Leaks Location of Micro leaks in FFLP by Hydraulic Model

PART 2 “Devices and Experimentation”

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ABSTRACT

Building the device to measure and calculate with the measurements the probable location of a hydraulic fault in an FFLP cable is a technological activity. The device is a thermodynamic platform capable of measuring: pressure, temperature and leaked volume at time intervals during a very long sampling period. The treated cases allowed the development of an experiment capable of locating micro leaks in FFLP cables installed directly underground. The determination of the probable leak site has a probabilistic attribute, calculated with the ergodic theory.

KEYWORDS

FFLP, Underground Cables, Leaks Location, SCOF Cables, Ergodic Approach, Assets Management.

INTRODUCTION

The developed ergodic approach [1] was conjectured from the inventive conception of the FFLP cables [2] where the concept of self-contained oil pressure in the cable immediately invoked the first law of thermodynamics, between two states.

$$PV = [N - n]RT \qquad (1)$$

P Pressure inside oil feed tanks

V Volume of oil available in the tanks

T Oil temperature inside the tanks

R Perfect gas constants $8.31\ J/(Mol\ K)$

N **SUPREMA STATE** Maximum number of partitions in equilibrium

n **INFIMA STATE** Minimum number of partitions in equilibrium

The suprema state corresponds to the maximum operating pressure of the tanks and the FFLP cable line in their corresponding construction. The infima state corresponds to the minimum pressure for previous circumstances [1].

Figure 1 is an illustration of a line feed tank with FFLP cables. The tank is a thermodynamic device open for the insulating oil and closed for the gas inside the cells. The pressurized gas in the cells regulates the volume of insulating oil that feeds the cable insulated in impregnated paper of the FFLP type. The equation that informs the volumes exchanged by the tank is equation (2).

$$\Delta V = \frac{P_0 V_0}{T_0}\left(\frac{T_1}{P_1} - \frac{T_2}{P_2}\right) \qquad (2)$$

ΔV ***Variation of oil volume in the tank***

P_0 ***Reference pressure of the gas inside the cells***

T_0 ***Reference temperature of the gas inside the cells***

T_0 ***Reference volume of the gas inside the cells***

T_1 ***State temperature (1) of the oil in the tank***

P_1 ***State pressure (1) of the oil in the tank***

T_2 ***State (2) temperature of the oil in the tank***

P_2 ***State pressure (2) of the oil in the tank***

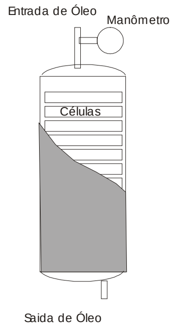

Figure 1 – Feeding tank

Equation 2 is a combination of the Boyle-Mariote and Charles-Gay Lussac laws containing an approximate error of 5% for values close to the minimum pressure of the tanks, but it operates well for values around the mean.

The same equation 2 can also be applied in real time. This is a natural requirement for the characterization of the ergodic process.

The variation in the volume available as a function of the absolute temperature can be neglected in ergodics, as this would appear in the measurement error, carried out in large quantities throughout the entire process.

Thus, with suitable modifications to the notation, the change in oil volume inside the tanks would be;

$$\Delta V_h = \frac{P_0^h V_0^h}{T_0^h}\left[\left(\frac{T_{t=0}^h}{P_{t=0}^h}\right) - \left(\frac{T_t^h}{P_t^h}\right)\right] \qquad (3)$$

$$\Delta V_l = \frac{P_0^l V_0^l}{T_0^l}\left[\left(\frac{T_{t=0}^l}{P_{t=0}^l}\right) - \left(\frac{T_t^l}{P_t^l}\right)\right] \qquad (4)$$

$$\Delta V_{total} = \Delta V_h + \Delta V_l \qquad (5)$$

Y_0^h ***Index {"o" initial) Index {"h" higher} Index {"l" lower};***

ΔV_h ***Variation of oil volume in the tank***

P_0^h ***Absolute pressure inside the air cells***

V_0^h ***Air volume inside the cells***

T_0^h ***Absolute temperature inside the air cells***

$T_{t=0}^h$ ***Absolute temperature of the oil in the tank at time $t = 0$***

T_2^h ***Absolute temperature of the oil in the tank at any time $t > 0$***

$P_{t=0}^h$ ***Absolute oil pressure in the tank at time $t = 0$***

P_t^h ***Absolute oil pressure in the tank at any time $t > 0$***

Considering $T_0^h \sim T_0^l \sim T_{t=0}^h \sim T_{t=0}^l \sim T_t^l \sim T_t^h \sim T_0^h \sim T_0^l$ with its variations appearing in the measurement error;