Study Committee B1

Insulated Cables

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Single Point Bonding of 3-core Submarine Cables

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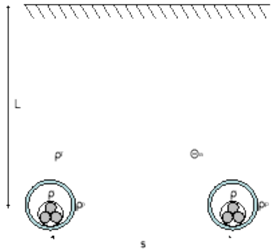
Motivation

- Relieving thermal bottleneck at landfall and/or OSS
- Cable Landing area often implies deep burial (L) with onerous thermal conditions (ρT, ϴA) and vicinity of other cable assets (s)
- Reduce cable losses on a limited section of the cable route

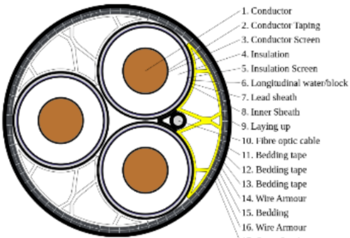


Method/Approach

- Single-point or mid-point bonding of a defined section of the cable system
- Insulated jacket on landfall section
- Open-end screen with SVLs at land-end
- Analytical work to obtain the correct impedance complex matrix, experimental work to obtain conductance matrix
- Investigate the standing voltage in normal operation and in fault conditions by utilizing a long-line cable model
- Ampacity calculations to assess the increase in current rating by using the single-point bonding method

Objects of investigation

- As an object for investigation, a typical submarine export cable system is chosen
- The design chosen is a three-core high voltage AC submarine cable system of the type 275 kV 3x1x1800mm2 Cu
- The case study cable system is assumed to have a 2-5 km long landfall section and a 20 km offshore section
- Assumed nominal current of 1100 A
- Physical short-length samples of the cable was used for experiments to provide input to the theoretical model



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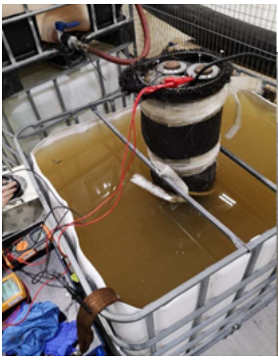
continued

Experimental setup & test results

- To provide proper input to the theoretical model experiments were performed to measure the conductance matrix of the cable system
- 3-phase cable samples were submerged in saline water (two experiments, 1 m and 50 m long samples). For each sample, the submerged end was sealed off with the other end protruding out of the saline water
- Using a voltage source, a voltmeter and an ammeter connected to the protruding end, the conductance matrix can be established
- Sheath-sheath and sheath-armour conductances were found to be approx. 30 S/km and 50 S/km, respectively



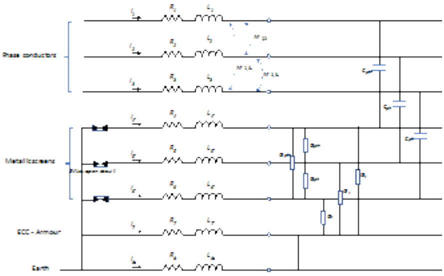
Electromagnetic model setup & results

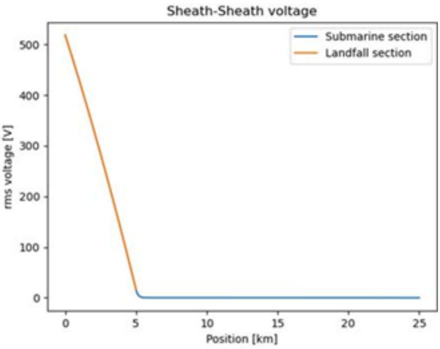
- The electromagnetic model solves the multiconductor telegrapher's equations for voltages **V** and currents **I**

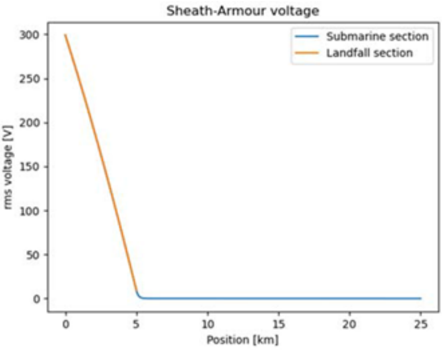
$$-\frac{d\boldsymbol{V}}{dx} = (\boldsymbol{R} + j\omega\boldsymbol{L})\boldsymbol{I}$$

$$-\frac{d\boldsymbol{I}}{dx} = (\boldsymbol{G} + j\omega\boldsymbol{C})\boldsymbol{V}$$

- Resistance matrix **R**, inductance matrix **L**, and capacitance matrix **C** are calculated whilst conductance matrix **G** is obtained experimentally







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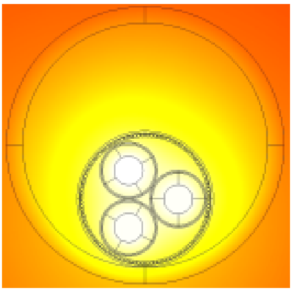

Ampacity model setup & results

- Landfall installation of 275 kV 3x1x1800mm^2 Cu cable is the base case studied
- The cable is assumed installed in a polyethylene Horizontal Directional Drilling (HDD) duct at the landfall. Both air and water filled ducts are analysed
- 4 – 15 m burial depth, 15 °C ambient temperature, 0.85 K.m/W soil resistivity
- The cable's ampacity increases by approximately **15 %** by going from the conventional both-ends bonding configuration to a single-point bonded configuration

Table 1: Cable rating values for modelled landfall installation. Cable placed in HDD.

Cable design	Burial depth	Conduit fill	Rating 2p bonding	Rating 1p bonding
300/275 kV 3x1x1800 mm^2	15 m	Water	835 A	955 A
300/275 kV 3x1x1800 mm^2	4 m	Air	880 A	1005 A
300/275 kV 3x1x1200 mm^2	15 m	Water	-	862 A
300/275 kV 3x1x1000 mm^2	15 m	Water	-	826 A

Discussion

- By using the single-point bonding method combined with insulating metallic screen jackets for the landfall section of submarine cable routes, screen circulating screen currents and corresponding losses are removed. This leads to an increase in ampacity and/or the possibility to reduce the cable's cross-section
- The induced electromotive-force will instead of causing a circulating current appear as a standing voltage for the landfall section, reaching a maximum at the landfall termination. This voltage must be handled properly, e.g. by using surge-voltage limiters and must be made sure not to exceed the voltage handling capability of the insulating jackets

Conclusion

- The paper presents an alternative cable system design which can prove valuable in overcoming thermal limitations of landfalls of wind farm export cable routes
- The alternative system design involves utilizing single-point bonding of the metallic screens at the landfall termination in combination with insulating jackets for the landfall section
- The single-point configuration will for the case studied in the paper increase the cable system's ampacity by approximately 15 %