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Experimental study of the effect of high electric voltage on the fatigue life of glass fiber composites

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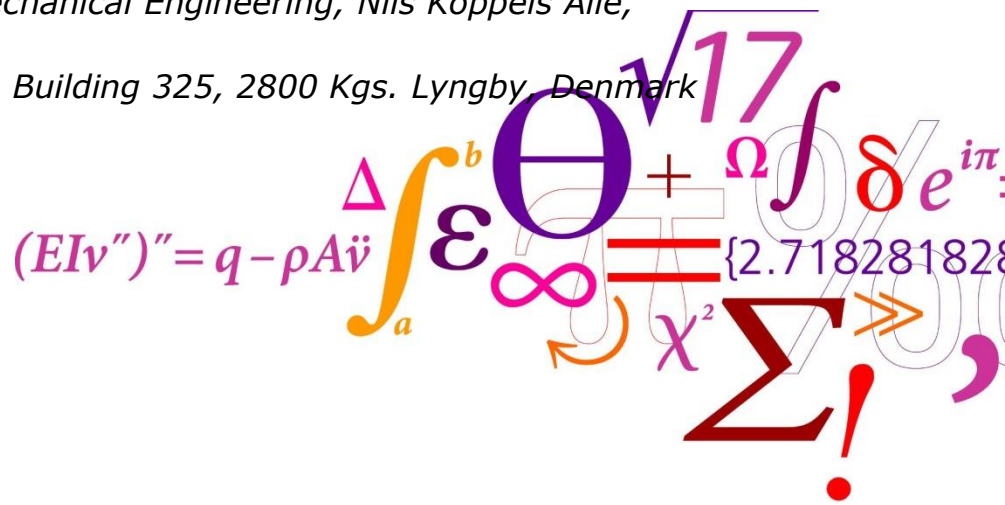
Mehrtash Manouchehr, Christian Berggreen, Joachim Holbøll

Lightweight Structures Group, Department of Mechanical Engineering, Nils Koppels Allé, Building 404, 2800 Kgs. Lyngby, Denmark
Department of Electrical Engineering, Elektrovej, Building 325, 2800 Kgs. Lyngby, Denmark



DTU Mechanical Engineering
Department of Mechanical Engineering

Contents:

- Introduction of the project.
- Objective.
- Test plan, specimens and manufacturing.
- Test setup.
- Challenges.
- Concept of Partial discharges.
- Results of coupon tests.
- Full scale test setup.

Background and Motivation

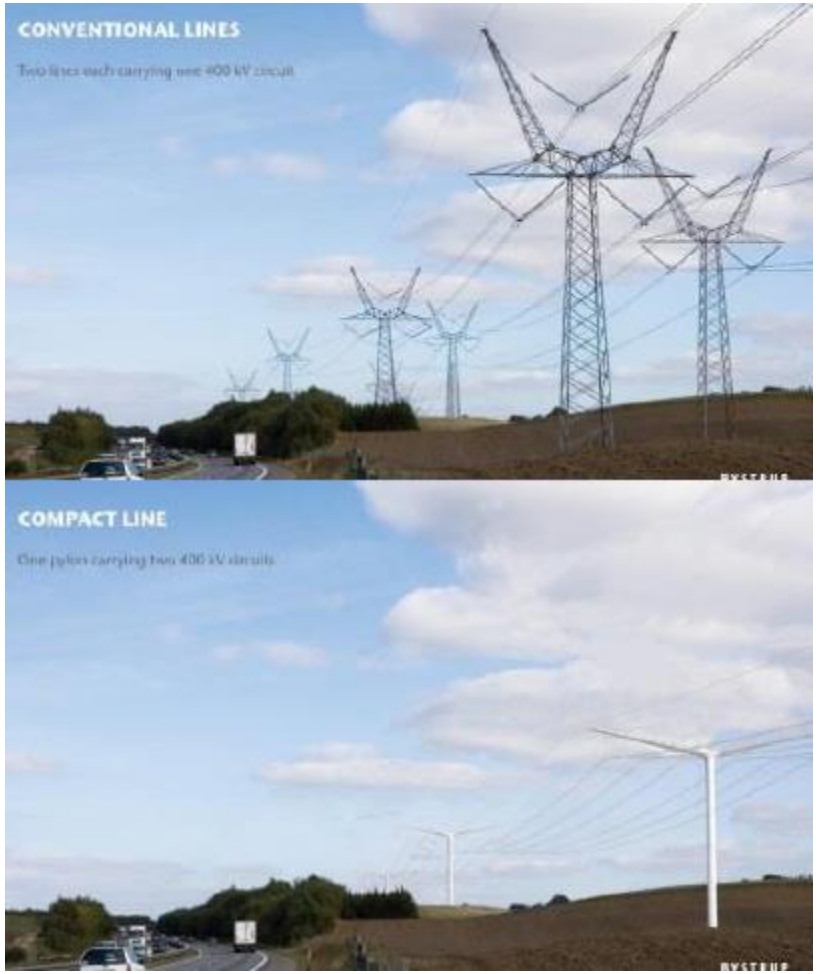
- The project is proposed by a Danish architecture company, Bystrup.
- Full composite pylon.
- Suitable for 2*400 kV power transmission lines.
- Collaboration between DTU MEK (2 Ph.D students structural and damping), Aalborg university (2 Ph.D students in electrical modelling and experiments) and TUCO (Manufacturer).

