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ECWS-4

Laboratory analysis of a piston-actuated pressure reducing valve under low flow conditions

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- Introduction
- The piston-actuated PRV and the test bed
- Laboratory tests
- Results
- Conclusions

Introduction

Pressure management in water distribution networks

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Pressure Reducing Valve (PRV)

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Set a pressure value downstream of the device

- diaphragm
- piston-actuated

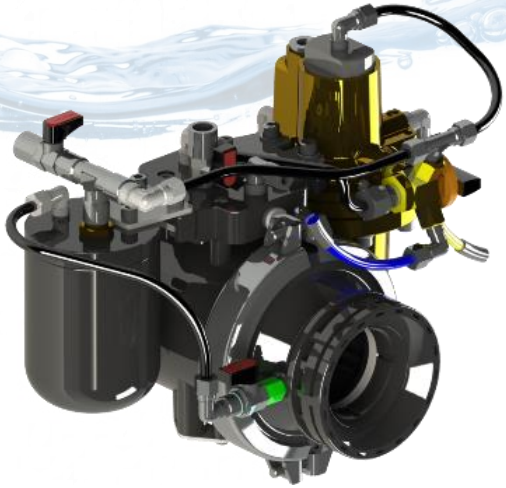
- [x] Effective in reducing bursts and water losses
- [ ] Physical behaviour of PRV investigated by a limited number of studies

<u>Purpose of this study:</u>

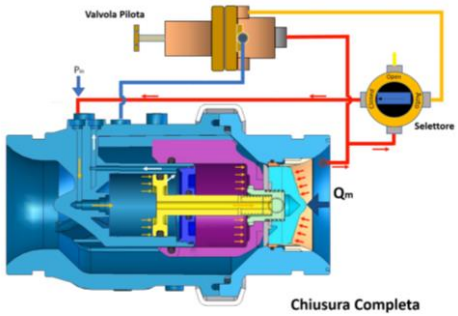
Characterisation of the behaviour of a piston-actuated PRV

The piston-actuated PRV (PA-PRV)

Characteristics of the **PA-PRV** (DN 50 mm) - Version “Normally open”:

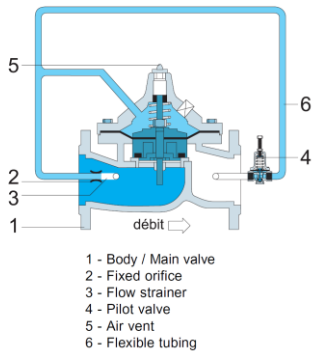


- Plastic material valve and independent control group consisting of pilot and three-position selector (*Open, Close, Auto*).
- Device functioning principle based on a balance of forces that is generated between the head of the piston and the pressure in the control chamber behind the piston itself.



