

EERA DeepWind'2014

Sub-sea Cable Technology

Hallvard Faremo
SINTEF Energy Research

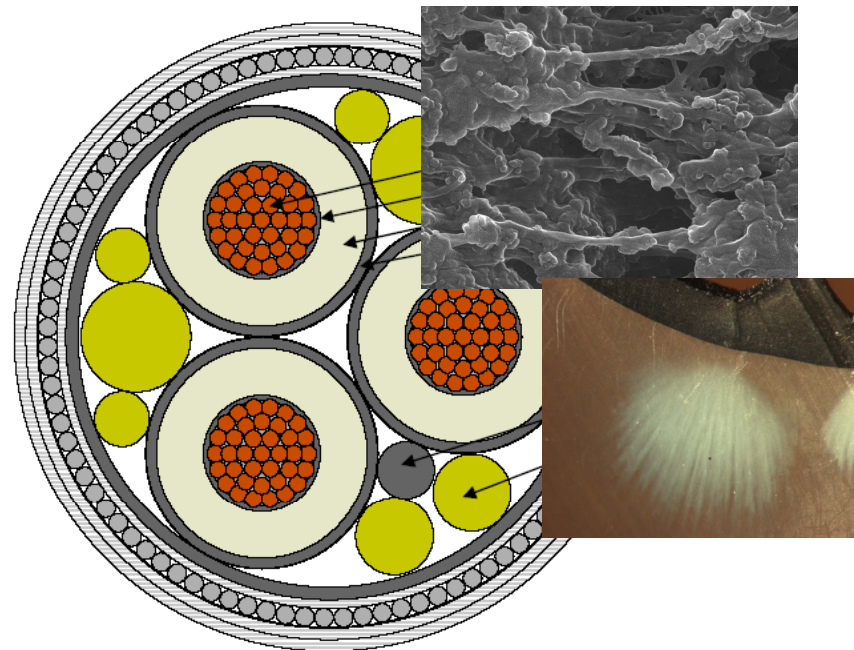
Brief presentation of:

Wind Farm Cable R&D project

High Voltage Subsea Cables Networking the North Sea

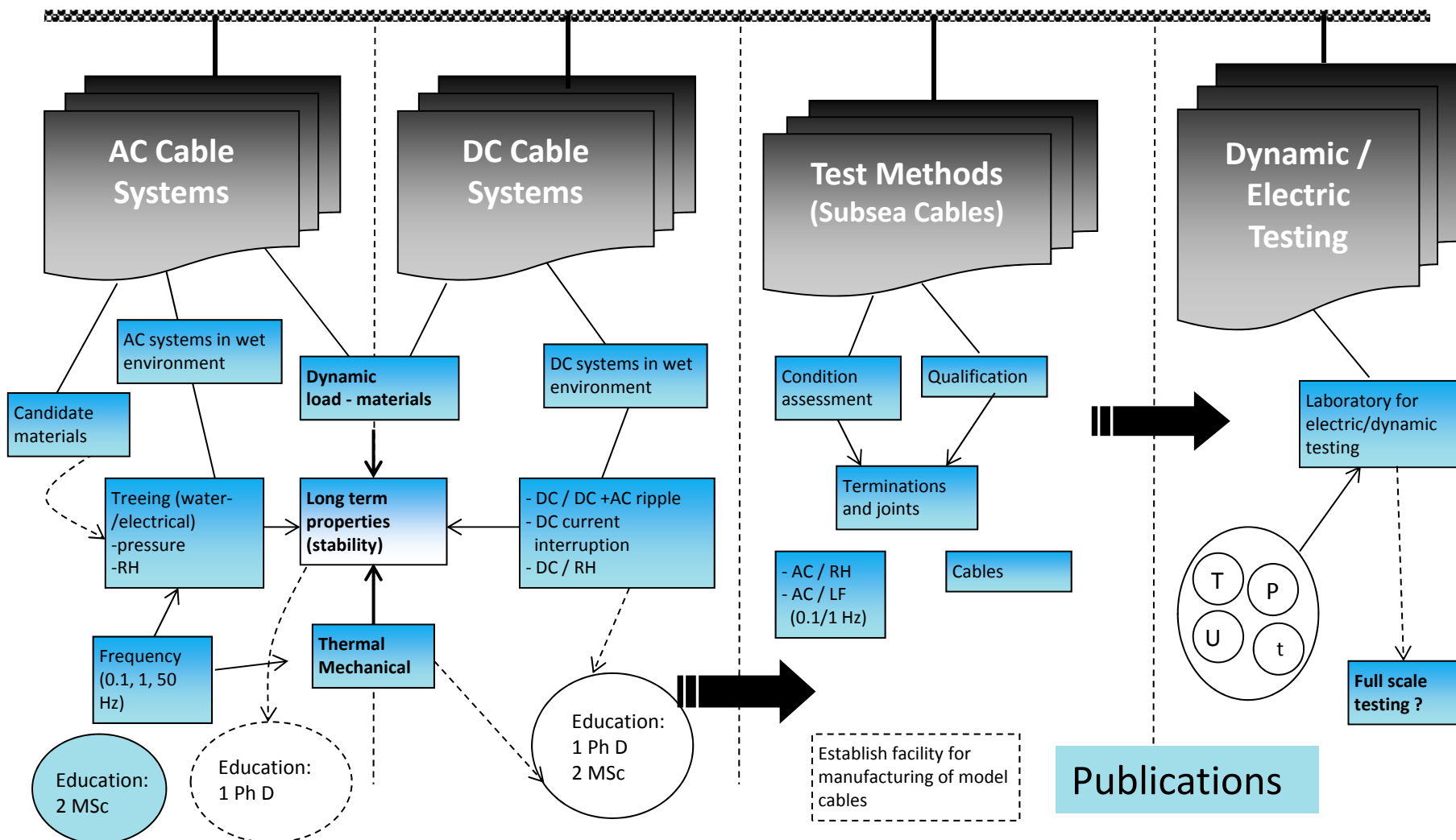
Application for a KMB project within the Research Council of Norway

