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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
04/30/2012				

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	Ran Gilmore	Manager, Programs & Components
N/A	NP		
	HQN	Sinnathurai Gajanetharan	Engineer, Major 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Site and NMM Procedures Canceled or Superseded By This Revision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

- Introduced Medium Voltage (MV) and Low Voltage (LV) abbreviations
- Clarified Section 1.0[1] that handholes that contain the program scope cables should be included in the In-scope Manhole List (IML)
- Added EPRI report TR-1022969 and INPO HOW TO document to Section 2.1 and 2.2 respectively
- Added definition for “Potential Adverse Localized Environments”
- Revised Section 4.9[3] to require cable risk ranking for LV In-scope Cables
- Revised Section 4.9[6] to clarify that the engineering is required to ensure that Condition Reports are generated
- Added Section 4.9[12], 4.9[13], 4.9[14], 4.9[15], and 4.9[16] to clarify the responsibility of component engineering at site
- Clarified Section 5.3[3] to allow combining risk ranking and In-scope Cable List into one for MV cables
- Added Section 5.3[6] to require cable risk ranking for LV In-scope Cables and to allow combining risk ranking and LV In-scope Cable List into one
- Revised Section 5.4[2] to use EN-MA-138
- Added Section 5.5[2] to require cable replacement if un-shielded cable aging is identified and long-term wetting cannot be eliminated, the cable should be replaced prior to failure
- Added EN-MA-138 to Section 6.0
- Corrected Site Specific Commitments reference number for VY
- Revised the Tan Delta acceptance criteria for Highly Aged Insulation Condition with the proper use of greater than sign (>)
- Clarified the proper way to use the Delta Tan Delta
- Revised Insulation Resistance acceptance criteria

- Added the word “Known” prior to the word “Splices” in Attachment 9.3 and 9.4
- Added the word “if Known” next to “Height of Lowest Cables from the Floor” in Attachment 9.5
- Added the word “Red” in Attachment 9.6 Section 4(e)
- Added the word “Known” prior to the word splices in Attachment 9.6 Section 7(a), 7(b), 7(c), and 7(d)

* Requires justification for the exception

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1.0 PURPOSE

[1] The purpose of this procedure is to provide guidance to establish and monitor the insulation condition of underground Medium Voltage (MV) and Low Voltage (LV) power cables using appropriate testing and evaluation of test results. Also, this procedure provides guidance on manhole and handhole (hereafter referred to as manhole) inspection and dewatering.

[2] The purpose of the Cable Reliability Program is to provide the means to effectively manage underground MV and LV 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 MV and LV 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 MV and LV 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”

[21] EPRI TR-1022969, “Electrical Cable Test Applicability Matrix for Nuclear Power Plants”

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”

[5] INPO HOW TO, “Power Cable Aging Management”

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”

2.3 cont.

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

[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”

2.4 cont.

[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

[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] 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 (LV) 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 (MV) 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.

3.0 cont.

[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.

[13] Potential Adverse Localized Environments and Service Condition – Environments in the plant area that are significantly more severe than the specified service condition for that area. This includes an area that could potentially place aging stresses on cables, such as the presence of water at the cable surface, area with elevated temperatures, area with high radiation, or area with chemical exposure to cables.

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

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

[16] 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.

[17] 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.

[18] 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.

[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.

4.7 cont.

[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.

[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 for Medium Voltage In-scope cables and Low 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] Ensuring Condition Reports (CRs) are initiated for conditions that fail to meet the acceptance criteria or cable failure.

4.9 cont.

[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.

[12] Ensuring relevant technical documents and engineering procedures are maintained up to date and consistent with other controlled documents.

[13] Overseeing program support and implementing activities.

[14] Participating in program audits and assessments.

[15] Evaluating industry and internal operating experience for the program and identifying and applying lessons learned to both the site and fleet, when applicable.

[16] Updating management on overall condition of the plant cable program health including program execution.

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.

4.10 cont.

[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 shielded MV 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 MV and LV 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 MV and LV 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 MV and LV 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.

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

5.2[6] cont.

(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/Withstand) (or industry recommended methods) testing can be used for condition monitoring and aging assessment of shielded MV 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 (DC Withstand) testing 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.

