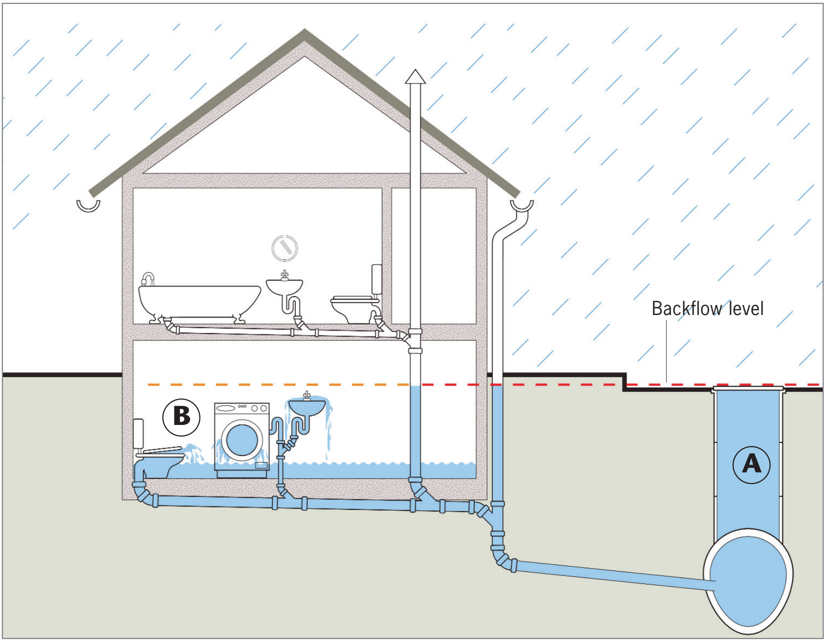
Backflow protection

1. Principles

1.1 Causes of backflow

The frequency of heavy rainfall is increasing everywhere in Europe. For example, there were six “floods of the century” in Germany between 1995 and 2005 alone. These floods affected almost all parts of Germany. This does not necessarily mean that the total amount of rainfall over the year is increasing, but only that the intensity has increased: heavy periods of rainfall follow long dry periods in a trend that can be observed world wide.
Extremely heavy rainfall of this type produces run-off which exceeds the capacities of public sewers. When this happens, the wastewater in the sewers can rise in the sewer shafts until it floods the shaft, flows out through the manhole cover (backflow level) and floods the surface of the road.



When backflow occurs, the wastewater backs up in public sewer access shafts (A) until it reaches the surface of the road (backflow level). Anything connected to public sewer systems below the backflow level (B) is at risk of flooding.

1.2 Consequences

According to EN 12056 the backflow level is defined as the highest possible wastewater level at a specified position in a sewer system.
Backflow can occur during very heavy rainfall and flooding and is a serious risk for buildings and land in particular. Other causes of backflow are pipe blockages or when pipes are being deliberately flushed. Backflow can also affect mixed sewers as well as grey water sewers. Because of the principle of communicating pipes, there is a risk that the wastewater from the public sewers can enter the house and flow out of sanitary installations located below the backflow level. This can cause extensive damage to property and furnishings. The critical backflow level defined in accordance with EN 12056 is usually the surface of the road (see Figure in Section 1.1) above the sewer (unless another point is specifically mentioned).

A flooded cellar as a result of backflow.

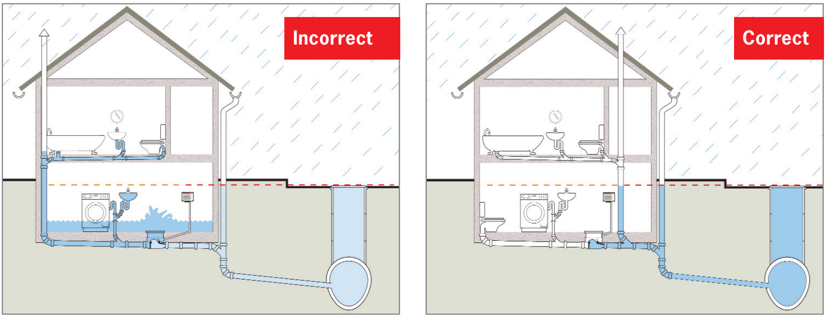
1.3 Legal aspects

Home owners and developers have to bear the costs of cellar flooding themselves in the event of sewer backflow because the local authorities cannot be held liable for such damage. Owners are also liable to their tenants for any damage caused. The relevant standards therefore stipulate that sanitary installations which are located beneath the backflow level must be protected by lifting plants (active backflow prevention) or by backflow stops (passive backflow prevention).
Although it is now possible to take out insurance against such damage, the insurance companies usually turn down any claims if building regulations have not been implemented or have been incorrectly observed.

1.4 Protecting sanitary drainage installations

According to EN 12056-4, only drainage installations lying beneath the backflow level have to be protected. Safeguards must therefore be in place to ensure that wastewater generated above the backflow level can “flow past” any backflow stops which are installed.
EN 12056 therefore stipulates that all drains lying above the backflow level must be drained by a natural gradient. This naturally also includes roofs and their rainwater downpipes.

The use of a wastewater lifting plant above the backflow level is usually only permitted in very unusual circumstances, e.g. during house refurbishment.
As referred to earlier, drainage points lying above the backflow level must not drain via lifting plants or into backflow stops. This is particularly critical when backflow stops are installed because these units not only totally seal off any backflowing wastewater, they also totally seal off any wastewater pipes flowing to the backflow stops.

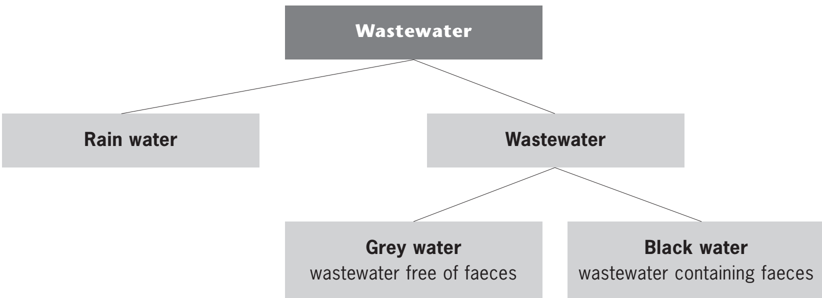


Wastewater draining off above the backflow level must not be drained via a backflow stop.

The incorrect installation shown above reveals that during backflow situations, it is also not possible for wastewater to be drained away from areas above the backflow level during the whole period the backflow stop is affected by backflow.

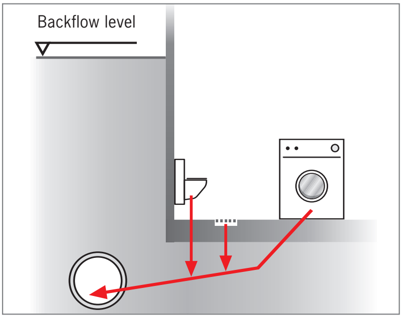
1.5 Definition of wastewater types

We differentiate between the following types of wastewater:



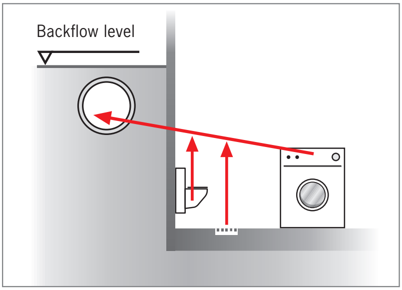
Please note here that the main difference in the use of backflow stops is between wastewater containing faeces and wastewater free of faeces. Wastewater samples may need to be chemically analysed in the case of industrial wastewater.

