation of portions of the regulatory requirements for quality assurance programs. The NRC also includes these quality assurance requirements in 10 CFR 50.34(a)(7) for CP applicants and in 10 CFR 50.34(b)(6) for OL applicants. In addition, 10 CFR 52.79(a)(25) contains similar requirements associated with quality assurance for COL applicants and 10 CFR 52.157(f)(17) states similar requirements for ML applicants. More specific requirements associated with inspections, tests, analyses, and acceptance criteria (ITAAC) for 10 CFR Part 52 applicants are discussed below. ITAAC, however, need not cover operational program requirements except for emergency planning. The NRC describes requirements for preoperational testing and initial operations in OL, COL, and ML applications in 10 CFR 50.34(b)(6)(iii), 10 CFR 52.79(a)(28), and 10 CFR 52.157(f)(27) (for an ML, necessary parameters to be used in developing plans for preoperational testing and initial operation only), respectively.

The need for the NRC to make a finding that the as-built facility has been constructed and will be operated in conformance with the approved design and license is embodied and codified in both 10 CFR Part 50 and 10 CFR Part 52. The regulations in 10 CFR 50.57(a) state the following:

Pursuant to § 50.56, an operating license may be issued by the Commission, up to the full term authorized by § 50.51, upon finding that:

- (1) Construction of the facility has been substantially completed, in conformity with the construction permit and the application as amended, the provisions of the Act, and the rules and regulations of the Commission; and
- (2) The facility will operate in conformity with the application as amended, the provisions of the Act, and the rules and regulations of the Commission,

Similarly, 10 CFR 52.97, "Issuance of combined licenses," states the following:

(a)(1) After conducting a hearing in accordance with § 52.85 and receiving the report submitted by the ACRS, the Commission may issue a combined license if the Commission finds that:

(iii) There is reasonable assurance that the facility will be constructed and will operate in conformity with the license, the provisions of the Act, and the Commission's regulations.

Also, 10 CFR 52.103(g) states as follows:

The licensee shall not operate the facility until the Commission makes a finding that the [ITAAC] acceptance criteria in the combined license are met....

Application Guidance

The PITAP is generally divided into two phases: Phase 1 is the preoperational phase (prior to initial fuel loading), and Phase 2 is initial startup testing (initial fuel loading and initial power ascension). The application should describe how all tests identified in the Phase 1 program can be performed prior to loading fuel. For Phase 2, the current application guidance for initial startup testing contained in Regulatory Guide (RG) 1.68, "Initial Test Programs for Water-Cooled Nuclear Power Plants" (Ref. 7) is applicable to LWRs only. However, non-LWR applicants may glean some useful insights from RG 1.68, as applicable, in developing their Phase 2 programs.

If the application is for a CP, the PITAP description can be limited to descriptions of the Phase 1 inspection, testing, and verification program elements required by the quality assurance program under § 50.34(a)(7). In particular, the PITAP descriptions should include the inspection and testing proposed to satisfy the requirements of Part 50, Appendix B, Criterion III, Design Control, Criterion X, Inspection, and Criterion XI, Test Control. Criterion III specifies that the QA program include measures for verifying or checking the adequacy of design, such as by the performance of a suitable testing program. Criterion X and Criterion XI respectively specify that inspection and verification activities must be performed to ensure that SSCs are installed in accordance with design documents and that testing is performed to demonstrate that SSCs will perform satisfactorily in service. For an OL, the application should describe those elements of the inspection, testing, and analysis program to be completed following the completion of the program described for the CP as well as the pre-operational plans to meet the requirements of 10 CFR 50.34(b)(6)(iii).

The COL, DC, and ML application under 10 CFR Part 52 should describe the Phase 1 inspection, test, and verification programs and the Phase 2 test programs, as well as the scope, objectives, and programmatic controls associated with the test programs. Under 10 CFR Part 52 applicants must include inspections, tests, analyses, and acceptance criteria (ITAAC) as part of their PITAPs to meet the requirements of either 10 CFR 52.47(b)(1), 10 CFR 52.80(a), or 10 CFR 52.158(a), as applicable. The ITAAC will be included as license conditions in any COL issued to assure that the facility has been constructed in accordance with the approved design. (ITAAC are not required for an application under 10 CFR Part 50.)

