White Paper

Low Voltage Air Circuit Breaker Service
Making the case for preventive maintenance

Power and productivity
for a better world™

The Case for Maintenance

Equipment intensive businesses understand that the uptime and reliability of their assets are vital to business success. Owners and facility management teams are increasingly concerned with their abilities to keep their equipment working at peak performances. This leaves them with the task of managing the myriad of maintenance challenges, which include extending equipment life cycles, maintaining and improving efficiencies, decreasing unscheduled downtime, planning for the unexpected failures – and all this while decreasing maintenance costs.

The National Fire Protection Association standards, NFPA 70B: Recommended Practice for Electrical Equipment Maintenance, aptly states that 'Electrical equipment deterioration is normal, but equipment failure is not inevitable. As soon as new equipment is installed, a process of normal deterioration begins. Unchecked, the deterioration process can cause malfunction or an electrical failure. An effective Electrical Preventive Maintenance program identifies and recognizes these factors and provides measures for coping with them.' It goes on to highlight that 'without an Electrical Preventive Maintenance program, the management assumes a greatly increased risk of a serious electrical failure.'

It is essential to have a properly implemented preventive maintenance program for electrical equipment.

Maintenance for your Switchgear and Breakers

Electrical switchgear are made up of numerous, interconnected, mechanical and electrical components, which are often forgotten after installation. Studies show that the rate of electrical component failures is three times higher in facilities that do not perform preventive maintenance (source IEEE).

It has also been found that if a circuit breaker is not tested and maintained according to the manufacturer's instructions, the failure rate could be very high. An IEEE study shows that failure probability could reach 50% in five years. Further in the study, it was found that 73% of all circuit breaker failures are disruptive to plant operations, and require the technical teams' emergency, round-the-clock efforts to rectify. All of the above can be greatly reduced if preventive maintenance is performed.

The following are the most common causes of switchgear malfunction –

- Failure of components, including the circuit breakers
- Loose connections
- Insulation deterioration
- Ingress of moisture, dust and other foreign objects
- Accelerated deterioration from special electrical loading conditions and harsh environmental conditions

The circuit breaker is essentially a mechanical system with numerous moving parts. Its life expectancy is dependent on the wear and tear of all its components, including the frame, main contacts, jaw type contacts, auxiliary contacts, operating mechanisms, electrical and mechanical accessories, trip unit, and lubricating products.

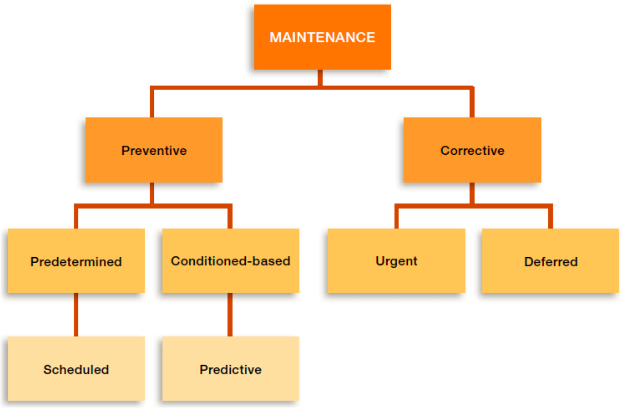
The aforementioned causes can be detected and corrected during maintenance actions. When left uncorrected, the breaker can fail to open under fault conditions. Potential consequences of inaction include devastating equipment damages, fires, personnel safety hazards, and production downtime which could result in lost revenue and corporate reputation.

Standards such as the NFPA, IEEE, NEMA, IEC have extensively documented requirements for maintenance of electrical equipment. These studies address the frequencies of maintenance and technicians' skill sets for maintenance actions. Comprehensive instructions on how maintenance actions can be carried out can also be obtained from equipment manufacturers.

A well administered Electrical Preventive Maintenance program will reduce accidents, improve personnel safety, and minimize costly breakdowns and shutdowns of production equipment. Impending troubles can be identified, and corrected before they become major problems and require more expensive and time consuming solutions. (NFPA 70B)

Maintenance Strategies

The following diagram illustrates the maintenance strategies commonly used for electrical equipment –



Corrective Maintenance, also known as run-to-failure, assumes that all failures are age-related and inevitable. As the name suggests, no maintenance actions are carried out on the equipment. Upon failure, corrective actions such as repairs or replacements are made. This maintenance strategy should only be applied to equipment with negligible failure consequences.

