Study Committee A3

High Voltage Equipment

Working Group A3.29
DETERIORATION and AGEING OF HV SUBSTATION EQUIPMENT

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Introduction

Managing an ageing high voltage asset population is a key task for utilities and other asset owners. Differing opinions exist regarding the expected life of substation assets and the factors that dictate this life. However, generally speaking, assets are being expected to remain in service for longer than ever before. At the same time, definitive guidance and recommendations in this field are not readily available. In order to enhance the available guidance in this area, SC A3 has set up a working group to undertake a comprehensive review of experience in the fields of degradation processes, lifetime assessment & life extension techniques, and the role of condition monitoring, refurbishment and re-verification.

Working Group Scope

- **Material and equipment deterioration/degradation**
  - ✓ Deterioration mechanisms and precise knowledge about materials
  - ✓ Forensic analysis of aged equipment
  - ✓ Rate of development from material defects to minor/Major Failures and associated risks for equipment
  - ✓ Diagnostic methods, evaluation of results, condition assessment
  - ✓ Mitigation and maintenance considerations
  - ✓ Impact of service stresses (excluding overstressing) on equipment condition
- **Lifetime (residual life) management techniques**
  - ✓ Expected total life for different high voltage equipment
  - ✓ Life limiting components and useful life of new and reconditioned parts
  - ✓ Relation between material deterioration, condition assessment techniques, equipment degradation and performance.
  - ✓ Impact of changed situations (for instance changed maintenance policy or large overhaul)
- **Life extension**
  - ✓ Experience with life extension
  - ✓ Possibilities and problems with re-testing old equipment
  - ✓ Impact of life extension on overhaul and expected period between major overhaul
- **Life management for new equipment**
  - ✓ Expected life and maintenance intervals for new equipment
  - ✓ Requirements for, and value of, testing in relation to life cycle management (endurance tests)

Ageing

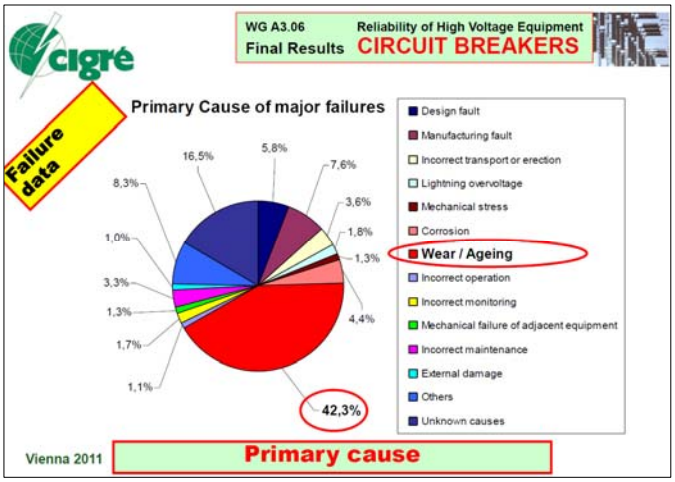
Ageing is a process that leads to change in equipment properties over its life time, whilst the equipment is exposed to its design service conditions.

The design service conditions include overloading but within the limits prescribed by the standards/ manufacturer.

CIGRE WG A3-06 "Reliability of HV Equipment"

Circuit Breakers

Primary cause for major failure (MaF) is Wear/Ageing

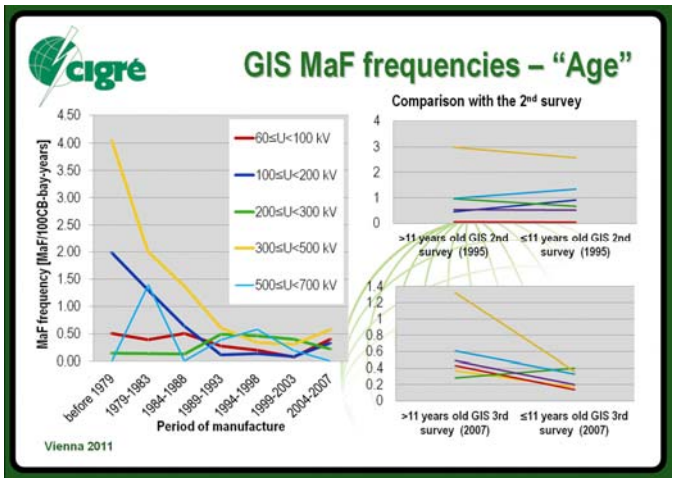


CIGRE WG A3-06 "Reliability of HV Equipment"

Gas Insulated Switchgear Reliability

Increase of MaF frequencies due to Ageing

More than 40% of MaF cause is Wear/Ageing and Corrosion



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Method

- Describe the ageing processes for different equipment and its components
- Identify possible causes that contribute to ageing
- Identify mitigation techniques to prevent ageing and/or manage ageing
- The work will leverage on input from both manufacturers and end-users

