



Leakage Protection for your Home

A short Introduction, edited by Dr. Christian Paetz, Aqua-Scope Technologies OÜ

Water – Danger inside your home



Our sweet home is threatened by many dangers - fires, burglary, floods, tornadoes or lightning strikes. However, one hazard is 10 times more common than all other dangers combined: damage from leaking water.

Insurance companies pay more than \$ 25 billion annually worldwide to regulate water-related damage to buildings and facilities. In Germany it is more than 2.5 billion euros. This sum does not even cover the entire damage; on average, only about 60% of the damage incurred is replaced by the insurance company and the intangible damage caused by lost memories, dirt and anger can hardly be quantified.

What danger is caused by water

Water in the house can be assigned to four areas:

- Drinking water
- water inside the heating system
- Rain and ground water
- Sewage

Drinking water constantly comes from the outside through the main water supply and is distributed inside the house via the house water distribution system to toilets and taps (for wash basin, shower, dishwasher, washing machine, bathtub). Most installations connect domestic water distribution to hot water preparation, which distributes the heated water with or without

a buffer water storage tank using a parallel distribution pipe system. A special feature of drinking water distribution is that water taken from the pipes or the hot water buffer tank is immediately replaced by fresh water from the domestic water connection. If there is a leak in the drinking water pipe, there is no inherent limit to the amount of water flowing out. Furthermore, the water distributions are permanently under a water pressure of 2 ... 8 bar favoring the occurrence of leaks.



This is different with the heating water circuit. This is a closed system with a certain and limited amount of water. Leakage and water loss can also occur here. The pressure loss in the heating circuit that arises as a result is quickly recognized here and the total amount of

water that can escape from the circuit is limited.

External water sources such as rain, ground or flood water also lead to damage in the house. However, this damage is usually closely related to heavy rain events and therefore quite foreseeable.

Sewage water from the use of the drinking water supply is undoubtedly a danger to the building structure as well if there is a leak over a longer period of time. Sewage water is not under pressure and only flows when the drinking water supply has been used. Insurance statistics show that only well under one percent of all water damage is associated with wastewater.



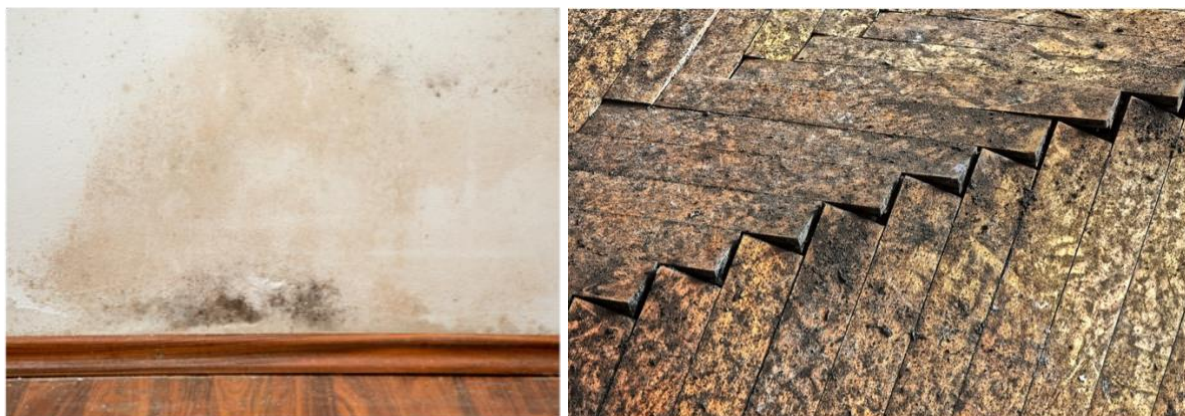
Because of the unlimited inflow of water under pressure, the drinking water distribution is the central component where leakage protection in the house.

Damage caused by water from the drinking water distribution can now be divided into two areas:

- **Malfunction:** This denotes leaks in the distribution, i.e. corroded and leaky pipes or hoses or connectors or leaks in other faulty installation technology (warm water buffer tank, etc.).
- **Incorrect operation:** This includes the overflow of a sink, bathtub, or shower. Overflow usually occurs due to a combination of incorrect use, i.e. some persons forgets about turning off the water again and a partially or completely blocked overflow on the sink or the bathtub. Showers can cause an overflow when the sewage pipe is blocked due to the common mixture of soap, dirt hairs and other things that usually do not belong into a shower.

