

DISTRIBUTION SOLUTIONS SERVICE

SWAPs maintenance



- Ensures safety and protection of personnel and assets
- Guarantees continuous and reliable operation of processes

“Maintenance is a combination of all technical and management actions intended to retain an item in, or restore it to, a state in which it can perform as required”.

Maintaining electrical equipment and reducing the risk of failures requires the right mix of proper maintenance plan and individual technical skills.

SWAPs maintenance program is ABB solution, providing the right combination for keeping your equipment at peak performance.

Table of contents

004	ABB strength, your benefits
006–007	SWAPs maintenance program
008–009	Conditions relevance
010	Monitoring and diagnostic effect
011–016	SWAPs for Medium Voltage equipment
017–023	SWAPs for Low Voltage equipment
024	End of Life and Retrofitting
025	Reference standards

ABB strength, your benefits



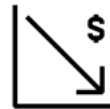
Productivity

Maximize
your output



Reliability

Protect
your assets



Efficiency

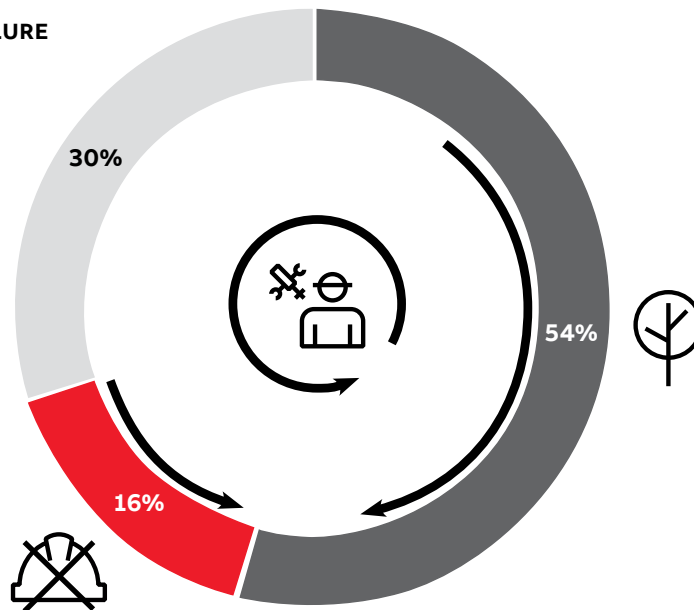
Optimize
your investments



CAUSES OF FAILURE

According to a
IEEE study
(IEEE 493-2007)

- Environmental conditions
- Other
- Inadequate maintenance

**Thanks to SWAPs you can:****Maximize your productivity**

- Keeping your installation up and running
limiting failures

Protect your asset

- Recommending the right maintenance program
for your installed base

Optimize your investments

- Making the best use of your maintenance
budget

SWAPs maintenance program

SWAPs is a maintenance program for electrical equipment tailored to your assets. In SWAPs, four levels of maintenance activities are scheduled based on a prior assessment of the equipment's environmental and operational conditions. Furthermore the scheduling is influenced by the age of the equipment and by the maintenance that has been performed previously. The schedule continues till the equipment reaches its end of life, also recommending the right time for relay and circuit breaker retrofit. Additional to these four levels there is a fifth level called "secure". It will be carried out by trained ABB specialists for critical situations.

The condition is assessed through multiple environmental and operational parameters that are being defined by IEC, IEEE and GB Standards and ABB experience (see page 11). The end of life (EoL) of the equipment is also depending on the condition. The worse the condition the shorter will be its lifetime.

SWAPs is available for medium and low voltage switchgear (and related components), but also gives the possibility to include UPS maintenance into the maintenance plan, through a dedicated widget in the tool.



Trained personnel

Dedicated ABB trainings for maintenance personnel

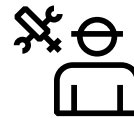


ABB certified technician

SEE	WATCH	ACT	PERFORM	SECURE
Overall visual Inspection	In-depth inspection (de-energized panel)	Cleaning, lubrication and functional testing of the equipment	In-depth analysis of the asset and immediate corrective actions	Special maintenance for critical situations



Maintenance levels for different equipment:



- **Circuit breaker:**
 - A** Act
 - P** PerformSee and Watch would require the breaker racking into test position and therefore makes sense to merge them into Act.



- **Switchgear:**
 - S** See
 - W** Watch
 - A** Act
 - P** Perform



- **Relay:**
 - W** Watch
 - A** Act
 - P** PerformSee is merged into Watch for relays.