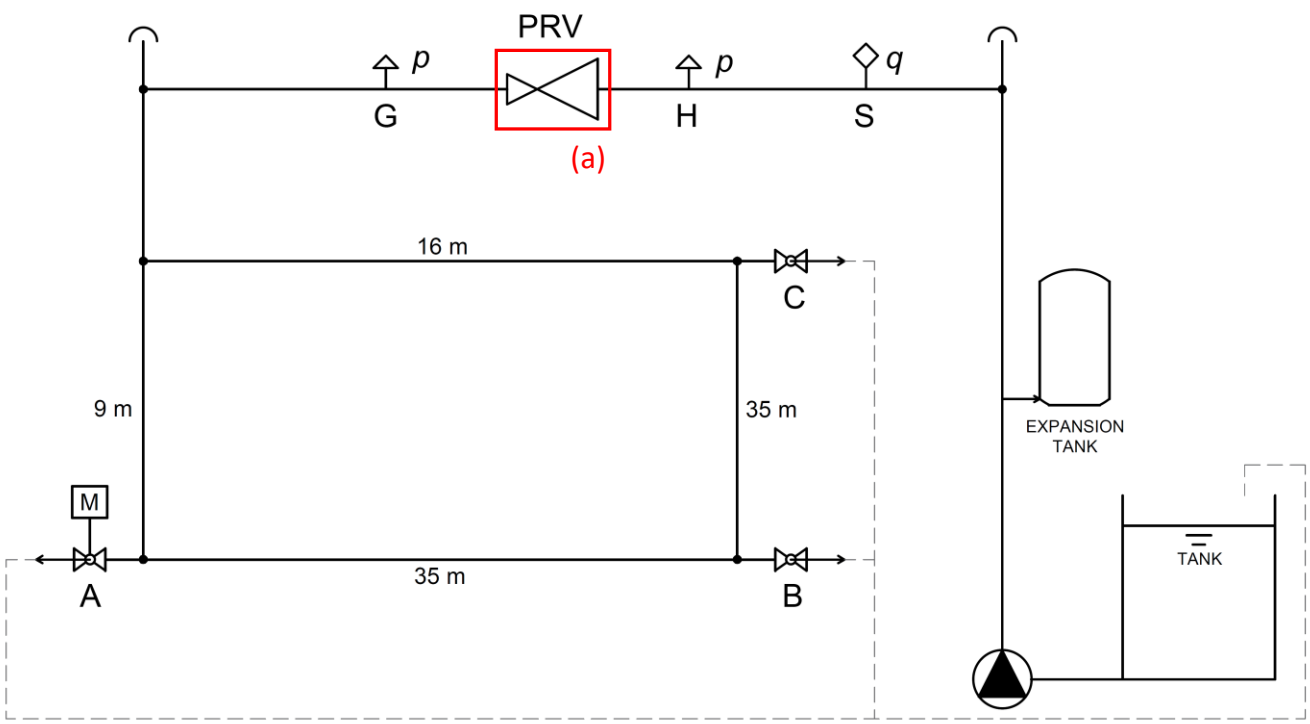
- Closure in 2-5 seconds with the technology “*Linear Flow Linear Control* (LFLC)” theoretically capable of avoiding the establishment of potentially dangerous pressure transients for the system: it does not have a manual control system for the speed of adjustment of the piston.
- Functioning field: 0 - 25 bar e 0 - 80 m³/h.

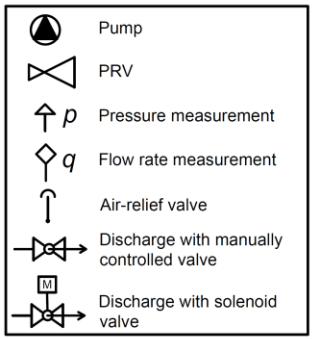
Piston actuated PRV

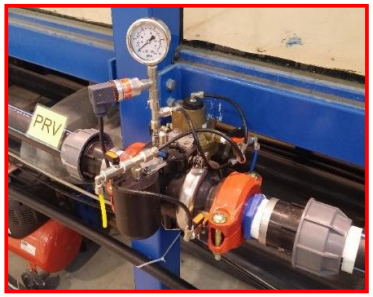


Diaphragm PRV

The test bed







(a)

Layout of the testbed developed in the Hydraulic Laboratory of the University of Ferrara.

Laboratory tests

Characterisation of the PA-PRV by means of laboratory tests divided in two phases:

- **I phase**
  The system is subjected to a rapid flow rate variation ΔQ starting from a pre-established initial flow rate value ***Qin*** (tests are carried out imposing the same flow rate variations ΔQ and considering different initial flow rate values ***Qin***);

- **II phase**
  The behaviour of the PA-PRV is analysed subjecting the system to an historical series of flow rates observed at the inlet section of a real hydraulic district.

Verify the ability of the PA-PRV to maintain the imposed set-point value in the face of different flow rate values.

Laboratory tests: I phase

- Set-point PA-PRV: **2.4 bar**

Initial flow rate ***Qin***: 9 values

Constant variation of flow rate ΔQ: **0.5 L/s**

Final flow rate ***Qfin***: 9 values

Test	a	b	c	d	e	f	g	h	i	
	1.4	1.3	1.2	1.1	1.0	0.9	0.8	0.7	0.6	L/s
	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	L/s

