STUDOR®
INVENTIVE TECHNOLOGY

The **STUDOR**® **P.A.P.A.**™

POSITIVE **A**IR **P**RESSURE **A**TTENUATOR

A revolutionary product from **STUDOR**

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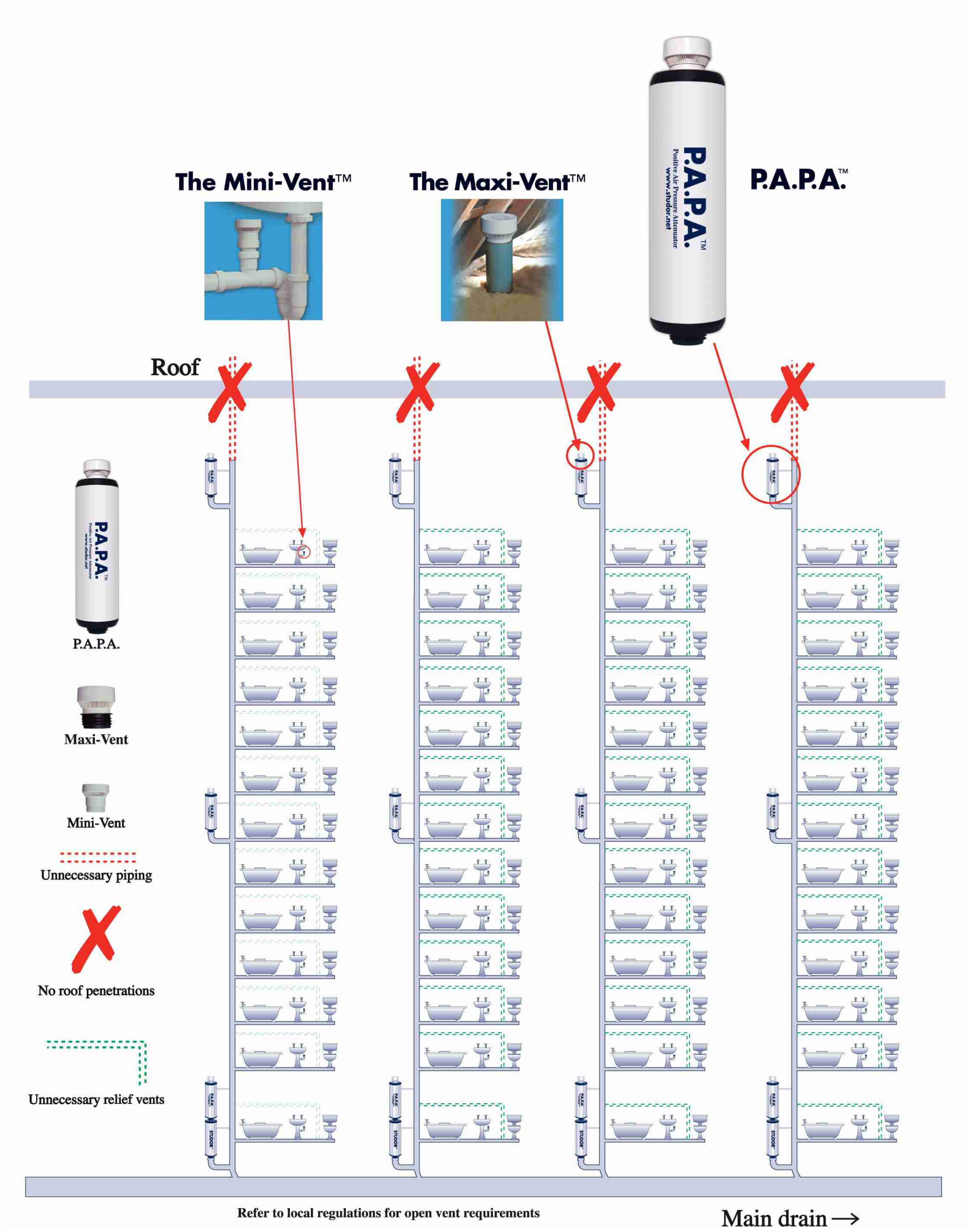
Glossary

