

# NRC INSPECTION MANUAL

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## INSPECTION PROCEDURE 51053

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### ELECTRICAL COMPONENTS AND SYSTEMS - WORK OBSERVATION

PROGRAM APPLICABILITY: 2509

#### 51053-01 INSPECTION OBJECTIVES

01.01 By direct observation and independent evaluation of work performance, work in progress and completed work, determine whether activities relative to safety-related electrical systems and components are being controlled and accomplished in accordance with NRC requirements, safety analysis report (SAR) commitments, and licensee procedures.

01.02 Determine whether inadequacies in completed work, partially completed work, or work activities in progress associated with electrical equipment indicate a management control problem or generic weaknesses.

#### Inspection Schedule

##### May Be Started

After work  
has started

##### Must Be Started

Before work is  
20% complete

##### Must Be Completed

Before work is  
90% complete

For the electrical systems and components listed in this inspection procedure (IP), periodic inspections shall be performed on a frequency commensurate with construction progress but, in general, no less frequently than semi-annually. The frequency of inspection for Subsection 02.02a, Receiving Inspection, and Sub-section 02.02b, Storage, or a particular subsection of Section 02.01 may be reduced to annually when no significant deviations or other concerns are identified during the first two inspections of those activities.

#### 51053-02 INSPECTION REQUIREMENTS

##### 02.01 Inspection of Electrical Systems and Components

###### a. General

1. Inspection of selected electrical systems, components and associated items shall be accomplished by observation and evaluations of both in-process and completed work at the appropriate stage of completion for the activity to be inspected.

2. Sample selection shall be based on importance to operational safety and shall include redundant components and a diversity of components and locations.
  3. Before inspecting selected items, review the specifications, drawings, work procedures, quality assurance/quality control (QA/QC) procedures, and work schedules applicable to the systems or components selected for inspection. In addition, review the results of inspections performed according to IP 51051.
- b. Raceway Systems
1. For each periodic inspection of the activities in Section 02.02 below, select a representative sample of two safety-related raceway systems.
  2. Complete the inspection requirements of Subsections 02.02a, b, d, e, and f for the sample selected.
- c. Emergency Diesel Generator
1. For each periodic inspection of the activities in Section 02.02 below, select a representative sample of two electrical components in the diesel generator system and associated electrical auxiliary systems.
  2. Complete all the inspection requirements of Section 02.02 for the sample selected.
- d. DC Systems
1. For each periodic inspection of the activities in Section 02.02 below, select a representative sample of two components and associated items in DC systems.
  2. Complete the inspection requirements of Subsections 02.02a, b, d, e, f, and g for the sample selected.
- e. Distribution, Control, and Protective Apparatus
1. For each periodic inspection of the activities in Section 02.02 below, select a representative sample of three components in this category, such as transformers, switch gear, large motors, M-G sets, motor control centers, and heaters.
  2. Complete all the inspection requirements of Section 02.02 for the sample selected.
- f. Other Electrical Components
1. For each periodic inspection of the activities in Section 02.02 below, select a representative sample of three electrical components not selected in Subsections b through e above. The selections shall include components such as motor-operated valves, solenoid valves, limit switches, interlocks, containment penetrations, circuit breakers, fuses, and electrical control panels.
  2. Complete the inspection requirements of Subsections 02.02 a, b, d, e, and f for the sample selected.

## 02.02 Inspection Activities

- a. Receiving Inspection. Observe and evaluate portions of receiving inspection activities pertaining to the electrical components and associated items selected for inspection in the appropriate subsections of Section 02.01 above. Determine whether receiving inspection activities are being controlled and performed in a manner that will ensure applicable requirements are satisfied in the following areas:
  1. Identification appears on components and in receiving documents.
  2. Physical condition (damage, deterioration, etc.) is indicated.
  3. Documentation relative to quality requirements (e.g., results of functional and qualification testing) received with components is reviewed to and meets requirements. Where qualification testing of components to be placed in a harsh environment (e.g., inside containment) is not a requirement of the specification, follow up with the licensee to determine what means will be used to ensure that applicable environmental qualification will be satisfied.
  4. Nonconforming components.
  5. An adequate number of qualified personnel are available to perform the receiving inspection function.
- b. Storage. Observe and evaluate storage activities and conditions for the components selected in the appropriate subsections of Section 02.01. Determine whether:
  1. Components are stored in the proper storage level designation.
  2. Components are properly identified.
  3. Storage conditions (temperature, humidity, cleanliness, etc.) and requirements are controlled and monitored as specified by the applicable specification and those specified by the manufacturer.
  4. Licensee and contractor inspection and monitoring activities are being performed in accordance with procedural requirements, if in progress during NRC inspection.
  5. Nonconforming items placed in storage are identified and/or segregated as required.
  6. In-place storage requirements are satisfied.
  7. An adequate number of qualified personnel are available to perform the required storage functions.
- c. Handling. As inspection scheduling permits, determine whether handling activities are being controlled and performed as specified when large electrical components are being moved during receipt, storage, and installation.
- d. In-Process Installation. Observe and evaluate in-process installation pertaining to the components and associated items selected in the appropriate subsections of Section 02.01. Determine whether:

