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REGULATORY GUIDE

OFFICE OF NUCLEAR REGULATORY RESEARCH

REGULATORY GUIDE 1.218

(New Regulatory Guide, draft was issued as DG-1240, dated June 2010)

CONDITION-MONITORING TECHNIQUES FOR ELECTRIC CABLES USED IN NUCLEAR POWER PLANTS

A. INTRODUCTION

This guide describes a method and techniques that the staff of the U.S. Nuclear Regulatory Commission (NRC) considers acceptable for use in implementing the regulatory requirements specified below with regard to monitoring the performance of electric cables used in nuclear power plants.

Criterion XI, "Test Control," of Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," to Title 10, of the *Code of Federal Regulations*, Part 50**,** "Domestic Licensing of Production and Utilization Facilities" (10 CFR 50) (Ref. 1), requires that, a test program be established to ensure that all testing required to demonstrate that structures, systems, and components will perform satisfactorily in service is identified and performed.

The Commission's regulations in 10 CFR Part 50 require that structures, systems, and components that are important to safety in a nuclear power plant must be designed to accommodate the effects of environmental conditions (i.e., they must remain functional under postulated design-basis events (DBEs)). Toward that end, General Design Criterion (GDC) 1, "Quality Standards and Records," GDC 2, "Design Bases for Protection against Natural Phenomena," GDC 4, "Environmental and Dynamic Effects Design Bases," and GDC 23, "Protection System Failure Modes," of Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50 contain the general requirements. Augmenting these general requirements are the specific requirements pertaining to qualification of certain electrical equipment important to safety in 10 CFR 50.49, "Environmental Qualification of Electric Equipment Important to Safety for Nuclear Power Plants."

GDC 18, "Inspection and testing of electric power systems," states, in part, "Electric power systems important to safety shall be designed to permit appropriate periodic inspection and testing of

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This guide was issued after consideration of comments received from the public.
Regulatory guides are issued in 10 broad divisions—1, Power Reactors; 2, Research and Test Reactors; 3, Fuels and Materials Facilities; 4, Environmental and Siting; 5, Materials and Plant Protection; 6, Products; 7, Transportation; 8, Occupational Health; 9, Antitrust and Financial Review; and 10, General.

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important … features, such as wiring, insulation, …to assess the continuity of the systems and the condition of their components…" Regulatory Guide 1.211, "Qualification of Safety-Related Cables and Field Splices for Nuclear Power Plants," (Ref. 2) states that "Programs for monitoring of environmental conditions (such as temperature, radiation levels), and condition monitoring should be implemented for safety-related power, instrumentation, and control cables." This new Regulatory Guide 1.218 discusses the methods which the staff finds acceptable as condition-monitoring techniques.

The regulation in Paragraph (a)(1) of 10 CFR 50.65, " Requirements for monitoring the effectiveness of maintenance at nuclear power plant," states that "Each holder of an operating license for a nuclear power plant...shall monitor the performance or condition of structures, systems, or components...in a manner sufficient to provide reasonable assurance that these structures, systems, and components...are capable of fulfilling their intended functions." As an alternative to complying with paragraph (a)(1) of the Maintenance Rule, licensees may comply with the requirements of paragraph (a)(2). Paragraph (a)(2) allows a licensee to forego monitoring if it can demonstrate that the condition or performance of a structure, system, or component within the scope of the rule is being effectively controlled through preventive maintenance.

Regulatory Guide 1.160, "Monitoring the Effectiveness of Maintenance at Nuclear Power Plants" (Ref. 3), provides general guidelines for complying with 10 CFR 50.65(a)(1). This new Regulatory Guide 1.218 provides specific guidance for condition monitoring of cables. In particular, this regulatory guide describes a programmatic approach to condition monitoring of electric cable systems and their operating environments, as well as acceptable condition-monitoring techniques. The programmatic approach and condition monitoring may be used to demonstrate compliance with paragraph (a)(1) of the Maintenance Rule.

