Hydraulic Failure Caused by Air in Pipelines of the Experimental Area Ring of ALBA Synchrotron Light Source: Research, Simulations and Solutions

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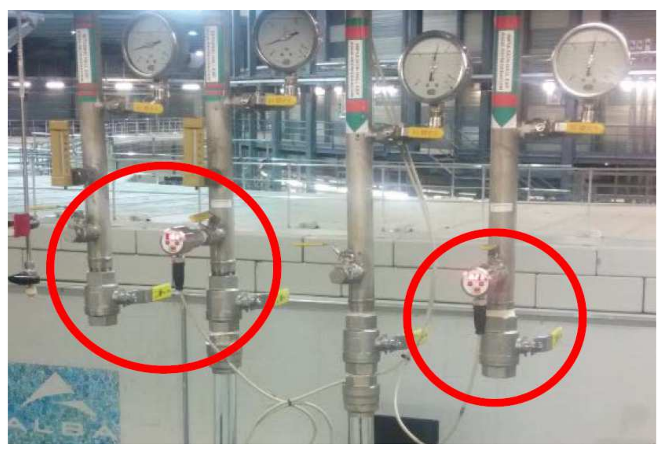
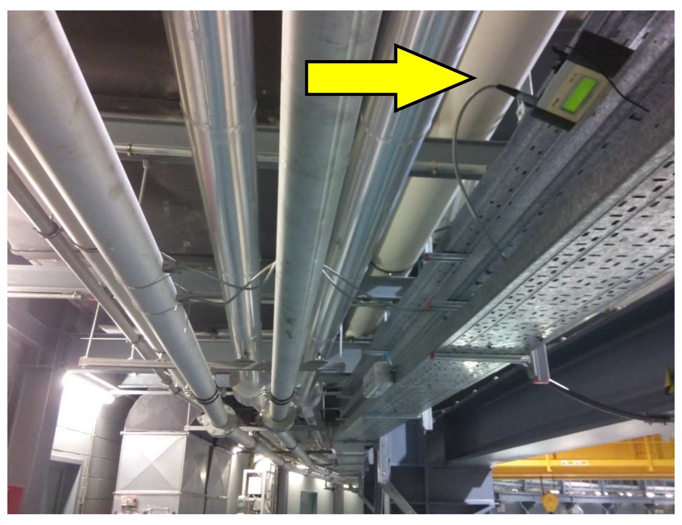
Abstract

After five years in operation of the ALBA Synchrotron Light Source a hydraulic failure caused a maximum decreasing of water flow about 40% of its nominal value, hampering the refrigeration of the local components. The problem was mainly caused by the air accumulated in pipes due to very low velocities of water flow. A literature review was conducted about the minimum water flow velocity for removing air in pipelines as design criteria. The aim of this work is to develop hydraulic solutions in order to achieve the minimum flowrate in pipelines of the Experimental Area (EA) ring. In the short term it is proposed to install a controlled bypass in the EA. A numerical simulation using the software Pipe Flow Expert has been implemented in order to determine the requirements of the bypass that works under different conditions to assure a minimum flowrate all along the ring. The velocity map in EA ring is simulated for different scenarios: 180 and 360 degrees distribution for both clockwise and anticlockwise rotation. For the long term a design of pipes with variable cross section is proposed which optimizes the flow velocity magnitude in EA ring in agreement with the design criteria.

Experimental Area: Data measurements and verification



Flow data has been acquired using ultrasonic flowmeters and pressure sensors.



EA Ring feeds 7 out of the 32 beamlines (the capacity of ALBA), at a 8,6 bar and flowing at 27 m^3/h.

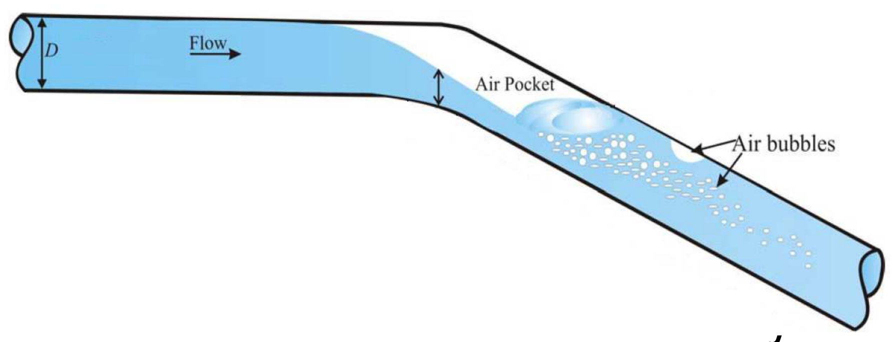
There are about 19 points of water, ready to refrigerate local consumptions.