1. The latest approved revision of applicable construction specifications, drawings, and/or construction procedures are available and used by the installers.
  2. The components are as specified, such as type, size or rating, and material.
  3. The components are installed in the proper location and orientation by qualified craft personnel using suitable equipment and tools.
  4. Associated mounting hardware, supports, and anchors are of the type (welded, bolted, etc.) and material specified and are properly located.
  5. The required component identification is properly established or maintained.
  6. Installed components are adequately protected from damage by adjacent construction activities.
  7. Licensee and contractor inspections are performed or scheduled to be performed, before "covering up" the work to be inspected; QC hold points are observed.
  8. Inspection activities are completed in a timely and proper manner by qualified personnel.
  9. Documentation of installation and inspection activities are completed in a proper and timely manner.
  10. Nonconformances are identified and handled in accordance with established procedures. Where corrective action is being taken, determine whether it meets the appropriate requirements.
- e. Completed Work. Observe, inspect, and evaluate the completed installation of electrical components and associated items selected in the appropriate subsections of Section 02.01. Determine whether:
1. Components are installed in accordance with design, construction specifications, and work procedures; components are at the correct location, configuration, and orientation.
  2. Specified materials are used.
  3. Bolts, anchors, weldments, other fasteners, and supports are as specified and properly mounted and secured.
  4. Protective coatings, softeners, bushings, and other specified materials have been used as specified.
  5. Equipment and item identifications have been maintained.
  6. Equipment and components are protected from hostile environments, such as high-pressure pipe, rotating equipment, and nonseismically supported equipment.
  7. Electrical components, such as conduit, tray, motors, and power distribution centers maintain specified physical and electrical separation and independence between redundant components.

8. Status of completion, maintenance, and readiness for preoperational testing is indicated or otherwise documented.
  9. Adequate actions or provisions have been taken and/or maintained (as needed) to ensure that the validation of the environmental qualification of components is maintained.
- f. As-Built Verification. When electrical components and associated items, as selected in appropriate subsections of Section 02.01, are completely (or essentially) installed and inspected, select two of the latest revisions (as-built, if available) of electrical design and/or installation drawings pertaining to the components selected. Review construction specifications and other applicable work instructions referenced by the drawing or otherwise applicable to the installation. Compare the actual installation with the above drawings and associated documents. For each drawing selected, determine whether several components shown on the drawing are of the type specified (function, range, qualification, material, etc.) and whether they have been installed, located, oriented, supported, protected, etc., in accordance with this drawing.
1. Before performing the above, verify the number and status of outstanding design changes on the selected drawings (and related specifications).
  2. Discrepancies observed may result from in-process changes, such as those initiated in the field. If in-process changes are involved, determine whether the licensee has properly controlled and documented these changes for engineering review, approval, and subsequent incorporation into the as-built drawings.
- g. Construction Testing. Observe construction testing activities for the electrical components selected in the appropriate subsections of Section 02.01. Determine whether:
1. The latest revision of applicable test procedures and/or specifications are available at the work location and used by personnel performing the testing.
  2. Properly identified, traceable, and calibrated measuring and test equipment are used.
  3. Equipment or components are able to obtain the degree of accuracy and tolerance specified or otherwise meet specified requirements.
  4. Required testing results are recorded during the activity; not after the testing has been completed. (Where test results are immediately available to the NRC inspector, note whether they are within specified limits.)
  5. Components that have been tested are adequately identified as to their status; that is, specified requirements have been met or deficiencies noted.
  6. Personnel performing the testing are properly qualified.
  7. Test personnel adhere to any special handling or removal requirements.
  8. Test discrepancies are properly identified for resolution.

02.03 Additional inspections may be conducted in the areas covered above if Regional management concludes that recent findings when evaluated by the SDP will likely result in an assigned color of 'white or above'. In these cases, particular consideration should

be given to an expanded sample of items to be inspected under Subsections 02.02d, e, and f, above.