- Project content
- Education (PhD / MSc)
- Scientific equipment
- Financing
- Research Partners



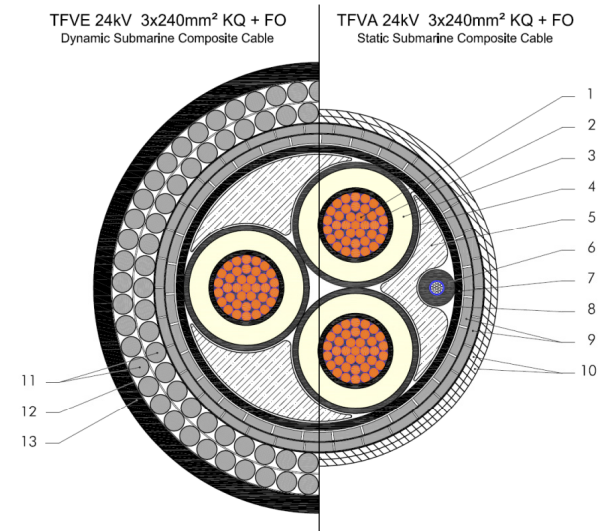
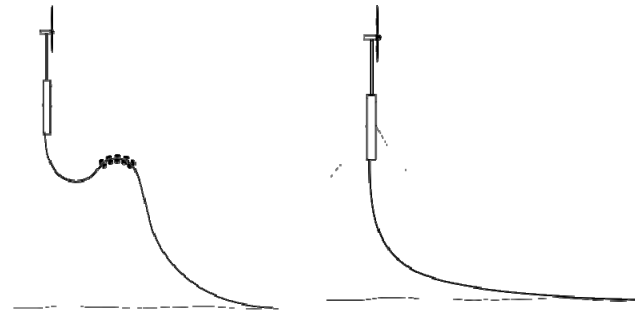
High Voltage Subsea Cables Networking the North Sea

Key words: Long operation times, Flexible designs, Qualification and test methods, HVDC/AC



