SWAPs Maintenance

The maintenance program for a successful and lasting use of your assets
Agenda

Customer needs
Maintenance
Failure trend and possible failures
Asset health management
SWAPs maintenance
Equipment’s conditions
SWAPs maintenance plan
Major maintenance activities
Condition based maintenance
End of life and retrofitting
Health & Safety
Recap
Customer needs

- Minimum downtime
- Lower costs
- High Reliability
- Avoid failures
- Be environmentally friendly!
- Less maintenance
- High availability
- Be safe!
- Be fast!
What is maintenance?
Mindset-changing

“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”¹

Performing a correct and periodic maintenance is essential to:
- Maximize productivity
- Protect the assets
- Optimize investments
Myths and facts
Common misconceptions

Widespread myths

- Electrical equipment does not need maintenance
- Maintenance is just dusting down
- No need to take care of electrical equipment, being very static

Proven facts

- Periodical checks on functionality and maintenance are required to guarantee the original performance level
- Maintenance consists of checking the integrity of all the electrical and mechanical components to limit aging effects on components and prevent faults
- Aging and environmental conditions wear down the equipment over time
Myths and facts
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Why maintaining?
Failure rates and related effects

Causes of failure

- Environmental Conditions: 30%
- Inadequate Maintenance: 54%
- Others: 16%

Indirect costs

- Higher risk in Health & Safety
- Reduction of products lifetime
- Management of urgencies
- Poor quality
- Energy consumption
- Environmental impact
- Resources availability
- Inefficiency in personnel
- Insurance policies
- Production losses
- Losses in market share
Failure trend
Through the equipment’s life

First phase:
- **Infant mortality** – widely ranging failure rate due to manufacturing and commissioning defects

Second phase:
- **Random failures** – constant failure rate caused only by random failures

Third phase:
- **Wear out** – increasing failure rate due to aging and wearing of the equipment
Possible failures

Switchgear¹

Low voltage compartment components
Panel frame and power circuit
Measuring transformers
Earthing switch
Switches
Interlocking
Shutters
Circuit breaker – see next slides
Relay – see next slides
Possible failures
Circuit breakers

Spring charging motor
Spring mechanism
Opening coil
Closing coil
Tulip contacts
Auxiliary plug
Dumper
Poles
Truck
Possible failures
Relays

Electronic cards
Plastic connectors
Software
Human Machine Interface (HMI)
Asset health management

Maintenance strategies

1. Run to failure
2. Time-based
3. Usage-based
4. Condition-based
5. Predictive
SWAPs maintenance
Starting point

- Run to failure
- Time-based
- Usage-based
- Condition-based
- Predictive
SWAPs maintenance

Inputs

- Environmental and Operational Conditions
- Monitoring and Diagnostic solutions
- Age of the equipment
- Previous Maintenance

1. Condition-based maintenance requires monitoring and diagnostic solution
SWAPs maintenance

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)
Equipment’s conditions
Environmental and operational

**Environmental**
- Temperature
- Humidity
- Rate of Change of temperature
- Condensation, formation of ice
- Heat radiation
- Flora and fauna
- Chemicals (salt, sulphur dioxide, chlorine, etc.)
- Presence of dust and sand
- Vibration and shock
- Altitude

**Operational**
- Age
- Number of operations
- Loading
- Short Circuit current interruptions
- Frequency of operation (inactivity time)
# Equipment’s conditions

## Classes of conditions

<table>
<thead>
<tr>
<th><strong>Optimal</strong></th>
<th><strong>Normal</strong></th>
<th><strong>Severe</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Favorable range within the Normal conditions, based on ABB experience</td>
<td>Defined by Standards from IEC, IEEE and GB</td>
<td>Outside the Normal range</td>
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<tr>
<td>Allow the deferral of the equipment’s aging</td>
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<td>Require higher attention</td>
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<td>One parameter might influence the whole performance</td>
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<td></td>
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<td>Can cause premature aging and wearing</td>
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<td>Higher safety risks due to higher probability of failure</td>
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</tbody>
</table>
Equipment’s conditions

Example of optimal and severe conditions

<table>
<thead>
<tr>
<th>Parameter</th>
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<tr>
<td>Temperature [°C]</td>
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<tr>
<td>Humidity [%]</td>
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<tr>
<td>Number of operations [%]</td>
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<td>Altitude [m]</td>
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More than 10 other parameters considered
Effects of the equipment's condition
Costs and downtime comparison

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<th>Condition</th>
<th>Cost Change</th>
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<tr>
<td>Normal</td>
<td>+100%</td>
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<tr>
<td>Optimal</td>
<td>-20%</td>
</tr>
<tr>
<td>Severe</td>
<td>+100%</td>
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</table>

1. Percentages are calculated with respect to the costs and hours required on normal conditions.
## SWAPs maintenance

## Maintenance levels

<table>
<thead>
<tr>
<th>See</th>
<th>Watch</th>
<th>Act</th>
<th>Perform</th>
<th>Secure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall visual Inspection</td>
<td>In-depth Inspection De-energized Panel</td>
<td>Basic Maintenance Cleaning, lubrication and functional testing of the equipment</td>
<td>Advanced Maintenance In-depth analysis of the asset and immediate corrective actions</td>
<td>Special maintenance for critical situations (It will not be included in maintenance plan)</td>
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</tbody>
</table>

Trained personnel
- Dedicated ABB trainings

ABB certified technician
Support by ABB

Why ABB Technicians?