air admittance valve	A device which allows fresh air to enter and vent the drainage system, but closes to prevent the release of foul sewer gases.
pressure attenuator	A device that reduces the peak air pressure by absorbing a percentage of the incoming transient.
back-pressure	A quasi-steady air pressure generated due to the passage of an entrained airflow through a water curtain at the base of a stack or at an offset.
induced siphonage	Caused by the discharge of water from another sanitary appliance connected to the same discharge pipe. As the water falls down the pipe and passes the branch pipe connected to it, it draws air from it, thus creating a partial vacuum and subsequently siphonage of the trap takes place.
line pressure	The air pressure in a branch or stack prior to the arrival of a transient.
modified one pipe system	Introduced from 1960s, a separate stack is provided for the waste and water discharge from appliances and a separate stack as a vertical system vent. Individual appliances are not directly connected to the vent stack, rather there are cross connections between the waste stack and the vent stack, typically on alternate floors. Note that the cross connections are angled upwards to prevent water flow into the event stack.
negative transients	A travelling pressure wave that reduces the line pressure, negative transients are generated by an increase in water flow and entrained airflow.
offset	A change of direction in the stack, not recommended as good design as it may cause local surcharge.
one pipe system	Introduced from 1930s, a separate stack is provided for the waste and water discharge from appliances and a separate stack as a vertical system vent. Individual appliances may be directly connected to the vent stack to provide individual venting.
peak flow	The maximum flow-rate achieved during an appliance discharge or during any observation period.
peak frequency	The highest oscillation frequency observed.
peak pressure	The highest pressure recorded during an observation period.
pipe period	The time taken for a transient to travel at its acoustic velocity to a reflector (typically a junction or branch termination) and return to its point of propagation.

positive transients	A travelling pressure wave that increases the line pressure, positive transients are generated by a decrease in entrained airflow or an interruption to the established airpath, for example a flow surcharge.
pressure profile	Either the graph of pressure versus time at any location within the network (often recorded by a pressure transducer) or the variation in pressure at any particular time throughout the system, usually confined to pressure at one time up the full height of the vertical stacks.
self-siphonage	Self-siphonage is caused in appliances such as wash basins, designed to be able to discharge their contents of water quickly. As the water discharges it sets up a plug of water which, as it passes down the pipe, creates a partial vacuum, causing siphonage of the trap to take place.
siphonage	Removal of a trap seal by the action of self- or induced siphonage where the pressure on the system side of the trap falls below atmosphere, effectively drawing the trap seal water into the network.
single stack system	Introduced in the UK in the 1970s, a drainage system where there is one vertical stack that acts both as a vent and as the conduit for waste and appliance discharge flow to the sewer connection.
trap seal	A water filled U-tube barrier placed between the appliance and the system branch to prevent the egress of contaminated air or noxious gas from the sewer into habitable space. As a U-tube is effectively a manometer, it responds to changes in system line pressure and may be depleted by the action of both positive and negative transients.
two-stack system	The original Victorian drainage network where foul and waste water were separated. Separate vent and waste stacks were provided, with each appliance vented individually to the appropriate vent stack. Fell into disuse after the 1930s.
water trap	See **trap seal**.
wave front	The leading edge of a pressure transient, positive or negative, that propagates throughout the system at its acoustic velocity.

Venting Technology from STUDOR

The unique design of the revolutionary **STUDOR P.A.P.A.** (**P**ositive **A**ir **P**ressure **A**ttenuator) unit provides protection against **positive transients** in drainage systems, thereby protecting the trap seals without the need for costly roof penetrations.



Positive Transients in Drainage Systems

Positive transients occur in gravity drainage systems. They are produced at offsets, fittings, peak flow and sudden blockages in the system. Positive transients move through the drainage system at speeds up to 320 m/s - the speed of sound. In extreme cases this could lead to the trap water seal blowing out of the appliance and foul air entering into the living space.

Single stack systems in building designs have been used to reduce the complexity of other venting system. Air Admittance Valves (AAVs) have been in use for over thirty years, with **STUDOR** being the leading innovator. AAVs are designed to deal with the negative transients in the drainage system, thus protecting the water traps from self- or induced siphonage. AAVs only have limited protection against positive transients in the system. As AAVs typically reduce the entrained airflow, the positive transient generated on interruption of that airflow has therefore been limited to venting buildings up to ten storeys high.