EA Ring can distribute the flow in both directions [1] using valve gates placed at the entrance .

Minimum velocity as a design criteria

Bibliographic research [2,3] uses Froude number to propose a range of minimum velocity from 0,3 to 0,8. In velocities it is equal to 0,31 m/s and 0,82 m/s.

As an example, a pipe with air pockets because the flow cannot remove the accumulation of air.

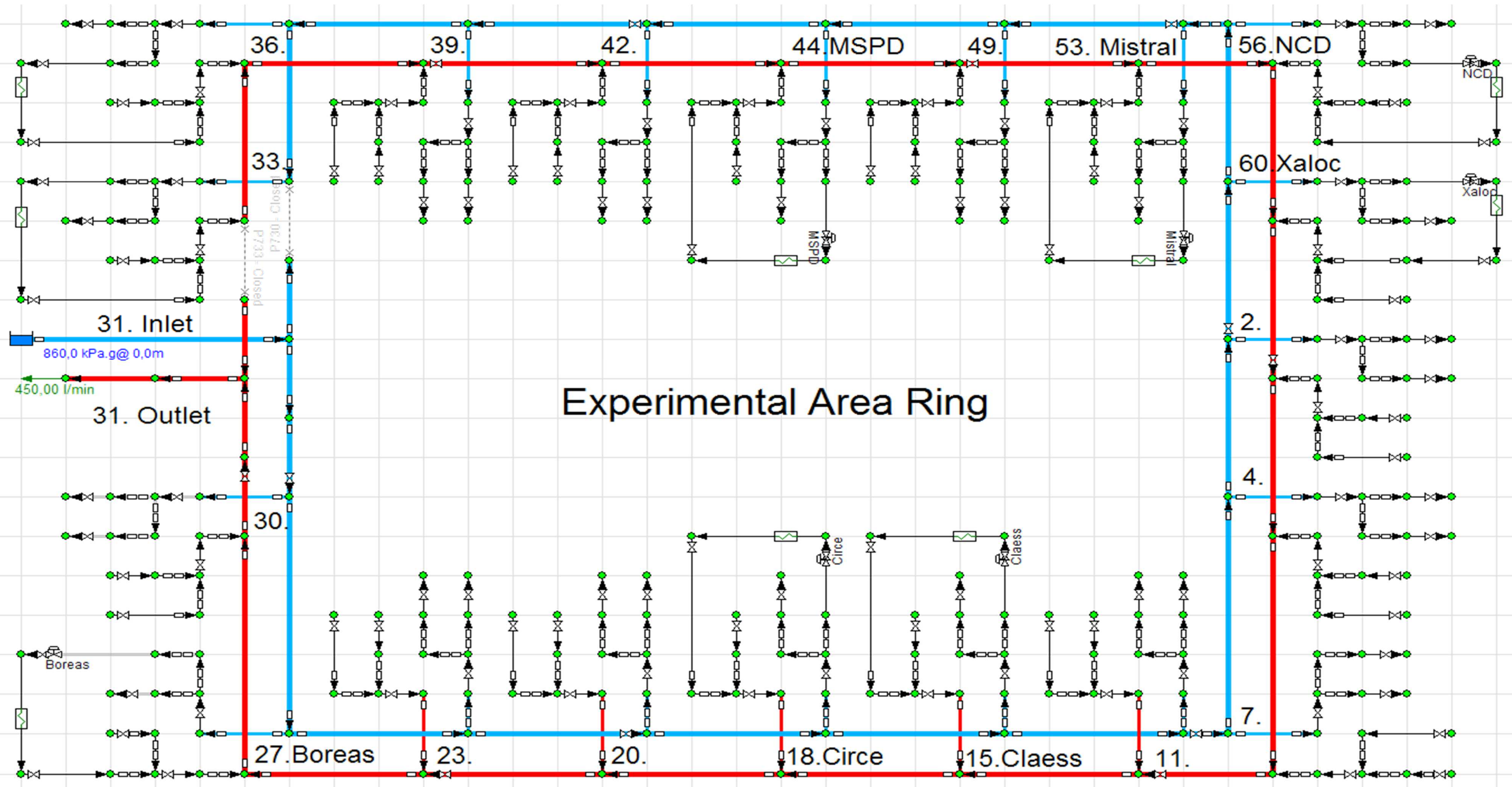


Upgraded the minimum velocity up to 0.6 m/s at all points of the installation.