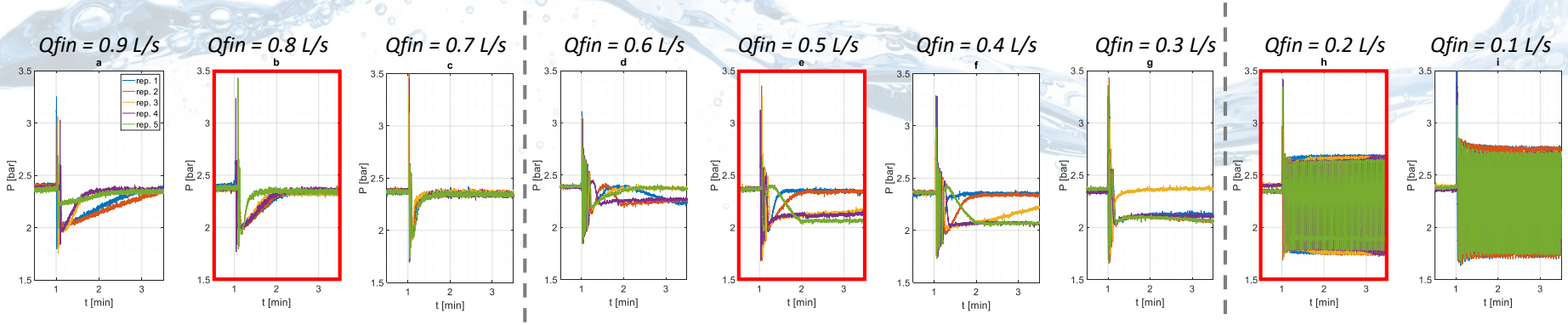
- Repetitions of each test: **5**
- Duration: **6 minutes**