As the construction industry has advanced with the introduction of new technology and materials, buildings are being built increasingly higher. One of the main disadvantages in tall buildings, with regards to drainage, is positive transients. Therefore, many of the world's regulatory bodies have insisted on the provision of a separate vent stack; either connected to each appliance – the one-pipe system; or cross connected to the wet stack on alternate floors – the modified one pipe system. However, with the use of the **P.A.P.A.** there is no longer a need to have one or more stack vents running the full height of the building!

Air pressure transients, both negative and positive, are undesirable but inevitable in building drainage systems. Unlike other fluid transportation systems, it is more difficult to predict the source of the transients in a drainage system, mainly because there are no valves to inhibit the flow and due to the existence of solids in the waste. The main cause of transients are blockages to prevent the passing of air caused as a result of waste water flowing from a branch into the stack, or a change of direction of the main drain at the base. Another design, which may cause problems, is an offset in the vertical stack.

The STUDOR P.A.P.A.

The **P.A.P.A.** unit is a device to enable designers and engineers to produce drainage systems with problem free venting. The **P.A.P.A.** unit will save time and space, both of which are at a premium in large projects. The designers will not have to incorporate the need for relief vent piping throughout the building in their plans. When using **STUDOR** products, the engineers can have confidence in their system planning because both negative and positive transients are taken care of.

The **P.A.P.A.** unit is the invention of Professor John A. Swaffield and Dr David Campbell of Heriot-Watt University in Edinburgh, Scotland. The Drainage Research Group at Heriot-Watt University, headed by Professor John A. Swaffield, is one of the world's leading authorities in scientific research in the field of drainage. **STUDOR** and Heriot-Watt University have worked in close partnership to produce a device that can solve the problem of positive transients in drainage systems and, in so doing, simplifying the venting of drainage systems. When using the **P.A.P.A.** unit, hydraulic engineers no longer have to plan complicated venting systems to maintain the water traps in their buildings.

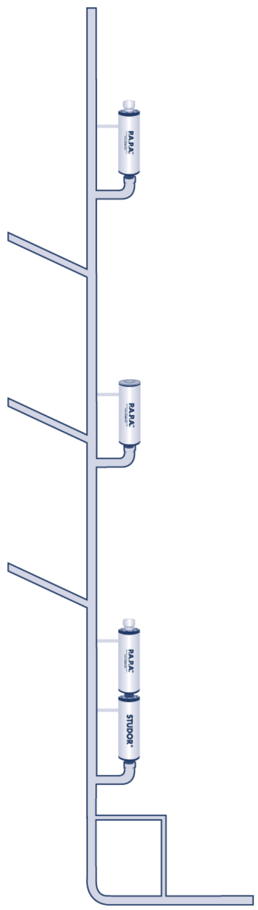
The unique design of the revolutionary **P.A.P.A.** unit provides protection against positive transients, thereby protecting the trap seals without the need to penetrate the roof and extensive vent piping.

The **P.A.P.A.** unit is compact in size, with a diameter of 200mm and an overall height from the cap to the bottom of the connector on the base of the unit of 750mm.

Advantages of the STUDOR P.A.P.A.

The **P.A.P.A.** unit has been designed with practicality in mind:

1. Simplifies the design of cost complicated drainage systems in high rise buildings.
2. Cost saving.
3. Labour saving.
4. One man installation (no health and safety issues).
5. No regular maintenance required.
6. Designed to work in extreme environments.
7. Resistant to many chemicals.
8. Suitable for installation on commercial sites.



The **P.A.P.A.** unit is a non-mechanical device, without any moving parts, and not requiring maintenance after installation. The operation of the **P.A.P.A.** is steered by the occurrence of transients.

Locating the STUDOR P.A.P.A.

In high rise buildings when the pressure in the system responds to the generation and propagation of transients by airflow interruption resulting from a sudden blockage, it will produce peak pressure relative to the line pressure in the system at that point in time. The transient propagates through the system, as the peak pressure is relative to the line pressure prior to the arrival of the wave front. This means that the pressure profile in the stack is constantly changing. It is virtually impossible to predict, without recourse to the available simulations, where the greatest area of risk in the system will be.