Safety

1. Safety is the first priority for all ABB services

Quality and performance

2. ABB Technicians have a deep knowledge of the product

Certification

3. All ABB technicians are registered and certified

Warranty

4. Warranty is granted on repaired components
## SWAPs maintenance plan

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</tbody>
</table>

### Frequency of SWAPs intervals:
- Optimal conditions allow to extend them by 30%
- Severe ones imply reducing them by 50%
**Major maintenance activities**

**Switchgear**

### See
- **Energized panel**
  - Perform an overall visual inspection
  - Check all indicators and instruments
  - Check for cleanliness, vibrations, moisture, rust, level of chemicals presence, unusual amount of ozone odor
  - Record number of operations and loading

### Watch
- **De-energized panel with main busbar live**
  - Visual inspection of the interlocks, line and earthing switches, overheating
  - Check the ventilation system
  - Check the voltage and current transformers
  - Inspect tracking on insulating surfaces on the power cable side
  - Verify operation of heaters and thermostats

### Act
- **De-energized busbar**
  - Clean all components and re-lubricate where necessary
  - Functional testing of mechanical parts
  - Measure primary circuit insulation and contacts resistance
  - Inspect tracking on insulating surfaces on the entire switchboard

### Perform
- **De-energized busbar**
  - Check bolted connections
  - Inspect and tighten secondary control wiring
  - Examine overheating carefully
  - Clean contacts on relays and switches, replace covers
  - Clean, check louvers, air filters and pressure flaps
  - Functional testing on controls, interlocks and voltages
  - Inspect, clean, functional test on current, voltage and control power transformers

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**ABB training for maintenance personnel**

**ABB certified technician**
Major maintenance activities
Circuit breaker

**Act**
- General inspection
- Servicing of switching device in general
- Suspect joint maintenance
- Testing of interlock conditions
- Checking of the auxiliary switches
- Functional testing

**Perform**
- Servicing of the operating mechanism
- Measurements of closing and opening times and simultaneity of contact
- Primary circuits contact resistance measurement

**ABB training for medium voltage equipment**

**ABB certified technician**
# Major maintenance activities

## Protection Relays

### Watch
- Check for mechanical damage
- Visual check of cleanliness
- Visual check for moisture
- Visual inspection of wiring terminal
- Check temperature surrounding the relay
- Visual inspection of relay HMI

### Act
- Checking the healthiness of auxiliary supply voltage condition
- Inspect secondary wiring tightness
- Restarting to initiate self-supervision check
- Check CB trip operation through relay
- Secondary injection testing
- Check relay settings
- Check Life Cycle status of installed base
- Software update check

### Perform
- Replacement of power supply and output relay modules

---

*Preventive Maintenance Program*
Condition – based maintenance
A step further

1. Run to failure
2. Time-based
3. Usage-based
4. Condition-based
5. Predictive

Value, savings
Monitoring and Diagnostic solutions
Enabling condition – based maintenance

**MyRemoteCare** 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.

MyRemoteCare collects diagnostic information from sources like **MySiteCare** and **SWICOM**.
# Maintenance plan

## Standard conditions with condition monitoring

| 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  | 10  | 13  | 13.5 |
|-------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Circuit breaker | A   | P   | A   | P   | A   | P   | A   | P   | A   | P   | A   | P   | A   | P   | A   | P   | A   | P   | A   | P   | A   | P   | A   | P   | A   | P   | A   | P   | A   | P   | A   | P   |

Intervals can be increased by 30%\(^1\)

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\(^1\)Standard conditions with M&D
## Condition-based maintenance

Benefits of condition monitoring

<table>
<thead>
<tr>
<th>Asset type</th>
<th>SWAPs level</th>
<th>Activities duration (h)</th>
<th>Activities duration with M&amp;D (h)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Circuit breaker</strong></td>
<td>Act</td>
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<td><strong>Switchgear</strong></td>
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<tr>
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</table>

### Benefits of condition monitoring

- **30% Maintenance activities duration’s reduction**
- **Up to 40% Maintenance activities’ cost reduction**

