ICEA Standard S-97-682 Hyperbaric Accelerated Water Treeing Test (AWTT) Performed at 1, 250 and 310 bar

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ABSTRACT

The Accelerated Water Treeing Test (AWTT) of ICEA standard S-97-682 has been performed on tree-retardant crosslinked polyethylene (TRXLPE) insulated cables having blocked and unblocked conductor strands, at 1 (ambient), 250 and 310 bar hydrostatic water pressure for up to 450 days. Minimum residual dielectric AC breakdown strength requirements of the ICEA standard after AWTT via a step-rise high voltage time test (HVTT) at 120, 180 and 360 days were met at all three (3) test pressures, and were statistically equivalent at all test pressures. Degradation rates of AC breakdown strength were also identical at all test pressures. The number of bow-tie trees observed at or near HVTT failure sites as a result of AWTT being performed at 250 and 310 bars were higher than at ambient pressure (1 bar). The bow-tie tree density (#/.in3) growth rates at 250 and 310 bar are also greater than at 1 bar. Vented treeing (either at the conductor shield or insulation shield interfaces) at 250 and 310 bar was essentially non-existent. These test results indicate that this TRXLPE insulation system can be expected to operate reliably at its intended operating voltage in sea water depths of up to 10,000 feet (3,100 m) for its projected 30 - 40 years life.

KEYWORDS

Accelerated Water Treeing Test, AWTT, AC breakdown strength, bow-tie trees, vented trees, hyperbaric pressure, TRXLPE, degradation rates, high voltage time test, HVTT, submarine cable

INTRODUCTION

The oil and gas industry is moving into ever increasing water depths in the search for new oil and gas supplies. Subsea developments and operators are looking towards subsea boosting technology as a means of getting the most out of their reservoirs. The power distribution cables and umbilicals, which are needed to supply electrical power to the subsea boosting equipment, will be challenged by more extreme conditions due to the deeper waters.

The incremental increase in production from pumps installed on the seabed or in the well, and / or compressors installed on the seabed can be the determining factor in the economic viability of a deep or ultra-deep water production field. When power is supplied from floating structures in deep waters, dynamic cables and multi-function umbilicals are required to supply power to the subsea electrical loads. In addition to one or more medium or high voltage three phase power circuits, the umbilicals may include fibre optic communication cores, control power conductors, and tubes for barrier, control, or other fluids. The dynamic submarine cables and dynamic umbilicals material and installation costs represent a significant portion of the subsea boosting cost.

Because of the significant costs, and frequently the limits in number of hang offs from floating structures, these cables are often un-spared, and are critical components of the production system. A single subsea load may supply the equivalent of 60,000 barrels a day. Production fields and facilities may have expected life of 25 to 30 years or more. In order to achieve the required reliability and availability throughout the life of the fields, it is imperative that all measures are taken to ensure proper design, manufacturing, testing, and installation of the submarine cables and umbilicals.

The installation of power cables in deep waters involves comprehensive engineering studies which analyse all critical installation aspects including interaction of mechanical, electrical and thermal properties between the power cables and umbilical or other installation components. Generally, this type of cable and umbilical installations will involve dynamic sections and static sections. Among other types of specific constraints (e.g. mechanical stresses –fatigue, tensile loads, creep, etc.) which will significantly influence the power cable designs and the qualification testing definition [1], high hydrostatic pressure is an important factor to take into account to fully evaluate the cable design and materials to be used.

For cables with wet design (without a metallic barrier to stop the radial diffusion of water into the insulation), it is of major importance to evaluate the water ageing behaviour of the cable insulation system (conductor shield, insulation, insulation shield materials and the cleanliness of the manufacturing process). The water-treeing degradation behaviour for land-based cables is well addressed via the Accelerated Water Treeing Test (AWTT) protocol stated in North American and International standards such as ICEA S-97-682 [2], Cenelec HD 620 [3] and Cenelec HD 605 [4].

Since these standards do not provide accelerated degradation conditions for hyperbaric applications and specific submarine cable design particularities [5], the present study has been carried out to gain knowledge of the influence of high pressure on the water ageing process. The intent is to compare the ageing behaviour (degradation of AC breakdown strength and water-tree growth rates) of different cable core designs (blocked and unblocked stranded conductor) at different pressures (1, 250 and 310 bar). The test procedures that were used comply with ICEA Standard S-97-682, Part 10 and AEIC Cable Specification 8, Section 15. AC breakdown strength