This regulatory guide contains information collection requirements covered by 10 CFR Part 50 that the Office of Management and Budget (OMB) approved under OMB control number 3150-0011. The NRC may neither conduct nor sponsor, and a person is not required to respond to, an information collection request or requirement unless the requesting document displays a currently valid OMB control number. The NRC has determined that this Regulatory Guide is not a major rule as designated by the Congressional Review Act and has verified this determination with the OMB.

B. DISCUSSION

Background

Electric cables are important components in a nuclear plant because they provide the power needed to operate electrical equipment and they transmit signals to and from the various devices used to perform safety functions and accident mitigation in a nuclear power plant. Despite their importance, cables typically receive little attention because they are considered passive, long-lived components that have been reliable over the years when subjected to the environmental conditions for which they were designed or qualified.

The integrity of electric cables is monitored, to some extent, through periodic surveillance testing of the equipment to which they are attached; however, this testing does not specifically focus on the cables and may not be sufficient to detect all of the aging and degradation mechanisms to which a particular cable is susceptible. While these tests can demonstrate the function of the cables under test conditions, they do not verify the continued successful performance of cables when called upon to operate under their worst case design loading conditions for extended periods, as they would under anticipated normal service operating conditions or under design-basis accident conditions. Therefore, periodic surveillance testing of associated equipment does not provide specific information on the status of aging degradation processes or the dielectric strength of insulation or physical integrity of cable jackets and insulation. Consequently, a cable circuit with undetected damaged or degraded insulation could pass a system functional test but still fail unexpectedly when called upon to operate under anticipated environmental conditions or the more severe stresses encountered in emergency operation during a design-basis event (i.e., fully loaded equipment, more extreme environmental conditions, extended operation in a heavily loaded state). Recent operating experience indicates in-service failures of several power cables. Insulation degradation under normal service environments is not detected in conventional test programs (Refs. 4&5).

Longer cable circuits may pass through several different operating environments over the length of their routing throughout the plant. Portions of such a cable circuit may pass through areas experiencing adverse localized environmental conditions, such as high temperature, high radiation, high humidity or moisture, wetting (i.e., an operating environment in which a cable is exposed to moisture or high humidity for extended periods of time, or submersion (i.e., an operating environment in which a cable is completely submerged in water continuously or for extended periods of time). Adverse localized environmental stressors can cause excessive aging and degradation in the exposed sections of a cable system that could shorten its life and cause unexpected early failures.

It should be emphasized that the occurrence of cable system operating environments or locally adverse conditions that are unanticipated or more severe than the original plant design may constitute a design deficiency. A cable system must be designed to meet applicable regulations and to perform its intended function in the plant environment under DBEs.

Special consideration should be given to the problem of monitoring the operating environment for cable circuits routed through inaccessible underground cable ducts and conduits, covered cable distribution trenches, bunkers, and manhole vaults. Because most of these underground distribution systems are largely inaccessible, wetted and flooding conditions may remain undetected for extended periods of time. Cables that are not designed to operate in a submerged condition are likely to experience early failures, potentially resulting in significant safety consequences. The NRC has described several of these incidents in Information Notice 2002- 12, "Submerged Electrical Cables," (Ref. 6); Information Notice 89-63, "Possible Submergence of Electrical Circuits Located Above the Flood Level because of Water Intrusion and Lack of Drainage," (Ref. 7); Information Notice 2010-26, Submerged Electrical Cables," (Ref. 8) and Generic Letter 2007-01, "Inaccessible or Underground Power Cable Failures that Disable Accident Mitigation Systems or Cause Plant Transients," (Ref. 9). Generic Letter 2007-01 observed that cable insulation degradation as a result of continuous wetting or submergence could affect multiple underground power cable circuits at a plant site. Should one of these medium-voltage cables fail, the resulting high-level fault currents and transient voltages may propagate onto the immediate power distribution system and potentially fail other systems with degraded power cable insulation.

