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PERIODIC TESTING OF DIESEL GENERATOR UNITS USED AS ONSITE ELECTRIC POWER SYSTEMS AT NUCLEAR POWER PLANTS

A. INTRODUCTION

Criterion XI, "Test Control," of Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," to 10 CFR Part 50, "Licensing of Production and Utilization Facilities," requires that a test program be established to ensure that systems and components perform satisfactorily and that the test program include operational tests during nuclear power plant operation.

Criterion 17, "Electric Power Systems," of Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50 requires that onsite electric power systems have sufficient independence, capacity, redundancy, and testability to perform their safety functions, assuming a single failure.

Criterion 18, "Inspection and Testing of Electric Power Systems," of Appendix A to 10 CFR Part 50 requires that electric power systems important to safety be designed to permit appropriate periodic inspection and testing to assess the continuity of the systems and the condition of their components.

This regulatory guide describes a method acceptable to the NRC staff for complying with the Commission's regulations with regard to periodic testing of diesel electric power units to ensure that the diesel electric power systems will meet their availability requirements. The Advisory Committee on Reactor Safeguards has been consulted concerning this guide and has concurred in the regulatory position.

B. DISCUSSION

The purposes of onsite electric power systems are (1) to provide power promptly to engineered safety features if a loss of offsite power and an accident occur during the same time period and (2) to provide power to equipment needed to maintain the plant in a safe condition if an extended loss of offsite power occurs. Diesel generator units are the most common source of onsite electric power.

High reliability must be designed into the diesel generator units and maintained throughout their service lifetime by appropriate testing, maintenance, and operating programs. Branch Technical Position EICSB 2, "Diesel-Generator Reliability Qualification Testing," dated 11/24/75, of the Standard Review Plan (Appendix 7-A of NUREG-75/087[1]) establishes a reliability goal of 0.99 (at a nominal 50% confidence level) and an acceptable qualification testing program for diesel generator units of a type or size not previously used as standby emergency power sources in nuclear power plants. The preoperational and periodic testing provisions set forth in this guide have been designed to provide a basis for taking those corrective actions needed to maintain high inservice reliability of installed diesel generator units. In addition, the data developed will provide an ongoing demonstration of performance and reliability for all diesel generator units after installation and in service. Reliability objectives concerning the entire onsite electric power system's probability of failure depend on the interconnections among the system's components and are not within the scope of this guide. "Failure" is taken here to mean the failure to start, accelerate, and assume the design-rated load within and for the time prescribed during an emergency or a valid test.

* Lines indicate substantive changes from previous issue.

[1] NUREG-75/087, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants," U.S. Nuclear Regulatory Commission. Copies may be purchased from the National Technical Information Service, Springfield, Virginia 22161.

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Comments and suggestions for improvements in these guides are encouraged at all times, and guides will be revised, as appropriate, to accommodate comments and to reflect new information or experience. This guide was revised as a result of substantive comments received from the public and additional staff review.

Comments should be sent to the Secretary of the Commission, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, Attention: Docketing and Service Branch.

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The testing of the diesel generator unit should simulate, where practicable, the parameters of operation (automatic start, load sequencing, load shedding, operation time, etc.) and environments (temperature, humidity, etc.) that would be expected if actual demand were to be placed on the system.

This guide provides design and operational provisions for the performance of periodic testing of diesel generator units used for onsite electric power for nuclear power plants. A "diesel generator unit" consists of the engine, generator, combustion air system, cooling water system up to the supply, fuel supply system, lubricating oil system, starting energy sources, autostart controls, manual controls, and diesel generator breaker.

C. REGULATORY POSITION

1. General

a. The design of a diesel generator unit should be such that it can accommodate diesel generator testing as defined in Regulatory Position C.2.

b. Diesel generator units should be designed to be testable during operation of the nuclear power plant, as well as while the plant is shut down. The design should include provisions so that the testing of the units will simulate the parameters of operation (outlined in Regulatory Position C.2) that would be expected if actual demand were to be placed on the system.

(1) Capability should be provided to test each diesel generator unit independently of redundant units. Test equipment should not cause a loss of independence between redundant diesel generator units or between diesel generator load groups.

(2) Testability should be considered in the selection and location of instrumentation sensors and critical components (e.g., governor, starting system components). Instrumentation sensors should be readily accessible and designed so that their inspection and calibration can be verified in place. Testability should be considered in selecting critical components, and the overall design should include status indication and alarm features.

