United States Nuclear Regulatory Commission Official Hearing Exhibit

In the Matter of: Entergy Nuclear Operations, Inc. (Indian Point Nuclear Generating Units 2 and 3)

ASLBP #: 07-858-03-LR-BD01
Docket #: 05000247 | 05000286
Exhibit #: ENT000237-00-BD01
Identified: 10/15/2012
Admitted: 10/15/2012
Withdrawn:
Rejected:
Stricken:
Other:

ENT000237
Submitted: March 29, 2012

Cable Reliability Program

Procedure Contains eB NMM REFLIB Forms: YES ☐ NO ☒

Effective Date	Procedure Owner: Title: Site:	Gerald Lantz Supervisor, Major Components HQN	Governance Owner: Title: Site:	Oscar Limpias VP, Engineering HQN
06/14/2011				

Exception Date*	Site	Site Procedure Champion	Title
	ANO	William Greeson	Manager, Programs & Components
N/A	BRP		
	GGNS	Linda Patterson	Manager, Programs & Components
	IPEC	Michael Tesoriero	Manager, Programs & Components
	JAF	Patrick Scanlan	Manager, Programs & Components
	PLP	Jim Miksa	Manager, Programs & Components
	PNPS	Steven Woods	Manager, Programs & Components
	RBS	Charles Coleman	Manager, Programs & Components
	VY	George Wierzbowski	Manager, Programs & Components
	W3	Michael Haydel	Acting Manager, Programs & Components
N/A	NP		
	HQN	Luis Terrazas	Manager, Programs & Components

Site and NMM Procedures Canceled or Superseded By This Revision

None

Process Applicability Exclusion: All Sites: ☐

Specific Sites: ANO ☐ BRP ☐ GGNS ☐ IPEC☐ JAF ☐ PLP ☐ PNPS☒ RBS ☐ VY ☒ W3 ☐

Change Statement

Revision 2 includes the following changes:

- Added underground low voltage power cables to the scope of the program.
- Clarified that the implementation of new or changed requirements per any revision of this procedure will be governed by the change management plan associated with that revision.
- Clarified cable component engineers responsibility.
- Added requirement to prepare low voltage in-scope cable list.
- Added information for DC high potential test, insulation resistance test, and partial discharge test.
- Added requirement to identify all manholes that contains program scope cables.
- Added actions for underground low voltage power cables.
- Suggested to use corrective action process for trending cable-rewetting occurrences [CR-HQN-2011-00491].
- Added ANO-1 and ANO-2 License Renewal Commitments in Site Specific Commitments section.
- Clarified Tan Delta test acceptance criteria.
- Added Insulation Resistance Acceptance Criteria.
- Clarified information needed for in-scope cables and manholes.
- Removed Section 5.7 from the procedure.
- Minor editorial changes throughout the procedure including page numbers.

*Requires justification for the exception

TABLE OF CONTENTS

1.0 PURPOSE

[1] The purpose of this procedure is to provide guidance to establish and monitor the insulation condition of underground medium voltage and low voltage power cables using appropriate testing and evaluation of test results. Also, this procedure provides guidance on manhole inspection and dewatering.

[2] The purpose of the Cable Reliability Program is to provide the means to effectively manage underground medium voltage and low voltage power cables that are safety related, non-safety related cables whose failure could affect safety related equipment, or serving equipment that is in maintenance rule scope. Any license renewal commitments related to underground medium voltage and low voltage power cables shall be included in the Cable Reliability Program. The goal is to achieve high reliability while reducing the likelihood of in-service failures.

[3] The Cable Reliability Program elements include the following:

(a) A combination of program activities with the basic goal of ensuring that underground medium voltage and low voltage power cables are capable of performing their intended function(s).

(b) Confirming that maintenance practices, testing, and trending are sufficient to ensure that cables will perform their intended function(s).

(c) Confirming that manhole maintenance practices and trending water levels are sufficient to keep the cables from submergence as applicable or evaluation should be performed to determine cable insulation and support integrity.

[4] This procedure can also be used as guidance for evaluating cables that are not included in the scope of the Cable Reliability Program.

[5] Implementation of new or changed requirements per any revision of this procedure will be governed by the change management plan associated with that revision.

2.0 REFERENCES

2.1 ELECTRIC POWER RESEARCH INSTITUTE (EPRI)

[1] EPRI 1016689, “Plant Support Engineering: Medium-Voltage Cable Aging Management Guide”

2.1 cont.

[2] EPRI 1015070, “Failure Mechanism Assessment of Medium-Voltage Ethylene Propylene Rubber Cables”

[3] EPRI 1013085, “Advanced Diagnostics and Life Estimation of Extruded Dielectric Cable”

[4] EPRI 1013187, “Plant Support Engineering: Life Cycle Management Planning Sourcebooks: Medium-Voltage (MV) Cable and Accessories (Terminations and Splices)”

[5] EPRI 1011871, “Continuous On-Line Partial Discharge Monitor for Medium-Voltage Cable Feasibility Study”

[6] EPRI 1015209, “Line Impedance Resonance Analysis for Detection of Cable Damage and Degradation”

[7] EPRI 1003456, “Aging Management Guideline for Commercial Nuclear Power Plants –Electrical and Mechanical Penetrations”

[8] EPRI 1003664, “Medium-Voltage Cables in Nuclear Power Plant Applications – State of Industry and Condition Monitoring”

[9] EPRI 1003663, “Integrated Cable System Aging Management Guidance”

[10] EPRI 1001391, “Training Aids for Visual/Tactile Inspection of Electrical Cables for Detection of Aging”

[11] EPRI 1007933, “Aging Assessment Field Guide”

[12] EPRI 106687, “Cable Aging Management Program for D.C. Cook Nuclear Plant Units 1 and 2”

[13] EPRI 109619, “Guideline for the Management of Adverse Localized Equipment Environments”

[14] EPRI 114333, “Review of Emerging Technologies for Condition Assessment of Underground Distribution Cable Assets”

[15] EPRI 1003317, “Cable System Aging Management”

[16] EPRI 1020804, “Aging Management Program Development Guidance for AC and DC Low-Voltage Power Cable Systems for Nuclear Power Plants”

2.1 cont.

