Substation Equipment Maintenance Requirements

Attachment 7, Circuit Breaker Maintenance Template

(Includes air, oil, vacuum, and sulfur hexafluoride [SF_6] circuit breakers and reclosers used as circuit breakers.)

This template lists maintenance tasks used on circuit breakers to detect deterioration or abnormal conditions. Performing these tasks helps prevent failure and keeps circuit breakers safe, reliable, and fully functional.

This template applies to activities assigned in the SAP Work Management System (WMS) for circuit breakers. Maintenance tasks are classified as either preventive maintenance tasks (see Table 1 on Page 2) or corrective maintenance tasks (see Table 2 on Page 8).

PG&E substation circuit breakers are classified as follows:

1. **Transmission class:** PG&E substation circuit breakers installed to operate at a system nominal voltage of 60 kilovolts (kV) or above.
2. **Distribution class:** PG&E substation circuit breakers installed to operate at a system nominal voltage of 38 kV or below.

This attachment constitutes part of the PG&E Transmission Maintenance and Inspection Plan, as defined under NERC Reliability Standard FAC-501-WECC-2, “Transmission Maintenance.”

Substation Equipment Maintenance Requirements

Attachment 7, Circuit Breaker Maintenance Template

Table 1. Preventive Maintenance Tasks – Type PR Notifications

Equipment Type	Maintenance Task	Standard Text Key	Notification Type	Intervals and Comments	Reference

Circuit Breaker	Station inspection	ETS58	PR	**Time-based trigger:** Monthly, or every other month, depending on the type.
				
				Visual inspection includes, but is not limited to:
				• Checking the following items:
				  ○ Oil and gas levels
				  ○ Mechanical position indicator
				  ○ Breaker operations counter
				  ○ Position-indicating lights
				  ○ Mechanism condition
				  ○ Air and hydraulic systems
				• Recording specific readings.
				
				Initiate corrective actions, as needed.
					TD-3322M, *SM&C Manual*, "Substation Inspections" booklet:
					• Subsection IV.D, "Circuit-Breaker Information" (Page 16)
					• Subsection V.J, "Circuit-Breaker Inspection Items" (Page 55)
					
					Forms:
					• TD-3322M-F02, "Substation Condition Assessment Checklist"
					• TD-3322M-F04, "Circuit-Breaker Operations Report"

Circuit Breaker	Breaker oil analysis (BOA™)	ETS07	PR	**Time-based trigger:** As part of mechanism service. **Condition-based triggers:** • 100% accumulated critical current (ACC) • 50% ACC BOA™ is **not** required for substation oil-filled reclosers. Perform BOA™ on oil-filled circuit breakers (CBs) to determine their internal condition.	TD-3322M, *SM&C Manual*, "Insulating Oil" booklet, Subsection IV.E.5, "BOA™" (Page 28) "BOA™ Breaker Oil Analysis Oil Circuit Breaker Sample Data"

Substation Equipment Maintenance Requirements

Attachment 7, Circuit Breaker Maintenance Template

Table 1. Preventive Maintenance Tasks – Type PR Notifications (continued)

Equipment Type	Maintenance Task	Standard Text Key	Notification Type	Intervals and Comments	Reference
Circuit Breaker	Compressor/ pump service	ETS11	PR	**Time-based trigger:** • Every 4 years for air systems along with the mechanism service. • Every 4 or 8 years for hydraulic systems along with the mechanism service. **Condition-based triggers:** • Overhaul of circuit breaker. Service includes, but is not limited to: • Pressure switch rundown or relief valve test. • Performance testing, adjustments, or replacement, as needed, to verify proper operation.	TD-3322M, *SM&C Manual*, "Circuit Breakers" booklet: • Subsection 1.V.C, "Performing a Compressor Service" (Page 14) • Subsection 1.V.D, "Performing a Hydraulic-System Service" (Page 15)
Circuit Breaker	SF_6 gas quality test (breaker gas analysis [BGA™])	ETS56	PR	**Time-based trigger:** As part of mechanism service. **Condition-based triggers:** • 100% ACC • 50% ACC Perform BGA™ on transmission class and ABB type 15PM SF_6 CBs to determine their internal condition.	TD-3322M, *SM&C Manual*, "Circuit Breakers" booklet: • Section 7, "SF_6 Circuit Breakers" (Page 129) • Section 8, "Handling SF_6 Gas" (Page 171)

