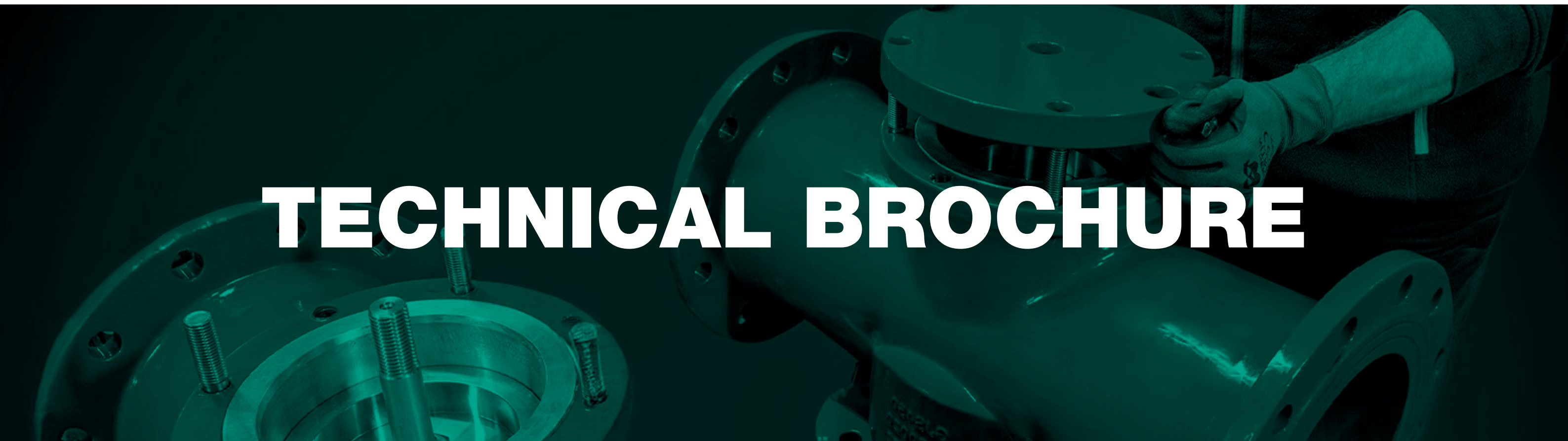
A.V.A.S.T.

Anti-water hammer tank



TECHNICAL BROCHURE

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Anti-water hammer tank

A.V.A.S.T.

The newly developed A.V.A.S.T. tank is designed to prevent water hammer and transient analysis problems caused by the negative pressure triggered when lifting devices are suddenly switched off, both in water and sewage pipelines. The fully automatic device is highly reliable and innovative, thanks to the absence of compressors, electromechanical parts or diaphragms with pre-charging. A.V.A.S.T. is the ideal solution to prevent damage, sometimes irreparable, to hydraulic systems caused by uncontrolled negative pressures or overpressures.

Technical features and advantages

- Designed for use with treated and sewage water
- Available in sizes from 250 to 25,000 litres, with pressure ratings of PN 6, 10 and 16 bar.
- Patented, innovative technology without diaphragms and compressors.
- Reduced space requirements and minimal maintenance, compared to traditional systems with air vessels or bladders with pre-charging.
- Anti-water hammer device to allow the control of air release into the atmosphere and, at the same time, the entry of large volumes under negative pressure.
- Produced in various materials; welding in accordance with EN and ASME standards
- Calculation programmes are available for dimensioning, and technical support for the transient analysis.

Applications

- Main supply systems
- Pressure sewerage pipelines
- Systems for irrigation or civil use

Water hammer

The term water hammer, which recalls the idea of a sudden, noisy phenomenon related to abrupt pressure changes, is commonly used as a synonym for transients, sometimes responsible for devastating effects on system integrity.
Pipelines, both for water and sewage, are vital for our modern civilization and their safety and protection should be one of the top priorities. Using numerical simulations, it is possible to ascertain the behaviour of pipelines in the presence of transient analysis phenomena and to assess potential damage.