Preventive Maintenance is the systematic inspection, detection, correction, and prevention of incipient failures, before they become actual failures. This can be further divided into planned and predictive maintenance. Objectives include the following –

- Maintain original equipment functionalities
- Reduce unplanned downtime
- Optimize useful lifetime of equipment
- Decrease long-term maintenance costs

Scheduled Maintenance is the form of preventive maintenance where the equipment is shut down regularly. This enables maintenance personnel to test and inspect the multiple components in the system, and carry out the necessary actions to keep the system running with all the intended functionalities and performance levels.

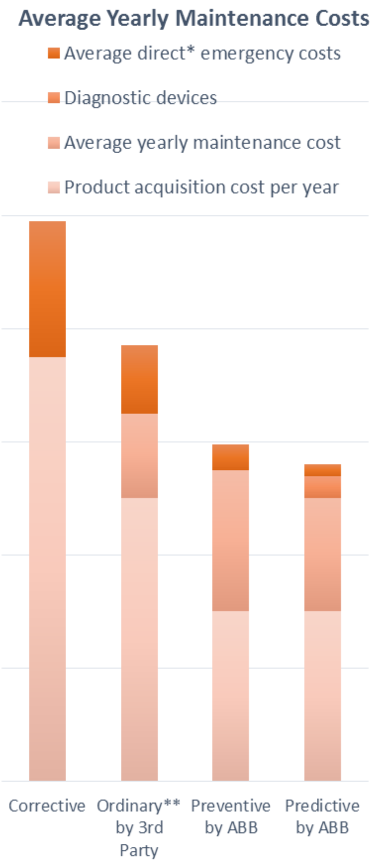
Predictive Maintenance, another form of preventive maintenance, is also known as condition-based maintenance. It is a systematic approach to determine the need for actions to be taken before failure. This limits maintenance activities only to those that are required. Monitoring systems detect abnormal conditions on measurable indicators such as temperatures changes and equipment performance efficiencies. Built-in diagnostic features use algorithms to predict and communicate the health status of each sensitive component, thereby allowing facility and maintenance personnel to make timely decisions on maintenance actions and requirements.

Advantages	Disadvantages
Corrective Maintenance	
• Low cost • Less staff required for management	• Increased cost due to unplanned downtime of equipment • Increased labor cost, especially if overtime is needed • Cost involved with repair or replacement of equipment • Possible secondary equipment or process damage from equipment failure • Inefficient use of staff resources
Preventive Maintenance	
• Cost effective in many capital-intensive processes • Planned maintenance interval can take into account plant schedules • Increased component life cycle • Reduced equipment or process failure • Estimated 8% to 18% cost savings over corrective maintenance program	• More labor intensive compared with Corrective Maintenance • Includes performance of unneeded maintenance when compared with Predictive Maintenance
Predictive Maintenance	
• Increased component operational life/availability • Allows for preemptive corrective actions • Decrease in equipment and process downtime. • Decrease in costs for parts and labor • Improved worker and environmental safety • Energy savings • Estimated 8% to 12% cost savings over preventive maintenance	• Increased investment in diagnostic equipment • Increased investment in staff training • Savings potential not readily seen by management

Costs

Maintenance costs, especially the indirect costs, are not always evident or easily justified. IEEE STD 902 states: 'In planning an electrical preventive maintenance program, consideration must be given to the costs of safety, the costs associated with direct losses due to equipment damage, and the indirect costs associated with downtime or lost or inefficient production.'

Due to the different natures of various maintenance strategies, their overall costs also differ. The following diagram illustrates the total costs that are associated with maintenance.