Example of SWAPs maintenance program

Caption
S See
W Watch
A Act
P Perform

Years	1	2	3	4	5	6	7	8	9	10	EoL
Circuit Breaker													
			A		P			A		P			Retrofit
Switchgear													
		S	W	S	A		S	W	S	P			
Relay													
		W	A	W	W	W	W	A	W	P			Retrofit

Conditions relevance

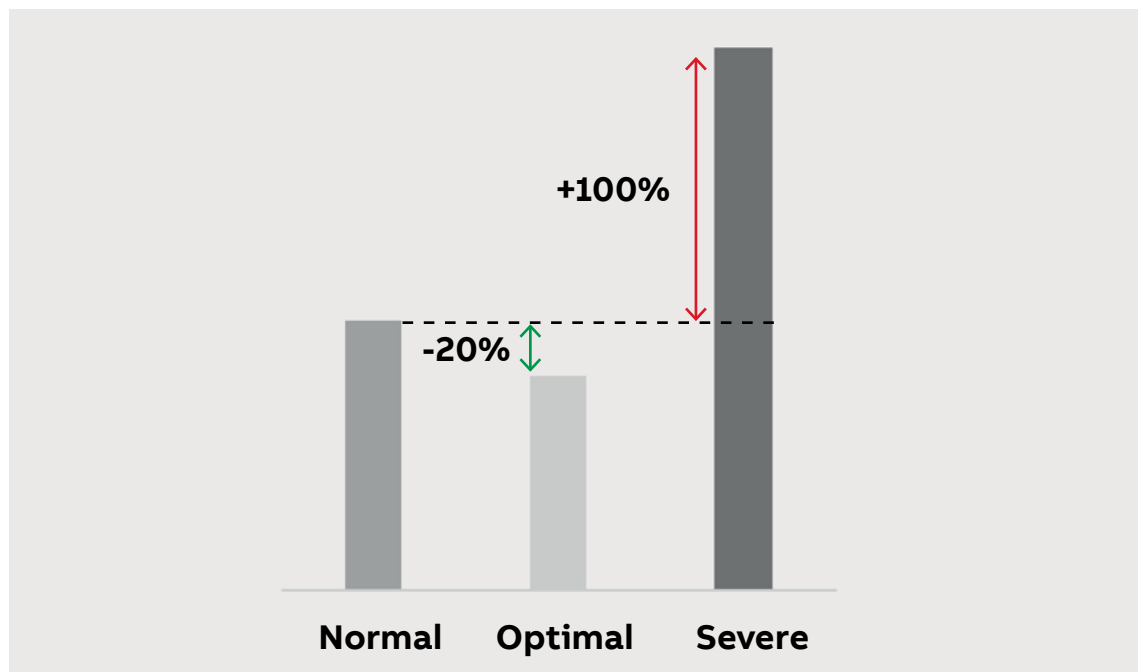
Environmental and operational conditions of the equipment affect the SWAPs program.

They are divided into three classes:

- **Normal condition** is defined by international Standards (IEEE, IEC, GB)
- **Optimal condition** is the favorable range within the normal conditions, based on ABB experience
- **Severe condition** is outside the normal condition and can cause premature aging and wearing leading to higher safety risks and probability of failure

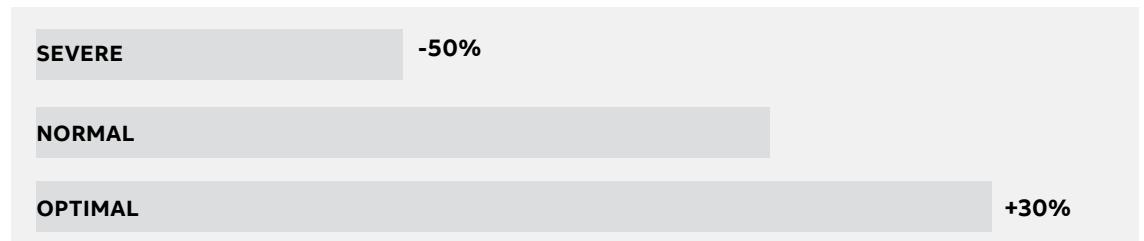
Effects of the equipment's conditions on costs and downtime

Costs and downtime comparisons ¹



¹ - Percentages are calculated with respect to the costs and hours required on normal conditions

Frequency of SWAPs intervals: optimal conditions allow to extend them by 30%, while severe ones imply reducing them by 50%.



