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The pre-pressure for an expansion vessel in the attic

White paper

October 2015

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A half is more than one

The relationship between pre-pressure, filling pressure and final pressure

There are many theories about the best pressure to fill a central heating installation with in relation to the pre-pressure of the expansion vessel and the final pressure in the system.

An incorrectly set system can cause problems:

- If there is too much water in the system, the final pressure of the system will be reached too quickly. The safety valve then opens unnecessarily and the boiler malfunctions.

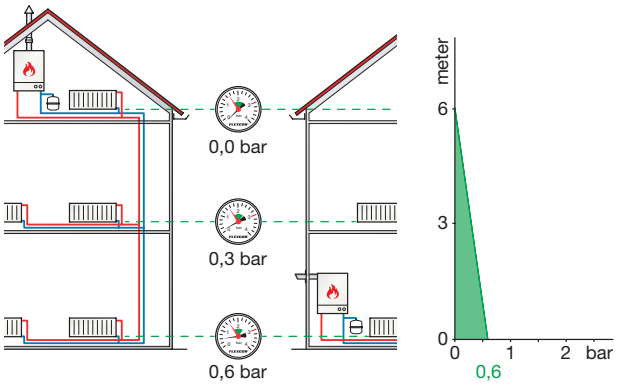
- Insufficient filling of the system can cause the expansion vessel to run dry when the system cools down. This causes the pressure to drop suddenly, which also results in the boiler malfunctioning. A vacuum may even arise, causing problems with air in the system.

In this white paper, we explain which pre-pressure is best for an **attic installation**.

Some basic terms

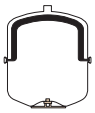
Static pressure

This the pressure that is caused by the weight of the water column above the measuring point. If the system is merely filled with water and not pressurised, the pressure at the top will be 0.0 bar. For a system that is, say, 6 metres in height, a pressure of 0.6 bar can be measured at the bottom.



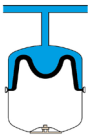
Pre-pressure

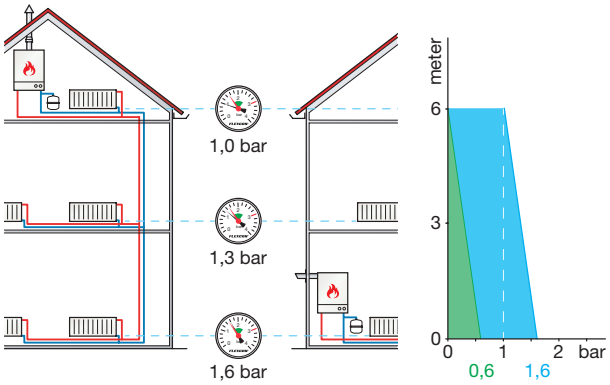
This is the pressure of the gas in the expansion vessel when it is not yet connected to the system.



Filling pressure

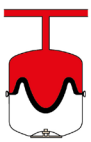
As soon as additional water is added to the system, the pressure increases. This additional pressure of, say, 1 bar is in addition to the present static pressure.
The filling pressure is the pressure to which the system is filled when cold. As soon as the pressure in the system exceeds the pre-pressure in the expansion vessel, water runs into the vessel. In this way, the pressure in the system remains the same as the pressure in the expansion vessel.

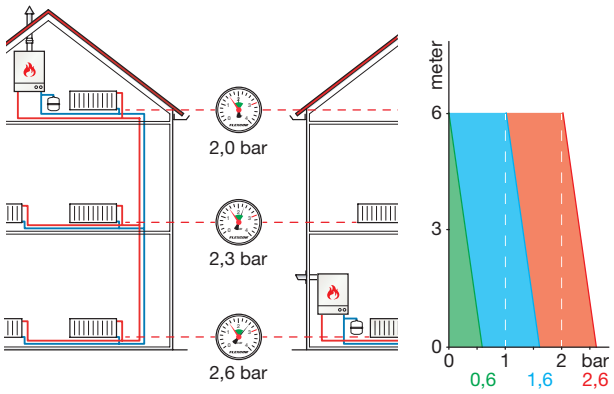




Final pressure

When water in a sealed system is heated, it expands and increases the pressure. The pressure rises until the maximum temperature is reached or until the safety valve opens. The final pressure is the pressure produced at the maximum temperature. The maximum permissible final pressure is determined by the set pressure of the safety valve.





