Water hammer arrester

525 series

01020/08 GB



Function

Water hammer phenomenon occurs in closed pipes when the fluid is accelerated or decelerated very quickly, due to the rapid closure of valves or taps or as a consequence of a circulation pump stopping.
The effect consists in the propagation of over- and underpressures along the pipes, which may result in noise and damage to the whole system.
The water hammer arrester, when installed close to single-lever mixing taps, solenoid valves, ball valves, etc., prevents such negative effects.

The use of water hammer arrester is recommended in particular by UNI 9182 regulation “Cold and hot water supply and distribution systems. Design, testing and management criteria”.

WRAS APPROVED PRODUCT

Product range

Code 525040	Water hammer arrester	size 1/2” M
Code 525130	Water hammer arrester for under sink and washhand basin application	size 3/8” F with nut x 3/8” M
Code 525150	Water hammer arrester for washing machines	size 3/4” F with nut x 3/4” M

Technical specifications

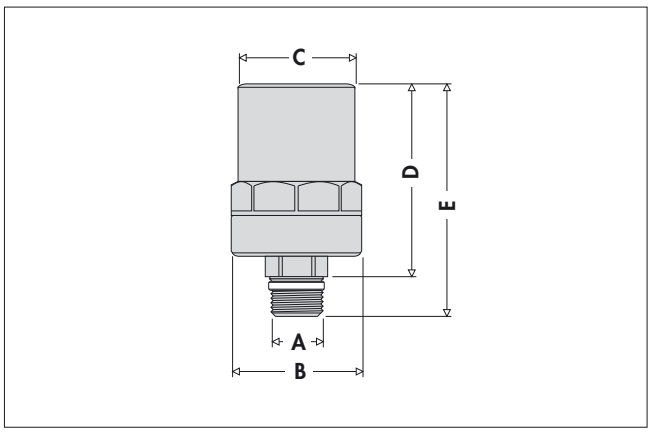
Materials

Body:	brass EN 12165 CW617N, chrome plated
Damping element:	high resistance polymer
Spring:	steel
Seals:	EPDM

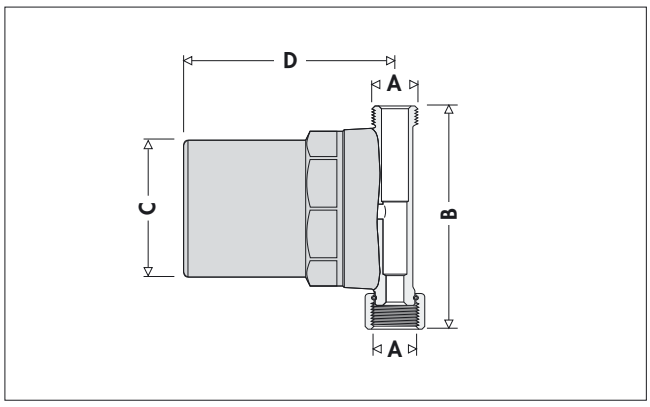
Performance

Medium:		water
Max. working pressure:		10 bar
Max. medium temperature:		90°C
Max. water hammer pressure:		50 bar
Operating start pressure:		3 bar
Connections:	- 525040	1/2” M with PTFE seal
	- 525130	3/8” F with nut x 3/8” M
	- 525150	3/4” F with nut x 3/4” M

Dimensions



Code	A	B	C	D	E	Weight (kg)
525040	1/2”	Ø 52	Ø 46	74	89	0,492



Code	A	B	C	D	Weight (kg)
525130	3/8”	75,5	Ø 46	71	0,492
525150	3/4”	84,5	Ø 46	74	0,538

The water hammer phenomenon

In domestic water systems, water hammer phenomenon occurs when a pipe is closed rapidly by a device such as a single-lever mixing tap, solenoid valve, ball valve, etc.. The abruptness of the operation creates a perturbation in the water pressure which propagates along the pipe in the form of an overpressure wave. The perturbation starts from the check device, travels upstream, reflects against other devices or elbows in the pipe and returns downstream, damping progressively. The overpressure thus adds to the existing pressure in the pipe (as visible in the next page diagram), causing the following problems:

- breakage of pipes, tanks and hoses
- wear of seals, connecting welds and sanitary appliances
- damage to shut-off, check and regulating equipments
- high noise and powerful vibrations in both the pipes and the structures.