SWAPs for Medium Voltage equipment

Conditions	Device/ Year	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5
Normal	Circuit Breaker						A				P						A				P	
Severe				A		P			A		P			A		P			A		P	
Optimal							A						P								A	
Normal	Switchgear				S		W		S		A				S		W		S		P	
Severe			S	W	S	A	S	S	W	S	P	S	S	W	S	A	S	S	W	S	P	
Optimal							W				S		A						S		W	
Normal	Relay				W		A		W		W		W		W		A		W		P	
Severe		W	W	W	W	A	W	W	W	W	A	W	W	A	W	A	W	W	A	W	P	W
Optimal					W		A		W		W		A		W		W		W		P	

Caption
S See
W Watch
A Act
P Perform

SWAPs for Low Voltage equipment

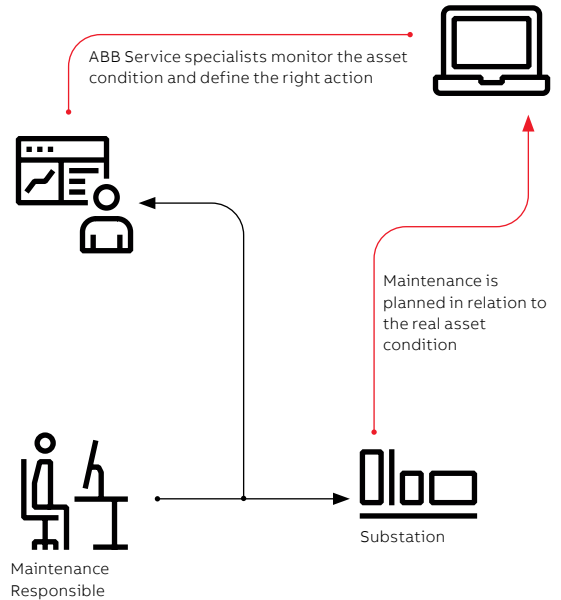
Conditions	Device/ Year	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5
Normal	Circuit Breaker		A		A		P		A		A		P		A		A		P		A		A		P	
Severe		A	A	P	A	A	P	A	A	P	A	A	P	A	A	P	A	A	P	A	A	P	A	A	P	
Optimal				A			A		P			A			A		P			A			A		P	
Normal	Switchgear		S		W		S		A		S		P		S		W		S		A		S		P	S
Severe		S	W	S	A	S	P	S	W	S	A	S	P	S	W	S	A	S	P	S	W	S	A	S	P	S
Optimal				S			W		S			A			S		P			S			W		S	
Normal	Relay				W		A		W		W		W		A		W		W		P				W	A
Severe		W	W	W	W	A	W	W	W	W	A	W	W	A	W	A	W	W	A	W	P	W	W	W	W	A
Optimal				W			A		W		W		W		A		W		W		W		A		P	

Monitoring and diagnostic effect

Condition-based maintenance services enable the prediction of equipment faults. ABB Ability™ Asset Manager enables ABB service engineers and operations teams to deploy continuous monitoring of remote assets and performance trends to define the correct maintenance procedures at the right time.

ABB Ability™ Asset Manager collects diagnostic information from sources like MySiteCare, SWICOM and CMES.

Effect of M&D on SWAPs maintenance intervals
Frequency of SWAPs intervals: monitoring and diagnostic allow to extend them by 30% irrespectively of the conditions.



Caption
S See
W Watch
A Act
P Perform

SWAPs for Medium Voltage equipment

Device/Year	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5
Circuit breaker						A				P						A				P						A	
Switchgear				S		W		S		A				S		W		S		P				S		W	
Relay				W		A		W		W		W		W		A		W		P				W		A	
<div>Intervals can be increased by 30%¹</div>																											
Device/Year	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	
Circuit breaker						A						P								A						P	
Switchgear						W				S		A						S		W						P	
Relay				W		A		W		W		A		W		W		W		P				W		A	
<div>Standard conditions</div>																											
<div>Standard conditions with M&D</div>																											