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The most important functions of an expansion vessel in a sealed central heating installation

Holding and returning central heating water

Water that is heated, by a boiler for example, expands. Unlike air, water cannot be compressed. Since most central heating installations are sealed, extra space has to be created for the expansion of the central heating water. The function of the expansion vessel is therefore to hold the extra volume of water created, which in turn limits the increase in pressure. As soon as the water cools again, the expansion vessel must ensure that the water is returned to the installation so that the system remains at the proper pressure.

If a central heating installation holding 100 litres of water is heated from 10°C to 80°C, the water will expand by about 3%. The expansion vessel must hold this 3%, or 3 litres for this particular system.
The pressure can be increased until the pressure in the central heating system reaches the opening pressure of the safety valve. Indeed, when the valve opens, the expansion water is drained away, causing the pressure to drop again. In most cases, a safety valve is used that opens at 3 bar.

However, it is not desirable for the valve to open. When expansion water overflows through the valve and the system cools down again, which makes the water contract again, the discharged expansion water can no longer be returned to the system. There is then a greater chance of there being too little water and thus too little pressure as well. In addition, the overflow can cause limescale to settle between the valve and the valve seat. Consequently, the valve will no longer close properly and will drip constantly. The system must then be regularly topped up with (oxygen-laden) tap water, which increases the chance of air and corrosion problems.

The system pressure must therefore be calculated so that it never reaches 3 bar. Safety valves also have a tolerance, so some leeway is necessary up to the 3 bar opening pressure. The best thing is to anticipate a maximum permissible final pressure of at least 10% below the opening pressure of the valve. This will ensure that the safety valve does not open under normal operating conditions.
In this calculation, the maximum permissible final pressure is therefore 2.7 bar.

Water reserve

Another function of an expansion vessel is to maintain system pressure in the event of slight water loss. The system needs additional water as a result of venting (air is replaced with water) or small leaks through a “sweating” coupling. Is there is no water reserve, the system pressure falls continuously and the system can even become depressurised as it cools. In some instances, if this occurs, the boiler will fail. If the boiler does not fail, the pump will start cavitating due to the low pressure and will ultimately fail. It is also possible that the water in the boiler will be temporarily converted into steam, which will cause a lot of damage to the components (such as the heat exchanger).
If an expansion vessel still has a little reserve in it when the system is cold, it will return it to the installation and thus ensure that pressure is maintained. The greater the available water reserve, the less often the system has to be topped up.

Returning water to the installation is only possible if the pressure in the installation is greater than the pre-pressure of the expansion vessel. Only then will there be water in the expansion vessel. As soon as the

pressure in the system is lower than the pre-pressure in the expansion vessel, the pressure in the installation drops to zero. Due to the membrane, however, the expansion vessel will never push any gas into the installation. The pre-pressure in the expansion vessel pushes on the water up to the water nipple.

The water reserve is easily calculated with the difference between the filling pressure and the pre-pressure.
Pressurising when cold:

$$\text{Water reserve} = \frac{(\text{filling pressure} +1) - (\text{pre-pressure} +1)}{\text{filling pressure} +1}$$

Expansion vessel with low pre-pressure
An expansion vessel with a low pre-pressure can hold more reserve water and thus maintain a system at pressure for longer. Most central heating boilers have a warning mark on the pressure gauge when the pressure drops too low. Mostly around the 0.7 bar mark. If the pre-pressure in the vessel is below this warning mark, e.g. 0.5 bar, there is enough time to top up the system.

