B.8.5. Développement de méthodes de prediction de la durée de vie en service des câbles à huile fluide

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B.8.5. Development of service life prediction methods for oil-filled cables

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At present there are no international recommendations on service life tests or even a consensus on the ageing pattern of oil-and-paper insulation of oil-filled cables. With the goal to investigate cable insulation ageing patterns, refine service life test procedures and develop life expectancy prediction methods, NIIPT built its cable test facilities using standard test equipment by TuR, Leipzig, and for a decade has been engaged in service life tests of 10 to 600 kV oil-filled cables and their paper-and-oil insulation.

In particular, such tests were given to 12-15 m long samples of advanced-design prototypes of 132 kV low-pressure and 245 kV high-pressure oil-filled cables with a smaller insulation thickness (E_o = 10-12 MV/m). During the tests the loss tangent tgδ of the insulation and the capacitance of the samples were measured. Oil samples were taken periodically and checked for the gas content, tgN, breakdown voltage etc.

Ageing studies were carried out in accelerated long-term tests, lasting from 6 months to 6.5 years, by stressing the samples both electrically, by voltage ranging from 1.0 UN to 2.5 UN, and thermally at core temperatures varying from 85°C to 140°C. Medium-term tests of 6 to 12 months were given to numerous insulation models (0.25 m long cable pieces) that were exposed to thermal ageing stresses only, to check the experimental conclusions of the critical importance of thermal stressing for the life of the insulation of oil-filled cables.

Analysis of the cable sample and insulation model tests has shown the thermal destruction of paper-and-oil insulation components and the resulting changes of the insulation's physical, chemical and electrical characteristics to be the governing factors in the insulation ageing pattern. In low-pressure cables the insulation life depends on the rate of formation of gases (basically CO_2) in the oil to a saturation point when ionisation processes in gas bubbles bring about an electrical breakdown of the insulation. As for high-pressure cables, the increase of the gas content affects primarily the dissipation factor tgδ, whose fast growth results in a snowballing overheating of the insulation and leads to a thermal breakdown.

These findings on the ageing patterns of the paper-and-oil insulation were used to develop techniques and procedures of accelerated service life tests for 132 kV to 525 kV oil-filled cables, which specify test conditions, modes and durations and provide mathematical models for predicting the cable life on the basis of the test results.

The insulation ageing regularities that were established by these studies permit development of a cable monitoring system, which would make possible analysis of the used and remaining life of a specific cable from its record of operational thermal loadings.