HydroCen Task 2.4
Turbine and generator lifetime

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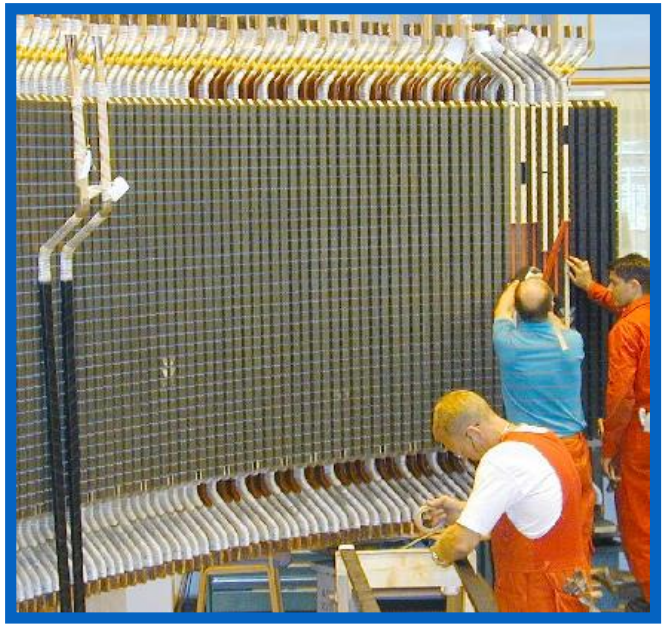
FME CENTRE FOR ENVIRONMENT-FRIENDLY ENERGY RESEARCH
The Research Council of Norway

Lifetime, ageing and condition monitoring



- Life-time models and estimation (Francis, Pelton)
- Condition assessment of spare windings
- Fault simulation – signature from known faults
- Electromagnetic fault detection

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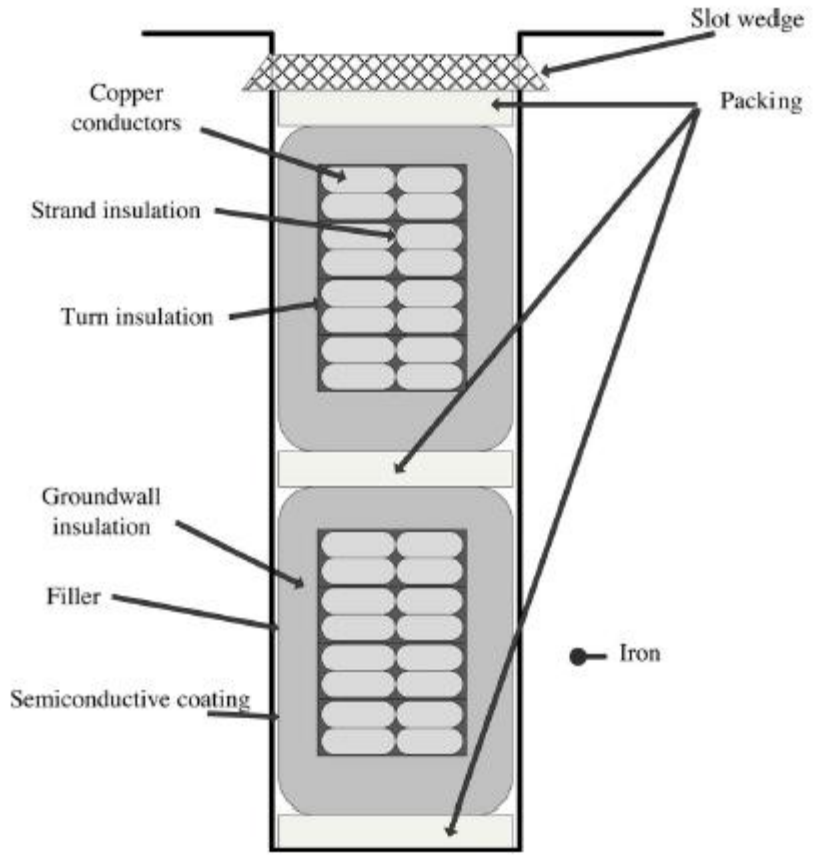
Activities