Further for an ML application, 10 CFR 52.157(f)(27) requires the ML applicant to provide the necessary parameters to be used in developing plans for preoperational testing and initial operation. In addition, 10 CFR 52.157(f)(17) requires a description of the quality assurance program applied to the design, and to be applied to the manufacture of, the structures, systems, and components of the reactor in accordance with Appendix B to 10 CFR Part 50, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants."

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Under either 10 CFR Part 50 or 10 CFR Part 52, the applicant can include a detailed description of the PITAP in the final safety analysis report (FSAR) or in a separate document referenced in the FSAR. If the activities are addressed by the quality assurance program, an applicant may cross-reference elements in that program to the PITAP elements in lieu of duplicating information.

The applicant's plans for the preoperational testing, including initial startup aspects of PITAP are required by 10 CFR 50.34(b)(6)(iii) for applications for an OL under 10 CFR Part 50 and by 10 CFR 52.79(a)(28) for applications for a COL under 10 CFR Part 52. In addition, 10 CFR Part 50, Appendix B, Criterion III, Design Control, requires measures for verifying or checking the adequacy of design, which may include a suitable testing program, including qualification testing. Further, Criterion III requires that the conditions of the final as-built plant are consistent with the associated analytical calculations (e.g., design changes during construction, including field changes, are reflected in updated analysis, where applicable). Furthermore, 10 CFR Part 50, Appendix B, Criterion X, Inspection, and Criterion XI, Test Control, specify that inspection and verification activities must be performed to ensure that SSCs are installed in accordance with design documents and that testing is performed to demonstrate that SSCs will perform satisfactorily in service as described in applicable design documents. If the application is for a CP, the PITAP description can be limited to the Phase 1 (described below) inspection, testing, and verification that would be required by 10 CFR Part 50, Appendix B, which should include a description of the scope, objectives, and programmatic controls associated with the pre-operational test program (prior to initial fuel loading).

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For applicants applying for a COL under 10 CFR 52.79 and referencing a DC under 10 CFR 52.47⁴ or a design with an ML under 10 CFR 52.157, the PITAP may include the ITAAC associated with the DC or ML (see 10 CFR 52.47(b)(1) and 10 CFR 52.158(a), respectively), or the ITAAC may be included in a separate document. For all COL applicants, the Commission will, in accordance with 10 CFR 52.97(b), identify the ITAAC in the COL as a set of license conditions.

Specifically, 10 CFR 52.47(b)(1) requires that a DC application contain the following:

The proposed inspections, tests, analyses, and 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, a facility that incorporates the design certification has been constructed and will be operated in conformity with the design certification, the provisions of the Act, and the Commission's rules and regulations.

⁴ 10 CFR 52.47 requires the development of interface requirements for those portions of the plant that are outside the scope of the design certification. In addition, 10 CFR 52.80(a) requires standalone COLs (COLs that do not reference an ESP, DC, SDA, or ML) to provide ITAAC for the custom design.

For COLs referencing a ML, much of the post-manufacturing inspection and testing to resolve ITAAC may be performed at the manufacturer's facility and not at the COL final site. The COL holder has the responsibility for verifying ITAAC are complete. As noted below, the COL holder could rely on testing performed at the manufacturing facility to verify ITAAC completion. The requirement for ITAAC to be included in ML applications (i.e., 10 CFR 52.158(a)) states, in part, the following:⁵

The application must contain:

(a)(1) Inspections, tests, analyses, and acceptance criteria (ITAAC). The proposed inspections, tests, and analyses that the licensee who will be operating the reactor 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:

(i) The reactor has been manufactured in conformity with the manufacturing license; the provisions of the Act, and the Commission's rules and regulations; and

(ii) The manufactured reactor will be operated in conformity with the approved design and any license authorizing operation of the manufactured reactor.

(2) If the application references a standard design certification, the ITAAC contained in the certified design must apply to those portions of the facility design which are covered by the design certification.

