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SIPHONIC ROOF DRAINAGE SYSTEMS: THE ROAD TO PRIMING

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SIPHONIC ROOF DRAINAGE SYSTEMS: THE ROAD TO PRIMING

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ABSTRACT
In this article the start up of a siphonic roof drainage system is described. It is intended to give better insight in the behavior of the system and help design systems that will work optimally and siphonic more often. The development of the hydraulic jump and the elimination of air from the system by the suction power in the downpipe are key items in the development of siphonic functioning. To reach siphonic drainage as quickly as possible a longer vertical tailpipe as well as a quick deceleration in the horizontal pipe is preferable.

1. INTRODUCTION

Siphonic roof drainage systems are designed to operate with full bore flow. The computations made for siphonic roof drainage systems therefore focus on single phase water flow. For the proper design of the maximum capacity of a siphonic system this is sufficient.

However it is necessary to have a good insight in the start up phase to siphonic functioning of the system as well. Most of the times the rain intensity will not be high enough to get the system to work siphonic. It is preferable to have the system work siphonic once or twice a year at least to self clean the system of debris. Also when the system works siphonic the noise production is lower than with two-phase flow (combined water/air flow).

In this article the start up phase will be described to have a better understanding of the phenomena and develop measures to stimulate full bore flow.

2. START UP PHASE

When the rain starts the roof drainage system slowly starts up. At first the water flows into the roof outlet at a low rate and shallow water level. The water flows along the vertical walls of the tail pipe creating an annular flow. At the bend to the horizontal tail pipe or collector pipe the flow collects at the bottom of the bend resulting in a separated flow in the horizontal pipe. In the downpipe behind the collector pipe the water is forming an annular flow again.

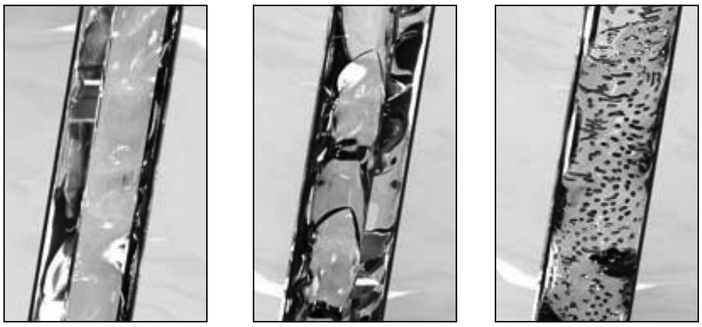

Illustration 1: flow regimes in vertical pipes: annular, slug and bubble flow.

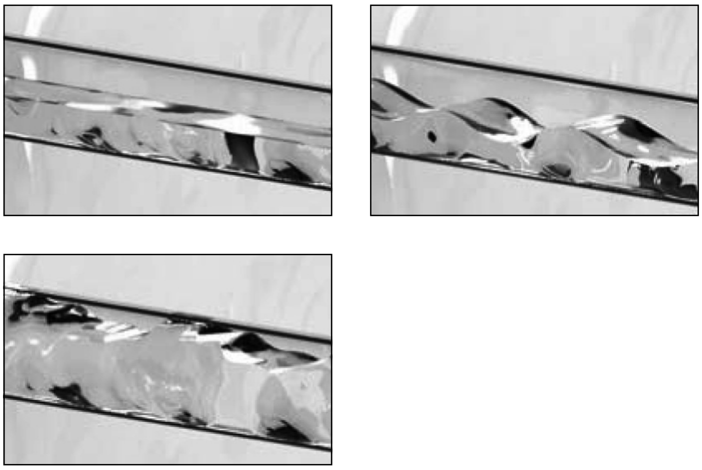

Illustration 2: flow regimes in horizontal pipes: straight, wavy and slug flow.

This is independent of the water velocity streaming into this pipe. The flow can follow the inner contour of the bend or splash onto the opposite wall. The point at which the annular flow is reinstalled will differ, as will the pressure distribution when the pipe is closed off by the splashing water.

At some higher flow rates the separated flow in the horizontal pipes will become wavy.

3. HYDRAULIC JUMP

When the water streams down the vertical tailpipe it is accelerated by gravity. When it flows into the horizontal pipe the flow is decelerated forming a hydraulic jump.

The principle can be compared to the stream of vehicles on highways or race tracks. Vehicles can accelerate optimally on roads that are straight and keep on being straight for miles. As soon as there is a curve in the road the vehicles have to slow down. When the first vehicle decelerates the one behind him has to decelerate also and the distance between the vehicles is decreasing. This is very often the moment for accidents to happen: there is an increasing chance for collision. Exactly this is the case for fluid particles in a stream. When particles are redirected from the vertical downfall to horizontal flow the fluid is decelerated. As fluid particles have no brakes they will collide and the only way they can go is up, creating height and thus a hydraulic jump.

Illustration 3: hydraulic jump.

The above explains 2 things: first of all why an increasing length of vertical tail pipe leads to earlier priming, second why an increasing resistance in the collector pipe leads to this same result.

An increasing length of tail pipe leads to more length to accelerate the fluid coming from the roof, thus to higher velocities in the bend to the horizontal pipe. This will lead to a higher hydraulic jump when the flow is decelerated in the horizontal pipe.

Also the more the flow is decelerated in the horizontal pipe, thus the higher the resistance downstream of the bend, the higher the hydraulic jump will be.

Eventually the hydraulic jump will close off the whole pipe diameter, leading to below atmospheric pressures in the system behind the closure and priming will start.

4. START OF PRIMING

When the hydraulic jump closes off the whole periphery of the pipe the air behind the jump has only one way to leave the system and that is through the downpipe. To transport the air through the downpipe the friction forces between the water and the air have to overcome the buoyancy forces of the air. In other words the water has to drag the air along against its tendency to rise. To make this happen the flow rate has to increase further.

5. MEASURES TO ENHANCE PRIMING

As stated above to enhance the priming of the system a longer tail pipe can be chosen or the deceleration of the flow in the horizontal pipe can be increased in order to make the hydraulic jump close off the periphery of the pipe as quickly as possible leading to earlier priming.

6. CONCLUSIONS

In this article the start up of a siphonic roof drainage system has been described. It is intended to give better insight in the behavior of the system and help design systems that will work optimally and siphonic more often.

The development of the hydraulic jump and the elimination of air from the system by the suction power in the downpipe are key items in the development of siphonic functioning.

To reach siphonic drainage as quickly as possible a longer vertical tailpipe as well as a quick deceleration in the horizontal pipe is preferable.

7. REFERENCES

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