The main causes of water hammer are:

- Sudden changes in demand
- Pump start-up
- Pump failure
- Rapid closing and opening of isolation devices
- Rapid filling of fire-fighting systems
- Opening and closing fire hydrants
- Pipe flushing and training operations
- Draining of feed tanks

The water hammer can also be described as a propagation of energy, similar, for example, to the transmission of sound. In a wave motion, energy is associated with the elastic deformation of the medium.

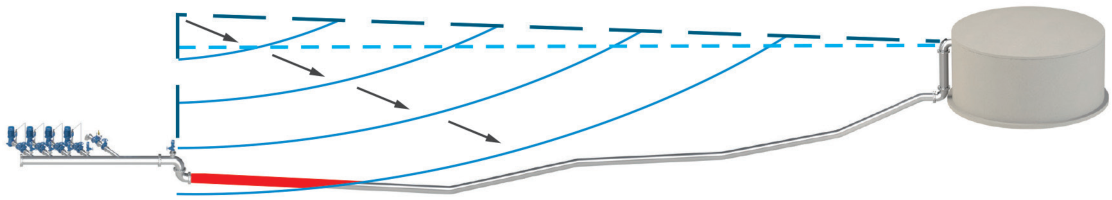
The speed of sound waves in fluids can be expressed by the following formula:

$$a=\sqrt{\frac{\frac{K}{\rho}}{1+K\cdot\frac{D}{E\cdot e}}}$$

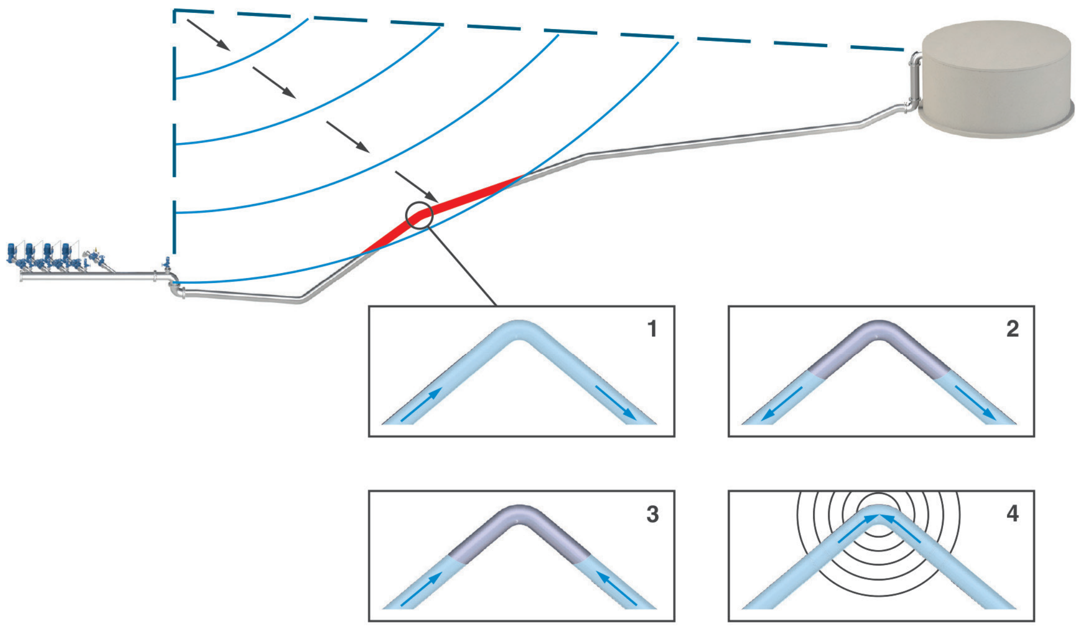
Where **E** is the modulus of elasticity;
D is the diameter of the pipe;
e is the wall thickness;
K is the mass modulus;
ρ is the density of the fluid medium.