[17] EPRI 1020805, “Aging Management Program Guidance for Medium-Voltage Cable Systems for Nuclear Power Plants”

[18] EPRI TR-109619, “Guideline for the Management of Adverse Localized Equipment Environments”

[19] EPRI TR-103834-P1-2, “Effects of Moisture on the Life of Power Plant Cables”

[20] SAND96-0344, “Aging Management Guideline for Commercial Nuclear Power Plants – Electrical Cables and Terminations”

2.2 INSTITUTE OF NUCLEAR POWER OPERATIONS (INPO)

[1] INPO EPG-16, “Engineering Program Guide - Electric Cable Reliability”

[2] AP-913, “Equipment Reliability Process Description”

[3] INPO SEN 272, “Underground Cable Ground Fault Causes Forced Shutdown”

[4] INPO Topical Report TR10-69, “Cable Aging and Monitoring”

2.3 INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

[1] IEEE 48, “IEEE Standard Test Procedures and Requirements for Alternating Current Cable Terminations 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV through 500 kV”

[2] IEEE Std 383, “IEEE Standard for Qualifying Class 1E Electric Cables and Field Splices for Nuclear Power Generating Stations”

[3] IEEE Std 400, “IEEE Guide for Field Testing and Evaluation of the Insulation of Shielded Power Cable Systems”

[4] IEEE 400.2, “IEEE Guide for Field Testing of Shielded Power Cable Systems Using Very Low Frequency (VLF)”

[5] IEEE Std 400.3, “IEEE Guide for Partial Discharge Testing of Shielded Power Cable Systems in a Field Environment”

[6] IEEE 404, “IEEE Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500V to 500,000V”

2.3 cont.

[7] IEEE 422, “Guide for the Design and Installation of Cable Systems in Power Generating Stations”

[8] IEEE 576, “IEEE Recommended Practice for Installation, Termination, and Testing of Insulated Power Cable as Used in Industrial and Commercial Applications”

[9] IEEE 690, “IEEE Standard for the Design and Installation of Cable Systems for Class 1E Circuits in Nuclear Power Generating Stations”

[10] IEEE 1205-2000, “IEEE Guide for Assessing, Monitoring and Mitigating Aging Effects on Class 1E Equipment Used in Nuclear Power Generating Stations”

2.4 NUCLEAR REGULATORY COMMISSION (NRC)

[1] Regulatory Guide 1.211, “Qualification of Safety-Related Cables and Field Splices for Nuclear Power Plants”

[2] Generic Letter 2007-01, “Inaccessible or Underground Power Cable Failures that Disable Accident Mitigation Systems or Cause Plant Transients,” Dated February 7, 2007 (ADAMS ML070360665).

[3] Response to Nuclear Energy Institute (NEI) letter dated March 26, 2007 – “Re-Interpretation of Generic Letter (GL) 2007-01, inaccessible or underground power cable failures that disable accident mitigation systems or cause plant transients,” Dated April 13, 2007 (ADAMS ML070940311).

[4] 0CAN050701, “Response to Generic Letter 2007-01 Arkansas Nuclear One – Units 1 and 2”

[5] GNRO-2007/00022, “Response to Generic Letter 2007-01 Grand Gulf Nuclear Station”

[6] NL-07-055, “Submittal of Indian Point Response to Generic Letter 2007-01”

[7] JAFP-07-0059, “Response to Generic Letter 2007-01 James A. Fitzpatrick Nuclear Power Plant”

[8] 513789, “Response to Generic Letter 2007-01 Inaccessible or Underground Power Cable Failures That Disable Accident Mitigation Systems or Cause Plant Transients," for Palisades Nuclear Plant

2.4 cont.

[9] E LN RC 1.2.07.034, "Pilgrim Response to NRC Generic Letter 2007-01, Inaccessible or Underground Cable Failures"

[10] RBF1-07-0070, "Response to Generic Letter 2007-01 River Bend Station – Unit 1"

[11] BVY 07-028, "Vermont Yankee Response to Generic Letter 2007-01"

[12] W3F1-2007-0017, "Response to Generic Letter 2007-01 Waterford Steam Electric Station, Unit 3 (Waterford 3)"

[13] Inspection Procedure (IP) 71111.01, "Adverse Weather Protection"

[14] Inspection Procedure (IP) 71111.06, "Flood Protection Measures"

[15] Information Notice 2002-12, "Submerged Safety-Related Electrical Cables"

[16] NUREG/CR-5643, "Insights Gained From Aging Research"

[17] NRC Inspection Manual Part 9900, "Technical Guidance, Operability Determinations & Functionality Assessments for Resolution of Degraded or Nonconforming Conditions Adverse to Quality or Safety"

[18] NUREG 1801, "Generic Aging Lessons Learned (GALL) Report, XI.E3 Inaccessible Power Cables not Subject to 10 CFR 50.49 Environmental Qualification Requirements"

[19] NRC Information Notice 2010-26, "Submerged Electrical Cables"

2.5 NUCLEAR ENERGY INSTITUTE (NEI)

[1] NEI 06-05, "Medium Voltage Underground Cable - White Paper"

3.0 DEFINITIONS

[1] Adverse Condition – An event, defect, characteristic, state, or activity that prohibits or detracts from a safe, efficient nuclear plant or a condition that could credibly impact nuclear safety, personnel safety, plant reliability or non-compliance with federal, state, or local regulations. Adverse conditions include non-conformances, conditions adverse to quality and plant reliability concerns.

