Modular Test System for testing super long AC & DC cables

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ABSTRACT

Due to the increase in energy consumption, the demand for long and very long cables is constantly increasing too. The challenge lies in the production of such cables and, as a result, in the testing of these lengths. For the testing of subsea cables and long land cables after installation, conventional test systems have reached their technical limits. The shown test setup is capable of testing AC & DC cables up to four times the length of established test setups and simultaneously reducing the comparative masses and footprints of the whole test system. It is PD-free as required for cable testing and of modular design, to achieve an equivalent test power of >500 MVAr at 50 Hz by an optimized test arrangement.

KEYWORDS

Modular AC test system, AC cable, DC cable, on-site test, factory test

INTRODUCTION

As a result of the trend towards renewable energy sources, high-performance power plants such as wind farms or hydroelectric power plants are moving further and further away from end consumers. The energy source is located where people do not live and work in an urban environment. The long transmission paths require an adapted energy transmission. It makes sense to increase the transmission voltages (HVDC), but the type of transmission via direct current (DC) or alternating current (AC) must also be selected according to the conditions or depending on the operator. The hydrogen technology for lossless energy transport that has not yet been applied was associated with too many unsolved problems, but also the energy generation by means of solar thermal or photovoltaics in the deserts of Africa (DESERTEC) would have required at least known high-voltage direct current transmission (HVDC), but with a whole series of other problems to be clarified. The necessary transmission paths can be from wind farms in the sea to the land, with long AC and DC sea cables, but also AC and DC land cables or gas-insulated transmission lines. In addition, the energy supply of islands, some of which are far from the mainland, is also being considered.

The various test possibilities for these cables are already reported in [1]. The requirements for the AC test systems required for long or super-long cables are described below. A system is presented which can be adapted modularly to the various cable lengths and test voltages to be tested.

FACTORY TESTING OF LONG AC AND DC CABLES

Routine testing is required for both AC and DC cables.

According to CIGRE TB 496 [2], for DC cables up to 500 kV, an AC test should be considered for routine testing, provided that the insulation system and the design concept of the cable itself make an AC test possible in the first place. For large production lengths, such as those produced by continuous extrusion, AC testing has been subject to debate, as correspondingly powerful testing equipment is not commonly available. A special feature of AC and DC subsea cables is the practice of connecting individual production lengths of several tens of kilometres each to very long cables using factory joints which are installed under ideal assembly conditions at the factory. Despite only a few of these factory joints being used for a very long cable, AC testing is recommended for DC factory joints as far as the design of the joints permits [2]. The reason for this is limited experience with the evaluation and interpretation of partial discharge phenomena during routine testing while using DC voltage as the test voltage.

A long subsea cable was subjected to factory testing in 2018. This 3-phase AC subsea cable with a length of 37.7 km on a turntable was successfully tested at 318 kV for 30 minutes per phase. The test frequency was 10.24 Hz, the test current of 200 A being fed into the cable by single side feeding. Due to the need to reduce shielding and cable losses when testing long cable systems, a test frequency of 10 Hz was selected in accordance with the recommendations of CIGRE 490 [3]. The components of the test system were designed for the above-mentioned test frequency of 10 Hz. This resulted in a substantial reduction of losses in the cable as well as a reduction in the feeding power required for the test system. The routine test was carried out using 4 high-performance reactors of a new design (see Figure 1), developed especially for testing very long cables.

These 4 high-performance reactors of the new type were thus able to provide an apparent power for testing of 110 Mvar, i.e. a type power of 458 Mvar, with the maximum possible output test voltage of 450 kV at 244 A.

A test system consisting of 8 of the previously available reactors of conventional design with a combined type power of 250 Mvar (see Figure 2) can be replaced by only 2 of the new high-performance reactors. While 4 high-performance test reactors require a footprint (with HV components) of only 120 m², the same test power requires 16 units of the conventional reactors, with a footprint of 620 m².