# HYDRAULIC MODELLING OF WATER TRANSMISSION AND DISTRIBUTION SYSTEMS

## Goals of Hydraulic Modelling

The design of a pipeline system (for transport and transmission) is developed in several steps with the aim of obtaining the planned flow condition at the least possible cost. At the same time, a safe operation must be guaranteed under all possible load conditions.

A steady-state simulation of the system enables the engineer to dimension (based on the planned max. flow rate) all the hydraulic equipment such as pumps, valves, etc. Since a steady-state simulation cannot ensure a safe operation, a transient simulation is carried out in a next step.

In the operation of a pipeline system transient flow processes occur whenever the flow rate is modified. In the case of a (abrupt) pump trip or during the opening or closing of valves, so called surge pressures may occur in the system. The pipeline system may not be able to withstand the resulting excessive under- or overpressure of a surge pressure if designed insufficiently.

The transient simulation considers all the worst case load conditions which have to be studied carefully and eventually serve as proof for a safe operation of the pipeline system.

## What are the important aspects to be considered in the hydraulic design?

In a steady-state flow process the flow rate, the flow velocity and the pressure at a cross section remain constant (in a period of time considered). The main results of a steady-state simulation are listed below and enable the engineer to design (based upon the planned max. flow rate) i.e. the pipe diameter, the pumps and the valves.

- Hydraulic Grade Line (HGL)
- Continuous Pressure Loss (through wall friction) and Local Pressure Losses at hydraulic equipment
- Maximum Pressure in the pipeline system in the context of its profile

In a transient flow process the flow rate, the flow velocity and the pressure (at an arbitrary cross section) vary over time.

These flow changes may occur very rapidly. The main focus is on the pressure which (in the case of a surge pressure) may exceed or go below the pressure in the steady-state condition or even fall below the vapor pressure (risk of cavitation) or get negative (risk of pipe implosion). On this basis, the engineer can define the pipe's wall thickness, the size of safety equipment required (such as surge vessels, pressure relief valves) and the tele control system.

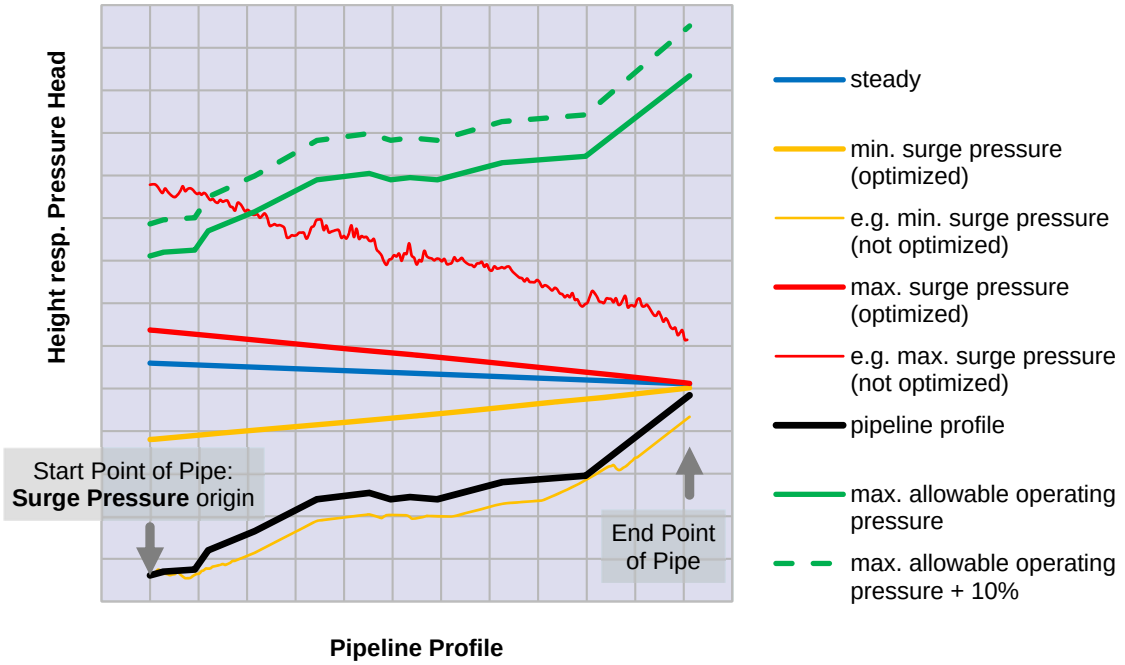
For an optimal and safe technical design of the hydraulic equipment of a pipeline system an appropriate engineering experience is important. The number of transient load conditions to be analyzed is very high for complex pipeline systems (e.g. for systems with branches or loops). The challenge is to determine the worst case load condition.

Safety hydraulic equipment such as surge vessels are in many cases the simplest solution to control / protect from a surge pressure, but often the most expensive. The engineer assumes the determining responsibility by keeping the overview of the whole system (incl. wall thickness, tele control system, surge vessels etc.) and working out the best solution with regard to construction cost and safety.

## How can IBG help?

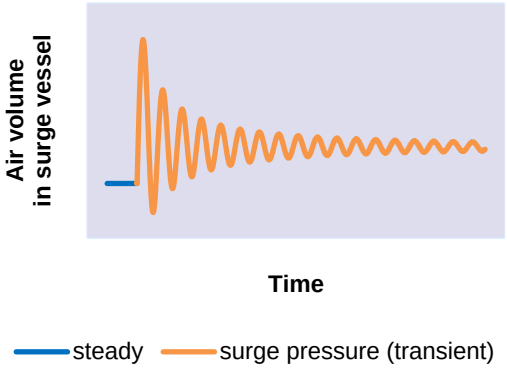
Thanks to a wealth of experience with the hydraulic design of water transportation and distribution systems and under the application of WANDA (state-of-the-art hydraulic software of Deltares) we are specialized in the design, optimization and control of simple to complex pipeline systems. In particular, we are able to implement specific combination solutions of safety equipment and tele control systems at a time. Thus, we can develop the best pipeline system solution in each case, whether it is a simple, branched or looped system.

### Surge Pressure Calculation of a Pipe:




Taking the not optimized design example, inadmissibly excessive pressures occur.

### Time Series of a Surge Vessel's Air Volume:




In the case of a surge pressure the surge vessel interacts with the pipeline system and absorbs the pressure extremes of the system. It ensures in the worst case load condition that the pressure head does not fall below the pipeline profile (negative pressure and risk of pipe implosion) and that the maximum pressure does not exceed the maximum allowable operating pressure (danger of pipe burst).