1.6 Determining the use of a backflow safety device



A gradient to the sewer is needed for backflow stops to function

Backflow protection can be achieved with active or passive backflow safety valves. Cellar drains with backflow safety valves and backflow stops for continuous pipes are classified as passive backflow safety valves. The word “passive” here refers to the way the backflow safety device functions. The backflow unit (in this case, in the form of a flap) always lies passively on a seat and is merely opened by the pressure of flowing water when upstream water drains through the backflow safety device.



The base of the sewer is higher than the sanitary drainage installations. A lifting plant must be installed to transport the wastewater into the sewer via a backflow loop.

Active backflow safety valves on the other hand come in the form of wastewater lifting plants, pumps and pump stations. Active backflow safety valves require external energy (electricity) to move effluent or rain water against any backflow.

1.7 Inspection and maintenance

Backflow safety valves must be regularly maintained and inspected to guarantee safe operation in the interests of the operator.
Maintenance must be carried out in accordance with the relevant standards and manufacturer’s maintenance regulations. In addition to proper professional installation, it is therefore essential for regular maintenance of the backflow safety valves to be conducted by trained staff.
Depending on the type of backflow safety valve, the maintenance also involves servicing which has to be carried out by either properly qualified personnel or a properly qualified technician in accordance with the definition in the EN 1999-100. Properly qualified personnel are defined as staff working for the operator or third parties whose training, knowledge and practical experience ensure that they can properly carry out the necessary evaluations or tests required in the relevant areas.

Properly qualified technicians are defined as the staff of third party companies, experts or other institutions with certified special technical knowledge on the operation, maintenance and testing of the drainage installations described here.

2. Passive backflow safety valves (backflow stops)

2.1 Planning

All cellar drains with backflow safety valves and backflow stops for continuous pipes are manufactured and tested in accordance with EN 13564-1.

Passive backflow safety valves are only permissible under certain conditions:

- Wastewater must be capable of draining away along a natural slope
- There must only be a small number of users
- Installation must be located in a room with inferior utilisation
- The drainage points cannot be used during a backflow situation

DIN EN 13564-1 defines six different types of backflow stop, of which types 0 to 3 involve backflow stops for continuous pipes. Pipes 4 and 5 are used in cellar drains with backflow safety valves. In general, the different types differ from one another by the number of closing devices and the presence of manually lockable emergency seals or powered emergency seals.

Type	Use	Automatic seal	Emergency seal	Fields of application
0	Horizontal pipe	1	0	Rainwater utilization plants
1	Horizontal pipe	1	1*	Rainwater utilization plants
2	Horizontal pipe	2	1*	Rainwater utilization plants /wastewater free of faeces
3	Horizontal pipe	1 (operated electrically or pneumatically)	1	Wastewater with and without faeces, marked with „F“
4	Installed in floor drains	1	1*	Wastewater free of faeces
5	Installed in floor drains	2	1*	Wastewater free of faeces

Assignment of backflow stop types pursuant to EN 13564-1.

*Emergency seal can be combined with automatic seal.

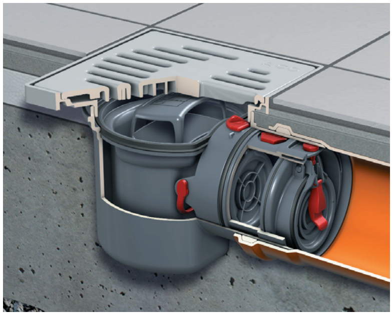
The use of the different types is regulated by national law. The following table defines the specific authorisations applying to Germany, Austria and Switzerland.

Country	Types approved for use
Germany	For rainwater utilization plants, types 0 and 1 are approved. For wastewater free of faeces, types 2, 3 and 5 are approved. In the case of wastewater containing faeces, only type 3 with “F” marking may be used.
Austria	For wastewater free of faeces, types 0 to 5 are approved. In the case of wastewater containing faeces, only type 3 may be used.
Switzerland	Backflow stops may only be used following project-related authorization.

State-specific approvals for passive backflow stops.

2.1.1 Cellar drains with backflow stops (type 4 or 5)

Cellar drains are normally installed in the floor plates of private cellars. Water from mopping the floor or accidental spills (from a leaky washing machine for instance) is drained off through the grating of a cellar drain. The wastewater from other installations such as showers, wash basins and washing machines can be connected to the floor drain if required via lateral inlets.
There is normally absolutely no problem connecting other installations to a cellar drain. If the drain is generally only used to drain off water when mopping the floor, there is a risk that the odour seal will dry out. This can be avoided by connecting the drain up to an installation which is regularly used (e.g. a shower).

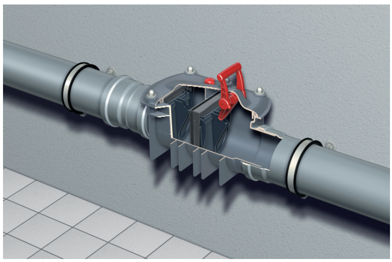


ACO JUNIOR- Cellar drain for installation in a floor plate.

Cellar drains with (or without) backflow stops must only be used to drain off wastewater free of faeces. Toilets or urinals must not be drained via cellar drains for various reasons: hygiene, the avoidance of smells, and the risk of blockages.
Cellar drains are normally supplied with a DN 100 lateral outlet socket and have class K3 gratings (suitable for walking on). These dimensions are usually completely adequate for their use in private homes.

2.1.2 Backflow stops for continuous pipes for wastewater free of faeces (type 0 - 2)

Unlike cellar drains with type 4 and 5 backflow safety valves, type 0 to 3 backflow safety valves are not actually designed for point drainage. These are pipe-shaped backflow stops which prevent backflow into several drainage installations.
The backflow stops are designed for either wastewater containing faeces or wastewater free of faeces depending on the type of wastewater being drained through the backflow safety valve. The type of wastewater which could backflow into the safety valve (containing faeces or free of faeces) is not important.
Backflow stops for continuous pipes are normally installed in a recess in the floor plate. To ensure simple maintenance and inspection, these products must be used with either appropriate shaft constructions or by constructing suitable access on site.



Example of a backflow stop in a continuous pipe.

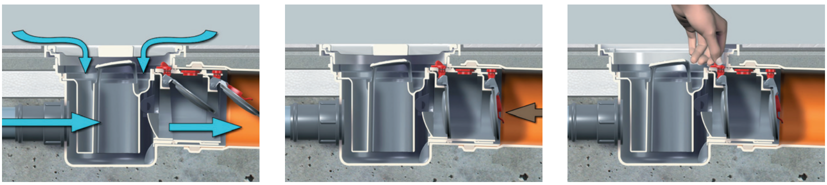
2.1.3 Backflow stops for continuous pipes with wastewater containing faeces (type 3)

Type 3 backflow stops can be used to protect a toilet against backflow when the toilet is installed below the backflow level. It is important that the persons for which the installation is being installed have access to another WC above the backflow level.
Backflow stops for wastewater containing faeces are usually operated pneumatically or electrically. An alarm integrated in the control panel warns the operator of malfunctions or backflow. This alarm should therefore be installed in a location which is easily accessible to the users. The type 3 backflow stop is the only backflow stop with an alarm. Types 0 – 2 have no alarm.