The amount of the overpressure is influenced by numerous factors, which make the phenomenon difficult to reproduce under laboratory conditions:

- equipment closing times
- length, diameter and material of the pipe
- velocity of the water.

For the practical purpose of calculating the water hammer overpressure, the following formula combines the most common variables in a domestic water system:

$$\Delta p = \frac{2 \cdot v_1 \cdot L}{g \cdot t} \qquad (1) \qquad \left[\text{formula valid for } t > t^*, \text{ see next definition} \right]$$

Δp = overpressure due to water hammer (m w.g.)
v_1 = water velocity at time of closure start (m/s)
L = length of pipe (m)
g = acceleration of gravity (9,81 m/s^2)
t = valve closing time (s)

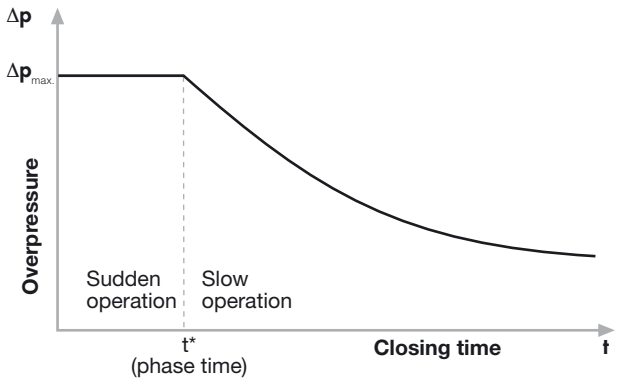
We can briefly indicate the physical significance of the "closing time" (better defined as "phase time") with the following formula:

$$t^* = \frac{2 \cdot L}{v_2} \qquad (2)$$

t^* = valve phase time (s)
L = length of pipe (m)
v_2 = velocity of the perturbation propagation (m/s) (as a function of the medium, pipe material, inner diameter and thickness of the pipe).

For mechanical devices such as single-lever mixing taps, solenoid valves, ball valves, etc., all closing times $t \leq t^*$ are defined "sudden operations" and induce a water hammer in the pipe with an overpressure at the maximum intensity, which is the same for any operating time. On the other hand, a closing time $t > t^*$ is defined "slow operation" and causes a less intense water hammer effect, which may even be negligible.
By setting $t = t^*$ within the formula (1), we obtain the maximum overpressure Δp value for the water hammer effect.

This will be evident from the following graph.



Numerical example: pipe length 10 m, diameter equivalent to 1/2", steel, copper and PE-X pipes with water velocity v_1 = 2 m/s. We give the values of the velocity of the perturbation propagation v_2, sudden operating times t^* (phase time) and the overpressure Δp obtained with the formulas.

	L (m)	v_1(m/s)	v_2 (m/s)	t* (ms)	Δp (m w.g.)	Δp (bar)
Steel	10	2	1411	14,2	288	28,8
Copper	10	2	1400	14,3	285	28,5
PE-X	10	2	885	22,6	180	18

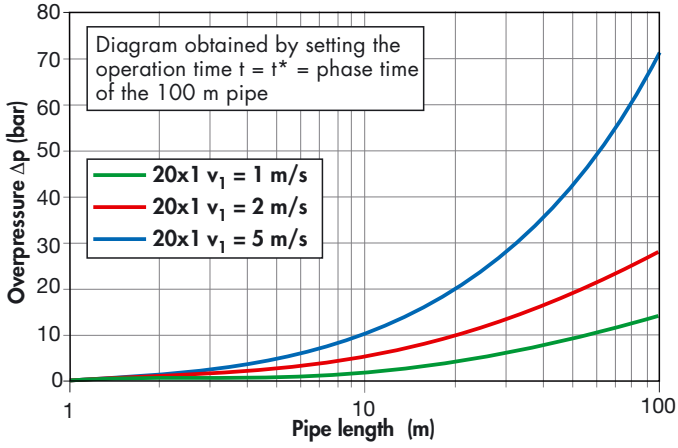
Due to the greater stiffness of metal pipes, the velocity of the perturbation v_2 is greater than in plastic pipes and close to the velocity of sound in water (1420 m/s at 7°C). From these results, it is evident that plastic pipes for domestic water systems are more easily subject to water hammer, since they have a longer phase time t^* than metal pipes. In practice, this means that closing operating times must be slower than in metal pipes. Although the overpressure values Δp for plastic pipes are lower than those for metal pipes (since they are less stiff, they partially dampen the water hammer), such overpressures can nonetheless stress the pipes beyond their resistance limit. Furthermore, in wall installations, the presence of a corrugated sheath or insulation influences the stiffness of plastic pipes, making the calculation of the water hammer even more complicated.
From the example given, it is clear that the use of a water hammer arrester, already useful for metal pipes, is even more advisable for domestic water systems with plastic pipes, especially if installed externally.