[2] Aging – The deterioration of cables caused by their remaining in service for extended periods of time with little or no preventive maintenance.

3.0 cont.

[3] Condition Report (CR) – A computer generated or paper form used to document issues into the corrective action process.

[4] Degraded Condition – A condition of a structure, system, or component in which there has been any loss of quality or functional capability.

[5] Insulation – A material that offers high electric resistance suitable for covering components, terminals, and wires to prevent the possible future contact of adjacent conductors resulting in a short circuit.

[6] Jackets – Cable coverings used to protect cables during installation in raceways and to protect insulation from the effects of beta radiation in environmentally qualified cables.

[7] Long-term Wetting – A condition where the cable sits in or is covered by water for a period of weeks to months.

[8] Low Voltage Power Cable – Electrical cable operating voltage between 400 V and 2.3 kV (including 2.3kV).

[9] Maintenance Rule – A federal regulation (10CFR50.65) which requires the performance or condition of certain structures, systems, and components (SSCs) to be monitored against licensee-established goals to provide reasonable assurance that those SSCs are capable of performing their design functions.

[10] Medium Voltage Cable – Electrical cable operating voltage between 2.3 kV and 34 kV.

[11] Monitoring – A periodic review and comparison of specific cable information to established norms and to Alert or Action Levels for the purpose of determining the current condition of the cable.

[12] Operating Experience (OE) – Information received from various industry sources that describe events, issues, equipment failures, etc. that may represent opportunities to apply lessons learned to avoid negative consequences or to recreate positive experiences, as applicable. Some examples of Operating Experience sources are: INPO SEE-IN Documents, NRC Information Notices, Vendor Bulletins, 10CFR Part 21 Reports, NRC Event Reports, INPO Nuclear Network download, NSSS Owners group reports, etc.

3.0 cont.

[13] Shield – A cable in which an insulated conductor is enclosed in a conducting envelope which controls the electrical stress between conductors.

[14] Trending – An analysis of cable information over time for the purpose of predicting cable degradation or failures.

[15] Underground Cable – An electrical cable that is routed below ground level. Typically, these cables are inaccessible and include direct buried, buried conduit, cable trenches, cable troughs, duct banks and / or underground vaults.

[16] Water Tree – A collection of water filled micro-voids that propagate over time in insulation in the direction of the electrical field when energized (voltage dependent). Treeing is caused by contaminants and protrusions and occurs when the insulation of an energized cable is immersed in water.

[17] Work Request (WR) – The document used to identify items for screening to determine if it will be processed via the work order process.

4.0 RESPONSIBILITIES

4.1 **Vice President, Engineering (HQN)**, is responsible for:

[1] The overall implementation of the Cable Reliability Program described in this procedure.

4.2 **Director, Engineering (HQN)**, is responsible for:

[1] Providing corporate management and oversight of the Cable Reliability Program activities from a fleet perspective.

[2] Ensuring fleet focus and alignment of the Cable Reliability Program implementation.

[3] Ensuring fleet coordination of cable reliability activities.

4.3 **Director, Engineering (site)**, is responsible for:

[1] Providing management and oversight of the Cable Reliability Program activities.

4.4 **Manager, Engineering Programs and Components (HQN)**, is responsible for:

[1] Assigning the appropriate personnel to the Cable Reliability Program.

4.4 cont.

[2] Providing governance for the Cable Reliability Program across the fleet.

[3] Standardizing the Cable Reliability Program from site-to-site.

[4] Resolving conflicts that may arise in the interpretation of this procedure.

4.5 **Manager, Engineering Programs and Components (Site)**, is responsible for:

[1] Assigning the appropriate personnel to the Cable Reliability Program.

[2] Ensuring adequate training of Cable Reliability Program owners and backup personnel.

4.6 **Supervisor, Major Components (HQN)**, is responsible for:

[1] Providing management oversight of the Cable Reliability Program across the fleet.

[2] Monitoring the overall effectiveness of the Cable Reliability Program and incorporating program changes based on fleet history, performance, industry experience, and periodic reviews conducted on the program.

4.7 **Supervisor, Components Engineering (Site)**, is responsible for:

[1] Directing overall site implementation of the Cable Reliability Program.

[2] Oversight of personnel assigned to the Cable Reliability Program.

[3] Monitoring the overall effectiveness of the Cable Reliability Program and incorporating program changes based on plant history, performance, industry experience, and periodic reviews conducted on the program.

[4] Providing proper notifications when degrading trends on cable are identified and assisting with recommending proposed corrective actions.

4.8 **Engineer, Major Components (HQN)**, is responsible for:

[1] Acting as chairperson of the Cable Reliability Program Working Group.

[2] Maintaining cognizance of industry issues/events, operating experience, and best practices.

4.8 cont.

[3] Coordinating with site implementation personnel and management, as necessary, to ensure effective implementation of the Cable Reliability Program.

[4] Coordinating periodic meetings and teleconferences with the site Cable Reliability Program owners.