2.2 Function

2.2.1 Cellar drains with backflow stops (type 5)

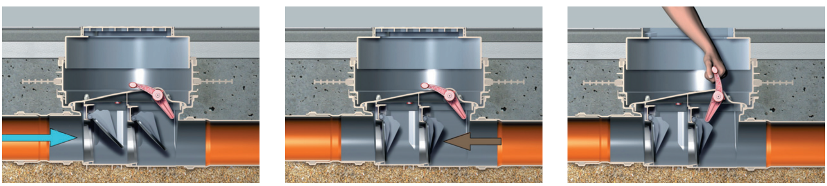
In cellar drains with backflow flaps, the flaps fit flush against a fitted seal during normal operation. The force of flowing wastewater pushes open the flap in the flow direction to drain the wastewater in the direction of the sewer.
If there is backflow, the wastewater backing up from the sewer flows against the normal flow direction and comes into contact with the outer backflow flap. The flap is pressed against the flap sealing ring to seal off the cellar drain. No wastewater can now flow into or out of the cellar drain.
If the outer backflow flap is ineffective and leaky, the second flap takes over the protective function and seals off the cellar drain. The second flap can be locked manually in an emergency. During long periods away from home (e.g. holidays) it is recommended engaging this emergency lock. But remember to release it again when returning home.



Cellar drain modus operandi with backflow flaps. Example: ACO JUNIOR

2.2.2 Backflow stops for continuous pipes with wastewater free of faeces (type 2)

Backflow stops in continuous pipes for wastewater free of faeces operate along the same lines as cellar drains with backflow safety flaps.

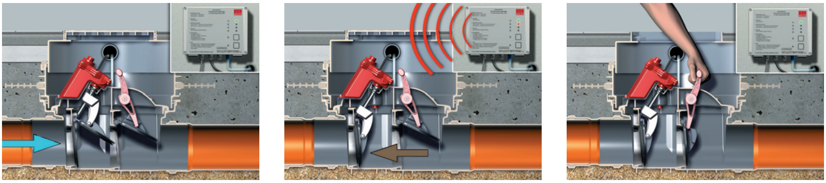


Modus operandi of a backflow stop for wastewater free of faeces. Example: ACO TRIPLEX-K

2.2.3 Backflow stops for continuous pipes with wastewater containing faeces (type 3F)

Backflow safety valves for wastewater containing faeces comply with EN 13 564-Type 3-F. Backflow stops of this type have an automatic, motor-driven closing mechanism and a manual blocking mechanism. A backflow pressure switch automatically closes the motor-driven operating seal during a backflow situation.

The backflow stop is opened again when the backflow has subsided. The status of the backflow stop is shown on a visual display in the control box. An acoustic alarm also sounds when the operating seal is being closed.



Modus operandi of a backflow stop for wastewater containing faeces. Example: ACO QUATRIX-K.

2.3 Installation and assembly

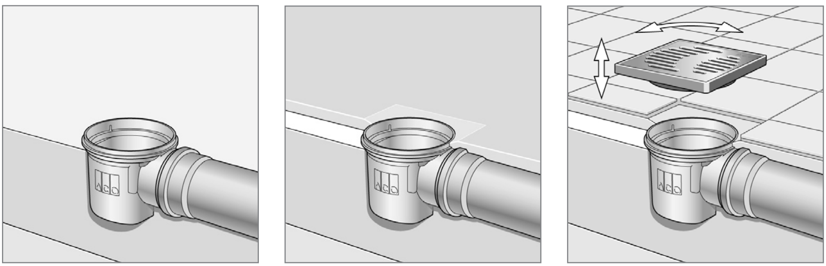
2.3.1 Cellar drains with backflow stops

The ACO JUNIOR is used here as an example to describe the assembly of a cellar drain with a backflow stop. Various methods can be used to install the drain body.

a) Before the concrete floor plate is poured, the backflow stop is connected to the pipes. Take the open height of the completed floor into consideration when installing the drain body.

b) Once the floor plate has been poured, the backflow stop is installed in a freshly prepared rebate, and then connected to the pipe before pouring concrete into the space around the drain body in the rebate.

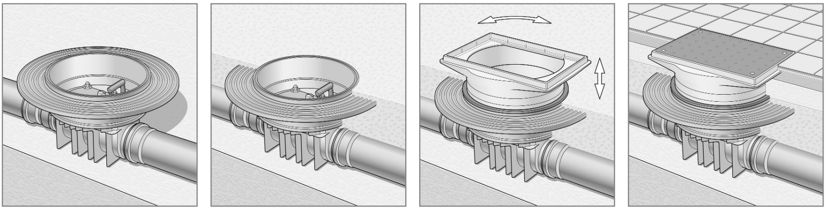
c) When a building is being refurbished, the existing backflow stop is removed and replaced e.g. with an ACO JUNIOR. The ACO JUNIOR benefits from small size, which means that the rebate dimensions can be kept to a minimum.



Installation of an ACO JUNIOR cellar drain with backflow stop.

2.3.2 Backflow stops for continuous pipe for wastewater free of faeces

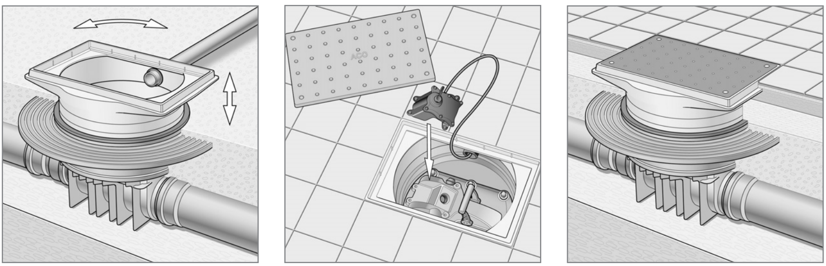
These backflow stops are installed in continuous pipes so that several drainage installations at risk of backflow can be protected at the same time.
Take care during installation that the backflow stop is installed horizontally and properly bedded in so that the backflow flaps always lie properly against the seal.
When constructing the rest of the floor, care must be taken to ensure that a shaft is built above the backflow stop which is large enough to ensure proper maintenance and inspection work. The shaft must be fitted with a matching cover. Alternatively, backflow stops can be supplied with top sections and covers.



Installing a backflow stop for wastewaster free of faeces with a top section and a cover for recessed installation

2.3.3 Backflow stops for continuous pipe for wastewater containing faeces

These backflow stops are installed in the same way as 2.3.2 but additionally require an electric motor and a pneumatic regulator.
An empty duct therefore has to be laid in the raw floor from the backflow stop to the position of the control box. The duct has to be closed at both ends. Install the control box in a position where all of the alarms can be readily heard by the users.
Take care that the pressure hose for the pneumatic control is always laid in a continuous slope from the control box to the backflow stop.

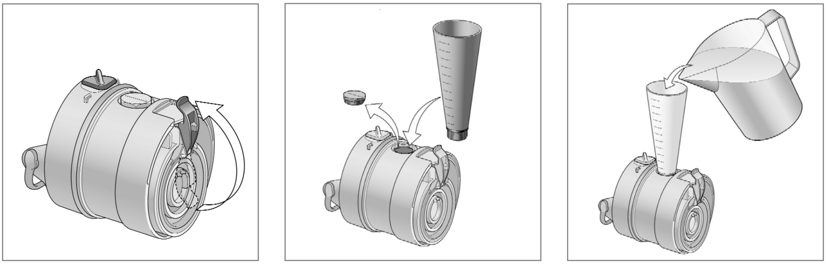


Assembling the wiring and the switch for a backflow stop for wastewater containing faeces.

