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General Comment

See attached file for comments on DG-1240

Attachments

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Add = R.A. Jervey (RAJ)
M. Case (MJC)

EPRI | ELECTRIC POWER RESEARCH INSTITUTE

August 13, 2010

Rules, Announcements, and Directives Branch,
Office of Administration
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Subject: Transmittal of Comments on Draft Regulatory Guide, DG-1240 – *Condition Monitoring Program for Electric Cables Used in Nuclear Power Plants*

Dear Madame or Sir:

Attachment 1 contains comments prepared by myself and Andrew Mantey of the Electric Power Research Institute, Plant Support Engineering staff on Draft Regulatory Guide, DG-1240, that was issue for comments in June 2010. The comments indicate that the document should either be withdrawn or rewritten to correct significant technical errors. Because DG-1240 states that the guidance in NUREG/CR-7000, *Essential Elements of an Electric Cable Condition Monitoring Program*, should be considered when developing an electric cable condition monitoring program, I am enclosing comments on that document as Attachment 2. I recommend that NUREG/CR-7000 be withdrawn and be reissued after corrections. Significant work has occurred in the nuclear and electrical distribution industries on cable condition monitoring in the past two decades. The test methods and their applicability should be described correctly and the descriptions should agree with the current consensus standards such as IEEE Std 400, IEEE Std 400.1, and IEEE Std 400.2. These standards cover testing at elevated voltage and describe their applicability to cable types. Our comments provide specific instances where the discussions in DG-1240 and NUREG/CR-7000 are diametrically opposed to the consensus guidance of these state of the art IEEE standards.

I thank you for this opportunity to comment on the Draft Regulatory Guide DG-1240 and hope to continue working with the Staff and the industry in developing guidance on cable condition assessment.

Sincerely,

Gary Toman
Senior Project Manager, PSE

Attachment 1. EPRI Comments on DG-1240
Attachment 2. EPRI Comments on NUREG/CR-7000

c: Bo Clark, PSE Program Manager, EPRI
Andrew Mantey, Senior Project Manager, PSE, EPRI
David Modeen, Director of External Affairs, EPRI

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Review of Draft Regulatory DG-1240 Condition Monitoring Program for Electric Cables Used in Nuclear Power Plants, June 2010

Prepared by Gary Toman and Andrew Mantey, Electric Power Research Institute, June 14, 2010

This Draft Regulatory Guide is meant to provide guidance on the development of programs for condition monitoring of electrical cables at nuclear power plants. While Item 1 of Section C, *Regulatory Position*, provides a reasonable guidance on the elements of a condition monitoring program, Section B, *Discussion*, contains numerous technical errors. Beyond direct errors in the content of Section B, a major deficiency of the discussion is that it mixes medium voltage and low voltage cable issues together as well as concepts related to wet and adverse dry conditions. The failure mechanisms and concerns for medium voltage cable such as water/voltage related degradation, partial discharge, and corona affects do not apply to low voltage cable. Accordingly, in most cases, the test methods that are useful for medium voltage cable do not apply to low voltage cable and vice versa. The present text in Section B will cause increased confusion and possibly cause utility personnel to misapply condition monitoring techniques and come to erroneous conclusions about the condition of their cables. The technical discussion should be logically separated into medium and low voltage failure mechanisms and the condition monitoring methods should be discussed in relative to the degradation and failure mechanisms they can identify.

One possible alternative is to have Section B refer to the EPRI Guides 1020804 and 1020805 and to delete the discussion of the test methodology from the Regulatory Guide. Replacement of much of B with a reference to the EPRI Guides would reduce the cleanup work and provide users with a clear path for determining the test and assessment techniques that could be used.

NUREG/CR-7000 contains similar technical errors and has similar problems. The NUREG should not be referenced as a basis for identifying condition monitoring methods until it too is corrected.

The following table provides specific comments on Section B and C of the Draft Regulatory Guide.