[5] Participating in industry meetings, benchmarking, and INPO review visits related to cables as applicable.

[6] Monitoring timely implementation of industry and regulatory requirements within the site Cable Reliability Program.

[7] Updating / revising this procedure as needed.

4.9 **Engineer, Components Engineering (Site)**, is responsible for:

[1] Creating and maintaining the Medium Voltage In-scope Cable List (MVICL).

[2] Creating and maintaining the Low Voltage In-scope Cable List (LVICL).

[3] Creating and maintaining cable risk ranking of Medium Voltage In-scope cables.

[4] Creating and maintaining In-scope Manhole List (IML).

[5] Ensuring the cable test data is evaluated for insulation conditions.

[6] Initiating Condition Reports (CRs) for conditions that fail to meet the acceptance criteria or cable failure.

[7] Interfacing with other discipline Engineers as required to implement this procedure and to obtain cable and manhole information.

[8] Generating Action Requests (AR) in Asset Suite providing instructions for Planning to develop the new Preventive Maintenance (PM) activities in accordance with fleet PM templates.

[9] Providing long-range plans and updates to Site Integrated Planning Database (SIPD) for cable replacement work.

[10] Providing technical reviews and input for new cable purchases.

[11] Participating in fleet or industry peer group meetings, equipment upgrades, and industry initiatives.

4.10 **Superintendents/Supervisors, Maintenance (Site)**, are responsible for:

[1] Providing support, as necessary, for the Cable Reliability Program testing activities on cables under their authority.

[2] Assigning maintenance personnel to support routine activities carried out in support of the Cable Reliability Program.

[3] Calibrating, maintaining, and storing test equipment.

[4] Coordinating with the other departments, as required, for performing cable monitoring, including cable replacement in conjunction with scheduled plant activities.

[5] Ensuring maintenance conducts cable testing in accordance with approved plant procedures or approved work order instructions.

[6] Ensuring the cable engineer or designee is notified of completed cable testing in accordance with approved plant procedures or approved work order instructions.

4.11 **Manager, Design Engineering (Site)**, is responsible for:

[1] Supporting the Cable Reliability Program with design changes, as required.

[2] Providing technical support and cable information to the Cable Reliability Program, as required.

[3] Executing design basis reviews and calculations related to the Cable Reliability Program.

[4] Ownership of cable procurement specifications and engineering standards.

4.12 **Manager, System Engineering (Site)**, is responsible for:

[1] Providing technical support to the Cable Reliability Program, as required.

4.13 **Training** is responsible for:

[1] Providing input on training related issues.

[2] Training electricians in cable testing practices.

5.0 DETAILS

5.1 PRECAUTIONS AND LIMITATIONS

[1] Consider the need to have a replacement plan, including spare cable, before doing Tan Delta testing on medium voltage cables (as alternate for a replacement, cable rejuvenation for non-EQ and non-safety related cables can be considered).

[2] The limitations for the different types of tests, such as Tan Delta testing, require the cable to be disconnected at both ends or isolated from the equipment.

5.2 GENERAL

[1] The Cable Reliability Program shall be administered and maintained by Engineering Programs and Components (EP&C) group.

[2] The objective of the Cable Reliability Program is to ensure the cable operability of underground medium voltage and low voltage power cables is maintained. This involves program elements to perform testing and evaluate the test data to identify any In-scope Cable List (ICL) cable insulation degradation.

[3] For underground medium voltage and low voltage power cables with license renewal commitment, cable testing shall be performed as stated in the plant specific commitment and have the test frequency as specified in the plant specific commitment.

[4] For underground medium voltage and low voltage power cables with license renewal commitment, manholes that contain these cables shall be inspected as stated in the plant specific commitment and have the inspection frequency as specified in the plant specific commitment.

[5] Energized cables in wet environments may accelerate the insulation aging effects. Therefore, cables should be kept from submergence if possible to increase the longevity of the insulation system.

[6] The development and maintenance of the Cable Reliability Program is based upon, but not limited to, the following plant activities and factors:

(a) Licensing requirements and commitments.

(b) Licensing renewal requirements and commitments.

(c) Nuclear Regulatory Commission (NRC) regulations and guidelines.

5.2[6] cont.

(d) Industry guidelines (EPRI, NEI, and IEEE).

(e) Practical Experience / Operating Experience (OE) with plant cables.

(f) Cable failure trending analysis.

(g) Cable manufacturer's recommendations.

(h) Engineering evaluations and recommendations.

[7] Tan Delta and Very Low Frequency (VLF) AC High Potential (Hi-Pot) (or industry recommended methods) tests can be used for condition monitoring and aging assessment of shielded medium voltage cables.

(a) Tan Delta tests are used to measure the ratio of the resistive leakage current through the insulation divided by the capacitive current.

(1) Tan Delta is a bulk test and does not provide location information.

(2) Tan Delta can be performed at line frequency or VLF.

(3) Tan Delta can be used to identify water related cable insulation degradation.

(b) VLF Hi-pot testing applies a high enough voltage to detect any weak spots in the insulation which is likely to cause a service failure before the next scheduled test. At the same time, the test voltage should not be so high as to damage any sound insulation.

[8] DC Hi-Pot test applies a DC voltage to the main conductor and measures the leakage current to the cable's shield. The DC Hi-Pot is a preferred test method for new cable installation test and not recommended for cables that have been in service.

(a) The applied voltage is normally 1 to 5 times the rated cable voltage.

(b) The voltage is increased in uniform steps until the final test voltage is reached, while the leakage current is being monitored.

