# Experimental Graduation Project
## Visualization of cavitating flow through a ribbed pipe

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# I Background

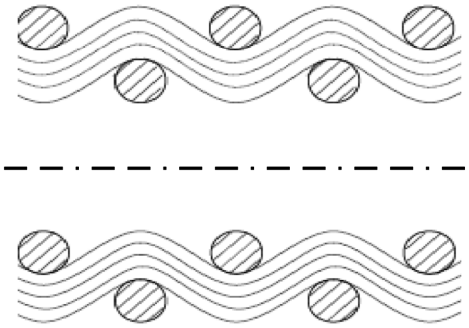
The project originates from the offshore-industries. To be specific: The transport of Liquefied Natural Gas (LNG) over short distances (e.g: from the platform to a ship, or from one ship to another). The natural gas is liquefied by cooling it just below its boiling temperature (-163 °C).

For this type of transport specific hoses are required. They must be:

- flexible (motion of the ocean)
- mechanically strong
- non-porous for a components of natural gas
- resistant to very low temperatures
- thermally insulating to prevent the LNG to heat up

All these requirements leave little options for hose design. An often applied type of hose consists of many fabric layers wrapped in between a double spiraled steel wire. The hose in application can be seen in figure 1a, a schematic cut-through of the hose in figure 1b.

(a)



(b)

Figure 1

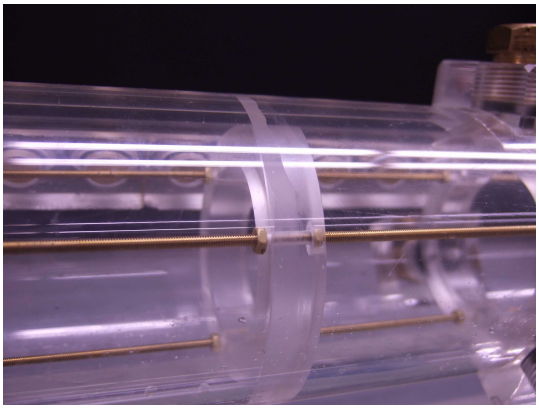
For optimal process-operation it is crucial to be able to model every component of the system. This results in better component design. However, because of the many scales involved (fabric roughness, spiral roughness, hose-diameter) and the local occurrence of two-phase-flow (the local pressure drops below the cavitating pressure, thus gas-bubbles appear), the flow is very difficult to understand as a whole. Without this understanding the important flow-characteristics, (e.g. flow-resistance and pressure-fluctuations) for the component design are difficult to predict and model.

# II The MSc Project

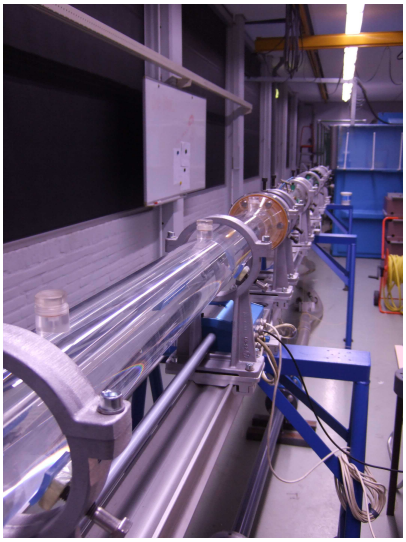
## II.1 The whole project

Your Master-project will be part of a PhD-project. This project, which started in 2011, aims at understanding the flow in the hose and focusses at the scaling behavior. The complicated hose-geometry is simplified and constructed of transparent materials. As a working fluid water will be used, at ambient pressure and at low pressure to mimic the boiling/cavitating behavior of the LNG-flow. Different flow regimes as a function of cavitation-intensity and geometry will be investigated by doing for instance pressure measurements.

The photos below show the current status of the experimental setup (figure 2).



(a) Part of the test-section



(b) The set-up

Figure 2

## II.2 Your part

The MSc-project is not a strict part of this project that has to be fulfilled. The general idea is to perform visualization-experiments of the boiling/cavitation in the flow. This will involve preparing experiments, including a literature-search, building up the visualization-system (the flow itself is already present) and post-processing and interpreting obtained data.

The two-phase flow is a result of both the near-boiling condition of the liquid and the flow patterns induced by the geometry. The flow itself is again influenced by the presence of vapor-bubbles. Your project will mainly aim at this interaction, by investigating the "bubbly zones" in combination with other flow-measurements. The exact content of the project will depend on the starting moment and also personal preferences do play a role.

## II.3 More Information

For more information about the content of the project, or about prerequisites, please contact me:

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