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NRC INSPECTION MANUAL

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TRAINING: No special training requirements have been identified for the inspection document issued with this change notice.

REMARKS: IP 50001 (Steam Generator Replacement Inspection) is issued to provide overall direction to the inspection effort to be performed during the replacement of a steam generator.

DISTRIBUTION: Standard

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NRC INSPECTION MANUAL

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INSPECTION PROCEDURE 50001

STEAM GENERATOR REPLACEMENT INSPECTION

PROGRAM APPLICABILITY: 2515

SALP FUNCTIONAL AREA: ENGINEERING (SOETS-0)

50001-01 INSPECTION OBJECTIVES

01.01 To verify that engineering evaluations and design changes associated with steam generator (SG) replacement are completed in conformance with requirements in the facility license, the applicable codes and standards, licensing commitments, and the regulations.

01.02 To verify that SG removal and replacement activities are performed safely and satisfy regulatory and licensee requirements.

01.03 Verify that the SG post-installation test program is technically adequate, in conformance with requirements, and satisfactorily implemented.

01.04 To evaluate the effectiveness of the licensee's quality assurance program(s) associated with SG replacement.

50001-02 INSPECTION REQUIREMENTS

02.01 Inspection Scoping. Develop a comprehensive site-specific inspection plan to review the safety-related aspects associated with the major phases of the SG replacement project (SGRP). A typical SGRP involves three major phases: design and planning, SG removal and replacement, and post-installation verification and testing.

02.02 Design and Planning Inspections.

- a. Conduct SG replacement engineering and technical support inspections in accordance with the inspection plan by performing selective inspections, consistent with the safety significance and inspection resources, that will:
 1. Review the design change and modification process to determine if administrative controls have been established and implemented for design activities that are consistent with the licensee's quality assurance program.

2. Verify that design changes and modifications made to systems, structures, and components described in the Final Safety Analysis Report (FSAR) are reviewed in accordance with 10 CFR 50.59.
 3. Review key design aspects and modifications for the replacement SGs and other modifications associated with SG replacement to ascertain that applicable requirements have been satisfied.
- b. Review the SGRP procurement and receipt inspection activities to verify that:
1. The procurement and receipt inspection activities satisfy applicable quality assurance program requirements.
 2. The procurement specifications satisfy the design requirements.
 3. The SG is fabricated according to applicable code requirements and the procurement specifications.
 4. SG and equipment handling and storage provisions and controls are in place to avoid degradation during handling and storage.
- c. Review the applicable engineering design, modification, and analysis associated with SG lifting and rigging including: (1) crane and rigging equipment, (2) SG component drop analysis, (3) safe load paths, and (4) load lay-down areas.
- d. Review radiation protection program controls, planning, and preparation in the following areas:
1. Dose estimates and As Low As Reasonably Achievable (ALARA) considerations.
 2. Exposure and contamination controls.
 3. Emergency contingencies.
 4. Project staffing and training plans.
- e. Review SGRP activities in the following areas:
1. Project management organization and staffing.
 2. Controls for contractor oversight and interface.
 3. Plans for identifying, tracking, and resolving nonconformances.
 4. Plans for implementing quality assurance requirements.
 5. Plans for the use of "third party" inspection agencies and the extent of their participation.
 6. Training of licensee and contractor personnel.
 7. Security considerations associated with vital and protected area barriers that may be affected during replacement activities.
 8. Where applicable at multi-unit sites, the controls and plans to

minimize any adverse impact to the operating unit and common systems.

02.03 Steam Generator Removal and Replacement Inspections. Conduct SG removal and replacement inspections in accordance with the inspection plan by performing selective inspections, consistent with the safety significance and inspection resources, of the following areas:

- a. Inspect the following cutting, welding, and non-destructive examination (NDE) activities:
 1. Where applicable, special procedures for cutting, machining, welding, and NDE.
 2. Training and qualifications for personnel performing cutting, machining, welding, and NDE.
 3. Set up and testing of cutting and welding equipment.
 4. Preparations to measure and the measurement of any pipe deflection that may occur after cutting.
 5. Cutting of reactor coolant system (RCS), steam, and feedwater piping and instrument lines, etc., and where applicable, SG girth cutting.
 6. Fitup and welding preparations for the new SG.
 7. Welding of RCS, main steam, feedwater, and other lines and where applicable, welding of SG girth welds.
 8. NDE including radiography results and work packages.
 9. Weld heat treatment.
- b. Review activities associated with lifting and rigging including:
 1. Preparations and procedures for rigging and heavy lifting including any required crane and rigging inspections, testing, equipment modifications, lay-down area preparations, and training.
 2. Lifting and rigging of SG component(s) from the containment.
 3. Movement and lifting of new SG into place.
 4. Transportation of old/new SGs to/from storage.
- c. Inspect the following interference removal and restoration activities:
 1. The administrative measures (procedures) that control the process for interference removal and the restoration of affected items to their required condition.
 2. Interference removal including SG and RCS piping restraints, snubbers, and supports and removal of SG restraints ("belly-bands"), snubbers, and supports.
 3. Removal of piping and instrumentation interfacing the SG.

4. Restoration of SG component and piping and RCS restraints, snubbers, and supports.
5. Restoration of interferences, piping, and instrumentation.
- d. Inspect the following activities associated with containment access:
 1. Establishment and/or enlargement of the containment access for equipment and components.
 2. Where applicable, containment restoration and inspection.
- e. Inspect the following activities throughout the process as appropriate:
 1. Establishment of operating conditions including defueling, RCS draindown, and system isolation and safety tagging/blocking.
 2. Implementation of radiation protection controls.
 3. Implementation of quality assurance.
 4. Cleanliness, flushing, and foreign materials exclusion controls.
 5. Security considerations.
 6. Control of combustibles and ignition sources.
 7. Installation, use, and removal of temporary services. These include temporary structures, systems and components (SSCs) as well as temporary piping supports. Verify that these temporary services have been evaluated for both operational and physical impact on plant equipment and systems important to safety.
 8. Management controls and oversight including contractor interface and control of nonconformances.

02.04 Post-installation Verification and Testing Inspections. Conduct SG post-installation verification and testing inspections in accordance with the inspection plan. Perform selective inspections, consistent with the safety significance and inspection resources, of the following areas:

- a. Inspect the following SG post-installation verification and testing activities:
 1. Containment testing, as applicable.
 2. The licensee's post-installation inspections and verifications program and its implementation.
 3. The conduct of RCS hydrostatic testing and review the test results.
 4. The conduct of the SG secondary side hydrostatic testing and review the test results.
 5. Calibration and testing of instruments affected by SG replacement.
 6. The procedures for equipment performance testing required to confirm the design and to establish baseline measurements and the conduct of

testing.

7. Preservice inspection of new welds.
 8. Completion of post modification activities such as drawing updates, procedure changes, resolution of outstanding issues, and training.
- b. Review the plans for the temporary storage and disposal of the retired SGs and components.

50001-03 INSPECTION GUIDANCE

General Guidance

SG replacement at a nuclear power plant is a significant modification/maintenance activity involving many different licensee disciplines and has historically required extensive contractor support. This activity can potentially affect the power plant safety analysis, the containment structure, and plant operational characteristics.

Comprehensive NRC inspection of SG replacement activities involves coordination of inspections to review engineering, safety assessment, operations, maintenance, welding, NDE, instrumentation, quality assurance, radiation protection, security, and testing. It is expected that inspections will be performed primarily by regional specialists and the resident inspectors.

Although early steam generator replacements were processed as license amendments, recent replacements have been accomplished under 10 CFR 50.59. However, because of the engineering scope of a replacement project and its safety significance, licensees have voluntarily participated in extensive interactions with the regions and NRR technical branches. This interaction starts early (three or more years before scheduled replacement) in the design effort and prior to contracting a vendor for SG fabrication. It is expected that these interactions will continue with future SGRPs. Because of the complexity of the SGRP, technical support from NRR for engineering reviews during the inspections should be considered. Those engineering reviews should be coordinated through the NRR project manager.

All inspections of SG replacement activities should be performed in accordance with this procedure and the site-specific inspection plan developed to support this procedure. The site-specific inspection plan should be developed and administered by the regional office to integrate the inspection activities of the specialist inspectors.