(c) A significant increase in leakage current may be an indication of pending cable failure.

5.2[8] cont.

(d) This requires relatively high voltages to be applied to the cable, which would be a concern due to the potential to damage the cable or surrounding equipment.

[9] Insulation Resistance test can be used to detect the deterioration of low voltage power cable insulation from wetting.

(a) Insulation Resistance testing is generally performed to evaluate the condition of the load connected to the cable.

(b) Test voltages are driven by the capabilities of the load, which are lower than the cable rated voltage.

(c) Insulation Resistance test identifies only reasonably gross damage, contamination, or deterioration.

(d) Insulation Resistance measurements are affected by ambient conditions such as temperature of the insulation, moisture surrounding the cable, and humidity in the vicinity of terminations and test leads.

[10] Partial Discharge test can be used for condition monitoring of medium voltage cables.

(a) Partial Discharge test is performed by applying sufficiently high voltage stress (the inception voltage) across a cable’s insulation to induce an electrical discharge (known as Partial Discharge or corona).

(b) The occurrence of partial discharge indicates the presence of insulation degradation.

(c) Partial Discharge test is potentially damaging since the discharge induced can cause degradation of the insulation over a period of time due to localized arcing.

(d) This requires relatively high voltages to be applied to the cable which would be a concern due to the potential to damage the cable or surrounding equipment.

5.3 PROGRAM SCOPE DETERMINATION FOR IN-SCOPE CABLES AND MANHOLES

[1] Identify all underground medium voltage and low voltage power cables that are safety related, non-safety related whose failure affect safety related equipment, cables serving equipment that is in maintenance rule scope in the plant and switchyard (within the plant jurisdiction), or cables with license renewal commitments.

[2] Prepare a Spreadsheet (Medium Voltage In-scope Cable List (MVICL)), with medium voltage cables that are in the scope of this program.

(a) Attachment 9.3 contains an example Spreadsheet of MVICL.

[3] Prepare cable risk ranking in accordance with Attachment 9.6 for MVICL.

[4] Identify which cables in the MVICL are shielded and which are un-shielded.

[5] Prepare a Spreadsheet (Low Voltage In-scope Cable List (LVICL)), with low voltage power cables that are in the scope of this program.

(a) Attachment 9.4 contains an example Spreadsheet of LVICL.

[6] Identify all manholes that contain medium voltage and low voltage power cables that are safety related, non-safety related whose failure affect safety related equipment, cables serving equipment that is in maintenance rule scope in the plant and switchyard (within the plant jurisdiction), or cables with license renewal commitments.

[7] Prepare a spreadsheet (In-scope Manhole List (IML)), with manholes that are in the scope of this program.

(a) Attachment 9.5 contains an example Spreadsheet of IML.

5.4 ACTIONS FOR SHIELDED MEDIUM VOLTAGE UNDERGROUND CABLES

[1] Consider preparing a contingency plan if Tan Delta test voltage exceeds $1V_o$ (V_o is the normal operating phase-to-ground voltage). This plan should cover source of replacement cables and accessories, pulling procedure, pulling tools, and skilled craft.

[2] Perform Tan Delta testing in accordance with approved fleet PM template.

5.4 cont.

NOTE

Tan Delta acceptance criteria have not been established for all insulation types. If a cable has an insulation type, which does not have acceptance criteria in Attachment 9.1, discuss with the peer group, other nuclear facility, EPRI, or the vendor to obtain allowable limits to classify as Good, Aged, or Highly Aged Insulation Condition.

[3] Tan Delta test acceptance criteria for cable insulation types are in Attachment 9.1.

[4] **IF** the Tan Delta test indicates Aged Insulation Condition per Attachment 9.1, **THEN** consider doing the following:

(a) Eliminate obvious problems.

(1) Inspect the terminations for accumulated dirt, moisture, tracking, and any surface problems.

(2) Clean and repair the terminations as needed.

(3) Verify that the terminations of the cable under test were well isolated from adjacent phase terminations and the cabinet/termination box to eliminate corona.

(4) If termination issues appear to be the cause, retest and determine if the Aged Insulation Condition indication still exists.

(5) If the cable contains splices that are not geometrically graded it will produce non-linear results. The non-linearity is not a defect but rather a characteristic of splices in this case.

(b) **IF** 5.4[4](a) is not successful, **THEN** consider doing the following:

(1) Increase the frequency of Tan Delta testing and compare test results to determine if condition is stable or worsening (e.g., Tan Delta test every refueling cycle).

(2) Document the condition using PCRS Condition Reports.

5.4[4](b) cont.

(3) If aged cable insulation is identified and long-term wetting cannot be eliminated, consideration should be given to use of an impervious cable design for the replacement cable. Alternatively, more frequent cable replacement can be considered.

[5] **IF** the Tan Delta test indicates Highly Aged Insulation Condition per Attachment 9.1, **THEN** consider doing the following:

(a) Perform VLF Hi-pot or other industry recommended methods to determine if the highly aged cable's condition is sufficiently stable to allow an interim period of operation to allow orderly staging for replacement. Replace the cable at first available opportunity.

(b) Document the condition using PCRS Condition Reports.

(c) Highly aged section(s) of cable shall be replaced and spliced to the good section(s). Minimize splices in submerged conditions.

(d) Forensic testing of any highly aged cable segment is recommended to gain insight into the nature of the degradation.

(e) If highly aged cable insulation is identified, and long-term wetting cannot be eliminated, consideration should be given to use of an impervious cable design for the replacement cable. Alternatively, more frequent cable replacement can be considered.