SWAPs for Low Voltage equipment

Device/Year	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	13.5
Circuit breaker		A		A		P		A		A		P		A		A		P		A		A		P		A	
Switchgear		S		W		S		A		S		P		S		W		S		A		S		P		S	
Relay				W		A		W		W		W		A		W		W		P				W		A	
<div>Intervals can be increased by 30%¹</div>																											
Device/Year	0.5	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10	10.5	11	11.5	12	12.5	13	
Circuit breaker			A			A		P			A			A		P			A			A		P			A
Switchgear			S			W		S			A			S		P			S			W		S			A
Relay				W		A		W		W		W		A		W		W		W		A		P			
<div>Standard conditions with M&D</div>																											

1-Independently of the equipment's conditions

SWAPs for Medium Voltage equipment

Environmental and operational conditions' parameters

Environmental conditions			
Criteria	Normal	Optimal	Severe
Temperature	-5°C...40°C	15°C...30°C	Applies if one or more parameters is outside the normal range
Humidity	5%...95%	10%...75%	
Rate of change of temperature	≤ 0,5°C/min	≤ 0,5°C/min	
Condensation / formation of ice	Possible	None	
Heat radiation	None	None	
Flora and fauna	Is avoided	Is avoided	
Salt mist	May be present	Absent	
Sulphur dioxide	≤ 0,1 mg/m³	≤ 0,1 mg/m³	
Hydrogen sulphide	≤ 0,01 mg/m³	≤ 0,01 mg/m³	
Chlorine	≤ 0,01 mg/m³	≤ 0,01 mg/m³	
Hydrogen chloride	≤ 0,01 mg/m³	≤ 0,01 mg/m³	
Hydrogen fluoride	≤ 0,003 mg/m³	≤ 0,003 mg/m³	
Ammonia	≤ 0,3 mg/m³	≤ 0,3 mg/m³	
Ozone	≤ 0,01 mg/m³	≤ 0,01 mg/m³	
Nitrogen oxides	≤ 0,1 mg/m³	≤ 0,1 mg/m³	
Dust	Visible	Not visible, but present	
Sand	None	None	
Ext. vibration	Insignificant	Insignificant	
Altitude	≤ 1000m	≤ 1000m	
Operational conditions			
Criteria	Normal	Optimal	Severe
Number of operations	≤ 50%	≤ 25%	>50%
Loading	≤ 100% current and voltage	≤ 90% voltage and ≤ 80% current	>100% voltage or current
Short circuit currents interruptions	≤ 50% of declared SC interruptions	≤ 25% of declared SC interruptions	>50% of declared SC interruptions
	≤ 90% of interrupted I _{sc}	≤ 80% of interrupted I _{sc}	>90% of interrupted I _{sc}
Frequency of operation	At least one operation every 6 months	Up to 100 operations per year	More than 6 months of inactivity

SWAPs for Medium Voltage equipment

Maintenance activities

The following activities cover electrical equipment without focusing on specific product lines' needs and requirements, for which the user has to refer to the relevant user manuals.

Switchgear

Level	Activity
See	Perform an overall visual inspection
	Check all indicators, meters and instruments for proper operation
	Check for undue noise and vibration that might loosen bolted connections
	Look for evidence of moisture on the switchgear surfaces
	Note presence of unusual amount of ozone odor ⁽¹⁾
	Record number of operations and loading
	Inspect auxiliary devices, wiring and terminal blocks
	Check the cleanliness and dust outside of the panel
	Check for moisture and rust presence inside the room and top of the switchboard
	Check the level of chemical presence in the substation environment
	Check the evolution of the equipment outside of the switchboard (e.g. added new generator, changed transformer, etc.)
	Insulating gas level check ⁽²⁾
Watch	Inspect cabling, terminal boxes, anti-ferroresonance circuit
	Inspect mechanical parts of the interlocks and check for humidity and corrosion
	Check the ventilation system, simple testing of centrifugal fan
	Inspect for overheating of accessible electrical and mechanical parts ⁽¹⁾
	Inspect tracking on insulating surfaces on the power cable side
	Check the voltage transformers
	Verify operation of heaters and thermostats
	Inspect line and earthing switches' kinematics and check for dirt, humidity and corrosion
Act	Monitor the core balance current transformer performance
	Clean the stationary portion of the switchgear ⁽¹⁾
	Withdraw and clean all draw-out components ⁽¹⁾
	Clean and lubricate of all parts requiring attention, identified during previous inspection
	Inspect tracking on insulating surfaces on the entire switchboard ⁽¹⁾
	Functional testing of mechanical parts of switchgear
	Measure primary circuit insulation
Perform	Measure primary contacts resistance
	Check bolted connections ⁽¹⁾
	Inspect control wiring for signs of wear and damage, if necessary replace
	Examine resistors and other devices prone to overheating
	Open all hinged doors and remove bolted panels
	Check wiring, clean contacts on relays and all necessary switches, replace all covers
	Ventilate louvers and air filters, clean or replace filters
	Functional testing on controls, interlocks and closing power rectifiers, check voltages
	Inspect, clean, functional test on current transformers, voltage transformers, and control power transformers
	Inspect secondary wiring bundles, replace if necessary
	Tighten secondary control wire connections
	Check for loose lug crimps and broken wire strands
	Inspect all power cables for tight connections
	Check bolted connections in bus bar compartment ⁽¹⁾
	Check the insulating cover of the main bus bars ⁽¹⁾
	Check the condition of pressure flaps or rupture discs
	Check the condition of arc-fault over-pressure sensors (if present)

