Air vented anti surge tank A.V.A.S.T.

The innovative anti-surge tank A.V.A.S.T. has been designed to contain the devastating effects of water hammer, more precisely the transients coming from the sudden pump failure both for water and sewer systems. The device, fully automatic, proved to be an innovative and reliable solution thanks to the absence of air compressors, electricity, panels, bladders, pre-charges. A.V.A.S.T. is the ideal solution to avoid damages sometimes fatal for our systems as a consequence of uncontrolled overpressures and negative pressure waves.

Technical features and benefits

- Designed for treated water and wastewater.
- Available from 250 up to 25000 litres PN 6/10/16.
- Innovative system (patent pending) to avoid bladders and compressors.
- Low maintenance and reduced volumes compared to air vessels, bladders and tanks working with pre-charges.
- Patented anti-shock device to control air outflow yet ensuring the maximum inflow during negative pressure conditions.
- Produced in different materials, welding in compliance with EN and ASME standards.
- Supported by CSA transient analysis and calculation software.

Applications

- To protect pumping station from negative and positive pressure conditions caused by pump failure and used in:
- Wastewater pressurized main lines.
- Irrigation.
- Water mains and distributions systems.

Water hammer

The term water hammer is commonly used as a synonymous of unsteady flow, suggesting noise and fast changing pressure variations sometimes related to devastating effects on the system.
Pipelines, both for water and sewage, are vital for our modern civilization and their safety and protection should be one of the top priorities. During the studying and assessment of the pipeline network their behaviour under transient conditions will reveal the potential for damages. This involves numerical simulations carried out to reproduce events, planned or accidental, with consequences on the system.

The main causes of transients are :
-sudden changes in demand
-pump start up
-pump failure
-rapid closing and opening of isolation devices
-rapid filling of pipe line and fire fighting installations
-opening and closing fire hydrants
-pipe flushing and draining operations
-feed tanks draining

Water hammer can also be described as a propagation of energy, as in the transmission of sound, and from basic physics as a wave motion the energy is associated with the elastic deformation of the medium.

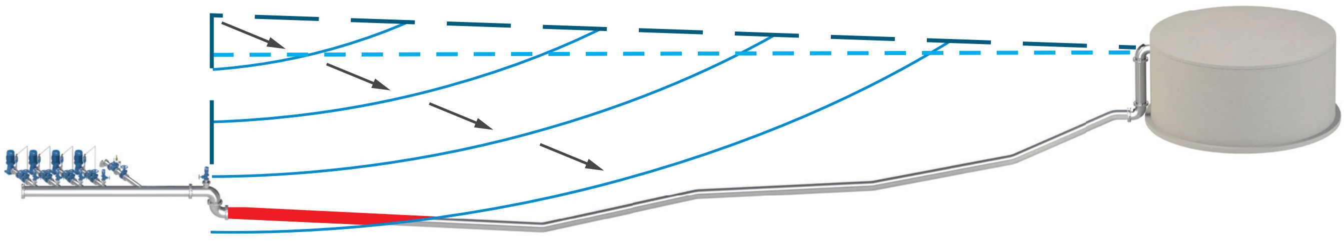
The celerity of sound waves a in rigid pipes is given by

