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U.S. NUCLEAR REGULATORY COMMISSION

REGULATORY GUIDE

OFFICE OF STANDARDS DEVELOPMENT

REGULATORY GUIDE 1.9

SELECTION, DESIGN, AND QUALIFICATION OF DIESEL-GENERATOR UNITS USED AS ONSITE ELECTRIC POWER SYSTEMS AT NUCLEAR POWER PLANTS

A. INTRODUCTION

General Design Criterion 17, "Electric Power Systems," of Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," includes a requirement that the onsite electric power system have sufficient capacity and capability to ensure that (1) specified acceptable fuel design limits and design conditions of the reactor coolant pressure boundary are not exceeded as a result of anticipated operational occurrences and (2) the core is cooled and containment integrity and other vital functions are maintained in the event of postulated accidents.

Criterion III, "Design Control," of Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," to 10 CFR Part 50 includes a requirement that measures be provided for verifying or checking the adequacy of design by design reviews, by the use of alternative or simplified calculational methods, or by the performance of a suitable testing program.

Diesel-generator units have been widely used as the power source for the onsite electric power systems. This regulatory guide describes a method acceptable to the NRC staff for complying with the Commission's requirements that diesel-generator units intended for use as onsite power sources in nuclear power plants be selected with sufficient capacity and be qualified for this service.

*The substantial number of changes in this revision has made it impractical to indicate the changes with lines in the margin.

[1]Copies may be obtained from the Institute of Electrical and Electronics Engineers, Inc., United Engineering Center, 345 East 47th Street, New York, New York 10017.

B. DISCUSSION

A diesel-generator unit selected for use in an onsite electric power system should have the capability to (1) start and accelerate a number of large motor loads in rapid succession and be able to sustain the loss of all or any part of such loads and maintain voltage and frequency within acceptable limits and (2) supply power continuously to the equipment needed to maintain the plant in a safe condition if an extended loss of offsite power occurs.

IEEE Std 387-1977, "IEEE Standard Criteria for Diesel-Generator Units Applied as Standby Power Supplies for Nuclear Power Generating Stations,"[1] delineates principal design criteria and qualification testing requirements that, if followed, will help ensure that selected diesel-generator units meet their performance and reliability requirements. IEEE Std 387-1977 was developed by Working Group 4.2C of the Nuclear Power Engineering Committee (NPEC) of the Institute of Electrical and Electronics Engineers, Inc. (IEEE), approved by NPEC, and subsequently approved by the IEEE Standards Board on September 9, 1976. IEEE Std 387-1977 is supplementary to IEEE Std 308-1974, "IEEE Standard Criteria for Class 1E Power Systems and Nuclear Power Generating Stations,"[1] and specifically amplifies paragraph 5.2.4, "Standby Power Supplies," of that document with respect to the application of diesel-generator units. IEEE Std 308-1974 is endorsed, with certain exceptions, by Regulatory Guide 1.32, "Criteria for Safety-Related Electric Power Systems for Nuclear Power Plants."

A knowledge of the characteristics of each load is essential in establishing the bases for

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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. However, comments on this guide, if received within about two months after its issuance, will be particularly useful in evaluating the need for an early revision.

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the selection of a diesel-generator unit that is able to accept large loads in rapid succession. The majority of the emergency loads are large induction motors. This type of motor draws, at full voltage, a starting current five to ten times its rated load current. The sudden large increases in current drawn from the diesel generator resulting from the startup of induction motors can result in substantial voltage reductions. The lower voltage could prevent a motor from starting, i.e., accelerating its load to rated speed in the required time, or cause a running motor to coast down or stall. Other loads might be lost if their contactors drop out. Recovery from the transient caused by starting large motors or from the loss of a large load could cause diesel engine overspeed which, if excessive, might result in a trip of the engine. These same consequences can also result from the cumulative effect of a sequence of more moderate transients if the system is not permitted to recover sufficiently between successive steps in a loading sequence.

Generally it has been industry practice to specify a maximum voltage reduction of 10 to 15 percent when starting large motors from large-capacity power systems and a voltage reduction of 20 to 30 percent when starting these motors from limited-capacity power sources such as diesel-generator units. Large induction motors can achieve rated speed in less than 5 seconds when powered from adequately sized diesel-generator units that are capable of restoring the voltage to 90 percent of nominal in about 1 second.

Protection of the diesel-generator unit from excessive overspeed, which can result from a loss of load, is afforded by the immediate operation of a diesel-generator unit trip, usually set at 115 percent of nominal speed. In addition, the generator differential trip must operate immediately in order to prevent substantial damage to the generator. There are other protective trips provided to protect the diesel-generator units from possible damage or degradation. However, these trips could interfere with the successful functioning of the unit when it is most needed, i.e., during accident conditions. Experience has shown that there have been numerous occasions when these trips have needlessly shut down diesel-generator units because of spurious operation of a trip circuit. Consequently, it is important that measures be taken to ensure that spurious actuation of these other protective trips does not prevent the diesel-generator unit from performing its function.

The uncertainties inherent in estimates of safety loads at the construction permit stage of design are sometimes of such magnitude that it is prudent to provide a substantial margin in selecting the load capabilities of the diesel-generator unit. This margin can be provided by estimating the loads conservatively and selecting the continuous rating of the diesel-generator unit so that it exceeds the sum of the loads needed at any one time. A more accurate estimate of safety loads is possible during the operating license stage of review because detailed designs have been completed and preoperational test data are available. This permits the consideration of a somewhat less conservative approach, such as operation with safety loads within the short-time rating of the diesel-generator unit.

