Water air valves

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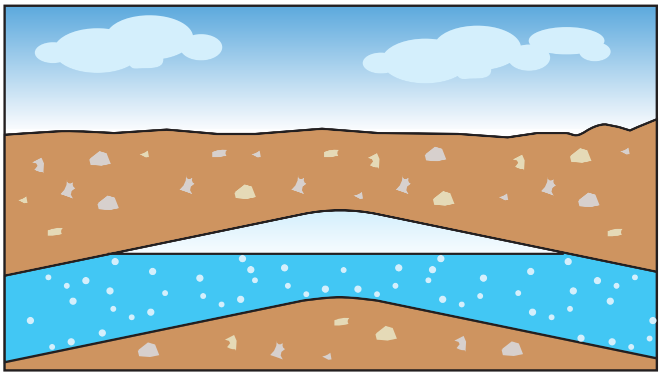
This catalogue is dedicated to air release valves, so air formation in pipe system and problems it may cause are hereinafter analyzed.

Air causes.
Air is introduced in pipelines on points where the internal pressure is near to atmospheric pressure.
Most frequent causes are:
- air inlet during pump starting phase;
- air intake when liquid level is under pump inlet nozzle;
- air intake in vortex created by the pump;
- air intake from a basin containing an air emulsion driven by imperfect pump gasket sealing;
- air emulsion dissolved in basins or dams;
- incomplete air evacuation when filling the conduit.

Air effects.
This air is dissolved in water as emulsion or bubbles, and it is accumulated in high points of the pipeline where air released from water (caused by pressure drop due to load losses) is added to transported air, a fluid mass is this way created, and it can seriously compromise system operation if it is not controlled and eliminated, causing the following problems:
- important flow rate reduction or even flow stop;
- pump release;
- siphon release;
- water hammers caused by uncontrolled air pocket intake or sudden air pocket expansion;
- an increase of general loss that requires a greater pump power and higher costs;
- metallic tube internal corrosion increase.



As above explained, air must be degassed or released in high quantities from the pipe system and it is also very important to let air in to avoid depression problems when the following arises:
- a water leaking break;
- accidental and uncontrolled discharging operations.

The following is necessary to solve this problem:

a) **determine a layout** that allows air accumulation on high points;

b) **carry out a proper choice** of air valves to be used;

c) suitably **locate and size air release valves**.

Layout

All pipelines must be designed to create a saw-toothed layout with slopes ranging from 2/3 per thousand for upstream sections to 5/6 per thousand for downstream sections. This structure helps air accumulation in the highest parts and thus its discharging through air release valves, and it does not allow air pocket advance in the steepest slope segment. It is not recommended to design and place pipelines in a perfectly linear layout, since air would not concentrate in a point but it would travel uncontrolled in increasing quantity and an accident, for example ground subsidence or settlement, would take the air to an undesired point.

As we will later explain, particular attention must be paid to slope changes, to layout maximum quota points downstream from partially opened gates or diameter changes; attention must also be paid to speed, as different researches have demonstrated the existence of a relationship between slope and decline in case of particularly low speed. The designer must determine a layout that helps air accumulation in one point to help air elimination through accurately placed automatic air valves.

The following paragraphs analyse such problems and offer some useful suggestions.

Air release valve choice

It is a normal practice to specify an air release valve with its diameter, without considering that air intake and discharge depend on: internal configuration and design, on main orifice dimension, on float dimension and weight, on pressure difference created through the main orifice, etc.

The following data must be considered when sizing air valves:

- **Large orifice section**: it must be large enough to guarantee a greater air intake in case of conduit break;
- **Air inflow**: to be searched on curves supplied by the manufacturer at a Dp max of 0.3 bar/ 4.35 psi on the main orifice because:

1) beyond such limit there is not a significant air flow rate increase (that reaches sonic speed around 0.5 bar/ 7.25 psi).