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

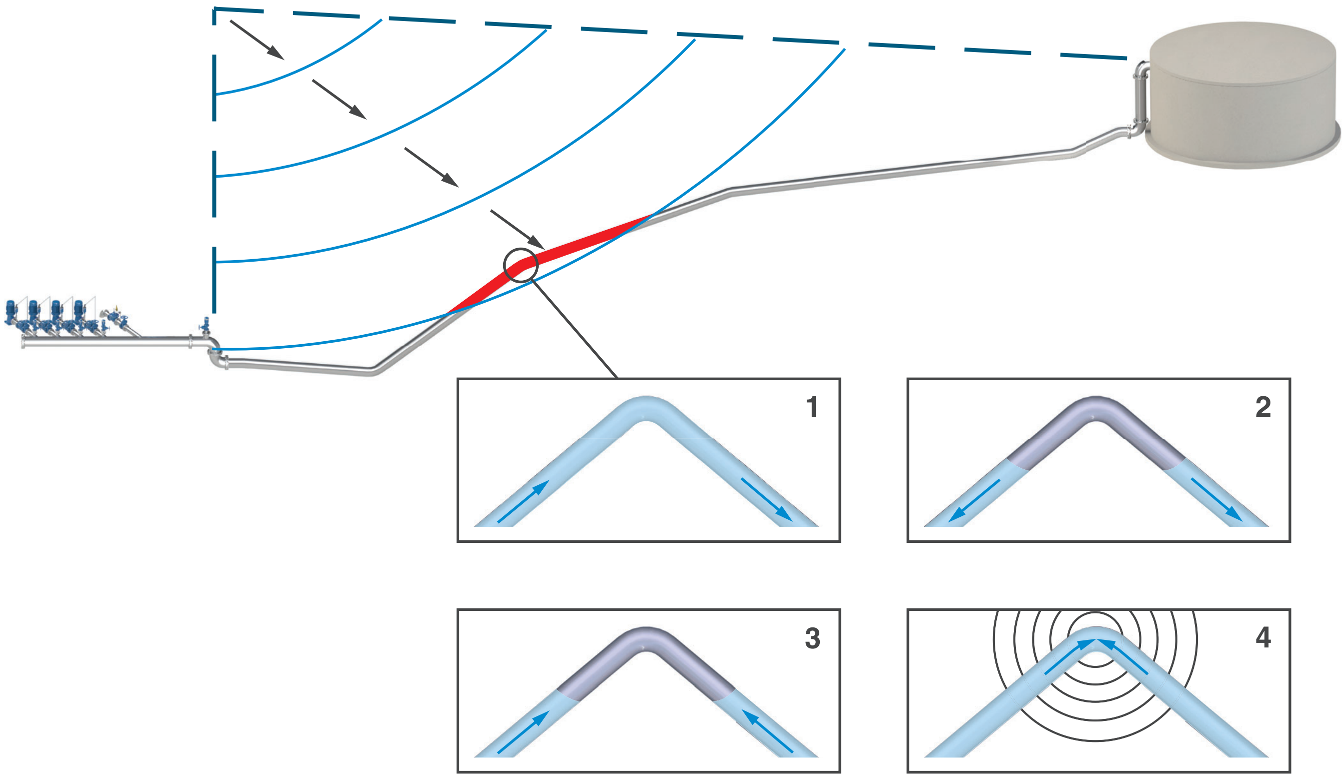
Where E is the modulus of elasticity;
D is the pipe diameter;
e is the wall thickness;
K is the bulk modulus;
ρ is the density of the fluid medium.