(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.

5.2 cont.

[9] Insulation Resistance (IR) testing can be used to detect the deterioration of LV power cable insulation from wetting.

(a) IR 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) IR test identifies only reasonably gross damage, contamination, or deterioration.

(d) IR 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 (PD) testing can be used for condition monitoring of MV cables.

(a) PD testing 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) PD 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 MV and LV 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.

5.3 cont.

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

(a) Attachment 9.3 contains an example MVICL spreadsheet.

[3] Prepare Cable Risk Ranking in accordance with Attachment 9.6 for MVICL. It is acceptable to combine the Cable Risk Ranking and MVICL into one spreadsheet.

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

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

(a) Attachment 9.4 contains an example LVICL spreadsheet.

[6] Prepare Cable Risk Ranking in accordance with Attachment 9.6 for LVICL. It is acceptable to combine the Cable Risk Ranking and LVICL into one spreadsheet.

[7] Identify all manholes that contain MV and LV 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.

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

(a) Attachment 9.5 contains an example IML spreadsheet.

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 Basis Template and EN-MA-138.

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 MV cable condition:

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

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

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

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

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

(f) Keep the cables from submergence if applicable.

5.5 cont.

[2] If un-shielded cable aging is identified and long-term wetting cannot be eliminated, the cable should be replaced prior to failure and consideration should be given to use of an impervious cable design for the replacement cable.

5.6 ACTIONS FOR LOW VOLTAGE UNDERGROUND POWER CABLES

[1] Perform IR testing for assessing wetted LV power cable degradation.

> NOTE
>
> The intent of this procedure is not to change the existing site procedures or processes already in place for measuring IR 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 IR 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 IR of the load is much lower than the IR of the cable. In many cases, the condition of the load dominates the results of the IR 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 IR test should not exceed approximately 6 years.

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

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

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

5.6[3] cont.

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** IR test indicates the IR value is less than the recommended IR 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 / HANDHOLE 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.

(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.

5.7[2](b) cont.

(1) If cable rewetting occurs, corrective action process shall be used for trending the occurrence and as found water levels. The submerged cables shall be evaluated. [CR-HQN-2011-00491]

(2) If un-shielded cable rewetting repeats or cannot be eliminated, the cable should be replaced prior to failure and consideration should be given to use of an impervious cable design for the replacement cable.

(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

[5] EN-MA-138, VLF Tan Delta and Withstand Testing of Electrical Power Cables

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.1.17

9.0 ATTACHMENTS

9.1 Tan Delta Test Acceptance Criteria

9.2 Insulation Resistance (IR) 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. Dev. ≤ 0.02	12 < Tan δ ≤ 50 or 3 < Delta Tan δ ≤ 10 or 0.02 < % Std. Dev. ≤ 0.04	Tan δ > 50 or Delta Tan δ > 10 or % Std. Dev. > 0.04
EPR – Pink / Red **EPR – Gray UniBlend®**	Tan δ ≤ 15 and Delta Tan δ ≤ 3 and % Std. Dev. ≤ 0.02	15 < Tan δ ≤ 30 or 3 < Delta Tan δ ≤ 8 or 0.02 < % Std. Dev. ≤ 0.04	Tan δ > 30 or Delta Tan δ > 8 or % Std. Dev. > 0.04
EPR -Black	Tan δ ≤ 12 and Delta Tan δ ≤ 3 and % Std. Dev. ≤ 0.02	12 < Tan δ ≤ 50 or 3 < Delta Tan δ ≤ 10 or 0.02 < % Std. Dev. ≤ 0.04	Tan δ > 50 or Delta Tan δ > 10 or % Std. Dev. > 0.04
EPR-Brown	Tan δ ≤ 50 and Delta Tan δ ≤ 5 and % Std. Dev. ≤ 0.02	50 < Tan δ ≤ 60 or 5 < Delta Tan δ ≤ 15 or 0.02 < % Std. Dev. ≤ 0.04	Tan δ > 60 or Delta Tan δ >15 or % Std. Dev. > 0.04
Other types	No data established	No data established	No data established

Notes:

1. Delta Tan Delta (Delta Tan δ) is an absolute value of the difference in Tan Delta (Tan δ) at the first and third Tan Delta values (typically, $1.5V_o – 0.5V_o$, 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. Dev. (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 (IR) TEST ACCEPTANCE CRITERIA

Sheet 1 of 1

Cable with End Equipment (Connected to the load)			**Cable Only (Disconnected from the load)**		
Normal Rating of the End Equipment in Volts	Test Voltage*	Insulation Resistance (IR) in MΩ*	Normal Rating of the Cable in Volts	Test Voltage*	Insulation Resistance (IR) in MΩ*
480V	500V	100 MΩ	480V	500V	100 MΩ/1000 ft
600V	500V	100 MΩ	600V	500V	100 MΩ/1000 ft
1000V	1000V	100 MΩ	1000V	1000V	100 MΩ/1000 ft
2000V	1000V	100 MΩ	2000V	1000V	100 MΩ/1000 ft

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

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

If the combined IR of the cable (with the load connected to one end) did not meet the 100 MΩ criteria, It is recommended that the cable be tested by itself (disconnected from the load) to ensure the IR of the cable is greater than100 MΩ/1000 ft.

The IR of a cable is indirectly proportional to its length. Accordingly, minimum values must be corrected to a specific length. If the circuit length is 250 ft, the minimum IR is 400 MΩ. Similarly, if the length is 2000 ft, the minimum IR is 50 MΩ.

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 Known 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 Known Splices	Cable Rated Voltage	Safety Functions	Notes
ANO-2	2P4A	OKONITE	EPR	1993	1066	Yes	0	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	0	5 kV	SR	
VY	P-7-1A	COLLYER	BUTYR (BR)	1967	975	Yes	0	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 Known 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 Known Splices	Cable Rated Voltage	Cable Application Voltage	Safety Functions	Notes
WF3	Motor (CMUEMTR214B-4H)	Unknown	1980	290 ft	0	600V	480VAC	MR	Drawing B424 sheet 1361
WF3	Panel (SSDEMCC222AB)	Unknown	1980	1070 ft	0	600V	480VAC	MR	Drawing B424 sheet 2461

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 if Known (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 if known	Notes
ANO-1	MH-01	CW cables Fire Water cables	Near SU1 XFMR Inside fenced in area, inside XFMR yard.	4160V	No	N/A	MH1, MH3, MH4, MH5 & MH6 are all interconnected	0”	Within 6’ of energized 22KV bus. Must be pumped during SU1 outage. WARNING: Close proximity to live bare 22kv. (EN-IS-123 requires min. 6 FT personnel clearance and min 10 ft crane or lifting device clearance. Use of a picker will not meet minimum safe clearance.)
ANO-2	2MH-05	SU3	West side of old LLRWB inside fenced area. (Requires RWP)	22KV	No	N/A	2MH4, 2MH5 & 2MH6 are interconnected	24”	Requires RWP; also, pump must be swiped by RP after pumping to get released from fenced in area
WF3	M301-NA	Condenser Vacuum Pump Motor 480V MCC	Refer drawing G349	120V 480V	No	N/A	None	6”	Drawing B424 sheet 1925

ATTACHMENT 9.6 CABLE RISK RANKING GUIDELINES

Sheet 1 of 3

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 MV 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 / Red 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 known splices and heavily loaded – 10
   b. Cable has known splices and lightly loaded – 8
   c. Cable has no known splices and heavily loaded – 3
   d. Cable has no known 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	Splice Risk Factor	Testing & Inspection Risk Factor	Score
ANO-1	Motor (P-3A)	A110A, B, C	Non-Outage	3	0	7	5	0	2	0	0	115
IPEC	Motor (21CWP-MTR)	Unknown	Outage	8	0	7	10	10	5	8	0	146
PLP	Transformer (Safeguard)	Unknown	Outage	10	10	10	10	5	5	8	0	198
RBS	Motor (CWS-P1A)	1CWSANH300 1CWSANH301 1CWSANH303	Non-Outage	8	4	7	5	7	5	3	7	144

Color	Score Criteria
Green	7 ≤ Score < 160
White	160 ≤ Score < 180
Yellow	180 ≤ Score < 200
Red	200 ≤ Score < 220