No.	Activity	Start	End
A2.4.1	Turbine fatigue lifetime calculation and monitoring (Hydroflex)	01.2017	12.2017
A2.4.2	Non-destructive condition assessment methodology for back-up generator bars	01.2017	12.2020
A2.4.3	Laboratory experiments and simulations in develop non-destructive condition assessment methods of back-up stator bars and effect of new stresses on old insulation designs. The postdoc is an extension of and in conjunction with A2.4.2. (PostDoc at NTNU Department of Electric Power Engineering)	06.2020	06.2022
A2.4.4	Hydro turbine and generator expert groups	01.2018	12.2020
(A2.4.5)	(Methods for approximating advanced models, simulations and experimental results)	-	-
A2.4.6	Fault simulation (introducing "artificial" faults) in hydropower equipment	01-2017	12-2017
A2.4.7	Electromagnetic analysis and on-line fault detection in hydropower generators (PhD at NTNU, Dep. Of Electric Power Engineering)	08-2018	07-2021

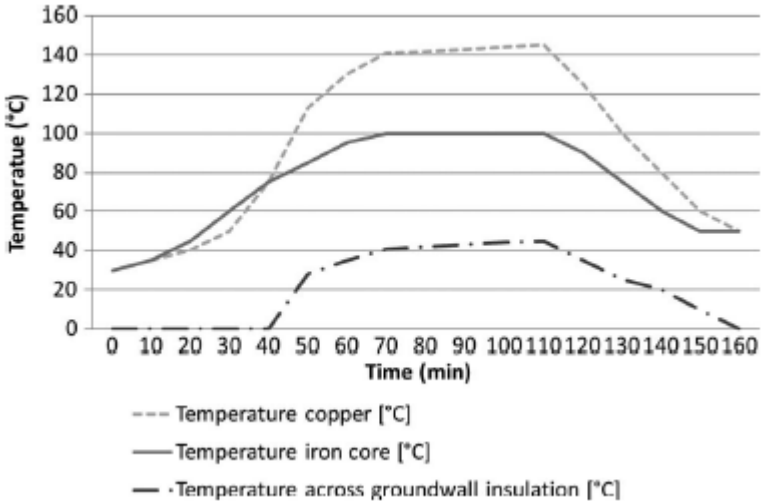
Assessment methodology for back-up generator bars

- Establish a reliable method to determine if back-up generator bars are in good condition after storage and can be put into service.
- Back-up bars selected based on a questionnaire sent out in 2018.
  - Aim to perform measurements on bars from different venders, ages and voltages (4.8-15.5kV).
  - Seven bars from two different venders tested in 2019 and at least three companies are sending bars for testing in 2020.



Hydro turbine and generator expert groups

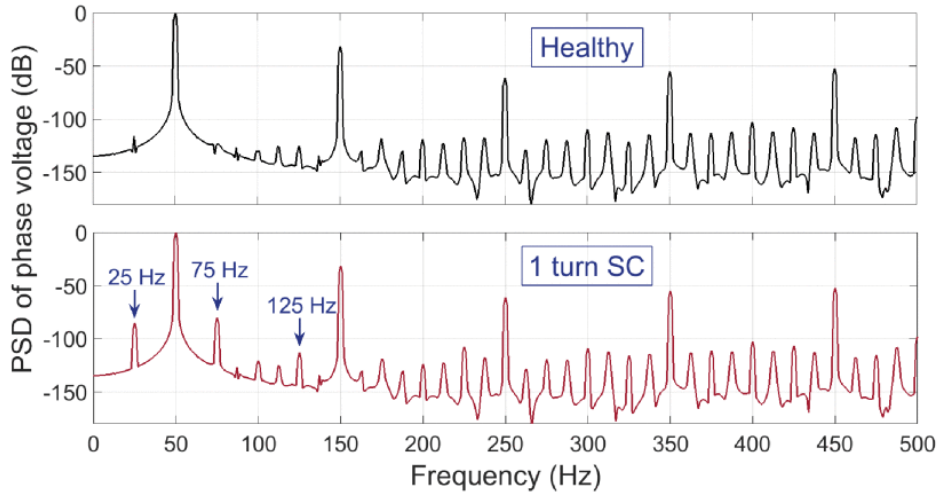
- Provide input to T3.2 "Remaining useful life and failure probability" related to cost of temperature cycles
- Relation between operating conditions and temperature of hydropower generators
  - Thermal cycling effect ageing of generators
  - Data collection ongoing
  - We want more data!
    - Info on generator type/design
    - Temperature measurements (preferably minute resolution)
      - Conclusions so far: hourly measurements does not provide enough information about the cooling/heating process.
    - Corresponding power measurements
    - Info on the cooling of the generators

