Performing of type tests for the qualification of three-core submarine cables and accessories for connections of offshore wind farms.

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ABSTRACT

Task was to demonstrate the suitability of cable accessories in conjunction with the presented cables. For this purpose in the period of 2011 - 2014 several type tests are carried out with an individual total core length of about 150 m.
Several technical problems had to be mastered:

1. *Due to the existing steel reinforcement, the submarine cable must be heated three-phase. At any time, the heating current shall be a symmetrical three-phase system, described are the technical solutions*
2. *The contacting of the cable shields in the cable accessories shall be suitable for the application. The connection must have a low inductivity so that no voltage between the conductive layers in screen area occurs.*
3. *Testing and measuring equipment had to be adapted for this purpose.*
4. *General technical requirements for cables do not necessarily lead to the same performance.*
5. *Slight deviations of structure elements have a big impact on the technical characteristics of the cable.*

Described is a type test of a cable supplier with selected accessory-sets, as well as a type test with cables and accessories from several suppliers, and the associated difficulties and lessons learned from the test mode, as well as conclusions for operation on site.

KEYWORDS

Testing, submarine cables, three-core cables, heating current, PD-measurement

INTRODUCTION

The task was to carry out tests to demonstrate the operational performance of three-core submarine cables in connection with cable accessories. For this purpose, in the period of 2011 to 2014 several type tests were performed with a total wire length of about 150 m.

For special applications and the general requirements of submarine cables right now there are no mandatory standards. However there have been published Electra and Cigre recommendations which are an important guide and can be refered to for the implementation of the various tests. For the electrical and non-electrical type test generally applicable standards for the appropriate cables were applied for buried cables. This compilation of regulations and recommendations was summarized in a Factory construction- and test-specification of the manufacturer for these submarine cables and supplemented by some requirements of the final customer. Through close collaboration of manufacturers, final customer and testing institute a comprehensive test program was developed, which formed the basis for the implementation and evaluation of the tests.

Below are details on selected aspects in the analysis of three-core submarine cables and accessories for 150 kV, which are used in offshore wind farms as export cable connection.

The following standards and technical descriptions were used for the deliverable tests :

- Electra No. 171, 04/1997, WG21.02, Recommendations for mechanical tests on sub-marine cables
- Electra No. 189, 04/2000, WG21.02, Recommendations for testing of long AC submarine cables with extruded insulation for system voltage above 30 (36) to 150 (170) kV
- Cigre TB490, WG B1.27, 02/2012. Recommendations for testing of long AC submarine cables with extruded insulation for system voltages above 30 (36) to 500 (550) kV
- IEC 60840, Ed, 4.0, 11/2011, Power cables with extruded insulation and their accessories for rated voltages above 30 kV (Um = 36 kV) up to 150 kV (Um = 170 kV) – test methods and requirements

This results in the subsequent test program [1], [2], [3], [4]:

Test	Kind of test and parameters
1	Check of the insulation thickness of the cable for the electrical type test
2	Tensile bending test
3	Rated withstand voltage test 325 kV / 1 min.
4	Partial discharge test at ambient temperature 2,5 U_0 = 218 kV / < 1 pC , Calibration 2 pC, EN 60885-3
5	Measurement of tan δ at high temperature U_0 = 87 kV
6	Heating cycle voltage test 8/16 h, 2.5 U_0 = 218 kV, 20x
7	Partial discharge test at ambient temperature 2,5 U_0 = 218 kV / < 1 pC , Calibration 2 pC, EN 60885-3
8	Partial discharge test at high temperature 2,5 U_0 = 218 kV / < 1 pC , Calibration 2 pC, EN 60885-3
9	Lightning impulse voltage test at high temperature 750 kV, EN 60230
10	AC voltage test 2,5 U_0 = 218 kV / 4h, HD 605
11	Partial discharge test at ambient temperature 2,5 U_0 = 218 kV / < 1 pC , Calibration 2 pC, EN 60885-3
12	Examination