The site-specific inspection plan should include the applicable inspection requirements outlined in Section 02. The expenditure of inspection resources and the emphasis on inspection activities should be based on the scope of the replacement activities and associated modifications, the safety significance of the activities, the licensee's historical performance in that area, and industry experience. Additional inspection emphasis may be considered for those aspects of the replacement project that include new or different management controls or involve new techniques. For example, there may be new administrative procedures or quality assurance programs for the project or specialized welding techniques such as the "narrow gap" method.

The inspection requirements in Section 02 are general and address the basic activities that should be inspected. Additional guidance for specific

inspections should be derived from inspection procedures relative to the area being examined. Those procedures include, but are not limited to, the procedures listed in Appendix A of this procedure. Note that some of the procedures listed applied to original construction activities, preoperational testing, and startup testing and may be used as guidance for inspection of SG replacement.

Specific Guidance

03.01 Inspection Scoping. The major phases of a SG replacement project are typically design and planning, SG removal and replacement, and post-installation verification and testing. The licensee's design and planning phase may begin several years before replacement. Contracts for SG procurement have been issued three or more years before replacement. The licensee may install temporary or permanent modifications to support the SGRP well in advance of the SGRP outage. Significant design work and outage planning may be complete a year before the outage.

An early review of the licensee's SGRP scope and schedule will provide advance opportunity to identify special inspection needs and plan the design and planning phase inspections. Inspections of the SG design and procurement specifications should occur before issuance of the procurement contract. For the significant support modifications installed prior to the outage, inspection before the SGRP outage is recommended. About a year before the SGRP outage, the licensee's outage scope and schedule should be detailed enough to develop the inspection plan for review of onsite work. Inspection planning has typically been performed by a region based inspector with input from the resident inspector.

03.02 Design and Planning Inspections

- a. The licensee's program for SG replacement activities should be reviewed to verify that the requirements of Appendix B to 10 CFR Part 50 and applicable standards are met. Differences in the design program for steam generator replacement and the licensee's existing program may be considered.

Review of the licensee's modification program should determine whether the program correctly screens modifications to identify those that may be affected by 10 CFR 50.59. The program should also require review of the modifications determined to be affected by 10 CFR 50.59 to identify unreviewed safety questions or changes to the technical specifications.

For those modifications required by 10 CFR 50.59 to have a safety evaluation, the safety evaluation should consider the following:

- the unreviewed safety question criteria
- systems and components affected by the change (What is the effect of the change on their capability to perform their specified or intended functions?)
- parameters of the accident analysis affected by the change (Are all the relevant design basis accidents and transients identified?)
- potential effects of system or component failure (That is the question, "what would happen if..." is explored and answered in the safety evaluation).

Additional guidance regarding 10 CFR 50.59 inspections can be found in Inspection Procedure 37001.

The licensee is required to submit to the NRC for review and approval, any changes that constitute an unreviewed safety question or require a change to the technical specifications. Instances where the inspector has concerns that the change should have received NRC approval and was not submitted should be discussed with NRC management for additional guidance.

The inspection should verify that (1) key SG design aspects and SG modifications, and the design of other significant modifications are reviewed and approved in accordance with procedures and (2) replacement materials and components meet the appropriate design technical requirements. Those technical requirements include the applicable codes and standards, NRC requirements, and other commitments made by the licensee in the FSAR.

Replacement SG design, fabrication, and material improvements should be reviewed to assess the effectiveness of the licensee's process to incorporate lessons learned from previous experience into the new SG. Lessons learned may include improved tube support design to minimize the entrapment of corrosive materials, tubing composition and fabrication controls to minimize susceptibility to corrosion, and actions taken to minimize residual stress at the tube-to-tubesheet expansion areas. Detailed reviews of SG improvements should be coordinated via the NRR Project Manager with the Materials and Chemical Engineering Branch, NRR.

The inspection should review design program attributes similar to those outlined in Section 02.02 of IP 93803.

