Maintenance Philosophy
ELK 1, 2, 3
Gas Insulated Switchgear
Maintenance Philosophy

Maintenance Philosophy for GIS type ELK1, 2, 3

Criteria
- ≥ 20 years of operation for indoor application
- ≥ 10 years of operation for outdoor application

Criteria
- Maximum No of CO* operation is reached
- Maximum No of SCC* switch operation is reached
- Combination of No of CO* and SCC*
- Recommendation in diagnosis report

* Information is mentioned in operational manual
CO: close-open operation
SCC: short circuit breaking current
Maintenance Philosophy
TBM & CBM Definition

- **TBM definition**
  - The criteria for time-based maintenance are aging of material based on environmental conditions of installation

- **CBM definition**
  - CBM is to maintain the correct equipment at the right time. With CBM you can exchange just the components or parts that have been subjected to the most wear over their many years of reliable operation

- The most efficient way for contributing to life time expansion is following maintenance strategy combined with product improvements and support services.
# Maintenance Philosophy

## TBM Time Based Maintenance

### Criteria
- ≥ 20 years of operation for indoor application
- ≥ 10 years of operation for outdoor application

### Replacement of:
- Dynamic Sealing Kit CB
- Dynamic Sealing Kit DS
- Dynamic Sealing Kit ES
- Dynamic Sealing Kit FAES

### Dynamic Sealing Kit contents:
- Replacement of dynamic stressed sealings
- Adsorber (filter)
Maintenance Philosophy
CBM Condition Based Maintenance

**Criteria**
- Maximum No of CO* operation is reached
- Maximum No of SCC* switch operation is reached
- Combination of No of CO* and SCC*
- Recommendation in diagnosis report

**Product**
- Overhaul CB
- Overhaul DS
- Overhaul ES
- Overhaul FAES
- Overhaul Drive HMB, AHMA, HKA, SN
- Retrofit instead of overhaul

- **Overhaul** contents:
  - Replacement of dynamic stressed sealings
  - Adsorber (filter)
  - All contact parts which are affected during switching, mechanical wearing

* Information is mentioned in operational manual
Maintenance Philosophy
CBM Condition Based Maintenance

condition based maintenance

Criteria
- If the data are not available?

Product
- Pilotoverhaul bay
- Pilotoverhaul CB

- **Pilot Overhaul** contents:
  - Replacement of dynamic stressed sealings
  - Absorber (filter)
  - All contact parts which are affected during switching, mechanical wearing
  - Laboratory analysis of material/contact parts with report document
SF$_6$ Gas Insulated Switchgear Maintenance of circuit-breaker
Maintenance of circuit-breaker

When do you need to maintain?

- If max. **life time of dynamic sealings** has been reached
  - >20 years for indoor application
  - >10 years for outdoor application

→ **Dynamic Sealing Kit**

- If max. **number of operation** have been reached
  - Max number of close-open operation
    (2’000 / 5’000 / 10’000 CO, exact figure is mentioned in operational manual)
  - Max number of short circuit breaking current
    (10 / 15 / 20 times the max. breaking current, exact figure is mentioned in operational manual)
  - Combination of close-open operations and short circuit breaking current

→ **Overhaul**
Maintenance of circuit-breaker
When do you need to maintain?

- If no information available about number of operations and number of short-circuit breaking current and the circuit-breaker is older 10 years

→ Diagnosis or Pilotoverhaul
Maintenance of circuit-breaker
Dynamic Sealing Kit – scope of work

1. Linear movement bushing
2. Operating road
3. Support insulator
4. Current connection
5. Chamber insulator
6. Filter / Adsorber
7. Current connection

- De-commissioning of circuit-breaker includes gas quality check, gas leakage check, travel curve and dynamic resistance measurement
- Installation of Dynamic Sealing Kit
- Re-commissioning of circuit-breaker includes gas quality check, gas leakage check, travel curve and dynamic resistance measurement

(r) = replaced
(o) = overhauled
Maintenance of circuit-breaker
Overhaul – scope of work

- De-commissioning of circuit-breaker includes gas quality check, gas leakage check, travel curve and dynamic resistance measurement
- Installation of Overhaul Kit
- Re-commissioning of circuit-breaker includes gas quality check, gas leakage check, travel curve and dynamic resistance measurement
Maintenance of circuit-breaker
Pilotoverhaul – scope of work