5.5 ACTIONS FOR UN-SHIELDED MEDIUM VOLTAGE UNDERGROUND CABLES

[1] The following can be used to assess the un-shielded medium voltage cable condition:

(a) Applying lessons learned from forensic analysis of un-shielded medium voltage cables with the same insulations from other plants.

(b) Applying lessons learned from operating experience from related un-shielded medium voltage cables under similar conditions.

(c) Removal and testing of un-shielded medium voltage cable removed from service.

(d) Removal and testing of abandoned un-shielded medium voltage cable.

5.5[1] cont.

(e) Full forensic analysis of un-shielded medium voltage cables if failure occurs.

(f) Keep the cables from submergence if applicable.

5.6 ACTIONS FOR LOW VOLTAGE UNDERGROUND POWER CABLES

[1] Perform Insulation Resistance testing for assessing wetted low voltage power cable degradation.

> NOTE
>
> The intent of this procedure is not to change the existing site procedures or processes already in place for measuring Insulation Resistance of the cable as part of other PMs (e.g. Motor PM, Breaker PM, etc). If the existing PM task includes cables in the scope, it may be used.

[2] **IF** an existing PM task for performing Insulation Resistance test includes cables in the scope, **THEN** the testing frequency (should not exceed 6 years), the test voltage, and the acceptance criteria under that PM shall be considered as acceptable.

> NOTE
>
> Typically, the Insulation Resistance of the load is much lower than the Insulation Resistance of the cable. In many cases, the condition of the load dominates the results of the Insulation Resistance test reading. Therefore, a meaningful trending cannot be achieved if the cable is tested with the load.

[3] **IF** a cable is not covered by any existing PM task, **THEN** create a new PM task.

(a) The recommended frequency for performing Insulation Resistance test should not exceed approximately 6 years.

(b) Suggested test voltages and recommended Insulation Resistance acceptance criteria are provided in Attachment 9.2.

(c) The Insulation Resistance test results should be compensated for the temperature and humidity to the extent possible.

5.6[3] cont.

(d) If the cable is tested without the load, the Insulation Resistance value should be trended. Low or significantly decreasing trend in Insulation Resistance is indicative of insulation degradation.

NOTE

Care must be taken when comparing tests performed at different times. Changes could be the result of different temperature or moisture conditions during the tests.

(e) **IF** Insulation Resistance test indicates the Insulation Resistance value is less than the recommended Insulation Resistance acceptance criteria, **THEN** consider doing the following:

(1) Create Work Orders (WO) to separate the load from the cable.

(2) Determine whether the cause is the load or the cable.

(3) Document the condition using the PCRS Condition Reports as appropriate.

(4) Replace or repair the cable as needed

(5) Ensure splices made during the replacement will not be in submerged condition.

(6) Forensic analysis of the old cable is recommended to gain insight into the nature of the degradation.

5.7 MANHOLE INSPECTION AND DEWATERING

[1] Manhole inspection should be performed in accordance with the approved PM template.

[2] Energized cables in wet environments may accelerate the insulation aging effects. Even though cables are identified as being designed to operate in a wet environment, water can permeate through the jacket and insulation. Cables should be kept from submergence if possible to increase the longevity of the insulation system.

5.7[2] cont.

(a) Sump pumps should be installed wherever practical in manholes, vaults, and duct systems which contain Medium Voltage In-scope Cable List (MVICL) or Low Voltage In-scope Cable List (LVICL) cables that have the potential for submergence.

(b) If manual inspections and pumping are used to maintain a cable system dry, the intervals must be sufficient to keep the cables dry. Adjust intervals as necessary, based on inspection results.

(1) If cable rewetting occurs, use of the corrective action process is recommended for trending the occurrence and as found water levels. [CR-HQN-2011-00491]

(c) Where automatic sump pumps are being used to maintain a cable system dry, sump pump and limit switch inspections and preventive maintenance tasks should be in place.

6.0 INTERFACES

[1] EN-AD-103, Document Control and Records Management Programs

[2] EN-DC-310, Predictive Maintenance Program

[3] EN-DC-324, Preventive Maintenance Program

[4] EN-LI-102, Corrective Action Process

7.0 RECORDS

None

8.0 SITE SPECIFIC COMMITMENTS

Step	Site	Document	Commitment Number or Reference
All	ANO-1	1CAN010003	NRC Commitment A-17874, License Renewal, Implement new electrical component inspection program and maintain program as described in the source documents
All	ANO-2	2CAN100302	NRC Commitment A-17922, License Renewal, Implement and maintain non-EQ inaccessible medium-voltage cable program

Step	Site	Document	Commitment Number or Reference
All	IP2	NL-07-039 NL-07-153	NRC Commitment LAR-2008-130-15, License Renewal, Implement Non-EQ Inaccessible Medium-Voltage Cable Program as described in LRA Section B.1.23.
All	IP3	NL-07-039 NL-07-153	NRC Commitment LAR-2008-130-15, License Renewal, Implement Non-EQ Inaccessible Medium-Voltage Cable Program as described in LRA Section B.1.23
All	PLP	Letter 8/25/05 (Enclosure 2) [ML052410206]	RLC LO-LAR-2009-244-26, " Non-EQ Electrical Commodities Condition Monitoring Program," License Renewal, Develop and implement non-EQ commodities condition monitoring program, LRA Section B2.1.12
All	PNPS	LTR 2.07.029	NRC Commitment RC07-2029-15; License Renewal, Implement the Non-EQ Inaccessible Medium-Voltage Cable Program as described in LRA Section B.1.19
All	VY	BVY 06-009	NRC Commitment A-16782, License Renewal, Implement Non-EQ Inaccessible Medium-Voltage Cable Program as described in LRA Section B.1.19