Expansion vessel with high pre-pressure
If an expansion vessel has 1 bar of pre-pressure, the installation will become depressurised if the pressure in the system drops below 1 bar. The central heating boiler will not have given a warning by this point. In this case, a half is more than one!

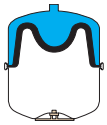
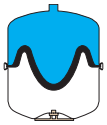
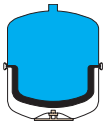
Pre-pressure, filling pressure and final pressure

So what happens at a pre-pressure of 0.5 or 1 bar if the maximum final pressure in the system is 2.7 bar? An expansion vessel of 18 litres is installed and the system capacity is 100 litres. We have already read that water expands about 3% when it is heated from 10°C to 80°C.

Expansion vessel with a pre-pressure of 0.5 bar
An expansion vessel with a pre-pressure of 0.5 bar already has 4.5 litres of water in the expansion vessel at a filling pressure of 1 bar. This is thus the water reserve.

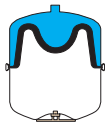
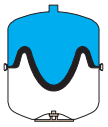
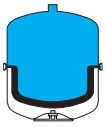
Between 1 bar and 2.7 bar, the expansion vessel can hold an additional 6.2 litres, which is the so-called expansion volume. This is more than sufficient for the 3 litres of actual expansion water.

If we take a filling pressure of 1.5 bar in this situation, then the water reserve is 7.2 litres and the expansion volume is 3.5 litres. This is insufficient.

Installation filled cold up to 1 bar		**Installation filled cold up to 1.5 bar**		**Installation filled cold up to 2 bar**	
	There are now 4.5 litres of water in the vessel (reserve)		There are now 7.2 litres of water in the vessel (reserve)		There are now 9 litres of water in the vessel (reserve)
There are 6.2 litres left over for 3 litres of expansion water		There are 3.5 litres left over for 3 litres of expansion water		There are 1.7 litres left over for 3 litres of expansion water	
Enough ‘space’ for expansion water				1.3 litres of water disappears via the safety valve. This causes the installation pressure to automatically drop.	

Expansion vessel with a pre-pressure of 1 bar
If we apply a pre-pressure of 1 bar with a filling pressure of 1 or 1.5 bar, the following happens:

Filling pressure 1 bar: no water reserve! However, 8.3 litres of expansion volume is available.
Filling pressure 1.5 bar: 3.6 litres of water reserve and 4.7 litres of expansion volume.
Filling pressure 2 bar: 6 litres of water reserve and 2.3 litres of expansion volume (too small).

Installation filled cold up to 1 bar		Installation filled cold up to 1.5 bar		Installation filled cold up to 2 bar	
	There is now no water in the vessel.		There are now 3.6 litres of water in the vessel (reserve)		There are now 6 litres of water in the vessel (reserve)
There are 8.3 litres left over for 3 litres of expansion water		There are 4.7 litres left over for 3 litres of expansion water		There are 2.3 litres left over for 3 litres of expansion water	
Enough ‘space’ for expansion water				0.7 litres of water disappears via the safety valve. This causes the installation pressure to automatically drop.	

If we compare these two pre-pressure settings, we therefore see that the expansion vessel with 0.5 bar pre-pressure performs much better. In addition, the system pressure only falls below 0.5 bar, allowing the expansion vessel to maintain pressure in the system for longer.

We can therefore draw the following conclusions:

- A greater difference between pre-pressure and final pressure delivers better performance by the expansion vessel. The range for holding water is greater, giving more space for expansion water and water reserve.
- The greater the difference between pre-pressure and filling pressure, the more water reserve the expansion vessel holds. Note: there must still be sufficient space ‘left over’ for the expansion water.
- The smaller the difference between filling pressure and final pressure, the less space for expansion water. If the filling pressure is too high, the safety valve may open!
- The lower the pre-pressure, the longer the expansion vessel maintains pressure in the system.

On the basis of the above examples and conclusions, a pre-pressure of 0.5 bar is preferable in an attic set-up.

If you have any further questions, please contact:

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