- New design pylons that are smaller, more compact and are more visually acceptable.

- Further reduction in OHTLs construction cost due to an even smaller and more compact pylon.

- Easier installation of the pylon.

- A reduction of the corona noise and magnetic fields by the use of non-conductive composite materials.



picture courtesy of Bystrup.

Objectives of this work:

- This Ph.D is focused on the effect of high electric voltage on the fatigue life time of glass fiber composite materials.

- Main Criteria's:

  - electric field and mechanical loading should be applied on the specimens simultaneously to see if the is any coupling effect. the uncoupled mechanical and electrical testing is very common and used quite often in insulator manufacturing industry.

Test plan

1. Standard material testing.
2. Combined mechanical-electrical fatigue testing on material which the full arm will be made of. (Fatigue at few load levels and comparing the results with pure mechanical fatigue tests).
3. Combined mechanical-electrical test at a fix number of cycles for specimens with defects and compare it to pure mechanical fatigue tests.
4. Full length arm combined mechanical and electrical test to predict the structure life time reduction (if any) due to the presence of high electric voltage.

Specimens.

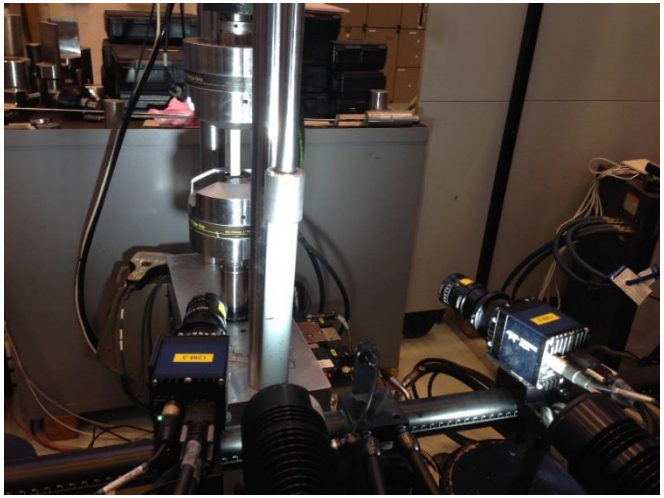
- 2 series of coupon specimens and 1 full length arm have been designed and manufactured for project.

1. Coupon specimens with same material configuration as the full arm have been manufactured by SAERTEX in Germany (sub supplier for TUCO). Panels with different size was delivered by TUCO which later were fabricated at DTU to the final required form.
2. Coupon specimens manufactured at DTU to present different common defects in composite materials.
3. Full arm manufactured by TUCO with sock method.

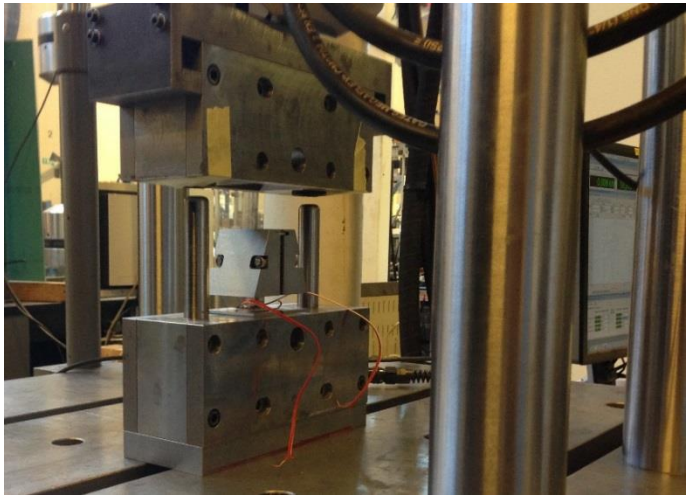
Material Characterization.