The insurance industry, the main victim of leaks, describes all events that lead to damage due to water in the house as "Escape of water".

How water destroys



Escaping water dampens building materials such as wood or insulating materials, softens and destroys furniture, clothing, books and electrical and electronic devices such as televisions or even cell phones.

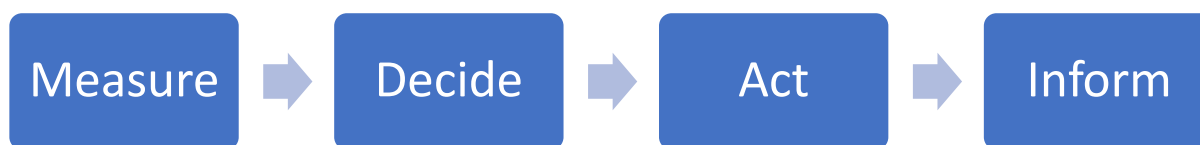
While water usually destroys electronic devices immediately, the damage to materials such as wood, paper and textiles depends on the amount of water and especially on the exposure time of this water. These materials swell due to prolonged exposure to water and are therefore unusable. In addition, mold forms on the surface of wet organic materials.

A quickly recognized water damage, even with a large amount of leaked water, is therefore regularly less harmful than small but undetected amounts of water that could affect materials over a very long period of time.

What is Leakage Protection?

Leakage protection prevents or limits escaping water and / or shortens the exposure time of this water.

Leakage protection follows a process with four sub-steps.



Effective leakage protection systems should adequately map all four sub-steps. However, products are also available on the market that only cover partial aspects of effective leakage protection.

Variety of Leakages

A good leak protection system must be able to identify all possible damage cases in reasonable time. Damage cases can be of very different types and occur with very different probability.

Typical damage cases are:

- Over the years, a metal pipe rusts from the inside. The rusted area only has a small orifice where only a few drops of water escape. Since the metal pipes are mostly installed in the wall or on riser manholes, no one notices the small defect. Due to further corrosion, the orifice widens, and the entire wall is moistened. If the damage is visible to the owner, it is usually too late.
- There is more frequent damage around the sinks. The flexible hoses between the corner valve and faucet leaks, the corner valves can tear off due to thermal and mechanical stress.
- Water from the washing sink can get under the wash basin due to overflows or simple flooding.
- The connection between pipe segments is realized by mechanical coupling elements, so-called 'fittings'. Depending on the connection technology used, the soldering or pressing points on the fittings can tear off. This quickly leads to a considerable leak of water.



- Installations such as boilers, water storage tanks, instantaneous water heaters or filters connected to the drinking water can leak. Water escapes at connection points or by simply rusting through the outer wall of the installation equipment.
- A jammed toilet flush does not leak water. However, good leakage protection will recognize this malfunction and warn against unnecessary waste of water.

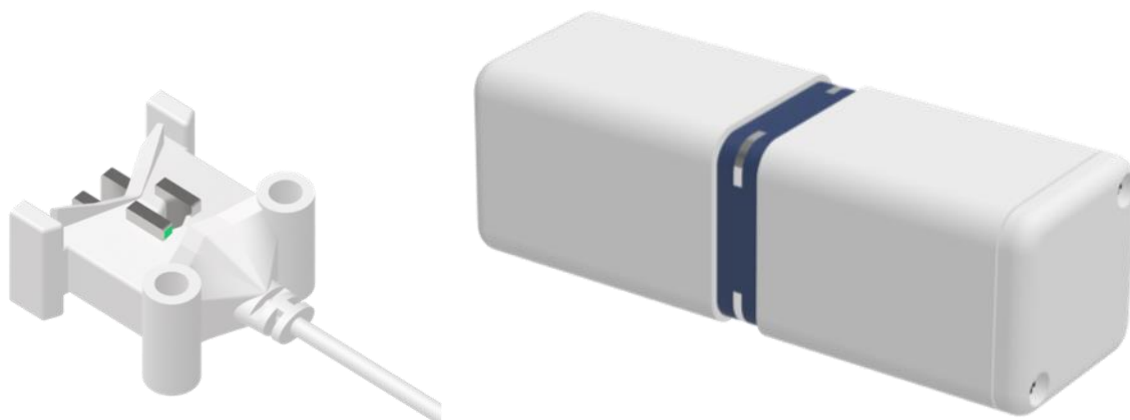
Effective leakage protection systems must detect all these cases and even more using suitable sensors or a combination of sensors. The following five principal damage events play a role:

1. The sudden leakage of a lot of water by tearing off a pipe or other installation.
2. The unusually long leakage of water due to a normal size leak.
3. The permanent leakage of very little water through a so-called micro leak.
4. The overflow of water from the sink / bathtub due to misconduct by the residents.
5. Unusual water withdrawal, for example from a jammed toilet.

