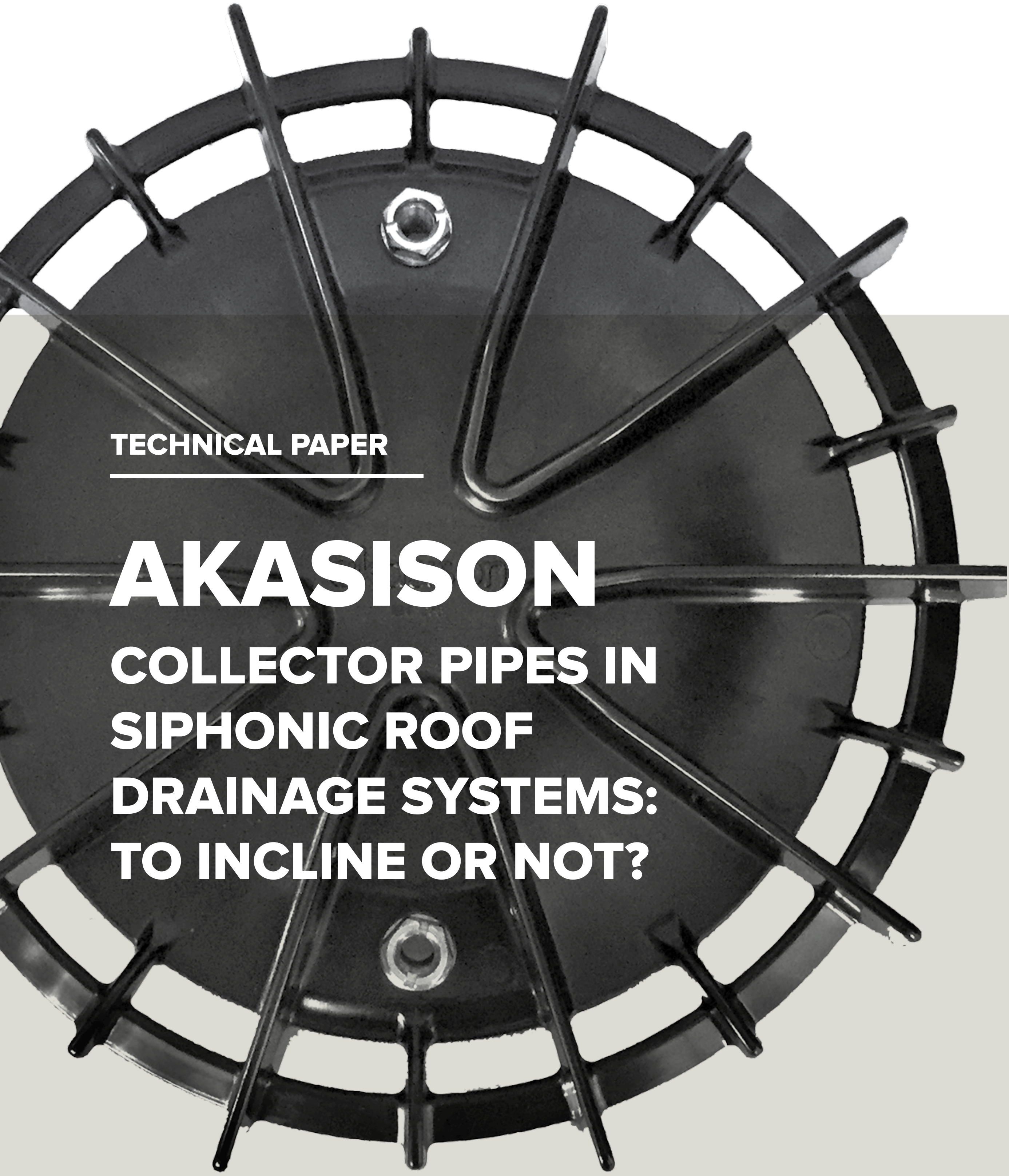

TECHNICAL PAPER

AKASISON

COLLECTOR PIPES IN SIPHONIC ROOF DRAINAGE SYSTEMS: TO INCLINE OR NOT?

akasison

PRACTICAL BY PRINCIPLE.

