UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

NRC INSPECTION MANUAL

INSPECTION PROCEDURE 93811

ELECTRICAL DISTRIBUTION SYSTEM FUNCTIONAL INSPECTION
(EDSFI)

PROGRAM APPLICABILITY: 2515

FUNCTIONAL AREA: ENGINEERING (ENG)

93811-01 INSPECTION OBJECTIVES

01.01 To assess the capacity of the electrical distribution system (EDS) to perform its intended functions during all plant operating and accident conditions.

01.02 To assess the capability and performance of the licensee's engineering organization in providing engineering and technical support (E&TS).

01.03 To examine the interfaces between the technical disciplines internal to the engineering organization and the interfaces between the engineering organization and the technical support groups responsible for the operability of the EDS.

93811-02 INSPECTION REQUIREMENTS

02.01 Inspection Planning. To ensure the availability of licensee personnel and documentation, the team leader should provide advanced notification to the licensee 2-3 months prior to the inspection. At least 1 month before the inspection, the team leader should discuss the following items with the licensee staff:

a. Inspection scope and schedule.

b. Number of participants on the team and office space and communication equipment requirements.

c. Documents to be made available for the inspection.

d. Scope of licensee personnel involvement and licensee's organization charts to help identify the licensee's principal contacts and participating discipline contacts.

e. Advance arrangements for plant site access, including radiation protection training, security, and fitness for duty requirements, to avoid unnecessary delays.

f. The need for advance copies of identified review materials, such as the licensee's engineering office organization, station one-line and three-line wiring diagrams, selected piping and instrument diagrams (P&IDs), logic diagrams, elementary wiring diagrams, significant modification packages related to the EDS or to the fluid systems that could impact the EDS, and engineering calculations, procedures and guidelines related to the design and design change control process.

g. The licensee should be requested to provide a presentation following the entrance meeting which should as a minimum address the following:

   1. Licensee's organization charts pertaining to the organizations responsible for EDS operability.

   2. Station ac and dc distribution system arrangements.

   3. Interlocks and ties to various offsite and onsite power sources.

   4. Transfer capability of the systems following the loss of normal sources.

   5. Specific regulatory commitments, if they are unique in nature.

   6. Licensee's in-house programs for load growth, modification control, setpoint control, etc.

   7. Licensee's in-house monitoring and self assessment programs, if any.

   8. Functional information on EDS mechanical support systems identified by the team leader.

02.02 Inspection Preparation. The team (2-3 team members) conducts the pre-inspection visit (bagman) trip to the site and engineering offices to assemble the documents requested by the team leader, to be familiar with the site organizations and engineering staff, and to discuss the administrative aspects of the inspection.

In preparation for the inspection the team should review and fully understand the goals and scope of the inspection. The team should be familiar with the

design and licensing bases, design criteria, the safety evaluation reports, and the electrical distribution scheme in general. During the preparation phase, the inspectors shall develop individual inspection plans to meet the individual assignments made by the team leader and the inspection objectives listed in Section 01. The inspectors should identify additional documents needed for completing the in-office and on site inspection by reviewing the documents received during the bagman trip. Their requests for such documents will be verbally provided to the licensee.

In addition, the team leader should discuss with the Electrical Systems Branch and Project Manager of the Office of Nuclear Reactor Regulation (NRR) the status of any current electrical issues at the planned inspection site. The inspection team should be familiar with the results of the EDSFIs performed at various sites in accordance with Temporary Instruction 2515/107. Generic and significant issues identified during these inspections were identified in various information notices. These are referenced in Section 05 of this procedure.

02.03 Conduct of the Inspection. Perform a review of general activities outlined in the following Sections for selected sample load path(s) at each voltage level of the ac and dc electrical distribution system for conformance with the design requirements. A load path is defined as the electrical power flow path between the selected load circuit and all available power source(s).

a. Engineering Office Inspection

1. Verify that the installed EDS is capable of providing quality power to engineered safety features (ESF) loads on demand to support the safe shutdown of the plant and accident mitigation functions. This includes a verification of the onsite and offsite power sources capacity.

   (Quality power is power which has specified acceptable voltage, frequency and current such that connected loads will perform their design safety functions.)

2. Verify that the design of the EDS is in agreement with regulatory requirements, licensing commitments and applicable industry standards.

