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PERIODIC TESTING OF ELECTRIC POWER AND PROTECTION SYSTEMS

A. INTRODUCTION

Section 50.55a, "Codes and Standards," of 10 CFR Part 50, "Licensing of Production and Utilization Facilities," requires in paragraph (h) that protection systems meet the requirements set forth in the Institute of Electrical and Electronics Engineers' Standard, "Criteria for Protection Systems for Nuclear Power Generating Stations" (IEEE 279).[1] Section 4.9 of IEEE Std 279-1971 (also designated ANSI N42.7-1972) requires, in part, that means be provided for checking the operational availability of each protection system input sensor during reactor operation and includes examples of how this can be accomplished. Section 4.10 of IEEE Std 279-1971 requires, in part, that capability be provided for testing and calibrating protection system equipment other than sensors and indicates when such equipment must be tested during reactor operation. General Design Criterion 21, "Protection System Reliability and Testability," of Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50 requires, in part, that the protection system be designed to permit its periodic testing during reactor operation including a capability to test channels independently to determine failures and losses of redundancy that may have occurred. General Design Criterion 18, "Inspection and Testing of Electric Power Systems," requires, in part, that electric power systems important to safety be designed to permit periodic testing, including performance of the components of the system and the system as a whole. The testing should be carried out under conditions as close to design as practical and should involve the full operational sequence, including operation of portions of the protection system, as well as transfer of power among the nuclear power unit, the offsite power system, and the onsite power system. Criterion XI, "Test Control," of Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," to 10 CFR Part 50 requires, in part, that a test program be established to ensure that all testing, including operational testing required to demonstrate that systems and components will perform satisfactorily in service, is identified and performed.

This guide describes a method acceptable to the NRC staff of complying with the Commission's regulations with respect to the periodic testing of the protection system and electric power systems for systems important to safety.[2] It also provides supplementary guidance to that included in Regulatory Guide 1.32, "Criteria for Safety-Related Electric Power Systems for Nuclear Power Plants," regarding the periodic testing of electric power systems. The Advisory Committee on Reactor Safeguards has been consulted concerning this guide and has concurred in the regulatory position. *

B. DISCUSSION

IEEE Std 338-1975, "Criteria for the Periodic Testing of Nuclear Power Generating Station Class IE Power and Protection Systems," was prepared by Subcommittee 3, Operations, Surveillance and Testing, of the Institute of Electrical and Electronics Engineers Nuclear Power Engineering Committee (NPEC). IEEE Std 338-1975 was subsequently approved by NPEC on November 7, 1974, and by the IEEE Standards Committee on February 27, 1975.

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* Lines indicate substantive changes from previous issue.

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

[2] Systems important to safety are defined in Regulatory Guide 1.105, "Instrument Setpoints."

IEEE Std 338-1975 is ancillary to IEEE Stds 279-1971 and 308-1974 and includes criteria, requirements, and recommendations for the development of periodic testing programs for electric power and protection systems in commercial nuclear power plants. The criteria and requirements are indicated by the verbs "shall" and "must," and the recommendations are indicated by the verb "should."

C. REGULATORY POSITION

The criteria, requirements, and recommendations contained in IEEE Std 338-1975 are considered by the NRC staff to be generally acceptable methods for the periodic testing of electric power and protection systems, subject to the following:

1. Section 5 of IEEE Std 338-1975 should be supplemented by the following:

> "Means shall be included in the design to facilitate response time testing from sensor input to and including the actuated equipment. Equipment used to implement these means shall be included in the determination of system operational availability."

2. The term, "protective action system," as used in item (6) in Section 5 of IEEE Std 338-1975 should be understood to mean, collectively, the electric, instrumentation, and controls portions of those systems actuated or controlled by the protection system that are required to implement a protective function.

3. Item (7) of Section 5 of IEEE Std 338-1975 lists alternative means of including the actuated equipment in the periodic testing of protection system equipment. The method in which actuated equipment is simultaneously tested with the associated protection system equipment is preferred by the NRC staff; however, overlap testing is acceptable. In addition to the requirements of item (2) in Section 6.1, complete system tests should be performed at suitable intervals.