* Indirect emergency costs have not been included in this table

** Ordinary maintenance refers to maintenance done by non-ABB personnel, but in accordance with ABB Installation and Maintenance Manual

Frequencies

In normal operational conditions, manufacturer standards recommend minimum maintenance activities to be carried out on products at intervals of a specified number of operations, or at least once a year, whichever comes first. These frequencies can vary depending on the criticality of the application, the loading of the equipment, and the environment it is installed in. It is the responsibility of the user to check with the manufacturers for the appropriate intervals for their equipment, and thereafter plan accordingly. Where predictive maintenance strategies are employed, maintenance intervals can also be adjusted, depending on current breaker conditions.

For circuit breakers, maintenance actions involve visual inspection, general cleaning, lubrication of the mechanical parts where required, checking for contact wear and alignment, and inspection of arc chutes especially after opening in a fault condition. Maintenance frequencies depend largely on the environmental conditions of the surrounding area. Environments with dust, lint, moisture, or other foreign matter indicate the need for higher frequencies. Special note should also be taken for installations where vibrations are present. Criticality of the application is also a major factor in deciding maintenance intervals.

In addition to these planned interventions, the following are some situations where circuit breakers should temporarily be taken out of service for functionality checks –

- *Fault due to short circuit condition:*
  Before resetting the breaker, it, along with the circuit and equipment, should be tested and inspected, by a qualified person, to ensure a short circuit condition does not exist in the system and that it is safe to reset the breaker. Resetting the breaker when the short circuit condition still exists is a critical situation that can cause burn injuries resulting from explosions of electrical equipment.
- *After a high level fault has occurred in equipment that is properly rated and installed:*
  It is not always clear what damage has occurred within the equipment. The circuit breaker may appear virtually clean while its internal condition is unknown. Qualified personnel should be engaged to inspect the

system and verify circuit breaker functionalities and integrities

- *When the circuit breaker has not been operated for extended periods of time:*
  The circuit breaker should be manually opened and closed to check that the mechanism works properly
- *Unknown failures or tripping of the system:*
  Equipment must be checked for short circuit conditions. If the breaker cannot interrupt a second fault, it will fail and may destroy its enclosure and create a hazard for anyone working near the equipment.

Conclusion

In order to protect equipment and people, proper preventive maintenance must be performed. Several standards and guides exist to assist users with electrical equipment maintenance. When overcurrent protection devices are properly operated and maintained, equipment damage, arc flash hazards and unplanned outages are greatly reduced.

Maintenance for Low Voltage Air Circuit Breakers
ABB solutions, skills, advantages

Choosing ABB Solutions

Investing in failure prevention, rather than living with its consequences, is a primary concern for many businesses. Successful prevention of failure can positively influence a company's long term competitiveness.

Over the years, ABB Low Voltage Service has developed people and software to become a one-stop solution for the maintenance of ABB electrical equipment. With this infrastructure in place, the team partners with our customers to maximize equipment performance throughout their life cycles.

With ABB as a service provider, the customer can be confident that its equipment is maintained by skilled and certified technicians who use genuine, quality parts.

ABB Field Service Engineers

ABB has an extensive network of qualified field service engineers. In accordance with local and international standards on skilled personnel, these engineers have undergone intense, theoretical and hands-on training conducted by the ABB factory. The certification levels are administered through a formal system, which ensures that all the knowledge and expertise of all certified engineers remain current.

Equipped with specific technical know-how and access to all the manufacturer's resources on our equipment, ABB engineers are qualified to handle a wide range of issues that can arise.

Apart from routine maintenance work, services by the technical team also include customer training, troubleshooting and problem solving, repair/replacement of components, and other advanced engineering solutions.

Companies who choose to have their services done by the ABB team of engineers can be assured of quality services that comply with manufacturers' requirements.

ABB declines all liability for damages to persons or property caused by failure to comply with maintenance instructions detailed in the installation and service manuals.

Preventive Maintenance Program

Preventive Maintenance Program, or PMP, is a systematic and functional means of maintaining a specific breaker. It is a scheduled maintenance program developed by ABB. Based on studies and existing statistics, it is designed to preserve the breakers' original integrities and functionalities so that failure probabilities will be reduced. Steps taken at pre-determined times of the life cycle include partial and complete overhauls of the ACB, cleaning and lubrication of moving parts, replacement of worn parts etc.