3. Verify that the ratings and setpoints have been correctly chosen and controlled for protective and control relays and circuit breakers to assure proper coordination, protection, required automatic action, and annunciation.

4. Verify that the EDS mechanical support systems such as the HVAC, EDG fuel oil transfer system, EDG cooling water system and

air-start system are adequate to support operation under design basis conditions.

5. Verify that design modifications to the EDS, including electrical load growth, have been properly controlled.

b. On Site Inspection

1. Verify that the installed configuration of the EDS corresponds to the design requirements and is in agreement with the facility documents.

2. Verify that the surveillance and test procedures are adequate to demonstrate the functionality of the equipment or system being tested or the design assumptions being verified.

3. Verify that the scope, depth and frequency of maintenance, surveillance and testing (including post-modification testing) of electrical components in the load path is adequate to verify functional performance.

4. Verify that design assumptions, operational restrictions and other pertinent design or vendor information are accurately and appropriately reflected in operating, maintenance, test, training, and surveillance procedures.

5. Verify that the licensee's engineering organization provides adequate engineering and technical support to the station operating staff and to the station maintenance and surveillance staff when required.

6. Verify that definitive root cause analyses are accomplished for operational problems, and corrective actions are appropriate. Where necessary, verify that the engineering support staff participates with the plant operating staff to accomplish definitive root cause analyses of operational events or to review nonconforming conditions or conditions adverse to quality.

7. Verify, on a sample basis, engineers and craftsmen who are responsible for installation and testing of system and components have appropriate knowledge and skills.

General Guidance

For this inspection, a vertical slice sample from the existing EDS design will be evaluated, as well as corrective actions associated with operational events of an electrical nature and modifications to the electrical system since receipt of the operating license. The size and scope of the inspection sample may be adjusted for each facility as determined necessary. This inspection is intended to focus on elements of the EDS which plant experience and probabilistic risk assessment (PRA) indicate are of higher risk to safety, and which will generate information sufficient to reach specific conclusions which are indicative of the functionality of the electrical distribution and the E&TS capability of the licensee.

The inspection should sample representative electrical attributes at each voltage level of the ac and dc safety-related and nonsafety-related EDS in load paths that power the ESF loads from all available power sources that could affect the EDS from a risk point of view. Such power sources would include the offsite power supply, the onsite ac emergency power supply, and the station dc system including the Class 1E batteries, inverters and chargers. The inspection team should evaluate on a sample basis the design, design changes, operation, maintenance and surveillance of the as-configured electrical distribution system including modifications made since receipt of the operating license.

The team should also review the validity of the root cause analyses of selected operational problems and the effectiveness of the associated corrective actions implemented, the disposition of nonconformances and conditions adverse to quality and the effectiveness of the interface between the engineering, plant operating and support staffs. Verify that the plant staff has been trained regarding the interface control procedures.

The team leader should establish the general scope of the inspection by selecting one or more load paths from the various sources of electrical power (i.e., the switchyard, the unit generator and the EDGs for the ac system and the batteries, inverter and charger for the dc system) to the driven loads at each voltage level. In selecting a sample load path or sample electrical loads, the team leader should review the inspection and performance history in the electrical area for the facility including past failures and known weaknesses and the potential contribution of the load or load path to the probability for core melt and other risk-based information. Consideration should be given to selecting load paths containing EDS support equipment (such as HVAC systems involved with EDS and service water cooling components for EDS).

The results of the inspection should provide a reasonable basis for the team to draw overall conclusions regarding the ability of the EDS to perform its intended function, adequacy of E&TS, the ability of the licensee to manage and

control the plant configuration, and the interface between the engineering and the plant operating staff. Specific conclusions also should be drawn regarding:

a. The ability of the existing configuration of the EDS to provide quality power to ensure that the safe shutdown and accident mitigation functions can be accomplished on demand.

b. The degree to which diagrams, specifications, calculations, "Q" lists, engineering and plant procedures, and drawings are complete, consistent, technically adequate, conservative with adequate margins, reflect as-built configuration, are controlled, and provide an adequate basis for future design modifications.

c. The degree to which the existing EDS configuration is in compliance with regulatory requirements and licensing commitments.

d. The adequacy of surveillance and test procedures and their implementation for electrical components.

e. The effectiveness of the licensee's self assessment programs in the areas inspected.

f. The effectiveness of the licensee's training programs in the areas inspected.