Staff Review Guidance

In addition to the review guidance in this ISG, the NRC staff may use guidance for the review of PITAP content for the inspection, testing, analysis, and acceptance criteria (i.e., ITAAC) in NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition," Section 14.3, "Inspections, Tests, Analysis, and Acceptance Criteria" (Ref. 4). Although the guidance in NUREG-0800, Section 14.3, is applicable to Part 52 LWR applications, it may contain insights that are useful for non-LWR application reviews. The guidance in Appendix C, "Detailed Review Guidance," to NUREG-0800, Section 14.3, may only be applicable if the features described are within the scope of SR or safety-significant systems covered by this ISG. In addition, the NUREG-0800, Section 14.3, guidance pertaining to verification of compliance with the GDC should instead focus on verifying compliance with the applicant's proposed principal design criteria. The application may be acceptable to the staff

⁵ The NRC staff notes there are potential business models that could involve a manufacturing licensee also holding a combined license (the manufacturing site COL) for the purpose of operational testing. Under that model, the manufacturing site COL may include ITAAC redundant to some ITAAC included in the COL for the location at which the reactor will eventually be installed and operated (i.e., the deployment site). Accordingly, such a model could involve completion of some of the ITAAC included in the deployment site COL at the manufacturing facility under the manufacturing site COL. Under this business model, the holder of the deployment site COL would be responsible to ensure that all ITAAC have been completed including those performed at the manufacturing facility and those performed at the deployment site. These business models and the potential for future guidance in this area are described in SECY-24-0008, "Micro-Reactor Licensing and Deployment Considerations: Fuel Loading and Operational Testing at a Factory (Ref. 11). The NRC staff will update this ISG, as appropriate, pending further direction from the Commission on this matter.

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even if an applicant uses a unique format for inspection, test, and verification program content, as the format guidance in NUREG-0800, Section 14.3, is not mandatory. It should be noted that the scope of ITAAC is limited to the preoperational phase prior to initial fuel loading.

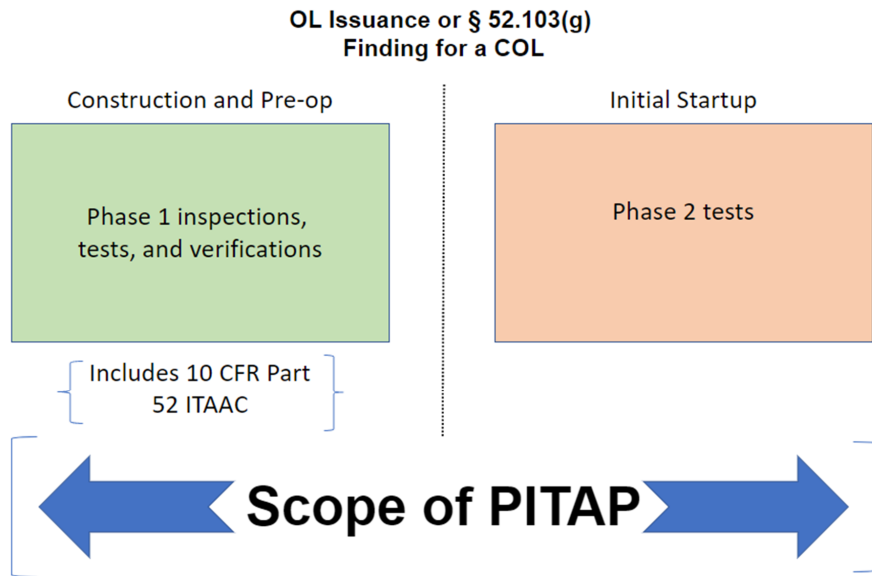
NRC staff review guidance for Phase 2 is provided in NUREG-0800, Section 14.2, "Initial Plant Test Program - Design Certification and New License Applicants" (Ref. 8) and is specific to LWRs, however, this section may include insights that are useful for review of a non-LWR application. While this ISG does not address PITAP (and ITAAC) for emergency planning and physical security hardware, NUREG-0800, Section 14.3.10, "Emergency Planning—Inspections, Tests, Analyses, and Acceptance Criteria" (Ref. 5), and NUREG-0800, Section 14.3.12, "Physical Security Hardware—Inspections, Tests, Analyses, and Acceptance Criteria" (Ref. 6), respectively, contain guidance on these topics.