4. If actuated equipment is not tested during reactor operation, in addition to the requirements of items (7)(a),(b), and (c) in Section 5 of IEEE Std 338-1975, it should be shown (1) that there is no practical system design that would permit operation of the actuated equipment without adversely affecting the safety or operability of the plant and (2) that testing only when the reactor is shut down provides a satisfactory test interval.

5. Item (8) in Section 5 of IEEE Std 338-1975 should be supplemented by the following:

> "Designs that do not require the use of bypasses in order to test all or part of a safety system are preferred over those that require bypasses."

6. The term "safety system" is used in IEEE Std 338-1975 (e.g., item (7) in Section 5). For the purposes of this guide, "safety system" should be understood to mean, collectively, the electric, instrumentation, and controls portions of the protection system; the protective action system; and auxiliary or supporting features that must be operable for the protection system and protective action system to perform their safety-related functions.

7. Consistent with the provisions of item (2) in Section 6.1 and the first item (1) in Section 6.4 of IEEE Std 338-1975, item (13) in Section 5 and the last full paragraph on page 11 in Section 6.3.4 should not be construed to imply that use of simulated trip signals inserted in lieu of sensor outputs is preferred over tests that involve perturbing the monitored variable (the same or a substitute process variable). Instrumentation channel tests should include perturbing the monitored variable wherever practical. Wherever this is not practical, it should be shown that the proposed substitute tests are adequate.

Where simulated signals are used, or in other cases where protective channels can be effectively bypassed during a test, care should be exercised to ensure that more channels are not bypassed than are necessary to perform the test. The remaining channels (those not bypassed) should provide that safety function consistent with the provisions of Section 5(4) of IEEE Std 338-1975.

8. Test equipment, methods, and procedures should not circumvent any of the provisions of Section 5 of IEEE Standard 338-1975. Therefore, instead of item (3) in Section 6.1 of IEEE Standard 338-1975, the following should be used:

> "(3) Test equipment, methods, and procedures shall not circumvent the provisions of Section 5."

9. Instead of item (1) in Section 6.3.1 of IEEE Std 338-1975, the following should be used:

> "(1) Comparing readings on channels that monitor the same variable accounting for any known differences in the actual process variable between sensor locations."

10. Instead of item (5) in Section 6.3.2 of IEEE Std 338-1975, the following should be used:

> "(5) Testing to verify trip setpoints that are continuously calculated shall be performed to verify each variable that enters into computation. While the signals for one or more parameters are varied to achieve tripping or change in computer output, the signals for other variables shall be maintained at their expected values. The parameters to be varied shall be selected based on expected accident conditions."

11. Section 6.3.2 of IEEE Std 338-1975 should be supplemented as follows:

"(7) Testing the status and operability of bypasses, bypass indications, and bypass annunciation circuits.

"(8) Testing the operability of test indication and/or test annunciation equipment, where such features are provided."

12. Section 6.3.4 of IEEE Standard 338-1975 states that sensors that should be response time tested are:

"(1) Those sensors whose response time is shown to be critical to reactor safety in the safety analysis report.

"(2) Those sensors whose response time is a significant part of the overall system response time and is expected to suffer response time degradation."

Section 6.3.4 of IEEE Standard 338-1975 also states that "those components comprising a portion of a system whose expected worst case response time is not a significant fraction of the total overall system response time (less than 5 percent) need not be tested provided the remaining portions of the system are tested." Testing of the response time of all portions of the safety system should be performed, consistent with the requirements of item (7) of Section 5 of IEEE Std 338-1975. This includes periodic testing of sensors to determine if their response time is satisfactory. Therefore, instead of Section 6.3.4 of the standard, the following should be used:

"6.3.4 Response Time Verification Tests. Safety system response time measurements shall be made periodically to verify the overall response time (assumed in the safety analysis of the plant) of all portions of the system from and including the sensor to operation of the actuator.

