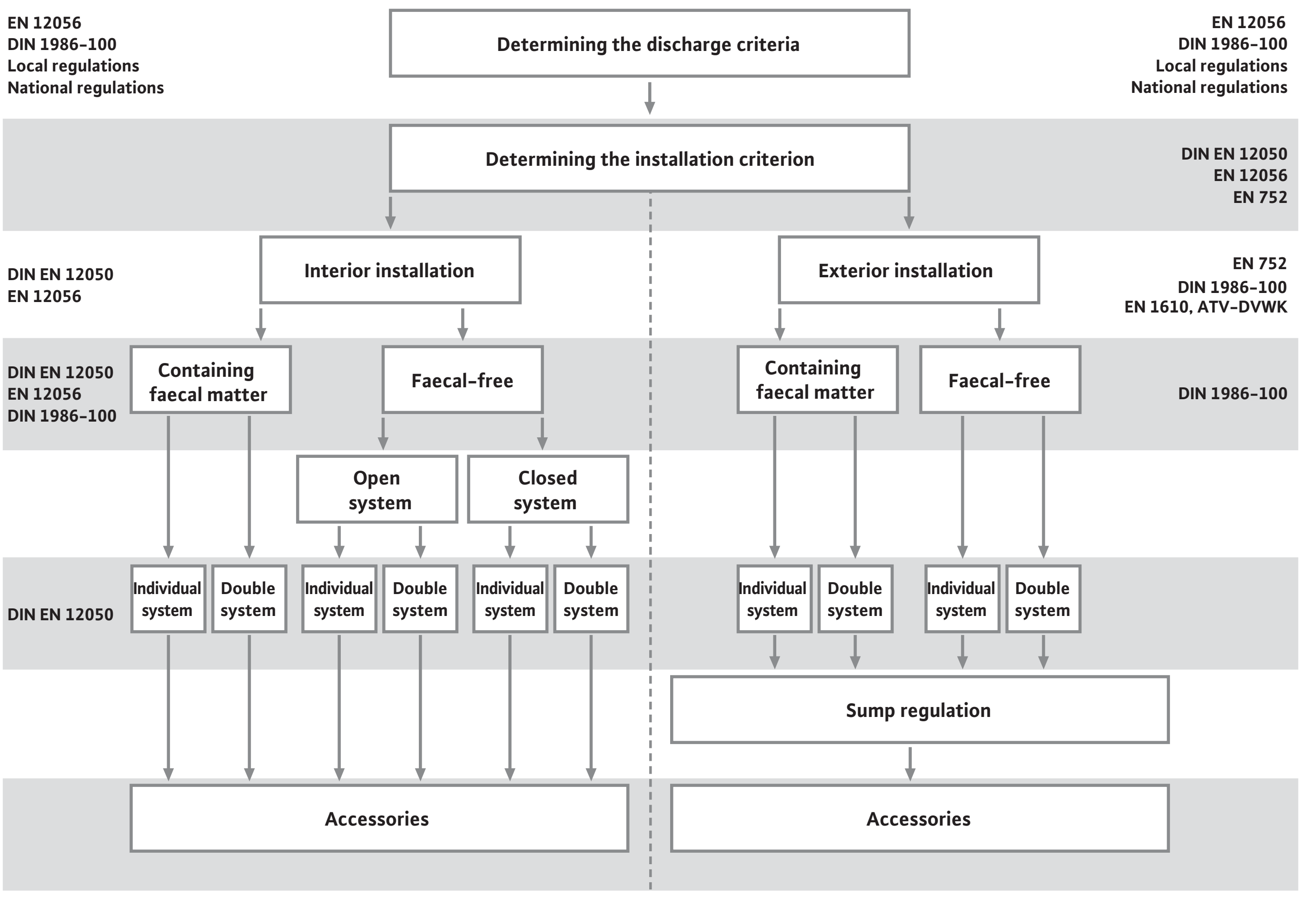
Pumpen Intelligenz.

Sewage Engineering

Planning Guide

2005

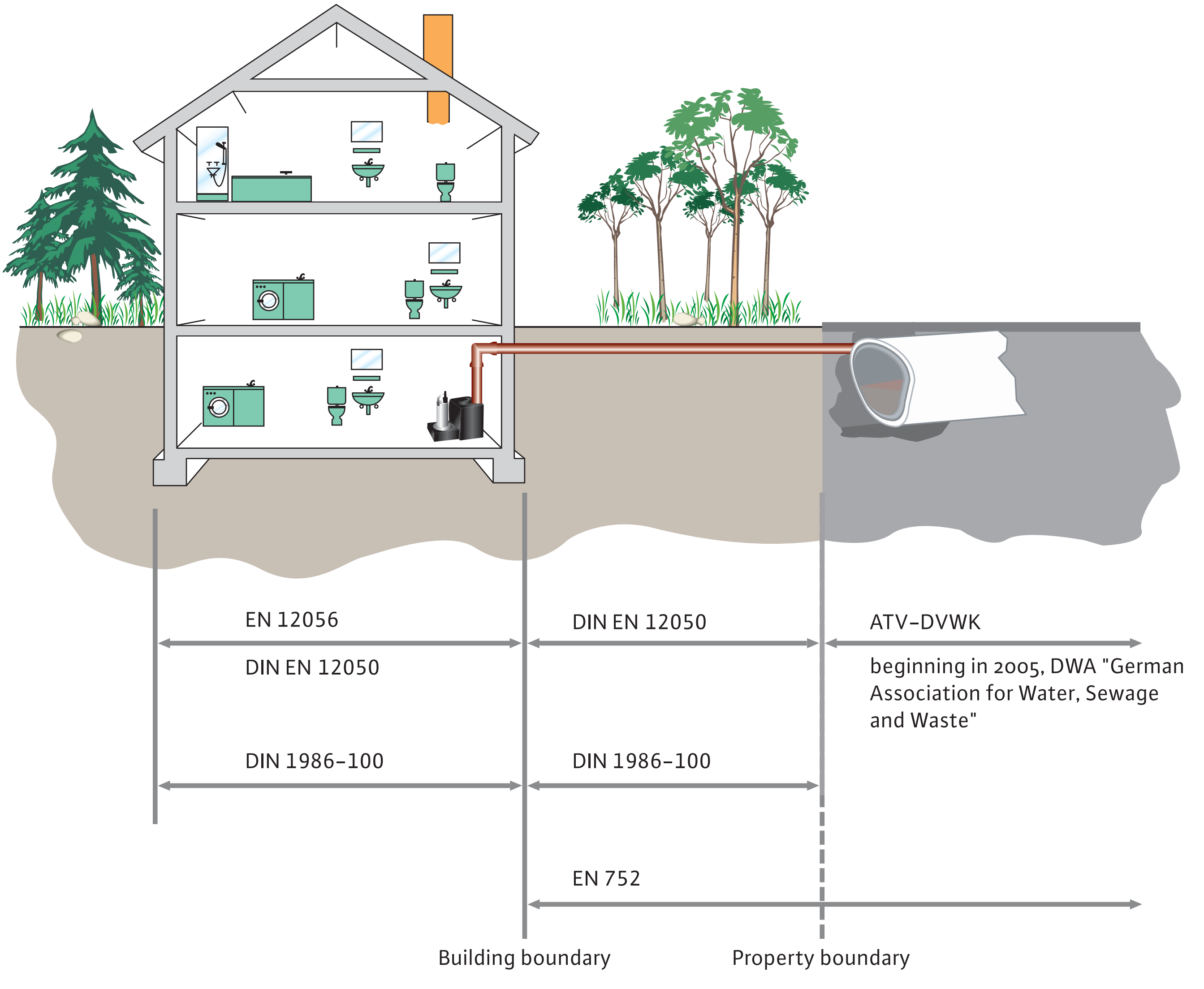
Rough calculation procedure for sewage systems under consideration to normative guidelines