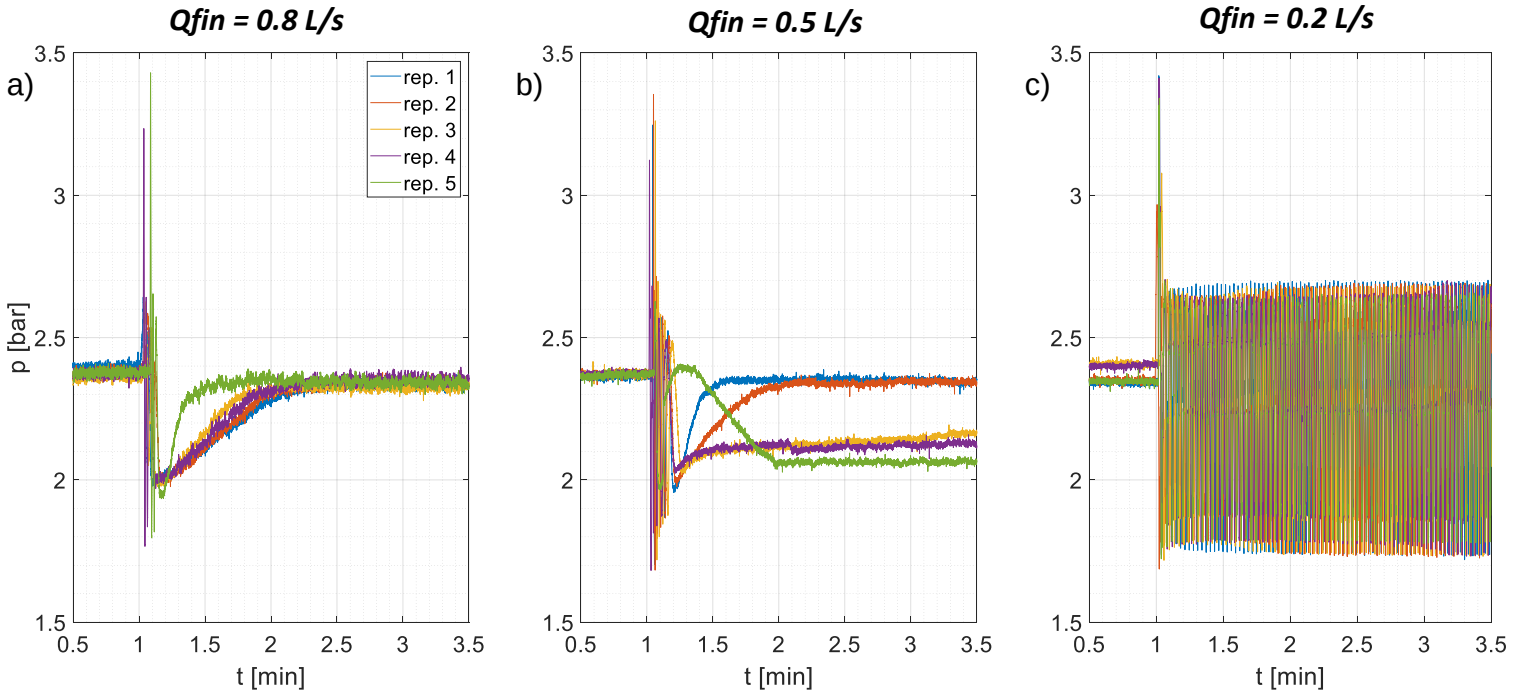
Qin

A [%]	100	55	47	45	39	34	29	24	18
B [%]	70	70	60	60	55	50	49	49	50
C [%]	0	0	0	0	0	0	0	0	0

The variation of flow rate ΔQ is carried out closing rapidly the discharge valve at the manoeuvre section B.

Results: I phase





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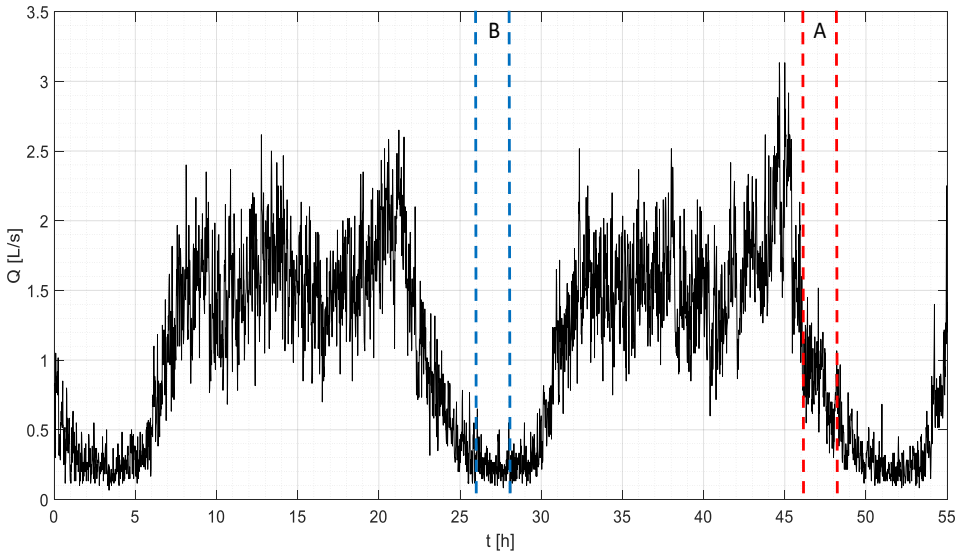
Laboratory tests: II phase

The system is subject to a historical series of observed flow rates with a one-minute time step at the inlet section of a real hydraulic district (about 300 users).

Gorino Ferrarese (FE)



Observed flow rate trend with a one-minute time step at the inlet section of the hydraulic district that serves Gorino Ferrarese (Ferrara, Italy) from 15/01/2018 to 17/01/2018. The periods A and B reproduced in laboratory tests are also indicated.