Technical Comments

Section/Page/Paragraph	Topic	Comment	Resolution
B/page 2/2nd paragraph/ 1st sentence	Background	This sentence discusses periodic "surveillance" tests, but calls them "inservice" tests, which are generally more significant tests used to establish adequacy of components or systems, such as NDE of reactor vessel welds.	Change "inservice tests" to "surveillance tests."
B/page 2/2nd paragraph/ 2nd sentence	Background	This sentence infers that cables operated "fully loaded" would be expected to fail. Nuclear power plant cables are operated well below their ampacity limits such that normal and emergency loads are well within their capacity. There is no basis for stating that operating loaded will adversely affect cable function. Cables fail if they cannot withstand voltage. Current related issues are limited to only to connections that have installation errors or multi-conductor per phase cables that are not magnetically or electrically balanced.	Delete "fully loaded" from the sentence.
B/page 2/2nd paragraph/ 3rd sentence	Background	The sentence states that tests do not evaluate the dielectric strength of jackets. The dielectric strength of jackets is not an important factor.	Reword sentence to: "...or the dielectric strength of insulation or physical integrity of jackets and insulation."

Section/Page/Paragraph	Topic	Comment	Resolution
B/page 2/3rd paragraph/ last sentence	Background	This sentence states that degradation could "significantly shorten its qualified life..." The only cables that have regulated "qualified lives" are those subject to 10 CFR50.49. The qualified lives are highly controlled and adverse environments are carefully considered and accounted for. Circuits in mild environments do not have "qualified lives" under NRC regulations. EQ cables must and are replaced before the end of their qualified lives. Qualified lives in nuclear power plants range from an operating cycle to more than the entire licensed period including license renewal.	Delete the word "qualified" from the sentence or change the sentence to read: "... in the exposed sections of a cable that could lead to failure."
B/page 3/1st full paragraph/2nd sentence	Background	This sentence states that flooded conditions always remain undetected. This may be true at some plants but is not the case at others.	Change to "may remain undetected for extended...."
B/page 3/1st full paragraph/ 3rd sentence	Background	The document states: "Eventually, power and control cables that are not designed to operate in a submerged state will experience early failures, often resulting in significant safety consequences" There is no proof that any significant portion of the population will experience early failures. Early failures are possible but are not a given.	Restate as "Eventually, power and control cables that operate in a submerged state may experience early failures that may result in a safety consequence." This would be a correct characterization.

Section/Page/Paragraph	Topic	Comment	Resolution
B/page 3/1st full paragraph, last sentence	Background	The document states "...should one of these medium-voltage cables fail, the resulting high-level fault currents and transient voltages would propagate onto the immediate power distribution system and potentially fail other systems with degraded power cable insulation." This concept has no physical basis and is an unsupported hypothesis. There are no phenomena that would lead to this condition. If the statement is meant to mean that over trips are possible, that should be stated. There is no basis to say that it is likely that additional cable failures will result. There is no history of such events.	Delete the sentence.
B/page 3/2nd full paragraph, 1st sentence	Background	This sentence states that operating experience indicates an increasing trend in failures. This statement is based on an inadequate review of the data. Failure trends are stable and have not increased significantly. Failures are occurring, but not with an increasing rate, nor at a particularly high rate.	Delete the sentence or provide a statistically sound assessment of the data. See EPRI 1019160 for a statistical analysis of medium voltage cable failures.
B/page 3/2nd full paragraph/3rd sentence	Background	The second half of the sentence is confusing. It should directly indicate that some events were in-service failures and not detected prior to failure. There have been very few failures that have occurred the instant a non-energized cable was energized. Failures most often occur some period after energization.	Change the sentence to read "While in many cases cable degradation was detected by current testing practices, some degradation led to failures during service and sometimes shortly after energization of a normally de-energized cable."

Section/Page/Paragraph	Topic	Comment	Resolution
B/page 3/2nd full paragraph/last sentence	Background	"Therefore, it is necessary to monitor the condition of electric cables throughout their installed life through the implementation of a cable condition monitoring program." There is no need to assess all cables, especially those in benign conditions. There is no need to evaluate cables through their entire lives given that there are long inception periods for all of the aging concerns.	The concept should be revised to incorporate "cables subject to adverse conditions should be monitored for condition at or before the point of susceptibility to the adverse condition"
B/page 3/3rd full paragraph, last sentence	Background	This paragraph presents a list of "ideal" characteristics. Almost no condition monitoring test exists that meets all of these conditions. Useful tests are rarely non-intrusive. Medium voltage testing especially is likely to demand that cables be disconnected and subjected to elevated voltages. Some tests such as withstand tests, are purposely destructive to deteriorated cables. Some tests provide an indication of current acceptability and a reasonable expectation of a period of acceptable performance, but cannot provide a quantifiable remaining life. Some of the most useful tests will not provide a location of the degradation.	Providing the list of ideal attributes serves no useful purpose. It could be deleted.
B/page 4/1st paragraph after list	CM Techniques	This paragraph essentially disparages the use of condition monitoring and makes it seem impractical or extremely difficult. It provides no useful information and generally adds more confusion than useful insights.	Delete the entire paragraph or implement the subsequent more specific comments.

