The Siphonic Guide

A guide to Siphonic Roof Drainage

by the Siphonic Roof Drainage Association

Contents

Preface – What is the Siphonic Roof Drainage Association?

The Siphonic Roof Drainage Association (SRDA) was set up in 2004 to promote a wider understanding of the principles of siphonic drainage, to promote good practice among siphonic companies, and to provide a recognised platform for specifiers to seek advice.

Members have to comply with the following requirements to gain membership:

1. A suitable siphonic outlet.
2. A pipe and bracket system capable of accepting the pressure and dynamic loading from siphonic flow.
3. Design software capable of accurately assessing the very complex flow regime in the system.
4. Not use misleading advertising, which makes false claims about benefits of a particular product, or denigrates another.

All the requirements must have been assessed as suitable by a third party organisation.

All members are subjected to an annual random check by the Association to confirm that their design and installation procedures are being properly implemented.

This helps to ensure that standards are maintained, and that there is a thorough understanding of these important factors throughout the company structure.

By using a member of the SRDA, a specifier can ensure that they are going to a company which has the tools and experience to do the job properly.

The Association can answer technical questions about siphonic roof drainage specification, design, or problems with existing systems. Contact the Secretary, Dr Malcolm Wearing at:

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The members of the SRDA are:

Aquaphonix
Dallmer
Geberit
Saint-Gobain Pipelines
Sapoflow

Associate members are:
RWP (UK) Ltd

Corporate Members are:
CGL Systems Ltd

1.0 The history of siphonic roof drainage

The principle of siphonic roof drainage was first developed by the Finnish engineer Olavi Ebeling in the late 1960's. The first commercial installation was in a Swedish Turbine Factory by a consulting engineer, Per Sommerhein, founder of the UV-System company. Siphonic roof drainage then spread through Europe, and arrived in the UK in the 1980's, with Geberit and Sapolite (UV-System) being the original companies.

During the 1990's there were serious problems with some roof drainage designs. The ruling British Standard, BS6367:1983 had been written when construction methods and materials were very different, and the move from fibre cement to plastisol coated steel roofing products, created much higher run off into gutters than the standard anticipated. BS6367 was ambiguous in its design guidance with respect to suitable rainfall intensities, and thus many gutters were seriously under designed. Although this problem occurred in both gravity and siphonic drainage systems, in the case of the siphonic installation, the method of drainage was often blamed, rather than the design guidance.

The siphonic industry today is a progressive one, with 6 major companies, all committed to designing to the much improved standard BSEN12056-3:2000. A dedicated British Standard for siphonic drainage, BS8490:2007 was published in March 2007, which formalises standards already met by the members of the SRDA.

A specifier and their client can be sure, if they use a member of the SRDA, that they are dealing with a company which has the design and installation experience to do the job properly.

Furthermore, by specifying Siphonic drainage they can use a tried and tested method of drainage with over 30 years proven track record in installations across the globe.

2.0 Siphonic drainage explained

The basic theory behind siphonic roof drainage is very simple and all systems work in the same way. Water dropping down the downpipe creates a negative pressure at the highest point, in a similar way to the action of a simple siphon, such as would be used to drain a fish tank. This negative pressure is harnessed to draw water along a horizontal collector pipe, removing the need for many downpipes in the building. This gives a number of benefits compared to a traditional system:

- Internal underground drainage can be eliminated in the building, and significant reductions can be made in external underground drainage. This can provide considerable cost savings and enhance the construction programme on all sites, and particularly on contaminated ones.

- Pipe sizes are reduced overall, reducing the loads on the structure, when compared withy lateral gravity drainage.

- There will be a significantly reduced number of downpipes for each gutter, which can be located at the end of the gutter. This can free floor space and allow columns to be omitted.

- The collector pipe, which runs horizontally, can be very close to the roof or gutter, allowing full use of internal space.