2.4 Maintenance and control

2.4.1 Cellar drains with backflow stops

Cellar drains with backflow safety valves must be visually checked according to EN 13564-1once a month by the operator, and the emergency valve must be operated to check that it is functioning properly.
The backflow stop should be serviced by properly qualified personnel[1) every six months.
Servicing involves cleaning the backflow unit, testing the backflow unit to ensure it is functioning properly, and replacing any defective seals if necessary. A function test has to be carried out using a test pipe in accordance with EN 13564-2.
During this test, the test pipe is filled with clean water. If the water column drops up to a water column of 100 mm over a period of 10 minutes, it has to be topped up again so that the water column is again 100 mm high.
The backflow stop is considered to have passed the function test if no more than 500 cm^3 of clean water has to be topped up within the specified 10 minutes.



Function test of the ACO JUNIOR backflow unit. The flap has to be locked manually before carrying out the test.

2.4.2 Backflow stops for continuous pipes with wastewater free of faeces

Backflow stops for continuous pipes with wastewater free of faeces are maintained as described in Section 2.4.1. The backflow stops should therefore be checked visually once a month by the operator and the emergency seal should be operated. Servicing should take place at least twice a year by properly qualified personnel[1).
The first step during servicing is to remove the cover of the backflow stop. The flaps can then be removed from the backflow stop and checked. The body of the backflow stop is flushed out before reinstalling the flaps. The cover is then screwed back on to the body of the backflow stop.
The tightness test pursuant to EN 13564-2 is carried out in a similar way to that described under Section 2.4.1. The manual seal is locked, the sealing plug removed from the test opening, and the test pipe screwed into place. The test then proceeds as described in Section 2.4.1.

[1) see Chapter 1.7

Dismantling the fittings, cleaning and tightness test

2.4.3 Backflow stops for continuous pipes with wastewater containing faeces
Backflow stops for continuous pipes with wastewater containing faeces are maintained in the same way as the backflow stops for wastewater free of faeces. The backflow stops should therefore be visually inspected by the operator once a month and the emergency seal should be operated

Servicing should be carried out at least **twice a year** by a **properly qualified technician**.

This involves removing the cover from the backflow stop. Flaps are then removed from the backflow stop and inspected. The body of the backflow stop is flushed clean before replacing the flaps. The cover is then screwed back onto the body of the backflow stop. Proper functioning of the control and the motor must also be tested.

Dismantling the fittings, cleaning and tightness test

The tightness test pursuant to DIN EN 13564-2 is conducted in a similar way to that described in Section 2.4.1. This first involves locking the manual emergency seal in operating mode. The automatic seal is then also closed by pressing the relevant button on the control box. The sealing plug is then removed before carrying out the tightness test and the test pipe is screwed into position. The test is then carried out as described in Section 2.4.1.
At the end of the tightness test, reopen both flaps (by pressing the button on the control box, and by manually operating the emergency seal).

3 Active backflow safety valves

(Wastewater lifting plants and pump stations)

3.1 Planning

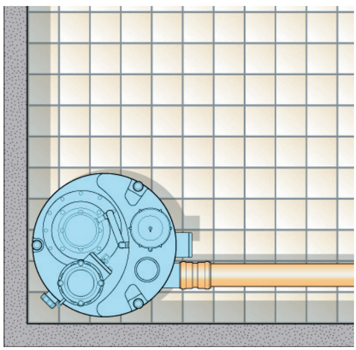
Active backflow safety valve units are also differentiated according to the type of wastewater: either wastewater containing faeces or wastewater free of faeces. A large number of lifting plants, submersible pumps and pump stations are available for this purpose. Active backflow safety valves are used wherever there is no natural gradient towards the sewer, or when wastewater must be disposed of even during backflow affecting a system with a proper natural gradient.
Wastewater lifting plants are normally equipped with one pump.
If wastewater drainage or wastewater inflow must be maintained without interruption during normal operations, EN 12056-4 specifies that a lifting plant with two pumps (twin system) each with the same output must be used. This always applies when draining deeper lying parts of multiplexes, offices, commercial buildings, hospitals, warehouses, or when wastewater is drained from separators.
The lifting plants/pump stations are operated so that the pumps are always operating alternately to ensure that they both undergo the same amount of wear. Twin units do therefore not mean that two pumps are normally operating at the same time.

3.1.1 Lifting plants

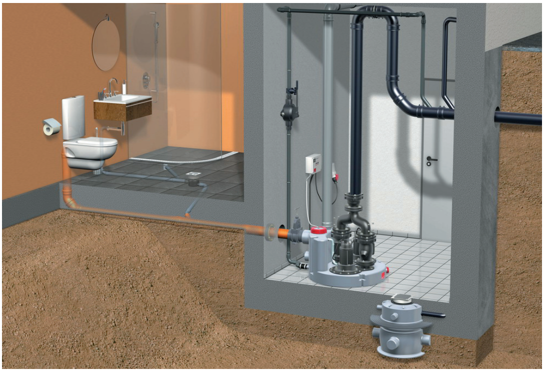
The wastewater lifting plants manufactured by ACO Haustechnik are compact systems for free-standing installation in cellars or shafts.
EN 12056-4 stipulates that a working space of minimum 60 cm height and width must be present above and around the operating units to ensure that the necessary maintenance and control work can be carried out. Another stipulation is that the room in which the lifting plant is installed is adequately ventilated and aerated, has lighting, and has a pump sump.
Electrical components which must not be flooded should be installed in dry rooms not at risk of flooding.
The following must be laid before installing a wastewater lifting plant:

- Inlet pipes
- Power supply
- Blank cable duct if necessary (when installed in floor recesses)

The wastewater is drained into the collecting tank of the wastewater lifting plant via the inlet pipes. The inlet pipes are usually DN 100 – DN 150 depending on the volume of wastewater.
All of the pipe connections must be unstressed. Pipes laid through walls and ceilings must be tight and sound proofed. (E.g. by using ACO Haustechnik APLEX pipe ducts).



Enough space must be available around a lifting plant for proper maintenance and inspection.



Installation example of ACO MULI-STAR duo

Make allowance during planning for the vent stack of the lifting plant which must be separately laid up through the roof of the building or fed into the main or secondary ventilation system. The vent stack of a lifting plant must not be connected to the inlet side vent stack of a grease separator. Ventilation and venting valves must not be used.
EN 12056-4 stipulates that the minimum strength of the pressure piping must be 1.5 times the max. pump pressure, and the base of the pressure piping must always be laid above the backflow level.
Make sure that the complete installation is protected from frost.
The inlet line and the pressure piping must always be fitted with a stop valve. In the case of lifting plant for wastewater free of faeces, no stop valve is required in pressure piping when the pipes have a diameter less than DN 80 and if it is possible to drain the pipes by an alternative means.
The minimum nominal width of the pressure piping of wastewater lifting plant is regulated by EN 12056-4, e.g. minimum DN 80 for lifting plant for wastewater containing faeces but without faeces grinders.
No other drainage pipes should be connected to pump pressure piping.