Substation Equipment Maintenance Requirements

Attachment 7, Circuit Breaker Maintenance Template

Table 1. Preventive Maintenance Tasks – Type PR Notifications (continued)

Equipment Type	Maintenance Task	Standard Text Key	Notification Type	Intervals and Comments	Reference
Circuit Breaker	Exercise	ETS16	PR	**Time-based trigger:** • Annually, for all transmission class circuit breakers and distribution class circuit breakers with current-trip coils that have not operated within 12 months, either by switching or relay action. • Biennially, for all other distribution class circuit breakers and reclosers used as substation CBs that have not operated within 24 months, either by switching or relay action.	TD-3322M, *SM&C Manual*, "Circuit Breakers" booklet, Subsections 3.IV.N.3.c, d, and e, "Functional-Performance and Exercise Test Triggers" (Page 52)

Substation Equipment Maintenance Requirements

Attachment 7, Circuit Breaker Maintenance Template

Table 1. Preventive Maintenance Tasks – Type PR Notifications (continued)

Equipment Type	Maintenance Task	Standard Text Key	Notification Type	Intervals and Comments	Reference

Circuit Breaker	Mechanism service	ETS28	PR	**Time-based trigger – 4 years:**
				• Transmission CBs:
				  ○ All manufactured by Kelman and ITE.
				  ○ All Allis Chalmers and Siemens type BZO.
				  ○ All ABB Type PMI and PMRI that are located in corrosive environments.
				  ○ All with OA3, OA4, HKA, MH2, MH3, or CCR54E mechanism types.
				  ○ ABB with Type FSA mechanisms that **do not** have the redesigned transfer roller assembly modification.
				  ○ All with air compressors.
				• Distribution CBs:
				  ○ That cannot be exercised – requires field specialist's approval on a case-by-case basis.
				  ○ All with current trip coils.
				Time-based trigger – 8 years:
				• Transmission CBs:
				  ○ Default interval – all CBs that do not meet the 4-year or 12-year criteria.
				• Distribution CBs:
				  ○ Default interval – all CBs that do not meet the 4-year or 12-year criteria.
				  ○ Vacuum-type substation reclosers such as the Cooper Type VSA.
					TD-3322M, *SM&C Manual*, "Circuit Breakers" booklet:
					• Subsection 1.V, "Performing Periodic Maintenance: Mechanism Service, Overhauls, and Compressor Service" (Page 14)
					• Subsection 3.IV.H, "Mechanical Measurements and Tolerances" (Page 38)
					• Subsection 5.VI.D, "Performing Mechanism Service for Metalclad Circuit Breakers" (Page 79)
					• Subsection 5.VIII.B, "Performing Mechanism Service" (Page 89)
					• Subsection 6.VI.D, "OCB Mechanism Service" (Page 117)
					• Subsection 6.VII, "Performing an OCB Mechanism Service" (Page 120)
					• Subsection 7.VII.F, "Servicing Mechanisms on SF_6 Circuit Breakers" (Page 154)
					• Subsection 7.VIII, "Servicing Mechanisms on SF_6 Circuit Breakers" (Page 158)
					• Subsection 9.VI.D, "Performing a Mechanism Service on Vacuum Circuit Breakers" (Page 217)
					• Section 10, "Cleaning and Lubricating Mechanisms" (Page 251)

Substation Equipment Maintenance Requirements

Attachment 7, Circuit Breaker Maintenance Template

Table 1. Preventive Maintenance Tasks – Type PR Notifications (continued)

Equipment Type	Maintenance Task	Standard Text Key	Notification Type	Intervals and Comments	Reference