1) Not applicable to gas insulated switchgear (GIS)

2) Applicable to gas insulated switchgear only



SWAPs for Medium Voltage equipment

Maintenance activities

Circuit breaker

Level	Activity
Act	General inspection on:
	- Operating mechanism
	- Medium voltage parts
	- Earthing connections
	- Auxiliary supply voltage
	Check auxiliary switches
	Test interlock conditions
	General servicing of switching device
	- Clean surfaces in general
	- Clean insulating material surfaces and conductive components ⁽¹⁾
	- Clean and lubricate pawls, support shafts and bearing surfaces
	Suspect Joint maintenance (if needed)
	- Open joint and inspect connection surfaces ⁽¹⁾
	- Clean surfaces ⁽¹⁾
	- Replace parts if necessary ⁽¹⁾
	- Replace contact fingers springs if necessary ⁽¹⁾
	- Tighten bolted connections ⁽¹⁾
	Functional Testing
	- Perform several switching operations under no load
	- Switch off charging motor (if fitted) and discharge the mechanism
	- Examine the condition of lubrication
	- Check the proper mechanical/electrical sequence
Perform	Servicing of the operating mechanism
	- Switch off charging motor (if fitted) and discharge spring mechanism
	- Replace climatic and mechanical sensitive parts
	- Check operating mechanism springs
	- Check the fit and tightness of fasteners
	- Replace removed spring lock washers, split pins and other fasteners
	- Check the general condition of the operating mechanism
	- Perform comprehensive mechanical and electrical functional tests
	- Check tightness of bolted joints
	After replacements
	- Measure closing and opening time
	- Measure main contacts simultaneous operation
	Timing and simultaneity of contact
	Measure primary circuits contact resistance

1) Not applicable to gas insulated switchgear (GIS)



SWAPs for Medium Voltage equipment

Maintenance activities

Relay

Level	Activity
Watch	Check for signs of mechanical damage on relay case
	Check for cleanliness, accumulation of dust on relay cover/case
	Check for evidence of moisture on the relay mechanical case
	Inspect wiring terminal and case for oxidation or discoloration
	Check temperature surrounding the relay
	Inspect the relay HMI:
	<ul style="list-style-type: none"> - Check power supply LED - Check display of internal relay fault indication - Check display of indication LEDs
Act	Check auxiliary supply voltage condition
	Inspect secondary wiring tightness
	Initiate self-supervision check process
	Perform secondary injection test
	Perform any available test through relay
	Check circuit breaker trip operation
	Check relay settings
	Check Life Cycle status of installed base
Perform	Check for software updates
	Recommendations according to Life Cycle status check
	<ul style="list-style-type: none"> - Replacement - Relay Retrofit Program (RRP)
	Relay preventive maintenance program (if applicable)
	Replace power supply and output relay modules
	Additional testing according to preventive maintenance concept



