Review of HVDC insulated transmission cables technologies

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ABSTRACT

The HVDC technology has an extensive application range in the today and the future network. Insulated cables are the necessary component of its deployment in many occasions. When considering all the network and converter station parameters, it is clearly concluded that a single cable system technology cannot be optimum in all cases. This paper updates the C6.4 paper of JICABLE 2011, by taking into account the new developments and the fast technical evolution of the considered technologies, and the new application fields.

KEYWORDS

HVDC, Mass Impregnated, DC XLPE, Underground, Submarine.

IDENTIFICATION OF THE NEED

During the closing session of JICABLE HVDC 2013 [1], a number of European utilities, i.e. National Grid, Amprion, Svenskä Kraftnät, Stanett, Energinet, Terna, RTE, gave their view about the future use of HVDC transmission technologies. This can be summarized in the Figure 1, where the planned HVDC links are shown.

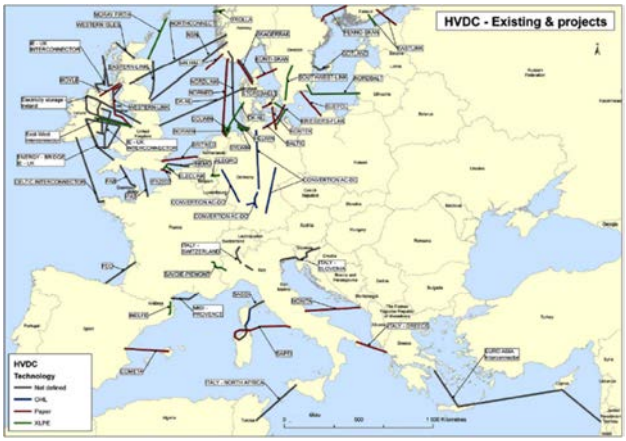

Figure 1: HVDC transmission links, existing and projects

When looking to this map we can see transmission links that connect:

- Different networks that are independent from each other.
  - In land
  - Across the sea (shallow or deep waters)
- Two remote portion of the same network (electrical highway)
- An offshore station to the mainland
- Two back to back converter stations

This points out the large diversity of the installation constraints that logically results in a different cable design.

In addition a considerable work has been performed regarding the HVDC – HVAC converters principles, technology and topology. Basically converters are classified as VSC (Voltage source converter) or LCC (Line commutated Converters).

This further enlarges the variety of the needs.

Finally, when considering the influence of the length, voltage, current and testing capability, we have a complex set of needs that the authors will try to pair with a HVDC transmission cable system technology.

HVDC TRANSMISSION CABLE SYSTEM TECHNOLOGIES.

HVDC cable systems have a long history. The first HVDC transmission cable (+/-2kV) was installed in 1882 over 57km between Miesbach and Munich. We will detail the different technologies by order of appearance.

Lapped oil filled systems:

The dielectric system of cable and accessories consist in a lapped insulation which is immersed in oil. Joints and terminations are made with the same materials as the cable. This void free insulation presents very good ageing properties (some cables are more than 60 years old). The dielectric system can work in AC and in DC.Pumping station(s) at one or two ends ensure the working pressure of the oil whatever the load of the link.

In practice, the length is limited to 80km.

From a dielectric standpoint, the impulse stress is the dimensioning parameter of the insulation thickness. Practically the mean permanent DC field in operation is up to 30kV/mm.

Maximum conductor temperature is 80°C

Cross section can be up to 3000mm² [2], and voltage up to 800kV [3].

These cables usually have a lead sheath

The thermal resistivity of the insulation is about 5 K.m/W

They can work in VSC and LCC condition, and in HVAC condition.

Maximum operating temperature is 85C, Temperature drop across the insulation has to be considered.