## 51053-03 INSPECTION GUIDANCE

### General Guidance

- a. Electrical components and systems consist of those items of the facility that are designed to supply, use, control, transform, condition, or interrupt electric power.
- b. This IP applies, but is not limited, to the following safety-related electrical equipment and associated items: raceways, raceway hangers and other supports, switchgear, motor control centers, transformers, batteries and racks, battery chargers, inverters, motor-generator sets, electrical penetration assemblies, motors, electric valve operators, local cabinets, limit switches, solenoid valves, and protective devices.
- c. Because of the importance and extent of electrical systems and components, inspection activities are to be conducted periodically. In-process installation inspections should be scheduled to match appropriate installation activities.
  1. It is expected that the scope of periodic inspections will vary with construction progress, problems encountered, etc. Additional inspections should be made when and where conditions warrant.
  2. Any installation activity that has been delayed or suspended for more than one year, or has been subject to significant procedural, design or personnel change, should be re-evaluated immediately after resumption of the work or after the above changes have been made. Determine whether additional NRC inspection is required.
- d. Applicable portions of the SAR, safety evaluation reports (SER) and NRR/licensee questions and answers should be reviewed during inspection preparation to determine licensee commitments relative to construction and inspection requirements. The inspector should then utilize the above information during the review of the licensee's construction specifications, drawings, work procedures, etc., before observing activities at the construction site. For example, during inspection some raceway or cable configurations may not meet specified physical separation criteria as documented in the SAR. However, the criteria may permit analysis to demonstrate that effects of lesser separation are acceptable. Refer to IP 51051, Section 03, for additional guidance, background material, and references.
- e. Cable raceway supports are generally required to withstand the safe shutdown earthquake (SSE) and remain functional [Position 1 of Regulatory Guide (RG) 1.29]. Cable raceways are generally required to be designed and constructed so that their failure during SSE would not reduce any safety feature of the plant to an unacceptable safety level (Position 2 of RG 1.29).
- f. The inspector may not be able to observe all facets of all work activities in progress relative to electrical systems and components selected for inspection. However, portions of important activities involving several crews should be observed directly.
- g. In addition to observing whether specific electrical components and associated devices are as specified, properly identified, located, mounted, etc., it is important also to ascertain whether certain components or conditions do not exist where prohibited. For example, some electrical components must be located so that they

are not exposed to potential hazards such as high-pressure piping or flammable material.

- h. The inspector should use judgment during sample selection for the various electrical components and installation activities to be inspected. In general, selections are to be made on the basis of importance to operational safety. Emphasis should be placed on components that perform a direct safety function.
- i. Penetration assemblies, as covered by electrical IPs, refer to assemblies installed in a containment structure opening (sleeve, nozzle or barrel) and not to the opening itself. The containment opening is considered to be a part of the containment structure.
- j. The inspector should bear in mind that the NRC's sample covers only a small portion of the electrical systems and components involved. Thus, substantive errors or departure from requirements identified in NRC's sample raise the issue of whether the licensee is adequately controlling the process.
- k. Findings from this inspection activity should address each functional area as being satisfactory, being unresolved and requiring resolution, or being in violation and requiring correction. When significant inadequacies are identified indicating weakness within the responsible organization, the inspector should inform cognizant Regional supervision. The issue should be addressed also at the appropriate level of licensee management.

#### 03.01 Specific Guidance

- a. Inspection Requirement 02.01a2. In general, selections are to be made on the basis of importance to operational safety. Also, because of the harsher containment environment, some of the items selected are to be located inside containment. The extent of inspection inside containment will vary with the type of containment. For example, more safety-related electrical components are located inside pressure water reactor (PWR) and Mark III boiling water reactors (BWR) containments than in Mark I and Mark II BWR containments.
- b. Inspection Requirement 02.01b. The type of raceway component to be inspected will vary with the type of inspection activity. For example, the type of components inspected during storage inspection will depend on what is in storage. Conversely, during inspection of completed work, all types of raceway components installed will (eventually) be available for inspection.
- c. Inspection Requirement 02.02a. RG 1.38 (ANSI N45.2.2) or equivalent receiving inspection requirements are applicable here.
  - 1. The SAR should identify and describe all electrical components which must operate in a hostile environment (e.g., high radiation, temperature, humidity) during or after an accident (e.g., loss of coolant, steamline break). Where environmental qualification testing or other qualification provisions (such as seismic) are specified, receiving inspection activities should include verification that required testing has been satisfactorily completed.
  - 2. All required documentation may not be received with the components. If not, this material can be reviewed in conjunction with IP 51055. However, the inspector should at this time determine whether the licensee is following their system for identifying, controlling, and maintaining the status of the required documentation. The system should ensure eventual documentation of satisfactory completion of required testing.