Operating experience reveals that the number of cable failures is increasing with plant age, and that cable failures are occurring within the plants' 40-year licensing periods. These cable failures have resulted in plant transients and shutdowns, loss of safety functions and redundancy, entries into limiting conditions for operation, and challenges to plant operators. Though in many cases the failed cables were identified through current testing practices, some of the failures may have occurred before the failed condition was identified (i.e., on cables that are not normally energized or tested). Based on operating experience, the staff determined that the inaccessible or underground power cables are no longer inherently reliable as initially thought during the implementation of the NRC's Maintenance Rule. Therefore, it is necessary to monitor the condition of electric power cables throughout their installed life through the use of cable condition-monitoring techniques. Condition monitoring of cables may be limited to a representative sample of cables and its frequency may be adjusted based on demonstrated plant-specific cable test results and operating experience. For cables that are inaccessible or installed underground, appropriate monitoring programs including testing of cables and visual inspection of manholes for water accumulation should be implemented to detect cable system degradation.

Condition monitoring involves the observation, measurement, and trending of one or more condition indicators that can be correlated to the physical condition or functional performance of the cable.

Cable Monitoring Methods and Techniques

Electric cable condition-monitoring tests may be grouped by whether the inspection or test is performed in situ on electric cables in the plant or is a laboratory-type test performed on representative material specimens in a controlled laboratory setting. These condition-monitoring test techniques may be performed to measure and assess the following:

a. electrical properties (such as insulation resistance, voltage withstand, dielectric loss/dissipation factor, time domain reflectometry, and partial discharge),
b. mechanical properties (such as hardness, elongation at break, and compressive modulus/polymer indenter test),
c. chemical and physical properties (such as density, oxidation induction time, oxidation induction temperature, and infrared spectroscopy),
d. physical condition and appearance.

Research and experience have shown that no single, nonintrusive, condition-monitoring method currently available, if used alone, is effective to predict the performance of electric cables under accident conditions. A combination of condition-monitoring techniques provide significant insights into the condition of cables.

Based on the operating parameters, cable insulation and jacket materials, cable construction (e.g., solid/extruded versus laminated, shielded versus unshielded), and environmental and operating stressors for each cable system application, licensees should select condition-monitoring inspection and testing techniques to detect, quantify, and monitor the status of the aging mechanisms may cause the degradation of the cable system. By selecting the condition-monitoring techniques that are best suited to the detection and monitoring of the anticipated stressors and associated aging and degradation mechanisms, licensees can more accurately monitor the condition of critical plant cables, assess their operating condition, and implement corrective actions to manage aging and degradation in those cables that are found to be experiencing stressors and aging and degradation rates beyond specified design conditions. The realistic and timely assessment of cable condition is the best means for managing cable degradation and avoiding unexpected early cable failures. Sections 3 and 4.5 of NUREG/CR-7000, "Essential Elements of an Electric Cable Condition Monitoring Program," (Ref. 10) provides guidance on the selection of condition-monitoring techniques for electric cables. Institute of Electrical and Electronics Engineers (IEEE) Std. 1205-2000 /Cor 1-2006, " Guide for Assessing, Monitoring, and Mitigating Aging Effects on Class 1E Equipment Used in Nuclear Power Generating Stations (Ref. 11) provides guidelines for assessing, monitoring, and mitigating aging degradation effects on Class 1E equipment used in nuclear power generating stations. This IEEE guide also includes informative annexes on aging mechanisms, environmental monitoring, condition monitoring, aging program essential attributes, and example assessments for five types of equipment (including electric cable).

Licensees can use a number of monitoring techniques to evaluate cable condition. A combination of monitoring techniques may be needed to validate cable performance. Some of the typical condition-monitoring techniques and inspection methods that have been or are being used for cable condition monitoring include those described below, which are recommended for use when appropriate. It should be noted that each of the techniques discussed below has advantages and limitations that must be carefully considered when selecting techniques to be used in a condition-monitoring program based on plant-specific cable system design, installation, and operating condition.

1. Direct Current High-Potential Test (dc High Voltage)

The direct current (dc) high-potential test (HPT) is a pass/fail test applicable to medium-voltage power cables. It is typically used for paper-insulated lead-covered (PILC) cables. Aging mechanisms detected by the HPT comprise thermally induced embrittlement and cracking, radiation-induced embrittlement and cracking, mechanical damage, water treeing, moisture intrusion, and surface contamination.