Pump failure

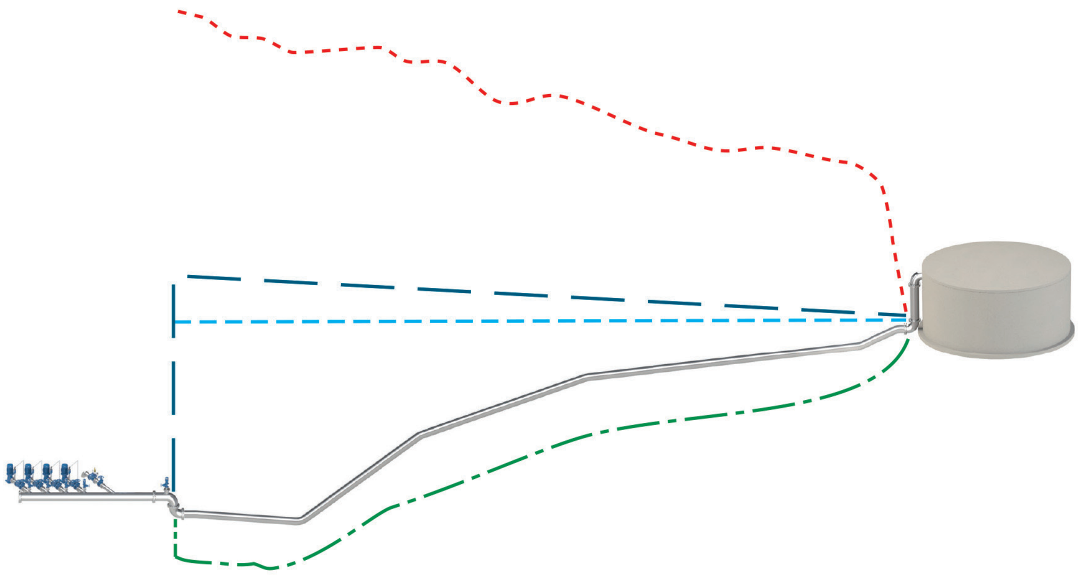
One of the most critical occurrences in water and wastewater system is pump failure. The complete shutdown of the pump causes a deceleration and, consequently, a negative pressure that propagates with a speed that depends on the characteristics of the fluid and the piping. Negative pressure can cause serious damage: deformation and rupture of pipes, displacement of gaskets and entry of contaminants through leakage points. If the HGL drops to a negative value corresponding to the vapour pressure there is the risk of column separation, generated by the formation and collapse of vapour pockets producing serious and unexpected high frequency rises in pressure, sometimes fatal for the system.



The schematic shows the profile of a pipeline, with pumps and downstream reservoir as boundary conditions. The dark blue dashed line represents the HGL and the light blue dashed line represents the static. The negative pressure wave propagating downstream as a result of the pump shutdown is highlighted; the red segment corresponds to the section affected by the depression during the initial phase of the event.



The second picture shows the negative pressure wave propagating downstream, as an effect of pump failure. The red segment depicts the area exposed to severe negative pressure. The change in slope represents a location at risk of column separation, caused by vapour pockets forming and then collapsing creating unwanted water hammer as explained in the 4 pictures.



The results of pump failure can be summarized in a plot showing the envelope of the maximum and minimum pressure values reached during the simulation, in the picture above shown respectively in green and red.
It is evident how the system reaches a full vacuum on the entire pipeline profile and the water hammer due to the column separation, occurred at the change in slope.

Prevention of transients

In order to prevent transients and unwanted damages on the pipeline systems we basically have to reduce the variations in velocity of the fluid and, when this happens, try to proceed as slow as possible. It will therefore be mandatory to:

- operate slowly during valve operations, especially in the last 20% of the stroke. The same precautions must be observed when opening, especially in the initial phase.
- verify by simulation that no negative pressure occurs, or use multifunctional water hammer vents, such as CSF or AWH models.
- introduce air or water into the pipeline, at those locations where negative pressure conditions are likely to occur.
- adopt gradual pump start-up systems.
- carry out detailed computer analysis to evaluate and assess the risk associated to the system and transient events.

One of the best and most reliable solutions to the problem is the air vented anti surge tank also called A.V.A.S.T.,
working as a standalone or in combination with other devices like anti-water hammer air valves and pressure relief valves.
The tank can be installed in derivation from the main line or directly on top of it, and simply provided with an isolation device to allow for maintenance. No additional check valves, by pass or restrictions are needed. Compared to other solutions A.V.A.S.T. doesn't need any kind of compressor, bladder or external source of energy. This means a reduced maintenance, higher reliability and, more important, a lower volume is needed to provide the same degree of protection, in comparison with bladder tanks or air vessels.

