Laboratory testing of 525 kV cable systems with transient overvoltages

Heiko **JAHN**, KEMA Labs, FGH Engineering & Test GmbH (Germany), Heiko.Jahn@kema.com,
Uberto **VERCELLOTTI**, KEMA Labs, CESI S.p.A. (Italy), Uberto.Vercellotti@kema.com
Grazia **BERARDI**, Prysmian S.p.A, (Italy), Grazia.Berardi@prysmiangroup.com
Marco **ALBERTINI**, Prysmian S.p.A, (Italy), Marco.Albertini@prysmiangroup.com
Stefano **FRANCHI BONONI**, Prysmian S.p.A, (Italy), Stefano.FranchiBononi@prysmiangroup.com

ABSTRACT

The increasing integration of extruded HVDC cables into the power transmission system raises new questions regarding transient fault voltage waveforms and their simulation in the laboratory. Numerical calculations reveal that waveforms not covered by the IEC standards can occur in the event of failures. In the meantime, such waveforms are proposed in the CIGRÉ TB 852. Still, the tolerances are wide, and the comparison of the test results may be difficult. However, such special test waveforms are required by transmission system operators (TSOs) and cable manufacturers. The article presents a possible solution for generating such waveforms on cable systems (terminations, cable and joints) with a typical length for type test loops, showing tests results on an actual 525 kV cable system. The article highlights also some criticalities and limitations of achieving such waveforms with equipment available in HV laboratories when requirements on time to peak and plateau time are too demanding.

KEYWORDS

HVDC extruded cable systems, Testing experiences, Standardization, Transient overvoltage.

INTRODUCTION

The transition towards renewable energy is spreading all over the world, very much linked to the capability to transmit and dispatch energy from one place (where the clean energy is produced) to another (where energy is consumed). New challenges thereby arise in the power grid, such as renewable energy source remoteness and increased power flow fluctuations. HVDC cable systems can alleviate such burdens, since they are capable of levelling out supply-demand imbalances over vast geographical areas.

The development of reliable and durable HVDC cable systems thereby plays a paramount role in future electrification efforts. As proof of this, the number of HVDC interconnectors in the construction stage is larger than ever before. Also, there are many projects in progress at various preliminary stages (planning, studies etc), and these interconnections are typically very long and with higher power ratings, thus pushing voltages to new levels with new cable technologies.

The cable market is one of the hot sectors in the clean energy transition, as demand for products such as undersea HV lines leads to order backlogs of 2 to 5 years for cable manufacturer portfolios. Furthermore, the consequences of climate change that bring more frequent and intense storms, floods, heat waves, fires and other extreme events are under the eyes of all, consequently the use of underground cable networks will grow as the latter are more resistant to these climate-related risks.

The integration and management of intermittent renewable sources but also the security of supply and the integration of electricity markets are asking for bidirectional interconnection systems, this is the reason why utilities are requesting a polarity reversal endurance test.

Furthermore, network operators and utilities recently highlighted the occurrence of long transient overvoltage (LTOV), which may occur during the operation of the cable in point-to-point connections comprising VSC converter technologies (preferred for extruded cables) [1], [2].

They have contacted KEMA laboratories to evaluate possible test circuits to simulate this phenomenon. It has been verified, firstly by numerical simulation, later by a pre-test [3] that waveforms similar to waveforms occurring in service can be generated in the Mannheim laboratory.

As result of such simulations new requirements have been addressed to the test laboratories to test cables additionally with special waveforms e.g. CIGRÉ TB 852 [4] and TB 853 [5]. This paper presents a possible solution for generating such waveforms on cable systems (terminations, cable and joints) with a typical length for type test loops. Tests on a 525 kV XLPE full cable system provided by Prysmian Group have been successfully performed and are hereafter presented.

HVDC REVIVAL

Due to population growth, development of digital economy and electric cars, the global demand for electricity is expected to explode in the near future, believes IEA (International Energy Agency), estimating a growth in 2050 over 75% higher in the STEPS (Stated Policies Scenarios) than it is today, driven in particular by China, India and developing countries [6]. Unfortunately, the bulk of the Energy resources needed to satisfy rising demands are not located near the load centres, the massive integration of renewable energy and the consequent need to transmit greater quantities of energy on the grids are therefore inevitably associated with grid losses.

The long distances between production centres and load, together with the high uncertainty of the large share of energy produced from renewable sources, can cause "disorder" of flows and therefore a significant change in direction of the same, contributing to increasing transmission losses on the electricity grid.