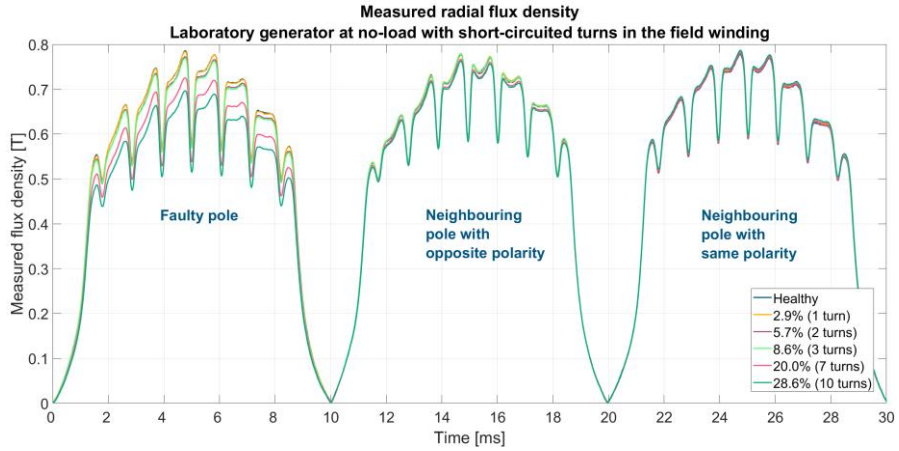


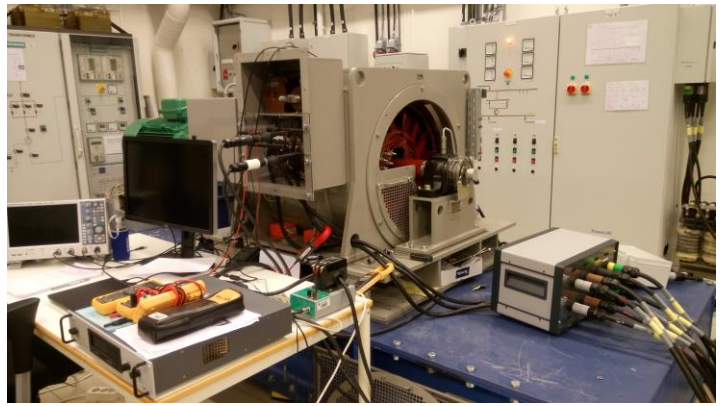
Electromateic fault detection

- Targettet faults:
  - Ecsentricity
  - Field winding short-circuit
  - Stator winding internal short circuit (coil-winding)
  - Stator ovality
  - Brocen damper bars
- Patent pending system
  - Flux sensors ant dissferet locations.
  - Analysis of terminal voltages/current

Simulations and measurements







HydroStator

Condition monitoring og stator winding insulaiton

Espen.eberg@sintef.no

Extract from Generatorforum, Gardermoen 31.10.2019

Suldal – Hydro Energi

Foto: Lars Lone (Hydro)

- Suldal G2
  - 95 MVA / 13 kV air-cooled(1965)
  - Röbelbars – Class F VPI (Micadur) insulation
- Replacement of stator due to power upgrade.
- Winding tested off-line and on-line before stop and removal