Circuit Breaker	Mechanism service
	
	(continued from Page 5)
		ETS28	PR	**Time-based trigger – 12-years:**
				• Distribution CBs
				  ○ ABB Type R-MAG and AMVAC
				• Transmission CBs
				  • All MEPPI transmission class except those equipped with air compressors.
				Note: All CB types and model designations have been abbreviated and include any type or model number that contains the designation shown above. *Example:* ABB model number 242PMI4020 is a type PMI.
				Condition-based triggers:
				• Transmission and Distribution CBs:
				  ○ Failed exercise
				  ○ Online performance-monitor alarm
				  ○ Operating malfunction
				  ○ Poor visual condition assessment
				Perform mechanism service to keep mechanisms working properly. Mechanism service includes, but is not limited to:
				• Cleaning and lubricating the mechanism.
				• Checking the condition of wire terminations, switches, and relays.
				• Checking mechanical adjustments.
				• Taking corrective actions, as needed.
					TD-3322M, *SM&C Manual*, "Circuit Breakers" booklet:
					• Subsection 1.V, "Performing Periodic Maintenance: Mechanism Service, Overhauls, and Compressor Service" (Page 14)
					• Subsection 3.IV.H, "Mechanical Measurements and Tolerances" (Page 38)
					• Subsection 5.VI.D, "Performing Mechanism Service for Metalclad Circuit Breakers" (Page 79)
					• Subsection 5.VIII.B, "Performing Mechanism Service" (Page 89)
					• Subsection 6.VI.D, "OCB Mechanism Service" (Page 117)
					• Subsection 6.VII, "Performing an OCB Mechanism Service" (Page 120)
					• Subsection 7.VII.F, "Servicing Mechanisms on SF_6 Circuit Breakers" (Page 154)
					• Subsection 7.VIII, "Servicing Mechanisms on SF_6 Circuit Breakers" (Page 158)
					• Subsection 9.VI.D, "Performing a Mechanism Service on Vacuum Circuit Breakers" (Page 217)
					• Section 10, "Cleaning and Lubricating Mechanisms" (Page 251)

Substation Equipment Maintenance Requirements

Attachment 7, Circuit Breaker Maintenance Template

Table 1. Preventive Maintenance Tasks – Type PR Notifications (continued)

Equipment Type	Maintenance Task	Standard Text Key	Notification Type	Intervals and Comments	Reference
Circuit Breaker	Overhaul	ETS42	PR	**Time-based trigger:** • Annually for tertiary reactor breakers on 500 kV systems. **Condition-based triggers:** • 100% ACC (includes all reclosers and CBs, except oil CBs). • BOA™ analysis. • BGA™ analysis. **Condition-based triggers – counters:** • 3,000 operations for all transmission-class CBs used for capacitor switching. • 5,000 operations for all GIS CBs. • 2,000 operations for ABB Types 242PA and 550PM CBs. Overhaul includes, but is not limited to: • Thorough mechanical and electrical, internal, and external inspections to identify any safety or reliability issues. • Performance testing, adjustments, or replacement, as needed, to verify proper operation.	TD-3322M, *SM&C Manual*, "Circuit Breakers" booklet: • Subsection 1.V, "Performing Periodic Maintenance: Mechanism Service, Overhauls, and Compressor Service" (Page 14) • Subsection 5.VI.E, "Overhauling Metalclad Circuit Breakers" (Page 79) • Subsection 5.VIII, "Overhauling Metalclad Switchgear" (Page 88) • Subsection 6.VIII, "Overhauling the OCB" (Page 125) • Subsection 7.VII.G, "Overhauling SF_6 Circuit Breakers" (Page 154) • Subsection 7. IX, "Overhauling SF_6 Circuit Breakers" (Page 163) • Subsection 9.VI.E, "Overhauling Vacuum Circuit Breakers" (Page 217) • Subsection 9.VIII, "Overhauling Vacuum Circuit Breakers" (Page 223) TD-3322M, *SM&C Manual*, "Insulating Oil" booklet, Subsection IV.E.5, "BOA™" (Page 28)
Circuit Breaker	Replace capacitor on ABB-type R-MAG CBs	ETS53	PR	**Time-based trigger:** 20 years. **Condition-based trigger:** Failure to pass an open-close-open test.	TD-3322M, *SM&C Manual*, "Circuit Breakers" booklet, Section 9, "Vacuum Circuit Breakers" (Page 205)
Gas Insulated Switchgear (GIS)	Calibrate/test SF_6 density monitors (GIS equipment only)	ETS49	PR	**Time-based trigger:** 8 years **Condition-based trigger:** Failure to alarm/trip due to low SF_6 pressure	TD-3322M, *SM&C Manual*, "Circuit Breakers" booklet, Section 4.III, "Testing Hybrid Density Monitors" (Page 61)

