Study Committee B1

INSULATED CABLES

10714_2022

Belgian experience with horizontal directional drilling (HDD) filling materials and thermal modelling of HDD

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Motivation

- A DTS/RTTR system revealed a hotspot on a link at the location of a HDD. After investigation, it was found that the HDPE tube was not properly sealed
- This led to questions on the behaviour of the filling material and its stability over time.

Method/Approach

Two studies were started to improve the thermal behaviour of the filling materials or improve the thermal modelling

- A first study was conducted to investigate the behaviour of different thermal filling materials.
- A second study consisted in the investigation of the difference between theoretical thermal models and the as-built transport capacity (using DTS-measurements).

Objects of investigation - 1st study

- The first study compares a solidifying product, a solid product and the product commonly used in Belgium
- The study consisted in a technical set-up representing a directional drilling situation comparing the different materials.
- Afterwards it the interesting product was test on site to compare the practical and thermal aspects with the standard filling material.

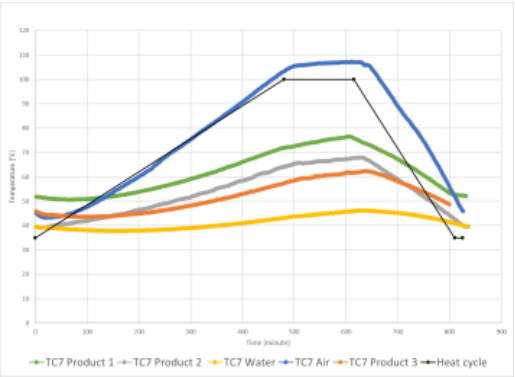
Experimental setup test results

- The test consists in putting three different filler in a HDD simulator and comparing the results obtained
  - Product 1 – standard mixture
  - Product 2 – solidifying product
  - Product 3 – solid product
- Each product undergoes the same heating cycle and thermocouples measure the temperatures on the cable and on the pipe

Test results & Discussion

The results show:

- Air acts as a thermal insulator.
- Water is the best to dissipate the heat.
- All three products tested obtained good results with temperatures below 80°C depending on the thermal resistivity of the filling materials used.



Conclusion - Observation

The following observations were made during the laboratory tests:

- The mixture water-sand-bentonite is difficult to inject because it is very viscous
- An important sedimentation was observed on the product mixture water-sand-bentonite. The two other products did not sediment
- The advantage of the new tested products (2 and 3) is that only water has to be added in the right quantity, unlike the product 1 (water-sand-bentonite mixture), which requires more attention.
- The use of solidifying products makes it possible to re-use pipes and cables easily (using a high-pressure cleaner) as opposed to the solid product which requires special equipment.

The result of the on-site testing shows that after 6 months the product is always stable in thermal conductivity and homogenous.

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Motivation

- ***Background of study***
  - Currently follow-up of HV cable trajectories by DTS and RTTR monitoring systems.
  - Track longitudinal temperature profile and hotspots along the cable links.
- ***Aim of study***
  - Compare obtained results of DTS/RTTR systems to challenge current theoretical thermal modelling of HDDs with the measured as-built transport capacity.

Method/Approach

- Compare the theoretical modelling of 3 different projects with HDD's with the as built thermal behaviour using the measurements of a DTS-system.

Objects of investigation - 2nd study

- Improve thermal modelling of HDDs by identifying and quantifying the parameters resulting in the difference between the as-built transport capacity and the result derived of the thermal models.

Experimental setup & test results

- Selected cable systems for the study with a summary of the characteristics of the investigated HDDs:

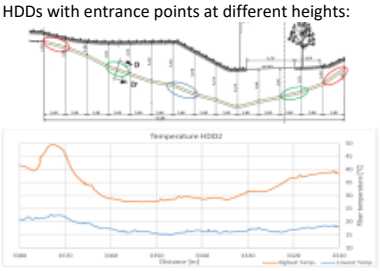
Cable connection	Type monitoring	Max. depth HDD (m)	Length HDD (m)	Thermal filler
150 kV - system 1	DTS/RTTR (perm. 2015)	5,35 - 10,3	42 - 281	Bentonite
380 kV - system	DTS/RTTR (perm. 2013)	8,4 - 21,5	513 - 686	Water
150 kV - system 2	Temporary DTS	25,6 - 42	338 - 1105	Partially water

- The comparison of the theoretical ampacity and the measured ampacity can be found below:

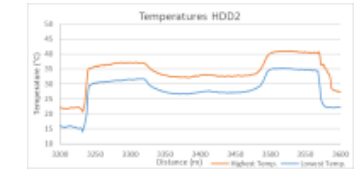
Cable connection	**150 kV cable system**			**150 kV cable system 2**		
# HDD	HDD1	HDD2	HDD3	HDD1	HDD2	HDD3
Location theo. hotspot	Deepest location	Deepest location	Deepest location	Not available	Not available	Not available
Theo. ampacity (A)	1549	1330	1449	1155	1155	1155
Location meas. hotspot	Entrance	Entrance	Entrance	Entrance	Entrance	Slope
Meas. ampacity (A)	1349	1435	1363	1355	1378	1401
Difference (%)	- 13	7	- 6	17	19	21

Discussion

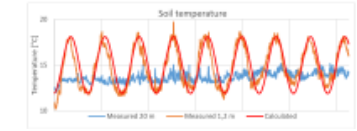
- HDDs with entrance points at different heights:



- Partially filling of HDDs:



- Impact soil temperature:



Recommendations simulations:

Shape HDD profile:

- Take into account potential **air pockets** for HDDs with different entrance heights.

Simulation thermal filler:

- In case of **partial filling** simulate the ampacity at the unfilled locations taking into account the presence of air.

Seasonal impact soil temperature:

- Considerable depth: soil temperature can be considered as a stable parameter
- Limited depth: a **seasonal impact** (potentially seasonal operational ampacities).

Recommendations installations:

The shape of the HDD profile:

- Preferably HDDs with entrance points at the same heights
- If it is not practically avoidable, extra care and verification during the filling of HDDs to assure a complete filling of the HDD.