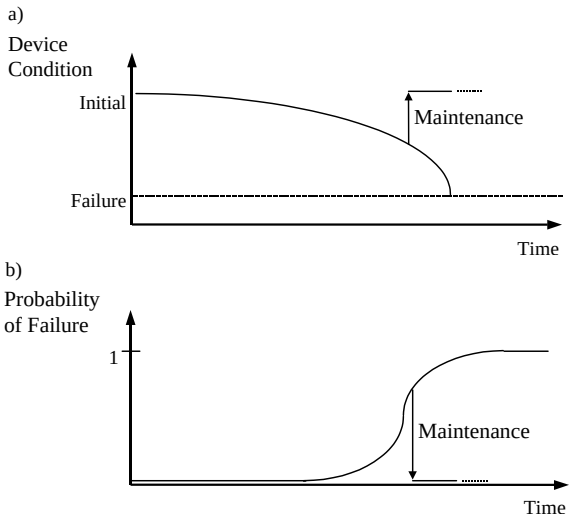
7. Maintenance Management

Maintenance management for networks is one of the key factors considering the overall costs of electric power systems. Usual are 1 .. 1,5 .. 2 % / a of the current value of the network devices. Great efforts are worth to reduce the maintenance costs. Technical, economical, organisational and operational constraints have to be considered.

Target:

Keep the network elements in such a condition, that it can be operated as economical as possible with a sufficient reliability. This requires information about the individual device and the importance of this device for the overall system performance.



Device Performance over Time

a) Condition Deterioration

b) Probability of failure

Definition of maintenance steps:

Upkeep: ① ***control***

② ***inspection***

③ ***repair, restore***

Preventive maintenance

Ageing process with different consequences and reset measures is to be considered.

Over-stress requires separate analyses

- **time-based**

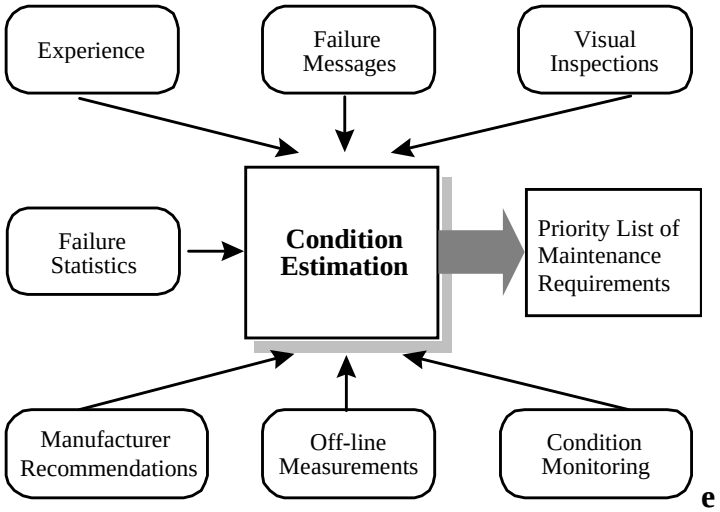
  - Inspections and revisions are made in definite time spaces

    (e.g.: circuit breaker is revised all 6 years following the recommendation of the producer; distribution function of failures; strategy of prolonging the operational time space to find an economical time space.)

- **condition-based**

  - Inspections and revisions are made in dependence of the estimated condition; diagnostic and monitoring information are used to estimate the actual condition of the individual device.

    (e.g.: circuit breaker revision after 25 switching-off short circuits; $\sum I_K^2 = x_0$)



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Corrective maintenance

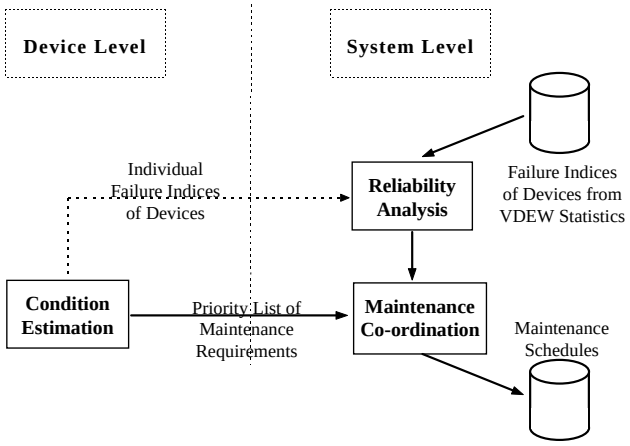
- A failure has happened and the element has to be repaired

  (e.g.: circuit breaker contact didn't open correctly)

Information concerning the condition of the individual device and a group of them can be separated from inspection reports, from revision reports and from the documentation of repair measures in combination with fault descriptions.

Maintenance Management

The operation together with the maintenance engineer has to consider several influences to organise the maintenance procedure.

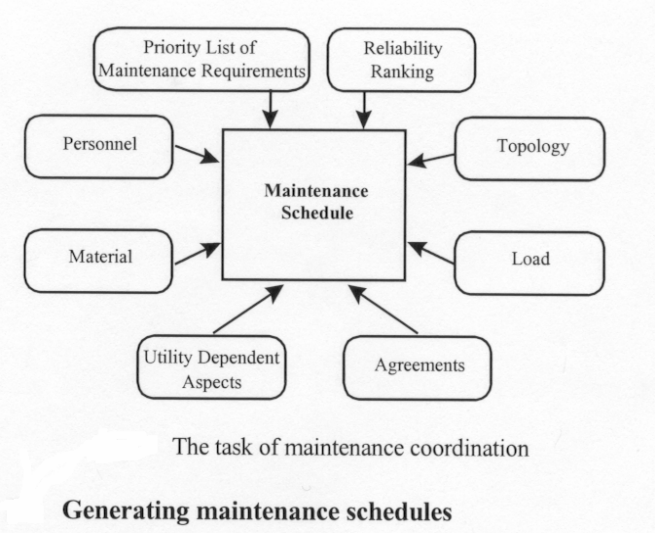


Tasks of maintenance management

- identification of the devices to be maintained
- estimating the operational period before maintenance is necessary
- estimating the duration of the work
- definition of priorities
- defining the detailed measures
- making available the needed spare parts
- analysing the reliability during the maintenance period
  - (n – 1)
  - calculating under consideration of the network topology, protection setting, ...
  - risk of customer interruption

⇨ defining the time schedule from the operational point of view

⇨ preparing all operational measures and documenting the steps of switching situations



Generating maintenance schedules

In developing status : Calculation programs for optimal maintenance schedules, using fuzzy logic decisions

Examples to be explained:

- 11 kV small volume circuit breaker
  - lightning overvoltages on MV OHL led to short circuit interruption
  - circuit breaker had to switch off very often
  - destruction of the oil chamber; oil became dirty by burned particles
  - simple problem solution possible

- 11 / 0,4 kV transformers
  - oil analysis showed to high acid percentage
  - by tests was found, that only the increase rate is to consider
  - loading more then 100 % of rated current
  - calculating life time consumption

- 110 kV switchyard
  - reliability
    - earth fault
    - short circuit
    - circuit breaker failure - aging of a sealing
    - protection adaptation

  today:
  - ⇨ monthly inspections are cancelled
  - ⇨ annual inspections only in selected substations
  - ⇨ inspections in other definite substations with extended time spaces

Critical aspects to be considered

- construction of devices
- material used
- operational stress
- quality of production
- actuality of statistics – life time of devices
- uncertainty of estimated conditions
- ....

The analysis of condition changes (why; what is the most probable reason; what are the consequences without doing anything) offers to prolong the operational period and saving money.

Producing only fault statistics or following the time-based method is not state of the art.