Sensors for Leakage Protection

In order to identify all these types of damage, different sensors must be installed, and their measured values are combined and evaluated.

Flood sensors



Flood sensors are small, battery-operated electronic devices that can detect water via external metal pins. If these metal pins are short-circuited, the electronics detect water and usually reports this wirelessly to a control center, which can then take further suitable measures such as switching off the water and / or alerting the resident.

Flood sensors are offered in different designs (arrangement of the metal pins) and with different wireless protocols, which enable integration into a possibly existing smart home system or operation as a single device. Particularly inexpensive products only report water acoustically.

Flood sensors are very well suited for detecting water at critical points in the house, such as under sinks, next to boilers etc. The difficulty is to find out exactly where these critical points are and how to position a corresponding sensor. Good sensors have – typically as additional option - a small additional sensor head connected with a cable, to be able to detect water in narrow gaps under a device without having to position the entire sensor, which is usually larger due to the battery. Instead of the sensor head, sometimes a water-sensitive cable (usually 1 ... 2 meters long) can be connected to a flood sensor. This can then be designed, for example, in a riser shaft so that a larger area of installation can be covered.

Flow Measurement

Flow measurements are an obvious way to detect unwanted water leaks. Unfortunately, it is anything but trivial to distinguish escaping (leaking) water from the desired water take. Depending on the sensor



system used to detect water flow, the minimum necessary flow velocity of the water, which a sensor can still detect, may be too high.

As an example, traditional mechanical water meters used by water works companies have a minimum flow threshold as high as 10...20 liters/hour.

Modern metering systems use ultrasonic sensors and can therefore detect significantly smaller water flows. However, the challenge remains of distinguishing escaping water from the legit water takes.

Some startups advertise the use of artificial intelligence and machine learning. This sounds very sophisticated but can lead to undesirable side effects. Example: In normal times of work, a shower is always taken between 6:00 and 6:30 in the morning. After a certain time, the system learned that a significant amount of water is always used during this period. It has to recognize an equally large water outflow at 8 a.m. or 9 a.m. as escaping water, because there is usually no one in the house and no water has been drawn off over a longer period of time. The whole thing goes well until the homeowner get the flu, stays in bed and then want to warm up in the shower at 8:30.

Micro leakage detection



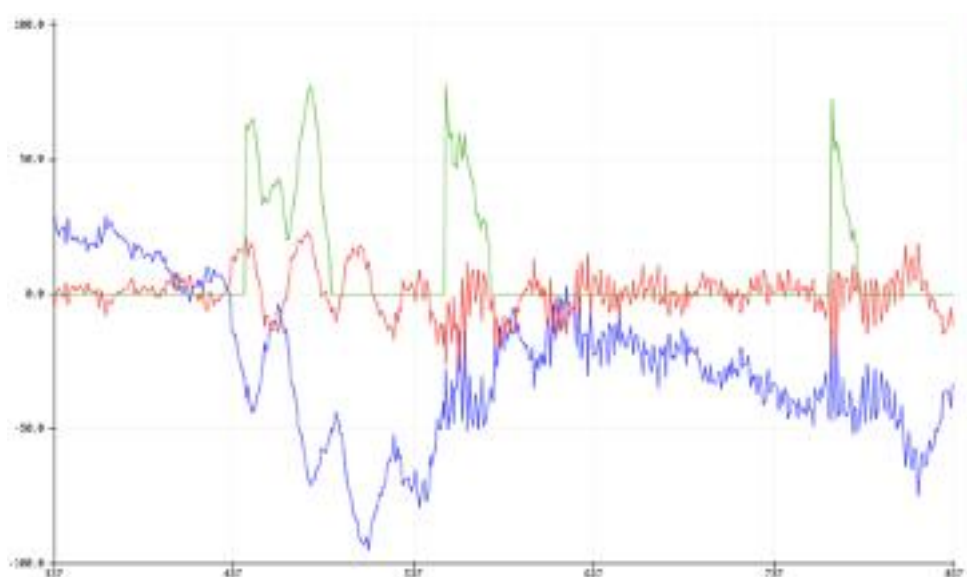
Micro-leakage detection is a process that is well known to plumbers from heating installations. The piping system is filled with water under a certain pressure and then disconnected from the supply line. If the pressure remains, the pipe system is tight, if the pressure drops, water must have flowed away somewhere - a leak. Since there is always water under a nominal pressure

of several bars in the tap water pipe, the pipe system only has to be disconnected from the main water supply and the water pressure measured for some time (usually some minutes only).