### Standard conditions

<table>
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<tr>
<th>Device/Year</th>
<th>0.5</th>
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### Standard conditions with M&D

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</table>

### Reduction of unplanned labor cost maximizing uptime

- **$1.2M per hour**
  - Average downtime costs for an automotive industry
- **$740K per outage**
  - Average downtime costs for data centers
- **$4.4M per day**
  - 120,500 barrels of oil lost per day oil & gas segment
- **$150M per outage**
  - Airline lost a switchgear with 3.7% stock drop in 2 days in 2016
- **$100K per panel**
  - Steel works loss per year per panel
- **$20K per panel**
  - Annual loss in semi-conductor production

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Slide 30

How to further extend equipment’s lifetime

Switchgear modernization

Upgrade solutions
- Arc fault protection
- Remote breakers racking
- Auxiliary equipment renewal
- Interlocking and safety features
- Condition monitoring

Retrofit solutions
- Relay replacement
- Circuit breaker replacement
## End of life and retrofitting

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<td>Relay</td>
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<td>Circuit breaker</td>
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<td>Switchgear</td>
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**Legend**

- **R** Relay retrofitting
- **EOL** End of life

Dedicated preventive maintenance programs are available as an alternative for some Relays lines.

**Circuit breaker retrofitting**
Health and safety
How to carry out maintenance in a safe way

Training & certification
Only trained and certified personnel should carry out maintenance

ABB offers different solutions:
- Training for your own personnel
- Trained ABB personnel to perform maintenance

Maintenance with de-energized panel
Maintenance plans mean preserving your equipment integrity

Reduces the risk of internal arc faults

Remote racking
TruckMaster
Reduces the risk for personnel on site

Active Arc Protection
UFES (Ultra Fast Earthing Switch)

Safety for personnel and equipment is the first priority
Reducing the risk of failure

The right mix

Managing conditions

Depending on the location of the equipment it is not always possible to control environmental conditions

Right maintenance

Tailored to your assets, according to your equipment’s conditions

Safer electrical equipment – for everybody!

Lower overall downtimes

Higher lifetime of your equipment

Condition monitoring

Online monitoring

Remote support

Predictive algorithms

Modernization

Upgrades and retrofits

Safer electrical equipment – for everybody!
Equipment’s conditions – Normal
Based on Standards by IEC, IEEE, NFPA

Environmental

Climatic conditions
- Temperature: -5°C... 40°C
- Humidity: 5%... 95%
- Temperature change: < 0,5°C/min
- Possibility of condensation and ice formation

Mechanically active conditions
- Presence of dust minimized, ingress of sand prevented.
  Visible dust layer

Mechanical conditions
- Insignificant vibration and shock. No external vibrations source

Altitude
- < 1000m

Special conditions
- No influence of heat radiation

Biological conditions
- The presence of flora and fauna is avoided

Chemical conditions
- Salt mist may be present in sheltered locations
  (coastal and offshore)
- Other chemicals limits¹

¹ Other chemicals limits include:
- Sulphur dioxide 0.1 mg/m³, Hydrogen sulphide 0.01 mg/m³, Chlorine 0.01 mg/m³, Hydrogen chloride 0.01 mg/m³,
  Hydrogen fluoride 0.003 mg/m³, Ammonia 0.3 mg/m³, Ozone 0.01 mg/m³, Nitrogen oxides 0.1 mg/m³
Equipment’s conditions – Normal

Based on Standards by IEC, IEEE, NFPA

**Operational**

Age
- Relay: <15 years
- Circuit breaker: <20 years
- Switchgear: <30 years

**Number of operations**
- <50% of declared mechanical life

**Loading**
- <100% (current AND voltage)

**Short circuit currents interruptions**
- <50% of declared number of max SC interruptions
- <90% of interrupted $I_{SC}$

**Frequency of operation (inactivity time)**
- At least one operation every 6 months
Equipment’s conditions – Optimal

Based on ABB’s experience

Environmental

Climatic conditions

- Temperature: 15°C... 30°C
- Humidity: 10%... 75%
- No condensation, no formation of ice

Special and Biological conditions: same as normal conditions

Chemical conditions

- Salt mist absence
- Other chemicals limits

Mechanically active conditions

- Present but not visible dust layer

Mechanical conditions, same as standard conditions

Altitude <1000m, same as standard conditions
Equipment’s conditions – Optimal

Based on ABB’s experience

**Operational**

**Age**
- Relay <10 years
- Circuit breaker <15 years
- Switchgear <20 years

**Number of operations:**
- <25% of declared mechanical life

**Loading**
- <90% voltage AND <80% current

**Short circuit interruptions**
- <25% of declared number of max short circuit interruptions
- <80% of interrupted $I_{SC}$

**Frequency of operation (inactivity time)**
- Up to 100 operations per year (number of operation of circuit breaker)