The following list illustrates typical topics that may need to be reviewed:

- the general design for removal and reinstallation of the SGs and related components
- the impact of changes in mass and center of gravity of the new steam generator on the seismic analysis for the containment structure, pipe stress analysis, and other safety systems and components
- the effect of the steam generator and related design changes on transient and accident analyses including tube ruptures
- the cumulative and synergistic effects, if any, of the steam generator, related design changes, and other modifications completed during the outage on transient and accident analyses
- adherence to and reconciliation of code requirements
- compliance with regulatory requirements including the incorporation of inservice inspection requirements of 10 CFR 50.55a (g)

- b. The inspection should verify that the procurement specifications contain the applicable quality assurance and technical requirements. The SG procurement design, material, and fabrication specifications should be inspected to ensure conformance with applicable code and regulatory requirements and licensee commitments. These inspections should be

performed as early as possible and preferably before the contract for the replacement SG is issued. A contract for fabrication may be issued three or more years before replacement.

The adequacy of SG fabrication should be verified via a review of selected fabrication documentation and/or by inspection of the SG vendor and actual SG fabrication. Inspection of selected receipt inspection activities or direct verification of critical SG characteristics may be performed. Vendor inspections should be coordinated with the Vendor Inspection Branch, NRR.

Special handling and storage provisions may be employed for the new steam generators to prevent degradation before installation. These provisions may include inert gas atmosphere, moisture content levels, and temperature controls.

Additional guidance for SG procurement and receipt inspection is contained in Inspection Procedure 38701, "Procurement Program," and Inspection Procedure 38702, "Receipt, Storage, and Handling of Equipment and Materials Program."

- c. Several heavy lifting evolutions are expected. While the radiological consequences of a heavy load drop are expected to be small (core defueled), a dropped component could result in an unwarranted radioactive release and severely damage equipment.

The licensee's plans and analysis for lifting and rigging of heavy loads are reviewed to verify the safe load path analysis for component removal and reinstallation is technically sound. Rigging and lifting device design, crane analysis, and laydown areas both inside and outside the containment should be evaluated to verify expected loads can be safely handled and to identify any needed modifications.

Modifications such as reinforcement of existing structures and/or floors, construction of new structures or platforms, and changes to the crane should be reviewed to verify that the modified equipment will safely handle expected loads. The potential impact of these modifications on safety-related equipment should be assessed for applicability under 10 CFR 50.59.

The component drop analysis should be reviewed to verify, in general, that the potential offsite releases at the exclusion area boundary are within 10 CFR Part 100 limits and equipment to maintain safe shutdown will be unaffected.

Additional information on lifting heavy loads is available in Generic Letter 81-07, "Control of Heavy Loads," and NUREG-0612, "Control of Heavy Loads at Nuclear Power Plants."

- d. The inspection should audit the licensee's outage radiation protection program and confirm that the dose estimates, program controls, contingency plans, training, and staffing plans are adequate to support the planned outage activities, including daily surveillance of work activities and verification of procedure adherence. In the past, licensee incorporation of lessons learned from earlier SGRPs has resulted in improvements in SGRP radiation protection planning. Refer to NUREG/CR-1595, "Radiological Assessment of Steam Generator Removal and Replacement Update and Revision," for additional information on

radiological considerations.

- e. Because of the unique demands imposed by SG replacement outages, review of licensee project management activities is of particular importance. Historically, licensees have established separate project organizations specifically chartered with managing the SGRP. As a result, the project organization, staffing, lines of authority, and responsibilities may be new and unfamiliar to the licensee and will most likely be unique for each SGRP.

Reviews of the licensee project activities should be focused on the aspects that differ from established programs and how the project activities will interface with those established programs. Project staffing plans, personnel qualifications, and training should be consistent with the organizational structure and the project scope for both licensee and contractor personnel.

Contractor interface and oversight may be atypical of previous licensee experience and therefore merit inspection emphasis. Controls for identifying, evaluating, and resolving nonconforming conditions should be reviewed to verify that they meet licensee QA program requirements. Likewise, project quality assurance implementation plans should be reviewed for consistency with requirements. Where NRC requirements and licensee commitments to the NRC are more restrictive than the minimum code requirements for welding and NDE, verify that the licensee's contractor oversight ensures conformance to the more restrictive requirements.

Security boundaries may be affected during the SGRP. The impact of the work on the boundaries and the licensee's contingency plans should be reviewed to verify conformance with the security plan.