The NRC staff should review the completeness of the PITAP information with respect to the license, permit, or certification being requested and the guidance provided below. The staff should note that inspection and verification activities performed under an applicant's quality assurance program do not need to be described separately in the PITAP application. Rather, the applicant may cross-reference documentation of these activities to the quality assurance program elements to facilitate NRC staff review.

For each PITAP area described below, the NRC staff should ensure that the application contains acceptance criteria for each inspection, test, and verification, including verification of analysis, and that those criteria are consistent with the facility's licensing basis. In general, the acceptance criteria should be objective and unambiguous. In some cases, the acceptance criteria may be more general because the detailed supporting information in the safety analysis does not lend itself to concise verification. For example, the acceptance criteria for the design integrity (i.e., functional arrangement) of piping and structures may be that a report "exists" that concludes the design commitments are met. The reviewer should verify that controls for creating the report are adequate. The PITAP acceptance criteria should include numeric performance values verifying SSC performance, where applicable.

The NRC staff should ensure that assumptions and insights from key safety and integrated plant safety analyses are adequately verified through inspections, testing, or analyses.

The figure below illustrates the scope of the PITAP.



A. Phase 1—Preoperational inspection, testing, and verification

1. Inspection

“Inspect” or “Inspection” means visual observations, physical examinations, or reviews of records based on visual observation or physical examination that compare the SSC condition to one or more design features and their associated design requirements described in the safety analysis. Examples include walkdowns, configuration checks, measurements of dimensions, or nondestructive examinations. “As-built” means the physical properties of the SSC following the completion of its installation or construction activities at its final location at the plant site. If technically justifiable, physical properties of the as-built SSC may be determined based on measurements, inspections, or tests that occur prior to installation (e.g., at a manufacturing facility or ML holder facility), provided that subsequent fabrication, handling, installation, and testing do not alter the properties.

The NRC staff should verify that the PITAP (or referenced elements of the quality assurance program) includes a post-construction (including post-manufacturing if applicable) (preoperational) inspection program that includes verification of the following:

- a. basic configuration and key design features for SR and safety-significant SSCs, including inspection of the functional arrangement of the as-built SR and safety-significant SSCs described in the safety analysis report
- b. electrical separation for SR and safety-significant SSCs where credited

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- c. materials of construction for SR and safety-significant SSCs in accordance with approved design codes and standards (e.g., American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (ASME Code), Section III, “Rules for Construction of Nuclear Facility Components” (Ref. 9))
- d. fabrication, installation, and inspection of SR and safety-significant piping and other components in accordance with approved design codes and standards (e.g., ASME Code Section III)
- e. design reports for the as-built SR and safety-significant piping in accordance with approved design codes and standards (e.g., ASME Code Section III)
- f. completion of design reconciliation for as-built SR and safety-significant SSCs in accordance with approved design codes and standards
- g. accessibility for inservice inspection and inservice testing, where necessary

2. Testing

“Testing” means the actuation or operation, or establishment of specified conditions, to evaluate the performance or integrity of as-built SSCs, unless explicitly stated otherwise. Testing includes functional and hydrostatic tests for the systems. Some of these testing activities will involve measurements or testing, or both, that can only be conducted at the vendor or manufacturer site due to the configuration of equipment or modules or the nature of the test (e.g., measurements of reactor vessel internals). For these specific items where access to the component for inspection or test is impractical after installation in the plant, the test completion documentation (e.g., test or inspection record) will be generated at the vendor site (e.g., manufacturing facility or ML holder facility) and provided to the licensee or permit holder. Onsite activities for these testing activities will likely be limited to the receipt and placement of the component or module in its final location.

In certain situations, a type test may be performed. A “type test” means a test on one or more sample components of the same type and manufacturer to qualify other components of that same type and manufacturer. A type test is not necessarily a test of the as-built SSCs.

