



EVENT, DATE

PGHV Service

Maintenance concept – Circuit breaker

Speaker, position



Agenda

Maintenance concept – Why maintenance?

Criteria for maintenance

Factors affecting the life span of circuit breaker

- Ageing
- Mechanical endurance
- Electrical endurance

Life cycle status based actions and recommendations

Maintenance Concept

Why maintenance?

- Circuit Breaker is an essential part of power system.
- Essential components within the Breaker are losing the ability to fulfill its functionality due to various factors.
- Ageing
 - Environmental
 - Lack of maintenance
- Mechanical Endurance
- Electrical Endurance

A non maintained breaker may lead towards not having a breaker at all



Maintenance Concept

Criteria for maintenance

-
- Ageing (Time based)
 - Aging refers to the set of chemical and physical changes of materials over the course of time, temperature and the environment.
 - In principal it's a running irreversible chemical and physical change of the material property
 - Mechanical Endurance (Event based)
 - Number of operations
 - Electrical Endurance (Event based)
 - Erosion of contacts material, Switched current
 - SF6 decomposition products
 - Exceeding the electrical lifetime will result in a major failure of the breaking chamber

Service Criteria

| | |
|-------------|----------------------|
| T/E based | Aging |
| Event based | Mechanical endurance |
| Event based | Electrical endurance |

Maintenance Concept

Circuit Breaker Life Span affected due to various Factor

- Ageing (Time based)
 - Due to natural condition, heat, light, diffusion, relaxation or corrosion
- Mechanical Endurance (Event based)
 - Different breaker types has different mechanical endurance.
- Electrical Endurance (Event based)
 - Operating at rated current and short circuit affects the lifespan.

Maintenance Concept

Circuit Breaker Life Span affected due to Ageing

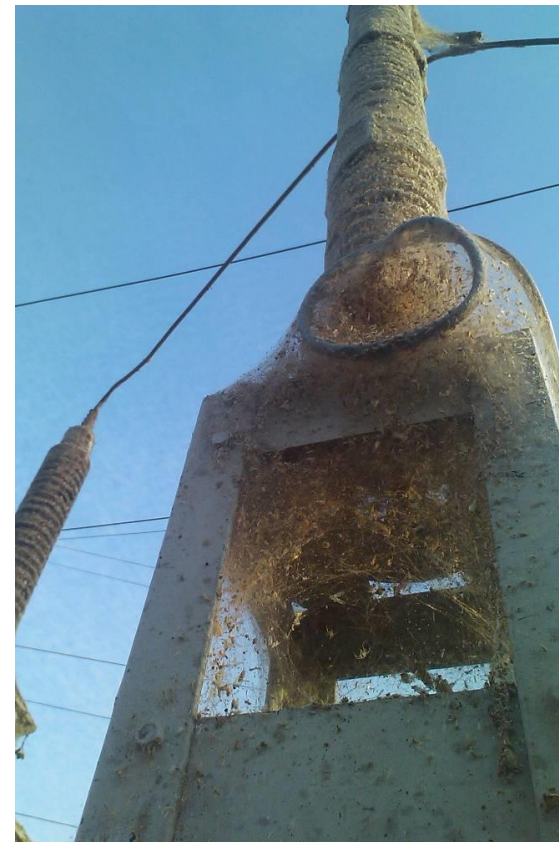
- Environmental factor
 - Where the breaker is located also plays an important role in the life span of circuit breaker
 - Pollution and humidity
Flashover problems, corrosion of metal/aluminum parts and increased ageing of organic parts can be results of the above mentioned environmental factors.
 - High Ambient temperature
Increased ageing of organic parts and control devices. For example grease vaporize more rapidly under these circumstances.
 - Low Ambient temperature
Affects the grease and might cause slow overall mechanical movement.



Maintenance Concept

Circuit Breaker Life Span affected due to Ageing

-
- Lack of maintenance
 - Failing to follow maintenance recommendations for the circuit breaker can shorten the lifespan of the circuit breaker as well as cause minor and major failures.



Maintenance Concept

Circuit Breaker Life Span affected due to Ageing

Affected part

- Insulating part
 - Insulator
 - Insulating washer
- Synthetic parts
 - Gasket
 - Sealing
- Grease
 - Lubrication grease
 - Contact paste
 - Adhesive

Example - With aging of sealing and guide rings the nominal parameters of opening/closing times, velocity and force cannot be guaranteed any longer.