With this method, even the smallest leaks can be identified, depending on how much time is available to carry out the test. Commercial systems usually perform this test at night for over 15 minutes. Should water be needed unexpectedly during this time, this would be recognized by a sudden drop in pressure due to an open water tap or the toilet flush. The feeder can then be opened again quickly, and the test is repeated later.

Good micro leakage tests can detect escaping water as low as 4 ml/hour.

Aqua-Scopes Acoustic Sensor Technology



Aqua-Scope uses a new and innovative sensor technology to detect leaks not only in the visible range but also hidden in the wall. The sensor is connected to the water system and analyzes sound waves inside the water pipe. Water is an excellent transmitter of sound waves and sound waves are transmitted about 5 times faster in water than in air.

Sound waves in water pipes are generated by various events:

- Water leakage from a faucet, toilet, shower, etc.
- Leaks of any kind anywhere in the house
- Sound caused by events outside the house such as a water supply pump
- General chemical and thermal processes within the water supply system.

To be able to cleanly distinguish between the individual events, the sound or the rapid pressure changes in the water must be measured very precisely and with low noise, and the measurement results must be permanently evaluated by suitable algorithms. In addition to the detection of leaks, the water consumption in the house can also be recorded quasi as a by-product.



Thanks to the very good transmission properties of water, a single sensor in the house is sufficient to record all events in the water pipe. It does not even matter where in the house the sensor is installed.

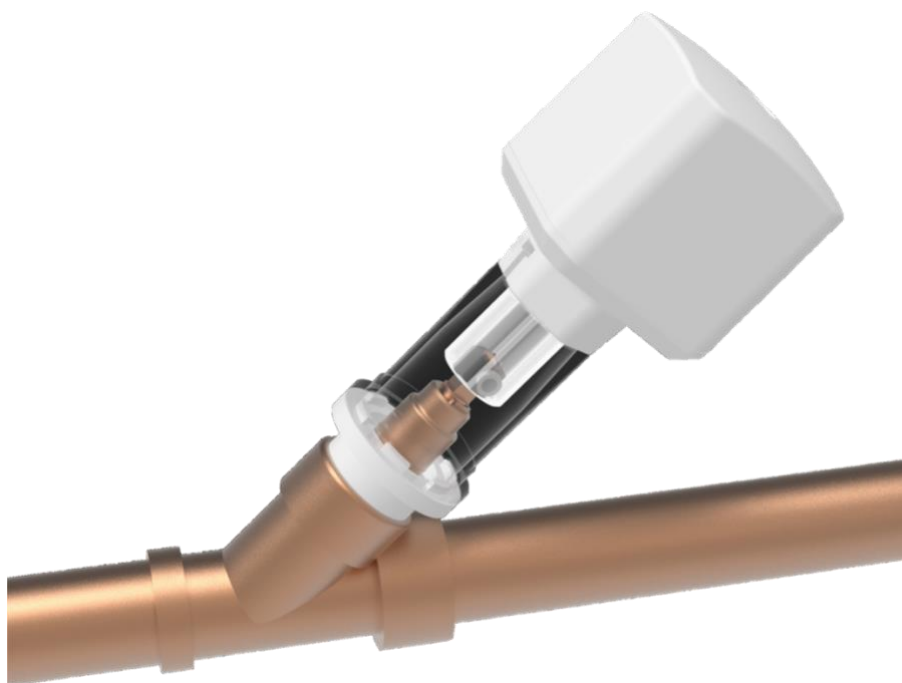
The sensor can be installed directly on all ¼ inch inspection openings of water fittings such as a pressure reducer, the backflow preventer or main shut-off valve, or via an adapter on the angle valve under the sink or - in some countries - on the toilet flush.

Water Shut Off

Once a leak is detected, the further supply of water via the domestic water connection must be stopped as soon as possible. If the resident is informed and nearby, he could do this manually by shutting off the main valve. In most cases, however, the water must be switched off automatically. There are a number of electrical shut-off options such as magnetic shut-off valves (solenoids) that can be easily switched via a control. Such shut-off valves are almost never installed in a normal domestic water distribution system and therefore have to be installed in the water supply by an installer first. For this purpose, the water supply is switched off, the main water pipe is cut at a suitable point and the corresponding component is inserted into the pipe. The installation of such a valve is not only cost-intensive but also involves an additional risk., There are two further coupling points with different expansion coefficients that are installed directly in the water pipe and thus represent further potential weak points for water leaks.



