Study Committee B1

B1 Insulated Cables

10880_2022

Evaluation of the HVDC VSC cable system behavior in presence of transient voltage phenomena

J.M ARGÜELLES ENJUANES (1), Gregorio DENCHE CASTEJON (1), Abel FUSTIER (2), Nicola GUERRINI (2), Pierre HONDAÂ (3), Francesc PADILLO (2), Pascale PRIEUR (3), Lluís-Ramon SALES CASALS (2)

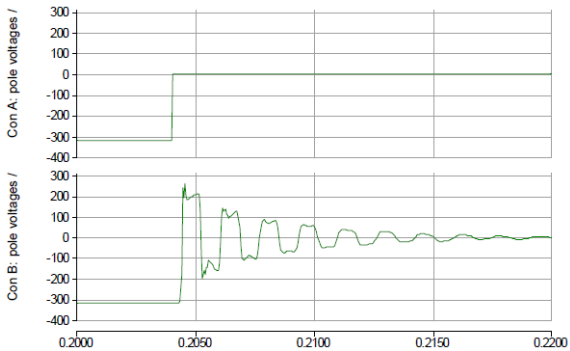
(1) REE, Spain ,(2) Prysmian Group, France (3) RTE, France

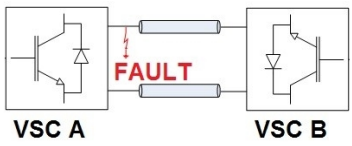
Motivation

- The present research study was carried out to verify the effects of chopped transient over voltages, (chopped TOVs) on HVDC cable systems, for this reason a specific test set-up was implemented on a HVDC laboratory and chopped TOVs were applied on the same samples of two different cable systems rated Uo=320kV that previously meet and exceed respective PQ tests.

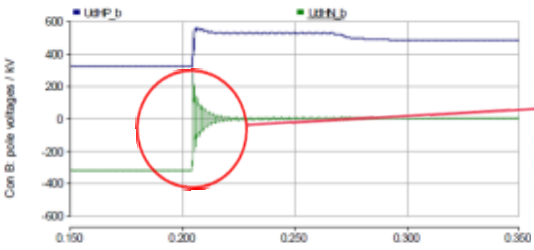
Approach

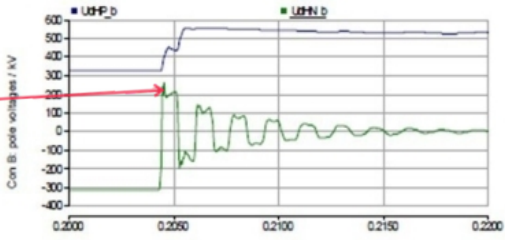
- Voltage fluctuations in converter station B caused by ground fault at one DC bus in converter station A.





- Simulations for a pole-to-ground fault on a HVDC monopolar symmetrical cable system. Voltages on the affected pole and on the unaffected pole .





- Each fault will generate a transient phenomenon shown on the right part of figure , that is characterized by quick time to front and repeated polarity reversals

Study Committee B1

B1 Insulated Cables

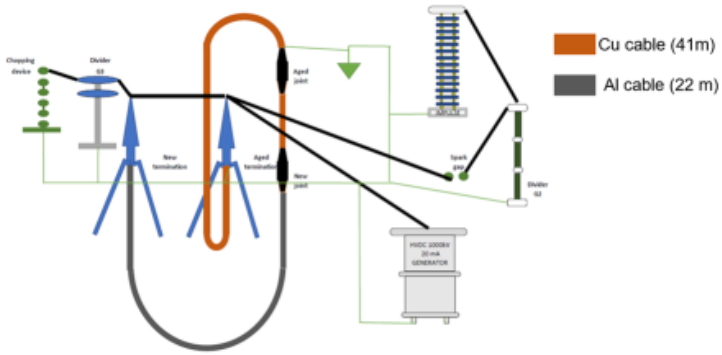
10880_2022

Evaluation of the HVDC VSC cable system behavior in presence of transient voltage phenomena

J.M ARGÜELLES ENJUANES (1), Gregorio DENCHE CASTEJON (1), Abel FUSTIER (2), Nicola GUERRINI (2), Pierre HONDAÂ (3), Francesc PADILLO (2), Pascale PRIEUR (3), Lluís-Ramon SALES CASALS (2)

(1) REE, Spain ,(2) Prysmian Group, France (3) RTE, France

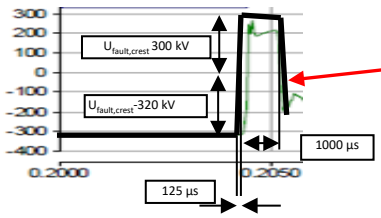
Experimental Setup

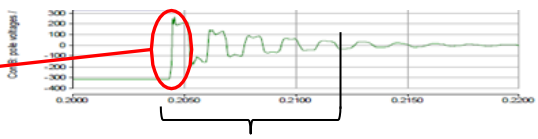


- The test equipment consists of an HVDC generator protected by a blocking resistance, an impulse generator protected by a sphere gap and a chopping device (multiple cut-off spark gap) connected in parallel to the test loop. Two heating transformers were used to heat the test loop and the dummy loop by means of current circulation in the conductor. Heating tapes have been placed above the outer sheath of the cables to minimize the different conductor temperatures due to the different conductor design, and to allow a more reliable temperature drop across the two cable insulations. The mentioned test setup allows to reproduce superimposed chopped impulses on the HVDC loop.