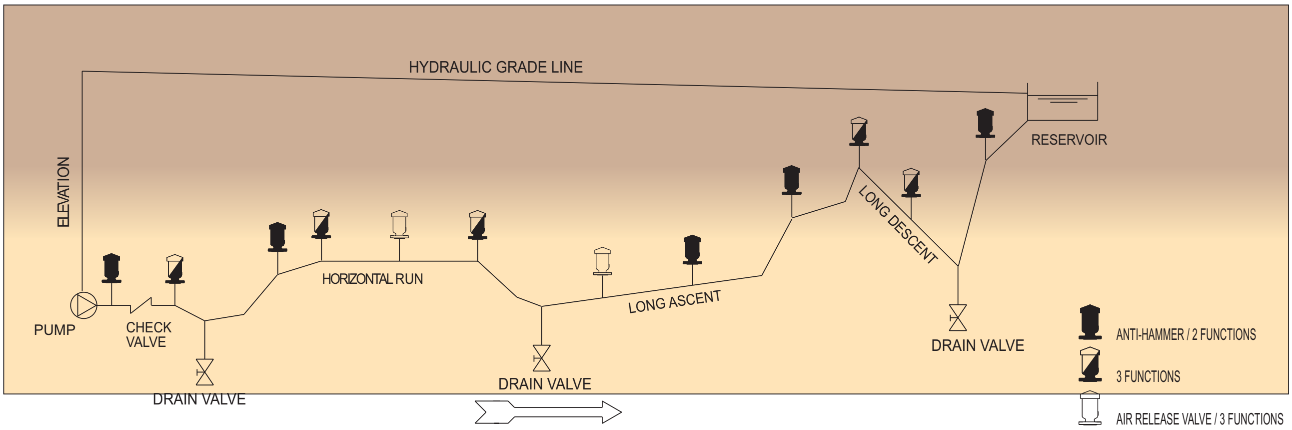
2) normally, the pipe system, the gasket and valves does not support greater vacuum conditions;

- **Air outflow**: that must be limited to a Dp of approximately 0.5 bar/ 7.25 psi on the large orifice, since a greater speed may cause water hammers during closing phase that may damage the entire system.
- **Detailed analysis of information** supplied by the manufacturer.

In particular cases, it is useful if air release valves in question are equipped with **automatic devices that limit water hammers** caused by the sudden closure of the air valve or as a consequence of column separation.

Air release valve application and sizing

We have designed a typical pipeline layout inserting the necessary air release valves for example purposes:

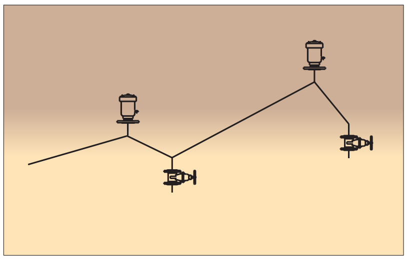


The air valves must be placed to support the following functions :

A) Admit large volumes of air through main orifice
B) Discharge large volumes of air through main orifice
C) Release air under pressure

A) Air inflow through the main orifice

They are normally dimensioned to protect pipeline from vacuum that may be caused by pipe bursting or by a sudden pump stop causing column separation; they must be placed as follows:



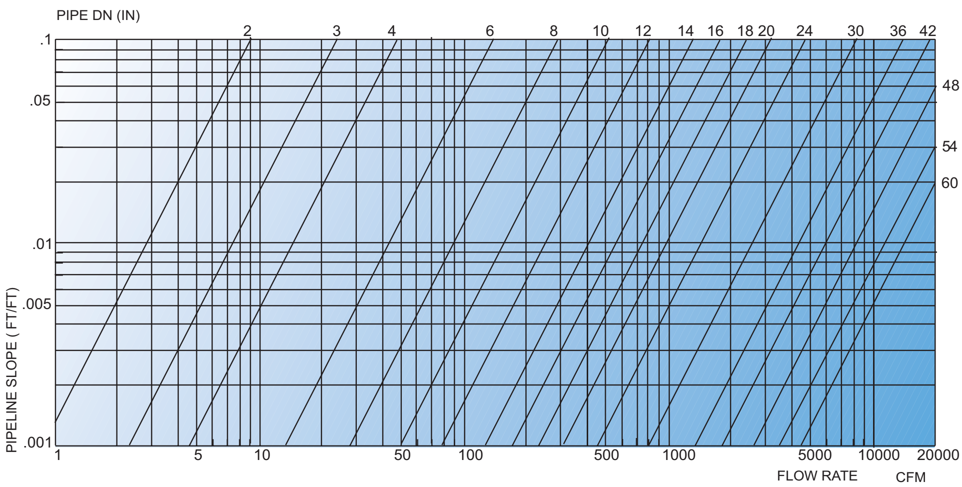
High geometrical points

To size an air valve, maximum flow rate in such point must be determined in case of pipe bursting using the following formula, that is valid in case of absolutely turbulent state.

$$h_f = Q^{1.852} * C_F * L / (C_{HW}^{1.852} * D^{4.87})$$

hf = head loss due to friction
Q = flow rate (expressed in cfs, m3/sec)
D = Pipe inside diameter(ft, mt)
CHW = Hazen Williams roughness coefficient
CF = unit conversion factor (4.73 English, 10.7 SI)
L = distance between two sections (ft, mt)