The following figure illustrates such a typical schedule –

MEGAMAX	Year from the production																				
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Mechanical Components																					
Arcing Chambers		I	I	(R)	I	I	(R)	I	I	(R)	I	I	(R)	I	I	(R)	I	I	(R)	I	I
Arcing and main contacts		I	I	P	I	I	P	I	I	P	I	I	P	I	I	P	I	I	P	I	I
Operating Mechanism		I	I	P	I	I	P	I	I	P	I	I	P	I	I	P	I	I	P	I	I
Racking-in/out device (for withdrawable circuit-breakers)		I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Jaw-type isolating contacts (only for withdrawable circuit-breaker)		I	I	(R)	I	I	(R)	I	I	(R)	I	I	(R)	I	I	(R)	I	I	(R)	I	I
Main circuit - Busbars connections																					
Terminals		I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Auxiliary Connections																					
Auxiliary Contacts		I	I	P	I	I	P	I	I	P	I	I	P	I	I	P	I	I	P	I	I
Electrical and mechanical accessories																					
Geared motor		I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Undervoltage release		I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Shunt opening release		I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Shunt closing release		I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Circuit-breaker locked in the open position (with key or padlocks)		I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Circuit-breaker auxiliary contacts		I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Locking devices for circuit-breakers connected and disconnected		I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Interlocking devices between circuit-breakers mounted side by side and/or one on top of another		I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I	I
Optional Performances																					
Thermographic check		(P)	(P)	(P)	(P)	(P)	(P)	(P)	(P)	(P)	(P)	(P)	(P)	(P)	(P)	(P)	(P)	(P)	(P)	(P)	(P)
Insulating resistence				(P)			(P)			(P)			(P)			(P)			(P)		
Electronical components																					
Protection trip unit		I	I	P	I	I	P	I	I	P	I	I	P	I	I	P	I	I	P	I	I

The results of maintenance according to the schedule include extended circuit breaker life, increased plant reliability and personnel safety, increased production reliability, and relatively lowers maintenance costs in the long run.

All interventions are carried out by engineers and technicians certified by ABB.

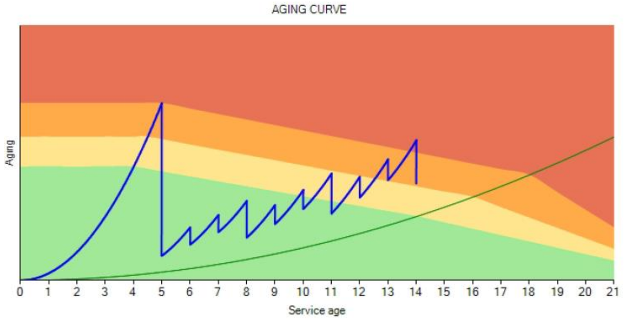
Please refer to www.abb.com or contact your local ABB representative for more information.

Life Expectancy Analysis Program

Life Expectancy Analysis Program, also known as LEAP, is a proprietary diagnostic tool developed by ABB. It periodically assesses the conditions of breakers on the plant. Using data pertaining to operating conditions, the algorithms, which are built into LEAP, determines the health of the circuit breaker, communicate failure probabilities, and recommends maintenance activities.

Rather than waiting to fix the equipment too late after a failure, or earlier than required when following a maintenance schedule, this form of condition based maintenance allows facility maintenance teams understand the health of the breakers and make the optimal maintenance decisions based on the actual equipment conditions. The results are reduced overall maintenance costs and equipment downtime, which translates to increased productivity.

LEAP, coupled with PMP, yields the following sample graph of circuit breaker health and failure probability.



When the indicators do not fall within normal operating ranges, a local alarm is triggered. By analyzing data to predict when assets are likely to fail, organizations can schedule preventive maintenance actions in a timely manner to avoid unplanned failures.

Our Commitment

ABB Low Voltage Service team is committed to being an active partner with our customers. The services offered by the team spans the entire value chain, from the first enquiry to delivery and installation, to disposal and recycling of the product. In addition to the maintenance services highlighted in this document, ABB provides training, technical support, and customized service agreements. All this is supported by one of the most extensive global and service networks.

Please contact your local ABB representative for more information on how we can improve your maintenance program.

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