Pump failure

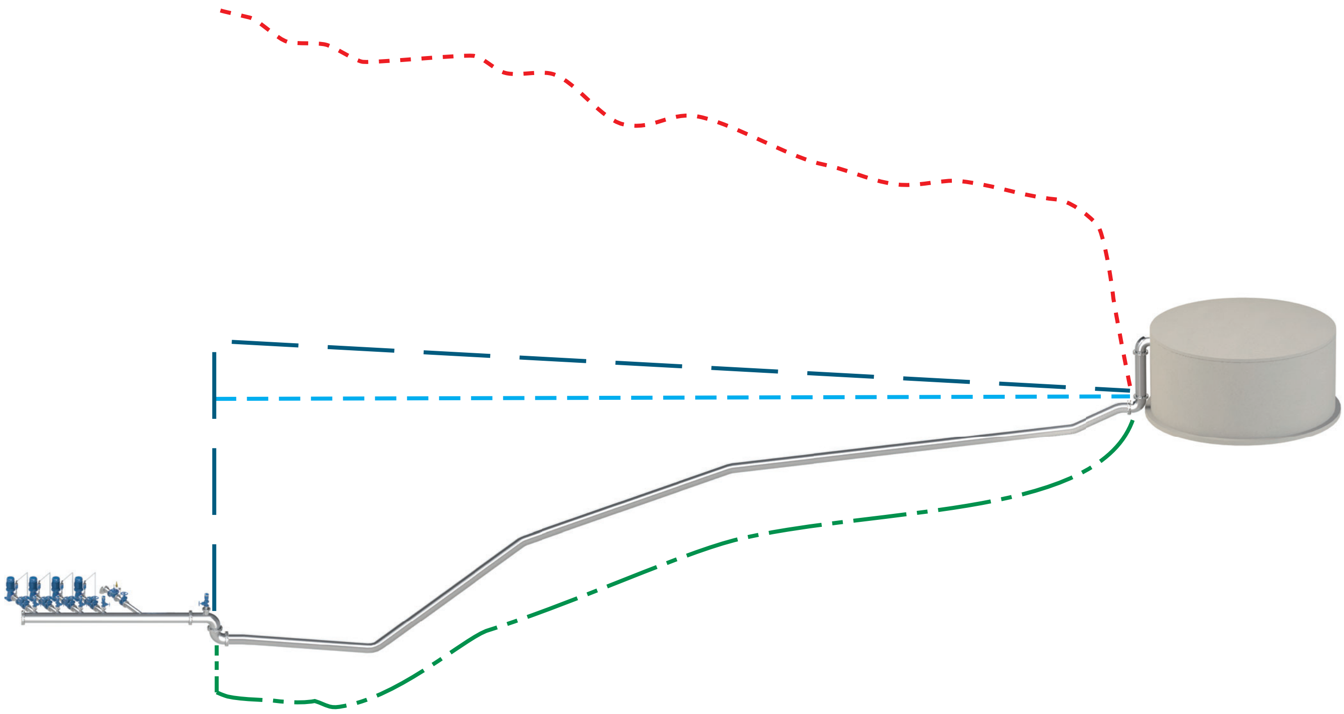
One of the most critical occurrence in water and wastewater system is the pump failure also called pump trip. This definition means actually a full blackout, interrupting the pump's head and causing a deceleration with consequent negative pressure variation propagating with a speed whose value depends on the fluid and pipe properties. Negative pressure is always a problem for possible pipe deformation, collapse, gaskets movements and entrance of contaminated water and pollution through points of leakage. If the hydraulic grade line, during the pump failure, 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 plot above shows a pipeline profile, with pumps and downstream tank as boundary conditions, where the dark blue dotted line represents the HGL and the light blue dotted line is the static. The picture represents the negative pressure wave propagating downstream as an effect of pump failure, where the red segment depicts the area exposed to negative during the initial phase of the event.



The plot above 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 on 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 profile and an extreme rise in pressure due to the column separation, occurred at the change in slope.

Water hammer prevention

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 on the final position of the device.
- control the pipe filling through the use of anti-surge combination air valves, example the CSA RFP models.
- introduce air or water into the pipeline, at those locations where negative pressure conditions are likely to occur.
- adopt controlled pump start up procedures to avoid rapid changes in flow.
- 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, and working as a standalone or in combination with other devices like anti-shock air valves and pressure relief valves, is the CSA air vented anti surge tank also called A.V.A.S.T.

This type of anti surge device 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 after pump failure

As a consequence of power failure A.V.A.S.T. will avoid negative pressure conditions, using the fluid and its storage capacity, by means of the force obtained thanks to the effect of the stand pipe and the automatic air compression around it.

1

First phase 1

In case of pump failure AVAST will supply liquid to the pipe, avoiding negative pressure conditions. The liquid level will therefore drop inside of it according to the variation in pressure.

First phase 2

When the liquid drops also inside the stand pipe the anti-shock air valve, located on top, will allow the entrance of large volumes of air avoiding negative pressure inside the A.V.A.S.T.

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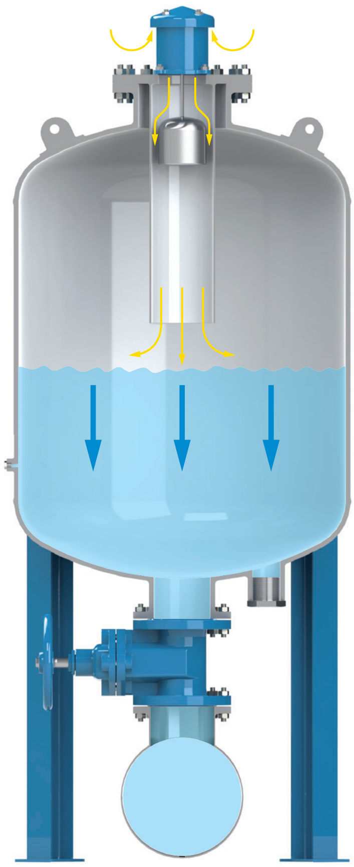


3

First phase 3

When the liquid drops below the stand pipe lowest point the air inflow through the air valve will recharge the air pockets around the stand pipe, previously expanded due to the variation in pressure.