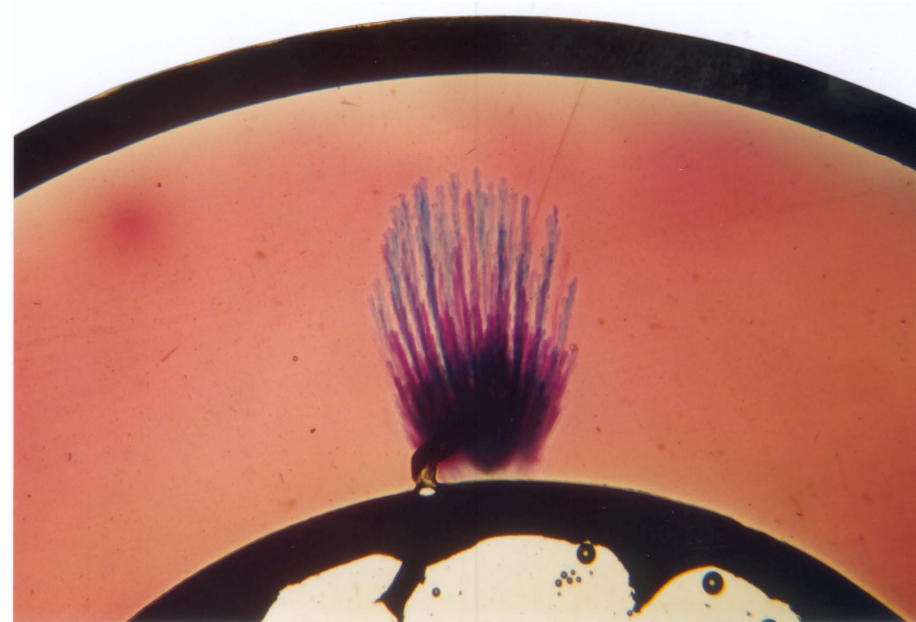
Project Content

- 1. AC cable systems
- 2. DC cable systems
- 3. Test methods
- 4. Dynamic / electrical testing (prototypes)
- 5. Education (NTNU)



AC Cable Systems

- Polymeric AC cables have been in use for decades in subsea environment
- In general the service experience is good
- Under some service conditions water treeing has caused premature failures
- Dynamic high voltage cables have now been in service for some years
- A PhD student (NTNU) is working with partial discharge questions



Water treeing in a 24 kV XLPE cable

DC Cable Systems

- Polymeric HVDC cables have been installed for more than a decade in Norway (The Troll Cables)
- The subsea HVDC cables are all water tight constructions (lead sheathed)
- Water treeing at DC stresses are not commonly expected to be a problem
- However, voltage ripple do exist in HVDC systems
- A PhD student (NTNU) is working with questions related to moisture ingress in XLPE insulation



Polymer HVDC cables

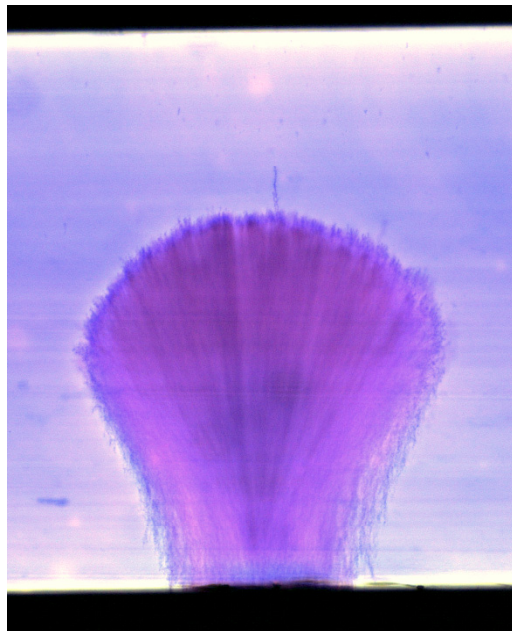
Combined AC and DC Stresses

- As HVDC systems have some percent ripple – an AC voltage stress will occur in HVDC cables
- This will not cause any damage under dry conditions
- Combined AC and DC stress may cause rapid water tree initiation and growth if the water barrier has been compromised

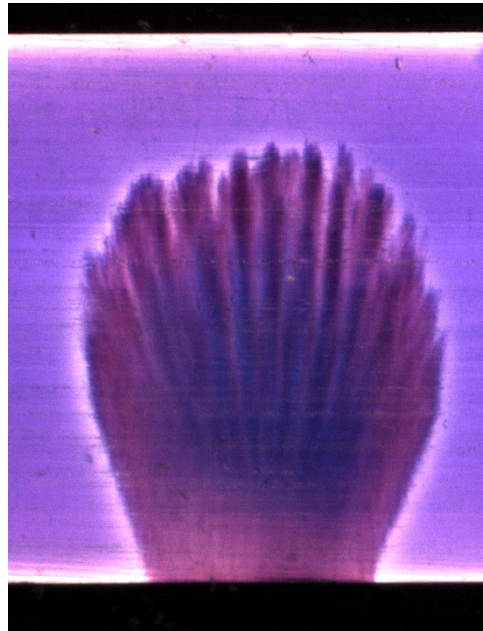


Electrical treeing due to rapid water tree growth under combined AC and DC stresses