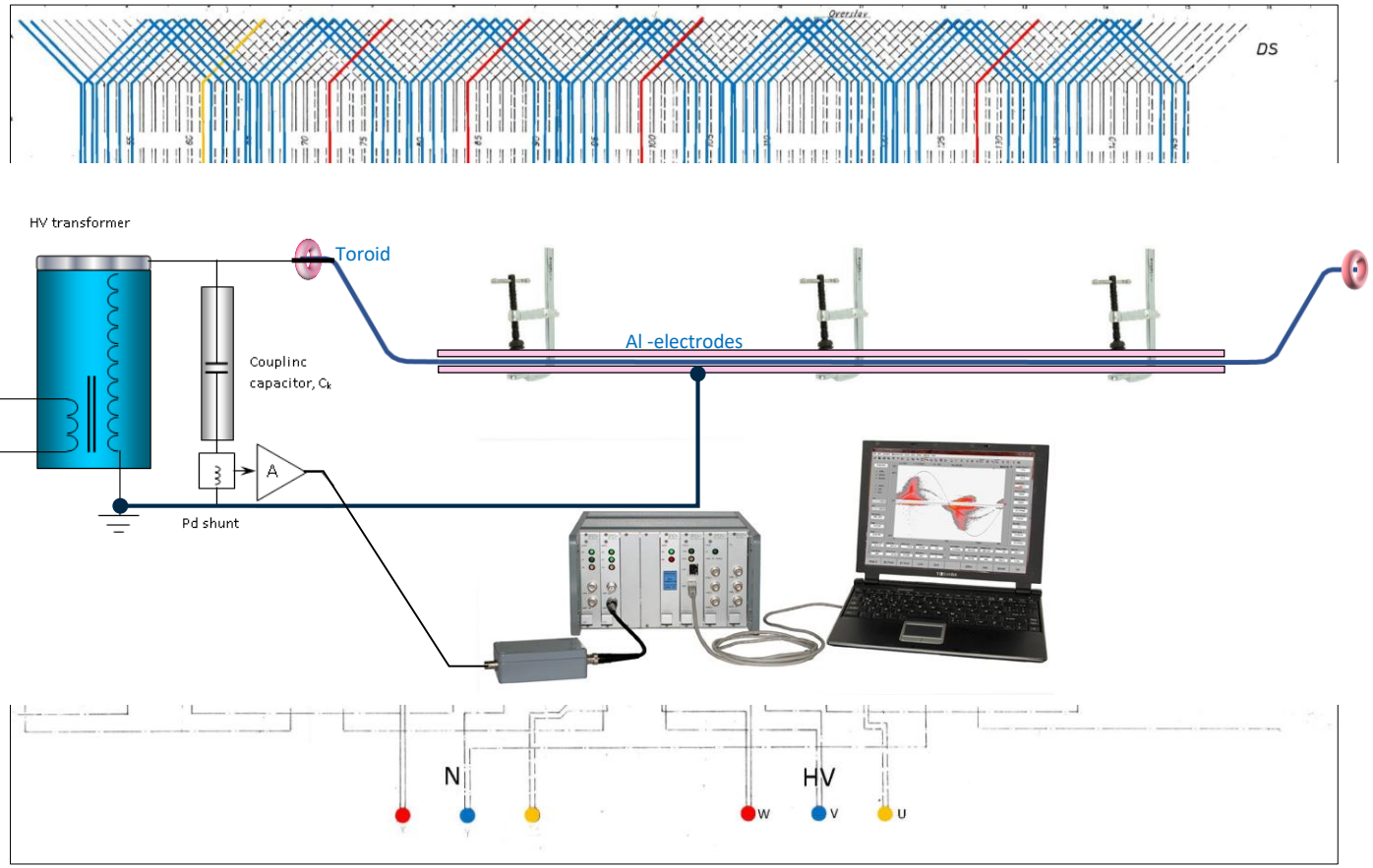
- Bars removed and tested in Trondheim
- Winding bars still under testing