The NRC staff should verify that the PITAP includes a post-construction (or post-manufacturing if applicable) (preoperational) testing program that includes safety and risk-significant functions for SR and safety-significant SSCs, such as (as applicable):

- a. reactivity control functions
- b. heat removal functions
 - i. pressure boundary integrity
 - ii. normal heat removal and control system performance
 - iii. residual heat removal system integrity and performance
- c. containment of radioactive material
 - i. functional containment performance

- ii. radiation and criticality monitoring system performance
- iii. radioactive waste processing, handling, and storage system performance

- d. testing required by consensus design codes and standards applied in the design (e.g., ASME codes, Institute of Electrical and Electronics Engineers standards) for items such as pumps, valves, dynamic restraints, and electrical equipment, as applicable
- e. flow-induced system vibration and thermal expansion tests
- f. electrical system performance for normal and emergency power
- g. equipment functions identified as necessary for defense in depth
- h. instrumentation and control systems relied upon in the safety analysis to perform SR or safety-significant functions
- i. fuel handling and storage system performance
- j. support system performance for SR and safety-significant equipment (e.g., cooling)

3. Analysis

“Analysis” means a calculation, mathematical computation, engineering or technical evaluation, or other analyses used to support key inputs or statements in the safety analysis. Engineering or technical evaluations could include, but are not limited to, comparisons with operating experience or design of similar SSCs. These analyses may include flooding analyses, overpressure protection, containment analyses, core cooling analyses, fire protection, transient analyses, anticipated transient without scram analyses, steam generator tube rupture analyses, radiological analyses, or other detailed key analyses. The NRC staff should verify that the PITAP (or referenced quality assurance program element) describes the analyses of SR and safety-significant SSCs that should be verified, including areas such as the following:

- a. thermal and hydraulic analysis important to the performance of credited safety functions
- b. seismic analysis
 - i. seismic Category I equipment can withstand seismic design-basis loads without loss of credited safety function
 - ii. as-built seismic Category I equipment, including anchorages, is bounded by the tested or analyzed seismic conditions
- c. equipment that must be qualified for a harsh environment can withstand the environmental conditions that would exist before, during, and following a design-basis event (DBE) without loss of credited safety function for the time within which the safety function must be accomplished

- d. critical assumptions from transient and accident analysis, including barrier performance and effluent release calculations
- e. for instrumentation and control SSCs, analytical limits associated with each key variable, the ranges (normal, abnormal, and accident conditions), and the rates of change for these variables to be accommodated until proper completion of the protective action is ensured

B. Phase 2—Initial Startup Testing

1. Testing

The NRC staff should verify that the PITAP includes a post-construction (including post-manufacturing if applicable) (initial startup) testing program for SR and safety-significant SSCs that includes the following, as applicable:

- a. initial fuel loading and reactor physics tests, such as
 - i. initial criticality
 - ii. shutdown margin
 - iii. reactivity control system performance
 - iv. shutdown time
 - v. manual scram function
 - vi. neutron monitoring instrumentation operation and calibration
- b. low-power testing, such as
 - i. reactivity control system worth (rod worth)
 - ii. neutron monitoring instrumentation operation and calibration
 - iii. neutron flux distribution
 - iv. neutron and gamma radiation surveys
 - v. operability of alarms and low-power protective features
 - vi. reactivity control system performance
 - vii. shutdown time
- c. power ascension testing, such as
 - i. reactivity coefficients and power to flow characteristics
 - ii. neutron flux and power distribution
 - iii. reactivity control system influence on power distribution and core design limits
 - iv. reactivity control system performance
 - v. shutdown time
 - vi. reactor coolant system performance
 - vii. flow-induced vibration monitoring
 - viii. neutron and gamma radiation surveys
 - ix. neutron monitoring instrumentation and calibration
 - x. operability of alarms and full-power protective features
 - xi. plant response to various anticipated operational occurrences (e.g., turbine trip, loss of normal power)

- d. performance of residual heat removal system
- e. performance of liquid and gaseous waste systems
- f. performance of first-of-a-kind SSCs and inherent or passive safety features
- g. flow-induced vibration and thermal expansion within design limits

