

### 3. Pipe Clearing Fluid Transients

Introduction: When high pressure gas is suddenly admitted into a pipe containing liquid, such as a drain line in a power plant or chemical plant, the liquid is forced out by the gas at high velocity and hits the pipe bends. This clearing of the liquid from the pipe can give rise to impact forces for which the piping was not designed for. In this experiment we would like to see how large these forces are.

Experiment : A section of plastic pipe in which a measurable amount of water can be trapped has been set up in the laboratory. This water is driven out of the pipe by an air flow which is metered by a choked flow orifice of known diameter, which is the throat area of the solenoid valve used to switch on the flow. The nominal orifice size is stated on the valve body. Due to the compact valve design, the discharge coefficient is significantly lower than 1. (If you have time, you can calibrate the discharge coefficient by discharging the tank; if you do not, you can assume a discharge coefficient of 0.6.) The mass flow rate through this orifice can then be calculated using formulas that are in your fluid mechanics text books under the section of compressible flow.

The force exerted on a pipe as this flow passes through a bend is detected by an LVDT installed on a pipe section which is supported as a cantilever. Its deflection, when it experiences the force transient due to the passage of the water around a pipe bend, is measured and is used to estimate the force.

Report: Condensate is often trapped in low sections of pipe where drainage is imperfect. The transient that results when the liquid is forced out in these pipes can damage piping supports. We would like you to explain the mechanism of the phenomenon and come up with an estimate of the impact force due to such a transient. The methodology then can be used to conservatively size the piping supports for drain lines. We should be able to use this methodology to set a tolerable gas flow rate so that excessive forces on the pipes will be avoided. The amount of water trapped, the pipe size, and the gas flow rate, among other variables, must enter into this model.

Note that the *impact force depends on the stiffness of the pipe support*. In the laboratory set up, the cantilevered pipe section is substantially less stiff than the configuration in a typical system. Explain how you could apply your results to a real pipe system.

