

Distribution Circuit Breakers - 4-13 kV Air Magnetic								
Component Classification Categories								
Criticality	I	X					DC, SS, TDC, TSS locations that serve O'Hare & Midway Airports	
	II		X				Locations exclusive of Criticality I, DC 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	N/A		
	Normal Load	N/A	N/A	N/A	N/A	N/A		
Service Condition	In Service	X	X	X	X	N/A		
	Spare	N/A	N/A	N/A	N/A	X	Designated spare equipment	
Condition Monitoring Tasks								
	Task Frequencies					Failure Codes		Comments
Check Red (Closed) Indicating Lamp	5W	10W	3M	6M	N/A	2a		
Visual Inspection	5W	10W	3M	6M	10W	5a-b, 6a-b		
Thermography	1Y	1Y	1Y	4Y	N/A	4b		
Contact Resistance (Ductor) Test	6Y	6Y	6Y	6Y	N/A	1c, 2d, 3d, 4a		
Time Directed Tasks								
	Task Frequencies					Failure Codes		Comments
Exercise Mechanism	3Y	3Y	3Y	3Y	3Y	1a, 1d, 2b, 2e, 3b, 3e		
Aux Contact Block Inspection	6Y	6Y	6Y	6Y	6Y	1a, 2b, 3b		
Cubicle / Cabinet Maintenance	6Y	6Y	6Y	6Y	6Y	1a, 2b, 3b, 6a-b		
Mechanism Lubrication / Maintenance	6Y	6Y	6Y	6Y	N/A	1b, 2c, 3c		
Failure Finding Tasks								
	Task Frequencies					Failure Codes		Comments
Check Control Cabinet / Cubicle Heaters	5W	10W	3M	6M	10W	1a, 2b, 3a		
Condition Directed Tasks								
	Task Frequencies					Failure Codes		Comments
None	N/A	N/A	N/A	N/A	N/A			

FAILURE MODES

1. Fails to Close

2. Fails to Open

3. Fails to Interrupt

4. Fails to Provide Conduction Path
4. Fails to Provide Conductive Path

5. Fails to Provide Adequate Insulation Level
5. Fails to Provide Adequate Insulation Level

6. Fails to Maintain Boundary Integrity

FAILURE CAUSES

- 1a. Control Circuit Failure
- 1b. Lack of/Improper Lubrication
- 1c. Interrupter Failure
- 1d. Stored energy Failure

- 2a. Open Coil Failure
- 2b. Control Circuit Failure
- 2c. Lack of/Improper Lubrication
- 2d. Interrupter Failure
- 2e. Stored energy Failure

- 3a. Open Coil Failure
- 3b. Control Circuit Failure
- 3b. Control Circuit Failure
- 3b. Control Circuit Failure
- 3c. Lack of/Improper Lubrication
- 3d. Interrupter Failure
- 3e. Stored Energy Failure

- 4a. High Resistance Connection
- 4b. Bus Connections Failure

- 5a. External Contamination
- 5b. Solid Dielectric Failure

- 6a. Frame Weld Failure
- 6a. Frame Weld Failure
- 6b. Frame Corrosion
- 6b. Frame Corrosion

MAINTENANCE TASKS

- Exercise Mechanism
Check Control Cabinet / Cubicle Heaters
Cubicle / Cabinet Maintenance
Aux Contact Block Inspection
Mechanism Lubrication / Maintenance
Contact Resistance (Ductor) Test
Exercise Mechanism
- Check Red (Closed) Indicating Lamp
Exercise Mechanism
Check Control Cabinet / Cubicle Heaters
Cubicle / Cabinet Maintenance
Aux Contact Block Inspection
Mechanism Lubrication / Maintenance
Contact Resistance (Ductor) Test
Exercise Mechanism
- Check Control Cabinet / Cubicle Heaters
Exercise Mechanism
Cubicle / Cabinet Maintenance
Aux Contact Block Inspection
Mechanism Lubrication / Maintenance
Contact Resistance (Ductor) Test
Exercise Mechanism
- Contact Resistance (Ductor) Test
Thermography
- Visual Inspection
Visual Inspection
- Visual Inspection
Cubicle / Cabinet Maintenance
Visual Inspection
Cubicle / Cabinet Maintenance