Specific Guidance

03.01 Inspection Planning. Prior to the inspection, the team leader shall develop an inspection plan to address, as a minimum, the following points:

- Purpose of the inspection and background information related to the selected plant relative to significant issues between the responsible regional office and the licensee, particularly as it may relate to engineering and plant design.

- Key attributes and sample load path selected for review including applicable sections of procedure.

- Assignments of individual team members to specific areas of the design of electrical and mechanical systems, engineering and technical support functions and electrical distribution system equipment operation, maintenance and testing.

- A timetable of events involving inspection activities, such as schedule for the inspection, site access training, entrance and exit meetings, pre-exit or team debrief, team meetings, conference calls, and due dates.

- Inspection report outline, table of contents, and report writing style and format in accordance with MC 0610

03.02 Inspection Preparation. The following items should be reviewed by each inspector to achieve an in-depth understanding of the EDS and mechanical support system:

- Final Safety Analysis Report (FSAR) and Updated Safety Analysis Report (USAR).
- System descriptions and design basis documents (if available)
- Technical Specification requirements and surveillance test procedures including test data.
- Engineering calculations, analyses and drawings for electrical and mechanical support systems.
- Relevant regulatory information such as Information Notices, Generic Letters, applicable industry standards committed to by the licensee, and the staff safety evaluation report.
- Licensee Event Reports (LERs) and inspection reports for the last five years that apply to the EDS.
- Temporary and permanent modifications, including safety evaluations.

03.03 Conduct of the Inspection. This inspection has two components, a design inspection typically conducted in the engineering offices of the licensee and a concurrently conducted site inspection. This procedure is structured to have additional optional technical attributes that can be included in this inspection based on a knowledge of the performance and prior inspection history of the facility being inspected.

a. Engineering Office Inspection. For the selected load path(s) the inspection team should perform an in-depth evaluation of engineering and design aspects of the actual as-built configuration of the ac and dc electrical distribution system and associated components. This review should include the inspection of modifications made to the facility since receipt of the operating license. The review should also address the adequacy of the original design to the extent necessary to evaluate the adequacy of the existing as-built design. The engineering office inspection should selectively review the following design attributes and considerations as applicable for equipment in each load path or for the modifications selected:

1. Regulatory requirements and licensing commitments have been implemented and the EDS will perform its intended safety functions.

2. Adequacy of the size and the rating of electrical equipment in the selected sample load path which may include motors, breakers, fuses, contactors, motor control centers (MCCs), load break switches, cables, buses, transformers, penetrations, EDGs, batteries, inverters, chargers, capacitors, resistors and thermal overload heaters.

3. Adequacy of the load study, voltage profiles, voltage drop calculations, motor starting study, load shedding, ESF bus load sequencing and overload trip settings for ESF loads including consideration of steady state and accident transient loads, acceleration of the loads during degraded voltage conditions that may occur during various modes of plant operation and accident mitigation scenarios.

4. Adequacy of the calculations for the EDG loading and load sequencing.

5. Adequacy of short circuit calculations, design of protective relay logic and relay setting calculations, grounding calculations and schemes, and protective device coordination studies.

6. Redundancy and conformance with the single failure criterion, including the potential for "sneak circuits" that could compromise single failure capability.

7. Electrical separation of redundant Class 1E electrical divisions and non-Class 1E and Class 1E loads, as applicable, including electrical isolation of associated circuits.

8. Proper control logic for system actuation and operation including interlocking and permissives for protection, indication, annunciation, and for correct manual and automatic operation of the safety systems during normal and abnormal conditions of the plant. Accurate translation of control and interlocking logic into electrical elementary diagrams using relays, solid state modules and programmable controllers.

9. Correctly chosen setpoints for overcurrent protective relays 1) to assure proper breaker coordination between different voltage levels; 2) to prevent exceeding the vendor specified thermal limits on motors, containment electrical penetrations and cable insulation systems; 3) to allow starting of electrical equipment under degraded voltage conditions; and 4) to provide adequate pre-trip alarms, when applicable.

