

*Revisions to this document shall be communicated in accordance with program document AM-EU-P034 to ensure alignment between PCM Templates and field work procedures.*

<b>Low Pressure Fluid Filled (LPFF) Cable System</b>			
Component Classification Categories			
Criticality	I	X	All Locations
	II		
Duty Cycle	Heavy Load	N/A	
	Normal load	X	
Service Condition	In-Service	X	
	Spare	N/A	
<b>Condition Monitoring Tasks</b>			
	<b>Task Frequencies</b>	<b>Failure Codes</b>	<b>Comments</b>
<b>Check Fluid Reservoir Levels</b>	4Y	1, 2a-b, 3c	Done in conjunction with Manhole Inspections
<b>Record Insulating Fluid Pressures</b>	4Y	1, 2a-b, 3c	Done in conjunction with Manhole Inspections
<b>Inspect, Vent Terminations</b>	4Y	3a, 3d	Done in conjunction with DGA Sampling at Terminations
<b>DGA (Dissolved Gas Analysis) Sampling</b>	4Y	3a	
<b>Fluid Quality</b>	4Y	3b	
<b>Time Directed Tasks</b>			
	<b>Task Frequencies</b>	<b>Failure Codes</b>	<b>Comments</b>
None	N/A		
<b>Failure Finding</b>			
	<b>Task Frequencies</b>	<b>Failure Codes</b>	<b>Comments</b>
<b>Test Alarms</b>	1Y	1, 2a-b	
<b>Inspect Bonding Transformers and Inductors</b>	4Y	2b	Done in conjunction with Manhole Inspections
<b>Inspect Joint Casings</b>	4Y	3d	Done in conjunction with Manhole Inspections
<b>Inspect Manholes (Including Auxiliaries)</b>	4Y	1, 2a-b	
<b>Condition Directed Tasks</b>			
	<b>Task Frequencies</b>	<b>Failure Codes</b>	<b>Comments</b>
None	N/A		

### **FAILURE MODE**

1. Fails to Provide Adequate Capacity
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1. Fails to Provide Adequate Capacity
  
2. Fails to Maintain Boundary Integrity
  
3. Fails to Provide Adequate Electrical Insulation

### **FAILURE CAUSES**

1. Low Fluid Levels
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- 2a. Gasket / Joint Failure
- 2a. Gasket / Joint Failure
- 2a. Gasket / Joint Failure
- 2b. Corrosion
- 2b. Corrosion
- 2b. Corrosion
- 2b. Corrosion
  
- 3a. Tracking / Corona Discharge
- 3a. Tracking / Corona Discharge
- 3b. Moisture Intrusion Poor Fluid Quality
- 3c. Low Pressure Lack of Fluid
- 3d. Entrapped Air in Line or Termination
- 3e. Joint corrosion / Improper Bonding

### **MAINTENANCE TASKS**

- Inspect Manholes (Including Auxilliaries)  
Check Fluid Reservoir Levels  
Test Alarms
- Inspect Manholes (Including Auxilliaries)  
Check Fluid Reservoir Levels  
Test Alarms  
Inspect Manholes (Including Auxilliaries)  
Check Fluid Reservoir Levels  
Test Alarms  
Inspect Bonding Transformers and Inductors
- Inspect Terminations  
DGA Sampling  
Fluid Quality  
Check Fluid Reservoir Levels  
Vent Terminations  
Inspect Joint Casings

TASK	DEFINITION
Check Fluid Reservoir Levels	Inspect fluid reservoir levels, track any fluid loss and change desiccant on breathers of CC reservoirs.
DGA Sampling	Take syringe samples of insulating fluid from all reservoirs, termination reservoirs and joints.
Inspect Bonding Transformers and Inductors	Inspect for bushing leaks and case corrosion.
Inspect Joint Casings	Inspect protective wrapping integrity. Check exposed casings for corrosion or damage. Inspect bonding connection and casing lead wires for connection integrity. Inspect for leaks at led wipes and gaskets. Inspect for excessive cable movement.
Inspect Manholes (Including Auxilliaries)	Inspect structural integrity of manhole walls, floors and ceilings. Inspect hardware including ladders, cable racking, saddles, verticals, brackets, hangars and duct shields. Inspect frames, covers and necks. Inspect and clean ventilating grates. Inspect reservoirs and track fluid loss. Record insulating fluid pressures and end of section pressures. Inspect sump pumps and electrical equipment.
Inspect Terminations	Inspect for oil leaks, cracks, damaged or broken porcelain and surface tracking. Ensure insulator is clean.
Fluid Quality	Take 1 quart sample of insulating fluid from all reservoirs, termination reservoirs and joints.
Record Insulating Fluid Pressures	Record insulating fluid pressures in manholes.
Test Alarms	Test alarms and record appropriate information. Activate the alarm system as necessary to verify alarms are received at designated authority. Inspect relay boxes and gaskets, change desiccant in all boxes.
Vent Terminations	Bleed terminations to expel any trapped air or gas and verify they are filled with Insulating fluid.