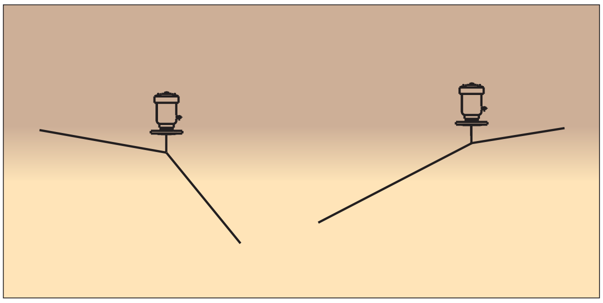
We suggest to evaluate flow rate curves shown for each air valve and choose a diameter that guarantees a vacuum condition less than 0.1 bar/ 1.45 psi inside the conduct.



For easier consultation, resulting flow rates have been traced for each DN from free discharge on given slopes for an adequate air valve sizing.

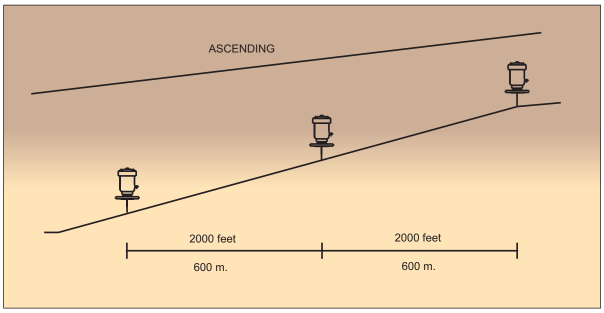
Negative slope changes

They are identified as descending segment slope increase or ascending segment slope decrease. In case of pipe bursting or pump stop, a gaseous cavity equal to the flow rate difference between both slopes is formed.
Gaseous cavity air flow rate Qc to be evacuated will be determined by equation Qc = Q2-Q1 where Q2 indicates flow rate in the steepest sloped section and Q1 indicates flow rate in the section with the flattest slope.



Long ascending segments

If the ascending segment is long, an air release valve should be placed at the top of the section and one every 600 m./ 2000 feet to guarantee air outflow and inflow during pipeline filling and draining operations.
Calculations must always be based on pipe bursting or pump stop.



Long descending segments

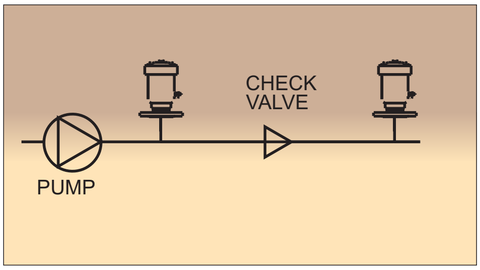
Air release valve choice and placement considerations are exactly like those regarding ascending sections.

Long horizontal runs

A conduct must ideally have a certain slope (*) to help air movement, that tends to reach high points.
Long horizontal segments must be avoided as much as possible, if it is not possible, we suggest to place an air release valve every 600 m./ 2000 feet, dimensioning them according to conduct filling operations.

Pumping station – downstream check valve.

Air valve flow rate must be equivalent to pump capacity. Let's suppose a pump suddenly stops causing column separation. Conventional air valves in this point are not able to control air discharge when the two waves fronts start to join and thus they will cause a water hammer. Air vessels or special and controlled air outflow valves, like our FOX Anti-shock, are used to prevent this phenomenon.



B) Air outflow through the main orifice

Rules analysed for air inflow and diameter choice are also valid in this case; also consider for this analysis that sometimes double float conventional air valves are prematurely closed discharging air with a maximum p on the main orifice exceeding 0.5 bar/ 7.25 psi due to **"dynamic closure"** phenomenon, while kinetic air valves may release air at high speeds.

(*) Please contact CSA technical support for more information.

C) Air release

Air release from each air release valve depends on the existence of a “critical relationship” between nozzle area and float mass. Under pressure air and water develop inside the valve equivalent forces that are opposed to each other, except for the small section in contact with the nozzle DN, that is subject to atmospheric pressure. The float is thus pushed upstream by a force which is:

F=AxP

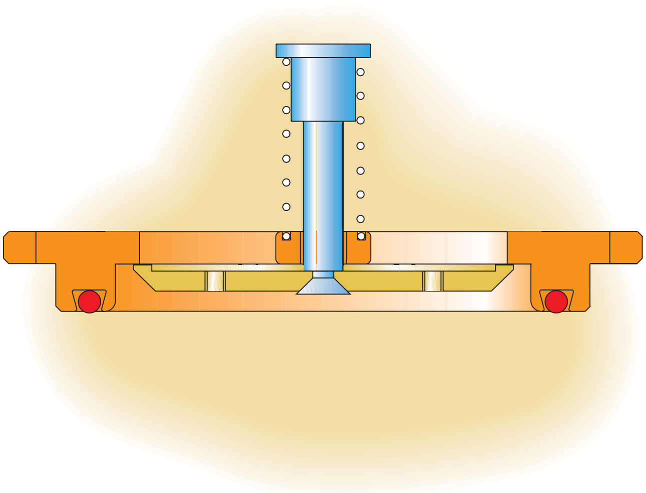
A = nozzle area
P = working pressure

if this force exceeded the float weight, the latter would remain always stuck against the nozzle and air releasing would never take place. This is the reason why the same air release valve can work with a larger hole nozzle at 10 bar/ 145 psi rather than at 25 bar/ 362.6 psi. It is difficult to determine in advance the amount of entrapped air which must be released from a given system and the sizing of Air valves is a decision based on experience. The 2% air content may change noticeably depending on temperature, pressure and head losses along the profile.

D) Water hammer control

In case of sudden pump failure what we actually experience is a lower pressure (compared to the steady state regime) wave propagating downstream which, when the pipes section is actually crossed, creates negative pressure. It is common knowledge the min. pressure value we can have in nature is the vapour tension, which corresponds to the physical state where the liquid remains in equilibrium with its own gas. Should the pressure drop to that threshold, the locations where that is likely to occur are the high points or the changes in slope where the difference in gradient is particularly severe, the vapour pockets tend to separate the water column into two different waves whose waterfronts are eventually rejoining causing serious overpressures sometimes extremely dangerous for the system. CSA FOX AS air valves have been designed with the purpose of avoid column separation allowing for the entrance of large volumes of air, therefore limiting negative pressure, to control its discharge by means of an exclusive system. They can also be used to protect pipelines against overpressures generated by rapid filling operations.

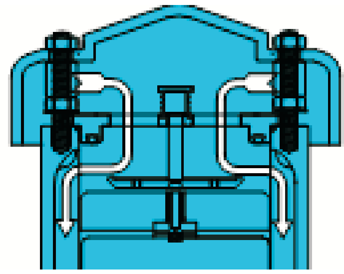
CSA Anti-water hammer device



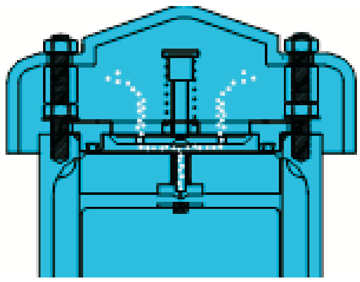
Construction

The automatism is composed of a metallic disk (with 2 or more small orifices), a guide bar and a stainless steel counteracting spring that lays directly on the sealing seat. Such simple construction guarantees high reliability and it may equip both the 2 and the 3 function air release valves.

Working principle



1) During vacuum condition the mobile block is laid over the aerodynamic diffuser, the antishock disk comes down pulling the stainless steel spring, allowing the entrance of a large volume of air through the main orifice to compensate for the vacuum effect.



2) When negative pressure conditions ends, the stainless steel spring pulls back the anti-shock disk to close the main orifice. Internal air must flow out now through the small disk orifices creating a counter-pressure inside the conduct that will slow down water speed avoiding upsurges.

Applications

Deep wells

In a deep well, the vertical pipe that connects conduct and the pump is normally full of air. When the pump is turned on, the water pushes air through the air valve at a very high speed, causing a sudden valve closure and a destructive water hammer when the water enters it. The use of CSA air release valve Mod. Anti-Shock will solve the problem by slowing down the speed of the incoming water column.

Column separation

Column separation is generated by fluid parameter variations that cause the pressure to decrease, reaching the vacuum condition, with a subsequent growth of air pockets and two wave fronts that travel independently. When such cavity closes due to the arrival of fluid columns, an over-pressure stroke arises; it is directly proportional to column speed, and it may be destructive for the system. Also in this case, CSA air valve Mod. Anti-Shock can be positioned in a critical point resulting in the best solution for such problem. This equipment will avoid vacuum conditions allowing the entrance of the air volume and controlling air out-flows to lower the sudden impact.

Installation

Before installing, accurately clean conducts to avoid any foreign bodies like stones or building material that may damage air releasing valves.