Section/Page/Paragraph	Topic	Comment	Resolution
B/page 4/1st paragraph after list/ second sentence	CM Techniques	"Many condition monitoring techniques (e.g., elongation at break, compressive modulus, density) are localized indicators of the condition at the specific place along a cable circuit where the measurement is made; cable properties measured at multiple points may show the cable to be in sound condition, but a measurement made only inches away at a more severely stressed section could show otherwise" The statement seems to be trying to prove the impossibility of assessment rather than that assessment is possible. Assessment of worst case stress points along a cable allows the condition of the rest of the cable to be determined.	Practical means of assessing cables should be described rather than inferring that assessment with existing practices are not possible. One must look at the highly stressed portion of a cable. If that section is in good condition, the rest of the cable is acceptable. If it is deteriorated, that section must be repair or replaced or the entire cable must be replaced.
B/page 4/1st paragraph after list/ 3rd and 4th sentences	CM Techniques	"Furthermore, the criteria used to define cable functional condition or accident survivability for a particular circuit are application specific. Consequently, the use of absolute acceptance criteria for a single specific condition monitoring technique is neither meaningful nor practical." These statements are not helpful Data and criteria exist that are useful for certain conditions and cable types. These statements are negative and not supportive of the desire to implement condition monitoring efforts.	Deletion of the entire paragraph is probably best. Characterizing CM in a positive light and describing what is currently possible would be much more useful. I do not suggest overstating the usefulness or state of the art in CM, but the statements given indicate that there is no hope. The reality is that CM processes will provide significant insights into condition of cable and allow decisions on which ones are satisfactory and which ones need corrective action.

Section/Page/Paragraph	Topic	Comment	Resolution
B/page 4/1st paragraph after list/ 5th and 6th sentences	CM Techniques	"It would be more effective to set administrative quantitative or qualitative acceptance criteria for screening-type cable condition monitoring inspections and tests (e.g., visual inspection, bulk electrical properties tests, or functional tests) that, when exceeded, could then administratively trigger more detailed inspection and retesting, or further testing using additional condition monitoring techniques to provide an expanded characterization of cable condition and degree of insulation degradation. The results of the expanded inspection and testing could then provide sufficient information to conduct a formal assessment of the cable's condition and initiate appropriate corrective actions." This concept is not based on any practical experience and provides no useful information on actual implementation of a program.	Delete the paragraph. Once plants begin implementation of aging management programs, the insights gained will drive the need for further actions. This paragraph provides no useful direction or insights.

Section/Page/Paragraph	Topic	Comment	Resolution
B/page 4/2nd paragraph after list/ last sentence	CM Techniques	NUREG/CR-7000 contains numerous technical errors, does not discriminate between medium and low voltage cable applications, or wet and dry applications. The operating voltages and environments and the associated degradation mechanisms drive applicability and selection of appropriate test methods. The NUREG could cause plant personnel to implement methods that provide no useful information and could lead to incorrect conclusions (e.g., that deteriorated cables are in acceptable condition). Useful guidance would provide indications of the direct applicability of methods for specific conditions and concerns. Generalized information and incorrect information is not useful to the industry.	This document should not reference NUREG/CR-7000.
B/page 4/ General Comment on List of Individual Condition Monitoring Methods	CM Techniques – General	The degradation mechanisms of cables are different for medium and low voltage cables and for wet and dry conditions. These differences drive the test and evaluation methodology that would be selected.	Divide the discussion of test techniques into applicability to medium and low voltage cables and further divide each into applicability to cables in wet and dry service conditions.

