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

Substation Capacitor Bank							
Component Classification Categories							
Criticality	I	X					DC, SS, TDC, TSS locations that serve O'Hare & Midway Airports
	II		X				Locations exclusive of Criticality I, DCs and ≤34kV ESS locations
	III			X			DC locations
	IV				X		≤34kV ESS locations
Duty Cycle	Heavy Load	N/A	N/A	N/A	N/A		
	Normal load	N/A	N/A	N/A	N/A		
Service Condition	In-Service	X	X	X	X		
	Spare	N/A	N/A	N/A	N/A		

Condition Monitoring Tasks	**Task Frequencies**				**Failure Codes**	**Comments**
Monitor Phase/Neutral Balance	**SCADA**	**SCADA**	**SCADA**	**SCADA**	**1a**	Where automatic unbalance relay installed
Time Directed Tasks	**Task Frequencies**				**Failure Codes**	**Comments**
None	**N/A**	**N/A**	**N/A**	**N/A**		
Failure Finding	**Task Frequencies**				**Failure Codes**	**Comments**
Visual Inspection	**5W**	**10W**	**3M**	**6M**	**2a-c, 3a, 6a**	
Check Control Cabinet Heaters - Vacuum/Oil Switch	**5W**	**10W**	**3M**	**6M**	**4a**	
Thermography	**1Y**	**1Y**	**1Y**	**4Y**	**1b, 5a, 6a**	
Condition Directed Tasks	**Task Frequencies**				**Failure Codes**	**Comments**
None	**N/A**	**N/A**	**N/A**	**N/A**		

Capacitor Bank Failure Modes

FAILURE MODE	FAILURE CAUSES	MAINTENANCE TASKS
1. Fails to Provide Adequate Volt-Amp Reactance (VAR)	1a. Loss of Individual Can	Monitor Phase/Neutral Balance
1. Fails to Provide Adequate Volt-Amp Reactance (VAR)	1b. Hot connection / Open Connection	Thermography
2. Fails to Provide Adequate Electrical Insulation	2a. Cracked or Broken Insulator	Visual Inspection
2. Fails to Provide Adequate Electrical Insulation	2b. External Contamination	Visual Inspection
2. Fails to Provide Adequate Electrical Insulation	2c. Vegetation / Animal Intrusion	Visual Inspection
3. Fails to Maintain Boundary Integrity	3a. Oil Leaking From Can	Visual Inspection
4. Fails to Open / Close	4a. Control Circuit Failure	Check Cabinet Heaters - Vacuum/Oil Switch
5. Fails to Provide Conduction Path	5a. Bus Connection / Bellows	Thermography
6. Fails to Maintain Adequate Insulation	6a. Cracked or Broken Insulator	Visual Inspection
6. Fails to Maintain Adequate Insulation	6a. Cracked or Broken Insulator	Thermography

Capacitor Bank Maintenance Task Definition

TASK	DEFINITION
Check Cabinet Heaters - Vacuum/Oil Switch	Visual / physical verification that cabinet heaters are operational.
Monitor Phase/Neutral Balance	Task is to document the use of the alarming feature via SCADA for locations where an automatic unbalance relay is installed.
Thermography	Infrared inspection of electrical equipment and power path components to identify any hot spots that may exist in the bus connections or individual cans. Comparisons should be made between like components on different phases.
Visual inspection	Visual inspection of the capacitor bank. Items to be checked include: -- Check to ensure fuses are intact -- Check for signs of oil leakage -- Check for unusual noises and smells -- Visually inspect for damaged, cracked or chipped porcelain insulators -- Check for loose, missing or damaged hardware -- Check condition of grounding connections -- Check to ensure inductors are intact

Capacitor Bank Maintenance Basis

Capacitor Template Summary

The Preventive Maintenance program is documented via maintenance templates. Templates have been developed that address transmission, substation, and distribution equipment that is owned and maintained by Exelon Utilities. 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 maintenance templates are the result of good industry practices, industry experience, and manufacturer recommendations.

References:
Internal failure reports
OEM Maintenance Manuals and Interviews
IEEE 1036-1992 Guide for application of Shunt Power Capacitors
IEEE C57.152-2013 "IEEE Guide for Diagnostic Field Testing of Fluid-filled Power Transformers, Regulators and Reactors"

Boundary Definition

The boundary of a substation type, Capacitor banks and associated vacuum switches is defined from bushing terminal of the bus breaker to include the vacuum switch and capacitor bank.

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

Failure Experiences

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

Vendor Recommendations

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

Disposition of Vendor Recommendations

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

Basis For Template Tasks

Capacitor Bank Maintenance Basis

Check Control Cabinet Heaters - Vacuum / Oil Switch: Continuous heater operation mitigates corrosion of components in the control cabinet.

Monitor Phase/Neutral Balance: This task is performed real-time and can detect developing problems and degradation. Alarms generated initiate corrective actions. Capacitor banks normally have an un-balance protection scheme associated with them to detect individual failed capacitor cans. When a capacitor fuse operates, there is an unbalanced in the bank phase impedance which the un-balance scheme will detect. On most banks 34kV and 13.8kV, the unbalance scheme is set to alarm for one can out, and trip for two cans out. On the 230 kV and 500 kV banks, the scheme is set to alarm at 2 cans out and trip at 3 cans out.

Thermography: IEEE C57.152 identifies thermography as a primary tool for detection of connection issues, bushing issues, and issues with the cooling systems.

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

CAPACITOR BANK - TEMPLATE DEVELOPMENT HISTORY

	Revision 0	**Date 06/17/2005**
Writer	George Leinhauser (Strategic Programs)	
Reviewer(s)	12/10/04 Template Challenge Session Attendees	
Approver(s)	Kathy McHugh (FAM Maintenance Planning)	
Reason Written	To document the maintenance program tasks, frequencies, failure modes, and maintenance basis	

	Revision 1	**Date 12/22/2006**
Writer	George Leinhauser (Strategic Programs)	
Reviewer(s)		
Approver(s)	Kathy McHugh (FAM Maintenance Planning)	
Reason Written	Task and periodicity review / update. General scrub.	

	Revision 2	**Date 11/30/2010**
Writer	Chris Stefanski	
Reviewer(s)	Ken Wendt (Mgr. Material Condition), Drew Reindel (Mgr. T&S Enginering)	
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.	

	Revision 3	**Date 04/29/2011**
Writer	Chris Stefanski (Material Condition)	
Reviewer(s)	Ken Wendt, Drew Reindel, Jim Crane	
Approver(s)	Bill Fluhler (ComEd) , Bill Sullivan (PECO)	
Reason Written	Modified criticality definitions and incorporated 10-week and 3-month inspection task frequencies	

	Revision CE 0	**Date 02/18/2015**
Writer	Chris Stefanski (Exelon Utilities)	
Reviewer(s)	Ken Wendt	
Approver(s)	Michael Moy (UFAM ComEd)	

CAPACITOR BANK - TEMPLATE DEVELOPMENT HISTORY

Reason Written	Revised criticality definitions and modified document to serve as the ComEd maintenance standard.

Revision CE 1	Date 02/12/2018
Writer	Hugo Castaneda (Material Condition)
Reviewer(s)	Dale Player (Mgr Material Condition), Doug Mason (T&S Equipment Stds)
Approver(s)	Michael Moy (UFAM ComEd)
Reason Written	3 year review with minor format changes and IEEE reference update. No content change.