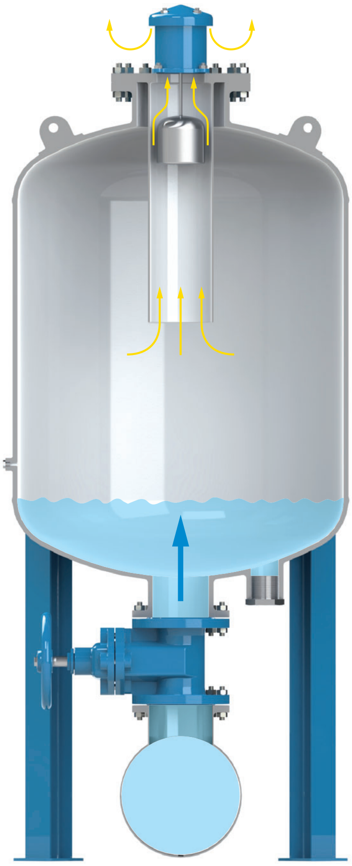
First phase 4

Thanks to its innovative operating principle A.V.A.S.T. will allow the drop in the liquid level to the very bottom of it, or even further, therefore using the entire storage volume. The protection against negative pressures will always be ensured through the air valve located on top.

4

Operating principle - Second phase of transient after pump failure

On the second phase of transient caused by pump failure water column will come back pushing air and water towards the pump station and the A.V.A.S.T. anti-surge device, whose technology is devised to absorb and cushion unwanted surges even during this event.



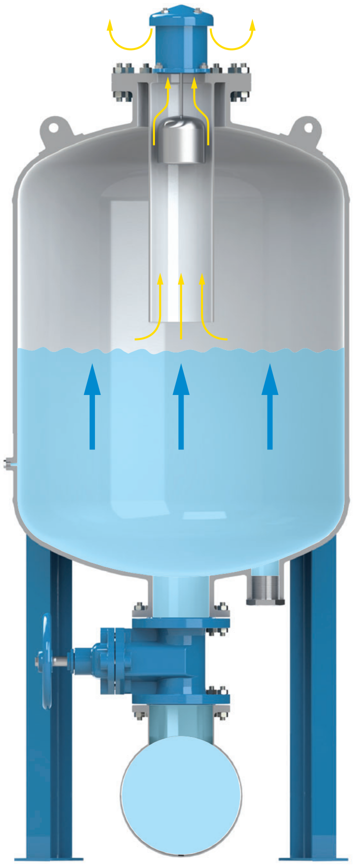
1

Second phase 1

On the second phase of transient water will comeback pushing the liquid level upwards, air will start flowing out of the anti-shock air valve system on top (pat. Pending) controlling the water approach velocity and avoiding unexpected rises in pressure.

Second phase 2

The more the pressure the more the fluid level will raise. As long as it remains below the bottom of the standpipe air is discharged through the upper anti-shock air valve system.