Section/Page/Paragraph	Topic	Comment	Resolution
B/page 4/bottom of page/ Item 1/1st sentence	CM Techniques DC High-Pot	"The direct current (dc) high-potential test (HPT) is a pass/fail test applicable to medium-voltage power cables and all insulation and jacket materials." DC high potential testing is only applicable to lead covered, paper insulated cable (PILC). IEEE Std 400 and 400.1, the standards that govern elevated voltage tests state that the dc test should not be used on extruded polymer cable. The first concern is that dc high-pot could cause additional degradation to XLPE without causing failure in the test or indicating a problem exists. But equally as important, IEEE Std 400 states that dc testing will miss very significant defects for any polymer insulated cable. Dc high potential tests are only recommended for PILC where they have been proven to be useful.	The only statement about dc high-pot testing that should be made is that it is not recommended for polymer *insulated cable, the dominant type of* insulation in the nuclear industry, but is useful for PILC. This entire section should be removed from the document. The "recent" EPRI research that is alluded to in the draft Regulatory Guide is from 1995 and is well accepted across the industry.
B/page 5/ Item 2	Step Voltage DC	All of the comments in the previous item apply here. The same problem exists with the step voltage test as the dc high pot test. It applies to PILC not polymer cable.	Delete this section or make it specific to PILC.
B/page 5/Item 3	Boroscopic Inspection	While a boroscope may be a useful tool for identifying wet conditions or damage to ducts, the method is unlikely to provide useful condition monitoring information concerning the ability of either low or medium voltage cable to continue to function. The method could never provide a clean bill of health for any cable and is unlikely to provide even an accurate picture of the physical health of the cable. It remains a useful troubleshooting tool for resolution of specific questions such as whether mid run wetting exists.	Boroscopic inspection should be listed as a troubleshooting or specialty information gather tool rather than a cable condition monitoring tool.

Section/Page/Paragraph	**Topic**	**Comment**	**Resolution**
B/page 5/Item 4	Visual Inspection	Visual inspection should be placed in context. It is a useful tool in evaluating thermal, radiation, chemical and oil related degradation for both low and medium voltage cable where access is possible (If tactile assessment is included, medium voltage cable should only be evaluated in a de-energized state.) Visual inspection may find surface corona damage of non-shielded medium voltage cable. However, it will not provide any indication of electrical deterioration in wetted or dry medium voltage cable.	The applicability of visual/tactile tests for low and medium voltage cable should be discussed.
B/page 6/Item 5/last sentence in section	Indenter Modulus	The document states "...and the test is not effective for XLPE cables that do not have a polyethylene jacket." Most cables have neoprene or CSPE jackets. The indenter can evaluate these and would give an early indication of thermal stress to an XLPE cable. A limited number of plants have some XLPE jackets on these cables. While degradation to the point of interest would take a long time, the indenter would likely be useful.	While the indenter has limited usefulness for XLPE itself, please indicate that the indenter could be used on the neoprene or CSPE jackets of XLPE cables, which would give leading indication of damage.

Section/Page/Paragraph	Topic	Comment	Resolution
B/page 6/Item 6	Dielectric Loss	While test via tan δ methodology may have been applied to low voltage cable in NRC research, there are no industry standards or acceptance criteria that exist for low voltage cable. Accordingly, the test method should not be suggested for low voltage cable. In addition, tan δ is considered a medium voltage condition monitoring test not a test for diagnosing problems. It applies only to shielded MV cable and currently cannot be used for non-shielded cable. The test does not relate conditions exterior to the insulation shield such as jacket damage or contamination unless they have affected the shield or insulation system. The second paragraph of this section states that tan δ should not be applied to low voltage cable having no shield. The majority of low voltage cables have no shield. Placing a high voltage test on shielded instrument cable is also unwise.	State that tan δ is a useful condition monitoring test for medium voltage shielded cables. State that it is not recommended for low voltage cable, whether shielded or not. It should also be noted that very low frequency test sets are available that allow use of smaller more portable test sets for medium voltage cable.

Section/Page/Paragraph	Topic	Comment	Resolution
B/page 6/Item 7	IR and PI	IR and polarization index tests are not recommended for condition monitoring of medium voltage cable because of limited sensitivity to aging of wet medium voltage cable until very severe degradation has occurred. Insulation resistance has little use for dry medium or low voltage cable because insulation resistance does not change even if severe thermal or radiation damage has occurred. Insulation resistance change would only occur after cracking of the insulation, which is past the point of failure (Under dry conditions, electrical function is possible even with through cracking). However, waiting for through cracking would defeat the concept of condition monitoring. Polarization index applies to motor windings and is not useful for medium voltage or low voltage cable. While a low insulation resistance would be indicative of a highly deteriorated (near failed) medium voltage cable, relatively high insulations resistances (100s of megohms) are likely to occur if just a thin layer of good insulation is in series with a significant degradation site. Use of IR testing is applicable and recommended for wet low voltage cable to determine if significant degradation has occurred.	Describe the limitations and usefulness of insulation resistance testing appropriately. Leave polarization index testing out of the discussion of applicable cable tests.