A = from 22:00 to 24:00, 16/01/2018

$Q_{max} = 1.4\ L/s$
$Q_{min} = 0.3\ L/s$

B = from 02:00 to 04:00, 16/01/2018

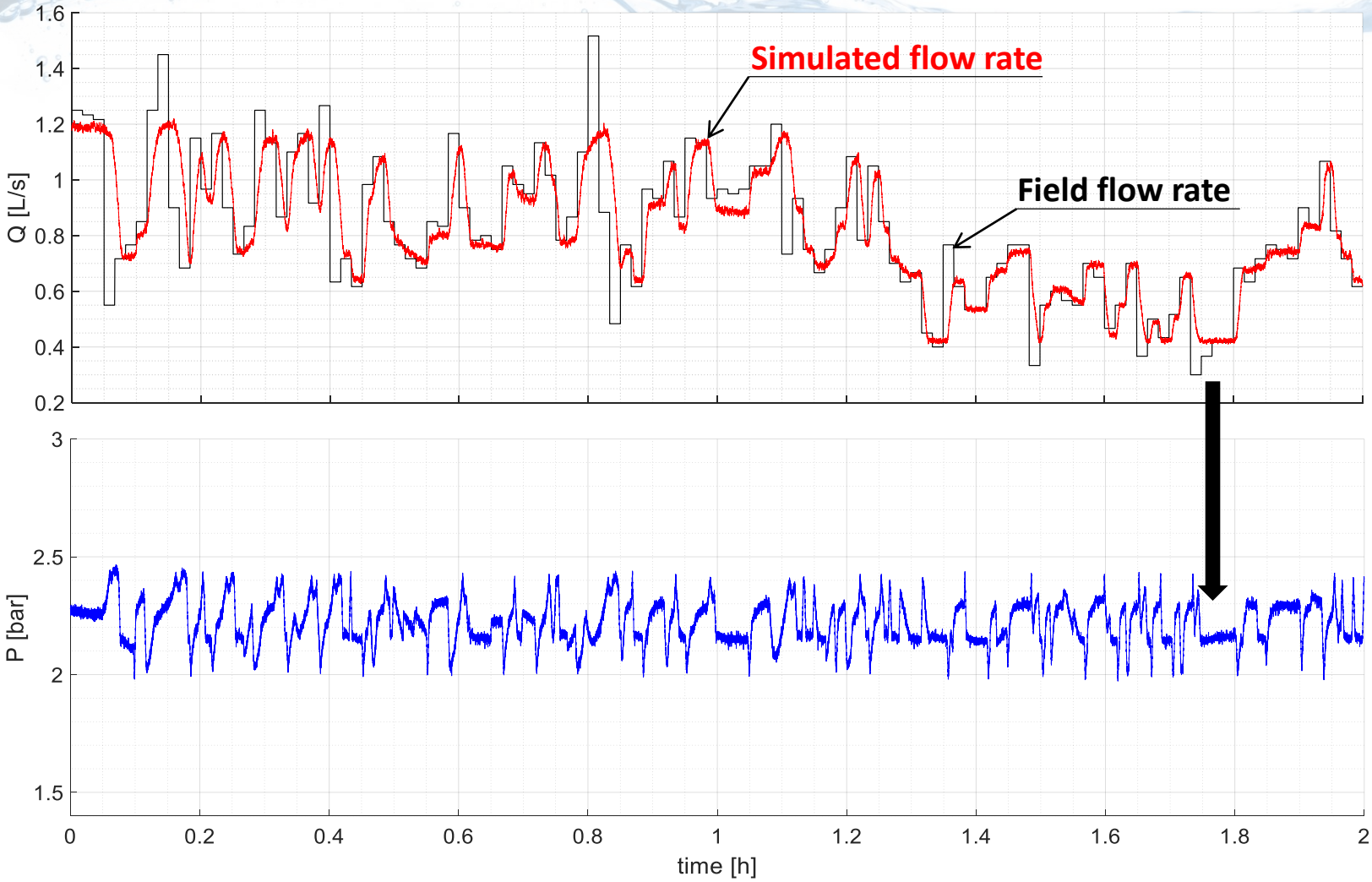
$Q_{max} = 0.7\ L/s$
$Q_{min} = 0.1\ L/s$

→ The flow rate in the system is varied by acting on the discharge valve controlled by the solenoid valve at the manoeuvre point A.