O/OPEN
SHUT/F

Basics

Validity of standards in building drainage



Because of the changed structures in Europe, the standards have now been revised (for all EU member states) on a cross-national basis. Country-specific standards have been revised into internationally valid EN standards, each of which contains slight adaptations to the typical situation of each country in its national foreword.

Country-specific, supplementary standards may also be in force, as long as these do not contradict or constrain the valid EN standards (for example, DIN 1986-100 for Germany). For Germany, this does not result in any substantial changes in the way of thinking, as one of the highest standards has since been used as the basis in that country.

In addition, the ATV-DVWK (German Wastewater Association) applies in Germany beginning at the property line outside private property. Beginning in 2005, this will be known as the DWA.

The standards are an official guideline with regard to scope of validity, applications, installations, safety precautions and maintenance, and have the status of recognised rules of technology. They are not laws with which compliance is mandatory. However, these standards are applied when difficulties are encountered in judging liability cases. For example, non-compliance can render insurance protection null and void, and the person who has carried out the work can be held liable.

General basic concepts

Runoff coefficient C

Specifies the value or the factor for precipitation relative to the composition of the surface, such as the pavement, on which the precipitation falls and from which it is drained.

Drainage coefficient K

Specifies the value for the frequency with which drainage sources are used. Accordingly, a nondimensional factor is assigned to every drainage source. *(Also refer to Table 1 of the Annex, "Values for characteristic drainage K")*

Abrasion

Material loss due to frictional contact of solid particles in the sewage fluid and the corresponding surfaces of the installation (such as pump components and pipelines). The most frequent cause of abrasion is sand.

Sewage generation

The quantity of sewage generated depends on the building type, times of use and the habits of the occupants. Precipitation water is added to the sewage generation. *(Also refer to "Combined system" on page 12, "Separate system" on page 14)*

Sewage types

Sewage is defined as any type of contaminated water generated in the residential or commercial area. This includes rainwater, water that becomes dirty through use, commercially used water etc.

Domestic sewage
Domestic (household) sewage is a mixture of drinking water and organic and inorganic materials in both solid and dissolved form. Experience has shown that the materials primarily encountered in household sewage are human faecal matter, hair, food waste, cleaning agents and detergents, as well as various types of chemicals, papers, rags and sand (for example in combined systems through rainwater erosion). However, experience has also shown that all kinds of waste are introduced as a result of ignorance or non-compliance, and must then be discharged through the drainage source.

However, the following materials should not reach the domestic sewage stream, as otherwise damage to the system and the adjacent installations is probable:

- Large waste items, such as domestic waste
- Solid particles such as sand, ashes, shards etc.
- Domestic, organic solid wastes such as vegetable waste, peels, bones etc.
- Cloth scraps, feminine hygiene products etc.
- Hazardous materials such as chemically aggressive solvents

Rainwater
Unused precipitation water contaminated only by air pollutants, impurities from dirt on the runoff surface or other ecological circumstances. The degree of contamination depends primarily on geography, proximity to cities (air and surface pollution) and frequency of rainfall. Impurities frequently contain oil, salt, sand, or grease.

DIN 1986-100

ATV-DVWK A118

Precipitation values can differ based on conditions that vary greatly according to climate. The precipitation values are distinguished according to frequency and intensity of rainfall. A table of these reference values is provided in DIN 1986-100 *(also refer to Table 4 of the Annex, "Rainfall intensities in Germany")*.

Because climactic conditions change, consult the German Weather Service or local institutions for more accurate information. A value of 300 l/(s x ha) can be used for rough calculations when flooding must be avoided under all circumstances.

The calculation of rainfall intensity is based on the experience that heavy rains last only a short time and are in the form of downpours. Rain that lasts longer does not have this intensity. The quantity of rain decreases when the duration increases. *(Also refer to "Design rainfall intensity" on page 9)*

Industrial sewage (= industrial water)
Industrial sewage requires more detailed analysis of the fluid, as the chemical components can vary greatly, thus posing a risk of damage to the installation. Corrosion damage is the most frequently observed type of damage. Special attention should be given to sewage from the textile and food processing industries. Impeller type (e.g. blockage), sump dimensioning (because of great differences in drainage) and the material combination (e.g. corrosion) are the central critical points in this regard.

Condensates

ATV-DVWK A251

Due to decreased mineral content, the pH value is below neutral (neutral = pH 7). The aggressiveness increases when the mineral content increases. According to German guidelines (such as ATV A251), condensates may not be discharged directly into the sewer system whenever the mixture proportion of sewage containing faecal matter (high pH value before hydrogen sulphide removal) and condensate (low pH value) is classified as critical.

Composition of condensation water (guide value):

Oil-fired boilers:	1.8 to 3.8 pH (neutralisation is mandatory!)
Gas-fired boilers:	3.8 to 5.3 pH

- Plants up to 25 kW are classified as harmless, as a sufficient blending of the generated condensate is assumed.
- Plants up to 200 kW are classified as harmless as long as twenty-five times the volume of sewage in proportion to condensate is discharged at the same transfer point, as this also results in sufficient blending.
- Larger plants require a general neutralisation before introduction into the condensate lifting unit or sewer system.

Sea water
Sea water generally refers to the water of the oceans with its different salt concentrations. A prerequisite for selecting materials in the design stages is knowing the concentration to which each component will be exposed. Because of the high ionisation, the conductivity is up to 7500 µS/m. The fluid already has an increased corrosive effect beginning at a conductivity of 3200 µS/m. In conjunction with the influence of the temperature, this causes increased corrosion, as an increasing temperature functions as a reaction accelerator. The following are reference values for the different ion concentrations pertaining to the sodium chloride ions:

Atlantic Ocean	3.0–3.7% = 30–37 g/l
Pacific Ocean	3.6% = 36 g/l
Indian Ocean	3.5% = 35 g/l
North Sea	3.2% = 32 g/l
Baltic Sea	< 2% = < 20 g/l
Caspian Sea	1.0–3.0% = 10–30 g/l
Mediterranean Sea	3.6–3.9% = 36–39 g/l
Dead Sea	29% = 290 g/l
Red Sea	3.7–4.3% = 37–43 g/l

Brackish water
Brackish water refers to a mixture of different types of water or water-based fluids. Brackish water refers to both a mixture of fresh water and sea water and a mixture of sea water with oils, petrol and faecal components. A non-uniform concentration of components (including those that vary according to time) makes the process of selecting the materials to be used complex. No product selection should ever be made without analysing the water.