C. REGULATORY POSITION

Conformance with the requirements of IEEE Std 387-1977, "IEEE Standard Criteria for Diesel-Generator Units Applied as Standby Power Supplies for Nuclear Power Generating Stations," dated June 17, 1977, is acceptable for meeting the requirements of the principal design criteria and qualification testing of diesel-generator units used as onsite electric power systems for nuclear power plants subject to the following:

1. When the characteristics of loads are not accurately known, such as during the construction permit stage of design, each diesel-generator unit of an onsite power supply system should be selected to have a continuous load rating (as defined in Section 3.7.1 of IEEE Std 387-1977) equal to or greater than the sum of the conservatively estimated loads needed to be powered by that unit at any one time. In the absence of fully substantiated performance characteristics for mechanical equipment such as pumps, the electric motor drive ratings should be calculated using conservative estimates of these characteristics, e.g., pump runout conditions and motor efficiencies of 90% or less.

2. At the operating license stage of review, the predicted loads should not exceed the short-time rating (as defined in Section 3.7.2 of IEEE Std 387-1977) of the diesel-generator unit.

3. During preoperational testing, the predicted loads should be verified by tests.

4. In Section 5.1.1, "General," of IEEE Std 387-1977, the requirements of IEEE Std 308-1974 should be used subject to the regulatory position of Regulatory Guide 1.32.

5. Section 5.1.2, "Mechanical and Electrical Capabilities," of IEEE Std 387-1977 should be supplemented with the following:

"Each diesel-generator unit should be capable of starting and accelerating to rated speed, in the required sequence, all the needed engineered safety feature and emergency shutdown loads. At no time during the loading sequence should the frequency and voltage decrease to less than 95 percent of nominal and 75 percent of nominal, respectively. Frequency should be restored to

within 2 percent of nominal, and voltage should be restored to within 10 percent of nominal within 60 percent of each load-sequence time interval. (A greater percentage of the time interval may be used if it can be justified by analysis. However, the load-sequence time interval should include sufficient margin to account for the accuracy and repeatability of the load-sequence timer.) During recovery from transients caused by step load increases or resulting from the disconnection of the largest single load, the speed of the diesel-generator unit should not exceed the nominal speed plus 75 percent of the difference between nominal speed and the overspeed trip setpoint or 115 percent of nominal, whichever is lower. Further, the transient following the complete loss of load should not cause the speed of the unit to attain the overspeed trip setpoint."

6. In Section 5.4, "Qualification," of IEEE Std 387-1977, the qualification testing requirements of IEEE Std 323-1974, "IEEE Standard for Qualifying Class IE Equipment for Nuclear Power Generating Stations,"[1] should be used subject to the regulatory position of Regulatory Guide 1.89, "Qualification of Class IE Equipment for Nuclear Power Plants."

7. Section 5.5, "Design and Application Considerations," of IEEE Std 387-1977 should be supplemented with the following:

"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 Guide 1.108, "Periodic Testing of Diesel-Generator Units Used as Onsite Electric Power Systems at Nuclear Power Plants") that would be expected if actual demand were to be placed on the system.

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

8. Section 5.6.2.2, "Automatic Control," of IEEE Std 387-1977 should be supplemented with the following:

(3) "With the exception of the engine overspeed trip and the generator differential trip, all diesel-generator protective trips should be either (1) implemented with two or more independent measurements for each trip parameter with coincident logic provisions for trip actuation or (2) automatically bypassed during accident conditions. The design of the bypass circuitry should satisfy the requirements of IEEE Std 279-1971 at the diesel-generator system level and should include the capability for (1) testing the status and operability of the bypass circuits, (2) alarming in the control room abnormal values of all bypass parameters, and (3) manually resetting of the trip bypass function. (Capability for automatic reset is not acceptable.)"

9. Section 5.6.3.1, "Surveillance Systems," of IEEE Std 387-1977 should be supplemented with the following:

"In order to facilitate trouble diagnosis, the surveillance system should indicate which of the diesel-generator protective trips is activated first."

10. In Section 6.3, "Type Qualification Testing Procedures and Methods," of IEEE Std 387-1977, the requirements of IEEE Std 344-1975, "Recommended Practices for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations," for seismic analysis or seismic testing by equipment manufacturers should be used subject to the regulatory position of Regulatory Guide 1.100, "Seismic Qualification of Electric Equipment for Nuclear Power Plants."

11. The option indicated by "may" in Section 6.3.2(5)(c) of IEEE Std 387-1977 should be treated as a requirement.

12. Section 6.5, "Site Acceptance Testing," and Section 6.6, "Periodic Testing," of IEEE Std 387-1977 should be supplemented by Regulatory Guide 1.108.

13. Section 4, "Reference Standards," of IEEE Std 387-1977 lists additional applicable IEEE standards. The specific applicability or acceptability of these referenced standards has been or will be covered separately in other regulatory guides, where appropriate.

D. IMPLEMENTATION

This proposed guide has been released to encourage public participation in its development. Except in those cases in which an applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method to be described in the active guide reflecting public comments will be used in the evaluation of applications for construction permits docketed after the implementation date to be specified in the active guide. This implementation date will in no case be earlier than July 1979.

If an applicant wishes to use this draft guide in an application docketed prior to the implementation date, the pertinent portions of the application will be evaluated on the basis of this draft guide.