SWAPs for Low Voltage equipment

Environmental and operational conditions' parameters

Environmental conditions			
Criteria	Normal	Optimal	Severe
Temperature, min and max values	-5°C...40°C	15°C...30°C	
Temperature, average value over a period of 24 h	≤ 35°C	≤ 30°C	
Humidity	5%...95%	10%...75%	
Rate of change of temperature	≤ 0,5°C/min	≤ 0,5°C/min	
Condensation	Yes – moderate condensation may occasionally occur due to variations in temperature	None	
Formation of ice	None	None	Applies if one or more parameters are outside the normal range
Pollution Degree	Conductive pollution occurs or dry, non-conductive pollution occurs which is expected to become conductive due to condensation	No pollution or non-conductive pollution occurs	
Flora and fauna	Is avoided	Is avoided	
Dust	None	None	
Sand	None	None	
External vibration / shocks / seismic occurrences	Insignificant	Insignificant	
Altitude	≤ 2000m	≤ 1000m	
Operational conditions			
Criteria	Normal	Optimal	Severe
Number of operations	≤ 50%	≤ 25%	> 50%
Loading	≤ 100% current and voltage	≤ 90% voltage and ≤ 80% current	> 100% voltage or current
Short circuit currents interruptions	≤ 50% of declared SC interruptions ≤ 90% of interrupted I_{sc}	≤ 25% of declared SC interruptions ≤ 80% of interrupted I_{sc}	> 50% of declared SC interruptions > 90% of interrupted I_{sc}
Frequency of operation	At least one operation every 6 months	Up to 100 operations per year	More than 6 months of inactivity

SWAPs for Low Voltage equipment

Maintenance activities

The following activities cover electrical equipment without focusing on specific product lines' needs and requirements, for which the user has to refer to the relevant user manuals.

Switchgear

Level	Activity
See	Verify accessibility conditions: room accessibility and escape routes, cleanliness, presence of any unauthorized equipment
	Verify ambient conditions: temperature, relative humidity, air quality, dust, water ingress
	Check room ventilation system: ventilation, air conditioning available (no obstruction, functioning)
	Check switchgear ventilation: cleanliness of ventilation louvres
	Check condition of enclosure/outside part of assembly
	- Ingress protection (IP class, IEC60529)
	- Any damage or corrosion present
	- Missing parts such as module doors or covers
	- Compartment doors closed, locks operable
	- Roof plate contaminated/covered/obstructed
	- Fastening of cable compartment doors, side and back walls
	- Position of withdrawable modules (present and in operating or isolated position)
	- Correct labels, safety signs all legible
Watch	Documentation available and updated (drawings, parameter settings)
	Installed equipment diversity/density factor of switchgear as per design criteria
	Check equipment compartment
	- Check diversity/density factor
	- Internal conditions – e.g. presence of dust, Surface of electrical contacts blackening, loosened screws
	- Clean if required
	Check cable compartment / cable terminal compartment (Sufficient room/strain relief, Cable routing and fixing, bending radii, Protective covers/bellows in place and fixed accordingly)
	Check control equipment compartment (if present)
	- Check diversity/density factor
	- Internal conditions – e.g. presence of dust, loosened screws
	- Cable routing and connection
	- Clean if required
Act	Check that measuring loops are in accordance with circuit diagram
	Check of mechanical functionality (operation and interlocks)

Switchgear

Level	Activity
Perform	Busbar compartment
	- Check busbar sections
	- Check busbar supports
	- Visual inspection of the condition of the busbar insulation (if present)
	- Tightening marker present and correct
	- Check for cracks, dust, signs of contamination or flashover, discharge marks, color change at bolted connections, corrosion, correct installation of covers
	- Clean and replace parts if required
	Earth and Neutral busbar joints and related connections
	- Check busbar supports
	- Check for cracks, dust, discoloring, corrosion
	- Tightening marker present and correct
	- Clean and replace parts if required
	Check for insulation damage on assembly of conductors and measure insulation resistance
	Check electrical equipment installed
	- Check contact corrosion, contact gaps are line with the requirement and grease is present and not discolored, ionization chamber, arc splitter, rated currents, settings and tripping.
	Required protection class is in line with project documentation
	Check efficiency of protective conductor connection
	Functional test of the control device: check numbers of control connection cables if present
	Modules maintenance
	- If needed, perform primary Injection test and verification of Motor Protection relay
	- Thermal Overload Relay maintenance as per manufacturer instructions
	- Checking of Alarms, Firmware Version, Parameter Backup and Diagnostic Test (If applicable)