Operating principle

First phase of transient analysis following pump failure

In the event of pump failure, A.V.A.S.T. prevents the formation of depressions by injecting the fluid contained inside the pipeline, exploiting the pressure generated by the compressed air in the upper part of the tank, around the central pipe.

First phase -1

When the pumps stop, A.V.A.S.T. injects water from the pipeline, avoiding negative pressure conditions. The fluid level inside drops, depending on the change in pressure.

First phase -2

As soon as the liquid drops inside the central pipe, the vent at the top opens, allowing large volumes of air to enter and thus limiting the pressure drop inside A.V.A.S.T.

First phase -3

When the free surface drops below the mouth of the central pipe, the inflow of air into the tank through the vent allows the accumulation that had previously expanded due to the pressure change to be recharged.

First phase -4

Thanks to A.V.A.S.T.'s innovative operating principle, the liquid level drops to the bottom of the tank, or even higher, thus allowing the entire available volume to be utilised. The functionality of the system against water hammer is ensured at every phase.

Second phase of transient analysis following pump failure

In the second phase of the transients, the column of fluid returns to the pumping station, pushing out, into the atmosphere, the air previously fed into the tank. Again, the system is protected by two damping effects, thanks to the anti-water hammer vent and the central pipe.

2

Second phase -1

During the second phase of the transient analysis, as water flows back into the tank, air escapes from the upper vent, which regulates its speed, thus preventing sudden pressure increases.

Second phase -2

As a result of the increased fluid pressure, the level rises.

As long as the level remains below the central pipe, air is discharged through the vent at the top.

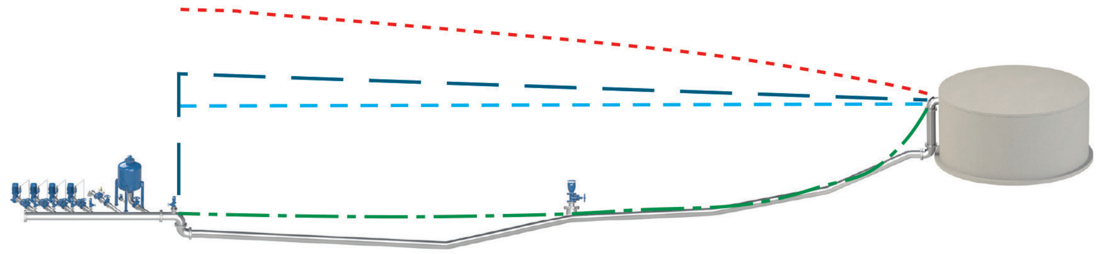
4

Second phase -3

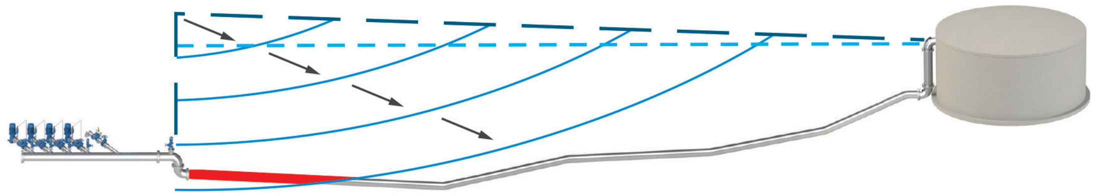
After the liquid has risen past the mouth of the central pipe, the air around it begins to compress as the pipe fills and the outflow through the vent continues.

Second phase -4

At the end of the transient phase, once the pressure has stabilised, the liquid rises in the central pipe until it reaches the float, which, by rising, closes the vent. The degree to which the accumulated air is compressed, and thus the level of the free surface, depends on the pump's operating conditions.



The figure illustrates the consequences of the transient analysis, caused by pump failure, on a pipeline protected by the A.V.A.S.T. tank. The red and green curves show the maximum and minimum pressure values obtained in the simulation; the benefit on negative pressures is clearly visible, which has the effect of also reducing the risk of water hammers.



If A.V.A.S.T. is installed in combination with water hammer vents (AWH series), the effect of the vent will allow the use of a smaller tank, reducing costs. The maximum and minimum pressure values are shown in red and green. A.V.A.S.T. can be placed at a lifting unit or along the line, and also paired with pressure relief valves.