03.03 Steam Generator Removal and Replacement Inspections

- a. Significant cutting, machining, and welding activities are expected with SG replacement outages. Emphasis should be placed on verification that licensee and contractor welding and NDE procedures contain the applicable requirements for the modification and that the requirements are correctly implemented to control the specialized processes.

Reviews of the training and qualifications of licensee and contract machinists, welders, quality control/assurance inspectors, and NDE examiners are reviewed to verify personnel meet site and code qualification requirements and are prepared for the site specific tasks. In the past, mockups have been used for qualifying welding procedures and training and qualifying welders, machinists, and NDE inspectors.

To identify the presence of any stresses caused by pipe deflection, the licensee should be prepared to measure any pipe movement that occurs after severance from the SG. The amount of pipe deflection is an indicator of the magnitude of "residual stresses," which may not be bounded by the original analysis. If pipe deflection is noted, assistance in reviewing the licensee's resolution of the issue may be coordinated with the NRR Project Manager. In some cases, the piping design may include some deflection (cold springing) that may be captured in the original analysis.

Reviews of the controls and issue of welding materials and the control

and use of welding tools should be made. Several procedures are listed in Appendix A under the maintenance section that contain useful guidance for welding inspections.

Attention should be given to requirements and limitations imposed by the SG vendor. Because of past problems, such as excessive weld porosity, identified during narrow gap welding of RCS piping, attention should be given to "narrow gap" or "narrow groove" welding techniques.

Inspection of the following pressure boundary welds made in the field should include (pipe sizes refer to diameter):

- all RCS piping greater than 2 inches
- all main steam line and main feedwater piping greater than 2 inches and inside containment
- other piping, inside containment, that is greater than 2 inches and communicates directly with the SG
- where applicable, the steam generator girth weld

Welds associated with the steam generator and reactor coolant system piping supports should be inspected.

The inspection should select for review a sample of other field welds. That sample should be a representative cross section of welding activities and should review welds performed (1) on equipment and structures other than that specified above, (2) by various welders and welding contractors, and (3) using various welding processes on various materials. Considerations such as physical location, difficulties of the weld, and limited accessibility should be incorporated into the selection. The sample size of field welds should be sufficient to determine that the welding program is being properly implemented. An increase in sample size may be warranted to confirm needed corrective action if welding/NDE program problems are indicated.

The methods used to inspect all of the above welding activities should be a combination of inspection of welds, welding operations, heat treatment, weld documentation, actual NDE examinations, and NDE results including radiographic results. The need for independent verification of welds by the NRC NDE van should be considered.

- b. Dependant on the crane design, some lifts may exceed rated capacity requiring crane modifications and/or special precautions and examinations. Lifting activities covered in licensee/contractor procedures should ensure supervision by qualified personnel and contain precautions to protect equipment from physical damage during lifting and handling evolutions.

Additional information on lifting heavy loads is available in Generic Letter 81-07, "Control of Heavy Loads," and NUREG-0612, "Control of Heavy Loads at Nuclear Power Plants."

- c. The inspection should verify that interference items, such as component and pipe supports or restraints (including snubbers), structures, and other equipment, that must be partially or completely disassembled or removed are properly identified, removed, handled, and stored. Likewise,

the inspection should verify that interfacing piping and instrument lines that are disassembled or removed are properly handled, reinstalled, restored, and configured in the required condition according to design requirements. Post-installation tests and inspections may be reviewed for critical equipment such as instrumentation that provides an input to the reactor protective system. The program to control interference removal and restoration should be documented in approved procedures in a complete and retrievable manner.

- d. The containment access may need to be enlarged to allow for the movement of SG components. The inspections should verify that the procedures and methods used to enlarge and restore the containment access ensure that the design assumptions and requirements are satisfied and that the containment is restored to at least its required strength and integrity criteria. If the containment access is enlarged, design reviews should be coordinated with the Civil Engineering and Geosciences Branch, NRR, via the Project Manager, to confirm the restored design margin. Post restoration testing should demonstrate that the containment has been properly restored.
- e. Implementation of controls for personnel access to radiologically controlled work areas should be performed. Reviews should be made of the implementation of radiological exposure, contamination, and airborne contamination controls planned for cutting, welding, and other activities including contaminated interference removal. Also, implementation of any special controls for contaminated tools and waste should be reviewed. Where applicable, controls for shielding installations should consider the effects of additional weight loads on equipment.