SWAPs for Low Voltage equipment

Circuit Breaker

Level	Activity
Act	General inspection and cleaning of the circuit breaker
	- Make sure the circuit breaker is clean
	- Remove dust, dirt, oily substances, excess grease
	- Check that the rating plates with the technical specifications of the apparatus are present and clean them
	Check connection terminals (Circuit-breaker connections and connections between circuit breaker and switchboard)
	- Remove dust or soil
	- Make sure there are no tracing of overheating
	- Check the tightness of fastening bolts for all connections to the terminals
	Inspection of electrical and mechanical accessories
	- Check that the accessories are securely fixed to the circuit-breaker
Perform	- Check that the accessories are connected correctly to the circuit-breaker
	- Make sure that the coils, if present, are in good condition (no excessive wear and tear, overheating, rupture)
	- Make sure that the mechanical operation counter functions correctly (if present) by operating the circuit-breaker
	- Check the wear on the brushes of the gearmotor and if necessary, replace them
	Check that the vertical or horizontal interlocking devices (if provided) are installed and that they operate correctly
	Final checks
	- Perform 10 opening and closing operations (in both local and remote modes, if applicable)
	- Perform 10 tripping operations via Trip test
	- Check the proper operation of coils, gearmotor, auxiliary contacts, lock for circuit-breaker in open position (key or padlock)
	In-depth inspection of the circuit breaker ⁽¹⁾
	- For withdrawable circuit breakers, remove all traces of dust, mould, condensation and oxidation inside the fixed part
	- Make sure that there are no traces of overheating or cracks, which could impair the insulating parts
	- Check the integrity of the separation pliers
	- Check the jaw contacts for traces of erosion or discoloration
	- Make sure that the screws that fasten the fixed part to the switchgear are well tightened)
	Cleaning and lubrication of the operating mechanism
	Check for wear on the contacts ⁽¹⁾
	Final suggested tests
	- Measure opening and closing time
	- Measure primary circuits contact resistance

1) Not applicable to Emax 1.2



SWAPs for Low Voltage equipment

Relay integrated in the circuit breaker

For integrated relay, the maintenance calendar follows the circuit breaker's schedule.

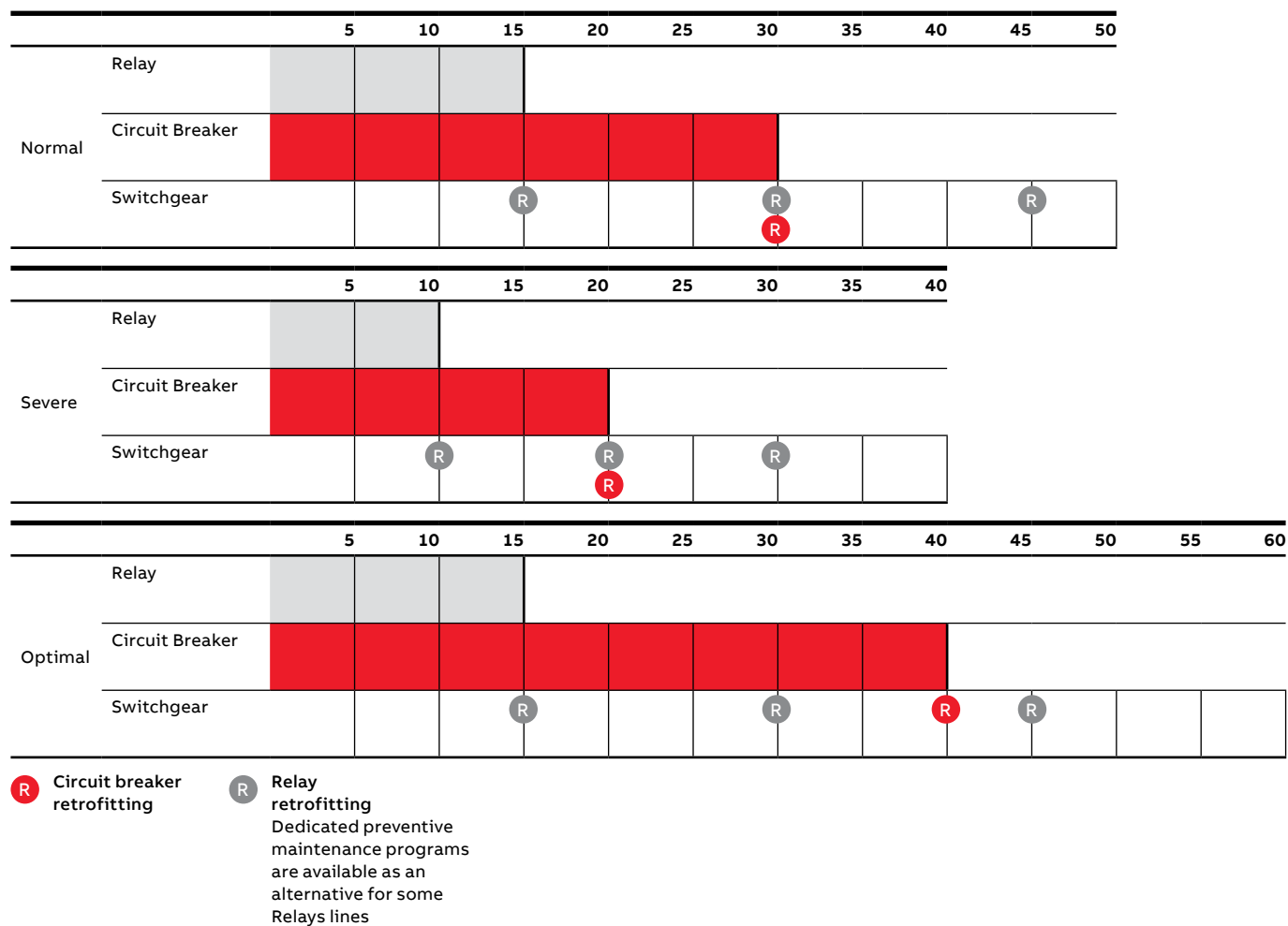
Level	Activity
Act	General inspection and cleaning; if necessary, remove any dust or traces of other materials
	Inspection of Trips and Status messages
	Check relay auxiliary supply voltage condition
	Perform any available test through relay (e.g. Trip unit LED test, Check on the presence of the internal battery, Check circuit breaker trip operation)
	Check relay settings and software updates
Perform	Perform diagnostic test via Software, if applicable