Limited-use plants

EN 12056-1 and DIN EN 12050-3

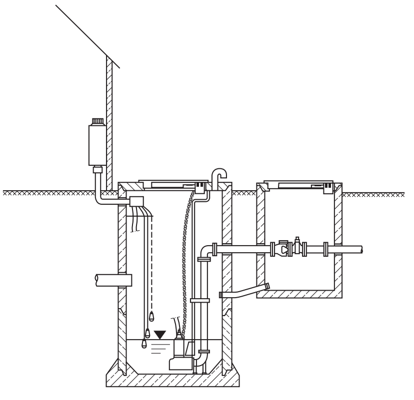
These mini lifting plants (such as the Wilo-Drain-Lift KH 32) are installed immediately behind a toilet located below the backflow level *(also refer to page 12)*. However, the use of these systems is subject to certain restrictions. For example, there must be an alternative toilet above the backflow level for use in case the mini lifting plant fails. In addition, the inlets are restricted to a maximum of one hand wash basin, one shower and one bidet (urinal), all of which must be located in the same room. Bathtubs, washing machines or dishwashers are not permitted. Installation above the backflow level is permitted only in special cases, such as renovations.

Drain connection value DU

Indicates the average drainage quantity of a drainage source. The values are listed in l/s. *(Also refer to Table 2 of the Annex, "Drain connection values (DU) for sanitary fixtures")*

Installation types

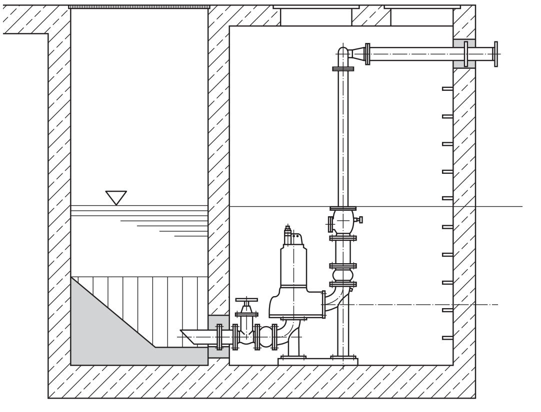
Stationary wet sump installation



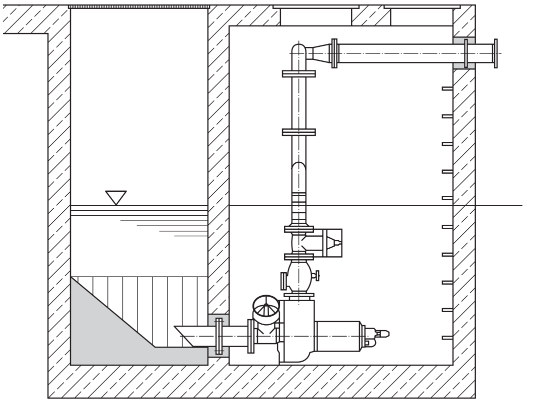
In recent years, prefabricated pump sumps made of concrete and plastic have come into widespread use, as they can be installed quickly and easily, lowering installation costs. The advantages of pumps in wet sump installations lie in cost and space considerations, as a separate pump chamber is not required for pump installation as is the case in dry sump installation. On the other hand, when maintenance is required, the effort for checking and repairing the pump is increased due to the need to lift the pump.

For these complete solutions, which are offered by most pump manufacturers (such as the Wilo-Drain WS), the sumps are already adapted to an optimum geometry that will guarantee durability and a long service life. In addition, all components are matched to each other, and all accessories are included in the scope of delivery.

Stationary vertical dry sump installation



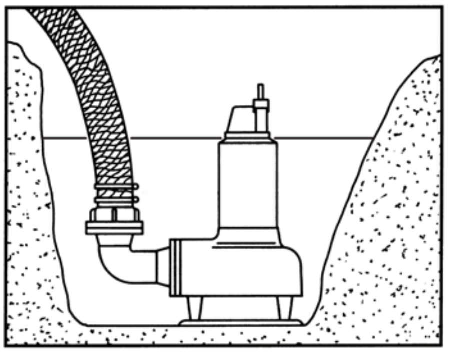
Stationary horizontal dry sump installation



In the past, many pumping stations were equipped with glanded pumps. However, this has changed for the reasons listed below, with the result that more pump stations are being installed with dry submersible pumps, regardless of whether they are installed horizontally or vertically.

The reasons > advantages:
- Flood-proof **> Operational reliability**
- No stuffing box seals, instead low-maintenance SiC/SiC mechanical seals
  > Cost reduction
- No couplings or V-belts, meaning fewer wear parts and less maintenance effort
  > Cost reduction
- No sealing water connections or separate grease lubrication > Cost reduction
- Integrated forced-flow casing cooling
  > Noise reduction
- Easy access for maintenance and repair
  > Cost reduction

Portable wet sump installation



In portable wet sump installation, the units are equipped with a pump base. The delivery connection is either flexible (high-pressure hose) or rigid (via pipeline). For draining pits or tanks, the pumps are temporarily lowered into the fluid.

It should be ensured that the pumps are positioned on the foundation in a way that is solid and torsion-proof and thus cannot begin to drift or twist. In addition, the units may not be operated suspended from a chain or the cable. Portable set-ups are temporary installations! If they are used as a long-term solution, reduced service life caused by increased vibrations and corresponding negative effects on the pump should be taken into account.

Buoyancy protection

Buoyancy protection is a means of anchoring a unit/pump to the floor (or to the underground sump) to prevent it from buoying upwards in case of flooding of the area (or increased groundwater level), as this could cause damage to connections/pipelines which could, in turn, cause fluid leaks. The buoyancy protection is located directly on tanks, is retrofitted, or is integrally cast.

Ventilation

Air vents are permitted in compliance with prEN 12380 for gravity drainage systems. The dimensioning must be carried out in conjunction with the connection pipe or wastewater downpipe. Ventilation of lifting plants must be in accordance with EN 12056-1.

prEN 12380
EN 12056-1

Design rainfall intensity

The value is defined by local authorities. Reference values are provided in DIN 1986-100 and ATV-DVWK A 118, Tab. 3. A minimum value of r5 (0.5) is to be assumed. If no value is specified for r, 200 l/ (s x ha) can generally be assumed for surfaces with limited infiltration. If flooding must be generally prevented, experience has shown that a value of 300 l/(s x ha) can be used for calculation. However, the specifications of the authorities must always be followed. *(Also refer to "Sewage types – Rainwater" on page 6)*

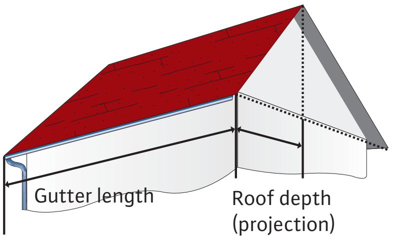
DIN 1985-100
and
ATV-DVWK
A118

Roof area (effective)

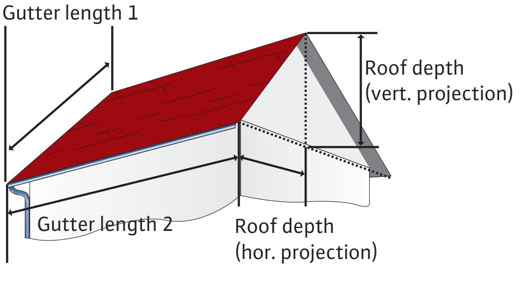
EN 12056-3

The roof area necessary for the calculation is determined by multiplying the gutter length of the roof by the horizontally projected roof depth. The effect of wind is generally not taken into consideration unless required by applicable national legal directives. This calculation must be carried out for each roof area.