Maintenance Concept

Circuit Breaker Life Span affected due to various Factor

Mechanical Endurance (Event based)

- Different breaker types has different mechanical endurance.

Maintenance Concept

Circuit Breaker Life Span affected due to Mechanical Factor

Mechanical Endurance (Event based)

- Number of Mechanical Operation.
- The circuit breaker mechanical lifetime will be reached after around 10,000 operations. (A mechanical operation means switching a few hundred ampere)

| Product | | Overhaul (Criteria) | |
|----------------|---------------|---------------------|----------------|
| Breaker Type | Technology | Time Based (Years) | |
| | | # | Mechanical (N) |
| EDF SK 1-1 | SF6/Spring | 10 | 10,000 |
| ELF SF 2-1® | SF6/Pneumatic | 10 | 10,000 |
| LTB 145 D1 | SF6/Spring | 10 | 10,000 |
| ELF SL 4-1 | SF6/Pneumatic | 10 | 10,000 |
| LTB 245 E1 | SF6/Spring | 10 | 10,000 |
| LTB 420 E2 | SF6/Spring | 10 | 10,000 |
| ELF SP 6-21/22 | SF6/Pneumatic | 10 | 10,000 |
| ELF SL 6-2 | SF6/Pneumatic | 10 | 10,000 |

* Details derived from respective product manual , # May depend upon site condition N = Number of operation

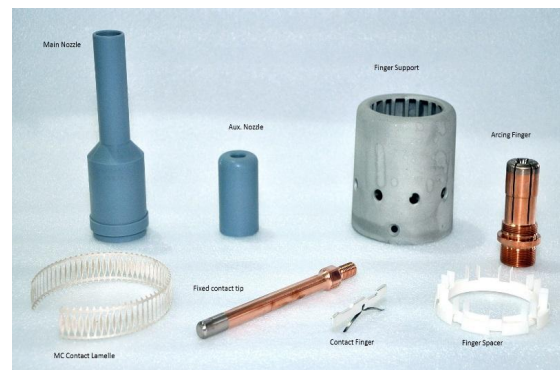
Maintenance Concept

Circuit Breaker Life Span affected due to Mechanical Factor

Due to wear, vibration, shock, seismic, general expendable items, mechanical friction

– Affected Parts

- Contact finger
- Bearing
- Nozzle
- Gasket
- Contact Ring
- Piston
- Sleeve
- Spring
- High tension spring ring



Maintenance Concept

Circuit Breaker Life Span affected due to various Factor

Electrical Endurance (Event based)

- Operating at rated current and short circuit affects the lifespan.

Maintenance Concept

Circuit Breaker Life Span affected due to Electrical Factor

Electrical Endurance (Event based)

- The electrical lifetime will be reached after certain operations at the rated current or at its maximum amount of operations at the rated short-circuit breaking current or equivalent breaking duty.

| Product | | Overhaul (Criteria) | | Electrical Life $\sum n \times I^2$ | | |
|----------------|---------------|---------------------|---------------|-------------------------------------|---------------|-------------|
| Breaker Type | Technology | Time Based | Electrical(N) | Rated Fault current (KA) | At Rated | At 50% of |
| | | (Years) # | | | fault current | rated fault |
| | | | | | (N) | current(N) |
| EDF SK 1-1 | SF6/Spring | 10 | 2,000 | 31.5 | 8 | 32 |
| ELF SF 2-1® | SF6/Pneumatic | 10 | 2,000 | 31.5 | 40 | 156 |
| LTB 145 D1 | SF6/Spring | 10 | 2,000 | 40 | 13 | 50 |
| ELF SL 4-1 | SF6/Pneumatic | 10 | 2,000 | 40 | 25 | 100 |
| LTB 245 E1 | SF6/Spring | 10 | 2,000 | 50 | 8 | 32 |
| LTB 420 E2 | SF6/Spring | 10 | 2,000 | 50 | 8 | 32 |
| ELF SP 6-21/22 | SF6/Pneumatic | 10 | 2,000 | 50 | 18 | 70 |
| ELF SL 6-2 | SF6/Pneumatic | 10 | 2,000 | 50 | 18 | 70 |