- For sites with a requirement for a sustainable drainage solution (SuDS), siphonic drainage will allow water to be delivered to a specific point on the site, at a shallow depth. This can significantly reduce the storage construction costs, especially for pond based designs.

Water is collected from the gutter in small diameter “tailpipes”, which fill with water (or “prime”) very quickly, and then fill the rest of the system. Once the whole system is primed, full siphonic action occurs, and flow rates achieve the design level.

There are four vitally important concepts to ensure in design of a system, which mean that it is a task for a specialised company. These are:

- The system must be carefully balanced, so that the friction losses in the pipework ensure that the correct amount of water passes through each outlet. This is normally achieved by making the tailpipes on the outlets closest to the downpipe a smaller diameter than those further away. Another alternative is to space the outlets unevenly, so the outlets closest to the gutter take more flow. Whichever system is used, it is very difficult to undertake these calculations without a specialised computer program. All SRDA members utilise sophisticated (and independently proven) analytical software to properly balance the designed systems, eliminating any risk of air being drawn into the system therefore retaining the full integrity and effectiveness of the system at all times.

- The system must be designed so that the peak negative pressure in the system is within the negative pressure capability of the pipe system, and above the threshold where cavitation (air coming out of suspension in bubbles) occurs. To ensure this, the maximum negative pressure in the system should be 8.8m (863mbar), or less negative if pipework type dictates it. To accurately assess the pressure, software must evaluate friction, bend and junction losses.

- The system must fill quickly enough (or "prime") to operate in a 2 minute storm. All siphonic systems must be able to fill the collector pipe using only the flow from the primed tailpipes. This flow will be much smaller than the fully primed capacity of the system. If this does not happen within approximately 50-60 seconds, the gutter may be overcome before the system operates. The only exclusion to this would be gutters or flat roofs where storage is acceptable, and thus the system does not have to function as quickly.

- The system must have sufficient drop between gutter and collector pipe to allow enough flow to be generated to fill the downpipe. VDI 3806, (the German siphonic standard) contains a specific design clause which relates the tail drop to the maximum downpipe diameter. If the collector pipe is too close to the gutter sole, there will be very little energy gain during the early part of filling process, and it is possible that the system will not function.

2.1 "Self-Priming"

All siphonic systems operate in exactly the same way, and so titles such as "self-priming" apply to all systems. Comparison tests carried out at HR Wallingford in 1996 (SR463) showed that pipework design was the key factor in performance, and the outlets tested all behave in the way predicted by the theory. If small diameter outlets are fitted to a large carrier system, the siphonic pipework will tend to prime slowly, and so water depth in the gutter may rise above the final steady running level. A system which has been better matched at design stage will not overshoot, provided it uses any functional siphonic roof drainage outlet.

2.2 Primary and secondary systems

The introduction of BS EN12056-3:2000, and the steady increase in building size, has lead to a situation where greater and greater volumes of water are being drained from roofs. This means that for a single siphonic roof drainage system to drain a gutter, the collector pipes can be very large. This has a number of disadvantages:

- The time for the system to fill can become longer.
- The larger pipes impose significant static and dynamic loads to the building structure.

For these reasons some UK companies favour a primary & secondary approach to design.

The primary system will cater for the 1-2 year event, and the secondary system will drain any surplus water in longer term events. In most cases there is not enough capacity in underground drainage to cope with above ground requirements, and so this secondary drainage can be discharged harmlessly onto external surfacing.

However, the primary & secondary approach has its drawbacks, the main one being that the gutter needs an adequate depth for it still to function as a gutter with water running into the secondary system. With gutter sizes gradually getting smaller due to increased insulation thickness, this can often be hard to achieve, and so a primary only system can often be the best solution. Gutter depths will be covered in more detail in the next section.

2.3 Gutter design

Although siphonic roof drainage systems work in a fundamentally different way to a gravity system, the gutters which they drain work in exactly the same way. When a siphonic system is designed, calculations should be carried out using either the free or restricted flow analysis procedures in BS EN12056-3:2000, using water depth information from outlet testing.

