CHALLENGES TO DEVELOP A HEAT MITIGATION SOLUTION FOR A COMPLEX INTERSECTION AT A 230KV CABLE CROSSING

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ABSTRACT

This study was undertaken to confirm the steady-state and transient thermal rating of a 230kV Self-Contained Fluid-Filled cable systems crossing three (3) distribution duct banks (DDBs) in Vancouver downtown at a very busy intersection. The three DDB contain total of 23 circuits that comprise 8 different medium voltage (MV) cables while there is only one circuit of 230 kV transmission cables installed in a duct bank below and perpendicular to these three DDBs. The study explored the use of different heat mitigation techniques such as a) alternate backfill (Powercrete), b) embedded heat pipes and c) a design of an underground ventilation vault with normal and forced convection system.

KEYWORDS

Cable ampacity, cable crossings, heat mitigation measures

INTRODUCTION

A busy intersection in downtown Vancouver contains a crossing of three (3) duct banks with distribution cables and one (1) duct bank with transmission cables. The duct banks with distribution cables (distribution duct banks or DDB) are under Main St (North-South). The DDB contain a total of 23 circuits that comprise 8 different medium voltage (MV) cable types and two different voltage classes, namely 12.5 kV and 25 kV. The MV cables are either PILC three-core [400kcmil (202 mm^2) or 600kcmil (304 mm^2)] or XLPE single-core constructions (6 different types and sizes). There is only 1 circuit per conduit (many conduits are empty) and each circuit consists of either a single PILC cable or three XLPE cables in trefoil configuration. The distribution cables are two-point bonded.

The 230 kV transmission cables are installed in a duct bank below and perpendicular to the DDB, i.e. under East Georgia St (East-West). There is only one circuit of low-pressure oil-filled (LPOF, or SCFF – self-contained fluid-filled) cables with paper-oil insulation, 2150kcmil (1090 mm^2) copper conductor and smooth aluminum sheath.

The goal of this project was to determine continuous (steady-state) thermal rating in various conditions as well as presentation of mitigation measures if the 2L032 LPOF cable temperature limit of 85°C is exceeded. This paper describe the problem, the solution approach and presents the results.

SCOPE OF THE STUDIES

The studies have the following goals

- Calculate summer and winter steady state ratings of the T-circuit at E Georgia St and Main St using measured thermal backfill and also considering the future maximum distribution feeder cable maximum concurrent loads as per Table 1. A steady state rating of 970A and 1000 A (winter) for the 230kV Cable is required under these D-cable loading conditions which may require remedial measures.
- Determine suitable remediation options to achieve existing ratings that are practical and will restore (or get as close as reasonably practical to the original steady-state summer and winter ratings.

INPUT DATA

This section presents information provided.

Environmental data

- Native soil thermal resistivity 1.2 K·m/W in summer and 1.0 K·m/W in winter.
- Backfill thermal resistivity 0.767 K·m/W (conductivity of 1.3 W/(m*K)) in summer and 0.55 K·m/W (conductivity of 1.82 W/(m*K)) in winter.
- Transmission duct bank (TDB) concrete thermal resistivity 0.75 K·m/W.
- Distribution duct bank (DDB) concrete thermal resistivity 0.77 K·m/W.
- Soil temperature 20°C in summer and 15°C in winter
- Outdoor air temperature 30°C in summer and 0°C in winter.

Table 1: Thermal resistivity of thermal backfill

Percent Standard Proctor Compaction	Percent Dry Density (kg/m^3)	Thermal Resistivity (K.m/W)		
		2% Moisture Content	2% Moisture Content	2% Moisture Content
100	1932	76.7	69.2	54.9

In addition to the environmental data presented above, three different installations are considered. These installations include Powercrete instead of the thermal backfill, heat pipes in addition to the current thermal backfill and underground vent vaults (manholes). These installations require additional information that is summarized below:

a) Thermal conductivity of Powercrete: between 3 W/(K·m) and 6 W/(K·m) [1],
b) Thermal conductivity of heat pipes between 400 W/(K·m) and 400000 W/(K·m)

Geometry

The cross section of the geometry of the DDB is shown in Figure 1.