Test Protocol

- The cable systems have been set to different temperatures and at each temperature the following sequence has been applied:
- At 70°C, 8 cycles, equivalent to 8 faults, with 40 chopped TOVs corresponding to 80 polarity reversals, this sequence covers all expected polarity reversals that could occur along the entire life of a cable system.
- At 70°C, 8 additional cycles, to verify the safety margin in the cable system.
- At 80°C, 8 additional cycles, for investigational purpose.
- At 90°C, 3 additional cycles, for investigational purpose.





1 fault = 5 chopped Impulses (10 Polarity reversals)
Assessment of 8 faults for 40 years → 80 Polarity reversals

Study Committee B1

B1 Insulated Cables

10880_2022

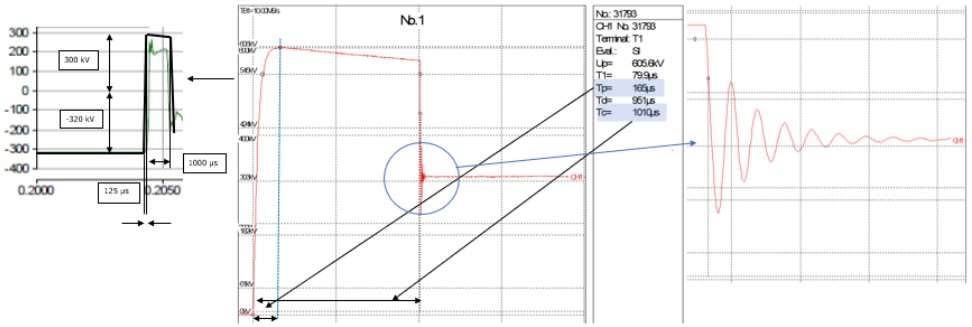
Evaluation of the HVDC VSC cable system behavior in presence of transient voltage phenomena

J.M ARGÜELLES ENJUANES (1), Gregorio DENCHE CASTEJON (1), Abel FUSTIER (2), Nicola GUERRINI (2), Pierre HONDAÂ (3), Francesc PADILLO (2), Pascale PRIEUR (3), Lluís-Ramon SALES CASALS (2)

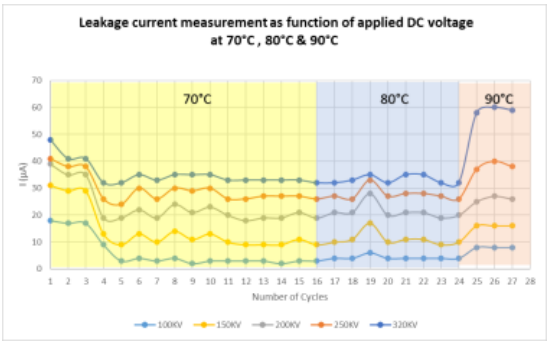
(1) REE, Spain ,(2) Prysmian Group, France (3) RTE, France

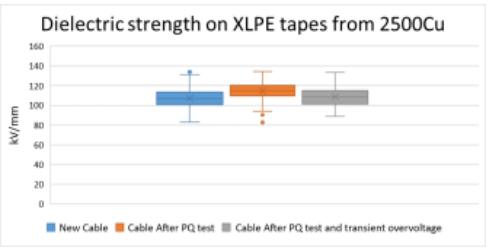
Test Results

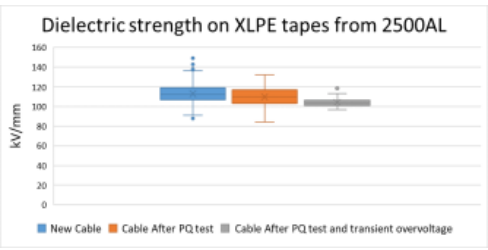
- The transient voltage curve that has been obtained is shown in figure:



- Example of chopped superimposed impulse waveshape with zoom on the high-frequency polarity reversals of the curve. On the left: example of voltage applied on the test loop







Discussion

- The evolution of the leakage current along the cycles does not show any sign of deterioration. The measurements stabilize at the three different conductor temperature steps.
- The dielectric strength to breakdown performed on the insulations of reference cables , remains at a very high level.

Conclusion

- Two HVDC cable systems were tested in the same loop, 135 chopped TOVs with 270 polarity reversals were applied at different conductor temperatures on the same cable system samples after successful completion of the respective PQ tests.