Results: II phase

A = from 22:00 to 24:00, 16/01/2018

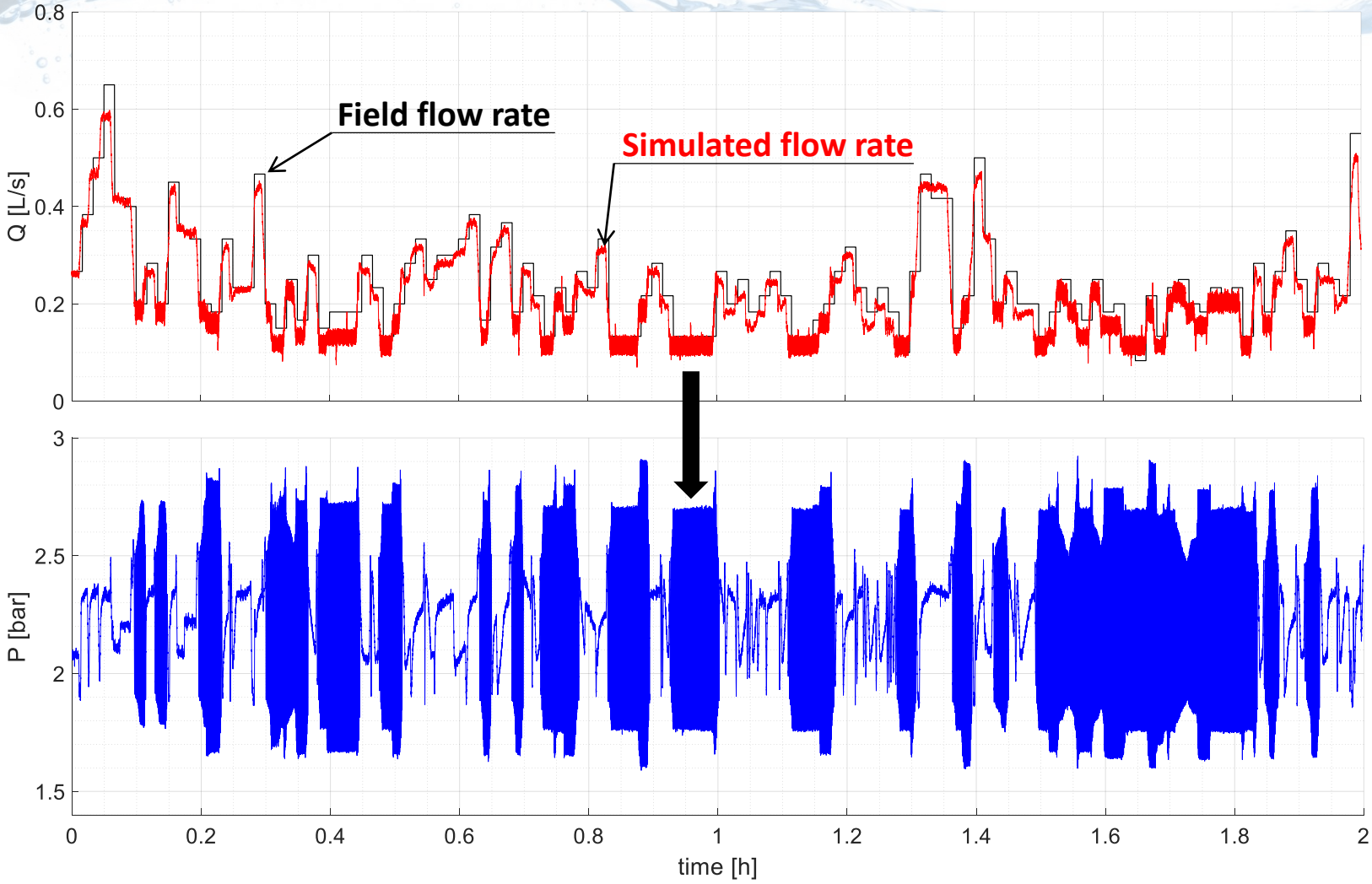
$Q_{max} = 1.5\ L/s$
$Q_{min} = 0.3\ L/s$



Results: II phase

B = from 02:00 to 04:00, 16/01/2018

$Q_{max} = 0.7\ L/s$
$Q_{min} = 0.1\ L/s$



Conclusions

- **I phase**

The PA-PRV behaviour with the decreasing of the flow rate characterizing the different test configurations:

  - $Q_{fin} \geq 0.7\ L/s$: correct functioning;
  - $0.7\ L/s < Q_{fin} < 0.2\ L/s$: failure in the maintenance of the imposed set-point;
  - $Q_{fin} \leq 0.2\ L/s$: persistent instability.

- **II phase**

For particular flow rate intervals circulating in the system, the device tends not to respect the set-point value imposed until it shows, under certain flow values, an important instability that can potentially occur in the ordinary operational conditions of a real hydraulic district.

Future studies: Characterisation of the field behaviour of similar valves

Thank you for the attention

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