3.1.2 Pump stations

Pump stations are wastewater lifting plants which are usually installed outside of buildings directly in the ground. They consist of a prefabricated monolithic collecting shaft with integrated submersible motor pumps and the electric controls.
Pump stations basically function in exactly the same way as wastewater lifting plants. If pump stations are installed under paths or roads, observe the classifications stipulated in DIN EN 124 as follows:

Load class	Load up to	Example
A15	15 kN	Footpaths and cycle paths
B125	125 kN	Areas with slow moving traffic such as car parks
D400	400 kN	Public roads

Load class as per DIN EN 124

Depending on the groundwater level, check the buoyancy safety of the pump stations and undertake the necessary measures where required.
The greatest protection against backflow is only achieved using wastewater lifting plant when the base of the pressure piping rises above the backflow level.
The systems also need to be installed in locations where the pressure piping is protected from frost. This can be achieved by laying the pipes in frost-free areas, e.g., under a heap of soil, in thermally insulated garages or in heated outdoor cabinets.
If the pump stations are located in the vicinity of a used building, the pressure pipe can be laid in the building. The backflow loop can then be laid within the building. After the pump station has been installed, DIN EN 1610 stipulates a mandatory tightness test which has to be conducted before commissioning. DIN EN 476 stipulates the specifications for shafts.
Adequate power is required to operate the pumps. The switching unit must be installed in a dry, temperature-protected position, e.g. in a building or in an outdoor cabinet.

3.1.3 Layout of wastewater lifting plants and pump stations

Several specifications are required for proper dimensioning of wastewater lifting plants and pump stations:

Total wastewater inflow to plant Q_{tot}

$$Q_{tot} = Q_{WW} + Q + Q_C$$

and total delivery head H_{tot}

$$H_{tot} = H_{geo} + H_{v,a} + H_{v,r}$$

Legend

Q_{tot}	= total wastewater inflow, l/s
Q_{ww}	= grey water inflow, l/s
Qc	= permanent inflow, l/s
Q	= rainwater inflow, l/s
H_{tot}	= total delivery head, m
H_{geo}	= static delivery head, m
Hv,a	= pressure head loss in fittings, m
Hv,r	= pressure-side pipe friction losses, m
V	= collector tank working volume, l
T	= minimum running period of pump, s
V	= delivery flow of pump, l/s

By means of these indications, plant size can be determined.
Calculation example:
Multiplex house 2 apartments below the backflow level, in Frankfurt am Main, with following drainage objects:
4 washing basins, 2 showers, 2 single urinals, 2 bath tubs, 2 kitchen sinks, 2 dish-washers,
2 washing machines and 4 toilets with toilet tanks of 6 litres volume.

Distance: Erection location of lifting plant up to sewer connection 10 m (length of pressure pipe).
Static delivery head: 2.5 m.

Calculation example pursuant to EN 12056-4:

a) Q_{ww} determine grey water inflow
b) Q determine rainwater inflow
c) Q_{tot} determine total wastewater inflow and permanent inflow Q_c
d) $H_{v,r}$ pressure-side pipe friction losses
e) $H_{v,a}$ determine pressure head loss in fittings
f) H_{tot} determine total delivery head
g) V_P selection of pump
h) newly determine H_{tot} with pump performance of lifting plant selected
i) V calculate working volume of collector tank
j) compare working volume with pipe volume
k) check container size

a) Wastewater inflow

The wastewater inflow volume is calculated from the sum of the defined connection values of each of the connection pipes or drainage installations pursuant to DIN 1986-100. This is done by multiplying the number of drainage installations by the associated connected loads (DU). The separate results (sum DU) are then added up to give the total connection (total DU).

Drainage object	Number	Connection value (DU)	Sum DU
Wash basin, bidet	4	0.5	2.0
Shower without plug	–	0.6	–
Shower with plug	2	0.8	1.6
Single urinal with toilet tank	2	0.8	1.6
Urinal with pressure flush	–	0.5	–
Stand urinal	–	0.2/apiece	–
Bath tub	2	0.8	1.6
Kitchen sink	2	0.8	1.6
Dish-washer (domestic)	2	0.8	1.6
Washing machine up to 6 kg	2	0.8	1.6
Washing machine up to 12 kg	–	1.5	–
WC with 4.0 l toilet tank	–	not approved	–
WC with 6.0 l toilet tank	4	2.0	8.0
WC with 7.5 l toilet tank	–	2.0	–
WC with 9.0 l toilet tank	–	2.5	–
Floor drain DN 50	2	0.8	1.6
Floor drain DN 70	–	1.5	–
Floor drain DN 100	–	2.0	–
		total DU	21.2

Example of drainage objects and their connecting values pursuant to EN 12056-2 (system I)

Depending on character of building, an adequate outflow figure has to be chosen:

Character of building	Outflow figure to be used (K)
Irregular use, e. g. in houses, pensions, offices	0.5
Regular use, e. g. in hospitals, schools, restaurants, hotels	0.7
Frequent use, e. g. in public toilets and/or showers	1.0
Special use, e. g. laboratory	1.2

We selected irregular use for our calculation example (K = 0.5).

Calculating the wastewater inflow (Qww) is based on the formula:

$$Q_{WW} = K * \sqrt{\text{total DU}}$$

$Q_{WW} = 0{,}5 * \sqrt{23.2}$

$Q_{WW} = 2.30$ l/s

b) Rainwater inflow

The rainwater inflow (Q) is calculated using the following equation:

$$Q = (r(D,T) * C * A)/10000$$

Here, the following values are taken into consideration:

$r_{(T,n)}$	The reference rainfall in litres per second per hectare (l/[s * ha] determined statistically based on a 5 minute reference rainfall period expected once every two years[2] (see Table A1, DIN 1986-100). Use the value **r 5**,100 from the same table if property is at risk.
C	The outflow coefficient
A	The rainfall area in square metres projected from the floor plan

The reference rainfall $r(T,n)$ is determined from rain maps. The reference rainfall derived in this way is taken from the tables contained in e.g. DIN 1986-100.

2) The revised version of DIN 1986-100 stipulates a 15 minute reference rainfall which is to be expected once every two years.

The outflow coefficient C to determine the rainfall inflow is calculated from the following table:

No.	Surface types	Outflow coefficient C
1	Impermeable surfaces, e.g.	1.0
	– roofs >3° slope	1.0
	– concrete surfaces	1.0
	– ramps	1.0
	– paved surfaces with sealed joints	1.0
	– asphalt surfaces	1.0
	– paving stones with grouted joints	1.0
	– roofs <= 3° slope	1.0
	– gravel roofs	0.5
	– greened roofs[a]	
	–> for intensive greening	0.2
	–> for extensive greening up to 10 cm thickness	0.3
	–> for extensive greening less than 10 cm thickness	0.5
2	Partially permeable and partially absorbing surfaces, e.g.	
	– concrete paviors, laid in sand or slag, surfaces with slabs	0.7
	– surfaces with cobbles, joint surfaces greater than 15%	
	e.g. 10 cm x 10 cm or smaller	0.6
	– wet surfaces	0.5
	– children's playgrounds with partially paved areas	0.3
	– sports grounds with drainage	
	–> tartan track, Astro turf	0.6
	–> tamped ares	0.4
	–> lawns	0.3
3	Permeable surfaces with or without minor drainage, e.g.	0.0
	– parks and vegetated areas, gravel and slag surfaces, pea gravel on partially paved surfaces such as garden paths with moist surfaces or drives and car parking areas with concrete lawn grids	0.0

Listing of outflow coefficients C as per surface types.