9.0 ATTACHMENTS

9.1 Tan Delta Test Acceptance Criteria

9.2 Insulation Resistance Test Acceptance Criteria

9.3 Medium Voltage In-scope Cable List (Example)

9.4 Low Voltage In-scope Cable List (Example)

9.5 In-scope Manhole List (Example)

9.6 Cable Risk Ranking Guidelines

ATTACHMENT 9.1 TAN DELTA TEST ACCEPTANCE CRITERIA

Sheet 1 of 2

Insulation Material	Good Insulation Condition	Aged Insulation Condition (Further Study Required)	Highly Aged Insulation Condition (Action Required)
Butyl Rubber	Tan δ ≤ 12 and Delta Tan δ ≤ 3 and % std ≤ 0.02	12 < Tan δ ≤ 50 or 3 < Delta Tan δ ≤ 10 or 0.02 < % std ≤ 0.04	50 < Tan δ or 10 < Delta Tan δ or 0.04 < % std
EPR – Pink **EPR – Gray UniBlend®**	Tan δ ≤ 15 and Delta Tan δ ≤ 3 and % std ≤ 0.02	15 < Tan δ ≤ 30 or 3 < Delta Tan δ ≤ 8 or 0.02 < % std ≤ 0.04	30 < Tan δ or 8 < Delta Tan δ or 0.04 < % std
EPR -Black	Tan δ ≤ 12 and Delta Tan δ ≤ 3 and % std ≤ 0.02	12 < Tan δ ≤ 50 or 3 < Delta Tan δ ≤ 10 or 0.02 < % std ≤ 0.04	50 < Tan δ or 10 < Delta Tan δ or 0.04 < % std
EPR-Brown	Tan δ ≤ 50 and Delta Tan δ ≤ 5 and % std ≤ 0.02	50 < Tan δ ≤ 60 or 5 < Delta Tan δ ≤ 15 or 0.02 < % std ≤ 0.04	60 < Tan δ or 15 < Delta Tan δ or 0.04 < % std
Other types	No data established	No data established	No data established

Notes:

1. Delta Tan Delta is an absolute value of the difference in Tan Delta between $0.5V_o$ and $1.5V_o$ (where V_o is the normal phase to ground operating voltage).

2. The difference in Tan Delta is normally positive. Negative differences should be treated as very significant and may indicate a problem with a test or an indication of the presence of a significant defect.

3. The Tan Delta acceptance criteria have been significantly changed from the previous acceptance criteria (because of EPRI report 1020805). However, previous data will remain acceptable since the circuits have been returned to service and the data will be used for trending.

4. The % std (percent standard deviation) is an additional indicator of instability in the insulation, especially at lower test voltages, when the Tan Delta and delta Tan Delta values may still be within the acceptable limits.

ATTACHMENT 9.2 — INSULATION RESISTANCE TEST ACCEPTANCE CRITERIA

Sheet 1 of 1

Normal Rating of Equipment in Volts	Test Voltage*	Insulation Resistance in Megohms (with the load connected to the cable)*	Insulation Resistance in Megohms (cable only)
480V	1000V	100	$IR_{\min} = 1000 \times \left(\frac{kV + 1}{L} \right) M\Omega$ kV – Rated cable voltage, in kilovolts L – Cable length, in feet
600V	1000V	100	
1000V	1000V	100	
2000V	1000V	100	

* The test voltage and Insulation Resistance value are only for new PMs. Any existing site procedures or processes (including test voltage and Insulation Resistance value) already in place for measuring Insulation Resistance shall be considered acceptable.

Typically, Insulation Resistance of a cable is much greater than 100 Meg-ohms (usually in Giga-ohms range). Therefore, measuring Insulation Resistance of a cable with the load connected to one end indicates that the Insulation Resistance of the cable itself is greater than the measured Insulation Resistance (greater than 100 Meg-ohm).

If the combined Insulation Resistance of the cable (with the load connected to one end) did not meet the 100 Meg-ohms criteria, cable shall be tested itself (disconnected from the load) to ensure the Insulation Resistance of the cable is greater than the calculated value using the equation.

ATTACHMENT 9.3 **MEDIUM VOLTAGE IN-SCOPE CABLE LIST (EXAMPLE)**

Sheet 1 of 2

The following information should be collected and included into the Medium Voltage In-scope Cable List (MVICL):

a. Plant

b. Supporting Equipment

c. Manufacturer

d. Insulation type

e. Installed Year

f. Length

g. Shielding

h. Number of Splices

i. Cable Rated Voltage

j. Safety Functions

k. Notes

ATTACHMENT 9.3 — **MEDIUM VOLTAGE IN-SCOPE CABLE LIST (EXAMPLE)**

Sheet 2 of 2

Plant	Supporting Equipment	Manufacturer	Insulation Type	Installed Year	Length	Shielding	Number of Splices	Cable Rated Voltage	Safety Functions	Notes
ANO-2	2P4A	OKONITE	EPR	1993	1066	Yes		5 kV	SR	The insulation is Red EPR. Previous cable (Anaconda) had Black EPR insulation and was replaced because of its water absorption characteristic not compatible to underground installation
ANO-2	2A9 Switchgear	OKONITE	EPR	1995	1335	Yes		5 kV	SR	
VY	P-7-1A	COLLYER	BUTYR (BR)	1967	975	Yes		5 kV	SR	