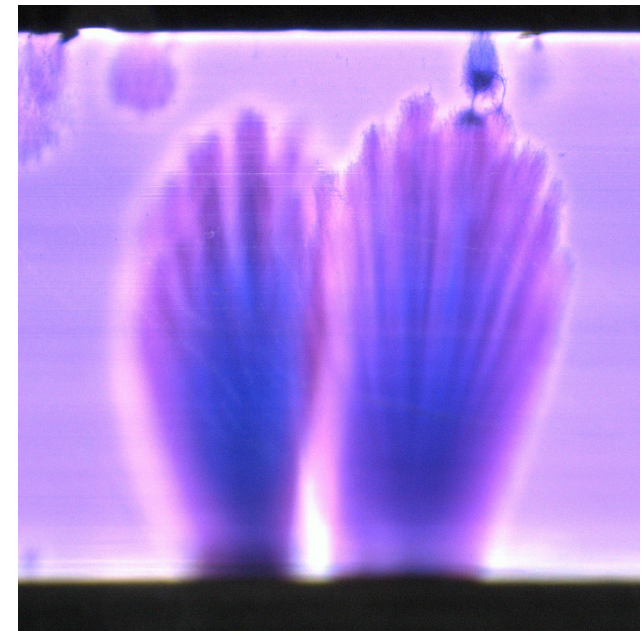
Combined AC and DC Stressing - Water tree analysis