- Both static and fatigue material characterization of finial arm material configuration was carried out at DTU structural lab to achieve in plane properties of the specimens.

Shear



Tensile



Compression

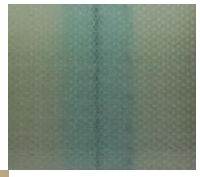
Manufacturing of internal specimens

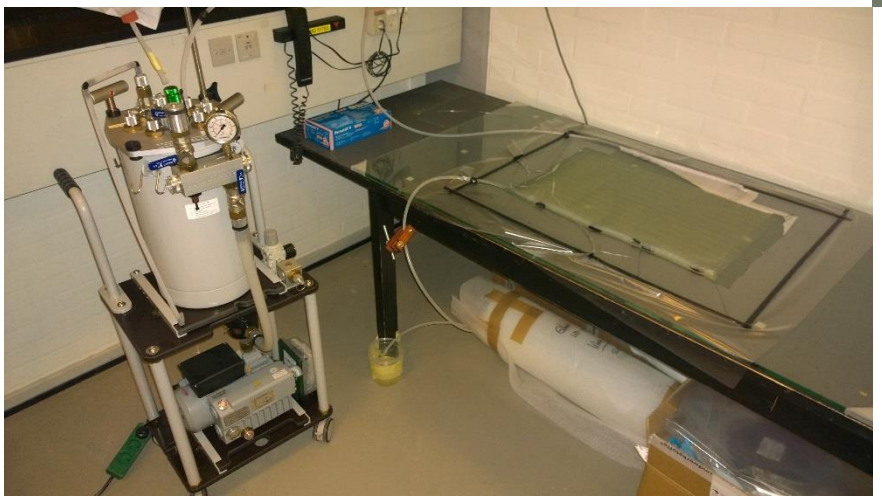
- 3 types of specimens were manufacture at DTU to investigate the effect of combined loading on common defects in composite materials.

- Specimens with good quality (for comparison).

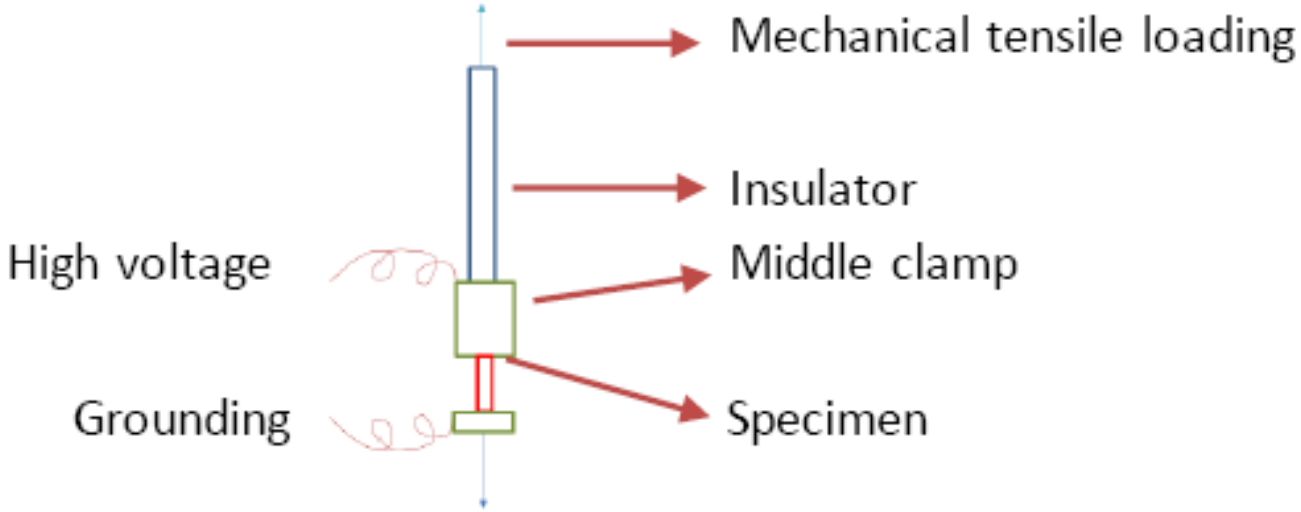
- Specimens with void.