1D numerical simulation

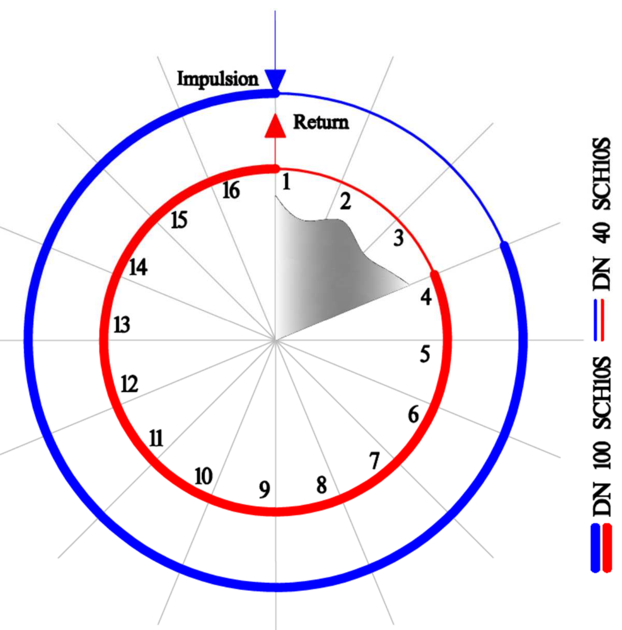
Simulation performed using PipeFlow Expert. EA Ring and beamlines under different configuration have been tested:

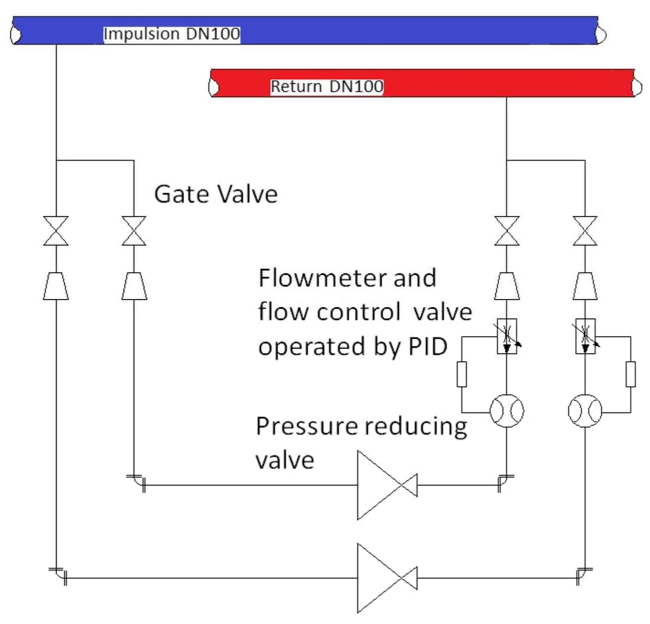
- Current configuration: velocity map distribution
- Other configuration: backspin and 180º distribution



Improvements and implementation

Two improvements have been proposed for increasing the minimum velocity through the ring.





Conclusions

A design issue has leaded the installation into problems previously and still has to be prevented. The new minimum velocity criteria will mend the flowrate failure sweeping air pockets accumulated.

The two improvements assure the flow in different stages of development of ALBA and have different implementation cost and impact to the reliability of the ALBA installation.

References:

[1] Cooling System Operation, M. Quispe, , 21st Meeting of the ALBA Scientific Advisory Committee, Barcelona, Spain, December 2015

[2] Investigating hydraulic removal of air from water pipelines , M. Escarameia, Water Management 160 (1), p. 25 – 34, 2007.

[3] Investigation on the Effects of Entrained Air in Pipelines, O. Pozos, I. W. der Universität Stuttgart