Section/Page/Paragraph	Topic	Comment	Resolution
B/page 7/Item 8	Partial Discharge	"Aging mechanisms detected by the PDT include thermally induced embrittlement and cracking, mechanical damage, radiation-induced embrittlement and cracking, and water treeing." Partial discharge testing identifies points where there is a gap between insulation and the conductor or shield, or a void exists that is discharging under electrical stress. It does not detect water trees until they have converted to an electrical tree. It will likely detect a crack if the electrical stress is high enough. It will not detect embrittlement (there is no electrical phenomenon). Water treeing is a slow long term degradation taking 25 years or more to become significant in nuclear plant cable. During this period there is no partial discharging. If the water tree converts to an electrical tree (not an assured phenomenon), the electrical tree may go to failure in a period of weeks to months. Accordingly, only a short window for detection of the PD may be available. In addition, the dominant shield type in nuclear cables is a helical copper tape shield. When subjected to long-term wet aging, a slight surface corrosion is likely on the tape. This does not affect operation but is likely to cause attenuation of high frequency partial discharge signals, making them undetectable from cable terminations. Partial discharge is a useful tool for concentric neutral cables as may be used in off site feeds for determining if splice degradation has occurred.	The abilities of PD testing should be characterized correctly. The practical constraints and useful applications should be described properly. In addition, PD test voltages would not adversely affect healthy cable and would only have a potential to damage severely aged cable, the type that should be replaced. This test is not applicable to non-shielded cables. A shield is necessary to have a ground plane for testing.

Section/Page/Paragraph	Topic	Comment	Resolution
B/page 7/ Item 9	TDR	TDR is an excellent trouble shooting tool once failure has occurred. It can identify through wall insulation failure if the damaged insulation is wet or contaminated. It may identify the presence of water in insulation, but cannot assess the degree of degradation unless failure has occurred. It should not be characterized as a condition monitoring tool.	Correctly characterize TDR as a troubleshooting tool rather than as an aging monitoring tool.
B/page 7/Item 10	LIRA	LIRA is a useful technique that is under development. Research has shown that it is a useful condition monitoring test for identification of thermal and radiation damage and providing a reasonable indication of the degree of damage. It has been proven to identify failure locations in medium voltage cable and for use in detection of failure of lead jackets with water ingress on paper insulated lead covered cable. To date the ability of LIRA to assess water treeing or any other degradation in medium voltage cable has not been proven. In addition, the cable must be disconnected at one end to allow testing. The load end may be either open or shorted without affecting test results.	The LIRA system should be correctly categorized as a low voltage cable assessment tool at its current state of development for the detection of thermal and radiation damage and identification of the location of the degradation. The need for disconnecting one end of the cable to allow connection should be stated. The test is simple to perform; however interpretation will likely take training and experience.
B/page 8/Item 11/ first paragraph/third sentence	Infrared thermography	Infrared thermograph can identify and assess hot spots to identify elevated temperature locations on cables and their connections. It can identify the actual operating temperatures that would allow analysis of the expected results of the condition with time. However, it gives no direct information concerning the effect of the elevated temperature on the degradation of polymers; it does not assess embrittlement or cracking	Delete the statement that infrared thermography can assess embrittlement and cracking.