Various industry factors, such as the introduction of Part L of the Building Regulations, have led to insulation thicknesses increasing, and consequently gutters getting smaller. This can make it very difficult to make a primary/secondary siphonic system work properly. Be very cautious of companies who claim that water depth in gutters is not important with a particular outlet or gutter type. For all siphonic systems, gutter calculations should be undertaken to show that there is adequate capacity, based on outlet water depth information from a third party source (BBA or independent testing).

It should be noted that problems caused by a lack of gutter depth do not only apply to siphonic drainage. Many gravity gutters are very hard to design because of lack of available depth.

2.4 Underground drainage

In UK design practice underground drainage is typically designed to carry approximately half the flow of the roof drainage. This is for two reasons:

- Roof drainage is designed to protect the building for its lifetime (usually 90 years plus) whereas below ground drainage can flood in events over 30 years.
- Water concentrates very quickly on a roof, and so roof drainage design is based on a 2 minute storm as opposed to the 3-5 minute storm used for underground drainage. It is a general rule that the longer the event, the lower the intensity of rainfall.

Most siphonic systems use the full building height to generate their flow, and thus it is vitally important that when the system discharges it has no restriction. It is therefore recommended that a vented manhole lid be fitted at the discharge point to allow air drawn in during the priming process to be released, and any surplus water to overflow without any risk to building. SRDA members can provide standard details for this on request.

2.5 Maintenance

Many specifiers are concerned that siphonic roof drainage systems need much higher levels of maintenance, but the fact is that all roof drainage systems need adequate maintenance, gravity or siphonic. All gutters should be inspected at least bi-annually, and cleaned when appropriate. Inspections and cleaning may need to be carried out more regularly where there is a high density of trees or other sources of airborne debris.

Siphonic outlets are more complex than conventional ones, and so it should be explained to gutter maintenance staff that they must be re-assembled with all their original parts if they have to be removed for maintenance.

Debris should never be swept into any roof drainage system, but this is particularly important for siphonic drainage, where tailpipes may be reasonably small diameter.

3.0 Specifying Siphonic Drainage

When specifying siphonic drainage there are a number of key factors which must be covered. These are:

- Rainfall intensity - The rainfall levels should be determined from BS EN 12056-3:2000, using the projected building life, and a suitable factor of safety.

- It is specifically stated in BS 8490:2007, that there should be no differentiation between siphonic and conventional drainage when calculating rainfall intensities for design.

- The contents of the building should be considered as well as building type. The more years specified the lower the risk to the building, but the more expensive the system, so it is always a balance to suit the acceptable level of risk.

- The minimum drainage requirements set out in BS EN12056-3:2000, stipulate a 1.5 or 4.5 factor of safety to be applied to building life. 4.5 is normally used for building where the consequences of flooding wood be more significant, though these are never explicitly defined.

- Many large developers consider that for distribution buildings, the 25 year standard building life is too short to adequately protect the buildings contents, and so a factor of 4.5 is often used (Category 3) giving an overall protection life of 112.5 years.

- Office buildings often have a longer building life such as 60 years, and so the factor of safety of 1.5 (Category 2) gives a much greater level of protection.

- Specification of rainfall intensity is the responsibility of the architect, and the SRDA can give no absolute guidance, but it should be noted that if the overall protection life including safety factor is 30 years or less there is a serious risk that water will flow into the building during its lifespan.

- Most importantly "75mm/hr" should never be specified for internal gutters as it will lead to over flow into the building every 1-2 years, depending on location.

- Filling time and gutter calculations - It is vitally important that the siphonic contractor provides calculations to show that the system will fill within the required time period, and that the gutter will function correctly i.e. will not over-top. In the UK the design rainfall event (the most intense period of a storm) is 2 minutes, and so a siphonic system must begin to function within half this time unless roof storage is provided, or the roof may flood. In the past some companies have claimed that their systems do not need to fill to operate, but this is simply not correct. Gutter calculations should be to BSEN12056-3:2000, using outlet data from a BBA certificate or other third party source.

