ECONOMICAL DESIGN OF CABLE CONDUCTORS

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ABSTRACT

Most of the time, the engineer selects the smallest conductor size allowing the required maximum operating temperature in order to limit the investment cost of an underground cable system. However, it can be attractive to consider larger conductors with fewer losses. Despite their higher cost at the purchasing date, they may lead to a competitive present cost of losses, with many technical or operational advantages, and a lower environmental impact.

A tool was developed to perform more visual results than with the IEC 60287-3-2 conventional approach, to assess the most cost-effective conductor size according to technical and financial scenarios.

Another study was carried out to harmonise a wide range of available conductors and their specific accessories. It was possible to rationalize larger volumes of purchasing, leading to an easier stock control.

KEYWORDS

Underground cable systems, current rating calculation, losses, investment cost, global cost, conductor size, design criteria.

INTRODUCTION

A transmission underground cable system must be designed with a special care because of its technical stakes and investment cost. Its life span of several decades (typically 40 to 60 years) makes it difficult to forecast some influent parameters (power demand, prices of raw material) and to anticipate the consequences of severe financial events, societal or environmental evolutions.

RTE, the French Transmission System Operator, has launched an exploratory discussion in order to assess long-term costs. The authors present their methodology and a prospective tool for decision-making.

THERMAL DESIGN CRITERION

The selection of a conductor to transmit power through an underground cable system is linked to many criteria: electrical considerations, thermal design, environmental impact, installation techniques, mechanical stresses, etc. Obviously complying with an attractive economically advantageous tender…

Since the current rating of a cable system is assessed according to its thermal behaviour, the cable is designed to withstand the maximum temperature of the insulating layer in any operation modes. IEC standards describe calculation data for steady state [1], cyclic and emergency [3] or short-circuit [4] current ratings.

Other thermal constraints may decrease the permissible current value: maximum temperature to prevent the risk of soil drying and thermal runaway, maximum temperature to avoid an environmental impact for cultivation above the circuit, maximum temperature of air in restricted rooms or tunnels.

Most of the time, the engineer selects the closest conductor size allowing the required operating temperature, on the safe side within a wide range of standardised sizes. The fewer conducting metal, the less expensive cable.

RATIONALISATION OF CONDUCTOR RANGE

Up to now, this way of selection led to the minimal investment cost. But consequently, a high number of cable sizes with their made-to-measure accessories have been installed on the grid, with the following drawbacks:

- Heterogeneity of the grid,
- Specific or lower volumes of cables and accessories manufacturing for a given size,
- Lost launching lengths and useless handling and operations between different cables production, complexity of the planning for the manufacturers,
- Larger stocks of spare items to fulfil many different sizes, otherwise risk of stock shortage and power link unavailability,
- Multiplicity of engineering studies,
- Duplication of assembly instructions, multiplicity of tools, specific skills, etc.

RTE made a study in order to harmonise an optimised range of components. Moreover, the qualification of transition joints made it possible to connect new cables to existing systems, and cables of different sizes in order to match local requirements along the cable route.

It was possible to rationalize larger volumes of purchasing, leading at the same time to an easier stock control: seven conductor sizes were confirmed from an initial range of fourteen.

TAKING INTO ACCOUNT DISCOUNTING COST OF LOSSES

The global cost of a power link depends not only on the investment cost (cost of the installed length of cable) but also on the discounting cost of losses (present value, or equivalent cost at the date the installed system was purchased, of the losses during an economic life of *N* years). This calculation is described in the IEC 60287-3-2 standard [2], leading to the proposal of the most cost-effective conductor size.