Advantages associated with the HPT test are that it does not require access to the entire length of the cable, and that the test can potentially detect degradation sites before failure in service. The disadvantages of HPT are that the cable must be disconnected to perform the test, and the high voltages used during testing may damage the cable insulation.

Recent research by the Electric Power Research Institute (EPRI), TR-101245, "Effect of DC Testing on Extruded Cross-Linked Polyethylene Insulated Cables," Volumes 1 (1993) and 2 (1995), (Ref. 12), on medium-voltage cross-linked polyethylene (XLPE) and ethylene propylene rubber (EPR)-insulated cables has shown that a dc HPT of field-aged cables could potentially damage or cause extruded cables, especially field-aged XLPE-insulated cable, to fail prematurely Among the conclusions reached in the EPRI study are that dc HPTs of field-aged cables can reduce cable life, dc HPTs of field-aged cables generally increase water tree growth, and pre-energization dc HPTs of new medium-voltage cable does not significantly reduce cable life. Another disadvantage is that the dc HPT does not provide trendable data.

Certain cable manufacturers recommend that this test only be done on new cable installations and that it not be performed after the cable has been in service for over 5 years.

2. Step Voltage Test (dc High Voltage)

The step voltage test (SVT) is a diagnostic test that can be applied to low- and medium-voltage cable. It is typically used for PILC cables. The SVT is capable of detecting aging mechanisms such as thermally induced embrittlement and cracking, radiation-induced embrittlement and cracking, mechanical damage, water treeing, moisture intrusion, and surface contamination.

An advantage of the SVT is that it does not require access to the entire length of the cable. The disadvantages of the SVT are that the cable must be disconnected to perform the test, and the high voltages used during testing may damage the cable insulation. The potential problems with the dc HPT identified by the recent EPRI research study are also applicable to the SVT. Another disadvantage is that the SVT does not provide trendable data.

Certain cable manufacturers recommend that this test only be done on new cable installations and that it not be performed after the cable has been in service for over 5 years.

3. *Very Low Frequency Test*

Very Low Frequency (VLF) testing methods can be categorized as withstand or diagnostic which utilize AC voltage signals in the frequency range from 0.01Hz to 1 Hz. The two most commonly used test voltage signals are the cosine-rectangular and the sinusoidal wave shapes. This test is applicable to shielded medium voltage cables with extruded and laminated dielectric insulation. This test is effective in monitoring the condition of a cable system including the insulation of the terminations and splices if they are included in the test circuit while minimizing or eliminating some potential adverse charging effects of the dc HPT test methods discussed above. The aim of a voltage test is to detect any existing fault, defect or irregularity prior to a breakdown during service of the cable. Furthermore, the test should not significantly reduce the lifetime of the cable.

In withstand testing, the cable must withstand a specified voltage applied across the insulation for a specified period of time without breakdown of the insulation. The magnitude of the withstand voltage is usually greater than that of the applied voltage.

Diagnostic testing is usually performed at lower voltages than withstand tests. This test allows the determination of the relative amount of degradation of a cable system section and establishes whether a cable system section is likely to continue to perform properly in service.

Advantages of the VLF tests are: This test works best when eliminating a few defects from otherwise good cable insulation; dangerous space charges are less likely to be developed in the insulation; and cables may be tested with an AC voltage approximately three times the rated conductor-to-ground voltage with a device comparable in size, weight, and power requirements to a DC test set.

Disadvantages of the VLF tests are: Cables must be disconnected for testing and when testing cables with extensive water tree degradation or partial discharges in the insulation, VLF withstand testing alone may not be conclusive. Additional diagnostic tests that measure the extent of insulation losses will be necessary, and cables must be disconnected for testing.