TASK	DEFINITION
Aux Contact Block Inspection	Verify tightness of connections, check for signs of arcing, check for brittleness of insulation, check labeling.
Contact Resistance (Ductor) Test	Apply DC current (100 Amps DC) between terminals of equipment under test to measure current path resistance. Contact resistance testing is done prior to performing maintenance and after completion of maintenance. The as-found and as-left resistance values are used to verify maintenance effectiveness.
Check Control Cabinet / Cubicle Heaters Check Red (Closed) Indicating Lamp Cubicle / Cabinet Maintenance	<p>Visual / physical verification that cabinet heaters are operational.</p> <p>Verify red indicating lamp is lit on all closed breakers to ensure trip circuit continuity and control fuses.</p> <p>This task includes the following:</p> <ul style="list-style-type: none"> Check wiring and terminals for tightness and corrosion Check fuses for integrity Check that all indicating lamps and receptacles are working Check all doors, latches and weather seals are effective Check grounding connections for tightness Inspect for rodent or insect presence Clean all dust and debris from enclosure Check condition of position indicator Visually inspect bus ports (cubicle side) for evidence of leaking compound Maintain and lubricate the racking mechanism on switchgear breakers
Exercise Mechanism	Open and close breaker electrically.

TASK

Mechanism Lubrication /
Maintenance

DEFINITION

Off-line detailed inspection of the operating mechanism.

Checks include:

- Operate breaker from local and remote control
- Slow close breaker if possible, to ensure mechanism works smoothly. Check contact pressure indicator.
- Trip from manual trip device and check electrical interlocks
- Check solenoids, limit switches, position indicators and counter for proper operation
- Verify all clearance dimensions (stops, latches, rollers, switches and links)
- Check wiring terminal blocks for tightness
- Wipe and clean accessible linkages, roller guides and wear points
- Apply approved lubricants to bearings and other specified areas on mechanism, including linkage wear points. Lubrication should not be added to sealed bearings.
- Check arc chutes for loose hardware.

Thermography

Infrared inspection of electrical equipment and power path components to identify any hot spots that may exist either in the contacts, bus connections or within control cabinets. Open cubicle doors on switchgear breakers.

TASK

Visual Inspection

DEFINITION

Visual assessment of the condition of the equipment. Items to check include:

- Check for signs of arcing / flashover
- Check integrity of compartment
- Verify mechanical position indicator for correct position and check operations counter
- Check mechanism spring charged
- Check mechanism cabinet for general cleanliness, evidence of moisture and signs of wildlife or insect infestation
- Check for signs of loose or worn parts in mechanism
- Check cabinet door for degradation of the door seal and for proper operation of the door latch. Check interior components, wiring terminals and fuse holders for rust or corrosion.
- Check for proper grounding
- Where visible, check closing and trip solenoid coils for evidence of heating. Check closing contactors for cleanliness and heating or burning of contacts

Air Magnetic Breaker 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:

IEEE C57.152-2013 "IEEE Guide for Diagnostic Field Testing of Fluid-filled Power Transformers, Regulators and Reactors"
Internal reports and operating experience
OEM Maintenance Manuals and Interviews
EPRI 1001779 Guidelines for the Life Extension of Substations

Boundary Definition

The boundary of an air magnetic circuit breaker is defined from bushing terminal to bushing terminal, including:

- Bushings
- Live parts
- Operating mechanism
- Linkage
- Contacts

Excluded from this treatment are: protective relays, DC supply, AC supply, switchgear

Failure Experience

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

Aux Contact Block Inspection:

Check Control Cabinet / Cubicle Heaters: Continuous heater operation mitigates corrosion of components in the control cabinet.

Check Red (Closed) Indicating Lamp: The red light is in series with the trip coil and when lit, indicates integrity of the trip circuit.

Contact Resistance (Ductor) Test: Performed bushing terminal to bushing terminal. Measures increased resistance at connection points along the current conduction path. Used to diagnose, or determine, problems internal to the breaker that would require an inspection.

Cubicle / Cabinet Maintenance:

Exercise Mechanism: This redistributes the lubricants in bearings and on other surfaces and prevents bearing set at pressure points.

Mechanism Lubrication / Maintenance: The mechanism of a circuit breaker is composed of multiple bearing and sliding surfaces that require periodic re-lubrication due to minimum movement of parts during breaker operation. CIGRE studies have concluded that the dominant failure mode of older style breakers is mechanism failure.

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.

Revision 0		Date 03/02/2015
Writer	Chris Stefanski (Exelon Utilities)	
Reviewer(s)	Ken Wendt	
Approver(s)	Mike Moy (UFAM ComEd)	
Reason Written	Revised criticality definitions and modified document to serve as the ComEd maintenance standard.	

Revision 1		Date 03/07/2018
Writer	Hugo Castaneda (Material Condition)	
Reviewer(s)	Dale Player (Mgr Material Condition), Doug Mason (T&S Equipment Stds)	
Approver(s)	Mike Moy (UFAM ComEd)	
Reason Written	3 year review. Updated industry standards in Maintenance Basis and updated document title to 4-13kV. No other content change.	