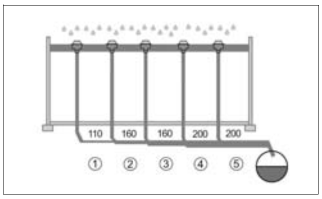
Akasison

1.1 Siphonic roof drainage systems

Akatherm expands the possibilities for buildings with large and complex roofs considerably. To respond, whether a consultant or installer, to the challenges faced by your clients and end users the Akatherm system offers the following benefits:

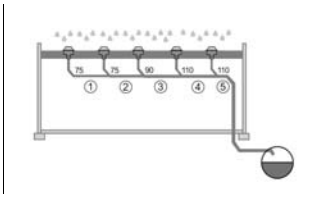
- Save space for the function and mechanical services of the building
- Total freedom & flexibility of roof drainage design
- Economical installation with a light, plastic (HDPE) and welded pipe system
- Full peace of mind from a sophisticated risk management system

Conventional roof drainage



- Many down pipes
- Gradient pipe work
- Larger diameters
- Groundwork in building structure
- Low speed

Siphonic roof drainage



- Fewer down pipes
- Level pipe work
- Smaller diameters
- Less groundwork in building structure
- High speed
- Self-cleaning

Akatherm siphonic roof drainage systems are engineered on the concept of full bore (a fill rate of 100%). This implies that rainwater flows at high speed through small diameter pipe work, at normally zero gradient. This siphonic effect is created by the (kinetic) energy derived from the hydraulic head, caused by the difference in height between the roof outlet and the discharge point in a building. Specialised roof outlets prevent air from being sucked into the system. The engineering principle of siphonic roof drainage design is based on the Bernoulli energy equation for a steady flow of an incompressible fluid with constant density. In order to balance the equation, and to guarantee the required siphonic effect according to the rainfall's intensity, the ideal pipe dimensions per flow path need to be determined.

$$\rho_1 / \rho . g + V_1^2 / 2 . g + Z_1 = \rho_2 / \rho . g + V_2^2 / 2 . g + Z_2 + \Sigma h_f$$

Equation 1.1

1.1.1 Basic principles

The capacity of siphonic roof drainage systems is calculated according to national standards and guidelines. The basic principles of a siphonic system are:

- Rain intensity for a standard system is measured in l/s/ha according to national figures (The Netherlands 300 l/s/ha).
  For an emergency overflow system higher figures must be used (The Netherlands 470 l/s/ha).
- Collectors can be installed level without any incline.
- For optimum under pressure, the collector must hang between 0,8 m and 1,0 m below the roof.
- Several roof surfaces can be connected to a siphonic roof drainage system provided that the height difference is not too great.
- The connection of a green roof and an ordinary roof on a single system is not permitted.
- Large roof surfaces (> + 5,000 m^2) must be connected to at least 2 independent down pipes.

1.1.2 Roof outlets

The total volume of rainwater that has to be evacuated by the system can be calculated using equation 1.2.

$$V = i . \alpha . \beta . A/1000$$

Equation 1.2

V = total drainage volume (l/s)
i = rain intensity (l/s/ha)
α = reduction factor rooftype
β = reduction factor effective roofsurface with roof under an angle
A = effective roof surface (m^2)

Having calculated the total volume of rainwater that has to be drained, the number of roof outlets can be calculated using equation 1.3.

$$N_{DT} = V / V_{DT}$$

Equation 1.3

N_{DT} = number of roof outlets
V = total drainage volume
V_{DT} = drainage capacity of one roof outlet (l/s)

The volume flow per roof outlet has to be limited to 85% of the drainage capacity of the outlet to be able to balance the system at a later stage in the design. Determining the number of roof outlets one has to take in account the structural details of the building like firewalls, roof construction and other (small) roofs that drain their rainwater onto the calculated roof surface. On each lowest point of the roof construction a roof outlet has to be placed. The maximum distance between 2 outlets is 20 m. From the product range of roof outlets the correct roof outlet can be chosen depending on roof construction, roof membrane or heating element.

1.1.3 Calculation principles

A roof from which rainwater is drained by means of a siphonic system generally contains several roof outlets that are collected into a single down pipe. The Bernouli equation needs to be applied to every flow path from roof outlet (entry point) to the transition to partial filling (exit point).