4. *Illuminated Borescope*

The illuminated borescope (IB) inspection technique is a screening method that can be applied to inaccessible low-voltage cables, de-energized medium-voltage cables with all types of cable insulation and jacket materials. The IB inspection technique is essentially an optically enhanced visual inspection using the IB tool to visually access cables in otherwise inaccessible conduits and ducts to assess their physical appearance and condition and to identify and locate water intrusion or contamination in the conduits or cable ducts. The IB test is capable of detecting aging mechanisms such as mechanical damage, potential for moisture intrusion, and surface contamination.

Advantages of the IB test are that the test can be relatively easy to implement and can be performed on inaccessible cables to detect the presence of stressors or cable damage and degradation. The disadvantage of the IB test is that it does not provide quantitative data that can be trended. Care should be taken not to damage the cables in conduits when using this inspection technique.

5. *Visual Inspection*

The visual inspection technique for accessible cables is a very simple yet extremely powerful cable condition-monitoring technique for evaluating cable system aging, because physical damage and many degradation mechanisms are readily detectable through sight. Visual inspection can be used to

0identify changes in physical and visual appearance, surface texture, and damage. Flashlights or magnifiers can aid visual inspection.

The advantages of visual inspection are that it is easy to perform, is minimally intrusive and nondestructive, and can easily detect degradation because of locally adverse conditions. Visual inspection may find surface corona damage of nonshielded medium-voltage cables. The disadvantages are that the cables to be inspected must be visible and accessible; results are not quantitative, making trending very difficult; and appearance is subjective and observations can vary from inspector to inspector.

6. Compressive Modulus (Polymer Indenter)

This technique is a mechanical properties (hardness) technique that is applicable to polymer jacket and insulation materials, such as polyethylene, EPR, Chlorosulponated Polyethelene (CSPE), and neoprene. The compressive modulus technique is most effective at detecting thermally induced embrittlement and radiation-induced embrittlement because it correlates to the phenomenon in elongation at break material test. The technique can detect and monitor the stressor effects of elevated temperature and radiation exposure.

Advantages of the compressive modulus test are that it is relatively easy to perform, it provides trendable data on commonly used cable insulation materials, and results can be correlated to known measures of cable condition. This technique is suitable for assessing short segments of the insulation. The disadvantages are that the cables must be accessible for in situ measurements; measurements are made on the outer surface, so the condition of underlying insulation must be inferred; the underlying cable construction, cable geometry, temperature, and humidity affect the results; aging-related changes in the compressive modulus are very small for some polymers until the end of life; the compressive modulus does not give direct correlation to changes in electrical properties (such as insulation resistance and dielectric strength); and the test has limited usefulness for XLPE cables. However, it can be used on XLPE cable with neoprene or CSPE jackets to provide a leading indication of damage.

7. Dielectric Loss-Dissipation Factor (Power Factor)

The dielectric loss-dissipation factor or power factor test (tan δ test) can be used to diagnose problems in medium-voltage cables. The dielectric loss-dissipation factor test has the ability to detect thermally induced cracking, radiation-induced cracking, mechanical damage, water treeing, moisture intrusion, and surface contamination.

Advantages associated with the dielectric loss-dissipation factor technique are that it provides trendable data on commonly used cable insulation materials, it does not require access to the entire cable, and the results can be correlated to known measures of cable condition. Disadvantages include that the end terminations of the cable must be disconnected to perform the test, the test is only applicable to cables that have shielded or sheath construction because it requires a defined ground return path of the loss (leakage) current back to the test set (supply source), the test should not be performed on low-voltage and medium voltage unshielded cables because of physical safety concerns and unreliable test results resulting from an undefined ground return path, and the amount of capacitance in the cable circuit limits the test such that standard test equipment cannot test very long and larger conductor cables.

8. Insulation Resistance

The insulation resistance test is a diagnostic test that is relatively effective with low-voltage cables using all types of insulation and jacket materials. The insulation resistance test is a standard test used to measure the dielectric integrity of cable insulation. Because of its sensitivity to temperature and humidity, it frequently is used as a pass/fail test because of the difficulties in obtaining an accurate and consistent absolute insulation resistance measurement.