- De-commissioning of circuit-breaker includes gas quality check, gas leakage check, travel curve and dynamic resistance measurement
- Installation of Overhaul Kit
- Re-commissioning of circuit-breaker includes gas quality check, gas leakage check, travel curve and dynamic resistance measurement
- Laboratory investigation of contacts
- Detailed laboratory report
- Maintenance recommendation for the rest of circuit-breakers within the GIS

1. Linear movement bushing
2. Operating road
3. Support insulator
4. Current connection
5. Chamber insulator
6. Filter / Adsorber
7. Current connection
8. Puffing cylinder
9. Diaphragm
10. Erosion finger, cylinder base, auxiliary nozzle, contact ring
11. nozzle
12. contact finger, finger retainer
13. fixed contact pin

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Maintenance of circuit-breaker

Advantages of planned maintenance

- Significant lifetime extension
- Reduced failure risk
- Cost effective solution (compared to unplanned activities)
- Minimized and planned outage time
- Maintain the value of the circuit-breaker
- Maximize switchgear performance
- Identify problems at an early stage, prior to escalation
  acquisition of background information for tailored maintenance activities through pilot overhaul
SF₆ Gas Insulated Switchgear
Maintenance of disconnector switch
Maintenance of disconnector switch
Allocation of disconnector switches within GIS
Maintenance of disconnector switch
Allocation of disconnector switches within GIS

- Disconnector operating mechanism (for 3 phases)
- Connecting rod
- Disconnector switches
Maintenance of disconnector switch
Types of disconnector switches

- Axial Disconnector
  - TE

- Cross Disconnector
  - TX

- Angle Disconnector
  - TV
  - TW
Maintenance of disconnector switch
Overview of disconnector switch

disconnector operating mechanism
disconnector switch
circuit-breaker
earthing switch
bushing
Maintenance of disconnector switch
When do you need to maintain?

- If max. **life time of dynamic sealings** has been reached
  - >20 years for indoor application
  - >10 years for outdoor application

→ **Dynamic Sealing Kit**

- If max. **number of operation** have been reached
  - Max number of close-open operation
    (2'000 / 5’000 CO, exact figure is mentioned in operational manual)
  - Max number of bus transfer current switching
    (100 CO @1600A / <40A exact figure is mentioned in operational manual)

→ **Overhaul**
Maintenance of disconnector switch
Dynamic Sealing Kit – scope of work

- De-commissioning of disconnector switch includes gas quality check, gas leakage check, motor current and running time measurement
- Installation of Dynamic Sealing Kit
- Re-commissioning of disconnector switch includes gas quality check, gas leakage check, motor current and running time measurement

Seal strip
Seal-ring
O-ring
Maintenance of disconnector switch
Overhaul – scope of work

- De-commissioning of disconnector switch includes gas quality check, gas leakage check, motor current and running time measurement
- Installation of Overhaul Kit
- Re-commissioning of disconnector switch includes gas quality check, gas leakage check, motor current and running time measurement

Seal-ring
Seal strip
Contact tube support
O-ring
Fixed contact
Maintenance of disconnector switch
Pilotoverhaul – scope of work

- De-commissioning of disconnector switch includes gas quality check, gas leakage check, motor current and running time measurement
- Installation of Overhaul Kit
- Re-commissioning of disconnector switch includes gas quality check, gas leakage check, motor current and running time measurement
- Laboratory investigation of contacts
- Detailed laboratory report
- Maintenance recommendation for the rest of disconnectors within the GIS
$\text{SF}_6$ Gas Insulated Switchgear
Maintenance of operating mechanism
AHMA 4/8
Maintenance of operating mechanism AHMA 4/8

Overview

- For overhaul the operating mechanism has to be removed from the circuit breaker
Maintenance of operating mechanism AHMA 4/8
When do you need to maintain?