ATTACHMENT 9.4 LOW VOLTAGE IN-SCOPE CABLE LIST (EXAMPLE)

Sheet 1 of 2

The following information should be collected and included into the Low Voltage In-scope Cable List (LVICL):

a. Plant

b. Supporting Equipment

c. Manufacturer (if known)

d. Installed Year (if known)

e. Length

f. Number of Splices

g. Cable Rated Voltage

h. Cable Application Voltage

i. Safety Functions

j. Notes

ATTACHMENT 9.4 — LOW VOLTAGE IN-SCOPE CABLE LIST (EXAMPLE)

Sheet 2 of 2

Plant	Supporting Equipment	Manufacturer (if known)	Installed Year (if known)	Length	Number of Splices	Cable Rated Voltage	Cable Application Voltage	Safety Functions	Notes

ATTACHMENT 9.5 IN-SCOPE MANHOLE LIST (EXAMPLE)

Sheet 1 of 2

The following information should be collected and included into the In-scope Manhole List (IML):

a. Plant

b. Manhole ID

c. Cables of Interest

d. Location

e. Voltage Class Level

f. Sump Pump Availability

g. Sump Pump Functional

h. Other Manholes Connected to this Manhole

i. Height of Lowest Cables from the Floor (level that submergence occurs)

j. Notes

ATTACHMENT 9.5 IN-SCOPE MANHOLE LIST (EXAMPLE)

Sheet 2 of 2

Plant	Manhole ID	Cable of Interest	Location	Voltage Class Level	Sump Pump Availability	Sump Pump Functional	Other Manholes Connected to this Manhole	Height of Lowest Cables from the Floor	Notes

Existing information regarding cables and raceway will be used to create a Cable Risk Factor (CRF) associated with each cable. A CRF for each cable will be calculated from all of the individual risk factors associated with each of the cable's parameters. Setting priorities for testing shielded medium voltage cables or developing contingencies plan for replacing unshielded cable will be based on the cable's CRF. A higher number represents a higher risk cable.

The database is a living document. Therefore, as new information associated with the cable parameter or risk factor becomes available, the database will be updated. The following parameters will be used to calculate the CRF:

1. Criticality Risk Factor – The following will be used to calculate Criticality Risk Factor:
   a. Supplying power to high critical multiple loads – 10
   b. Supplying power to high critical single load - 8
   c. Supplying power to low critical multiple loads – 7
   d. Supplying power to low critical single load -5
   e. Supplying power to non critical load but important for power operation – 3
   f. Supplying power to non critical load – 1
   g. Others – 0

2. Tech Spec / LCO Risk Factor – The following will be used to calculate Tech Spec / LCO Risk Factor:
   a. LCO ≤3 days or PRA High Risk – 10
   b. 3< LCO ≤14 days – 7
   c. 14< LCO ≤30 days – 4
   d. LCO greater than 30 days – 1
   e. No LCO or Compensatory actions – 0

3. Adverse Environment Risk Factor – The following will be used to calculate Adverse Environment Risk Factor:
   a. Cable submerged all the time – 10
   b. Direct buried cable – 10
   c. Cable submerged in the past – 7
   d. Never submerged – 2
   e. Dry cables – 0

4. Insulation Type Risk Factor – The type of cable insulation will be assigned an Insulation Type Risk Factor:
   a. XLPE – 10
   b. Butyl Rubber – 10

c. Black EPR – 10
d. Brown EPR – 5
e. Pink EPR – 5
f. Other types – 10

5. Service Life Risk Factor – Each cable will be assigned a Service Risk Factor based on whether the cable has been replaced or is an original installation:
   a. More than 30 years in service – 10
   b. More than 20 years but less than 30 years in service – 7
   c. More than 10 years but less than 20 years in service – 5
   d. More than 5 years but less than 10 years in service – 1
   e. Less than 5 years in service – 0

6. Ampacity Risk Factor – The following will be used to calculate the Ampacity Risk Factor:
   a. FLC is greater than 110% Ampacity – 10
   b. FLC is greater than 100% but less than 110% Ampacity – 7
   c. FLC is greater than 80% but less than 100% Ampacity – 5
   d. FLC is less than 80% Ampacity – 2

7. Splices Risk Factor – Cable splices are a significant contributor to cable failures. The following will be used to calculate Splice Risk Factor:
   a. Cable has splices and heavily loaded – 10
   b. Cable has splices and lightly loaded – 8
   c. Cable has no splices and heavily loaded – 3
   d. Cable has no splices and lightly loaded – 0

8. Testing and Inspection Risk Factor – A testing Risk Factor will be assigned to each cable based on the results of testing and inspection performed on the cable:
   a. Significant decrease in cable insulation – 10
   b. Indication of declining cable insulation – 7
   c. No indication of degraded insulation – 0
   d. Cable has never been tested – 4

Score = Criticality Risk Factor + Tech Spec / LCO Risk Factor + 15xAdverse Environment Risk Factor + Insulation Type Risk Factor + Service Life Risk Factor + Ampacity Risk Factor + Splices Risk Factor + Testing and Inspection Risk Factor

ATTACHMENT 9.6 CABLE RISK RANKING GUIDELINES

Sheet 3 of 3

Site	Supporting Equipment	Cable ID	Cable Accessibility	Criticality Risk Factor	Tech Spec/LCO Risk Factor	Adverse Environment Risk Factor	Insulation Type Risk Factor	Service Life Risk Factor	Ampacity Risk Factor	Splices Risk Factor	Testing & Inspection Risk Factor	Score