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3

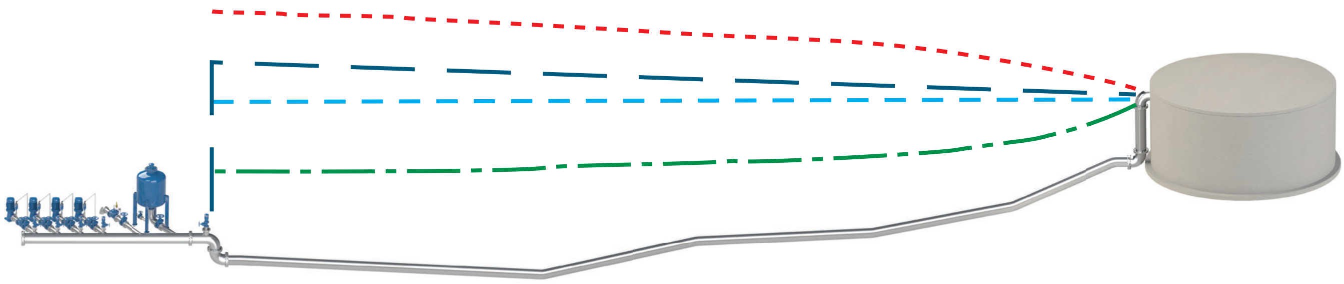
Second phase 3

As the liquid level rises above the standpipe lowest point air is compressed around it, while the air outflow through the anti-shock air valve on top will continue.

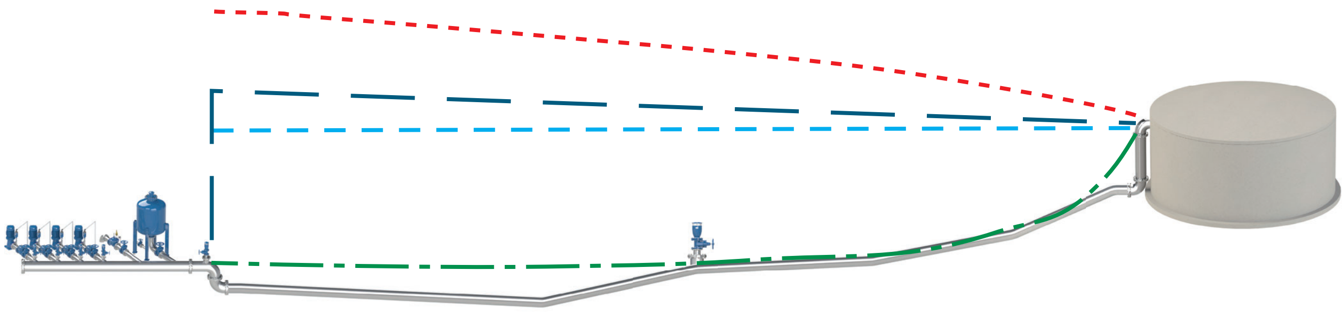
Second phase 4

At the end of the transient event, once pressure has stabilized, the liquid has filled up the standpipe compressing the air pockets around and closing the anti-shock air valve located on top. The liquid level around the standpipe depends on the A.V.A.S.T. geometry and operating pressure.