External relay

Level	Activity
Watch	Check for signs of mechanical damage on relay case
	Check for cleanliness, accumulation of dust on relay cover/case
	Check for evidence of moisture on the relay mechanical case
	Inspect wiring terminal and case for oxidation or discoloration
	Check temperature surrounding the relay
	Inspect the relay HMI:
	<ul style="list-style-type: none"> - Check power supply LED - Check display of internal relay fault indication - Check display of indication LEDs
Act	Check auxiliary supply voltage condition
	Inspect secondary wiring tightness
	Initiate self-supervision check process
	Perform secondary injection test
	Perform any available test through relay
	Check circuit breaker trip operation
	Check relay settings
	Check Life Cycle status of installed base
Perform	Check for software updates
	Recommendations according to Life Cycle status check
	<ul style="list-style-type: none"> - Replacement - Relay Retrofit Program (RRP)
	Relay preventive maintenance program (if applicable)
	Replace power supply and output relay modules
	Additional testing according to preventive maintenance concept



End of Life and Retrofitting





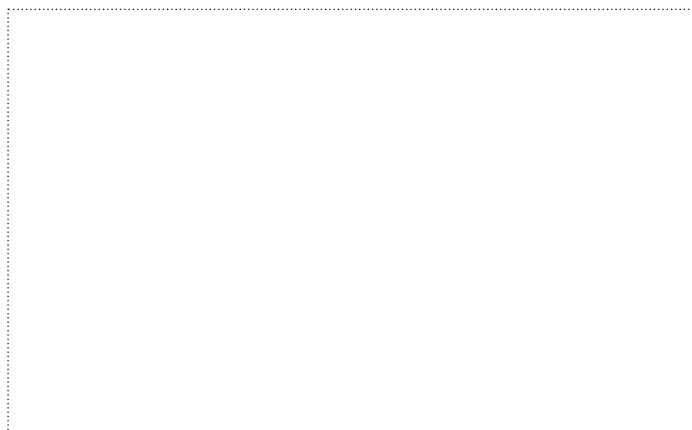
Reference standards

- IEC, IEEE and GB Standards for electrical Equipment
- IEC, Classification of environmental conditions –
–Part 3-3: Classification of groups of environmental parameters and their severities –
Stationary use at weather protected locations,
IEC Standard 60721-3-3, Part 3-3, 10/2002
- NFPA, Recommended practices for electrical equipment maintenance, NFPA Standard 70B, 2019 (U.S. National Standard)
- ISO, Petroleum, petrochemical and natural gas industries — Collection and exchange of reliability and maintenance data for equipment, ISO Standard 142224, 10/2016
- IEC, Low-voltage switchgear and controlgear assemblies - Part 1: General rules
IEC Standard 61439-1, Part 1, 05/2020





For more information please contact:



More product information:

abb.com/mediumvoltage

Your contact center:

abb.com/contactcenters

More service information:

abb.com/service