Advantages of the test are that it does not require access to the entire cable, it does not need to be corrected for temperature effects, and it can provide trendable data. The disadvantages are that the end terminations of the cable must be disconnected to perform the test, the test is not as sensitive to insulation degradation as other electrical properties techniques, and leakage currents are very small and sensitive to surrounding environmental conditions, making it difficult to measure accurately.

9. Partial Discharge Test

The partial discharge test (PDT) is a diagnostic test that applies to medium-voltage shielded cables using all types of cable insulation and jacket materials. Aging mechanisms detected by the PDT provide information that can be used to detect the presence of thermally induced cracking, mechanical damage, and radiation-induced cracking. Partial discharge is a useful tool for concentric neutral cables for determining if splice degradation has occurred. Partial discharge may not be effective for tape-shielded cable systems because of attenuation of the signal from shield corrosion.

Advantages of the PDT are that it does not require access to the entire length of the cable, it identifies the significant partial discharge sites in an insulation system, it provides information on the severity of the insulation defects, and it gives information on the location of each of the significant partial discharge sites (and insulation defects). Disadvantages are that the end terminations of the cable must be disconnected to perform the test, performance of the PDT is complex and requires a high skill level, the interpretation of PDT results requires a very high skill level and training, and the high testing voltage applied during the PDT has the potential to weaken and permanently damage the cable insulation. Also, because nearby operating electrical equipment in a plant environment could cause noise interference with the test, this test is most successful on shielded cables.

10. Time Domain Reflectometry

The time domain reflectometry (TDR) test is a diagnostic test that can be implemented on low- and medium-voltage cables using all types of cable insulation and jacket materials. The TDR test is able to detect the occurrence of aging degradation such as thermally induced cracking, radiation-induced cracking, and severe mechanical damage that have an effect on cable impedance. The TDR test can also identify the presence of water and its location along a cable run, the location and severity of electrical faults, and the location and severity of insulation damage. TDR testing may not be effective for tape-shielded cable systems because of attenuation of the signal from shield corrosion.

Advantages of the TDR test are that it provides useful information for identifying and locating potential defects and discontinuities in a cable that may indicate severe insulation degradation or impending cable fault, it is nondestructive, it can be performed in situ from one end of a cable, and data can be trended against a baseline reflectogram. Disadvantages are that the end terminations of the cable must be disconnected to perform the test; training and experience are required for best results; and transient conditions, such as immersion, are only detectable when present during the TDR test.

11. Frequency Domain Reflectometry

Frequency Domain Reflectometry (FDR) is a diagnostic test based on transmission line theory. An example is the LIRA method (line resonance analysis) which is based on frequency domain reflectometry techniques. It is applicable to low- and medium-voltage cables of all types of cable insulation and jacket materials. The FDR test can detect aging mechanisms such as thermally induced embrittlement and cracking, radiation-induced embrittlement and cracking, and severe mechanical damage to the cable insulation.

Advantages of the FDR test are that it can be performed in situ without disconnecting the cable, the test requires only a single access point, the analysis of results can account for the effects of loads attached to the cable, and it can accurately identify the site of localized degradation. Disadvantages are that the test is not simple to perform or interpret, and training and experience are needed to obtain meaningful results. It is relatively new technology.

12. Infrared Imaging Thermography

The infrared imaging thermography technique is a nondestructive, noncontact, electronically enhanced visual inspection technique for electrical equipment that is simple to perform and valuable in identifying potentially damaging service conditions where elevated temperatures are present. This technique is applicable to all cables. The infrared imaging test is able to provide information useful for detecting aging degradation such as thermally induced embrittlement and cracking. Infrared imaging provides a useful tool for identifying temperature hotspots that could lead to accelerated degradation of electric cable systems or that indicate high-resistance electrical joints in electrical connectors and splices because of loosening, dirt or contamination, or corrosion. The instrument's high-resolution temperature detection capabilities combined with image storage and analysis software make it possible to trend the thermal data obtained.

