Failure Frequencies for High Voltage Circuit Breakers, Disconnectors, Earthing Switches, Instrument Transformers and Gas Insulated Switchgear

CIGRÉ working group A3.06 “Reliability of High Voltage Equipment”:

The CIGRÉ reliability survey

- Equipment covered (U ≥ 60 kV):
  - Circuit breakers (only single pressure SF₆)
  - Disconnectors and earthing switches
  - Instrument transformers
  - GIS; including a “GIS practice survey”

- Failure and population data collected for the time period 2004 – 2007
- Both major and minor failures included
- 90 utilities from 30 countries participated by returning completed Excel-based questionnaires
- Six Technical Brochures containing all results under way

Failure frequency calculation

\[
\text{Failure freq.} = \frac{\# \text{ of failures}}{\# \text{ of components} \times \text{survey duration}} \left[ \text{year}^{-1} \right]
\]

Example:
Two failures over a four-year period in a population of 25 circuit breakers

Failure frequency: 2.0 failures / 100 CB-years

Surveyed service experience

- SF₆ circuit breakers: 281 090 CB-years
- Disconnectors and earthing switches: 935 204 DE-years
- Instrument transformers: 1 290 335 IT-years (1-phase units)
- Gas insulated switchgear: 88 971 GIS CB-bay-years

Major failure frequencies

- SF₆ single pressure circuit breakers: 0.30 (0.67) MaF / 100 CB-years
- Disconnectors and earthing switches: 0.21 MaF / 100 DE-years
- Instrument transformers: 0.053 MaF / 100 IT-years (1-phase units)
- Gas insulated switchgear: 0.37 (0.53) MaF / 100 GIS CB-bay-years

Failure definitions (IEC 60694 defs.)

Major failure (MaF):
“... failure of a switchgear and control gear which causes the cessation of one or more of its fundamental functions. A major failure will result in an immediate change in the system operating conditions, e.g. the backup protective equipment will be required to remove the fault, or will result in mandatory removal from service within 30 minutes for unscheduled maintenance.”

Minor failure (MiF):
“... failure of an equipment other than a major failure or any failure, even incomplete, of a constructional element or a sub-assembly which does not cause a major failure.”
**SF₆ single pressure circuit breaker major failure frequencies**

![Graph showing SF₆ single pressure circuit breaker major failure frequencies](image)

**Disconnector and earthing switches combined failure frequencies**

![Graph showing disconnector and earthing switches combined failure frequencies](image)

**Instrument transformer failure frequencies**

![Graph showing instrument transformer failure frequencies](image)

**GIS failure frequencies**

![Graph showing GIS failure frequencies](image)

Six Technical Bruchures containing all results are in print


“Part 1: Summary and General Matters”

“Part 2: SF₆ Circuit Breakers”

“Part 3: Disconnectors and Earthing Switches”

“Part 4: Instrument Transformers”

“Part 5: Gas Insulated Switchgear”

“Part 6: GIS Practices”

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