- d. Inspection Requirement 02.02b. RG 1.38 (ANSI N45.2.2) or equivalent storage requirements are applicable here.
- e. Inspection Requirement 02.02b1. Control of storage conditions for equipment stored in place usually requires special effort. The inspector should note whether the specified storage conditions are being maintained.
- f. Inspection Requirement 02.02b2. Readily visible and permanently marked tags or other identifying scheme should be used for all nonconforming components and materials, and records relative to the nonconformance should be available at the site and readily retrievable.
- g. Inspection Requirement 02.02b3. It is especially important that motor storage requirements (e.g., heaters energized, periodic shaft rotation, insulation tests) and battery maintenance requirements be met.
- h. Inspection Requirement 02.02c. Items to note include rigging used, attachment points, and positioning.
- i. Inspection Requirement 02.02d1. Similar looking electrical components can be inadvertently installed in the wrong location. Positive identification and control is necessary. The inspector should ascertain whether the control system in use is adequate and being adhered to.
- j. Inspection Requirement 02.02d3
  - 1. "Qualified craft personnel" means employees who have achieved suitable proficiency to do their assigned tasks by appropriate training and/or previous experience and who understand the installation procedures, drawings, and specifications necessary for their work.
  - 2. The inspector should note whether missile protection, physical independence, and separation requirements, as applicable, are adhered to.
  - 3. For seismically designed tray and support systems, no conduit may be attached to the tray to carry exiting cables. In this case, the conduit should be rigidly supported at close proximity to and above the tray, but not from the tray. Conduit connections through the tray bottom or side rail should be avoided.
  - 4. Drop fittings should be provided where required to prevent less than the minimum cable bending radii.
  - 5. Cable tray systems are generally electrically continuous and solidly grounded. When cable trays are used as raceways for solidly grounded or low-impedance grounded power systems, considerations should be given to the tray system continuity and ampacity as a conductor. Inadequate ampacity or discontinuities in the tray system may require that a ground conductor be attached to and run parallel with the tray. The NRC does not require grounding per se. It is only required when necessary for a safety-related function or condition.
- k. Inspection Requirement 02.02d4. For some of the supports and anchorages, the inspector should directly measure or otherwise independently verify that requirements pertaining to such items as location of equipment, location of supports, and bolt sizes are as specified.



1. During installation of equipment, anchorage holes are sometimes drilled in concrete structures. Indiscriminate cutting of reinforcing steel should not be allowed.
  2. The inspector should ensure that proper welding requirements are specified and controlled. AWS D1.1, Structural Welding Code, is usually specified for welding of supports. Construction specifications and drawings should specify the welding requirements to be used.
  3. While reviewing construction specifications and drawings, also look for missing or inappropriate approvals.
  4. Drawings and construction specifications used in the field should be reviewed periodically to ensure that the most recent approved revisions are used.
  5. Because of the uncertainties associated with scheduling of in-process installation inspections, it is expected that the scope of these periodic inspections will vary considerably. The intent is to observe the more important installation activities for a variety of electrical components and associated items during the time such activities are in progress.
- l. Inspection Requirement 02.02d6. Temporary protection during construction is generally required. Protection from overhead construction activities, especially welding and concrete placement, warrants special attention. In addition, protection from inadvertent damage during plant operation and maintenance should be adequate and properly installed.
- m. Inspection Requirement 02.02d8. The intent is to determine the effectiveness of inspection personnel associated with electrical activities and the management system for indoctrination, training and qualification of those personnel. The total number involved, or their formal education, is not as significant as their effectiveness.
1. Observe inspection (QC) activities in progress. Determine whether procedures are being properly performed at the specified frequency and whether records are being generated during inspection activities.
  2. Two or three QC inspectors should be interviewed to determine whether they are familiar with the quality requirements associated with the electrical components being inspected, what construction specifications and other criteria are used to determine acceptance, how their inspection results are recorded, etc.
  3. RG 1.58 (ANSI N45.2.6) or equivalent requirements are applicable for inspection personnel.
- n. Inspection Requirement 02.02d10. The intent is to verify that nonconforming conditions are identified by the licensee and result in the initiation of the appropriate nonconformance and corrective action documentation. Where the licensee is making repairs or alterations, verify that they are in accordance with properly approved corrective action dispositions.