C. General Guidelines

The PITAP should be planned and conducted in an orderly fashion. Accordingly, the NRC staff should ensure that the description of the PITAP in the application addresses the following programmatic items related to the development and conduct of the PITAP:

- (1) the PITAP objectives, including the objectives of each phase of the program
- (2) the scope of each phase of the PITAP
- (3) the organization and responsibilities for conduct and control of the inspection and testing program
- (4) a general schedule and sequence for conducting the inspections and tests, including established licensee hold points to allow for internal licensee review
- (5) the extent to which the test program will use plant operating, emergency, and surveillance procedures and technical specifications
- (6) the prerequisites for each inspection and test, including implementation of the technical specifications (Phase 2 tests only)
- (7) the information to be measured during each inspection and test
- (8) the description for each inspection, test, and verification activity, which should include the acceptance criteria that define the performance, physical condition, or analysis results that must be demonstrated to confirm that the performance of the design function is consistent with the design
- (9) where modifications have been made to SSCs, reinspection and retesting are conducted, as necessary
- (10) the conditions that would cause a test to be terminated prematurely
- (11) the review process and documentation to be applied for each inspection and test, including verification that any retesting has been completed satisfactorily
- (12) the review process and bases for concluding the PITAP inspection, test, and verification results support safe operation of the plant
- (13) measures for confirming analytical codes correctly predict SSC performance as tested

Once completion of preoperational inspection, test, or verification and the supporting design information demonstrates that a system has been properly constructed, it then becomes the function of other programs, such as the quality assurance program and configuration management program, to ensure that the system is not modified and remains in accordance with the approved design through OL issuance or the NRC finding that the ITAAC are met.

D. Guidelines for Testing

The NRC staff should ensure that the application includes a general description for each test, or group of similar tests (i.e., test abstract), to be conducted.⁶ Although the guidance provided in RG 1.68, "Initial Test Programs for Water-Cooled Nuclear Power Plants" (Ref. 7), is specific to water-cooled reactors, the staff may use RG 1.68 to gain insights for its review of the development of initial test programs for non-LWRs. The staff should ensure the following:

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- (1) The test descriptions in the application focus on providing the bases for the tests and test conditions selected, the instrumentation to be used, and how the tests will confirm the performance of the SSCs. Development of the PITAP reflect PITAP experience at other similar facilities and includes measures to reflect those experiences.
- (2) That each test directly, or indirectly through analysis, confirms that an SR or safety-significant SSC is capable of accomplishing its safety and risk-significant functions under the full range of applicable conditions enumerated in the design basis. In addition, the PITAP confirms the performance of other SSCs containing radioactive material (e.g., spent fuel storage).
- (3) That risk insights from the plant's probabilistic risk assessment and safety analysis are used to identify the specific systems and components, test objectives, test conditions, and test parameters selected so as to test the risk-significant equipment and conditions. Thus, a graded approach to testing can be applied, provided the test program gives reasonable assurance the SR and safety-significant SSCs will perform satisfactorily.
- (4) That the test program is sequenced and structured as appropriate so that plant safety is never entirely dependent upon untested SSCs or temporary plant equipment.
- (5) That the test program includes measures to ensure that tests are not initiated until all applicable prerequisites for the test have been completed or are in place. Each test sequence is established to ensure that testing is completed, and operability confirmed (for startup and power ascension testing) on systems and equipment needed to support future testing.

⁶ An ML holder may also seek a CP and OL or COL to conduct some or all of the PITAP in the factory before delivery to the deployment site. In these cases, the OL or COL for the factory testing would specify the portions of the PITAP that would be conducted in the factory. The OL or COL for the deployment site would specify what remaining tests must be conducted at the deployment site. The ML itself may need to include terms or conditions to ensure that all aspects of the PITAP are covered in the licenses authorizing operation. ML holders considering such an approach are encouraged to discuss their plans during the pre-application phase of the review.