- Specimens with pre delamination.





Set up proposal for combined testing:



Lets try some combined test!

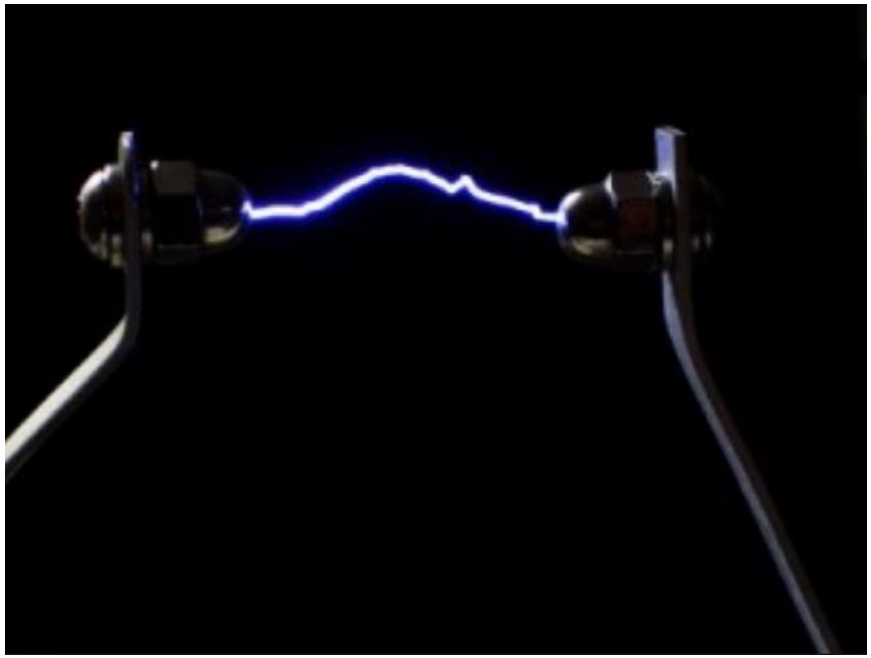
Anything wrong? Yes, sure!!

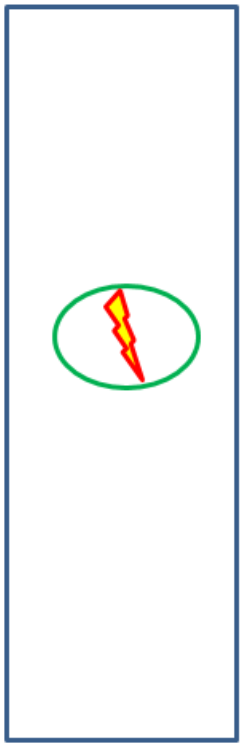
The controller is too sensitive to electro-magnetic waves during flashover and the electric boards keep breaking dawn!

O.K, Let’s spend few months on that then!

P.D (Partial discharge)

Simply small scale flash over which could accrue inside, on the surface and in the interface of the materials.





Why and how to detect P.D activities?!

- It is a well known phenomena in high voltage industry that P.D activities degrade materials in long term and should be avoided!