## Low Pressure Fluid Filled (LPFF) Cable Template Summary

The Preventive Maintenance program is documented via Performance Centered Maintenance (PCM) templates. Templates have been developed that address all transmission, substation, and distribution equipment that is owned, and / or, maintained by EED. Each template documents the program tasks, frequencies, failure modes, and maintenance basis for the associated equipment. Tasks and associated frequencies are designed to address known failure modes of the equipment covered by the template. In general, the tasks included in the PCM templates are the result of good industry practices, industry experience, and manufacturer recommendations.

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### References:

EPRI Report TR-101670, Underground Transmission System Reference Book (1992 Edition)  
EEI Underground Systems Reference Book (1957 Edition)  
Transmission Cable Maintenance Guide, Prepared by Detroit Edison Company (9/27/00)

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### Boundary Definition

The boundary of Transmission Low Pressure Fluid Filled Cable systems are defined from Termination to Termination, including:

- Auxiliary equipment
- Alarms and Control Systems
- Bonding Systems
- Joints
- Manholes
- Pressurized Systems
- Tanks
- Terminations

Excluded from this treatment are: protective, timing, and control relays and Cathodic Protection Systems.

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### Failure Experiences

Failures are subject to ACE/RCI investigation. Findings/recommended corrective actions are incorporated into the template as warranted.

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### **Vendor Recommendations**

OEM manuals were referenced and interviews conducted during the development of this template.

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### **Disposition of Vendor Recommendations**

Recommendations were incorporated into the template as appropriate based on operating experience.

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### **Basis For Template Tasks**

**Check Fluid Reservoir Level:** Inspect fluid reservoir levels, track any fluid loss and change desiccant on breathers of CC reservoirs.

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**DGA Sampling:** Analysis of the insulating fluid is used as a tool for detecting electrical degradation of the insulating system.

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**Inspect Bonding Transformers and Inductors:** Inspection approximates real-time condition monitoring that can detect developing problems and degradation, and provides condition data used to initiate corrective actions.

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**Inspect Joint Casings :** Inspection approximates real-time condition monitoring that can detect developing problems and degradation, and provides condition data used to initiate corrective actions.

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**Inspect Manholes (Including Auxilliaris):** Inspection approximates real-time condition monitoring that can detect developing problems and degradation, and provides condition data used to initiate corrective actions.

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**Inspect Terminations:** Inspection approximates real-time condition monitoring that can detect developing problems and degradation, and provides condition data used to initiate corrective actions.

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**Fluid Quality:** Analysis of the sample is used as a tool for monitoring aging and condition of the insulating system. The scope of testing includes: Dielectric Strength, Moisture Content, and Power Factor.

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**Record Insulating Fluid Pressures:** Recorded data may be trended.

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**Test Alarms:** Intent of this task is to verify that any alarm initiated by a device or sensor at the equipment results in a notification at the control building and/or at the control / operations center. Timely and appropriate response to abnormal equipment conditions is contingent on proper operation of the alarm systems.

<b>Revision 0</b>		<b>Date 11/06/2006</b>
Writer	George Leinhauser (Strategic Programs)	
Reviewer(s)		
Approver(s)	Kathy McHugh (FAM Maintenance Planning)	
Reason Written	To document the maintenance program tasks, frequencies, failure modes, and maintenance basis.	

<b>Revision 1</b>		<b>Date 11/30/2010</b>
Writer	Chuck Priebe	
Reviewer(s)	Ken Wendt (Mgr. Material Condition)	
Approver(s)	Bill Fluhler , Bill Gannon, Nitin Patel, Jim Crane, Bill Sullivan	
Reason Written	Added note to ensure template changes are communicated to affected work groups.	

<b>Revision 2</b>		<b>Date 06/15/2011</b>
Writer	Chuck Priebe (Mat'l. Condition)	
Reviewer(s)	Ken Wendt (Mgr. Mat'l. Condition), Frank Frentzas (Trans. Eng.), Rob Fournie (Mgr. Trans. Eng.)	
Approver(s)	Bill Fluhler	
Reason Written	Revised Tasks and Frequencies to align with material condition improvement and operating experience.	

<b>Revision 3</b>		<b>Date 06/18/2014</b>
Writer	Angelo DeAngelis	
Reviewer(s)	Frank Frentzas(Trans. Eng.), Ken Wendt (Material Condition)	
Approver(s)	Mike Moy (ComEd UFAM)	
Reason Written	a) Align Task Frequencies from 1YR to 3YR for manholes/components previously falling under the Central Business District Criticality Category; includes inspection Tasks for manholes, joint casings, bonding transformers/inductors, insulating fluid pressure, fluid reservoir levels. b.) Revised Condition Monitoring Task "DGA Sampling" to "DGA (Dissolved Gas Analysis) Sampling" .	

<b>Revision 4</b>		<b>Date 02/06/2015</b>
Writer	Frank Frentzas	
Reviewer(s)	James Flisk (Trans. Eng.), Angelo DeAngelis (Material Condition)	
Approver(s)	Mike Moy (ComEd UFAM)	
Reason Written	Aligned Task Frequencies to EU North Star Template as part of the PM Alignment initiative.	

<b>Revision 5</b>		<b>Date 02/02/2018</b>
Writer	Angelo DeAngelis (Material Condition)	
Reviewer(s)	Frank Frentzas (Trans. Eng.)	
Approver(s)	Mike Moy (ComEd UFAM)	
Reason Written	3 year review, no content changes.	