- The majority of siphonic drainage systems in Britain use high density polyethylene pipework. HDPE can be connected using either electrofusion couplings, which are heated by internal elements, or by butt-jointing, where the cut ends of the pipe
- are melted and then forced together under pressure to make a joint. Butt-joints should only be made using a machine incorporating a jig and control system to monitor the temperature, time and pressure required, as is required by BS8490:2007.

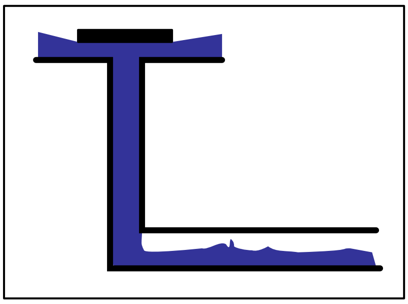
- Metal pipe systems (cast-iron, galvanized or stainless steel) can also be used for siphonic drainage. The specification should detail that installation should be according to their manufacturers recommendations for negative pressure.
- BS8490 sets out the following information to be provided by specifiers to siphonic contractors:

- Location of building and height above ordinance datum,
- Required design storm return period, or category of storm and design life of building.
- Roof plan indicating area to be drained.
- Roof covering and height of potential leakage paths into the building.
- Gutter positions and initial sizes.
- Preferred outlet locations
- Overflow positions
- Preferred downpipe routes
- Temperature and humidity of rooms intended to be heated
- Decibel rating of noise sensitive areas
- Building use
- Position of soft landscaping
- Levels of roof and external ground
- Structural arrangements of roof, including beam heights
- Location of movement joints
- Maximum depth of water on roof
- Details of connection to site drainage system
- CDM risk assessment for installion of outlets
- Any other relevant information

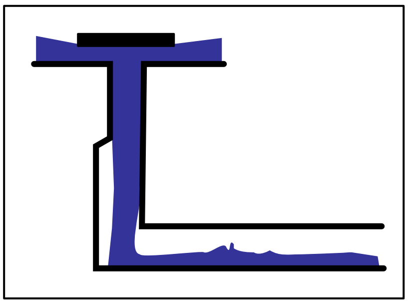
4.0 Recommended Design Practice

However complex the calculation program used by a siphonic company, the functionality of the system relies in the first instance on the pipes becoming full of water. In some cases this may not occur because of badly detailed pipework. The following are examples of recommended details which should be used to prevent problems in pipework design.

4.1 Expansion below the outlet



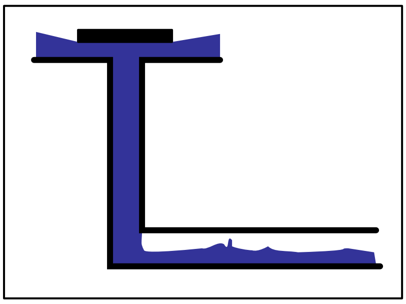
Good – Tail filled in vertical



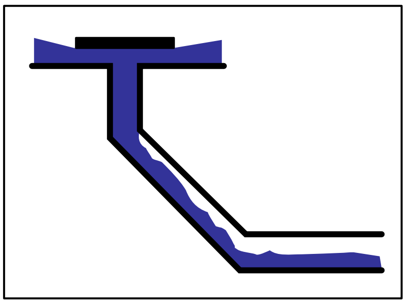
Bad – Tail may fail to fill

If the tailpipe below the outlet is too large, the outlet will not be able to fill it, leading to the situation where the outlet will be working at a tiny fraction of its design flow (All UK siphonic outlets will only drain 3-5 l/s when not connected to a primed pipe system). Expansion of one pipe size in the vertical is usually acceptable (ie 75 up to 90), but at figures beyond that the tail should be deemed not to be functional, unless it has been proved otherwise by third party physical testing. It should be noted that it is perfectly acceptable to increase the size of the horizontal component of the tailpipe. It is acceptable to have these non-functional tailpipes as perhaps one or two at the end of a large system, but they should be excluded from any fill time calculations.