Effectively the transient 'runs' over the line pressure profile in the stack, adding a positive pressure to the existing line pressure that may well be highly negative. An interesting consequence of this is that if a transmission is generated below a water inlet into the stack (where a large suction pressure may exist), it may be several floors above this blockage that the first positive pressures are recorded as a result of the pressure transient experienced. This may explain occurrences of trap seal loss in unexpected places. It may also be the case that trap seal problems, attributed to the siphonage in upper parts of the building, could have, in fact, been caused by positive transients interacting with the initial pre-transient pressure profile in the stack. There are therefore several issues to be recognised as the system responds to transient propagation:

- the pressure profile is constantly changing;
- the area of risk to trap water seals is dynamic and constantly changing;
- the volume of extra air in the system will depend on airflow rate, closure times of blockages and the AAVs' pipe period of the system - all of which are not constant.

To deal with these uncertainties, the **P.A.P.A.** units should be distributed throughout the system. The following is a guideline of how many **P.A.P.A.** units would be required per stack. This would vary depending on the plumbing design. For example, in the case of a restaurant situated on the 30th floor of a building, the peak frequency would be higher due to the peak flow demand. Therefore, it would be recommended that two **P.A.P.A.** units in series be installed below this floor.

5 - 8	floors:	one unit on the base
8 - 15	floors:	three units, one on the base, one halfway and one at the top
15 - 25	floors:	one unit on the base, then one unit on every fifth floor
25 - 50	floors:	two units in series on the base, then one unit on every third floor
50 +	floors:	please consult **STUDOR**

In the case of low flow discharge to stacks, the use of 1 **P.A.P.A.** unit at the base may serve 10 floors.

STUDOR offers a full planning service for designs of drainage venting systems incorporating the **STUDOR** products.

With the **P.A.P.A.** units installed throughout the system, the protection against positive transients would not be more than ten floors away. Therefore the transient is dealt with before it can affect the whole system. It is essential to recognise that to be effective, a pressure transient attenuator must be placed between the source of the transient and the appliance to be protected. The interaction between the positive transient and the line pressure over which it propagates also affects whether the attenuator will open to absorb the transient. Thus, a distributed series of attenuators becomes necessary within a tall building. The alternative to a blanket introduction of attenuators would be an in-depth analysis of the likely transient propagation for that building drainage system design, which could be prohibitive. Series installation therefore provides protection as the transient modifies the local system air pressure.

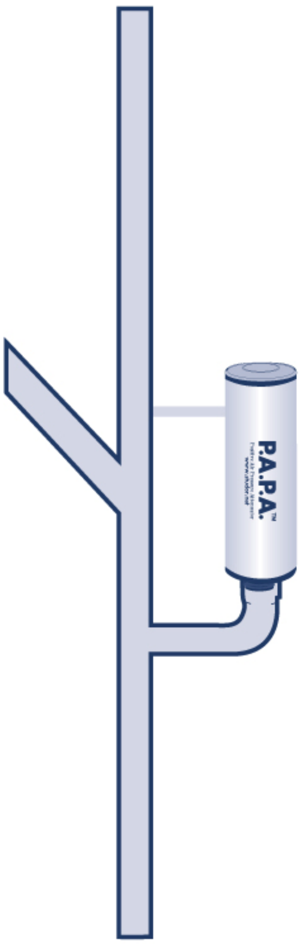
The base of the stack is the most likely place for a full blockage or surcharge to occur. As the distance between the base and top of the stack is the maximum distance possible, the time taken for a relief pressure wave to return to the source of the transient is the greatest for the system and therefore a blockage in this location will lead to the greatest possible rise in pressure. It is therefore recommended to use two **P.A.P.A.** units in series at the base of the stack on buildings over 20 storeys high. The **P.A.P.A.** units should be located below the lowest branch connected to the stack. This restriction is important as the **P.A.P.A.** units should be installed in a zone where the line pressure is normally below atmosphere. This ensures that the full expansion capability of the unit is available to attenuate the transient.

Installation method

The **P.A.P.A.** unit can be installed vertically onto the stack by using either one 90° bend, or two 45° bends, so it uses less space.