4

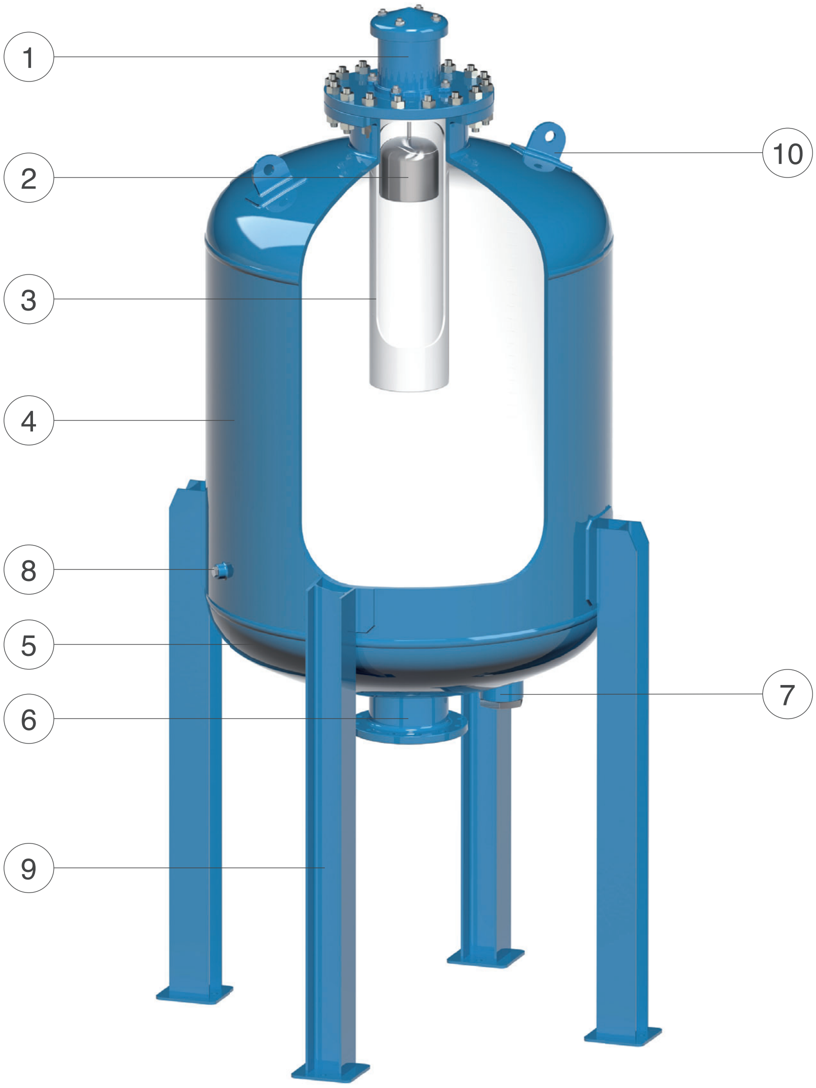


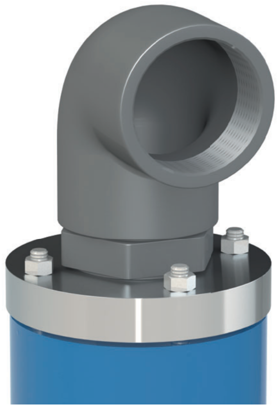
The plot above shows the pressure envelope of the transient event caused by pump failure on a pipeline with A.V.A.S.T. installed as a protection. The red and green are the maximum and minimum pressure values reached during the simulation, it is clearly visible the beneficial effect in terms of negative pressure and consequently reduction of water hammer.



The plot above shows the pressure envelope of the transient event caused by pump failure on a pipeline with A.V.A.S.T. installed as a protection, in combination with anti-shock air valves (CSA AS series). In this case the effect of the air valve will help reducing the volume of A.V.A.S.T., containing budget and design requirements. The red and green are respectively the maximum and minimum pressure values reached during the simulation. Depending on the fluid A.V.A.S.T. can be placed at the pumping station or along the profile and calculated to perform with air valves and pressure relief valves, CSA VRCA series, if required.

Technical details





Threaded elbow for air conveyance system supplied on request.

N.	Component	Standard material	Optional
1	Air valve CSA anti hammer type	in different executions for treated and wastewater	
2	Float	stainless steel AISI 316	polypropylene
3	Dipping tube	painted steel	different material on request
4	Shell	painted steel	different material on request
5	Base plate	painted steel	different material on request
6	Flanged outlet	painted steel	different material on request
7	Drain outlet	painted steel	2"-3" or flanged DN 50-150
8	Pressure outlet for gauge	painted steel	1/2"-2"
9	Legs	painted steel	different material on request
10	Lifting plates	painted steel	different material on request

The list of materials and components is subject to changes without notice.