(3) Periodic testing of diesel generator units should not impair the capability of the unit to supply emergency power within the required time. Where necessary, diesel generator unit design should include an emergency override of the test mode to permit response to bona fide signals.

(4) A surveillance system should be provided with remote indication in the control room as to diesel generator unit status, i.e., under test, ready-standby, lockout. A means of communication should also be provided between diesel generator unit testing locations and the main control room to ensure that the operators are cognizant of the status of the unit under test.

(5) The surveillance system should indicate which of the diesel generator protective trips is activated first in order to facilitate trouble diagnosis.

(6) All diesel generator protective trips should be in force during diesel generator unit testing.

c. Detailed step-by-step procedures should be provided for each test under Regulatory Position C.2. The procedures should identify those special arrangements or changes in normal system configuration that must be made to put the diesel generator unit under test. Jumpers and other nonstandard configurations or arrangements should not be used subsequent to initial equipment startup testing.

d. Subsequent to any failure, the cause should be determined and corrective action taken in a timely manner, with emphasis on preventing reoccurrence of the failure.

2. Testing

a. Testing of diesel generator units during the plant preoperational test program and at least once every 18 months should:

(1) Demonstrate proper startup operation by simulating loss of all a.c. voltage and demonstrate that the diesel generator unit can start automatically and attain the required voltage and frequency within acceptable limits and time.

(2) Demonstrate proper operation for design-accident-loading-sequence to design-load requirements and verify that voltage and frequency are maintained within required limits.

(3) Demonstrate full-load-carrying capability for an interval of not less than 24 hours, of which 22 hours should be at a load equivalent to the continuous rating of the diesel generator and 2 hours at a load equivalent to the 2-hour rating of the diesel generator. Verify that voltage and frequency requirements are maintained. The test should also verify that the cooling system functions within design limits.

(4) Demonstrate proper operation during diesel generator load shedding, including a test of the loss of the largest single load and of complete loss of load, and verify that the voltage requirements are met and that the overspeed limits are not exceeded.

(5) Demonstrate functional capability at full-load temperature conditions by rerunning the test phase outlined in Regulatory Positions C.2.a.(1) and (2) above immediately following (3) above.

(6) Demonstrate the ability to (a) synchronize the diesel generator unit with offsite power while the unit is connected to the emergency load, (b) transfer this load to the offsite power, (c) isolate the diesel generator unit, and (d) restore it to standby status.

(7) Demonstrate that the engine will perform properly if switching from one fuel oil supply system to another is a part of the normal operating procedure to satisfy the 7-day storage requirement.

(8) Demonstrate that the capability of the diesel generator unit to supply emergency power within the required time is not impaired during periodic testing under Regulatory Position C.2.c.

(9) Demonstrate the required reliability by means of any 69 consecutive valid tests[2] (per plant) with no failures, with a minimum of 23 or 69/n tests, whichever is the larger, per diesel generator unit (where n is equal to the number of diesel generator units of the same design and size).

b. Testing of redundant diesel generator units during normal plant operation should be performed independently (nonconcurrently) to minimize common failure modes resulting from undetected interdependences among diesel generator units. However, during reliability demonstration of diesel generator units during plant preoperational testing and testing subsequent to any plant modification where diesel generator unit interdependence may have been affected or every 10 years (during a plant shutdown), whichever is the shorter, a test should be conducted in which redundant units are started simultaneously to help identify certain common failure modes undetected in single diesel generator unit tests.

c. Periodic testing of diesel generator units during normal plant operation should:

(1) Demonstrate proper startup and verify that the required voltage and frequency are automatically attained within acceptable limits and time. This test should also verify that the components of the diesel generator unit required for automatic startup are operable.

(2) Demonstrate full-load-carrying capability (continuous rating) for an interval of not less than one hour. The test should also verify that the cooling system functions within design limits. This test could be accomplished by synchronizing the generator with the offsite power and assuming a load at the maximum practical rate.

d. After completion of the diesel generator unit reliability demonstration under Regulatory Postition C.2.a.(9), the interval for periodic testing under Regulatory Position C.2.c (on a per diesel generator unit basis) should be no more than 31 days and should depend on demonstrated performance. If more than one failure has occurred in the last 100 tests (on a per nuclear unit basis), the test interval should be shortened in accordance with the following schedule.:

(1) If the number of failures in the last 100 valid tests is one or zero, the test interval should be not more than 31 days.