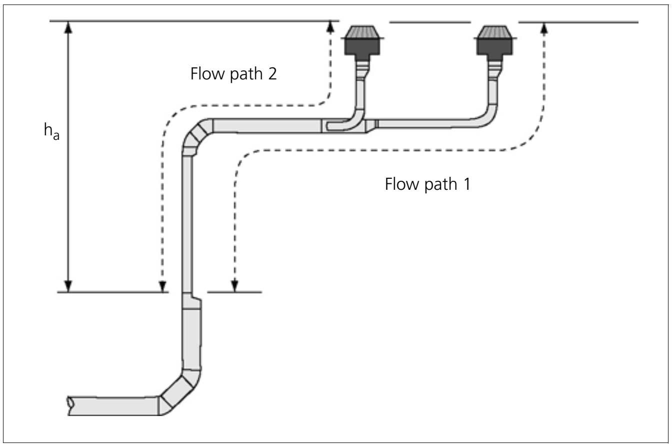


Illustration 1.1

The purpose of the calculation is to keep the static residual pressure at the exit point of every flow path within ±100 mbar. See paragraph 1.1.5 for further requirements for a siphonic system.

The static residual pressure of a flow path is equal to the available pressure difference created by the height difference between the entry point and the exit point (h_a in equation 1.5) minus the pressure loss caused by the pipe friction in the auxiliary sections of the system.

$$\Delta p_{rest} = \Delta p_{available} - \Delta p_{loss}$$

Equation 1.4

The available pressure difference is calculated as indicated in equation 1.5.

$$\Delta p_{available} = \Delta h_a . g . \rho$$

Equation 1.5

Δh_a = available height from roof membrane to exit point
ρ = mass density of water at 10°C: 1000 kg/m^3
g = gravitational acceleration: 9,81 (m/s^2)

Pressure loss is calculated as specified in equation 1.6.

$$\Delta p_{loss} = \Sigma (l . R + Z)$$

Equation 1.6

l = pipe length (m)
R = pipe friction pressure loss (Pa/m)
Z = drag (Pa)

1.1.4 Calculations

The calculation of the various flow paths must begin with the most unfavourable flow path (insofar as pipe friction is concerned). In most cases, this flow path is from the roof outlet furthest removed from the exit point.

To properly calculate the pressure difference and pressure loss for every flow path and to test it against the 100 mbar standard, every flow path is divided into pipe sections (PS, see illustration 1.2). The pressure loss calculations for each individual section are summed up (Σ in equation 1.6) and subtracted from the summed up pressure differences for each pipe section.
The pipe section runs from fitting (change of direction or diameter) to fitting, with the roof outlet being a separate pipe section (RO). If a section is longer than 10 m, it must be split into two parts in order to make the optimisation of diameters possible.

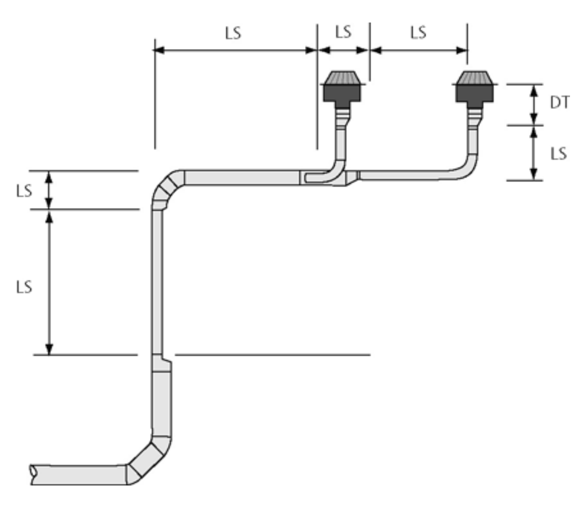


Illustration 1.2

Calculating the pressure difference of a pipe section

The available pressure difference of a pipe section is computed by replacing the Δh_a of equation 1.5 by the height difference of the pipe section.

$$\Delta p_{available,\ ls} = \Delta h_{ls} . g . \rho$$

Equation 1.7

Calculating the pressure loss of a pipe section

The pressure loss of a pipe section is calculated by using equation 1.6 without the accumulation symbol Σ.