Technical data

Operating conditions

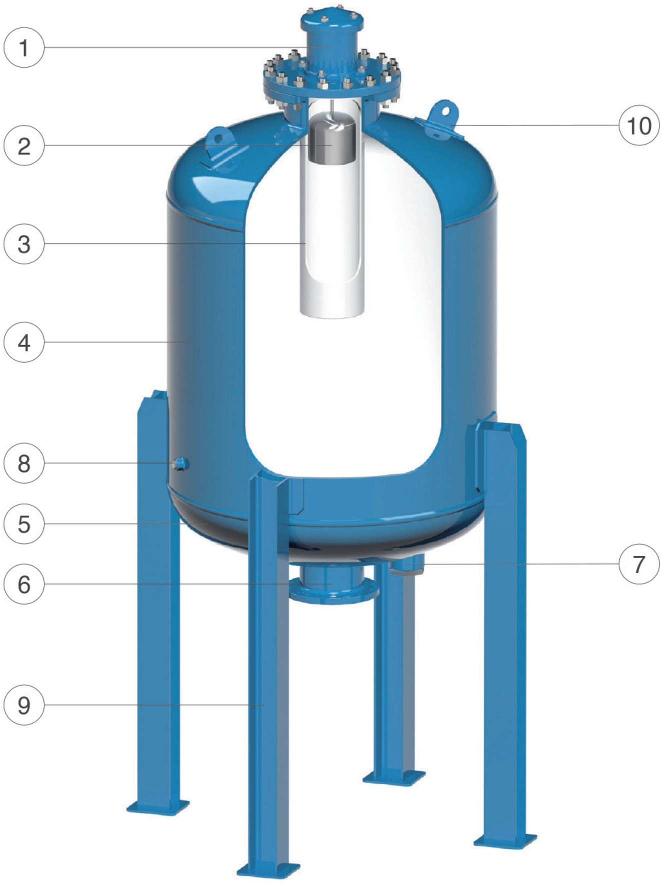
Treated or wastewater	Maximum temperature 70°C
Maximum pressure	16 bar
Minimum pressure at the top	0.5 bar

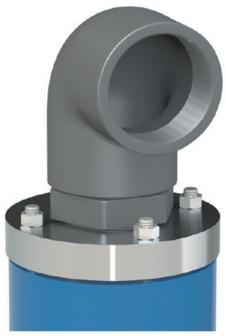
Project Standards

NDT calculations and analyses, and materials according to current standards, if agreed upon in the order

- Welding and painting according to project specifications
- Outlet flanges according to EN 1092/2 or ANSI; different on request
- Earthquake and wind stress calculation on request

Construction details





Threaded elbow for drain channelled, on demand.

No.	Component	Standard material	Optional
1	Anti-water hammer vent	various configurations for treated and waste water	
2	Float	AISI 316 stainless steel	polypropylene
3	Central pipe	painted steel	different materials on demand
4	Liner	painted steel	different materials on demand
5	Bottom	painted steel	different materials on demand
6	Flanged outlet	painted steel	different materials on demand
7	Drainage	painted steel	2"-3" or flange DN 50-150
8	Pressure outlet	painted steel	1/2"-2"
9	Supports	painted steel	different materials on demand
10	Lifting points	painted steel	different materials on demand