Without effect of wind



With effect of wind



For rain vertical to roof area:
Roof area = gutter length 1 x gutter length 2

Driving rain 26° to vertical:
Roof area = gutter length 2 x [roof depth (hor) + 0.5 x roof depth (vert)]

The wall area onto which the rain is being driven must also be taken into consideration with effect of wind. It is added to the roof area.
This means the following:

Wall area for rain calculation = 0.5 x wall area

Total area = roof area + wall area for rain calculation

DIN 1986

In Germany, parts of the DIN are valid only as remaining standards. DIN 1986 has been replaced by new standards such as DIN EN 12050 and EN 12056. Today, it is applied in Germany, in the form of DIN 1986-100, only as a supplemental standard to EN 752.

DIN EN 12050

DIN EN 1250

The geographic scope of this international standard is the EU. All EU countries are required to follow the specifications and instructions of this standard. DIN EN 12050, along with its parts, applies to the principles of construction and testing of plants and check valves.

DU value

See "Drain connection value DU" on page 8

Pressure drainage (in accordance with ATV-DVWK data sheet A116)

EN 1671

If a gravity sewer system (gravity drainage) is not possible or sensible for geographic or cost reasons, pumping stations can be used for drainage. The pipelines can be laid as a ring network or branched network from the drainage area to the treatment plant.

EN 1671 and DIN EN 12050-3

ATV-DVWK A116 and ATV-DVWK A134

For pump units without macerators, the pipeline diameters should be DN 80 with PN 10. For pumps with macerators, pipes with a diameter of DN 32 can be used. Pressurised air flushing stations support the removal of the wastewater by regulating the flow and discharge processes. This type of installation provides the advantages of a shorter retention time of the wastewater, reduced encrustation, and the injection of oxygen. The pump output should guarantee a complete exchange of the pipeline volume every 4–8 hours (every 4 hours in the main and collecting discharge pipelines, every 8 hours in the discharge pipeline).

Other good reasons to use pressure drainage systems include:
- Insufficient terrain gradient
- High groundwater level
- Low population density
- Difficult subsoil
- Intermittent sewage generation (campgrounds, excursion restaurants etc.)
- Environmental concerns

Evaluation of installation types and drainage techniques

	Indoor installation*	Outdoor installation*	Pressure drainage
Unwanted odour	–	o	o
Unwanted noise	o	+	+
Pipeline costs (costs for laying pipeline)	o	–	+
Installation costs	+	–	–
Ease of maintenance	++	o	+
Follow-up costs in case of malfunction such as failure of the power supply	– –	o	o
Combined water (with rainwater)	not possible	+	not possible

* without comminution
++ Very good
\+ Good
o Moderate
– Poor
– – Very poor

Electrical conductivity

Electrical conductivity is of importance both for some level measuring systems and the lifetime of units. It identifies the salt concentration in fluids. The conductivity is generally specified in µS/cm (=10-4 S/m) or µS/m.

EN 12056

EN 12056

The geographic scope of this international standard is the EU. All EU countries are required to follow the specifications and instructions of this standard. This standard is preceded by a national foreword for each member country. Its parts relate to the use of gravity drainage systems inside buildings. Thus, for example, the required installation space for lifting plants is defined in accordance with EN 12056-4, 5.1, as is tension-free installation, meaning that the weight of fittings and pipelines is supported. The maintenance intervals required for proper operation are also specified.

Fluid

Correct design and selection of a pump require exact knowledge of the pumped fluid. When a pump is used, this need not refer exclusively to sewage. The properties of sewage pumps mean that they can pump a variety of other fluids. *For a more precise definition of sewage, see "Sewage types" (page 6), "Materials properties" (page 16), "Free ball passage" (page 19), "Impeller types" (page 21).*

Noise development (also refer to "Sound insulation")

DIN 4109

When planning a building, the noise behaviour of an installation must be taken into consideration, as this creates a stress factor over the long term. The individual acceptable stress loads are defined in accordance with EN 12056-1 in the corresponding national and regional directives. In Germany, DIN 4109 is applied here. Thus, the maximum permitted noise level in the adjacent room is 30 dB[A].

Corrosion

EN 12056

The term "corrosion" refers to the reaction of a material with its gaseous or liquid environment. This reaction causes a structural change of the surface of the material and thus an impairment of its original function. The strength of the corrosion depends on the combination of the material with the aggressiveness of the fluid. Experience has shown that plastics and ceramic materials are the most resistant.

When metallic materials are used, weak points are damage to the surface or welds and connecting seams.

Chlorides
Chloride ions are aggressive towards metallic materials, which results in pitting of the metallic material beginning at a concentration of ~150 mg/l.

Nitrates
Nitrates are aggressive towards metallic materials even at low concentrations. Concentrations of up to 30 mg/l are enough to cause corrosion of metals with low overall hardness.

Nitrites
Nitrites are components of sewage containing faecal matter and are corrosive even at low concentrations.

Sulphates
Sulphate ions are aggressive towards all materials of metallic structure and towards concrete. They cause pitting beginning at concentrations of 250 mg/l, and decompose concrete at even lower concentrations. In this case, PE sumps are recommended.

Combined system

Sewage system that drains rainwater, contaminated sewage and water containing faecal matter through one pipeline. Information on whether use of a combined system is possible is provided in local statutes or can be obtained from municipal authorities.

Usable volume (= required impoundment volume)

The usable volume—also referred to as the required impoundment volume—generally refers to the volume between the cut-in and cut-out points of the pump. In special cases in which the inlet to the pumping station lies below the cut-in point of the pump and thus becomes backed up, the inlet volume can be used to cover the required impoundment volume. It should be exchanged during each pumping process.

Flow rate of the largest pump

$$V\,[m^3] = \frac{Q\,[l/s] \times 0{,}9}{z}$$

Frequency switching

pH value

The pH value indicates the aggressiveness of the water or of the hydrogen ion concentration. The water can contain salts, nitrates, sulphur or carbon dioxide components. Sulphates, sulphides, fats, petrols and solvents can also have an effect on the aggressiveness. On the other hand, if minerals are lacking, such as in partially or fully desalinated water, this also means increased aggressivity (here, for example, it means that the pH value sinks below the neutral level).