The **P.A.P.A.** unit is pushed into the pipe using the synthetic rubber connector that fits into 75 mm and 110 mm pipes.

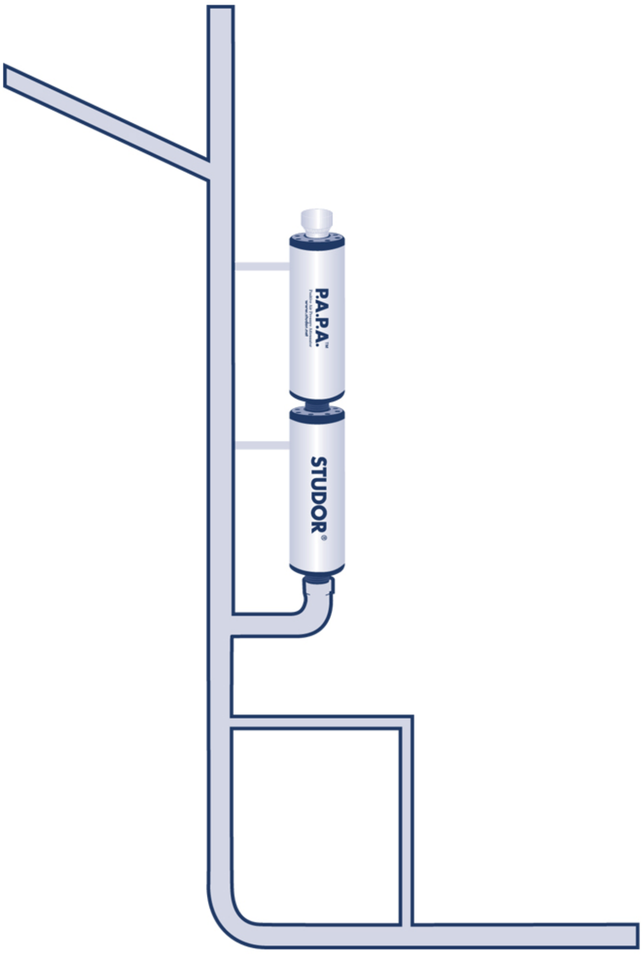
The **P.A.P.A.** units can be installed as a standalone fitting. The configuration of a **P.A.P.A.** unit installed without a **Maxi-Vent** should be used to solve problems on floors where no extra ventilation is required.



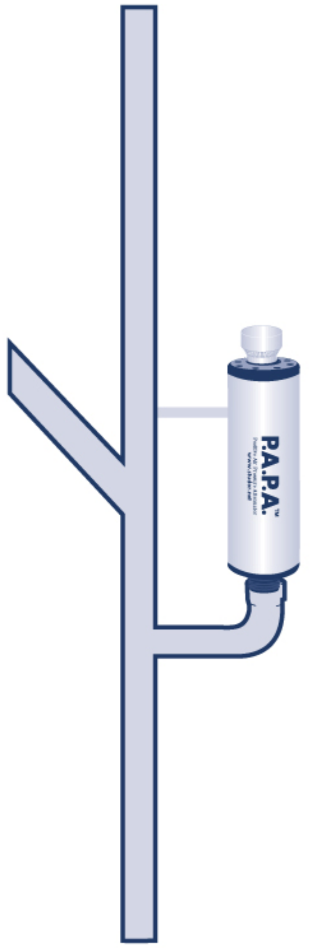
When installed without a **Maxi-Vent**, the **P.A.P.A.** unit may be positioned horizontally.

The **P.A.P.A.** units can be installed in series, which will add additional protection. This is recommended at the base of the stack, or at any point where heavy use is expected, for example sports stadiums, etc.

The **P.A.P.A.** units have been designed so they can be built in series, which enables them to solve - or prevent - problems in areas of large positive transients. Up to a maximum of four units can be placed in series.