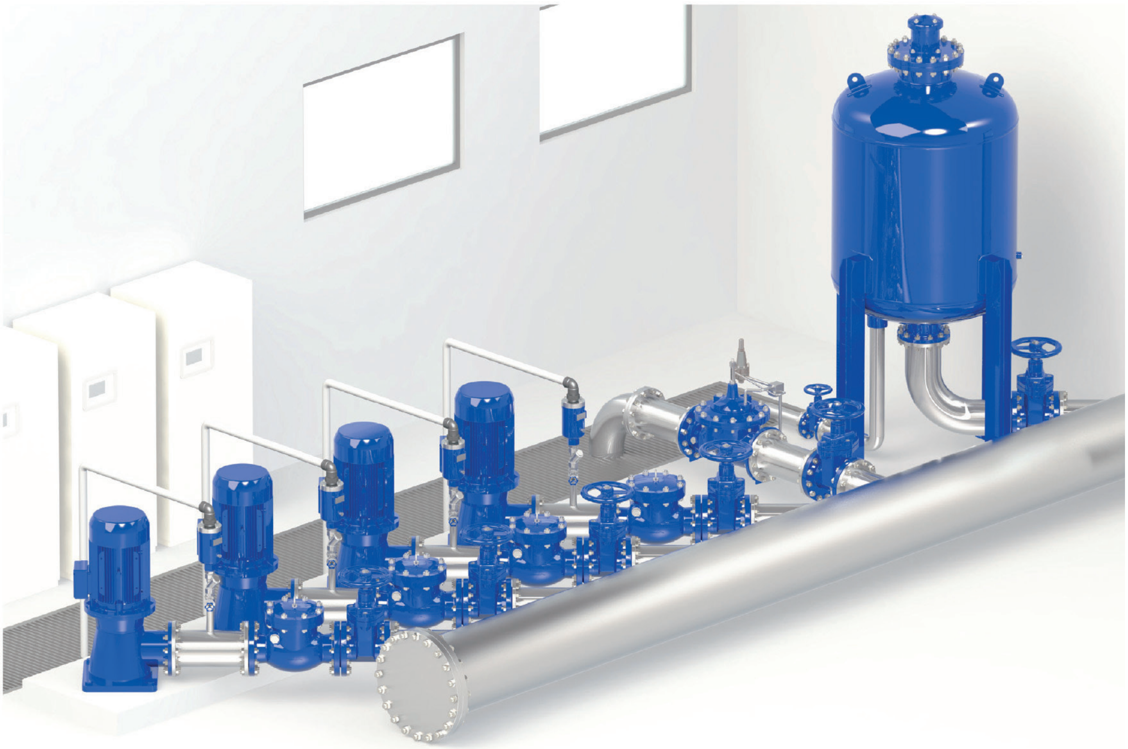
The table of materials and components is subject to change without notice.

Installation diagram

The anti-water hammer tank is one of the most versatile devices for protecting pumping stations; this is because it limits the acceleration/deceleration that occurs in case of a pump failure.

Aqueducts

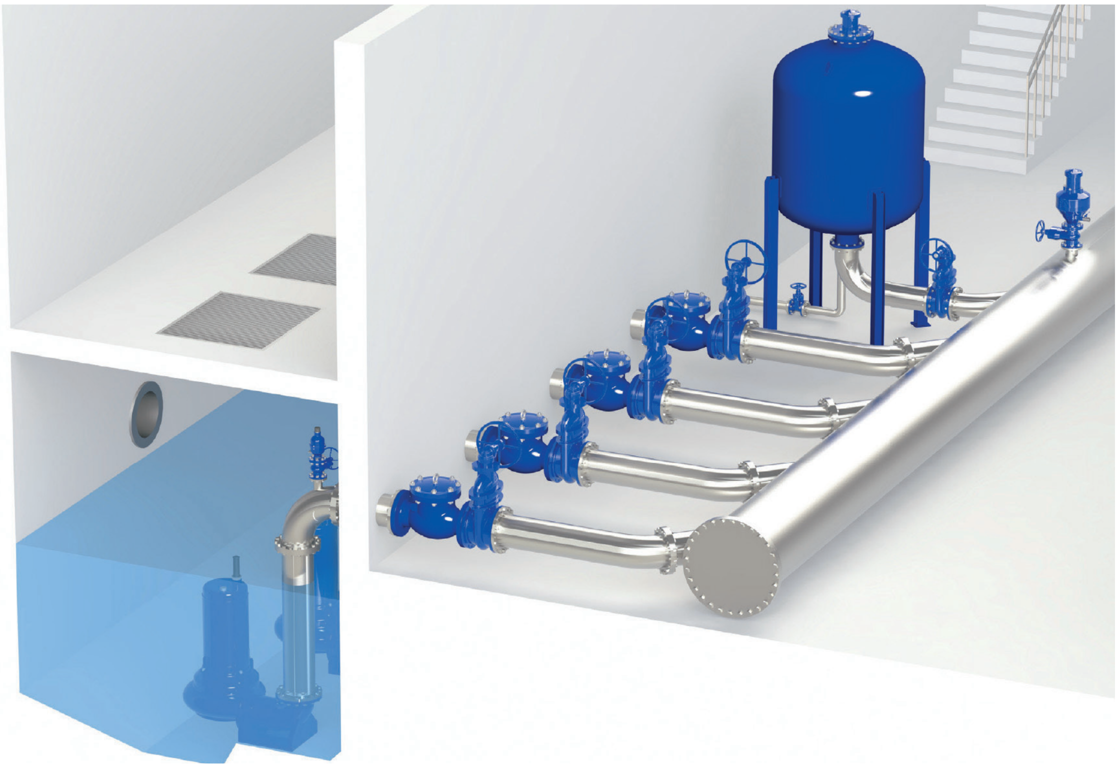
The following illustration shows the use of the A.V.A.S.T. model in a typical lifting station, without the need for check valves, bypass and restrictions required by air vessels and other solutions. A number of other Pietro Fiorentini products were also included to protect the system. In the hypothesis of transients, the effects of rapid negative and positive pressure variations must be evaluated and, therefore, the advisability of installing overflow valves together with the A.V.A.S.T.