The effectiveness of the management control system in this area can be determined, in part, by how promptly the root causes of nonconforming activities are identified and corrected. (Is management involved? Is management visible to construction personnel? Does management aggressively support proper corrective action? Does management act promptly to correct inadequate

performance?) The inspector should determine whether established procedures are being followed relative to identification, evaluation, and corrective action of nonconforming activities and components, including activities to preclude repetition.

o. Inspection Requirement 02.02e3

1. Some electrical components, such as panels, enclosures and their supports, or other anchoring means, are required to meet seismic requirements. (The SAR should indicate where applicable.) If specified for components selected for inspection, ascertain whether these requirements are met.
2. If the installation is different from approved drawings or specifications, determine whether the change is adequately documented and forwarded for review and approval.

p. Inspection Requirement 02.02e7. When specified separation criteria are not met, the SAR may allow the licensee to evaluate acceptability for specific deviations. If such provisions exist in the SAR and evaluation of deviations has not been completed or identified, this area should be considered deficient and not in compliance with the SAR. In general, the SAR will require NRR approval of deviations from the original separation criteria when the licensee demonstrates that the effects of lesser separation are acceptable.

q. Inspection Requirement 02.02f. The intent is to determine whether electrical components and associated items are being installed according to properly approved drawings and changes, such as engineering, design, and field change requests, and changes to correct nonconforming conditions. Because as this inspection requirement is to verify "as-built" systems, a new sample should be selected if it is found that extensive rework is in progress. However, the NRC inspector should verify that the changes resulting from rework are properly handled in accordance with established procedures.

1. Appropriate standards can be used as a guide in this area. For example, ANSI N45.2.11 requires that where changes to previously verified design have been made, design verification shall be required for the changes, including evaluation of the effects of those changes on the overall design. Further, N45.2 states that records correctly identifying the "as-built" conditions of items in the nuclear facility shall be maintained and stored for the life of the particular item while it is installed in the nuclear facility. Additionally, 10 CFR 50, Appendix B, Criterion III, states in part that design and field changes shall be subject to the same design control procedures as the original design.
2. Numerous changes may be made to electrical systems during construction that are different from the original (SAR) design. Such changes will result in the accumulation of various types of design change documents or marked-up drawings. Because these changes reflect as-built conditions, they should be adequately controlled so they will be readily available. These design change documents should be used with affected original design documents during future evaluations on the effect other design changes have on the overall design. In addition, the as-built process should result in proper and timely updating of the original or master drawings and specifications to incorporate such changes.
3. The inspection requirements associated with as-built verification cannot be done until the work to be inspected is essentially complete. Consequently, this inspection requirement should be scheduled during later periodic inspections.

- r. Inspection Requirement 02.02g. This item does not include preoperational testing. Construction testing generally verifies that certain components pass specific tests as required, but it is not a test of system capability, especially systems that include nonelectrical equipment. In general, only a small portion of the required equipment and system testing is done by construction personnel.
  - 1. The inspector should review the specified testing requirements and procedures before observing these activities. If special requirements are specified, the inspector should determine whether these requirements are being adhered to.
  - 2. If testing activities are in progress, determine whether the current (most recently approved) information is being used, and whether required procedures are being adhered to.
  - 3. Obviously, these inspection requirements cannot be done until testing activities are in progress. Inspection in this area should be scheduled accordingly.
  - 4. It may not be possible for the NRC inspector to observe all aspects of construction testing for all the components selected because of scheduling conflicts. The intent of this requirement is to determine whether the required testing is satisfactorily controlled and performed, and appropriate corrective action, if required, is initiated. Final testing and trip setting may be done later, usually during preoperational testing.
- s. Inspection Requirement 02.03. The inspection requirements relative to additional inspections are intentionally general. The extent and type of additional inspection should be based primarily on the SALP Board findings in conjunction with the specific site status.

03.02 Prevalent Problems and Concerns. The inspector should be alert to problems of a generic nature, such as the following:

- a. Inadequate work quality caused by rapid turnover of craft and/or inspection personnel.
- b. Poor attitude toward quality work.
- c. Lack of cooperation between craft and inspection personnel.
- d. Inadequate identification and control of similar components, especially during removal and replacement for modification or repair.
- e. Field changes made without proper authorization, and conversely, use of outdated drawings, installation specifications, or procedures.
- f. Unauthorized removal, modification, and replacement of components.
- g. Failure to meet separation criteria.
- h. Inadequate documentation relative to status of equipment qualification.

51053-04 REFERENCES

10 CFR 50, Appendix A - General Design Criteria for Nuclear Power Plants, Criteria 1, 2, 3, 4, 5, 17, 18, 19, 20, 21, 22, 23, 24, 34, 35, 38, 39, 40, and 46

10 CFR 50, Appendix B - Quality Assurance Criteria for Nuclear Power Plants

Facility SAR, Chapters 1, 3, 4, 5, 6, 7, 8, 9, and 17, including pertinent codes and standards referenced in the SAR

END