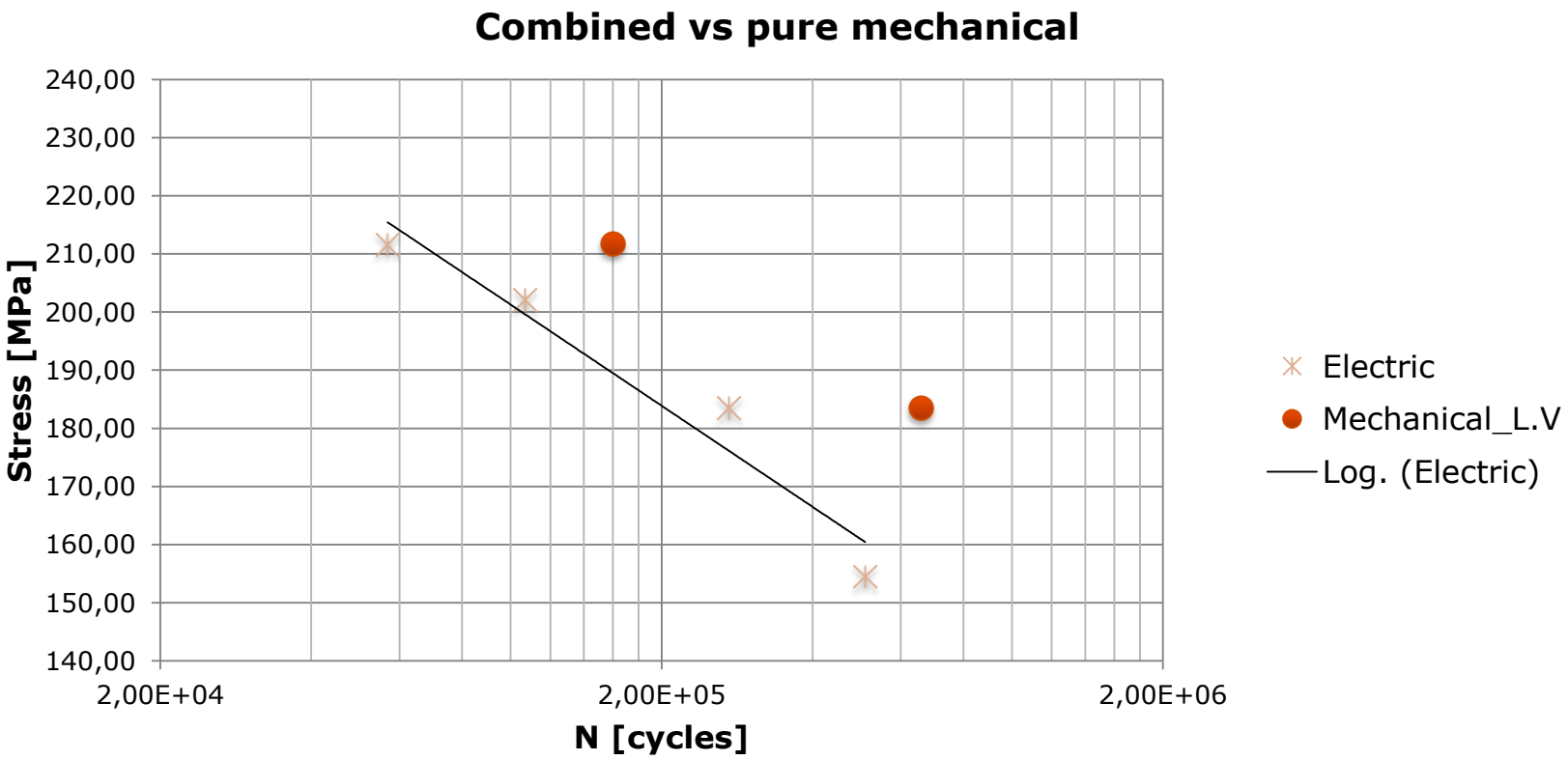
- Rough and simply you can detect it by listening to it.

- P.D measuring devices for accurate measurements.

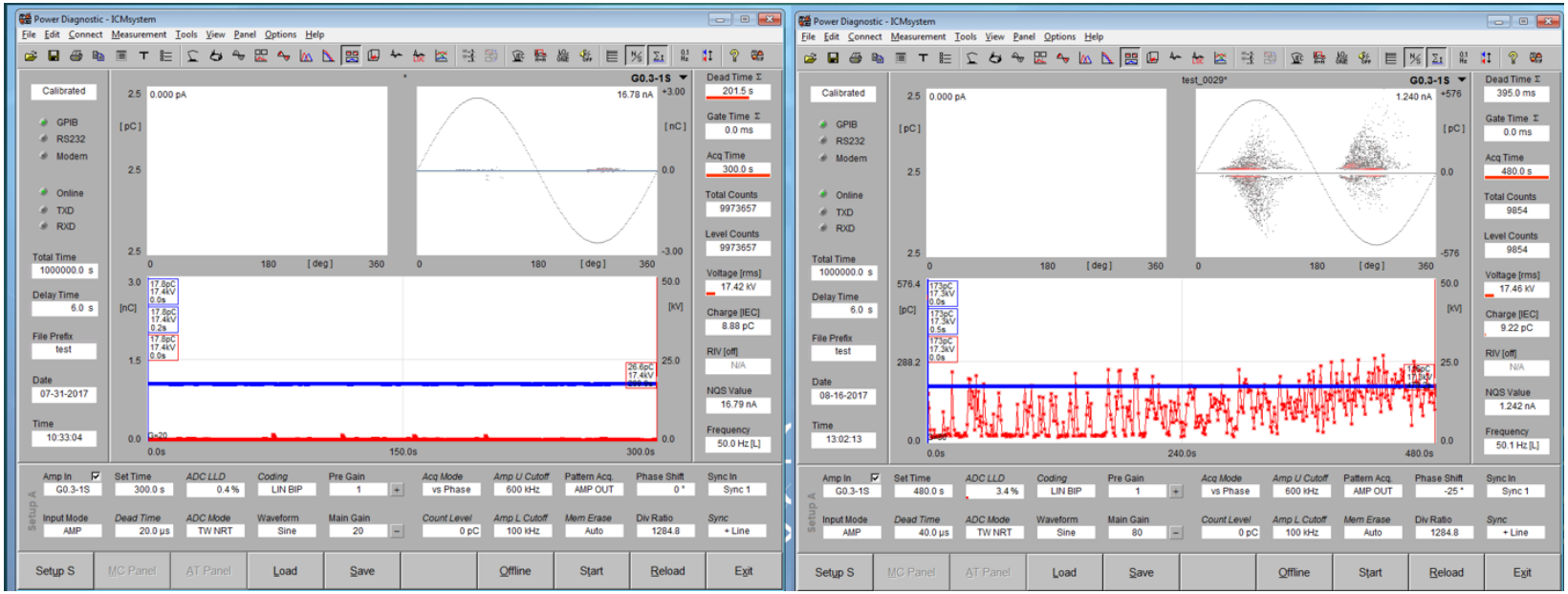
Test Setup.