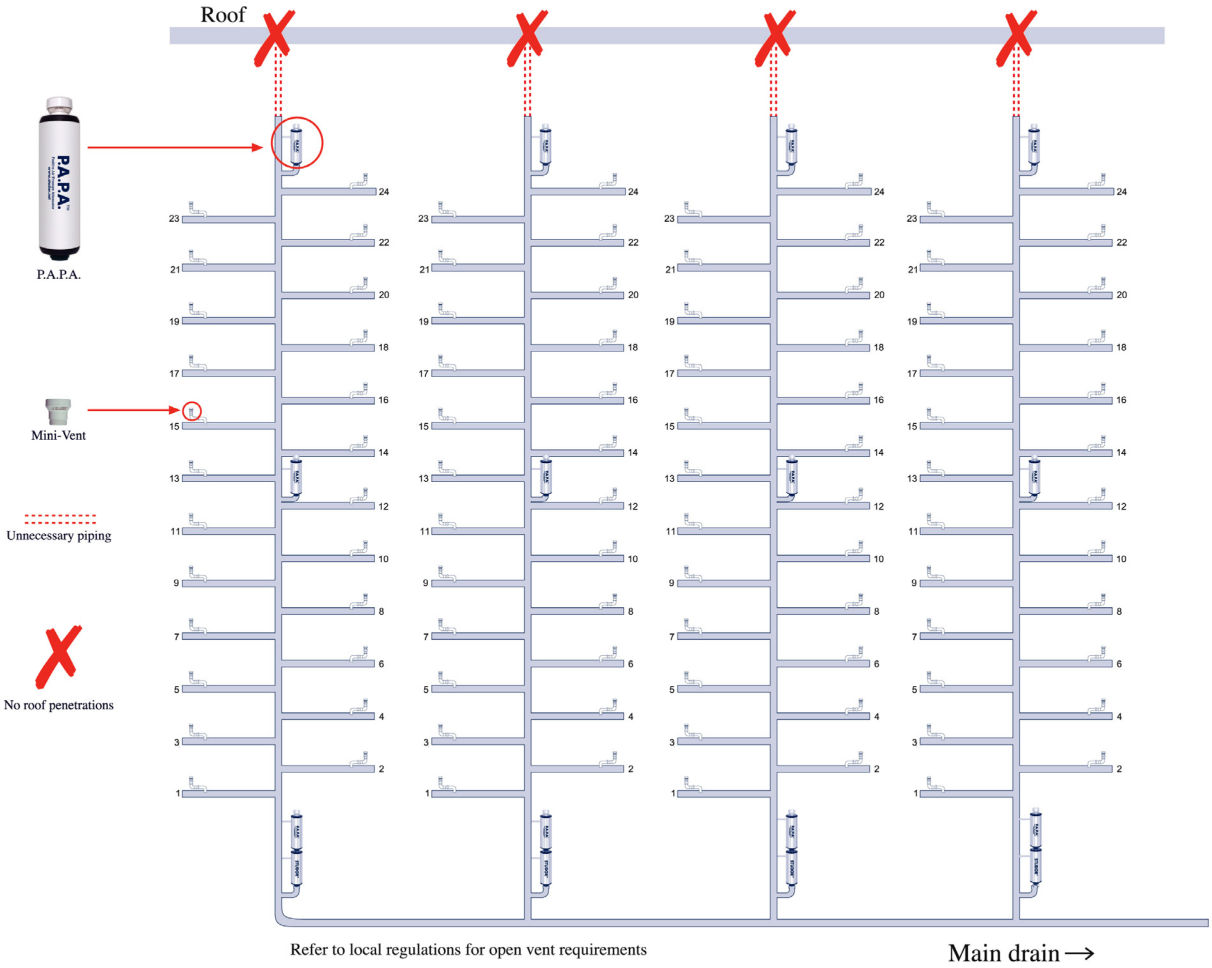


It is recommended that the **P.A.P.A.** units be installed with a **Maxi-Vent** on top. The cap of the **P.A.P.A.** unit should be removed and the **Maxi-Vent** pushed onto the unit using the connector. This will turn the **P.A.P.A.** unit into a positive and negative protection device. Distributed venting will limit the extent of the final pressure because the path of the air intake will be shorter.



When installed with a **Maxi-Vent** on top, the **P.A.P.A.** unit must be positioned vertically.

Note: The **P.A.P.A.** unit does not solve the problem of a slow buildup of pressure, a sustained positive pressure originating from deposits blocking the pipes, the blockage of a public sewer, an overloaded septic tank, etc.



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