$$\Delta p_{loss,\ ls} = l . R + Z$$

Equation 1.8

l = pipe length (m) = the length of the pipe section
R = pipe friction pressure loss (Pa/m) = (λ/d_i) (0,5 . v^2 x r)
λ = pipe friction factor according to Pradtl-Colebrook (wall roughness kb = 0,25 mm)
d_i = pipe section design diameter (m)
v = flow velocity in flow path (m/s) = Q_h/d_i
ρ = mass density of water at 10°C: 1.000 kg/m^3
Q_h = rainwater load for the total roof section drained by the pipe

The flow path design diameter (d_i) is the only variable in the entire calculation (with the exception of down pipe diameter) that can be modified if the 100 mbar standard cannot be met.

$$Z = \text{pipe friction (Pa)} = \Sigma \zeta . (0{,}5 . v^2 \times \rho)$$

Equation 1.9

ζ = pipe friction of fitting
v = flow velocity in flow path (m/s)
ρ = mass density of water at 10°C: 1,000 kg/m^3

Table 1.1 indicates the pipe friction factors for each fitting. If the pipe friction factor for the roof outlet is not reported separately, the standard factor can be taken from the table.

Fitting	ζ
Bend 15°	0,1
Bend 30°	0,3
Bend 45°	0,4
Bend 70°	0,6
Bend 90°	0,8
Branch 45° branch	0,6
Branch 45° through	0,3
Reduction	0,3
Transition to partial filling	1,8
Roof outlet	1,5

Table 1.1

In contrast to a standard reduction, the exit point (transition to partial filling) has a larger pipe friction factor. This point can be incorporated in the down pipe but also in the underground pipe (horizontal).

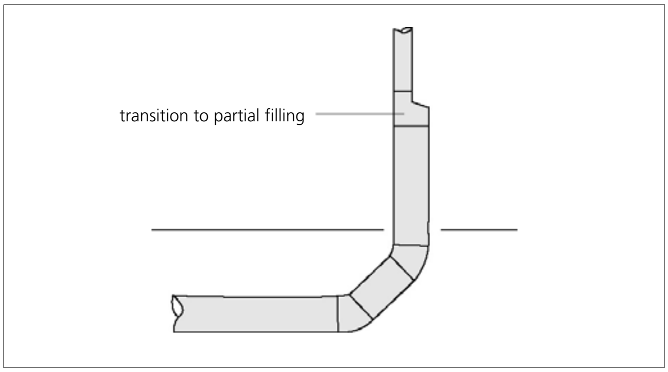


Illustration 1.3

The residual pressure is then determined by accumulating and offsetting the pressure differences and pressure losses of every pipe section.

$$\Delta p_{res} = \Sigma \, \Delta p_{available} - \Sigma \, \Delta p_{loss}$$

Equation 1.10

If the result of the residual pressure does not remain under the stated standard of ±100 mbar, the design diameters of one or more pipe section must be adjusted and retested. Akatherm has software to perform these calculations for you.

1.1.5 System requirements

Paragraph 1.1.5 provides details about the most important factor affecting the performance of a siphonic system: the static residual pressure of ±100 mbar at the exit point. In addition, there are a few other requirements relating to pipe strength, self-cleaning, flow velocity and the design diameter of the down pipe.

Static underpressure

Due to pipe strength, the static underpressure at any given point (x) in a flow path must remain within the below-stated limits:

40 - 160 mm (s12,5)	-800 mbar
200 - 315 mm (s12,5)	-800 mbar
200 - 315 mm (s16)	-450 mbar

In contrast to the exit point where the residual pressure only entails static pressure, the residual pressure at every other point (x) in the pipe system consists of static and dynamic pressure. The equation for residual pressure at point x is:

$$\Delta p_{res,x} = \Delta p_{static} + \Delta p_{dynamic,x}$$

Equation 1.11

The dynamic pressure in the system is calculated using equation 1.12.

$$\Delta p_{dynamic,x} = 0,5 \cdot v_x^2 \times \rho$$

Equation 1.12

v_x = flow velocity at point x

The available pressure difference and the flow losses for point x must then also be calculated. Equation 1.12 can hence be re-written as equation 1.13.

$$\Delta p_{static,x} + \Delta p_{dynamic,x} = \Delta p_{available,x} - \Delta p_{loss,x}$$

Equation 1.13

The applicable equation for static pressure at point x can now be written as equation 1.14.

$$\Delta p_{static,x} = \Delta p_{available,x} - \Delta p_{loss,x} + \Delta p_{dynamic,x}$$

Equation 1.14

$\Delta p_{available,x}$ = $\Delta h_x \cdot g \cdot \rho$ (available height difference between the entry point and point x)
$\Delta p_{loss,x}$ = $\Sigma\,(l.R + Z)_x$ (summed losses until point x)

Self-cleaning and velocities

To ensure the self-cleaning effect, the velocity in the system must be higher than 0,7 m/s. At the exit point (the transition to partial filling), velocity must not be higher than 2,5 m/s.