4.2 Sloping tailpipes



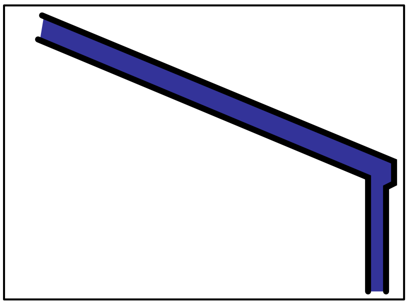
Good – Tail filled in vertical



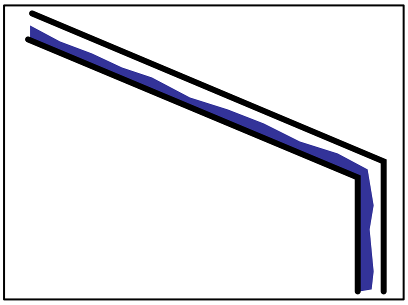
Bad – Tail may fail to fill

If tailpipes slope, there is a significant risk that water will accelerate down the slope in gravity flow such that the pipe will not run full and it will be left running in gravity. This will lead to the same effect as above, that the outlets will stay in gravity mode, reducing their effectiveness, and probably stopping the system priming and thus reaching full effectiveness.

4.3 Sloping lateral pipes (Greater than 1:100)



Good – Siphonic action
Promoted by smaller
downpipe



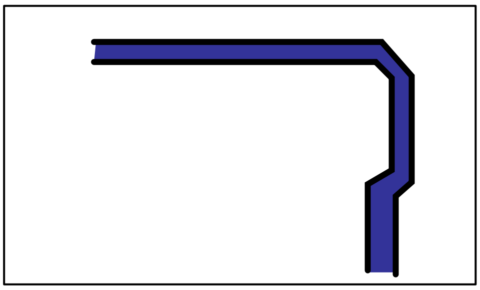
Bad – System may stay in
gravity

For the same reasons that it is best to avoid sloping tailpipes, the lateral pipe in a siphonic system should be installed horizontally. If the laterals are installed with a slope then care should be exercised to detail the pipework downstream such that the system will prime. The best way is usually to reduce the diameter of the vertical pipe downstream of the sloping section, to force it to prime the sloping section.

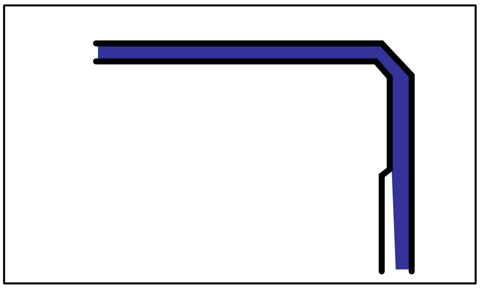
4.4 Configuration of the downpipe

Expansions in diameter of the downpipe should be avoided wherever possible, as there is a risk that the siphon will break at this stage. This will mean that if the system has been designed to be full to ground level, there will be much less capacity as the system will only have a proportion of the available drop. The other assumption that can be made is that the pipe will not fill lower down, and that the system becomes gravity at the expansion point. Unfortunately, the process is not reliable, and the pipe will sometimes fill and sometimes not, and so neither assumption can be made with confidence. There are two approaches that can therefore be pursued:

- Make the expansion in an offset which will ensure that the pipe primes all the way down



- Expand the pipe such that the filling degree in the lower section is only 20% which will inhibit the ability to prime



5.0 Materials for siphonic roof drainage systems

Many different materials can be used for siphonic roof drainage installations, the key thing being that they can resist the dynamic and pressure loadings the pipework will be subject to. Most pipe manufacturers do not provide negative pressure test data, and so manufacturers must carry out tests on pipe to ensure it is strong enough.