- (6) The SAR provides that approved test procedures are in a form suitable for NRC inspection or audit at least 60 days prior to their intended use or at least 60 days prior to fuel loading for fuel loading and startup test procedures.⁷

E. General Responsibilities

The NRC staff should ensure that the application describes the responsibilities and guidelines for conducting the PITAP. In general, the applicant is responsible for all aspects of the PITAP, although other parties (e.g., vendors) may conduct some of the testing. The staff should confirm that the application assigns the following responsibilities to the applicant:

- (1) defining the qualifications of the personnel managing, conducting, and reviewing the inspection, test, and verification program and its results
- (2) using contractor or vendor personnel, as appropriate
- (3) providing training as necessary to ensure that personnel are ready to perform their functions
- (4) developing the testing objectives, schedule, sequence, prerequisites, procedures, safety precautions, and acceptance criteria
- (5) managing, controlling, and approving key aspects (e.g., prerequisites, procedures) of the test program
- (6) establishing a defined set of qualified operating and technical plant personnel to review, evaluate, and disposition the inspection, test, and verification results
- (7) coordinating with other elements of the plant organization (e.g., engineering, design, operations), as necessary, in planning, conducting, and reviewing inspection, test, and verification results
- (8) preparing, approving, and retaining test reports
- (9) conducting the tests using detailed procedures approved by managers in the applicant's startup test program organization
- (10) ensuring the personnel conducting the tests (including contractors, vendors, or others) have the appropriate training, experience, and education determined necessary by management

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F. Acceptance Criteria

In reviewing the application, the NRC staff needs reasonable assurance that the requirements to conduct a PITAP, as stated in 10 CFR 50.34(b)(6)(iii), 10 CFR 52.47(b)(1), 10 CFR 52.79(a)(28) and 52.80(a), and 10 CFR 52.157(f)(27) and 52.158(a) are met for the

⁷ The staff observes that it will need applicants and licensees to provide timely notification to the NRC of changes in approved test procedures that have been made available for NRC inspection or audit in order for the staff to maintain efficient inspection schedules.

design and technology under review. This determination should be based on whether the information provided in the application is sufficient to conclude the following:

- (1) The Phase 1 inspection, testing, and verification program (including elements of the quality assurance program, as applicable) includes all SR and safety-significant SSCs that can reasonably be verified at the preoperational stage.
- (2) Acceptance criteria are provided for each inspection, test, and verification element, and they are consistent with the safety analysis and technical specifications.
- (3) The Phase 2 test program includes all SR and safety-significant SSCs (for functions that were not tested in Phase 1).
- (4) The applicant's responsibilities are clearly described.
- (5) The description in the application covers all of the overarching items listed previously for developing the PITAP, or deviations are justified.
- (6) Risk insights have been used to select the most important parameters to be inspected and measured.
- (7) First-of-a-kind SSCs and inherent or passive safety features are identified and included in the inspection, test, and verification program.
- (8) Applications for a COL, DC, or ML include the ITAAC as a standalone document.
- (9) The parameters to be measured in the test program are sufficient to determine, directly or through analysis, that the SSC performs as designed.
- (10) Information sufficient to confirm the analytical assumptions, limits, and models will be collected.
- (11) The applicant's process for reviewing inspection, testing, and verification results and determining their acceptability or, if unacceptable, providing for SSC modification and reinspection, retest, or reverification, are clearly described and reasonable.

With positive answers to the above items, the staff can conclude that the performance of each SR and safety-significant SSC of the design has been demonstrated and sufficient data exists to provide additional confirmation of the adequacy of analytical tools used in the safety analysis. Thus, there is reasonable assurance that the PITAP is in compliance with the applicable regulations for a CP, OL, COL, DC, or ML.

IMPLEMENTATION

The NRC staff will use the information discussed in this ISG to review non-LWR applications for CPs, OLs, COLs, DCs, and MLs under 10 CFR Part 50 and 10 CFR Part 52. The NRC staff intends to incorporate this guidance in updated form in the RG or NUREG series, as appropriate.

