DEVELOPMENT OF HIGH VOLTAGE EXTRUDED CABLES: THE ITALIAN EXPERIENCE

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ABSTRACT

High voltage extruded cables have been massively employed in the Italian distribution and transmission grid for more than 20 years. Approx 900 km circuit length of extruded insulated cables at rated voltages of 132-150 kV, have been placed in service, with an excellent record of service.
The development of a new cable system design together with the optimization of the installation procedures have permitted the reduction of the global cost of ownership and allows the realization of a number of new projects, both in urban and suburban area.
As well as a new category of accessories permitted the undergrounding of part of existing overhead lines crossing difficult areas as the penetration in the cities.

KEYWORDS

Underground Cable (UGC)
High Voltage (HV)
Extra High Voltage (EHV)
Overhead line (OHL)

INTRODUCTION

This paper illustrates the impressive development of the High Voltage (HV) cables in Italy.
For more than 50 years oil-filled cables were the only underground cables in Italy with an excellent track record in terms of reliability and performances.
During the last 25-30 years extruded cables practically totally replaced oil filled cables, up to t150 kV voltage and were used in a extensive amount for new connections both in urban and suburban areas in place of / or as a replacement for existing overhead lines.
After this period, the extruded cable systems demonstrated excellent reliability, similar or better than that of other electric apparatus. This experience confirmed the expected reliability level theoretically evaluated during the development process. Today we can affirm, with certainty and on the basis of practical experience, that the recommended methods for the prediction of the life and the evaluation of the quality of the new products, defined by institutions like CIGRE and Standards like IEC, are very effective.

THE HV AND EHV SYSTEM

The conformation of Italy and the localization of high density populated and industrialized areas require a very well meshed transmission and distribution network, in order to sustain the load demand.

Voltage systems

The Italian system voltages for HV distribution and EHV transmission are the following:

- 132 kV North
- 150 kV central, South, and islands
- 220 kV
- 380 kV

This paper takes into consideration mainly the 132 kV and 150 kV voltages (HV) that are used both for distribution and transmission, while 220 and 380 kV (EHV) are used only for transmission.
Concerning the selection of the cable system (cable and accessories) for the voltage range 132 -150 kV it was decided to adopt an unified voltage of 150 kV.

Composition of the grid

The Italian transmission and distribution grid is constituted mainly of overhead lines (OHL) but the adoption of underground cables (UGC) is rapidly growing especially for the HV up to 150 kV. The composition of the Italian grid and the length of the circuits in service at 2005 is given in table 1.

Table 1: Composition of the Italian grid at 2005

Voltage kV	Overhead lines km of circuit	Underground cables km of circuit
132-150	38280	910
220	10920	200
380	10650	34

CABLE TYPES

The transition from oil filled cables to extruded cables passed first trough the adoption of EPR (Ethylene Propylene Rubber) insulated cables that are still used for some applications and in a second time, by the adoption of a compact design of XLPE (Cross Linked Polyethylene) insulated cables.

EPR insulated cables

The first 150 kV EPR insulated cable was put in service in 1973, originally the cable was composed of a copper conductor with an insulation thickness corresponding to a maximum electric stress at conductor screen of 6 kV/mm, an extruded lead metallic sheath, and an extruded outer PVC or polyethylene sheath. In a second time a lighter cable having a copper or aluminium conductor, and a copper wires metallic screen (in place of the lead sheath) was employed. This latest cable was named wet design due to the fact that no impervious water barrier was applied Figure 1. The design of this cable was made possible thanks to the outstanding and well proven resistance of the EPR insulation to the water treeing phenomena.