- If max. **life time of operating mechanism** has been reached
  - >20 years for indoor application
  - >10 years for outdoor application

  → Overhaul

- If max. **number of operation** have been reached
  - Max number of close-open operation
    (10'000 CO, exact figure is mentioned in operational manual)

  → Overhaul
Maintenance of operating mechanism AHMA 4/8

Overhaul – scope of work

- guide bush (711, 713)
- check valve (301)
- connecting rod (o)
- working piston (o)
- pump motor (949)
- carbon brush (300)
- bevel wheel (11)
- dowel pin (103, 104)
- screw type coupling with protective cap (123)
- non return valve (7)
- filter (82)
- plug for locking device (253)
- screw plug (49)
- guiding rod (o)
- change over valve USR16 (167)
- plug (40)
- locking screw (119)
- screw plug (251)
## Maintenance of operating mechanism AHMA 4/8

### Overhaul – scope of work

<table>
<thead>
<tr>
<th>Item</th>
<th>Replaced</th>
<th>Overhauled</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>non-return valve for pump</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>straight tooth bevel wheel</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>plug</td>
<td></td>
</tr>
<tr>
<td>49</td>
<td>screw plug</td>
<td></td>
</tr>
<tr>
<td>82</td>
<td>filter</td>
<td></td>
</tr>
<tr>
<td>103, 104</td>
<td>dowel pin</td>
<td></td>
</tr>
<tr>
<td>119</td>
<td>locking screw</td>
<td></td>
</tr>
<tr>
<td>123</td>
<td>screw type coupling with protective cap</td>
<td></td>
</tr>
<tr>
<td>167</td>
<td>change over valve</td>
<td></td>
</tr>
<tr>
<td>251</td>
<td>screw plug</td>
<td></td>
</tr>
<tr>
<td>253</td>
<td>plug for locking device</td>
<td></td>
</tr>
<tr>
<td>300</td>
<td>carbon brush for pump motor</td>
<td></td>
</tr>
<tr>
<td>301</td>
<td>check valve</td>
<td></td>
</tr>
<tr>
<td>711, 713</td>
<td>guide bush</td>
<td></td>
</tr>
<tr>
<td>800</td>
<td>sealings</td>
<td></td>
</tr>
<tr>
<td>949</td>
<td>pump motor</td>
<td></td>
</tr>
<tr>
<td></td>
<td>working piston</td>
<td></td>
</tr>
<tr>
<td></td>
<td>connecting rods</td>
<td></td>
</tr>
<tr>
<td></td>
<td>guiding rod</td>
<td></td>
</tr>
</tbody>
</table>
Maintenance of operating mechanism AHMA 4/8
Overhaul – scope of work

- For outdoor application will be added following scope:
  - position indicator window (28)
  - O-ring seal for position indicator (112)
  - screws, washers (135, 136)
  - rubber seal (171, 1171, 1280)
  - sealing for cover (281)
SF₆ Gas Insulated Switchgear Migration Modules
Retrofit Modules

Retrofit Module S04
Filter to circuit breaker

Situation - Consequences

- The filter is made of aluminium oxide and is packaged in woven steel bags
- There is a possibility of exothermic reaction in case of arcing
- Filter and consequently closure melt through is possible

Proposed Solution & Benefits

- Upgrade to the new improved filter design:
  - molecular sieve filter material packed in woven polyester bags
- No meltthrough of enclosure as there is no exothermic reaction
- Work can be done on site
- Outage of bay required
- Part of Retrofit Module X08 (Rupture Disc) on the CB
Retrofit Modules

Retrofit Module A06
Change-over valve 32 to operating mechanism type HKA

Situation - Consequences

- Increased stress on piston sealings
- Internal oil leakage in change-over valve with 1-piece piston
- Higher pump starts and premature wearing out of components
- No operating safety

Proposed Solution & Benefits

- Upgrade and replace with a 2-piece piston
- Improved function of the hydraulic mechanism
- Assured operational safety
- Work can be done on site
- Outage of bay required
Retrofit Gascompartments

**Retrofit Module X06**  
**Particle filter to bypass tube**

**Situation - Consequences**

- No particle filter in the bypass tube installed
- Contamination of adjacent gas compartments in case of a flashover
- Extended outages because of cleaning procedures on top of the repair time

**Proposed Solution & Benefits**

- Upgrading and fitting of particle filter into bypass tube
- No cleaning required in adjacent gas compartments
- Retrofit can be done on site
- Shorter outage of bay required
Retrofit Bursting Disc

Retrofit Module X08
Exchange of rupture disk

Situation - Consequences

- Rupture disk is made of graphite
- Limited gas tightness under extreme conditions of operation
- Slow increase of humidity in the SF₆ gas
- Danger to personnel in case of activation. Small graphite parts will be blown into the adjacent area of the deflector

