Sheet E2 · Experimental validation · CALIBRATED

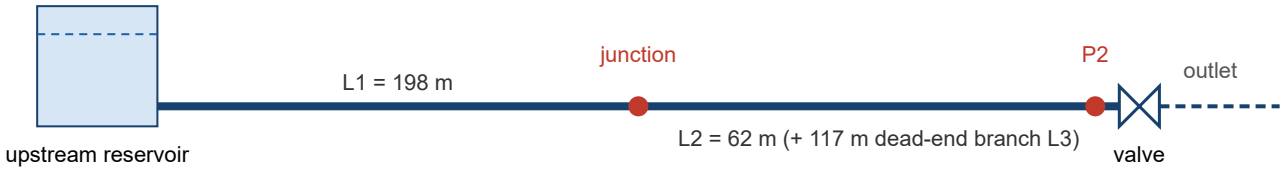
Y-shaped HDPE system, fast closure (University of Perugia)

Source : Pan et al., Water Resources Research, 2022; measurements Zenodo 10.5281/zenodo.6984669 (CC BY 4.0)

1. The question

In an HDPE network, the viscoelastic wall damps and distorts the wave. With the Kelvin-Voigt model and unsteady friction, does CBELIER reproduce the pressures measured at the valve and at the end of a dead-end branch?

2. The case

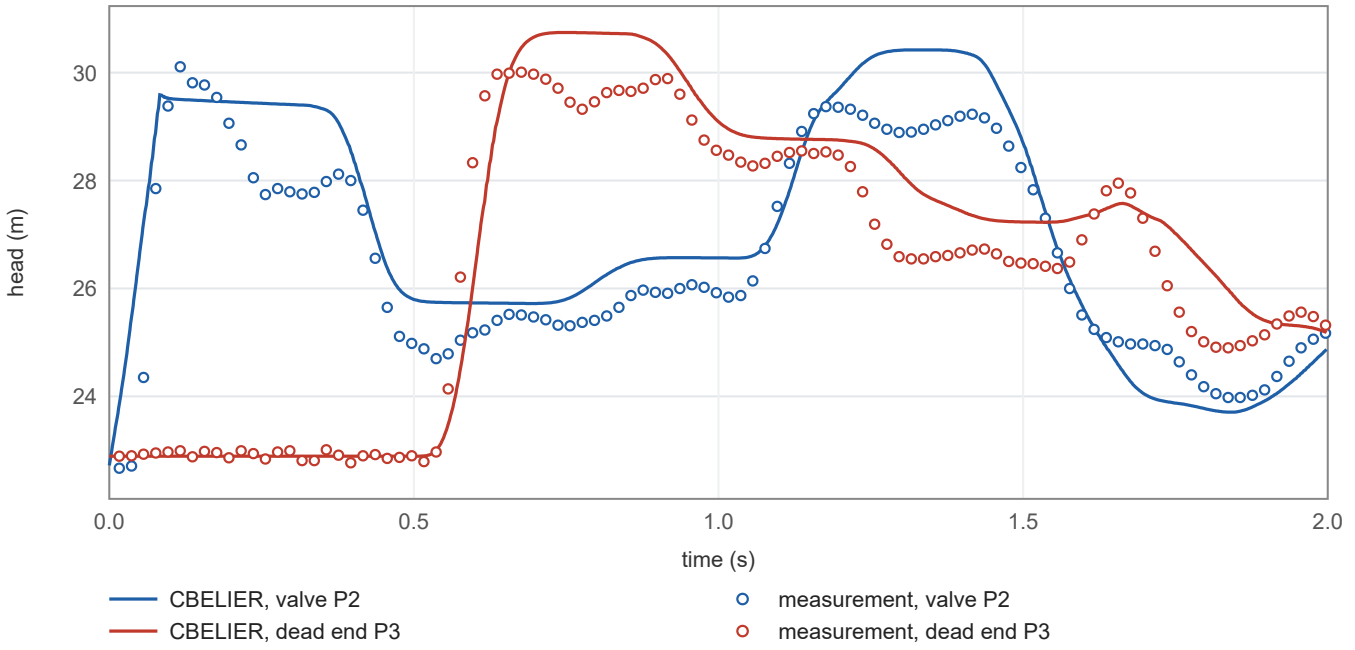


A reservoir feeds a 198 m pipe to a junction. A 62 m branch ends with a quickly closed valve; another, 117 m long, is a dead end. Head is measured at the valve (P2) and at the dead end (P3), over 4 s.

3. Data and status

Data	Value	Status
Measurements at sensors P2 and P3	200 Hz	PUBLISHED
Lengths L1, L2, L3	197.8; 61.8; 116.8 m	PUBLISHED
HDPE: D, thickness; Kelvin-Voigt (2 elements)	93.3 mm; 8.1 mm	PUBLISHED
Initial flow	1.26 L/s	PUBLISHED
Wave speed	396 m/s	CALIBRATED
Valve closure duration	83 ms	CALIBRATED
Junction-valve local loss K	82	CALIBRATED
Unsteady friction k (Vardy-Brown: 0.014)	0.2	CALIBRATED
Reservoir level	—	CALIBRATED

4. Results



Head at the valve and at the dead end over the first 2 seconds: CBELIER (lines) and measurements (circles, one in four).

5. Differences

Indicator	CBELIER	Reference	Difference
Maximum pressure rise ΔH, valve P2	7.70 m	7.43 m	3.7 %
RMS difference, valve P2	0.95 m	—	—
Maximum pressure rise ΔH, dead end P3	7.85 m	7.10 m	10.6 %
RMS difference, dead end P3	0.92 m	—	—

With its calibrated parameters, CBELIER follows both sensors within about 1 m RMS, for ± 4 m oscillations. Without unsteady friction the difference doubles: the effect is real, but the calibrated k is 14 times the theoretical value and absorbs other effects.

6. Limitations and assumptions

- CALIBRATED case: wave speed, closure, local loss, k and reservoir level are fitted to this test. It is not a prediction.
- Lengths, diameter, flow and Kelvin-Voigt parameters come from the paper, not re-read for checking; only the measurements (Zenodo) are verified.
- The maxima are overestimated; at the dead end the difference exceeds the 10 % target.
- The verification suite also re-runs a variant of this model written directly on the engine (verification/perugia): pressure rises of + 6 % and + 13 %, same conclusion.

Computation: CBELIER engine 3c.26, 2026-11-06. Re-run with every release by the verification suite (verification/qv1). Alfa Wamane engineering consultancy — cbelier.alfawamane.ma