TECHNICAL PAPER

COLLECTOR PIPES IN SIPHONIC ROOF DRAINAGE SYSTEMS: TO INCLINE OR NOT?

Ir. Marc Buitenhuis MTD
Hydraulic research engineer Akatherm BV, Panningen, The Netherlands

10-09-2008

ABSTRACT

Some install horizontal collector pipes of siphonic roof drainage systems under a fall angle or inclination. This is however causing a delay in the priming of the system and thus is not only unnecessary but even disadvantageous. The hydraulic jump that has to form to close the inner periphery of the pipe and make it work syphonic is less pronounced when the collector pipe has an inclination.

1. INTRODUCTION

Some install collector pipes of syphonic roof drainage systems under inclination thinking that the water will then be transported easier through the pipe system. This however is not the case in syphonic roof drainage systems as will be explained in this article. It will even delay the priming of the system and thus work disadvantageous.

2. PRINCIPLE OF SYPHONIC ROOF DRAINAGE

The working principle of syphonic roof drainage is the full bore flow of the system. At full bore flow the water column closing off the pipe diameter will generate a suction pressure dragging the water from the roof in its wake. One thus has to obtain and maintain a full bore flow for optimal functioning of the system.

The full bore flow is initiated by the hydraulic jump (see illustration 1) at the entrance of the horizontal part of tail pipe or collector pipe of the system. The shape of the hydraulic jump depends on 2 parameters:

1. The velocity of the flow streaming into the horizontal pipe.
2. The resistance of the pipe beyond the entrance of the collector pipe.

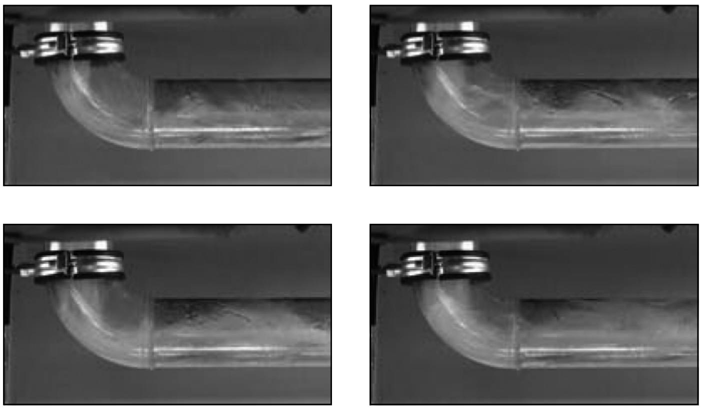

Illustration 1: Forming of the hydraulic jump at start up of siphonic roof drainage system

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

An increasing length of tail pipe gives more time for acceleration of the water coming from the roof, thus to higher velocities at 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.

The higher the hydraulic jump will be the earlier the full pipe diameter will be closed off by water and priming will start.

When the horizontal pipe is (slightly) inclined the water will run off easier and thus the hydraulic jump will be less pronounced, delaying the onset to priming of the system.

3. THEORETICAL BACKGROUND

In this section the theoretical background for the phenomenon described above will be derived.

In fluid dynamics the Navier-Stokes equations are the general form of the momentum equations that account for fluid motion and are written as:

$$\frac{D(\rho\vec{V})}{Đ} = \rho\vec{g} - \nabla p + \mu\nabla^2\vec{V}$$

where ρ is the density,
V is the velocity
ρ is the pressure,
μ is the viscosity

For incompressible inviscid flow they become:

$$\rho\frac{D\vec{V}}{Đ} = \rho\vec{g} - \nabla p$$

and are known in this form as Euler's equations.

The headloss ΔH is defined as ΔH = $\frac{p}{\rho g}$ Substituting this in the above Euler's equations and dividing by ρ gives:

$$\frac{D\vec{V}}{Dt} = \vec{g} - g\nabla H$$

In streamline coordinates along the x-axis and taking the z-direction the direction of gravity:

$$\frac{D\vec{V}}{Dt} = \frac{\partial V_x}{\partial t} + V_x\frac{\partial V_x}{\partial x} = -g\nabla z - g\nabla H =$$
$$- g \cdot \sin\beta - g\frac{\partial H}{\partial x}$$

With a constant diameter of the pipe and thus constant cross section, A, this can be further rewritten to:

$$\frac{D\vec{Q}}{Dt} = \frac{\partial Q}{\partial t} + \frac{Q}{A}\frac{\partial Q}{\partial x} = -A \cdot g\nabla z - A \cdot g\nabla H =$$
$$- A \cdot g \cdot \sin\beta - A \cdot g\frac{\partial H}{\partial x}$$

with ß the angle between the horizontal streamline x and the direction perpendicular to the gravity (ß positive when the streamline ascends).