$Q = 314\ l/s\ (s * ha) * 1.0 * 5m^2 / 10{,}000 = 0.157\ l/s$
A = concrete stairs covering $5m^2$.

The reference rainfall is selected if there is no risk to property.

c) Total water inflow and permanent inflow
The total wastewater inflow (Qtot) can be calculated from the wastewater inflow (Qww) and the rainwater inflow (Q). Permanent inflows (Qc) can also be taken into consideration as an option.

$$Q_{tot} = Q_{WW} + Q + Q_c$$

The optional permanent inflow could include for example wastewater from cleaning associated with an industrial process which continuously generates wastewater. Inflows of this type can also be specified in l/s and added to the total wastewater inflow.

Q_{tot} = 2.3 l/s + 0.157 l/s + 0 l/s = 2.46 l/s

d) Pipe frictional losses on the pressure side
To determine the pressure losses in the pipe, the total wastewater inflow must be converted to m^3/h (Q_{tot}* 3600/1000).

Conversion to m^3/h : 2.46 l/s * 3600 : 1000 = 8.85 m^3/h

The values Hv.j. and vm/s can then be read off from the following table. These values are dependent on the nominal width of the planned pressure pipe.
DIN EN 12056-4, Table 2 stipulates that the minimum nominal width of the pressure pipe in faeces lifting plant without faeces grinding must be min. DN 80.

A pressure pipe line with a nominal width of DN 80 is planned.
For a DN 80 pressure pipe, the following table reveals that the minimum flow rate is 13 m^3 at a flow velocity of 0.7 m/s and a pressure head loss Hv.r of 0.090 m per m pressure pipe.

m^3/h	DN 60 d_1 = 60.0 mm		DN 70 d_1=70 .0 mm		**DN 80** d_1=80.0 mm		DN 90 d_1=90.0 mm		DN 100 d^1=100.0 mm		DN 125 d_1=125.0 mm	
	$H_{v.j}$	v m/s	$H_{v.j}$	v m/s	$H_{v.j}$	v m/s	$H_{v.j}$	v m/s	$H_{v.j}$	v m/s	$H_{v.j}$	v m/s
11.0	0.003	1.1	0.014	0.8	–	–	–	–	–	–	–	–
11.5	0.033	1.1	0.015	0.8	–	–	–	–	–	–	–	–
12.0	0.035	1.2	0.016	0.9	–	–	–	–	–	–	–	–
12.5	0.038	1.2	0.017	0.9	–	–	–	–	–	–	–	–
13.0	0.041	1.3	0.019	0.9	**0.090**	**0.7**	–	–	–	–	–	–
13.5	0.045	1.3	0.020	1.0	0.01	0.7	–	–	–	–	–	–
14.0	0.048	1.4	0.022	1.0	0.011	0.8	–	–	–	–	–	–
14.5	0.051	1.4	0.023	1.0	0.012	0.8	–	–	–	–	–	–
15.0	0.055	1.5	0.025	1.1	0.012	0.8	–	–	–	–	–	–

Pipe friction losses (extract from DIN EN 12056-4 - Table A1)

The total pipe friction loss in the pressure pipe is calculated by multiplying the single figures – see d) – with the total length of the pipe.

$H_{v.r}$ = = length of pressure pipe (in metres) x $H_{v.j}$

$H_{v.r}$ = 10m * 0.090 m = 0.9 m

e) Pressure head losses in valves and fittings ($H_{v.a}$)

To determine the size of the losses in fittings, use the following table or the manufacturer's details. To do this calculation you require the flow velocity (Hv) read from the previous table and the type of fitting planned.

Type of resistor	
Gate valve*	0.5
Backflow stop*	2.2
Elbow 90°	0.5
Elbow 45°	0.3
Free outlet	1.0
T-piece 45° Passage at power consolidation	0.3
T-piece 90° Passage at power consolidation	0.5
T-piece 45° Branch at power consolidation	0.6
T-piece 90° Branch at power consolidation	1.0
T-piece 90° Counter direction	1.3
Cross-section extension	0.3

* Manufacturers indications should preferably be used.

Assumptions for calculated example:

- 1 shut off valve
- 1 backflow valve
- 6 bends 90°
- 4 bends 45°
- 1 T-piece 90°, bringing two flows together

The pressure head loss Hv.a per fitting can be read off from Table 4 in DIN EN 12056-4 using the previously calculated flow velocity of 0.7m/s and the Zeta value of the selected fittings:

	Loss coefficient (excerpt from DIN EN 12056-6 – table 4)												
v	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.5	3.0	3.5	4.0
m/s	Pressure head loss $H_{v.a}$ m												
0.7	0.010	0.015	0.02	0025	0.029	0.034	0.039	0.044	0.049	0.061	0.074	0.068	0.098
1.0	0.02	0.030	0.040	0.050	0.060	0.070	0.080	0.090	0.100	0.125	0.150	0.175	0.200
1.5	0.045	0.068	0.090	0.113	0.135	0.158	0.180	0.203	0.225	0.281	0.338	0.394	0.450
2.0	0.080	0.120	0.160	0.200	0.240	0.280	0.320	0.360	0.400	0.500	0.600	0.700	0.800
2.3	0.106	0.159	0.212	0.265	0.317	0.370	0.423	0.476	0.529	0.661	0.794	0.926	1.058

Calculation of pressure head losses $H_{v.a.}$ in fittings with flow velocity v=0,7 reflecting the actual cross-section through which the wastewater flows.
The values must be added. The result is the pressure head losses in the fittings $H_{v.a.}$

- 1 shut off valve = 0.0125 m
- 1 backflow valve = 0.0528 m
- 6 bends 90° = 0.0125 * 6 = 0.075
- 4 bends 45° = 0.0075 m * 4 = 0.03 m
- 1 T-piece 90°, bringing two flows together = 0.0125 m

$H_{v.a}$ = 0.1828 m

f) Total delivery head

The total delivery head is calculated by adding the static (geodetic) delivery head, the losses in the fittings, and the pipe friction losses in the pressure pipes.

$$H_{tot} = H_{geo} + H_{v.a} + H_{v.r}$$

$$H_{tot} = 2.5 \text{ m} + 0.1828 \text{ m} + 0.9 \text{ m} = 3.58 \text{ m}$$

g) Selection of pumps

Pumps can be selected from the ACO Haustechnik catalogue with the appropriate specifications from the previously calculated total delivery head Htot = 3.58 m, and the flow rate 13.0 m²/h , derived from Table A1 using the selected pressure pipe nominal widths.

Selection:

MULI-PE duo with specifications: **H_{tot} = 3.58 m**
V_P = 38.7 m³/h

A minimum output of 13.0 m³/h calculated from the minimum flow velocity of 0.7 m/s and the defined minimum nominal width DN 80 for pressure pipes in faecal lifting plant (see pipeline friction losses section DIN EN 12056-4, Table A1).
Because the capacity of the selected pump VP = 38.7 m³/h is higher than the minimum output, the new figure has to be used to make a second calculation of the pressure head losses in the pipe and in the fittings.
Another check is required to determine whether the flow velocity in the selected pressure pipe nominal width does not exceed the max. flow velocity. If the value exceeds 2.3 m/s, it will be necessary to select a different pressure pipe nominal width.

h) Re-determining the pipe friction losses and the fittings losses based on the pump capacity of the selected lifting plant

Based on the pump capacity of the selected pump Vp=38.7 m³/h, Table A1 is used to check the nominal width of the pressure pipe and to determine the new values for the calculations.
The flow velocity with DN 80 calculated from Table A1 would be 2.15 m/s. Although this figure is permissible, the value is already too close to the maximum permissible limit for residential property. Use is therefore recommended of the next largest nominal width of DN 100.