2 weeks



4 weeks

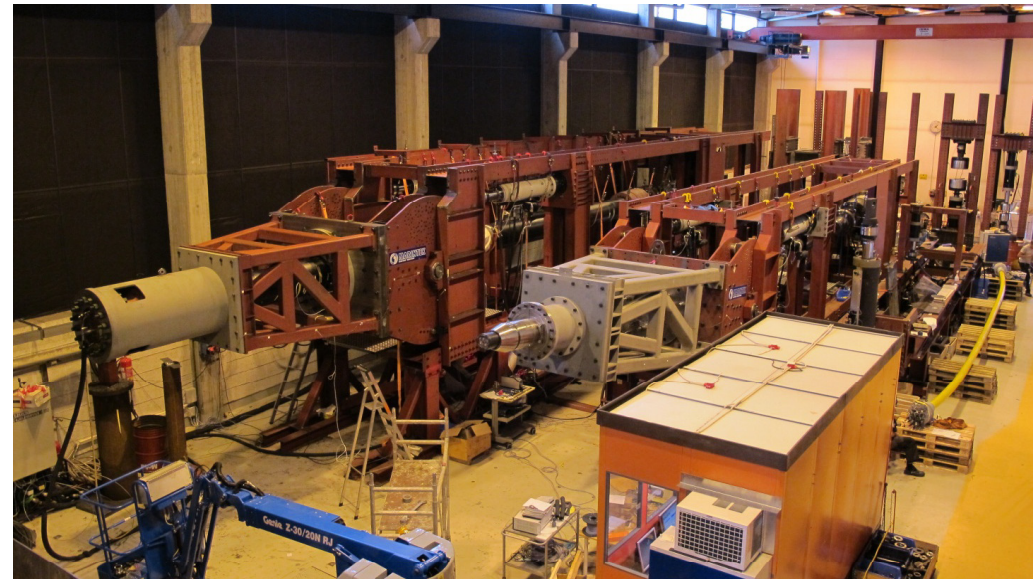


8 weeks

25 kV/mm DC + 2.5 kV/mm AC 5 kHz_{peak}

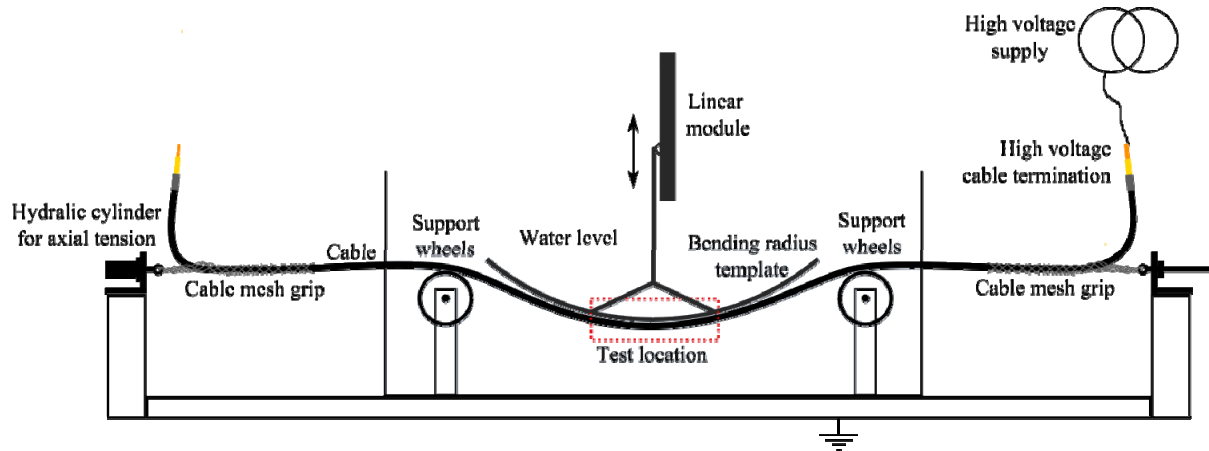
Dynamic / Electrical Testing

- Dynamic testing of high voltage cables have been performed for many years
- No electric stressing is usually applied under the dynamic tests



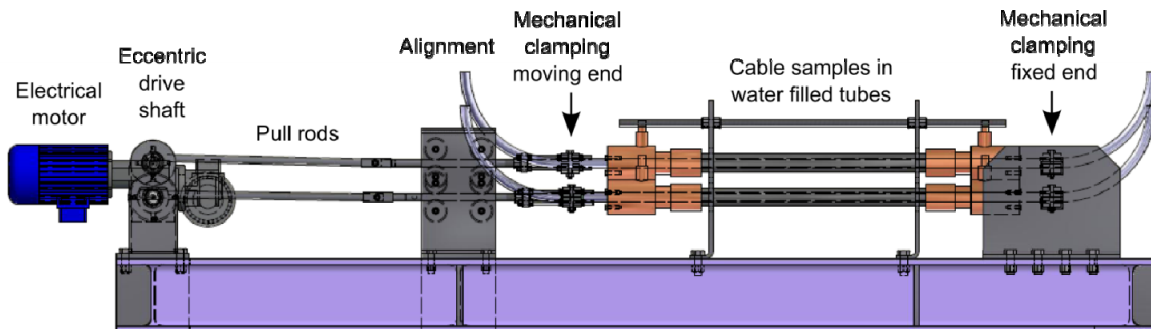
Marintek – Dynamic test rigs

Dynamic / Electric Testing



* Two different test rigs for combined dynamic and electrical testing have been developed

- Bending rig
- Axial strain rig



Dynamic / Electrical Testing

- Tests have been performed in both test rigs
- More than 3 million dynamic cycles have been applied to XLPE cables
- AC stressing according to CENELEC standard have been used (both 50 and 500 Hz)
- The results show an increased number of water trees when the XLPE cable insulation is exposed to combined dynamic and electrical stress
- The water tree lengths; however, do not increase
- Hence, as long as the dynamic stresses are kept at reasonable levels, no severe increased degradation is observed when the XLPE cable is aged under combined dynamic and electrical stresses

Summary

- The project was established in 2009
- Two test rigs for combined dynamic and electrical stressing of cable insulation have been built
- Long term tests have been performed in both test rigs
- Dynamic stressing at reasonable values (around 1 % elongation) do not result in detrimental ageing phenomena
- Combined HVDC and AC ripple has shown to result in enhanced ageing if moisture has penetrated the moisture barrier
- Two PhD students have been working in this project
- Several MSc students have also participated in the project

Pressure Testing – not part of this presentation



This presentation do not present results when testing in SINTEF's high pressure vessels. All tests presented is performed at ambient pressure



Thank you for your attention

Questions?



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