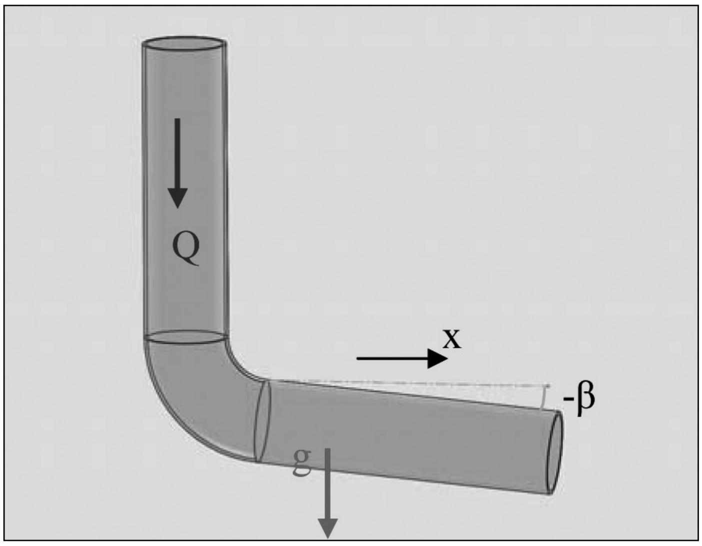

Illustration 2

For a descending collector pipe the angle ß thus is negative, the term with this parameter thus positive, driving the speed in the collector pipe up and thus making it decelerate less, producing a less pronounced hydraulic jump and thus delaying priming (full bore flow) in the system.

In a steady incompressible, inviscid, full bore flow integration of Euler's equations over a streamline gives the well known Bernoulli equation:

$$\frac{p}{\rho} + gz + \frac{V^2}{2} = const$$

This equation is often referred to to easily explain the principle of siphonic roof drainage

4. CONCLUSIONS

In this article it has been illustrated that other then for conventional roof drainage systems an inclination of the collector pipe in a siphonic roof drainage system is not advantageous and will delay the priming of the system. Thus it is advised to install the collector pipes horizontally for proper siphonic functioning.

5. REFERENCES

1. Fox, Robert W., McDonald, Alan T. *Introduction to fluid mechanics*, third edition, 1985, School of Mechanical Engineering Purdue University, John Wiley & Sons
1. Scott Arthur, John A. Swaffield, *Siphonic roof drainage: current understanding*, 2001, Water research group, Department of civil and offshore engineering, Heriot-Watt University, Edinburg, Scotland (UK)
1. G.B. Wright, S. Arthur, J.A. Swaffield, *Numerical simulation of the dynamic operation of multi-outlet siphonic roof drainage systems*, 2005, Drainage and water supply research group, School of the build environment, Heriot-Watt University, Edinburg, Scotland (UK)
2. Scott Arthur, The priming focused design of siphonic roof drainage, drain age research group, School of the built environment, Heriot-Watt University, Edinburg, Scotland (UK)
3. S. Arthur, G.B. Wright, Siphonic roof drainage systems – priming focused design, 2006, School of the built environment, Heriot-Watt University, Edinburg, Scotland (UK)
4. S. Arthur, J.A. Swaffield, Siphonic roof drainage system analysis utilizing unsteady flow theory, 2000, Department of building engineering and surveying, Heriot-Watt University, Edinburg, Scotland (UK)

akatherm

Akatherm BV
Industrieterrein 11
P.O. Box 7149
5980 AC Panningen
The Netherlands

Tel +31 (0)77 30 88 650
Fax +31 (0)77 30 75 232

info@akasison.com
www.akasison.com

02/16/327