Sheet V2 · Verification

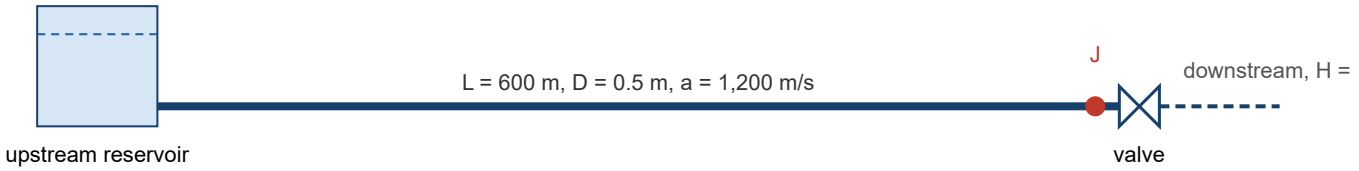
Gradual closure: three durations and the Michaud formula

Source : Independently written reference MOC (verification/cvb/run_cvb.js, cases CV-003, CV-004a, CV-004b) and the Michaud formula (verification/tests)

1. The question

When the closure lasts less than, as long as, or longer than a wave round trip, the pressure rise changes in nature. Does CBELIER follow a reference computation in all three regimes, and the Michaud formula for slow closures?

2. The case

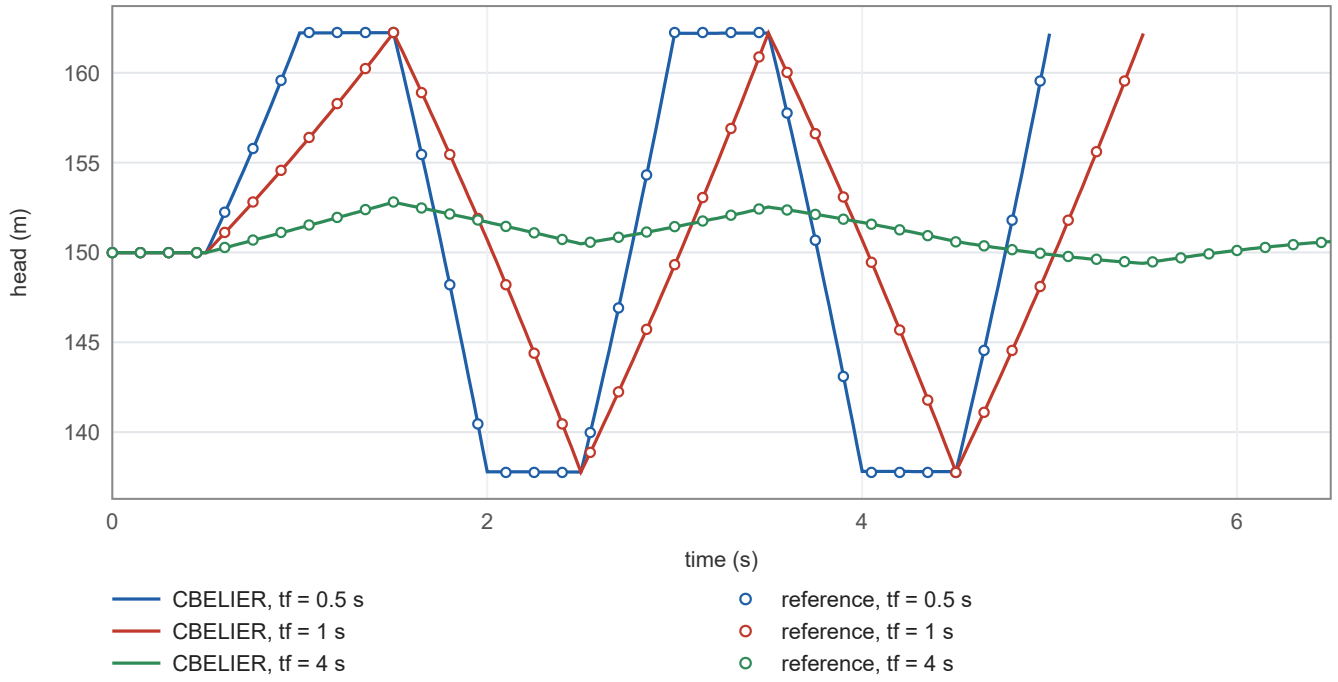


Same pipe as sheet V1. The valve closes linearly in 0.5, 1 and then 4 times 2L/a. For slow closures the verification suite also compares the pressure rise with the Michaud formula $\Delta H = 2 \cdot L \cdot V_0 / (g \cdot tf)$, on another reference pipe.

3. Data and status

Data	Value	Status
Pipe: length, diameter	600 m; 0.50 m	DEFINED
Wave speed a	1,200 m/s	DEFINED
Upstream reservoir; downstream of the valve	150 m; 100 m	DEFINED
Initial velocity V0 (small: friction negligible)	0.10 m/s	DEFINED
Mesh: 20 reaches, Courant number = 1	20	DEFINED
Reference: separately written frictionless MOC (same scheme)	—	DEFINED
Linear closure durations (2L/a = 1 s)	0.5; 1; 4 s	DEFINED

4. Results



Head at the valve for three closure durations: CBELIER (lines) and reference MOC (circles).

5. Differences

Indicator	CBELIER	Reference	Difference
Maximum pressure rise, tf = 0.5 s	12.24 m	12.26 m	−0.13 %
Maximum pressure rise, tf = 1 s	12.24 m	12.26 m	−0.15 %
Maximum pressure rise, tf = 4 s	2.81 m	2.83 m	−0.76 %
Michaud, slow closure tf = 4 s	—	—	1.6 %
Michaud, slow closure tf = 6 s	—	—	2.3 %
Michaud, slow closure tf = 10 s	—	—	3.0 %

All three regimes follow the reference computation within 1 % on the maximum. Against Michaud the difference stays below 3 %: the formula assumes a linearly decreasing flow, which is only approximate.

6. Limitations and assumptions

- Textbook case, as V1.
- The Michaud formula is itself approximate: a difference of a few per cent is expected.

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