Hands on session N^o 1: 1.2 evaluation of time to empty tank (incompressible fluid)

a.

Objectives:
- study the dynamics of an emptying tank;
- evaluate the effect of geometrical characteristics of the pipeline downstream the tank on the emptying time;
- compare experimental data with theoretical values.

Emptying tank

The part of the flow loop used for the experiment is sketched in Figure 1. The emptying tank is a cylindrical vessel with rounded bottom ($D = 0.80\ m$, $H_{max} = 5\ m$ from reference horizontal plane at ground level) connected with a pipe (overall length $L = 3.8 + 0.3 + 1.1\ m$) to the receiving tank ($3.0\ m^3$ capacity).

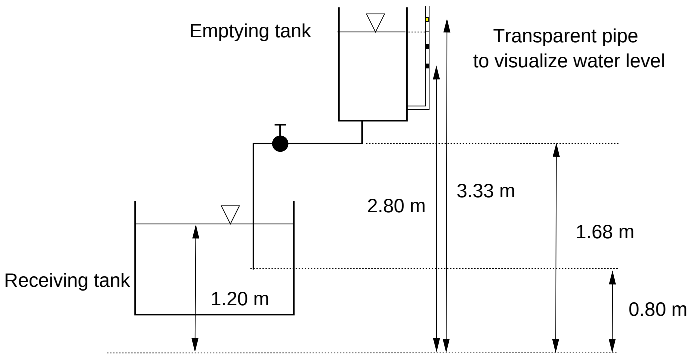

Figura 1. Portion of the flow loop used for the emptying tank experiment: pipe diameter is $D = 100\ mm$, line length is 52 D overall.

The pipe connecting the emptying tank to the receiving tank is made of three horizontal segments connected by bends (3×135^o bends and 3×90^0 bends). A butterfly valve is installed to regulate the outgoing flow. The height of reference points along the hydraulic line are indicated in Figure 1.
A transparent pipe is connected to the tank to visualize the water level. A yellow mark and two black marks on the transparent pipe are used to identify the initial level inside the tank (yellow) and the final level (lower black mark). A stopwatch is used to measure the time necessary to empty the tank (from yellow mark to lower black mark).

Test execution

The tank is filled by the pump up to the yellow mark keeping the butterfly valve closed. The stopwatch is used to measure the time necessary to reduce the liquid level in the tank from the yellow mark to the lower black mark. Two different conditions are considered:
- butterfly valve fully open;
- butterfly valve partially open;

1. Write the mass balance equation on the control volume corresponding to the fluid inside the tank; write Bernoulli equation to find the velocity inside the pipe when the valve is fully/partially open.
2. Estimate a value for the friction factor, f. Integrate the mass conservation equation to derive a measure of the time necessary to empty the tank (from yellow mark to lower black mark).
3. Compare the value of time with experimental data in the case of valve fully open. Evaluate the equivalent length of the pipe corresponding to the pressure loss due to the partially open valve.

Experimental data

Experimental data are the following:
Valve fully open → time to empty: 11.8 s
Valve partially open → time to empty: 31.5 s