10. Adequacy of setpoints and time delays for other protective relays for attributes such as under-voltage, under-frequency, reverse power, ground faults, differential current, thermal overload and phase synchronization to assure functionality of the EDS.

11. Mechanical loads, such as pump horsepower, correspond to actual system operating points during normal and accident conditions and have been correctly translated to electrical loads and incorporated in the electrical load list as appropriate.

12. EDS supporting systems, such as the EDG air start, cooling water, fuel oil storage and transfer, and HVAC for electrical equipment rooms, are adequately designed to perform both normal and accident functions.

13. Adequacy of switchyard design and availability and adequacy of independent preferred power sources, including bus transfers, and independence between onsite and offsite distribution systems.

14. The accuracy of the electrical load list by reviewing several large electrical loads and evaluating whether the actual steady state power requirements during various normal operating and accident mitigation modes are adequate.

15. The adequacy of root cause analyses, associated corrective actions and 10 CFR 50.59 evaluations by selecting several LERs, corrective action requests and temporary modifications related to the EDS. Assess the adequacy of the involvement of the engineering organization with the operating staff in problem solving and in the interpretation of surveillance and test data.

16. The involvement of the engineering staff in the specification of post-modification testing and the development of test acceptance criteria for the modifications inspected.

17. Electrical load growth monitoring and control program.

18. Setpoint calculation and control programs.

19. Procurement specifications, environmental conditions, and other applicable design documents to assess FSAR compliance and other design commitments implementation.

In addition to the above design attributes, the following supplementary attributes may be reviewed as determined by the team leader and as time allows.

20. Dedication of commercial grade components for use in safety-related applications and non-like-for-like replacements to assure that the appropriate critical variable ranges have been preserved.

21. Adequate incorporation of the design bases and operating limitations in normal and emergency operating procedures and adequate training of the staff.

22. Provisions for indication of bypass and inoperable status, and requirements for annunciation and the operator actions following annunciation.

23. The functional requirements of EDS support systems and verification that these have been correctly translated to logic and elementary wiring diagrams.

24. Engineering calculation performance and control program.

25. Licensee self assessment programs, including QA audits.

26. Design modifications and temporary modifications control programs.

b. On Site Inspection. To complement the engineering inspection efforts, a site inspection should be performed to evaluate the adequacy and effectiveness of the following attributes and their implementation for the load paths selected for review as part of the engineering review described in the above Section.

1. Field validation of the existing configuration of the EDS for selected equipment and components to ensure the EDS is in agreement with the facility drawings and documents such as the Q-list, FSAR, setpoint list, and equipment location drawings. Verify that appropriate physical separation has been maintained between redundant Class 1E electrical divisions and that no obvious problems exist for internal plant hazards such as Seismic II over I, seismic interactions, high and medium energy line breaks, and compartment flooding.

2. Material condition of electrical equipment.

3. Surveillance and testing were properly performed by the licensee to validate key attributes and parameters such as, protective relay settings, setting of timers, breaker trip settings, EDG load sequencing and starting logic, fuse and thermal overload sizes, and Class 1E battery and inverter capacity, to assure the functionality of the EDS. Surveillance and test intervals used by the licensee are consistent with those assumed in setpoint calculations,

licensee commitments and standard industry practice and are performed at the appropriate intervals.

4. With respect to E&TS capability, the inspection team should review work orders, maintenance requests and temporary modifications. Evaluate whether inadvertent design changes have been made through maintenance activities, and whether definitive root cause analysis is being performed for failed components or components that have recurrent problems. Determine whether temporary modifications have received an appropriate 10 CFR 50.59 review.

5. Post-modification testing is adequate to verify functionality of the component or system and to verify the design objectives of the modification(s).

6. Engineering involvement (e.g., as indicated by documentation) is adequate for station generated activities such as surveillance, maintenance, temporary modifications, procurement efforts, field initiated design changes, setpoint control program, and generation and implementation of calibration and surveillance procedures.

7. The effectiveness of the licensee's self assessment programs, including QA audits of engineering and EDS areas.

In addition to the above attributes, the following supplementary attributes may be reviewed as determined by the team leader and as time allows.

8. To the extent appropriate, determine whether the station normal and emergency operating procedures include any design assumptions regarding operator action and conversely whether prescribed operator actions with respect to the EDS can put the plant outside its design basis.