The graph at the bottom of the page shows the influence of the various parameters on the overpressure in copper pipes at the time of the pipe closure. The three curves were obtained setting a closing time t equal to the phase time t^* of a 100 m pipe of size 20x1.

Copper pipe	v_2 (m/s)	t* (ms) 100 m pipe
20x1	1393	143,5

We can draw the following conclusions:
1) The longer the pipe, the greater the phase time t^* and hence operations must be slower to prevent water hammer (formula (2)).
2) For a given operating time t and medium velocity v_1, the longer the pipe, the greater the Δp caused by the operation (formula (1)).
3) For a given medium velocity v_1 and length of pipe, larger diameters yield a slightly lower Δp (formula (1), but the difference is close to be negligible).
4) For a given pipe length and operating time t, if the medium velocity v_1 increases, the Δp generated by the operation also increases (formula (1) and graph at foot of page).

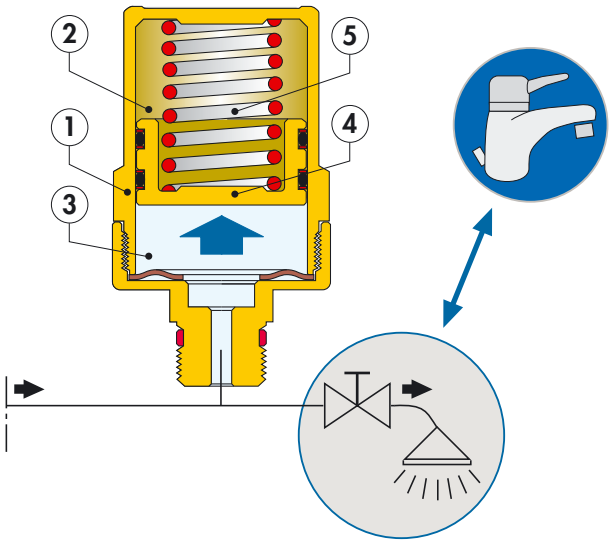
Overpressure in copper pipe 20x1



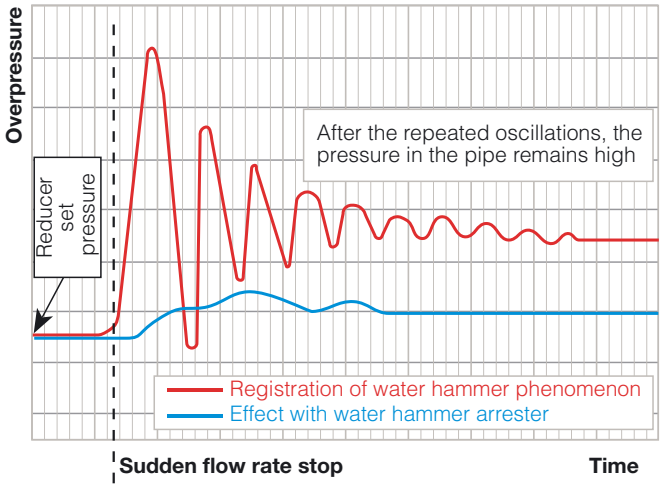
Operating principle

The Caleffi 525 series water hammer arrester is composed of a cylinder (1) divided into two chambers (2) and (3) by a piston with two o-ring seals (4). The closed chamber (2) contains air and acts as a damper due to the compressibility of the air. The open chamber (3) is connected directly to the pipe and fills with the system water. The water thrust on the piston is counteracted both by the air pressure variation in the chamber (2) and by the contrast spring (5) housed behind the piston in the air chamber.
The oscilloscope graph reveals the following:

- speed of the pressure increase
- oscillatory character of the phenomenon
- continuance of high pressure in the pipe even after the water hammer
- **effectiveness of the water hammer arrester.**



Water hammer arrester - effectiveness



Certified performance

The Caleffi 525 series water hammer arrester has been tested by KIWA (NL) to verify the conformity to the performance requirements for water hammer devices (reference standard BRL K632/02). The laboratory tests showed that the Caleffi 525 series provides a water hammer overpressure damping ratio of more than 60%.