"Where it is not possible to include sensors in in-plant individual or system response time tests, the sensors shall be periodically removed from their normal installations and tested. When this is necessary, the test installation shall duplicate as nearly as possible the expected environment and mechanical configuration of the actual installation.

"For channel testing, not including sensors, test equipment shall include that necessary to simulate sensor output over its full range and simultaneously record input and output conditions for determining the overall response time. The test input should span the normal trip setpoint sufficiently to reset the channel for the untripped condition and ensure complete tripping for the tripped condition.

"For protection tripping functions where two or more variables enter into the tripping action (for example, the trip point is computed from temperature, differential pressure, and nuclear flux signals), the channel response time shall be verified using each of the variables to produce the tripping action. During this tripping action, the test signals for the remaining variables shall be adjusted to within their expected operating range, but to a value that will produce conservative test results.

"The response time test shall include as much of each safety system, from sensor input to actuated equipment, as possible in a single test. Where the entire set of equipment from sensor to actuated equipment cannot be tested at once, verification of system response time may be accomplished by measuring the response times of discrete portions of the system and showing that the sum of the response times of all portions is equal to or less than the overall system requirement.

"Response time testing of all safety system equipment per se is not required if, in lieu of response time testing, the response time of safety system equipment is verified by functional testing and/or calibration checks where it can be demonstrated that changes in response time beyond acceptable limits are always accompanied by changes in performance characteristics that are detectable during these routine periodic functional tests and/or calibration checks."

13. For neutron detectors (1) tests of detector-cable assemblies for increased capacitance, (2) monitoring of noise characteristics of neutron detector signals, or (3) some other test that does not require removal of detectors from their installed location should be used to confirm neutron detector response time characteristics to avoid undue radiation exposure of plant personnel unless such tests are not capable of detecting response time changes beyond acceptable limits.

14. Section 6.4 of the IEEE Std 338-1975 should be supplemented by the following:

"Test procedures for periodic tests within the scope of this standard shall not require jury rig tests setups, the use of temporary jumper wires, the removal of fuses, or the opening of breakers except as follows:

"a. Temporary jumper wires may be used with portable test equipment where the safety system equipment to be tested is provided with facilities specifically designed for connection of this test equipment. These facilities shall be considered part of the safety system and shall meet all the requirements of this standard, whether the portable test equipment is disconnected or remains connected to these facilities.

"b. Removal of fuses or opening a breaker is permitted only if such action causes (1) the trip

of the associated protection system channel or (2) the actuation (startup and operation) of the associated Class 1E load group."

15. In addition to periodic tests to determine if saturation is occurring, it is important to determine, at suitable intervals, if foldover will occur. Foldover occurs when an output signal, which normally increases with increasing input, changes to a decreasing signal, or conversely for a normally decreasing signal. Accordingly, the example in the last item (3) of Section 6.4 of IEEE Std 338-1975 and the example in Section 6.3.3 should be construed to include foldover as follows:

a. In Section 6.4:

"(for example, by saturation of foldover)."

b. In Section 6.3.3:

"(for example, the bistable trip did not occur at the required setpoint, the analog output was out of tolerance, or saturation or foldover was observed). . ."

16. Test intervals, both initial and revised, should be such that significant changes in failure rates can be detected before multiple failures occur. Accordingly, Sections 6.5.1 and 6.5.2 should be supplemented as follows:

a. In Section 6.5.1 add item (8):

"(8) Detection of significant increases in failure rates before multiple failures occur."

b. In Section 6.5.2 add item (5):

"(5) Detection of significant increases in failure rates before multiple failures occur."

D. IMPLEMENTATION

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

Except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein will be used in the evaluation of submittals in connection with construction permit applications docketed after January 1, 1978.

If an applicant wishes to use this regulatory guide in developing submittals for applications docketed on or before January 1, 1978, the pertinent portions of the application will be evaluated on the basis of this guide.

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