# Opportunity of DC technology for powering pipe-in-pipe heating system

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## ABSTRACT

*The risks associated to a change in technology for heating system in pipe-in-pipe flowline technologies is evaluated. We show that the field distribution under DC stress is markedly different from that in case of AC stress owing to the high electrical conductivity of the splice joint insulation relatively to cable insulation. Model structures were used to investigate multilayer samples. Safe conditions regarding space charge accumulation were addressed. Finally, the field distribution in real joints was estimated considering the actual geometry. All in all, the results show that the cables can safely be operated under DC with at least same voltage as under AC stress.*

## KEYWORDS

Special cables, insulating polymers, DC stress, offshore environment

## INTRODUCTION

In some applications like offshore oil and gas transportation for example, fluids need to be transported over very long distances and may require electrically heated flow lines to facilitate the transfer. Pipe-in-pipe flowline technologies have been developed for this purpose, consisting in an inner pipe enclosed with a cable heating system and a very good thermal insulation inside a second outer pipe [1]. This technology is known as Electrical Heat Traced Flowlines (EHTF) and is shown in Figure 1 [2]. The heating system is provided by cables strung out along the pipe with joints to be formed between pipelines sections of typically 1.5 km long. The thermal insulation is ensured by combining a physical aerogel with de-pressurized environment in the inter-pipe spaces.

Historically, the cables are supplied with AC voltage for simplicity of supply, but a novel approach using DC voltage is under consideration as it would reduce or even eliminate some of the failure modes related to AC, notably partial discharges (PD)-driven degradation processes. PD harmfulness is enhanced by the low-pressure environment, due both to the decrease of the inception voltage when decreasing the pressure and to the increase in the energy of the discharge [3]. Additionally, moving to DC powering would also eliminate the capacitive losses over long distances, thus improving reach from a single point of supply.

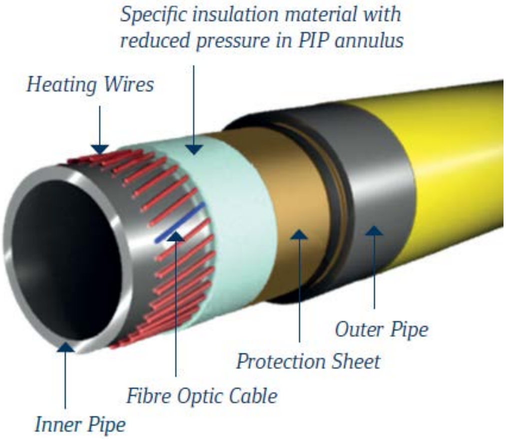

**Fig. 1: Typical cross section of an EHTF system [2]**

For the present application, the system is normally not operated at temperatures higher than 50°C. However, it can be exposed to higher temperatures (130°C) under flowing conditions. Therefore, materials must support such stresses.

With moving to DC, it is expected that the performances and reliability of the heating system could be improved. It is however important to study whether other degradation of failure scenarios occur due to the DC stress. Notably, the electric field distribution under DC stress is usually markedly different from that in case of AC stress owing to the resistive field grading within the insulations. Ensuring high reliability is all the more important as in the specific case of offshore pipe-in-pipes, the heating system has to function for decades with no possibility for repair. The design for the lifetime of such a heating system taking into account probability of failure of each splice is treated in another paper in this conference [4].

The objective of the research reported in this work is to estimate the potential new risks in powering existing cable technologies in DC, and to explore limit conditions. The cables used in the system are insulated with a thermostable polymer. Joints are manufactured by heat-shrinking tubes of semiconductor and insulations on splices. As in power cables, the joints a priori constitute weak points to the cable heating system. Therefore, focus is put on the behavior of the joints under DC stress and on possible failure due to the assembly.

## HEATING CABLE STRUCTURE

### Lay-out

Figure 2 shows a drawing of the cable structure and of a joint also called *splice*. The cable itself is made of copper conductor and Fluorinated Ethylene-Propylene copolymer (FEP) of 0.65mm thickness as bulk insulation. Semiconducting layers (semicon) are present on the conductor and on the outer part of the cable. In this way, the potential difference between the outer part of the cable and the inner pipe on which it is wound is low and the PD occurrence is minimized.