- **pH 0 to 3.9 = Highly acidic**
  (such as sewage from beer brewing* ~4, condensates from gas-fired boilers ~3.5, condensates from oil-fired boilers ~2.0)
- **pH 4 to 6.9 = Weakly acidic**
  (such as river water or fresh water from lakes* ~5.5, sewage after hydrogen sulphide removal < 6.5)
- **pH 7 = Neutral**
- **pH 7.1 to 10 = Weakly alkaline**
  (such as sewage from slaughterhouses* ~8.2, sea water ~8)
- **pH 10.1 to 14 = Strongly alkaline**
  (such as sewage containing faecal matter before hydrogen sulphide removal ~10.5)

*Specifications for approx. 20°C

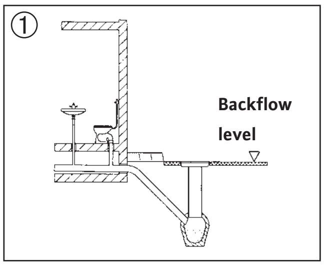
Domestic sewage is generally in the range from pH 6.5 to pH 7.5. In combined water systems, the more mineral-poor water (lower pH value) is mixed with salt-rich and mineral-rich water, which causes a relativisation (depending on the mix proportion) to a more neutral level.

Backflow level

Highest point in an installation to which the contaminated water can rise. The backflow level is in the area of the largest increase of diameter. Installations should be designed such that the water of the sewer system cannot flow back into the pumping station. This could happen in case of storms, floods and heavy rainfall if the municipal sewer system is not designed for such quantities. Damage caused in this way is not covered by insurance, and lawsuits are seldom successful. It is the responsibility of the owner/operator to provide protection. Information specifying the height of the backflow level is included in local statutes. Experience has shown that for rough calculations, the street level can be assumed as the backflow level.

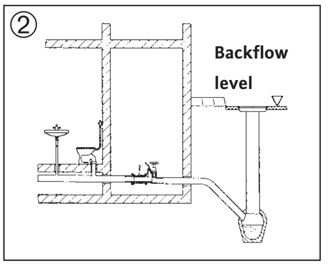
EN 12056-1

Installation above the backflow level

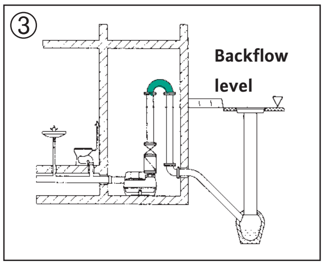


No lifting plant required

Installation below the backflow level

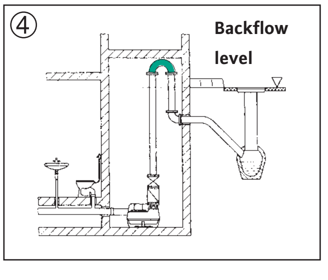


The use of a non-return seal is permitted for pump chambers, but does not provide 100% protection.



The use of a lifting plant provides guaranteed protection from backflow of fluid and reliable removal of the sewage by using a backflow loop.

Installation below the backflow level without natural gravity flow to the sewer system



The sewage can be removed only with the help of a lifting plant.

Reasons for a backflow can include unusually heavy rains, reduction of the free passage of the pipe due to encrustation or obstruction, as well as technical failures of downstream pump stations.

Backflow loop

A backflow loop is a pipeline that is artificially elevated (above the backflow level; also refer to "Backflow level" on page 12, graphics 3 and 4), so that backflowing water can first spread through all of the lower-lying empty spaces. Since it is to be assumed that sufficient volume is available in the entire pipeline system, the backflow loop is the most reliable alternative for backflow prevention.

If backflow protection is insufficient or lacking entirely, the liability falls on the person who carried out the work, and the homeowner loses insurance protection.

Sump cover

EN 124

Sumps are divided into certain load-carrying capacity classes. These classes are primarily defined by the dome and cover construction, while the strength of the shaft itself is defined by the earth pressure.

Class A:	Able to be walked on	Pedestrian paths, bicycle paths
Class B:	Able to be driven on with restrictions	Pedestrian paths, pedestrian areas, automobile parking areas, parking decks
Class C:	Able to be driven on	Kerb edge area within limits (protruding onto the roadway up to 0.5 m)
Class D:	Able to be driven on	Street roadways, road shoulders, parking areas, lorry traffic areas, logistics areas and industrial areas with forklift traffic
Class E:	Able to be driven on	Dock facilities, aeroplane runways
Class F:	Able to be driven on	Aeroplane runways

Sound insulation (also refer to "Noise development")

DIN 4108

For installations, suitable measures must be taken from the beginning to keep unwanted noise to a minimum. This is because retrofitted solutions are associated with high costs and/or decreased value of the entire area. The guideline for this is DIN 4109.

Suitably dimensioned fittings and appropriate flow velocities in pipelines, as well as appropriate wall ducts, can already reduce unwanted noise in advance. A maximum noise level of 30 dB[A] is permitted in living spaces and bedrooms. In classrooms and workspaces, a level of max. 35 dB[A] is permitted. This does not include short-term noise level peaks caused by valves, fittings etc.

If this is not complied with, a great disturbance can be caused by filling noises (for example, when the water jet hits the pipe wall) or emptying noises (excessive flow velocity, strong change in direction of flow etc.). As these noises are carried along through the pipelines and fluid by vibrations, suitable measures (baffles, flow velocity guide values, pipeline materials etc.) must be taken to counteract them.

Separate system

Drainage system in which rainwater and wastewater are drained in separate pipelines. The different types of sewage must also be separated if the sewage lifting unit is located inside the building.

Rainwater must not be piped into the building! *(Also refer to local statutes and/or municipal authorities)*

Maintenance

EN 12056-4

Refers to the technical inspection and, when required, replacement of components/wear parts that guarantee long-term operation of the system and protect it from damage and failure. Depending on the operating conditions and type of plant system, the following intervals are recommended or required by EN 12056-4:

Private use in small buildings (single-family homes):	Annually
Multi-family homes and apartments:	Every 6 months
Commercial use:	Quarterly

Water hardness

Water hardness refers to the concentration of alkaline earth ions. These are primarily chlorides, sulphates, hydrogen carbonates etc. The hardness categories are soft (total hardness up to 7 degrees of German hardness), medium-hard (up to 14 degrees of German hardness), hard (up to 21 degrees of German hardness) and very hard (> 21 degrees of German hardness). The higher the degree of hardness, the more ions are present in the water. Today, the term "degree of German hardness" (°d) is no longer used; the technical term mmol/l is used instead.

Total hardness [mmol/l]	[°d] (rounded)	Classification
0-1	0-6	Very soft
1-2	6-11	Soft
2-3	11-17	Medium-hard
3-4	17-22	Hard
> 4	>22	Very hard

Materials

ABS (acrylonitrile butadiene styrene)
Temperature-resistant, non-flammable plastic with excellent impact strength and good strength properties. It is used in the Wilo-DrainLift Con condensate lifting plant, for example.