In the picture on the right, you can see the anti-water hammer vent installed at the pump, immediately upstream of the check valve.
Venting is necessary to avoid, in any case, the risk of negative pressure, and to ensure the controlled release of air when the pump is operated. This is achieved by the AWH (anti-slam) device, and is extremely important to avoid water hammers that can be caused, for example, by the abrupt closing of conventional vents. The AWH combination model also allows for the degassing of air pockets, which originate during pump operation and start-up.

Sewers

The following illustration shows the use of the A.V.A.S.T. model in a typical sewage lifting station, without the need for check valves, bypass and restrictions required by air vessels and other solutions. In addition to the A.V.A.S.T., an anti-water hammer vent model SWH 3S-AWH is applied on the main pipeline. Our experience in water hammer analysis ensures the best solution, through the dimensioning and evaluation of the devices required for the correct protection of the system.



On the left is a detailed image of the water hammer vents, which are inserted on the pump pipelines immediately upstream of the check valves. When the pump is stopped, the pipe fills with air up to the liquid level in the pumping basin. Venting is necessary to avoid, in any case, the risk of negative pressure, and to ensure the controlled release of air when the pump is operated. This is achieved by the AWH (anti-slam) device, and is extremely important to avoid water hammers that can be caused, for example, by the abrupt closing of conventional vents.

Customer Centricity

Pietro Fiorentini is one of the main Italian international company with high focus on product and service quality.

The main strategy is to create a stable long-term oriented relationship, putting the customer's needs first. Lean management and thinking and customer centricity are used to improve and maintain the highest level of customer experience.

Support
One of Pietro Fiorentini's top priorities is to provide support to the client in all phases of project development, during installation, commissioning and operation. Pietro Fiorentini has developed a highly standardized intervention management system, which helps to facilitate the entire process and effectively archive all the interventions carried out, drawing on valuable information to improve the product and service. Many services are available remotely, avoiding long waiting times or expensive interventions.

Training
Pietro Fiorentini offers training services available for both experienced operators and new users. The training is composed of the theoretical and the practical parts, and is designed, selected and prepared according to the level of use and the customer's need.

Customer Relation Management (CRM)
The centrality of customer is one of the main missions and vision of Pietro Fiorentini. For this reason, Pietro Fiorentini has enhanced the customer relation management system. This enables us to track every opportunity and request from our customers into one single information point.

Sustainability

Here at Pietro Fiorentini, we believe in a world capable of improvement through technologies and solutions that can shape a more sustainable future. That is why respect for people, society and the environment form the cornerstones of our strategy.

Our commitment to the world of tomorrow

While in the past we limited ourselves to providing products, systems and services for the oil & gas sector, today we want to broaden our horizons and create technologies and solutions for a digital and sustainable world, with a particular focus on renewable energy projects to help make the most of our planet's resources and create a future in which the younger generations can grow and prosper.

The time has come to put the why we operate before the what and how we do it.

Pietro Fiorentini

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The data are not binding. We reserve the right
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