Substation Equipment Maintenance Requirements

Attachment 7, Circuit Breaker Maintenance Template

Table 2. Corrective Maintenance Tasks – Types LC or SO Notifications

Equipment Type	Maintenance Task	Standard Text Key	Notification Type	Intervals and Comments	Reference
Circuit Breaker	Add oil	ETS03	LC	As needed.	TD-3322M, *SM&C Manual*, "Circuit Breakers" booklet: • Section 6, "Oil Circuit Breakers" (Page 115) • Section 7, "SF_6 Circuit Breakers" (Page 129)
Circuit Breaker	Animal abatement	ETS06	SO	Apply or replace animal guards on distribution CB bushings, as needed.	TD-3322M, *SM&C Manual*, "General Information" booklet, Section 7, "Animal Abatement Materials" (Page 24)
Circuit Breaker	Bushing checks	ETS08	LC	Clean, repair, or replace bushings, as needed.	TD-3322M, *SM&C Manual*, "Circuit Breakers" booklet: • Section 2, "Receiving, Storing, and Installing" (Page 19) • Section 9, "Vacuum Circuit Breakers" (Page 205) TD-3322M, *SM&C Manual*, "Arrestors, Bushings, and Insulators" booklet, Section II, "High-Voltage Insulation Bushings and Insulators" (Page 1)
Circuit Breaker	Compressor/ pump service	ETS11	LC	The priority depends on the urgency of the situation. Service includes, but is not limited to: • Performance testing, adjustments, or replacement, as needed, to verify proper operation. • Pressure switch rundown or relief valve testing.	TD-3322M, *SM&C Manual*, "Circuit Breakers" booklet, Subsection 1.V.C, "Performing a Compressor Service" (Page 14) Form TD-3322M-F12, "Compressor Service"

Substation Equipment Maintenance Requirements

Attachment 7, Circuit Breaker Maintenance Template

Table 2. Corrective Maintenance Tasks – Types LC or SO Notifications (continued)

Equipment Type	Maintenance Task	Standard Text Key	Notification Type	Intervals and Comments	Reference
Circuit Breaker	Diagnostic/ performance test	ETS14	LC	To determine CB component performance. Diagnostic/performance testing includes, but is not limited to, the following items: • Testing capacitors for ABB-type R-MAG vacuum circuit breakers (VCBs). • Checking the hydraulic pre-charge pressure. • Checking the minimum-to-trip and close voltages. • Checking the trip and close voltage signal levels. • Testing the contact pressure. • Testing the contact resistance. • Testing component insulation resistance. • Testing the insulation of control wiring and CT blocks, etc. • Measuring the resistance of the trip, close, and other circuit paths and components. • Checking the timing close and trip. • Checking the timing with a CB analyzer. • Testing vacuum bottle high potential. • Measuring contact erosion on VCBs.	TD-3322M, *SM&C Manual*, "Circuit Breakers" booklet, Section 3, "Diagnostic Tests" (Page 29)

Substation Equipment Maintenance Requirements

Attachment 7, Circuit Breaker Maintenance Template

Table 2. Corrective Maintenance Tasks – Types LC or SO Notifications (continued)