Construction details

Reduced dimensions

Water hammer arresters are easy to install in the system, preferably in the vicinity of the shut-off devices which originate the overpressure to damp.

Maintenance free

Compared to pneumatic arresters, Caleffi 525 series arresters, since mechanical, are maintenance free.

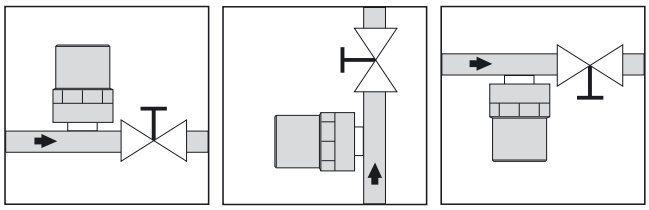
Foodsafe elastomers and other materials

The elastomers used in the seals and the other materials comply with the compatibility requirements for use with potable water as required by WRAS certifications.

Reference standards

Article 15 of UNI 9182 (IT) "Cold and hot water supply and distribution systems. Design, testing and management criteria", specifies that: *"All cold and hot water distribution systems must be equipped with water hammer arrester of the mechanical (spring) or hydropneumatic (permanent or serviceable air cushion) type..."*
The installation of the water hammer arrester must also comply with the *"Guidelines for the prevention and control of Legionnaire's Disease"*, as set out by the Ministry of Health and adopted by the Regional State Conference on 4.4.2000. The arresters must be installed in such a way as not to create zones of stagnant water, which may be difficult to reach for the purposes of disinfection.