Concrete
Material for building sumps in accordance with DIN 4034-1. The concrete quality used by Wilo corresponds to DIN EN 206 (formerly known as DIN 1045). The exact designation is B45WU, and it has a maximum water penetration depth of 30 mm as prescribed by the standard. Experience has shown that the maximum penetration depth of the Wilo-DrainLift WB is only around 20 mm. The following substances are aggressive towards concrete: fluids with pH value < 6.5, sulphuric acid, hydrochloric acid, butyric acid, lactic acid, sulphates, salts, and animal and vegetable fats and oils.

DIN EN 206 and DIN 4034-1

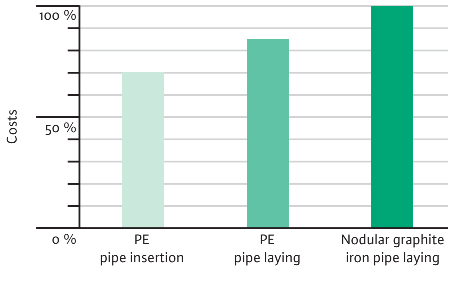
Cast iron
Cast iron is the standard material used in pump construction. For years now, most pumps have been made of cast iron. The primary advantages of cast iron are its price and robustness.

Stainless steel 1.4301 – V2A (AISI 304 – X5CrNi18-10)
The name "V2A" originates from the definition of Thyssen Krupp (the German "Versuchsreihe 2 Typ Austenit") for a chrome-nickel steel. This is the

stainless steel standard generally used in the pump industry, which combines good strength properties with good temperature resistance. In addition, the material has very good resistance to organic solutions. *(Also refer to "Materials properties" on page 16)*

Stainless steel 1.4404 – V4A (AISI 316L – X2CrNiMo17-12-2)
The name "V4A" originates from the definition of Thyssen Krupp (the German "Versuchsreihe 4 Typ Austenit") and refers to a more highly alloyed stainless steel (compared to 1.4301) with a molybdenum component that can sometimes also be used in sea water. High strength and elasticity are distinguishing characteristics that make stainless steel superior to cast iron. *(Also refer to "Materials properties" on page 16)*

HDPE (high-density polyethylene)
The most frequently used pipe material for sewer pipelines, with very good chemical resistance and extremely low surface roughness to prevent deposits and flow losses. Additional advantages are high impact strength and tensile strength with little temperature effect. The material PE100 is being used more and more in practical applications, where it is replacing PE80 and nodular graphite iron. Advantages such as pipe insertion for renovations provide a high cost savings potential *(also refer to "Materials properties" on page 16)*



PP (polypropylene)
Temperature resistance and chemical resistance are the distinguishing features of this material. Due to the high impact strength of the material, it is extremely robust. *(Also refer to "Materials properties" on page 16)*

DIN 8078

PUR (polyurethane)
PUR is available in many variations. Baydur GS, which has proven itself in industrial applications and is also used by Wilo, features high chemical resistance, for example to dilute acids, alkalines, motor oils, fats, petrols etc., and corrosion and microbial resistance. These outstanding advantages make it ideally suited for use in aggressive fluids. It also features superior wear resistance, resistance to rotting, weather resistance, thermoforming resistance and impact strength, all at a significantly lower weight than metallic materials such as cast iron. *(Also refer to "Materials properties" on page 16)*

PVC (polyvinyl chloride)
PE sumps are designed in accordance with DIN 19537-1 and provide great advantages compared to conventional concrete sumps, including durability, flexibility, ease of installation and reduced installation costs. This flame-retardant material unites mechanical strength and chemical resistance. *(Also refer to "Materials properties" on page 16)*

DIN 19537-1 and DIN 8075

DIN 8061

Materials-standards table

DIN description	US description	Chemical abbreviation	Standard	
			European	American
Material No.	AISI		EN	ASTM
Austenitic steels				
1.4301	304	X5CrNi18-9	10088-3	A 167 / 276
1.4401	316	X5CrNiMo17-12-2	10088-3	A 167 / 276
1.4404	316 L	X2CrNiMo17-12-2	10088-3	A 167 / 276
1.4571	316 Ti	X6CrNiMoTi17-12-2	10088-3	A 167 / 276

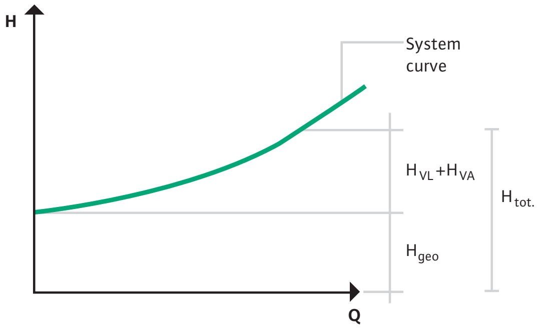
Materials properties

Designation	Temperatures of use [°C]	Resistant to	Not resistant to	Application areas
Seal materials				
EPDM	-30 to +120 -30 to +120	Water without chemical additives, caustic sodas, hydrochloric acid, phosphoric acid, saline water	Fuels, kerosene, sulphuric acid, nitric acid	Housing seals, mechanical seal bellows
FPM (= Viton)	-25 to +140	Sewage with pH 3 to pH 10, fuels, petroleum oils, phosphoric and sulphuric acid	Acetic acid, nitric acid, benzene	Housing seals, mechanical seal bellows
NBR	-30 to +100	Sewage with pH 6 to pH 10, water without chemical additives, fuels, petroleum oils, saline water	Nitric acid, sulphuric acid	Housing seals, mechanical seal bellows
Housing materials/peripheral materials				
PE	0 to +90	Sewage with pH 4 to pH 9, water without chemical additives, inorganic weak fluids	Concentrated acids and alkalines	Pump housing, impellers, pipelines, sumps and fitting shafts
PP	0 to +90	Sewage with pH 4 to pH 9, water without chemical additives, inorganic weak fluids, saline water	Concentrated acids and alkalines	Pump housing, impellers, non-return valves, sumps
PUR	0 to +80	Sea water*), acids, bases, pH 3 to 13, fats, machine oils, petrol	Extremely aggressive acids and bases	Pump housing, impellers, fasteners, agitators
Stainless steel 1.4301 (AISI 304, V2A)	-20 to +120	Petroleum oils, water without chemical additives, alcohols	Sea water*), hydrochloric acid, concentrated acids and alkalines	Motor housing, hydraulic housing, impellers
Stainless steel 1.4404 (AISI 316, V4A)	-20 to +120	Petroleum oils, water without chemical additives, alcohols, sea water*)	Sea water*), hydrochloric acid, concentrated acids and alkalines	Motor housing, hydraulic housing, impellers

*) Limited resistance depending on the fluid temperature and other organic and inorganic fluid contents

Basic hydraulic concepts and pipelines

System curve (pipeline curve)



H_{DP} = Pressure drops (losses) in pipelines
H_{DF} = Pressure drops (losses) in fittings
H_{geo} = Geodetic height difference (geodetic height to be overcome)
H_{Tot} = Total head losses

The system curve shows the delivery head required by the system H_{Tot}. It consists of the components H_{geo}, H_{DP} and H_{DF}. While H_{geo} remains (statically) independent of the flow rate, H_{DP} and H_{DF} increase (dynamically) through the different kinds of losses in pipelines, fittings, moulded parts, increases in friction due to temperature etc.