Results of the re-calculation:
H_{tot} = 3.28 m
V_P = 42 m³/h
The selected MULI-PE duo lifting plant now has a flow velocity of 1.5 m/s at the operating levels.

i) Working volume of the collecting tank (V)

The recommended working volume of the collecting tank is calculated as follows (this excludes equipment for limited applications pursuant to EN 12056-3):

$$V = T * V_P$$

Where:
T = minimum pump running period in seconds
V_P = output of pumps in litres per second.

The following empirical values can be used depending on the motor output when determining the minimum running periods of pumps:

Motor output kW	Minimum running period T_s
Up to 2.5	2.2
2.5 to 7.5	5.5
Above 7.5	8.5

NOTE: These are empirical values.

According to the catalogue, the selected lifting plant has an output of 1.0 kW (P1, corresponds to the power consumption).
The output (Vp) of the pump is calculated as 42 m³/h (=11.66 l/s).

V = 2.2 * 11.66 l/s = 25.65 | working volume.

j) Comparing the working volume with the volume of the piping
The minimum running periods T of other manufacturers may be different. The working volume must be larger than the volume in the pressure pipe from the backflow preventer to the backflow loop, and at least 20 l. This ensures that the volume in the pressure pipe can be replaced during one pump operation.

Volume of the pressure pipe
The volume of the pressure pipe is calculated as follows:

Volume of the pressure pipe = pressure pipe length (in metres) * pipe volume (per metre)

The value "volume per metre" can be taken from the following table depending on the diameter of the pressure pipe:

DN	32	40	50	65	80	100	125	150	200	250
Volume per meter [l/m]	0.8	1.3	2.0	3.3	5.0	8.0	12.3	18.0	31.0	50.0

Volume in litres dependant on the nominal pipe width per metre length

For 10 m pressure pipe DN 100 for instance, the pipe volume is: 10 * 8.0 l = 80 l

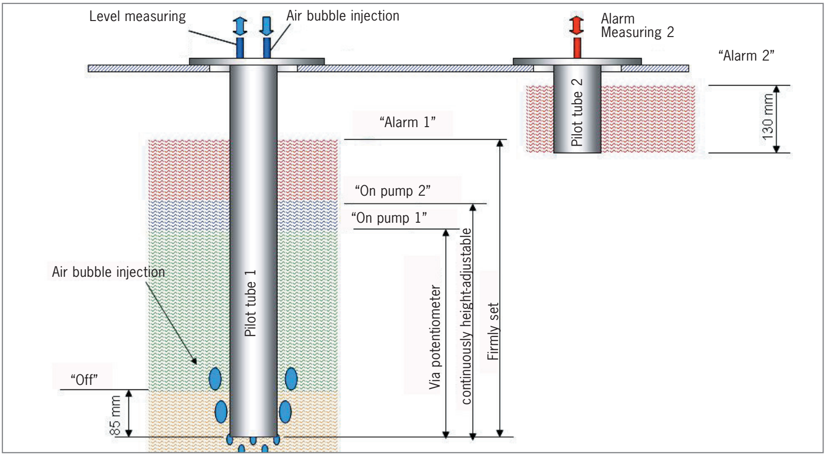
k) Checking container size
The selected lifting plant has a working volume of 100 l and therefore meets the aforementioned specifications.

3.2 Function

3.2.1 Lifting plants

ACO Haustechnik lifting plant merely consists of a collecting tank with several inlet sockets at various heights, plus the pump and the pump controls.
Wastewater flows via the inlet into the collecting tank of the lifting plant. The pumps can be installed either wet or dry. A compact underground mini lifting plant can be used when only small quantities of wastewater free of faeces is used. This underground lifting unit can be installed in the floor plate. Wastewater inflow to this plant enters via an inlet and/or a grating.
The pumps are usually controlled by an integrated pneumatic level measuring device positioned in the collecting tank. This continuously checks the liquid level in the collecting tank.
The backflow pressure pipe in the collecting tank is connected to the pressure switch in the controls. As soon as the water level rises in the collecting tank, air is compressed in the backflow pipe to automatically switch on the pump via the impoundment pressure switch when the preset pressure is exceeded.
Optional air bubble injection is useful particularly for greasy wastewater because it ensures that air continuously enters the impoundment pipe so that no solid layer of grease can block the pipe.

Two potentiometers are integrated within the switch box to adjust the ON and OFF points to the different inlet socket heights. The potentiometers allow points to be set with millimetre accuracy.



Each of the ON levels can be adjusted via the potentiometers in the switch box. The OFF points and the high water level alarm are permanent settings and cannot be modified

3.2.2 Pump stations

ACO Haustechnik pump stations are always wet pumps. All of the pumps and the pump stations built by ACO Haustechnik can be equipped with pneumatic water level controls or with float switching. The pneumatic water level control is used when the pump station is installed downstream of a grease separator. The function of the pneumatic control is described in Section 3.2.1.

Float switches are the preferred option when the distance between the pump station and the controls exceeds 30 metres.

Every float switch is suspended at the required switch ON level. The float switch contains a switch that breaks the circuit when the contact opens to send a signal to the switching device.

Ex-isolating relays can be used with the float switch to make it suitable for use in areas at risk of explosions (zone 1 for media containing faeces). This relay reduces the size of the current flowing through the wires to prevent sparks being created even during a malfunction which could ignite the medium or its surroundings.

The number of float switches depends on the number of pumps or the type and number of protective devices. Every float switch hangs down from above into the shaft and is free to move when it touches the surface of the medium or hangs in the air within the shaft.

When the set medium level is exceeded, the float switches tilt and send a signal to the switching device. The height at which the float switches operate is infinitely adjustable and depends on the length of cable used to suspend it in the shaft. To prevent several float switches from “tangling up” in the shaft if there is strong turbulence, use protective pipes around the cables to fix them into place.

3.3 Installation and assembly

3.3.1 Lifting plants

The lifting plant is positioned on the designated and prepared site and fastened to the floor to prevent it from floating upwards. The inlet sockets of the collecting tank (plastic lifting plant) are sealed when delivered and must be reopened by sawing off the front side approx. 10 mm behind the outer edge before connecting the pipe.
Standardised plastic pipe or SML pipe DN 100 (110 mm external diameter) or DN 150 (160 mm external diameter) can be connected to the sockets. The inlet pipes should also be equipped with stop valves to enable maintenance work to be carried out.
After positioning the plant, connect up all of the piping. All of the fastenings and pipe ducts must be elastic to ensure that no sound is transmitted via the brickwork and floors.
The pipes must not be under stress when connected. No forces or moments must be allowed to affect the plant.
The pressure pipe socket on the collecting tank is designed for connection to plastic, steel or cast iron pressure piping, usually with external diameters of 108 – 114.3 mm. Stop valves must be installed in the pressure piping.
EN 12056-5 Para. 6.3 stipulates that the weight of the pressure piping must be properly supported. In the case of elastic connections with non-longitudinal friction connections, the pipe has to be connected in such a way that the connections cannot slide apart during use. Make allowance for the reaction forces.
The vent pipe of the lifting plant has to be laid separately through the roof of the building and can be made of SML pipe or plastic pipe DN 100.
The electrical connection should be installed by a properly qualified company in compliance with the relevant VDE regulations (0100, 0113). Also make sure that the mains voltage complies with the type plate of the motor. Also comply with the technical connection regulations defined by the local utility companies.
Plugs have to be drilled into the wall to support the switch box. The cable and the pneumatic control pipe between the lifting plant and the switch box must be laid with a continuous gradient between the lifting plant and the switch box. The pipes can be shortened in situ if required.
The lifting plant can be commissioned once assembly is complete and all of the connections have been properly installed. Commissioning should be carried out by a properly qualified company in compliance with DIN 1986 Part 3, and the installation and operating instructions of the manufacturer. This involves test runs using several switching cycles.