Section/Page/Paragraph	Topic	Comment	Resolution
C/page 9/Item 1/a	Program Development	Some cables will be identified specifically in cable aging management programs such as medium voltage power cables. Others will be determined by identifying the adverse conditions first and, if there is degradation of cables, identifying the circuits. If there is no significant degradation, the cables will not be identified. Under the Maintenance Rule, individual components do not have to be identified if they are not causing adverse effects on function.	Have the document recognize that various options exist for managing aging of cables and that identifying *individual cables is not necessary in* many cases.
C/page 9/Item 1/b.	Program development	For some cable sets, such as wet medium voltage cable, information on cable condition will be directly linkable to individual cables. However, identification and evaluation of hotspots (thermal, radiation, chemical) are likely to be assessed and documented by plant location rather than specific cable until the degradation that is observed becomes significant enough to be concerned for effects on function of cables at which time the individual cables will be identified and followed. Accordingly, the information that will be recorded will not necessarily be cable based, but rather adverse condition location based until damage becomes significant.	The process should recognize that the focus will be cables in adverse conditions, not all cables, and that the database or information retained is likely to be a combination of specific cable results and tracking of location and condition at identified local hotspots.
C/page 9/Item 1/c	Program Development	The environments to be characterized should only be those that could cause adverse cable aging. Monitoring of the environment may or may not be useful. The more important item to monitor is the condition of the cable.	Limit required characterization to adverse environments. Monitoring of environments should be on an as needed basis.

Section/Page/Paragraph	Topic	Comment	Resolution
C/page 9/Item 2/1st Sentence	Discussion of Tests and to be employed	The document states "...a comprehensive cable condition monitoring program to be an acceptable method for satisfying the Commission's regulations with respect to condition or performance monitoring of electrical cables...." The only regulation quoted in the Regulatory Guide is 10CFR50.65, the Maintenance Rule. The Maintenance Rule provides various methods to assess effectiveness of maintenance. Setting up a cable program is one method; there are other acceptable alternatives such as monitoring performance and making improvements to performance via the corrective action process. Given that failures of cables are reasonably rare, citation of Maintenance Rule does not constitute a reason to require a large program.	The regulations that the program is intended to support or fulfill should be detailed in Section A of the Regulatory Guide.

Attachment 2: Comments on NUREG/CR-7000 and Request for Withdrawal of the Document.

Prepared by: Gary Toman, Electric Power Research Institute, February 10, 2010

Introduction

NUREG/CR-7000 is titled "Essential Elements of an Electric Cable Condition Monitoring Program." However, the efforts listed in it go well beyond that which are practical and "strongly" suggest that which is either exceedingly burdensome or not possible. While the intent has merit and is in agreement with the direction the industry is heading, much of the effort that is recommended will create much effort but little practical use. The effort is meant to be aging management yet it has focuses on identification of installation problems from plant startup and hypothetical tank failures that "might cause flooding" that are not aging issues and are not practical concerns. A large database that has little practical use and cannot be populated without many staff years of work is suggested. Multiple tests where one will do are also suggested. These are impractical suggestions and certainly not "essential".

Basis of Request for Withdrawal of NUREG/CR-7000

The critical problem with the document, which indicates that it should be withdrawn, is a major technical error related to use of dc high potential testing for condition monitoring of cable. The document also contains a number of lesser errors related to other test methods. Section 3.2.7 of the document, "DC High Potential Test" recommends that "...most cable insulation materials can sustain applications of high dc potential without damage for very long periods..." The section also states "Advantages and disadvantages of this test are similar to the ac voltage withstand test, with the exception that the dc test voltage is less likely to adversely affect the cable insulation." The section refers to IEEE Std 400.1 on dc testing. IEEE Std 400.1 applies to laminated paper insulation used in paper insulated lead covered cable (PILC) and not to extruded polymer insulation. PILC cable has been used in underground applications in only two plants in the US. Nearly all medium voltage cables are insulated with extruded polymers: crosslinked polyethylene, ethylene propylene rubber, or butyl rubber. IEEE Std 400-2001, *IEEE Guide for Field Testing and Evaluation of the Insulation of Shielded Power Cable Systems* states following disadvantages for dc high potential testing in all forms:

- "It is blind to certain types of defects, such as clean voids and cuts.
- It may not replicate the stress distribution existing with power frequency ac voltage. The stress distribution is sensitive to temperature and temperature distribution.
- It may cause undesirable space charge accumulation, especially at accessory to cable insulation interfaces.
- It may adversely affect future performance of water-tree-affected extruded dielectric cables.
- Leakage current readings may have wide variations due to atmospheric conditions and lack of control of charges at termination lugs."

DC testing will likely not find deterioration in all but the most degraded cables (i.e., it is not good at detecting degradation until an insulation is near failed). DC testing can adversely effect aged XLPE insulations causing them to fail earlier in the next period of operation, but at the same time not cause them to fail during testing as is desired. For these two reasons, both the IEEE Insulated Conductors Committee and EPRI have strongly recommended that dc high potential testing not be performed on polymer insulated cables. Rather the use of line frequency or very low frequency testing has been recommended.