BACKFITTING AND ISSUE FINALITY DISCUSSION

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The NRC staff may use DANU-ISG-2022-06 as a reference in its regulatory processes, such as licensing, inspection, or enforcement. However, the NRC staff does not intend to use the guidance in this ISG to support NRC staff actions in a manner that would constitute backfitting as that term is defined in 10 CFR 50.109, "Backfitting," and as described in NRC Management Directive 8.4, "Management of Backfitting, Forward Fitting, Issue Finality, and Information Requests" (Ref. 10), nor does the NRC staff intend to use the guidance to affect the issue finality of an approval under 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants." The staff also does not intend to use the guidance to support NRC staff actions in a manner that constitutes forward fitting as that term is defined and described in Management Directive 8.4. If a licensee believes that the NRC is using this ISG in a manner inconsistent with the discussion in this paragraph, then the licensee may file a backfitting or forward fitting appeal with the NRC in accordance with the process in Management Directive 8.4.

CONGRESSIONAL REVIEW ACT

DANU-ISG-2022-06 is a rule as defined in the Congressional Review Act (5 U.S.C. 801-808). However, the Office of Management and Budget has not found it to be a major rule as defined in the Congressional Review Act.

FINAL RESOLUTION

The NRC staff will transition the information and guidance in this ISG into the RG or NUREG series, as appropriate. Following the transition of all pertinent information and guidance in this document into the RG or NUREG series, or other appropriate guidance, this ISG will be closed.

ACRONYMS

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| ARCAP | advanced reactor content of application project |
| CFR | <i>Code of Federal Regulations</i> |
| COL | combined license |
| CP | construction permit |
| DANU | Division of Advanced Reactors and Non-Power Production and Utilization Facilities |
| DBE | design-basis event |
| DC | design certification |
| FSAR | final safety analysis report |
| ISG | interim staff guidance |
| ITAAC | inspections, tests, analyses, and acceptance criteria |
| LWR | light-water reactor |
| ML | manufacturing license |
| NRC | U.S. Nuclear Regulatory Commission |
| OL | operating license |
| PITAP | post-manufacturing and construction inspection, testing, and analysis program |
| RG | regulatory guide |
| SR | safety-related |
| SSC | structure, system, and component |
| TICAP | technology-inclusive content of application project |

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REFERENCES

1. Title 10 of the *Code of Federal Regulations* (10 CFR), Part 50, “Domestic Licensing of Production and Utilization Facilities.”
2. 10 CFR Part 52, “Licenses, Certifications, and Approvals for Nuclear Power Plants.”
3. U.S. Nuclear Regulatory Commission, DANU-ISG-2022-01, “Review of Risk-Informed, Technology-Inclusive Advanced Reactor Applications – Roadmap,” March 2024 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML23277A139).
4. U.S. Nuclear Regulatory Commission, NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition,” Section 14.3, “Inspections, Tests, Analyses, and Acceptance Criteria.”
5. U.S. Nuclear Regulatory Commission, NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition,” Section 14.3.10, “Emergency Planning—Inspections, Tests, Analyses, and Acceptance Criteria.”
6. U.S. Nuclear Regulatory Commission, NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition,” Section 14.3.12, “Physical Security Hardware—Inspections, Tests, Analyses, and Acceptance Criteria.”
7. U.S. Nuclear Regulatory Commission, Regulatory Guide 1.68, “Initial Test Programs for Water-Cooled Nuclear Power Plants,” Washington, DC

8. U.S. Nuclear Regulatory Commission, NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition," Section 14.2, "Initial Plant Test Program - Design Certification and New License Applicants."
9. American Society of Mechanical Engineers Boiler and Pressure Vessel Code, Section III, "Rules for Construction of Nuclear Facility Components."⁸
10. U.S. Nuclear Regulatory Commission, Management Directive 8.4, "Management of Backfitting, Forward Fitting, Issue Finality, and Information Requests."
11. U.S. Nuclear Regulatory Commission, SECY-24-0008, "Micro-Reactor Licensing and Deployment Considerations: Fuel Loading and Operational Testing at a Factory," January 24, 2024 (ADAMS Accession No. ML23207A252).

⁸ Copies of American Society of Mechanical Engineers (ASME) standards may be purchased at American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016-5990; telephone (800) 843-2763. Purchase information is available through the ASME Web site at <http://www.asme.org/Codes/Publications>.