The inspection should verify that program elements reviewed for Inspection Requirement 02.02 e., including quality assurance activities, are effective in implementing installation requirements and that problems are identified and dispositioned. IP 93803, Section 2.03, contains several modification installation areas that should be considered for performing this inspection.

Special security arrangements may be required to move the new SGs into the protected area and remove the old SGs from the protected area. Compensatory actions and additional controls on containment access may be needed.

Temporary services include items such as temporary electrical power or additional structural supports for equipment laydown. They also include temporary supports for piping cut during interference removal. Evaluations for both operational and physical impact on plant equipment and systems important to safety should be performed by the licensee to ensure that there is no adverse effect on systems important to safety. Inspections of temporary services plans, analysis, installation, and removal may be performed. Inspection of temporary pipe supports before the pipe is cut is recommended.

03.04 Post-installation Verification and Testing Inspections. The inspection should review the licensee's post-installation verification and testing program to verify that modifications are completed in accordance with the design; that drawings, procedures, and training have been updated as appropriate; that post-installation walkdowns and inspections are performed to ensure equipment is restored and temporary services are removed; that equipment cleanliness has been verified; that preservice inspection of welds to establish baseline data are

performed; and that deficiencies are properly dispositioned. In addition to reviewing the licensee's program to verify restoration, the inspector may perform independent walkdowns to confirm equipment restoration.

Direct inspection of portions of the primary and secondary hydrostatic tests and review of the test results should be performed. The inspection should verify that testing satisfies applicable code and regulatory requirements, that testing was conducted according to the procedure, and that results were satisfactory or properly resolved.

Section 02.04 of Inspection Procedure 93803 contains additional inspection guidance for testing inspections.

If the retired SGs are stored on site, the storage facility should be reviewed to verify that access is properly controlled and dose rates at the perimeter are below applicable limits. For additional information, refer to Generic Letter 81-38, "Storage of Low-Level Radioactive Wastes at Power Reactor Sites."

50001-04 INSPECTION RESOURCES

Approximately 320 hours of direct inspection effort per SGRP are estimated for completion of this inspection. Actual inspections at a specific plant may vary significantly based on the scope and depth of the inspections.

50001-05 REFERENCES

1. Generic Letter 81-07, "Control of Heavy Loads" (Microfiche locations 7964/024, 7900/310, and 90191/292)
2. NUREG-0612 "Control of Heavy Loads at Nuclear Power Plants" (Microfiche location 6411/280)
3. NUREG/CR-1595, "Radiological Assessment of Steam Generator Removal and Replacement Update and Revision" (Microfiche location 7309-019)
4. Generic Letter 81-38, "Storage of Low-Level Radioactive Wastes at Power Reactor Sites" (Microfiche location 10848-343)

END

Appendix

A. Applicable Inspection Procedures

APPENDIX A CONTINUED

70370 Testing Piping Support and Restraint Systems
70462 Reactor Coolant System Hydrostatic Test - Test Witnessing
70562 Reactor Coolant System Hydrostatic Test - Results Evaluation
73052 Inservice Inspection - Review of Procedures
73053B Preservice Inspection - Observation of Work and Work Activities
73055B Preservice Inspection - Data Review and Evaluation

Radiological Controls:

83726 Control of Radioactive Materials and Contamination, Surveys,
and Monitoring
83728 Maintaining Occupational Exposures ALARA
83729 Occupational Exposure During Extended Outages

Physical Security:

81064 Compensatory Measures

Procurement, Receiving and Storage:

35065 Procurement, Receiving and Storage
38701 Procurement Program
38702 Receipt, Storage, and Handling of Equipment and Materials
Program

Quality Verification:

35702 Inspection of Quality Verification Function
40702 Audit Program
40704 Implementation, Audit Program

Containment Inspections**:

70307 Containment Integrated Leak Rate Test - Procedure Review
70313 Containment Integrated Leak Rate Test

APPENDIX A CONTINUED

<u>Inspection Procedure No.</u>	<u>Inspection Area: Inspection Procedure Title</u>
70323	Containment Leak Rate Test Results Evaluation

** Applicable when the containment access has been enlarged.

END