Furthermore, solenoids tend to block due to dirt and corrossions and therefore they are not a reliable option to stop water flow in case of an emergency.



The retrofittable motor servos from Aqua-Scope Technologies offer an alternative. No additional component is introduced into the water distribution, but the already installed shut-off valve is retrofitted by an additional motor.

Aqua-Scope offers two different versions of motor servos for the two most commonly used valve types:

- BVS: For ball valves of diameters between ½ and 1 ½ Inch
- KVS: For Angled Seat Gate valves (KFR Valves) according to DIN 20, DIN 25 or DIN 32

The installation of these retrofit motor servos does not require much time or special knowledge. Any homeowner can do this without prior special training in a matter of minutes.

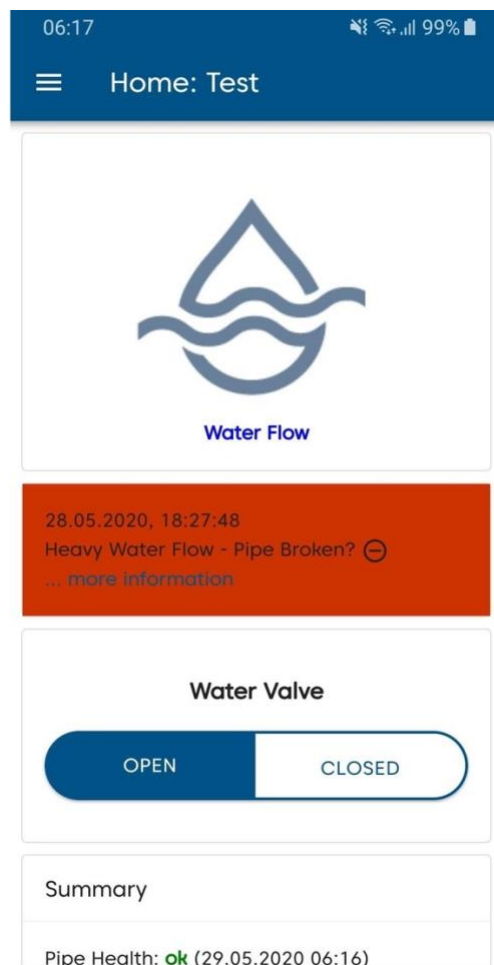
As soon as the motor servo receive a corresponding control command, they switch off the water in a few seconds. In order to ensure that the valve functions perfectly in case of a leak, the motor servo will regularly carry out a training run (close plus reopen) to briefly move the valve.

Alarming the home owner

At the same time that the water is turned off, the residents must be informed of the alarm situation. On the one hand, the water is turned off and certain functions such as a shower or toilet are no longer available. On the other hand, the alarm is only given after a certain amount of water has leaked out. With good leakage protection, this amount will be small, but it is never zero.

The mobile phone with a so-called push message, which is displayed directly on the screen, is suitable for the information. However, this presupposes that the user has also installed an appropriate app from the provider of the leakage protection. Good systems will therefore also use alternative information channels such as SMS or direct phone calls (automated or from an alarm center) and offer a possibility for alarm escalation. This means that an adjustable time is waited for after information has been given, for example by a push message. If the alarm was not acknowledged during this time, i.e. the resident is informed, then in a next wave of information other residents can be alarmed or other communication channels can be used.

As with any alarm system, the user should acknowledge receipt of the alarm information and thereby reset the alarm. This can be done remotely using an app or directly on the leakage protection devices.



Summary

Permanent fresh water is a blessing in every home and a great danger at the same time. Leaking water destroys a house and annually burns billions of euros/dollars in value.

Leakage protection can effectively reduce the damage caused by escaping water.

To do this, a system has to detect damage, make an appropriate decision, switch off the water if necessary and inform the resident. It is critical to recognize all possible damage cases and to distinguish them from the normal take of water. This is only possible through a sensible mix of different sensors and measuring methods.

Despite the considerable damage and losses caused by water leakage, leakage protection systems have so far hardly been installed. The biggest hurdle is the complex installation, which can only be done by trained installers.

The Aqua-Scope System is the world's first comprehensive leak protection that can be installed by the homeowner without outside help.