Equipment Type	Maintenance Task	Standard Text Key	Notification Type	Intervals and Comments	Reference
Circuit Breaker	Functional performance test (FPT) (for breakers 230 kV and below)	ETS17	LC	Used when an **unplanned** FPT is needed. The priority depends on the urgency of the situation.	TD-3322M, *SM&C Manual*, "Circuit Breakers" booklet, Section 3, "Diagnostic Tests" (Page 29)
Circuit Breaker	Bushing insulation coatings	ETS20	LC	As needed.	TD-3322M, *SM&C Manual*, "Circuit Breakers" booklet: • Section 1, "Introduction" (Page 1) • Section 2, "Receiving, Storing, and Installing" (Page 19) TD-3322M, *SM&C Manual*, "Arrestors, Bushings, and Insulators" booklet, Section II, "High-Voltage Insulation Bushings and Insulators" (Page 1)
Circuit Breaker	Leak repair	ETS21	LC	Used for non-SF_6 leak repairs.	TD-3322M, *SM&C Manual*, "Circuit Breakers" booklet ENV-4100P-01, "PCB Program Procedure"

Substation Equipment Maintenance Requirements

Attachment 7, Circuit Breaker Maintenance Template

Table 2. Corrective Maintenance Tasks – Types LC or SO Notifications (continued)

Equipment Type	Maintenance Task	Standard Text Key	Notification Type	Intervals and Comments	Reference
Circuit Breaker	Mechanism mechanical measurement checks	ETS27	LC	As needed.	TD-3322M, *SM&C Manual*, "Circuit Breakers" booklet: • Subsection 1.V, "Performing Periodic Maintenance: Mechanism Service, Overhauls, and Compressor Service" (Page 14) • Subsection 3.IV.H, "Mechanical Measurements and Tolerances" (Page 38) • Subsection 5.VI.D, "Performing Mechanism Service for Metalclad Circuit Breakers" (Page 79) • Subsection 5.VIII.B, "Performing Mechanism Service" (Page 89) • Subsection 6.VI.D, "OCB Mechanism Service" (Page 117) • Subsection 6.VII, "Performing an OCB Mechanism Service" (Page 120) • Subsection 7.VII.F, "Servicing Mechanisms on SF_6 Circuit Breakers" (Page 154) • Subsection 7.VIII, "Servicing Mechanisms on SF_6 Circuit Breakers" (Page 158) • Subsection 9.VI.D, "Performing a Mechanism Service on Vacuum Circuit Breakers" (Page 217) • Section 10, "Cleaning and Lubricating Mechanisms" (Page 251)

Substation Equipment Maintenance Requirements

Attachment 7, Circuit Breaker Maintenance Template

Table 2. Corrective Maintenance Tasks – Types LC or SO Notifications (continued)

Equipment Type	Maintenance Task	Standard Text Key	Notification Type	Intervals and Comments	Reference
Circuit Breaker	Misc. cleanup	ETS29	LC	As needed.	–
Circuit Breaker	Safety/ operating modifications	ETS31	LC	The priority depends on the urgency of the situation. Modifications may include manufacturers' safety or service advisories or an Apparatus Trouble Report/Protection Trouble Report (ATR/PTR) evaluation.	–
Circuit Breaker	Oil cleanup	ETS33	LC	As needed.	TD-3322M, *SM&C Manual*, "Circuit Breakers" booklet, Section 6, "Oil Circuit Breakers" (Page 115) ENV-4100P-01, "PCB Program Procedure"
Circuit Breaker	Oil diagnostics	ETS35	LC	To verify the safe handling limit (SHL). Perform a field dissolved gas analysis (DGA) **only.**	TD-3322M, *SM&C Manual*, "Insulating Oil" booklet, Subsection IV.E.5, "BOA™" (Page 28) "BOA™ Breaker Oil Analysis Oil Circuit Breaker Sample Data"
Circuit Breaker	Paint	ETS45	LC	As needed.	TD-3322M, *SM&C Manual*, "General Information" booklet, Section 8, "Painting Substation Equipment and Structures" (Page 38)
Circuit Breaker	SF_6 gas quality test (BGA™ or moisture)	ETS56	LC	BGA™ or moisture test.	TD-3322M, "*SM&C Manual*, Circuit Breakers" booklet: • Section 7, "SF_6 Circuit Breakers" (Page 129) • Section 8, "Handling SF_6 Gas" (Page 171)

