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NUCLEAR CABLES AND LIFETIME SIMULATION

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ABSTRACT

The aim of our studies is to appreciate the lifetime expectancy of cables installed in French nuclear power plants. For that, we follow the evolution in time of the elongation at break of sheaths and insulations of cables, in function of the temperature and dose rate. Experimental results obtained on cables test installed in the building reactor of Bugey during 1.3, 3 and 12 years are compared with simulation performed with the semi-empirical model based on chemical kinetic laws developed by EDF in the 90's. This study predicts a nuclear cable life expectancy upper than 60-year-old in service conditions.

KEYWORDS

EPR, Hypalon, kinetic model, mechanical and chemical analysis

INTRODUCTION

The ageing study of electric cables installed inside the building reactor of nuclear power plants is one of EDF's main concerns for many years. A semi empirical model based on the DAKIN's law was developed in the 90', to assess the evolution of elongation at break of the sheaths and insulation of cables, versus temperature and dose rate. This model applied to Hypalon and EPR materials was presented during Jicable in 1995. To coincide with these studies realized on materials with accelerated ageing conditions, test cables were installed for ageing in the reactor building of Bugey 4. Some samples were removed after 1.3, 3 and lately 12 years of aging on site. This paper presents the results of the different analyses done at the macro and microscopic level on test cables and leads to a comparison between the results from simulation and those from real ageing conditions, inaccessible conditions in a laboratory for such long period of time.

1. MACROSCOPIC ANALYSES

1.1 Identification of test cables

Test cables are EPR/Hypalon type cables K1 qualified similarly to those installed on site.

They were installed at the +20 meters level (near steam generators). Initially, different cable types were installed at that place : new cables and pre-aged obtained by thermal ageing at the temperature of 90℃ to 135℃ for 240 to 950 hours.

The test cables have been removed after 1.3, 3 and 12 years of ageing in the reactor building of Bugey.

1.2 Electric Analysis

Insulation resistance measurements have been performed on cables conductors (the core and the insulating envelop were taken separately and immersed in water). The measurement was performed between the core and the copper electrode immersed in water. A continuous tension of 500 Volts was applied during sufficient time to enable a stable measurement. At first, a visual inspection of the conductors is achieved.

> ***Visual outcomes*** : Several pitting corrosion on the internal face of steel armour. No track of oxidation of the conductors
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> ***Insulation resistance*** : Ki > 60000 MΩ.km.

It seems that the EPR/Hypalon cables were submitted to corrosion phenomena as oxidation tracks are observed on the internal steel armour.

1.3 Mechanical Analysis

Operating Mode

The elongation and stress at break are determined on H2 type test tubes by applying the NF T 46002 norm using the following characteristics :

- o distance between the jaws 50 mm,
- o traction speed 250 mm/min,
- o load applied of 0,2 kN.

Tests were performed in an air conditioned room at 20℃ +/- 1℃ and 50% +/- 5% of relative humidity.

Experimental Results

The two following tables present all the results of the mechanical tests done on the Hypalon sheath and the EPR insulation of the test cables.

The experimental results show the huge impact of the thermal pre-ageing, especially the one of 950 hours, on the residual mechanical properties of the Hypalon sheaths. The effects of pre-ageing seem negligible on EPR. The sheath plays perfectly its protective role, even against thermal solicitations.