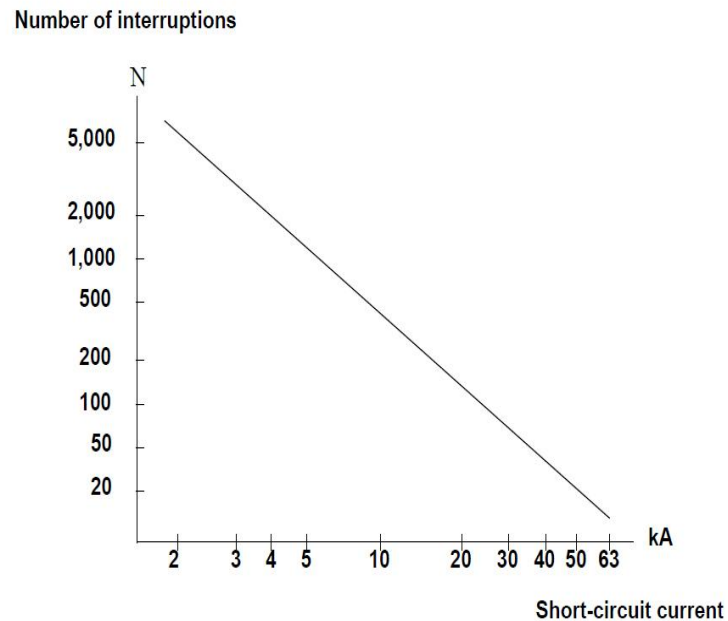
* Details derived from respective product manual , # May depend upon site condition N = Number of operation , I = Fault Current

Maintenance Concept

Circuit Breaker Life Span affected due to Electrical Factor

Electrical Endurance (Event based)

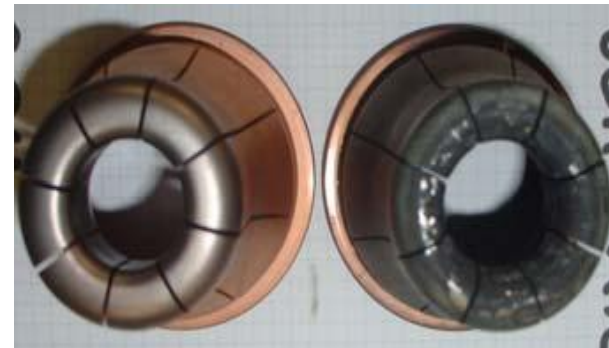
- The diagram below is an example and shows the number of interruptions* versus short-circuit current that circuit breaker can manage, before the metal losses due to burning becomes so great that they must be replaced.



Maintenance Concept

Circuit Breaker Life Span affected due to Mechanical Factor

- Erosion of the arcing contact material caused by the arc
- Contamination of the nominal contact system due to the burn off material from the arc
- Wear and tear due to mechanical operation



Maintenance Concept

Circuit Breaker Life Span affected due to Various Factor

Summary

Age

- Sealing system
- Corrosion
- Grease
- SF6 gas
- Dashpot
- Catchgear

Switching frequency/current

- Nozzles and internal insulation parts
- Main/break contacts
- Absorber
- SF6 gas

Number of operations:

- Linkage
- Bearings
- Joints
- Main/break contacts
- Insulating operation rod
- Tripping spring
- Dashp

Pollution/salt:

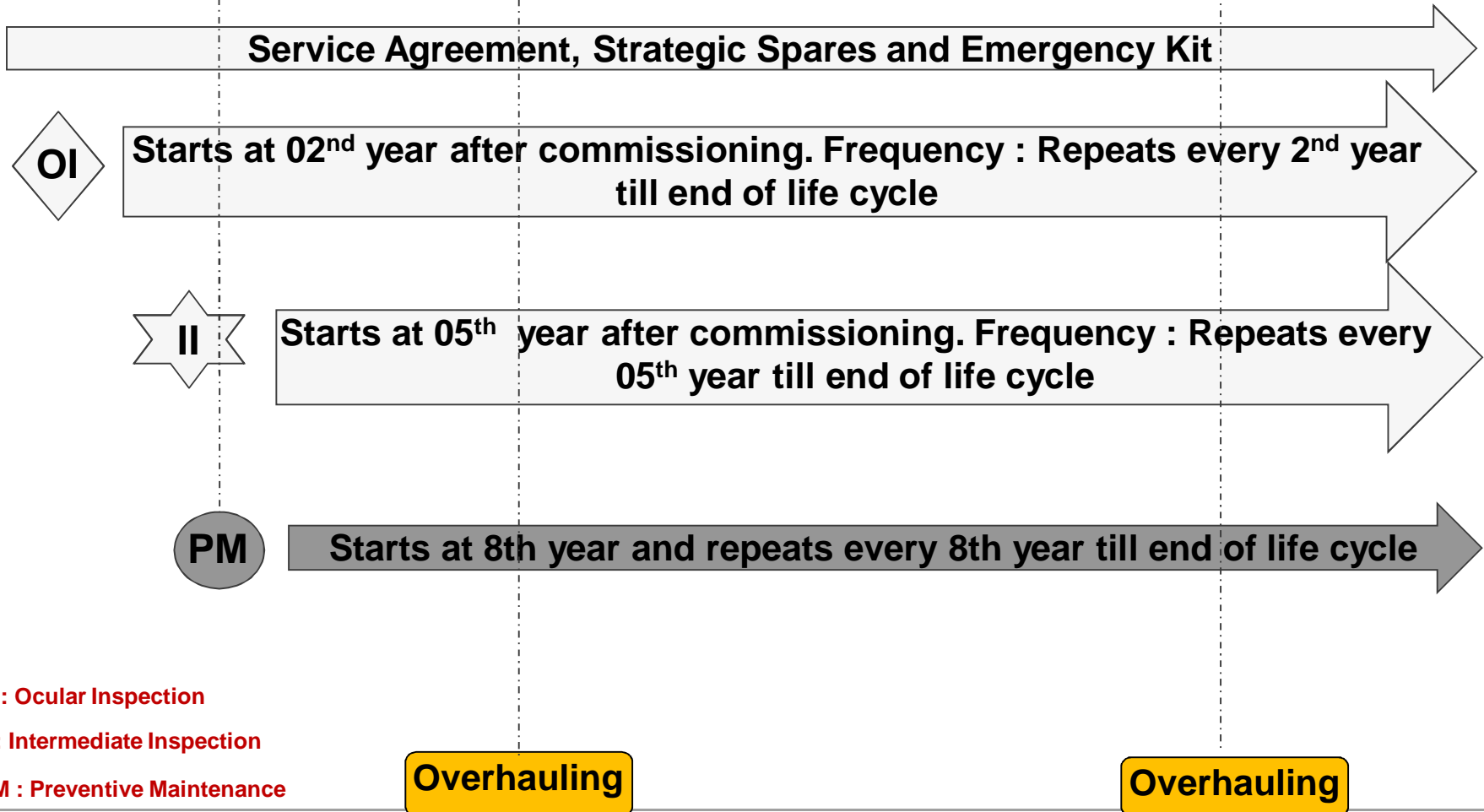
- Third Level
- Corrosion
- Porcelains
- Sealing system
- Grease

Temperature:

- Grease
- Bearing/joints
- Sealing system

Maintenance Concept - Basis

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35



Maintenance Concept

Basis

-
- Life Cycle Status based Actions and Recommendations
 - Ocular Inspection (Starts at 02nd year after commissioning. Frequency : Repeats every 2nd year till end of life cycle)

Criterion

Visual Inspection / Check Rating Plates

Check number of close-open operations

Check number of failure trips (customer input necessary)

Check anti-condensation heating

Check density monitor

Check condition of spring charging motor

Check spring charging indication

Visual Inspection of operating mechanism / Corrosion inspection

Visual Inspection of Porcelain Insulators

For details please refer manual

Maintenance Concept

Basis

-
- Life Cycle Status based Actions and Recommendations
 - Intermediate Inspection (Starts at 05th year after commissioning. Frequency : Repeats every 05th year till end of life cycle)

Criterion

Visual Inspection / Check Rating Plates

Check number of close-open operations

Check number of failure trips (customer input necessary)

Recording of switching time *

Check anti-condensation heating

Check density monitor

Check condition of spring charging motor

Check spring charging indication

Visual Inspection of operating mechanism / Corrosion inspection

Visual Inspection of Porcelain Insulators

For details please refer manual

Maintenance Concept

Basis

-
- Life Cycle Status based Actions and Recommendations
 - Preventive maintenance

Criterion

Visual Inspection / Check Rating Plates

Check number of close-open operations

Check number of failure trips (customer input necessary)

Functional test

Recording of switching time

Contact Resistance Measurement

Check anti-condensation heating

Check gas supervision relay

Check density monitor

Check condition of spring charging motor

Check spring charging indication

Check Dynamic contact resistance measurement

Check auxiliary switch

Measurement of spring charging time

Measurement of motor current *

Measurement of the resistance of the coils and heaters

Visual Inspection of operating mechanism / Corrosion inspection

Visual Inspection of Porcelain Insulators

Dew Point measurement

For details please refer manual

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ABB