Connecting sewer/pipe

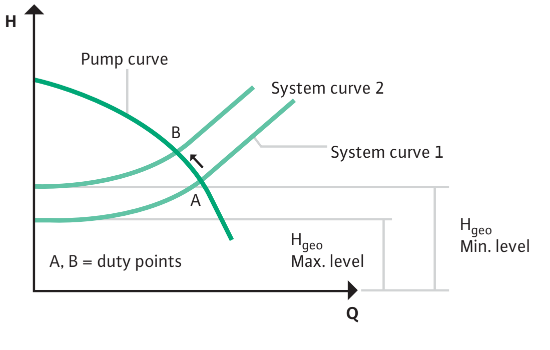
DIN 4045

In accordance with DIN 4045, describes the connection between the public sewer and the property boundary.

Duty point

The duty point is the point of intersection of the system curve and the pump curve. For fixed-speed pumps, the duty point adjusts itself automatically.

Example: fluctuating water level in the tank



The duty point changes if, for example, the geodetic delivery head fluctuates between a minimum and a maximum value in a stationary sewage pumping station. This changes the flow rate supplied by the pump, as the pump can only achieve duty points that are on the pump curve.

Reasons for fluctuation of the operating point could include different water levels in the sump or tank, as in this case the intake pressure of the pump changes due to the different levels. On the end discharge side, this change can also be caused by clogging of the pipelines (encrustation) or throttling by valves or consumers.

Discharge pipeline

DIN EN 12050-1 and EN 12056-4

This term refers to the pipes to the adjacent systems or pumps. The pipe diameters used are specified in DIN EN 12050-1 and EN 12056-4. For systems without comminution devices, a minimum nominal diameter of DN 80 is required; for systems with comminution devices, it is DN 32.

Water hammer

Water hammers are impacts in the pipeline system caused by changes in speed. Depending on their strength, they can damage or destroy the installation. Particularly at risk are installations in which the pipes are laid such that they are not on a steady incline or descent. As the water column can break away at the high points (vacuum formation), or increased pressure can be generated when the water columns collide, the pipes can burst.

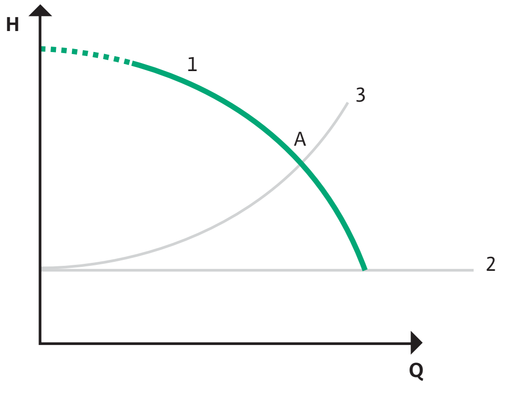
Particularly at risk for this are very large pipelines and systems with excessive flow velocities.

Pressure drops in pipelines and fittings

Pressure drops are reductions in pressure between the inlet and outlet of the component. These components include pipelines and fittings. The losses are due to turbulence and friction. Each pipeline and fitting has its own specific drop value depending on the material and surface roughness. Refer to the manufacturer's specifications for specific information. An overview of the fittings used by Wilo and their drop value is provided in the Annex. *(Also refer to Table 6 of the Annex, "Pressure drops relative to flow rates of HDPE plastic pipes")*

Individual operation

Refers to operation of a pump in an installation in which the duty point of the pump is at the intersection of the pump curve and system curve.



1 = Pump curve
2 = Required geodetic delivery head
3 = Losses in fittings and pipeline due to flow velocity/flow rate
A = Duty point of the pump

Ventilation

DIN EN 12050-1 and EN 12056-2

The design of the ventilation line for installations in buildings is described in DIN EN 12050-1, 5.3. In accordance with the standard for lifting plants for wastewater containing faecal matter, a ventilation line (ventilation above roof level) with at least DN 50 is currently adequate, while the old national guideline, DIN 1986, prescribed DN 70. This vent line may feed into both the primary and the secondary line. A ventilator/vent valve is not permitted as a replacement for a vent line of a lifting plant for wastewater containing faecal matter.

Ventilation is required for wastewater lifting plants, but the type and method are not specified by EN 12056-2. The ventilation should be routed above roof level or equipped with an active carbon filter.

Downpipe

Refers to all vertical pipes in and on the building, with vents above roof level where applicable.

Flow velocity

Solids and suspended matter in the sewage can cause deposits in pipelines and thus clog the drainage system. To prevent pipelines from clogging, we recommend observing the following minimum flow velocities:

Gravity drainage		
Standard	Value in accordance with standard	Recommendation
Horizontal pipelines –	–	V_{min} = 0.7–1.0 m/s
Vertical pipelines –	–	V_{min} = 1.0–1.5 m/s
Sewer lines –	Value in accordance with standard	V_{min} = 2.0–3.0 m/s
Pressure drainage		
Standard	Value in accordance with standard	Recommendation
Pressurised-air flushed pipeline EN 1671	$0.6 \leq V_{min} \leq 0.9$	$0.7 \leq V_{min}$
Non-flushed pipelines ATV-DVWK A 134	$0.5 < V_{min} < 0.9$	$0.7 \leq V_{min} \leq 2.5$

EN 1671 and DIN 1986-100

Depending on the composition of the fluid (e.g. high sand content, pumping of sludge), the values indicated above may be higher. However, the applicable regional and national standards and guidelines must be followed. The flow velocity is determined by the flow rate (m^3/s) per unit of surface area (m^2) and should generally be between 0.7 m/s and 2.5 m/s. The following points must be considered when selecting a pipeline diameter:

The greater the flow velocity, the fewer deposits there will be and thus less risk of clogging. However, the resistances in the pipelines increase when the flow velocity increases, which causes the system to become inefficient and can cause premature damage to system components through abrasive components of the fluid.

Free (ball) passage

Because fluids vary in content and composition, sewage pumps and their hydraulic parts are adapted accordingly. However, it must be considered which impeller design will best suit the respective fluid and its composition.

Note, however, that enlarging the free passage means reducing the hydraulic efficiency. As a result, more motor power is necessary to achieve the same hydraulic results, which affects operating and procurement costs. Therefore, careful design is essential from an economic standpoint.