Example: **Component Level Ageing Analysis** - Gas Circuit Breaker

Component	Sub-component	Part	Example of used material	Influencing factor / Stress	Ageing Phenomena	Consequence / Failure
Interrupter	Contact	Main contact	Cupper alloy, Silver plating	Operation Loss of lubrication	Wear, Increase of resistance, Overheat	Breakdown, Fail to open / close
		Arcing contact	Tungsten alloy	Breaking current Operation	Wear	Breakdown, Fail to break current
		Nozzle	Fluorine resin	Breaking current Operation	Wear, Electrical degradation (Loss of dielectric strength)	Breakdown, Fail to break current
		Puffer cylinder	Aluminum alloy, Silver plating	Operation Loss of lubrication	Wear	Breakdown, Fail to open / close
		Grease	Base oil Thickener Additives	Operation, Temperature, SF6 decomposition byproducts	Loss of lubrication due to Loss of base oil, Chemical reaction with SF6 decomposition byproducts, Contamination, Cake, Softening and drain	Acceleration of wear, Fail to open / close
		Piston	Steel	Operation Loss of lubrication	Wear, Deformation (Decrease of gas flow)	Fail to break current
	Insulator	Supporting insulator	Cast resin, FRP	Electric stress at power frequency, Lightning voltage, Switching voltage, Mechanical stress, Heat of arc	Electrical degradation (Loss of dielectric strength), Fatigue, Crack, Creep	Breakdown, Fracture, Fail to open / close (due to creep and displacement)
	Capacitor	Capacitor element	Ceramic	Electric stress at power frequency, Lightning voltage, Switching voltage	Change of capacitance, Electrical degradation (Loss of dielectric strength)	Breakdown
	Resistor	Resistor element	Ceramic	Operation	Crack, Shift of resistance	Fracture, Fail to suppress switching overvoltage

High Voltage Equipment in Scope

- **Included –** High voltage equipment operating at nominal voltages ≥ 60kV but ≤ UHV
  Circuit breakers, Load switches, Disconnect switches, Earthing switches, Surge arresters, Shunt capacitor banks, Post insulators, Conventional instrument transformers, Shunt/series reactors and other substation equipment such as busbars and accessories.

  Excluded - Fault current limiters, Series capacitors, Direct current equipment, Transformers, Line traps, Cables, Non-conventional instrument transformers, Static Var Compensators, Gas Insulated Substation and Hybrid systems

Related Working Groups & References

- **Active Working Groups**
  - WG A3.30 : "Impact of overstressing of substation equipment"
  - WG B3.32 : "Saving Through Optimized Maintenance of Air Insulated Substations"
- **CIGRE Technical Brochures**
  - TB 509-514: "Reliability of HV Equipment" (Part 1 – Part 6)
  - TB 499: "Residual Life Concepts Applied to HV GIS"
  - TB 165: "Lifetime Management of Circuit-Breakers"

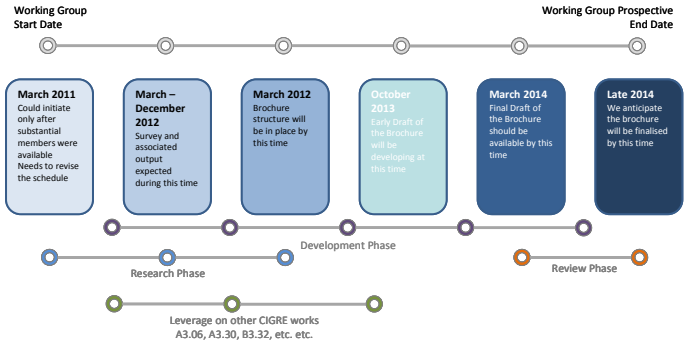
Outline of Technical Brochure

A Cigré Technical Brochure covering the detection and management of ageing in HV substation equipment will be produced.

1. Executive summary
2. Introduction
3. Nominated life of substation equipment
   - 3.1 Expected life(s) of substation equipment
   - 3.2 Factors that dictate nomination of these lives
   - 3.3 Ageing and influence of ageing on realised life of substation equipment
4. Methods for equipment life prediction
   - 4.1 Applications models
   - 4.2 End of life assessment methods
5. Ageing modes, their influence, detection and mitigation techniques
   - 5.1 Introduction
   - 5.2 Modes of ageing and their impact on degradation and detection methods
   - 5.3 Mitigation techniques to prevent ageing and Life extension techniques
6. Mitigation methods for new equipment
7. Summary, recommendations and conclusion

Appendices (Case studies, Glossary, References)

Time lines



Usefulness to the industry

Knowing the ageing mechanism, it is possible to increase equipment reliability and network availability by application of condition based risk management and reliability centered maintenance techniques. This enables efficient deployment of resources (investment, equipment and labor)

How can the industry support this work?

Provide input and supporting evidence/ experience

- Expected life time of equipment and their components
- Experiences regarding ageing
- Assessment techniques to identify ageing, application and use
- Asset management decision models & mitigation techniques
- Input into novel techniques under application/ review