Section 4.2 of IEEE Std 400 goes further and states "Testing of cables that have been service aged in a wet environment (specifically, XLPE) with dc at the currently recommended dc voltage levels (see IEEE P400.1) may cause the cables to fail after they are returned to service (see Fisher, et al. [B23], and Stennis, et al. [B48]). The failures would not have occurred at that point in time if the cables had remained in service and not been tested with dc (see Eager, et al. [B21], and Srinivas, et al. [B47]). Furthermore, from the work of Bach, et al. [B7], we know that even massive insulation defects in extruded dielectric insulation cannot be detected with dc at the recommended voltage levels."

NUREG/CR-7000 is wrong to recommend dc high potential testing as a key test for medium voltage cable, a test that would provide inadequate information and may do additional damage to an aged cable without causing it to be identified as being aged. For these reasons, the document should be withdrawn and corrected. These comments also apply to Section 3.2.8 on applying a dc high potential test in a step wise fashion.

Lesser Errors and Misinterpretations

The following identify other errors, impractical recommendations, and recommendations that are not based on industry recognized methodologies.

1. Section 3.2.3, Dielectric Loss

This section discusses the test that is likely to be most useful for testing shielded medium voltage cable. However, the section and later text seems to imply that it is a method that should be employed for non-shielded medium voltage and low voltage cable. While research is to be performed to see if there is any value to using dielectric loss (tan δ) testing for non-shielded triplexed cables, there are no standards or recognized methodology in existence for non-shielded cables and low voltage cables. The industry does not recognize the test as having usefulness for low-voltage cable.

2. Section 3.2.4, Insulation Resistance

Insulation resistance testing is recommended for evaluation of the condition of wetted low-voltage cable. However, it is not a recommended test for evaluating medium voltage cable in that it is not searching enough to detect partial but significant degradation. It would only detect highly degraded medium voltage cable insulation that would be at the point of near failure.

Attachment 2: Comments on NUREG/CR-7000 and Request for Withdrawal of the Document.

3. Section 3.2.5, AC Withstand Test

The purpose of this test is to breakdown localized deteriorations at a time when the cable can be repaired. It is recognized as a test that will cause a degraded cable to fail. This is not a disadvantage.

4. Section 3.2.6, Partial Discharge Testing

The section does not address the significant problem signal attenuation that has been recognized with testing of wet cables. Light corrosion of copper tape shields especially in wetted sections of cable causes the shield to act as an inductor and attenuate the very small, high frequency signals from partial discharge. This attenuation often makes PD testing impractical for the cables of most concern. The section does not indicate that PD testing is not possible for non-shielded cable. The section also states that references that PD testing may be used on low-voltage cable based on a 1990 paper. No work additional has been performed on use of PD testing on low-voltage cable and there are no standards for applying such a test. Inducing PD in a low-voltage cable would add to the electro-magnetic discharges into a cable system where we are trying to eliminate the effects of radio frequency discharges and would not be recommended.

5. Section 3.2.9, Time Domain Reflectometry

This section states that TDR could be used to identify thermal and radiation damage. However, TDR has been shown to not be able to detect even the most severe thermal damage until the cable insulation has powdered and moisture has entered. During trouble shooting at a plant, degradation in a cable having residual elongation at break of less than 20% absolute was not detectible with TDR. Removal of the cable from its conduit identified that the jacket had totally degraded and the insulation had deteriorated significantly. The original elongation at break was likely 300% or more. TDR is an excellent troubleshooting tool. A skilled operator can likely find wetted conditions if the cable was wet for an extended period. However, TDR cannot be used to analyze the degree of aging from wetting.

6. Section 3.2.12, Line Resonance Analysis (LIRA)

EPRI has performed an extensive assessment of LIRA (See EPRI 1015209). It is a promising technique and should be able to detect thermal and radiation aging and provide a means of assessing the degree of degradation. However, NUREG/CR-7000 incorrectly states that no disconnection is necessary to do the test. While it is true that the circuit does not have to be disassembled at the far end of the cable under test, the point at which the test is applied needs at minimum 1 lead of the circuit if not two to be disconnected to allow the test to be performed.