Advantages of the infrared imaging thermography technique are that it is relatively easy to perform, properly corrected data identify the temperatures and location of hotspots, measurements can be made when the circuit is operating with a full load, data may be stored and trended with appropriate software, the test is nondestructive and nonintrusive, and it does not require the cable system under test to be disconnected. Disadvantages are that it requires training and experience for best results, measurements made when the circuit is operating at load can lead to physical safety concerns, high-end imagers and analysis software are expensive, and the cables and accessories to be monitored must be visually accessible.

Further Information

Further information describing the selection and performance of many different types of cable condition-monitoring techniques, including in situ methods and laboratory tests, appears in Section 3 of NUREG/CR-6704, "Assessment of Environmental Qualification Practices and Condition Monitoring Techniques for Low-Voltage Electric Cables," Volume 2, "Condition Monitoring Test Results," (Ref. 13); Section 5 of SAND96-0344, "Aging Management Guideline for Commercial Nuclear Power Plants—Electric Cable and Terminations," (Ref. 14); IEEE Std. 400-2001, "IEEE Guide for Field Testing and Evaluation of the Insulation of Shielded Power Cable Systems," (Ref. 15); IEEE Std. 400.1-2007, "IEEE Guide for Field Testing of Laminated Dielectric, Shielded Power Cable Systems Rated 5 kV and Above with High Direct Current Voltage," (Ref. 16); IEEE Std. 400.2-2004, "IEEE Guide for Field Testing of Shielded Power Cable Systems Using Very Low Frequency (VLF)," (Ref. 17); IEEE Std. 400.3-2006, "IEEE Guide for Partial Discharge Testing of Shielded Power Cable Systems in a Field Environment," (Ref. 18); and Section 6 and Annexes A, C, and D.4 of IEEE Std. 1205-2000/Cor 1-2006, (Ref. 11).

C. REGULATORY POSITION

1. For the cables within the scope of Maintenance Rule, the NRC staff considers the following elements to provide effective cable condition-monitoring, within a core program of periodic inspections and tests, together with the results of surveillance testing, environmental monitoring and management activities, the incorporation of cable-related operating experience, periodic formal cable condition assessment review and trending, and problem identification and corrective action:

a. Select cables to be monitored.
b. Develop database for monitored cables.
c. Characterize and monitor service environments.
d. Identify stressors and expected aging mechanisms.
e. Select condition-monitoring techniques suitable to monitored cables.
f. Establish baseline condition of monitored cables.
g. Identify cable characteristics and aging effects being monitored by each selected condition-monitoring technique.
h. Perform test and inspection activities for periodic condition monitoring of cables.
i. Periodically review and incorporate plant and industry experience.
j. Periodically review, assess, and trend the condition of monitored cables.
k. Identify degraded conditions and take prompt corrective actions.

2. The NRC staff considers the use of appropriately selected combinations of typical cable condition-monitoring techniques, such as those discussed in Section B above, within the framework of a comprehensive cable condition-monitoring program to be an acceptable method for satisfying the Commission's regulations to assess the continuity of the systems and the conditions of their components. The condition-monitoring techniques selected should be based on plant-specific design, installation, and operating conditions and operating experience related to the cables used in nuclear plants.

3. Cable condition monitoring should be augmented for selected cables when the facility has (1) experienced failure of cables connected to critical equipment, (2) operational history indicates failure of cables, (3) there is a locally adverse operating environment; or (4) industry operating experience with similar conditions and equipment configuration to those at the licensed facility indicate a need for augmented monitoring. In other areas, condition monitoring of cables may be limited to a representative sample of cables. Further, frequency of condition monitoring may be adjusted based on demonstrated plant specific cable test results and operating experience.

D. IMPLEMENTATION

The purpose of this section is to provide information on how applicants and licensees[1] may use this guide and information regarding the NRC's plans for using this regulatory guide. In addition, it describes how the NRC staff complies with the Backfit Rule (10 CFR 50.109) and any applicable finality provisions in 10 CFR Part 52.