Proposed Solution & Benefits

- Upgrade and build in a metal rupture disk
- Improved gas tightness in any condition of operation
- Moisture absorption is eliminated
- Safety for personnel is increased
- Retrofit can be done on site
- Outage of bay or busbar required
Retrofit Disconnector

**Retrofit Module T08**
Coupling element to operating mechanism of disconnect and ground switches

**Situation - Consequences**
- The coupling element at the operating mechanism can break due to ageing
- Switches are no longer in defined position
- Possibility of dielectric failure

**Proposed Solution & Benefits**
- Upgrade and install a reinforced coupling element
- Improved operational safety
- Work can be done on site
- Outage of bay required
Retrofit Disconnector

**Retrofit Module T06**
Slipping clutch to operating mechanism of disconnect and ground switches

**Situation - Consequences**
- The pre-set limits of the slipping clutch can change with time
- Correct operation of the unit is not ensured
- Operational safety is affected

**Proposed Solution & Benefits**
- Upgrade and build in a new modified slipping clutch
- Exchange will be made together with the motor
- Assured safety
- Work can be done on site
- Outage of bay required
SF₆ Gas Insulated Switchgear
Example - Maintenance Philosophy
Example – Maintenance Philosophy

Example

<table>
<thead>
<tr>
<th>Switchgear A</th>
<th>Switchgear B</th>
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<tbody>
<tr>
<td>year of installation:</td>
<td>year of installation:</td>
</tr>
<tr>
<td></td>
<td>1990</td>
</tr>
<tr>
<td>circuit breaker:</td>
<td>circuit breaker:</td>
</tr>
<tr>
<td></td>
<td>1900 no of CO</td>
</tr>
<tr>
<td>circuit breaker:</td>
<td>circuit breaker:</td>
</tr>
<tr>
<td></td>
<td>3 no of SCC</td>
</tr>
<tr>
<td></td>
<td>(breaking current unknown)</td>
</tr>
<tr>
<td>disconnector switch:</td>
<td>disconnector switch:</td>
</tr>
<tr>
<td></td>
<td>500 CO</td>
</tr>
<tr>
<td>earthing switches:</td>
<td>earthing switches:</td>
</tr>
<tr>
<td></td>
<td>150 CO</td>
</tr>
</tbody>
</table>

**Process of data evaluation**

- Collecting data from operational manual or on-site
  - Application outdoor or indoor
  - Type of breaker
    - Max. no of close-open operation
    - Max. no of short circuit current
  - Max. no of operations for disconnector switch
  - Max. no of operations for earthing switch
    - indoor
    - SN 211
    - 5000 CO
    - 15 / 50kA
    - 2000 CO
    - 2000 CO
Example – Maintenance Philosophy
Exemplary solution

Switchgear A

<table>
<thead>
<tr>
<th>Component</th>
<th>Maintenance Kit</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circuit breaker</td>
<td>Dynamic Sealing Kit</td>
<td>21</td>
</tr>
<tr>
<td>Circuit breaker drive</td>
<td>Overhaul</td>
<td>21</td>
</tr>
<tr>
<td>Disconnector switch</td>
<td>Dynamic Sealing Kit</td>
<td>21</td>
</tr>
<tr>
<td>Earthing switch</td>
<td>Dynamic Sealing Kit</td>
<td>21</td>
</tr>
<tr>
<td>Fast acting earthing switch</td>
<td>Dynamic Sealing Kit</td>
<td>21</td>
</tr>
</tbody>
</table>

Optional:

<table>
<thead>
<tr>
<th>Component</th>
<th>Maintenance Kit</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Migration modules</td>
<td></td>
<td>improvements, if customers want it for next 25 years</td>
</tr>
</tbody>
</table>

Switchgear B

<table>
<thead>
<tr>
<th>Component</th>
<th>Maintenance Kit</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circuit breaker</td>
<td>Overhaul</td>
<td>combination of CO &amp; SCC</td>
</tr>
<tr>
<td>Circuit breaker drive</td>
<td>Overhaul</td>
<td>together with CB</td>
</tr>
<tr>
<td>Disconnector switch</td>
<td>Dynamic Sealing Kit</td>
<td>not required</td>
</tr>
<tr>
<td>Earthing switch</td>
<td>Dynamic Sealing Kit</td>
<td>not required</td>
</tr>
<tr>
<td>Fast acting earthing switch</td>
<td>Dynamic Sealing Kit</td>
<td>not required</td>
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