7. Section 3.3.1, Elongation-at-Break

While elongation-at-break testing is a benchmark polymer assessment technique, it should not be characterized as a "very accurate" test. The accuracy of an individual test is not high and would likely be ±10%. Multiple tests are performed to get results that are representative and to improve accuracy.

8. Table 3.2, Cable Condition Monitoring Technique Selection Matrix

The table states that surface contaminants are a concern. Contaminants (dust and dirt) are not a significant concern for the cables. In addition, the tests linked to surface contaminants in Table 3.2 will not detect them. If the intent was to indicate that surface contaminants may be a problem with certain termination systems, the text and table need to be more specific. Also, the types of contamination that would be a real concern at a nuclear plant should be stated. The industry should not be expected to search for hypothetical problems that have no likelihood of occurring.

The text following the table indicates that multiple tests are needed to address aging.. In reality, a section of cable, if it is affected at all, is generally affected by one significant adverse stressor not multiple stressors. Aging can often be evaluated by one test or assessment type for the specific concern. Multiple tests are needed for full forensic analysis, but are unlikely to be needed in most cases for basic aging management purposes.

9. Section 4, Essential Elements of a Cable Condition Monitoring Program

Section 4 contains concepts that may be used in a condition monitoring program. However, not all of them are essential nor are all of them practical. The medium voltage cable system has relatively few circuits and, as such developing, a list of cables that are in scope is relatively easy. Developing a scope and basis circuit by circuit can be performed. However, working from a cable list towards environments is not practical for low-voltage cable systems. Many plants do not have cable lists that include the information that would be required nor would developing a list be practical or cost effective. Walkdowns of plant sections having potentially adverse conditions is the means by which adverse conditions will be identified, and if they are identified, their effects on the cables will be assessed. If there is an adverse effect that requires correction, the specific circuits affected will be identified and actions will be taken to correct the problem.

10. Table 2.1, Summary of Stressors and Potential Aging Effects and Table 2.2

The Potential Aging Effects are the same for every insulation aging mechanism even though the aging stressor causes grossly different effects in the materials. For example, thermal aging does not cause an increase in leakage current until complete failure of the material; nor does breakdown strength change. Accordingly, measuring these parameters would be useless. The table should be revised to more appropriately indicate stressors and their effects. Some of the Comments column entries are general in nature when they should be specific. For example, tree retardant additives are recommended. Tree retardants are appropriate for XLPE but are not necessary, nor used in EPR. (In Table 2.2, tree retardants should not be recommended for use in splices and terminations.)

Table 2.2 implies that splices and terminations could be located in inaccessible locations. This is counter to all normal practice. No nuclear plant would allow a splice to be pulled into a duct or conduit. By definition, terminations are accessible. They are located inside termination boxes and equipment housings (e.g., circuit breaker cubicle backplanes) and are accessible.

Additional suggestions:

1. Section 2.2.3, first paragraph. This paragraph states that if a qualification is not performed, stress related degradation will occur. In reality, there is no linkage between qualification and susceptibility of a material to an aging mechanism. Some materials are not affected by a stressor while others are. This does not change when a qualification test is performed. The goal of the qualification test is to prove that a component has sufficient capability after exposure to a stress of a given intensity and duration to be able to perform its function. The lack of a qualification does not change the ability of a component to withstand a stress. It still may be able to perform adequately. Condition monitoring and assessment are intended to show functional capability for a foreseeable period especially when qualification is not possible.

2. Submarine cables are not a practical design for a nuclear plant. Submarine cables are constructed with steel strength members that would make them inflexible and not suitable for installation in trays and ducts. The type cables that could be used are labeled "impervious" and have a moisture/water barrier between the insulation system and the jacket. That barrier can either be an aluminum, lead or copper sheath. The EPRI *Common Medium Voltage Cable Specification for Nuclear Power Plants*, 1019159, contains a recommendation to use an impervious linear corrugated copper tape sheath for wet conditions. NUREG/CR-7000 should not indicate that submarine cables should be used in wet nuclear plant applications.

3. The goal of a Cable Aging Management Program is to control aging of the cable system. It is not designed to correct all possible ills that may have occurred during construction, startup and operation. Many other activities during design, installation, operations, and maintenance exist to assure the proper function and capability of cable and other components. Installation damage, manufacturing defects, and incidental damage may or may not be detected by an aging management program. Other activities and good practices are intended to control and correct these conditions.