Use by Applicants and Licensees

Applicants and licensees may voluntarily 2use the guidance in this document to demonstrate compliance with the underlying NRC regulations. Methods or solutions that differ from those described in this regulatory guide may be deemed acceptable if they provide sufficient basis and information for the NRC staff to verify that the proposed alternative demonstrates compliance with the appropriate NRC regulations. Current licensees may continue to use guidance the NRC found acceptable for complying with the identified regulations as long as their current licensing basis remains unchanged**.**

Licensees may use the information in this regulatory guide for actions which do not require NRC review and approval such as changes to a facility design under 10 CFR 50.59. Licensees may use the information in this regulatory guide or applicable parts to resolve regulatory or inspection issues.

This regulatory guide is not being imposed upon current licensees and may be voluntarily used by existing licensees.

If a licensee believes that the NRC is either using this regulatory guide or requesting or requiring the licensee to implement the methods or processes in this regulatory guide in a manner inconsistent with the discussion in this Implementation section, then the licensee may file a backfit appeal with the NRC in accordance with the guidance in NUREG-1409 and NRC Management Directive 8.4.

Use by NRC Staff

During regulatory discussions on plant specific operational issues, the staff may discuss with licensees various actions consistent with staff positions in this regulatory guide, as one acceptable means of meeting the underlying NRC regulatory requirement. Such discussions would not ordinarily be considered backfitting even if prior versions of this regulatory guide are part of the licensing basis of the facility. However, unless this regulatory guide is part of the licensing basis for a facility, the staff may not represent to the licensee that the licensee's failure to comply with the positions in this regulatory guide constitutes a violation.

If an existing licensee voluntarily seeks a license amendment or change and (1) the NRC staff's consideration of the request involves a regulatory issue directly relevant to this new or revised regulatory guide and (2) the specific subject matter of this regulatory guide is an essential consideration in the staff's determination of the acceptability of the licensee's request, then the staff may request that the licensee either follow the guidance in this regulatory guide or provide an equivalent alternative process that demonstrates compliance with the underlying NRC regulatory requirements. This is not considered backfitting as defined in 10 CFR 50.109(a)(1) or a violation of any of the issue finality provisions in 10 CFR Part 52.

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1 In this section, "licensees" refers to licensees of nuclear power plants under 10 CFR Parts 50 and 52; and the term "applicants," refers to applicants for licenses and permits for (or relating to) nuclear power plants under 10 CFR Parts 50 and 52, and applicants for standard design approvals and standard design certifications under 10 CFR Part 52.

2 In this section, "voluntary" and "voluntarily" means that the licensee is seeking the action of its own accord, without the force of a legally binding requirement or an NRC representation of further licensing or enforcement action.

The NRC staff does not intend or approve any imposition or backfitting of the guidance in this regulatory guide. The NRC staff does not expect any existing licensee to use or commit to using the guidance in this regulatory guide, unless the licensee makes a change to its licensing basis. The NRC staff does not expect or plan to request licensees to voluntarily adopt this regulatory guide to resolve a generic regulatory issue. The NRC staff does not expect or plan to initiate NRC regulatory action which would require the use of this regulatory guide. Examples of such unplanned NRC regulatory actions include issuance of an order requiring the use of the regulatory guide, requests for information under 10 CFR 50.54(f) as to whether a licensee intends to commit to use of this regulatory guide, generic communication, or promulgation of a rule requiring the use of this regulatory guide without further backfit consideration.

Additionally, an existing applicant may be required to adhere to new rules, orders, or guidance if 10 CFR 50.109(a)(3) applies.

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REFERENCES[3]

1. 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," U.S. Nuclear Regulatory Commission, Washington, DC.

2. Regulatory Guide 1.211, "Qualification of Safety-Related Cables and Field Splices for Nuclear Power Plants, U.S. Nuclear Regulatory Commission, Washington, DC.

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[4] Copies of standards are available for purchase from the IEEE Web site at http://www.ieee.org/portal/site. In addition, copies of the IEEE standards may be obtained from the Institute of Electrical and Electronics Engineers, Inc., IEEE Service Center, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855.

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