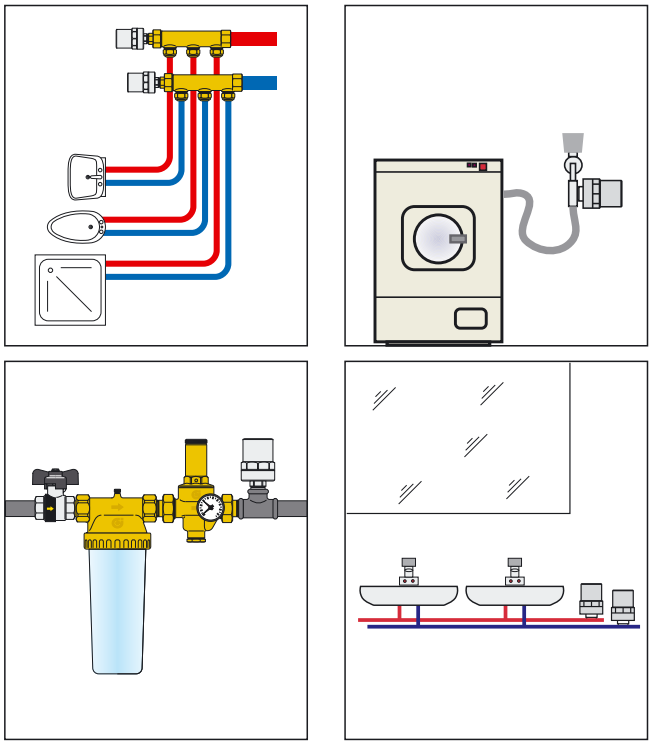
Installation



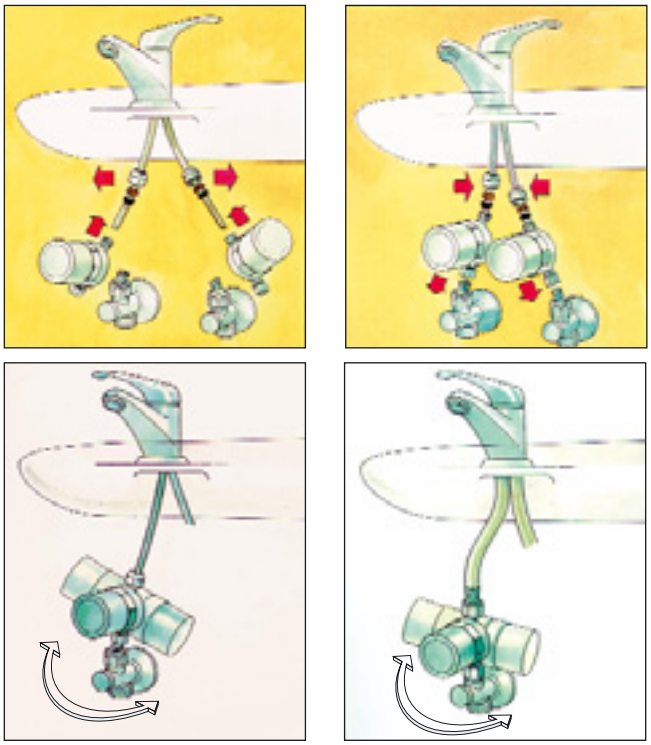
The Caleffi 525 series water hammer arrester must be installed as close as possible to the device which gives rise to the water hammer by suddenly shutting off the water flow, so as to damp the resulting overpressure as soon as possible. It may be installed horizontally, vertically or upside down.
For better results, the installation of the Caleffi 525 series should include the following:

- installation at the public network inlet of a pressure reducing valve to keep the system pressure at 3-4 bar, which is the optimal value for the operation of the water hammer arrester as well as the sanitary appliances;
- reduction of the water velocity in the pipes. The water velocity directly affects the overpressure in case of rapid closure of the pipe.

The recommended solution is that shown below, where the water hammer arrester is installed either next to the end user service or at the main connection of a distribution manifold for a small group of domestic appliances.



When installing the water hammer arrester under sinks and washhand basins, code 525130, create a space of 5-6 cm between the copper pipes and the threaded section of the shut-off valves. The radial connections enable water hammer arrester to be rotated to fit the available space.



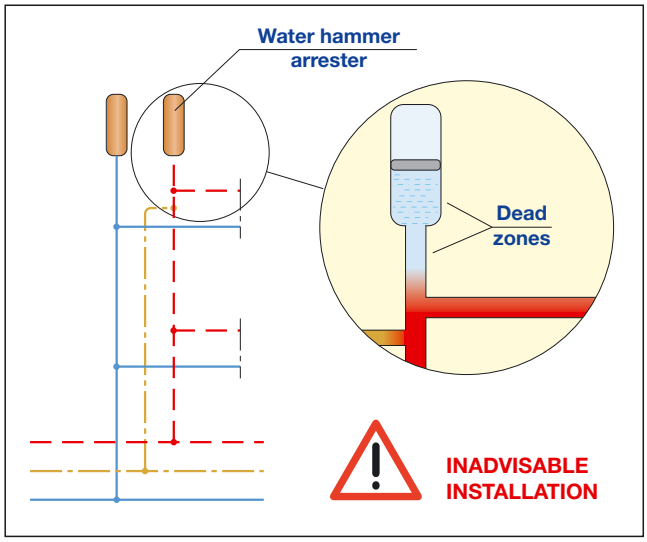
Installation recommendations

The Caleffi 525 series water hammer arresters are designed for single service installation (under washhand basins) or small groups of services, such as in a bathroom supplied by a domestic manifold. For larger scale water hammer problems, the solutions are different and must be designed to fit the particular case. One possible solution to water hammer may be to install an expansion vessel to act as an arrester.

The traditional approach of installing water hammer arresters at the top of rising column, requires a review in the light of legislation about Legionnaire's Disease.

Although this solution was effective in attenuating water hammer, it is counterproductive in terms of system disinfection (both thermal and chemical) since it creates two types of hard to reach dead zones:

- sections of pipe connecting the hot water rising pipes with the water hammer arresters above the recirculation connections;
- zones of stagnant water inside the water hammer arresters themselves.



SPECIFICATION SUMMARIES

525 series

Water hammer arrester. Threaded connections: 525040 1/2" M with PTFE seal on thread, 525130 3/8" F with nut x 3/8" M, 525150 3/4" F with nut x 3/4" M. Chrome plated brass body, high resistance polymer damping element, stainless steel spring, EPDM seals. Medium water. Maximum water hammer pressure 50 bar. Operating start pressure 3 bar. Maximum working pressure 10 bar. Maximum medium temperature 90°C.

We reserve the right to make changes and improvements to the products and related data in this publication, at any time and without prior notice.

CALEFFI

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