Cameras
Instron Controller
Load train
PD measuring device
Thermal Image
NI data accusation device
Insulator
Specimen

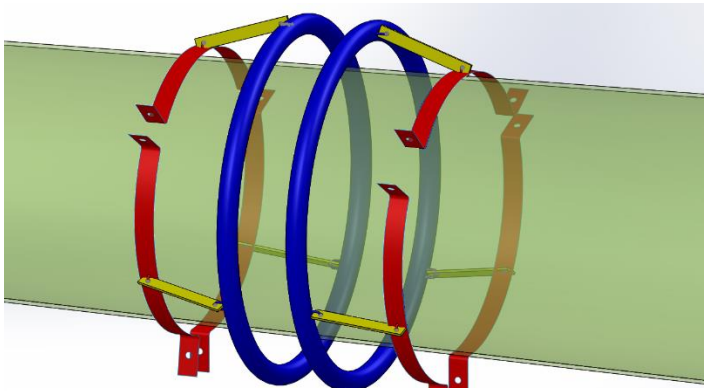
Fatigue data:

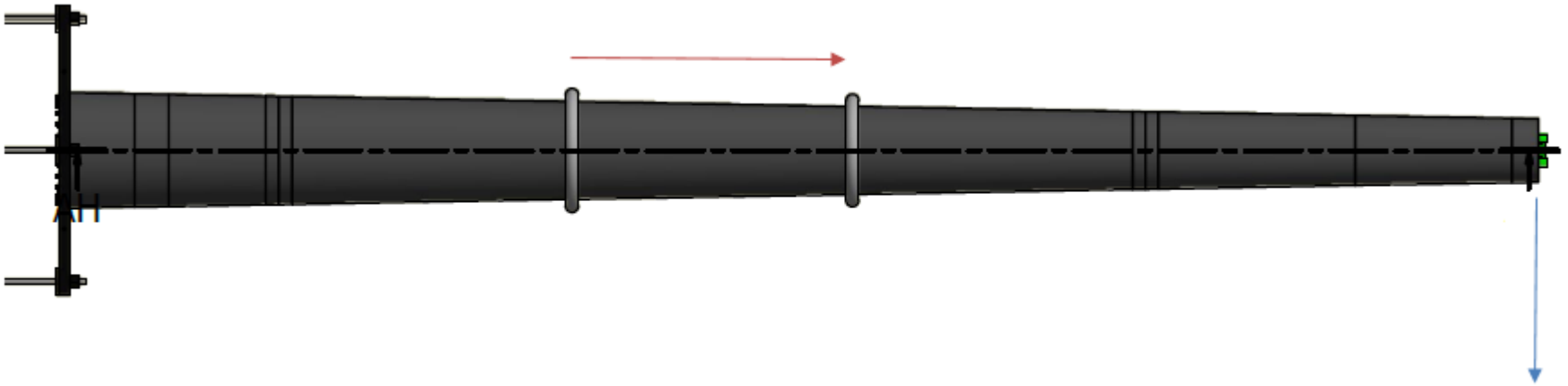


Partial discharge activities (P.D)



Full arm combined test setup.





Thank you for your attention!