Working conditions

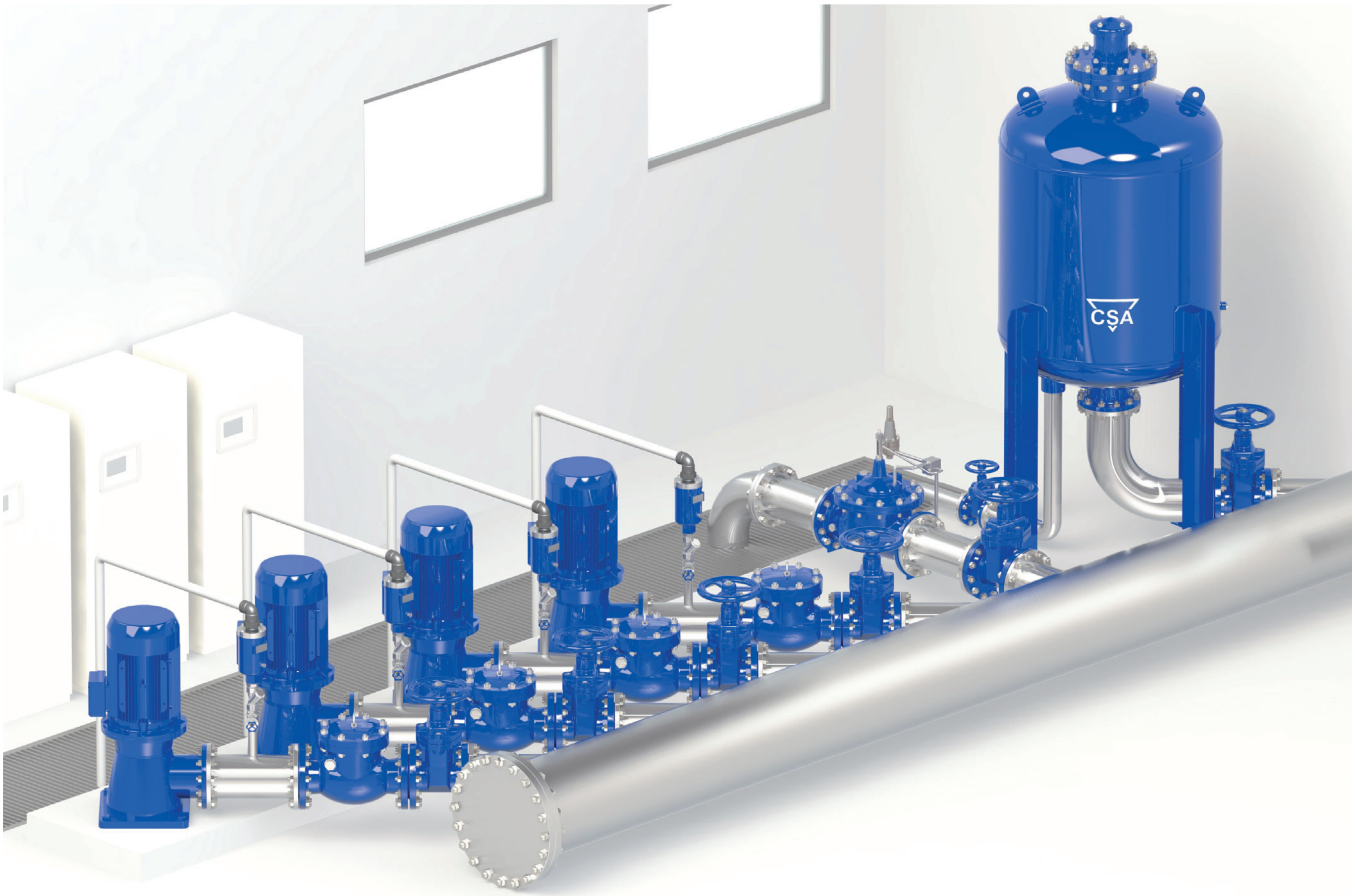
Treated water / Waste water 70° C max.;
Maximum pressure 16 bar;
Minimum pressure 0,3 bar on the top.

Design standards

NDT according to applicable standards to be specified in the order.
Welding and painting according to project requirements.
Outlet flanges according to EN 1092/2 or ANSI;
variations on flanges details available on request.
Wind, seismic events available on request.

Installation layout for water applications

CSA Air vented anti surge tanks A.V.A.S.T. represent one of the most effective and versatile means of providing protection at pumping stations. This is because they allow the introduction of flow during pump failure thus limiting the rate of acceleration/deceleration that occurs in the pipe in case of pump trip.
The illustration below shows the use of CSA A.V.A.S.T., in a common water pumping station, installed without the need if any check valves, by-pass and restrictions otherwise necessary for air vessels with compressors and different solutions. In addition to that, the picture shows more CSA equipment for the regulation and control of the system such as anti-shock air valves and anticipating control valves, sized and determined as a result of detailed water hammer analysis part of CSA consulting services.



CSA anti-shock combination air valves are extremely important at the pumping station located before and after the check valve. The first due to their protection against negative pressure on the riser when the pump is turned off, and consequent control of the air outflow at the pump start up preventing overload and rapid changes in flow and unwanted surged. The air valves downstream of check valves, for each pump and/or on the main line, are needed to avoid vacuum and the propagation of negative pressure waves along the system as a consequence of pump failure, controlling and slowing down the returning water approach velocity. CSA relief valves or surge anticipating are sometimes needed to discharge excess in pressure and to reduce the volume of A.V.A.S.T.