The following pipe types have successfully been used in installations in UK or in other parts of the world:

High Density Polyethylene (HDPE)	HDPE is the most commonly used pipe type in the United Kingdom industry.
Unplasticised PolyVinyl Chloride (uPVC) Cast Iron	uPVC for use in siphonic systems must be solvent welded pressure pipe, and suitable for negative pressure applications. Plain ended cast Iron to BS EN877, is often used in areas of buildings where a decorative feature is required, or to provide fire protection measures.
Galvanised Steel	Galvanised steel to EN 1123 with push fit joints is lighter than cast iron, less expensive than stainless steel, and has been used extensively on the continent.
Stainless Steel	Stainless steel with clamped push-fit seals is sometimes used in areas where a decorative feature is required.
Copper & other materials	In a similar way copper and other materials can be used, but must be checked for negative pressure resistance

6.0 Siphonic Glossary

Baffle plate	A flat or shaped device (sometimes part of leafguard) which prevents air entering the siphonic system.
Butt joint	A joint in HDPE pipework generated by heating pipe ends and forcing together under pressure.
Cavitation	Air bubbles coming out of suspension in water, causing damage to pipe material. Occurs when velocity very high and pressure very low, and will not occur if pipe system designed correctly.
Downpipe	Single pipe which drops down from lateral to ground level. Water flowing down this downpipe creates the negative pressure which drives a siphonic system.
Fill time	The time taken for the tail pipes (when running full bore, but by themselves) to fill the system and start overall prime.
Friction loss	The energy loss associated with the process of water running along the inside wall of the pipe.
Full bore	A pipe running full of water or "primed"
HDPE	High Density Polyethylene – a light, robust, impact resistant plastic pipe system used in the majority of UK siphonic installations.
Implosion	Pipe failure due to insufficient strength in material to withstand internal vacuum. Will not occur if pipe correctly specified and design undertaken correctly.
Minor loss	The energy loss associated with water passing through a junction, bend, or fitting.
Negative pressure	A vacuum created in pipe system by full bore flow down downpipe.
Priming	The process of the pipe filling with water. Once full of water it will be primed, and siphonic action will occur.
Secondary system	An additional pipe system, with outlets located at a small distance above the roof level or gutter sole which will drain larger storms, often onto hard surfacing outside

	the building
Self-cleansing	Flow in pipe systems needed to shift sediment. Flow velocities in priming siphonic systems are very high so self cleansing could be expected at figures as low as 10% of full design flow.
Self-Priming	A description of how all siphonic systems operate.
Siphonic Outlet	An outlet which has been specially designed to encourage full bore flow in a tail pipe at a shallow water depth.
Rail system	A metal rail connected to HDPE pipe using circular brackets, and fastened to structure at typically 2m centres. This rail is designed to restrain thermal movement of pipe.
Rainfall Intensity	The design level of rainfall in a 2 minute storm which the system will have to drain from roof.
Tail pipe	Small diameter pipes connecting the roof drainage outlets into the horizontal collector pipe.
Vented manhole	A manhole close to building with a vented cover to allow air to be vented during priming process, and water to escape in the event of lack of capacity in underground drainage.
Water depth	The depth of water at the outlet when it is primed. This will vary with flow rate and for some outlets with gutter width.

7.0 Further Reading

BS8490:2007	*Guide to siphonic roof drainage systems* British Standards Institution – September 2000
BSEN12056-3:2000	*Gravity Drainage Systems Inside buildings – layout and calculation.* British Standards Institution – September 2000
RP 463 Wearing et al., 2005	*Performance of Siphonic Drainage Systems for Roof Gutters* HR Wallingford Report Sept 1996, *Flow into modular plastic box structures from siphonic and other high flow drainage systems* – Proc of 3rd national Conference on Sustainable Drainage, Coventry, - June 2005.