Removing bars

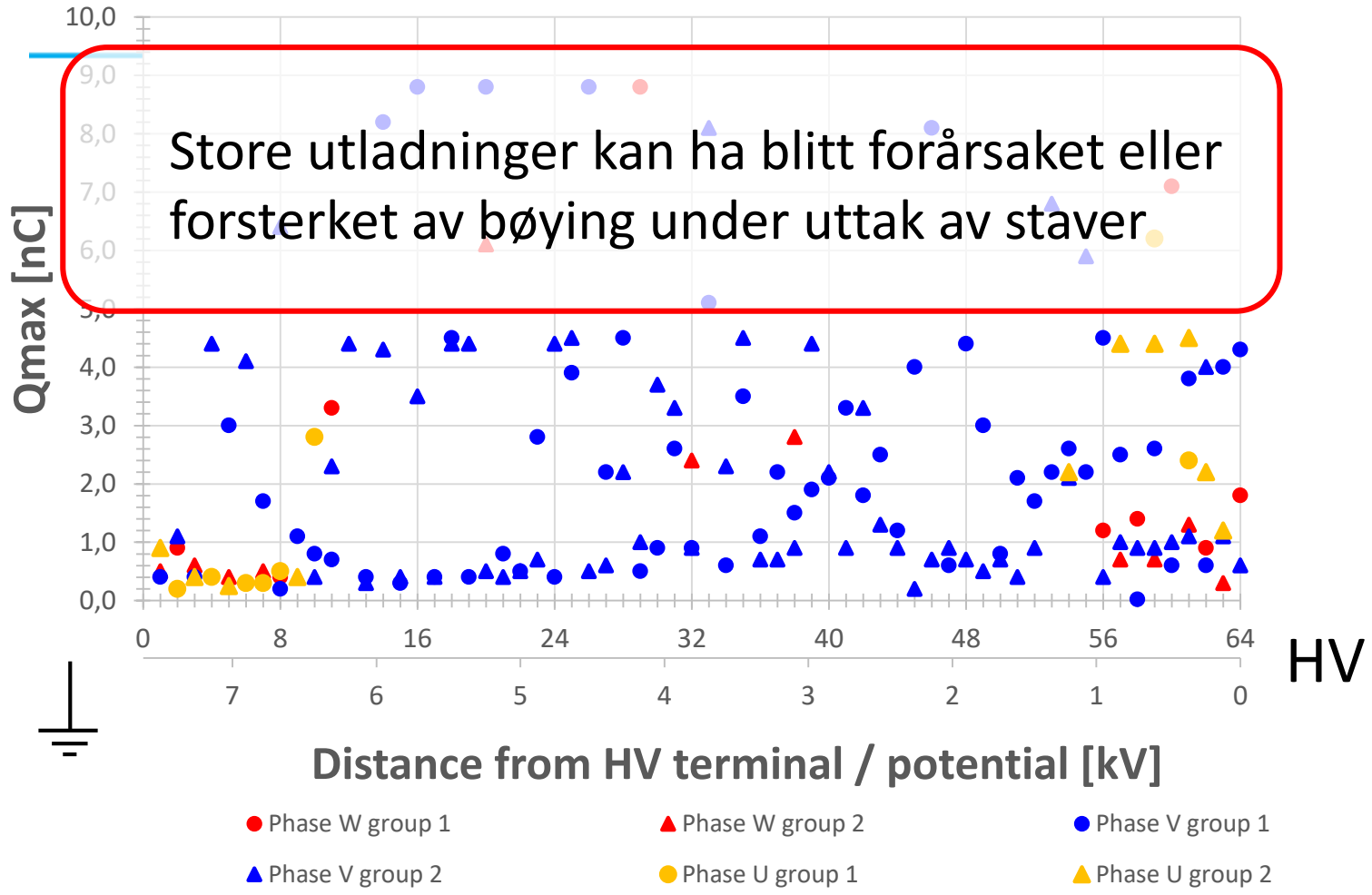
- Location notified for all bars
- Wedges removed by hammer
- Damages due to removing operation
- 161 (of 392) “approved” and sent to SINTEF Energi

PD screening

- 161 bars tested
- Visual inspection. Semi-condurs repairedwhen needed
- PD-measurement:
  - Conditioning in 15 min @ 1.2 U_0 (9 kV)
  - PRPDA accumulated in 60 s



Utladninger sfa. Posisjon på vikling



- Fokus på staver fra fase **V**
- Ingen tilsynelatende korrelasjon mellom utladninger og elektrisk stress/aldring

50% < 1.2 nC

91% < 4.5 nC

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