Installation layout for wastewater applications

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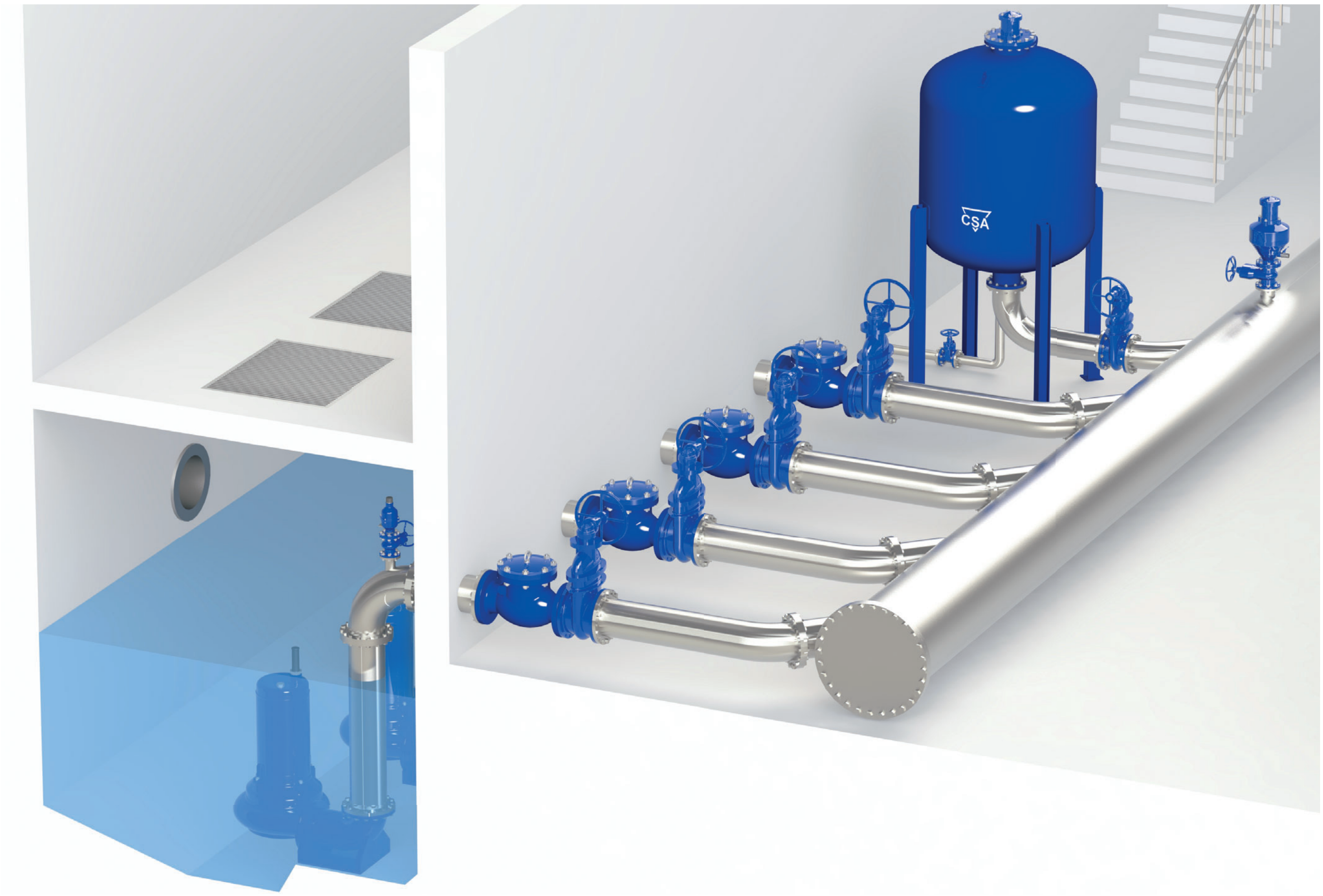

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