9. The maintenance program is adequate to maintain the EDS equipment operable, and to maintain the EQ status of the EDS equipment.

10. Temporary modifications to the safety systems are tracked and controlled and receive the required technical evaluation in a timely manner. Review the temporary modification documentation and tracking system.

11. Controlled copies of the control room drawings and other operation and training related documents reflect the as-built configuration of plant systems including modifications.

12. Review the material history of selected load path equipment to determine if component reliability matches that assumed for design basis or for PRA.

13. Verify, on a sample basis, that engineers and craftsmen who are responsible for installation and testing have appropriate knowledge and skills.

93811-04 Inspection Resources

04.01 Team Composition. Generally, the inspection team will be composed of the following six members:

a. One team leader

b. Two electrical power system design engineers

c. One mechanical systems design engineer

d. Two electrical field inspectors

However, the size of the team must be adjusted to accommodate the scope of the inspection and may vary from site-to-site based on the licensee's inspection and performance history in the electrical area for a given facility, and also based on input from NRR and regional management.

The team composition and the extent of effort for individual members may be adjusted by the team leader. The team composition may consist of consultants as well as regional and headquarters staff members. Each of the three design engineers should have extensive nuclear power plant design experience, preferably comparable to the experience gained through previous employment with an architect/engineering firm in a supervisory capacity.

All team members should be familiar with the site organizations and types of documents used on site to be able to identify design information and assumptions that should be captured in documents related to plant operations, maintenance, surveillance and test activities. In addition, each team member should have a sound appreciation of integrated plant operations, maintenance, testing, surveillance activities and quality assurance, as well as a fundamental understanding of the plant's design bases and design considerations, so that the inspectors will be able to relate their findings to the functionality of the plant safety systems during both normal operations and postulated accident scenarios.

04.02 Inspection Schedule. The following schedule is provided to allow the commitment of resources and planning for conducting an EDSFI. Prior to week 1,

the team leader may need an additional two weeks for the preparation of this inspection.

Week 1 - Pre-inspection visit by 2-3 team members to the site, and if necessary to corporate engineering office, to collect necessary background information. Make arrangements to distribute the necessary documents to all team members.

Week 2 - Each inspector performs in-office preparation by reviewing applicable inspection documents and develops an individual inspection plan.

Week 3 - The entrance meeting is held at the site. The team begins the inspection at the site and engineering office.

Week 4 - In-office review of inspection documentation and close out of open issues with the licensee. This period will give the licensee time to review the outstanding concerns and questions identified during the first week of inspection.

Week 5 - The team continues inspection at the site and engineering office to complete review of the assigned inspection areas and close out remaining open issues. The pre-exit meeting, at which NRC management representatives are present, is to be conducted prior to the exit meeting with the licensee.

Week 6 - The team prepares the input for the inspection report.

Week 7-11 - The team leader assembles and issues the inspection report with appropriate management review and approval within 45 days of the exit meeting.

93811-05 REFERENCES

a. 10 CFR 50, Appendix A, GDC 17.

b. 10 CFR 50, Appendix A, GDC 18.

c. 10 CFR 50, Appendix B, Criterion III, V, XI and XVI.

d. NRC Branch Technical Position PSB-1, "Adequacy of Station Electrical Distribution Voltages." [Based on NRC Multiple Plant Action (MPA) B-48]

e. Plant Technical Specifications and FSAR.

f. NUREG-0800, Standard Review Plan, Chapters 6, 8, 9 and 15.

g. Information Notices 91-29, and Supplements 1, 2 and 3 - Deficiencies Identified During EDSFIs.

h. Information Notice 91-51 - Inadequate Fuse Control Program.

i. Information Notice 92-40 - Inadequate Testing of Emergency Bus Undervoltage Logic Circuitry.

j Information Notice 92-53 - Potential Failure of Emergency Diesel Generators Due to Excessive Rate of Loading.

k. Information Notice IN 92-77 - Questionable Selection and Review to Determine Suitability of Electro pneumatic Relays for Certain Applications.

l. Information Notice 94-19 - Emergency Diesel Generator Vulnerability to Failure from Cold Fuel Oil.

m. Generic Letter 88-15 - Electrical Power Systems - Inadequate Control Over Design Processes.

END