Substation Equipment Maintenance Requirements

Attachment 7, Circuit Breaker Maintenance Template

Table 2. Corrective Maintenance Tasks – Types LC or SO Notifications (continued)

Equipment Type	Maintenance Task	Standard Text Key	Notification Type	Intervals and Comments	Reference
Circuit Breaker	Visual inspection	ETS63	SO	Other than monthly station inspection.	–
Circuit Breaker	Add SF_6 gas/SF_6 leak detection/SF_6 leak repair	ETS77 ETS78 ETS79	LC	Any time SF_6 gas is added or leak detection and repair are needed.	TD-3322M, *SM&C Manual*, "Circuit Breakers" booklet: • Section 7, "SF_6 Circuit Breakers" (Page 129) • Section 8, "Handling SF_6 Gas" (Page 171)

Substation Equipment Maintenance Requirements

Attachment 7, Circuit Breaker Maintenance Template

REVISION NOTES

When/Where?	What Changed?
June 2016:	
Table 1: GIS	Added item at the end of Table 1 to calibrate and test GIS gas density monitors.
November 2016:	
Table 1: Circuit Breaker Overhaul (ETS42)	Removed the 4,000 operation trigger and replaced it with a 3,000 operation trigger for all CBs used for capacitor switching.
October 2017:	
Table 1, Exercise (ETS16)	Separated breakers into annual (transmission and those with current-trip coils) and biennial (all other distribution class breakers and reclosers), per Utility Bulletin TD-3322B-060.
Table 1, FPT (ETS17)	Deleted requirement for functional performance tests, per Utility Bulletin TD-3322B-060.
Table 1, Mech Svc (ETS28)	Under the 4-year triggers for distribution breakers and under condition-based first sub-bullet, replaced “functional performance tested” with “exercised,” per Utility Bulletin TD-3322B-060.
Table 1, Overhaul (ETS42)	Under condition-based triggers for capacitor switching, clarified applies only to transmission-class CBs.
Tables 1 and 2	Corrected numerous page references to the Substation Circuit Breakers booklet, which was updated in January 2017.
July 2018:	
Table 1, Page 3, Exercise (ETS16)	Changed “bi-annually” to “biennially” to clarify this task is to occur every second year. (Bottom of page 3.)

Substation Equipment Maintenance Requirements

Attachment 7, Circuit Breaker Maintenance Template

REVISION NOTES (continued)

When/Where?	What Changed?
April 2019:	
Table 1, Pages 4, 5, Mech Service (ETS28)	• Removed three-year mechanism service requirement for transmission breakers at DCPP switchyard. • Under the 8-year cycle, added an exclusion for transmission breakers with a 12- year cycle. • Under the 12-year cycle, added all MEPPI transmission class breakers, except those with air compressors.
November 2019:	
Table 1, Page 3, SF_6 gas quality test (ETS56)	Added time-based trigger: as part of mechanism service.
January 2020:	
Table 1, Page 3, Compressor/pump service (ETS 11)	Added requirement to perform service on hydraulic systems every 4 or 8 years along with the mechanism service. Added reference to the Circuit Breaker booklet Subsection 1.V.D and corrected page numbers.
October 2020:	
Table 1, Page 3, SF_6 gas quality test (ETS56) Table 1, Page 7, Overhaul (ETS42)	Clarified that BGA™ is performed only on transmission class and ABB type 15PM SF6 breakers. Updated Circuit Breakers booklet reference page numbers throughout. Under “Condition-based triggers – counters,” added line for 5,000 operations for all GIS CBs.
March 2022	
Page 1	Added statement referencing NERC reliability standard FAC-501-WECC-2.
Table 2 (Pages 10 and 12)	Changed PCB references from TD-3324M to ENV-4100P-01.