Inspect the following before and after the test runs:

- Electrical connection
- Insert the fuses
- Direction of rotation of the motor
- Open the valves in the pressure piping and the inlet piping, allow water to flow in from the drainage installations
- Tightness of the plant, valves and pipes
- Pipe fastenings
- Pump and flow noises
- Motor protection settings

- Close the stop valve in the pressure piping
- Re-open the valve after the signal has been sent when exceeding the “max. water level” switch point
- Check the manual membrane pump by switching off the switching device (pull the plug) and emptying the tank by means of the hand membrane pump. Then replace the plug.

3.3.2 Pump stations

Follow the relevant civil engineering regulations when installing the pump stations.
The excavation should be approx. 30 cm deeper than the height of the collecting tank and the excavation must be secured to prevent caving. Fill up the excavation with filling sand (up to 2 mm grain size) to the installation depth of the tank.
Additional fastening to prevent the tank from floating may be required if the area is affected by high groundwater levels. Encasing the foot of the shaft in concrete is an option in this case.
Lower the tank into the excavation and set it into position on the prepared floor.
The subsurface must not contain any stones or large blocks. Fill up with filling sand if necessary. Use filling sand to fill up the excavation to the top edge of the foot, then install the manhole cover and connect the inlet pipes, ventilation, cable ducts and pressure piping. Use filling sand or gravel sand with 32 mm grain size. Do not use binding soil, rock debris, rocks or angular grains. It is essential to avoid one-sided filling of the excavation to prevent the walls of the shaft from collapsing.
The excavation should be filled in layers with a max. thickness of 30 cm. Each of the layers should be uniformly compacted with a compactor. If the shaft is constructed in fluvial mud, it has to be filled all round with a 30 cm thick gravel layer from the bottom to the top of the shaft. The subsurface in this case should also be covered with a 30 cm thick layer of gravel.
If a groundwater lowering plant was used during construction, do not switch it off until the excavation has been filled and compacted.
The pressure pipe should have a backflow loop (180° bend) above the backflow level and be fed into the collecting pipe or into the sewers with a continuous gradient (regulation EN 12056-4). The pressure piping must be protected from frost, and venting must comply with the regulations.
The electrical connections must only be installed by properly qualified electricians.
Remove any coarse dirt from the collecting tank and fill it with water before commissioning. If the control pipe (plastic hose) was connected to the impoundment pipe when the collecting tank was already full, empty the collecting tank first by pressing the “Manual” switch. After commissioning, the faeces lifting plant is normally operated with the switch in the “Auto” position.

3.4 Maintenance and control

3.4.1 Lifting plants and pump stations

The following must be observed when maintaining lifting plants in compliance with national standards. Inspection has to be undertaken by the operator. This involves inspecting the plant once a month by observing one switching cycle to ensure that the plant is operating properly and does not leak. Properly qualified technicians also have to undertake regular maintenance work. The length of the maintenance intervals depends on the type of application for which the lifting plant is being used. The necessary intervals listed in the following table depend on the application.

Object	Maintenance
Commercial enterprise	Every 3 months
Multiplex house	Every 6 months
Single-family house	Once per year

Maintenance intervals for lifting plant depending on application (example: German standard DIN 1986-3)

The following work is undertaken during maintenance:

- Inspecting the connections for leaks by checking the surroundings of the plant and the valves
- Operating the valves, checking that they move easily, and if necessary readjusting them and greasing them
- Opening and cleaning the backflow valve
- Cleaning the pump and all of the directly connected pipes and cables
- Cleaning the inside of the tank (observing special regulations if necessary)
- Inspecting the condition of the tank
- Testing the electrical system

The plant can be re-commissioned after carrying out the maintenance work and doing a test run. Records should be kept detailing all of the work carried out and the main data.
If any defects were found which could not be rectified, the maintenance company must immediately inform the operator of the plant in writing. The signed confirmation from the operator regarding the message must be archived.
The oil level of the submersible pumps must also be inspected when they are tested. Also inspect to see if any liquid (e.g. water) has penetrated the motor housing of the pump.

This can be checked by taking some oil from the oil chambers.
If the oil contains too much water, i.e. is strongly emulsified (creamy), or if a water layer has formed in the oil housing, it will be necessary to change the oil and replace the seal. Inspect the oil again one week after the oil change.
The oil housing may be under pressure, so please hold a cloth above the oil cap when opening to prevent any oil from spraying out.

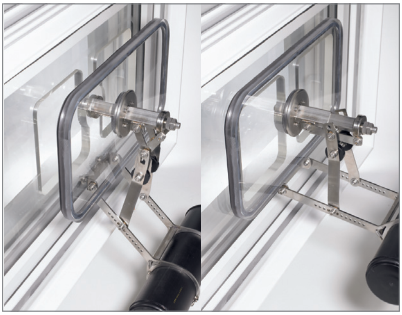
4. Flood protection for cellar windows

In addition to the backflow risk from overfilled public sewers, flood protection from over flowing rivers has recently also become a priority.
Flooding from rivers can occur when rain or melting snow causes rivers to flood their banks.
The increasing risk of flooding brings additional risks to homes – on top of the backflow risks discussed in the previous section – because the river flood water can penetrate buildings if the cellar windows and light shafts are unprotected.
Standard cellar windows are not resistant to water under pressure. When they leak, this can flood cellars if these are not properly protected.

There is an increasing trend for cellars to be converted into valuable hobby and recreation rooms. These assets therefore need to be properly protected.

In areas at risk of flooding from rivers, professional help is available in the form of the “ACO Therm flood-proof” cellar window. The “ACO Therm flood-proof” protects cellars from flood water. Pursuant to “Regulations for flood-proof windows and doors” January 2004 edition, issued by PTE Rosenheim GmbH, windows are classified as flood-proof if they can keep out water standing up to 1 metre above the base of the window.
This product can be used outside of cellars for every ACO soffit window, and is available in two models.

ACO Therm flood-proof – the bulkhead is installed manually to create a watertight seal in the window.



ACO Therm flood-proof – with an automatically closing ventilation flap to prevent flood water from entering the window.

The ACO Therm flood-proof (manual version) has a central ventilation opening. If there is a flood warning, this opening can be closed using the fitted bulkhead (see Figure).
The automatic version of this safety cellar window has a float system which automatically closes the ventilation opening in the light shaft when water levels rise.
Both versions guarantee a watertight seal during flooding and can prevent the penetration of flooding for at least 24 hours. This is valid if the water column does not exceed 1 metre (= 0.1 bar).

ACO Therm flood-proof – automatic version with float system.