(2) If the number of failures in the last 100 valid tests is two, the test interval should be not more than 14 days.

(3) If the number of failures in the last 100 valid tests is three, the test interval should be not more than 7 days.

(4) If the number of failures in the last 100 valid tests is four or more, the test interval should be not more than 3 days.

e. Valid tests and failures (under Regulatory Positions C.2.a.(9) and C.2.d) should be based on the following criteria:

(1) All start attempts (automatic, including those from bona fide signals, or manual) that result in a failure to start, except as noted in (2) below, should be considered valid tests and failures.

(2) Unsuccessful start and load attempts that can definitely be attributed to operating error, to spurious operation of a trip that is bypassed in the emergency operating mode, to malfunction of equipment that is not operative in the emergency operating mode (e.g., synchronizing circuitry) or is not part of the defined diesel generator unit design should not be considered valid tests or failures.

(3) Successful starts, including those initiated by bona fide signals, followed by successful loading (sequential or manual) to at least 50% of continuous rating and continued operation for at least one hour should be considered valid successful tests.

(4) Successful starts that are terminated intentionally without loading, as defined in (3) above, should not be considered valid tests or failures.

(5) Successful starts followed by an unsuccessful loading attempt should be considered valid tests and failures, except as noted in (2) above.

(6) Tests that are terminated intentionally before completion as defined in (3) above because of an alarmed abnormal condition that would ultimately have resulted in diesel generator damage or failure should be considered valid tests and failures.

[2] Valid test as defined in Regulatory Position C.2.e.

(7) Tests performed in the process of troubleshooting should not be considered valid tests. Tests that are performed to verify correction of the problem should be considered valid tests and successes or failures, as appropriate.

(8) Cranking and venting procedures that lead to the discovery of conditions (e.g., excessive water or oil in a cylinder) that would have resulted in the failure of the diesel generator unit during test or during response to a bona fide signal should be considered a valid test and failure.

3. Records and Reports

a. All start attempts, including those from bona fide signals, should be logged. The log should describe each occurrence in sufficient detail to permit independent determination of statistical validity in accordance with Regulatory Position C.2.e. Maintenance, repair, and out-of-service-time histories, as well as cumulative maintenance and operating data, should also be logged. Cumulative statistical analyses of diesel generator unit test results, together with results of operation of the diesel generator unit when required by actual demand, should be maintained. These analyses should include examination of the trend of critical failure mechanisms, human errors, and common mode failures.

b. All diesel generator unit failures, valid or invalid, should be reported[3] consistent with the licensee's reporting requirements. This report should (1) identify the diesel generator unit involved, (2) identify the failure as being the nth failure in the last 100 valid tests, (3) describe the cause of failure, (4) describe the corrective measures taken, (5) indicate the length of time the diesel generator unit was unavailable, (6) define the current surveillance test interval, and (7) verify that the test interval is in conformance with the schedule of Regulatory Position C.2.d. If the number of failures in the last 100 valid tests is seven or more, the reliability of the diesel generator units requires special evaluation, and the information provided on the report form should be supplemented, as needed, by additional narrative material that:

(1) Identifies the reported failure as the 7th or greater failure in the last 100 valid tests,

(2) Describes corrective measures, taken or planned, to increase the reliability of the generator units,

(3) Provides an assessment of the existing reliability of electric power to engineered-safety-feature equipment,

(4) Provides the licensee's basis for continued plant operation if that is planned, and

(5) Provides a summary of all tests (valid and invalid) that occurred within the time period over which the last 100 valid tests were performed, and verifies that surveillance testing during this period was in conformance with the schedule of Regulatory Position C.2.d.

Invalid failures experienced during troubleshooting should be included in the report of the failure (valid or invalid) that made the troubleshooting necessary.

[3] See Regulatory Guide 1.16, "Reporting of Operating Information."

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants regarding the NRC staff's plans for using this regulatory guide.

This guide reflects current NRC staff practice. Therefore, except in those cases in which the applicant proposes an acceptable alternative method for complying with the specified portions of the Commission's regulations, the method described herein is being and will continue to be used in the evaluation of submittals for construction permit applications until this guide is revised as a result of suggestions from the public or additional staff review.