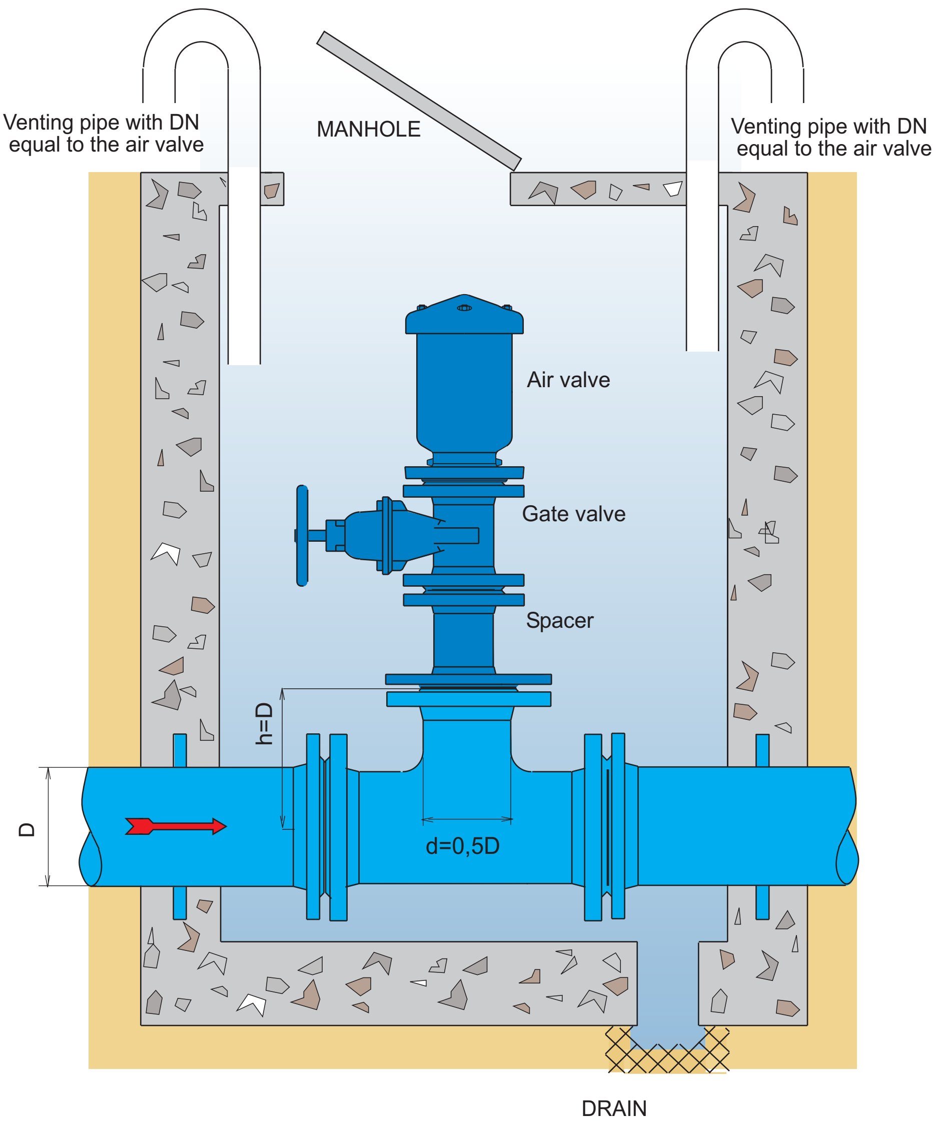
Air releasing valves must be assembled in wide enough and easily accessible pit to allow maintenance operations and inspection. They must be placed in a perfectly vertical position and on a “T” piece that must have a passage with a diameter at least equal to half main pipe diameter.

The pit must be equipped with a drainage pipe for cleaning operations, and at least one ventilation pipe to allow air intake and out-flow for chamber ventilation (one in-going and one out-going would be ideal).

Our MAX series air releasing valves are already equipped with a built-in gate valve for maintenance operations, therefore isolation valves are not necessary. This will save space and cost. For FOX and GOLIA model, a gate valve must be provided.

Never place an air release valve directly on the main pipe, to avoid that air return due to depression fills the main conduct without an accumulation point, being pushed when the pump is re-started causing section reduction and other problems that have already been mentioned.

In order to guarantee maximum efficiency, it is therefore necessary to place the ARV as high as possible on the pipe (as shown in the diagram) placing a flanged or threaded coil between it and the ARV that will allow air accumulation.



Maintenance

ARV valves have simple and safe construction and their performance will depend on working conditions. Internal parts subject to heavier wear can be easily replaced from the top with the equipment still installed.

For any further information, please consult the installation and maintenance manual enclosed with every valve, or simply contact our tech support.