Design diameter of the down pipe

If the collector pipe is less than 1 m below one or more entry points, the drainage at the transition point from collector pipe to down pipe must satisfy equation 1.15.

$$Q_{start} = Q_h \cdot \sqrt{\frac{\Delta H_i}{\Delta H_a}}$$

Equation 1.15

Q_{start} = minimum drainage at the transition point from the collector pipe to the down pipe (l/s)
Q_h = total rainwater load connected to the down pipe (l/s)
ΔH_i = height difference between entry point and the midpoint of the collector pipe (m)
ΔH_a = height difference between entry point and exit point (m)

Subsequently determine the design guidelines for the down pipe according to EN 12056, in which $Q_{start} > 1{,}2 . Q_{min}$ *and the length of the down pipe must be at least 4 m.*

1.1.6 Emergency overflow

According to the standards every flat roof should be able to cope with the 5 minute rainfall which occurs ones in a hundred years. A light construction (steel) roof should always have an emergency overflow system. With all other roofs it has to be checked if an emergency overflow system is necessary. This depends on the construction and shape of the roof and the expected rainfall. The emergency overflow should be able to drain the amount of rainfall exceeding the amount on which the standard system was dimensioned or even the maximum hundred-year storm (different per country).

In a standard situation an emergency overflow is a rectangular or round opening. This is for sure the most economical solution but unfortunately not always possible or desired. In many projects it is necessary to drain the extra rainfall with emergency overflow roof outlets which are placed higher than the roof surface. An emergency overflow system can be constructed in a number of ways:

- Spouts through the roof edge
- Traditional gravitational system
- Roof drainage siphonic system

In case of a siphonic emergency overflow system, the location of the emergency overflow roof outlets is important in order to prevent the intake of air. The location must be determined in collaboration between the builder and the designer of the emergency overflow system.

In addition, the roof outlets and the connected pipes of the emergency overflow system can be compartmentalised into smaller drainage areas, for which every collector has a separate outlet. The emergency overflow system may not be connected to the sewer. The distance between individual emergency overflow roof outlets may be no more than 30 m.

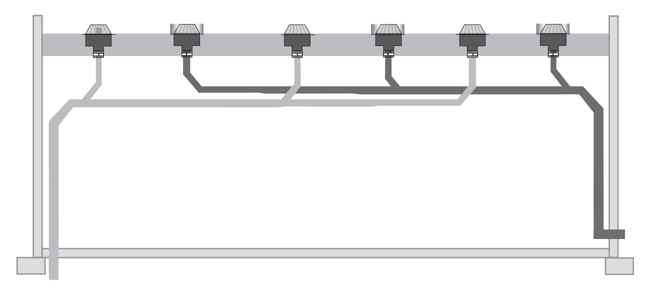


Illustration 1.4 Siphonic roof drainage system with siphonic emergency overflow (not connected to sewer)

Overflow collar

Akatherm offers collars which can be combined with the standard Akasison roof outlets. This combination is an important element in the emergency overflow system. The collars are only used in combination with roof outlets in case of an overflow system.

Illustration 1.5 Overflow collar

The Akasison siphonic roof outlet DN70 overflow collar is 55 mm high and has a capacity of 15 l/s (capacity as defined in standard EN 1253).

1.1.7 Akasison fixing system

The Akasison fixing system is designed for horizontal siphonic roof drainage pipe systems. It absorbs length changes without transferring stress onto the roof construction.
The brackets can be installed single-handed using easy clip-on mounting, allowing maximum freedom of action high up in the building.

Benefits of this fixing system:

- Larger spans possible
- Less mounting onto roof construction
- Prefabrication on ground level possible
- Only simple tools needed
- Room for applying insulation