Sewage that is free of faecal matter (= wastewater)

Required free passage	Recommended hydraulics	E.g. Wilo series
Drainage water		
10–14 mm	Free-flow, multi-vane	TMW, TS, CP, TC 40, VC
Leachate		
10–14 mm	Free-flow, multi-vane	TMW, TS, CP, TC 40, VC
Domestic sewage		
10–12 mm	Free-flow, multi-vane	TMW, TS, CP, TC 40
Rainwater, smaller runoff surfaces[1)], larger runoff surfaces[2)]		
12-35 mm 35-50 mm[1)] 70-100 mm[2)]	free-flow, single-vane, multi-vane	TMW, TS, CP, TC 40, TP 50-65, TP 80-150, STC 80-100
Commercial wastewater		
35–50 mm	Free-flow, multi-vane	TC 40, TS, TP 50-65, TC 40, TP 80-150, STC 80-100, STS 80-100
Wastewater from pump stations		
≥ 100 mm	Free-flow, single-vane, multi-vane	TP 100-150, STS 100, TP 80

Wastewater containing faecal matter, combined water (= sewage)

Required free passage	Recommended hydraulics	E.g. Wilo series
Domestic sewage		
10–80 mm Macerator	Single-vane, free-flow	MTS 40, TP 50-100
Commercial sewage		
< 80 mm	Single-vane, free-flow	TP 80-150, STC 80-100, STS 80-100

Gravity drainage line

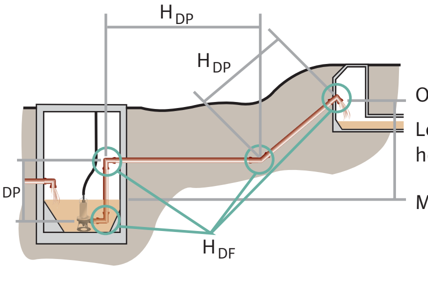
In a gravity drainage line, drainage is brought about by geodetic gradient. The line is filled only partially, to the crest of the pipe.

EN 476
DIN 1986-100

Delivery head

The delivery head H of a pump refers to the energy difference of the fluid between the inlet and outlet of the pump. The unit of delivery head is m or bar (10 m ~ 1 bar). The energy amounts are expressed as energy head (= delivery head). The pressure is a component of the energy head, but is used conversationally as a synonym for energy difference (energy difference = pressure).

The delivery head (energy difference) that must be supplied by the pump is the sum of the geodetic height difference (= static head difference) and the pressure drops (= drop in metres) in pipelines and fittings.

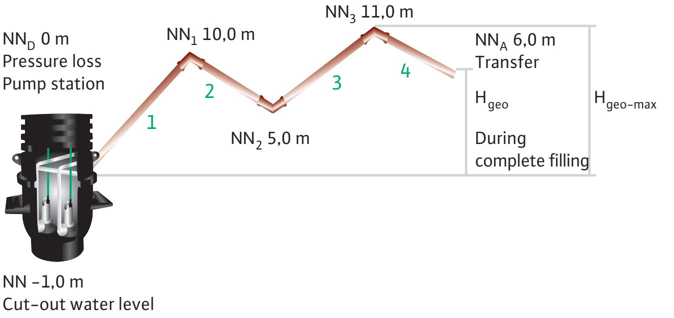


H_{DP} = pressure drops in pipelines
H_{DF} = pressure drops in fittings and bends

(Also refer to "System curve" on page 17)

When specifying the delivery head, it must be ensured that the pressure is designated exactly. There is a fundamental difference between the pressure at the optimum duty point, the pressure at the best efficiency of the pump (H_{opt}) and the maximum pressure of the pump (H_{max}). If specifications are misunderstood, resulting in oversizing or selection of pumps that are too small, this can cause damage to the installation and the unit and short-term failure of the systems. Possible high points must be given due consideration here, i.e. the maximum highest point of the pipeline is $H_{geo-max}$.

For discharge pipelines that are installed at varying inclines and have no ventilation, the individual values must be added according to the changes in height. This is due to the fact that, because of the individual height differences, it is most probable that the lines will be partially filled, and thus multiple superimposed water columns must be added.



For partially-filled lines, the ascending partial lines are added:

$$H_{geo-max} = (NN1 - NN) + (NN3 - NN2) = [10\text{ m} - (-1\text{ m})] + (11\text{ m} - 5\text{ m}) = 17\text{ m}$$

Were we to assume complete filling of the pipeline system, we would only need to calculate the geodetic height difference between the middle water level of the tank and the transfer.

When completely filled:

$$H_{geo} = NNA - NN = 6\text{ m} - (-1\text{ m}) = 7\text{ m}$$

Aid to calculation:
For pump start without ventilation: Add all ascending lines (line 1 + line 3), as the air in the descending line (line 2) is compressed. Therefore, a high pressure is required to overcome the high points.

During operation without ventilation: After the air has been pushed out of the pipeline, the pipeline is completely filled. Therefore, the pressure that must be supplied by the pump is only the maximum geodetic height difference H_{geo} between the outlet/transfer NN_A and the cut-out water level in the sump NN.

Pump start with ventilation: Here, the pressure differential between the water level in the sump (pump cut-in point) and the highest point of the system, $H_{geo-max}$, must be considered.

During operation with ventilation: During operation, the pump behaves in the same way described under "without ventilation" above.

Therefore, for proper operation of the pump, complete filling and partial filling amounts must be calculated, as the duty point can change drastically, causing the pump to operate outside the permitted ranges.

Flow rate (= delivery rate = flow rate)

The flow rate Q is the hydraulic flow rate supplied by the pump (quantity of fluid pumped) within a certain unit of time, such as l/s or m^3/h. The circulation required for internal cooling and leakage losses are power losses which are not included when calculating the flow. When specifying the quantity to be pumped, it must be specified whether this is the best point of the pump (Q_{opt}), the maximum required flow rate (Q_{max}) or the minimum required flow rate (Q_{min}) in operation.

If specifications are misunderstood, resulting in oversizing or selection of pumps that are too small, this can cause damage to the installation and the unit, as well as their short-term failure.

Ground pipe

Refers to the underground drainpipe to the sewer.

Cavitation (see also NPSH)

Cavitation refers to the formation and implosion of gas bubbles (cavities) as a result of local negative pressure formation under the vaporisation pressure of the fluid at the impeller inlet. This results in decreased output (delivery head) and efficiency, and causes rough running, noise and material damage to the interior of the pump. Through the expansion and collapse (implosion) of tiny air bubbles in areas of higher pressure (for example, in an advanced state, at the impeller outlet), microscopic explosions cause pressure impacts that damage or destroy the hydraulics. The first signs of this are noise from or damage to the impeller inlet.

The damage to the material depends on its composition. Thus, a stainless steel casting 1.4408 (AISI 316) is approximately 20 times more resistant than the standard material of the pump industry, cast iron (GG 25). For bronze, twice the lifetime can still be assumed.

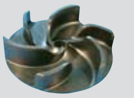
Taking advantage of the relationship of flow velocity, pressure and the corresponding evaporation temperature helps to prevent cavitation. A high flow velocity means low pressure, which, in turn, results in a lower boiling point of the fluid. Thus, for example, the formation of gas bubbles can be decreased/prevented by increasing the inlet pressure (for example, by increasing the water coverage, higher water level in the sump). *Additional starting points are provided in the chapter on "Fault diagnostics" on page 67 ff.*

Impeller types – Advantages of use

Single-vane or multi-vane impellers are suitable for fluids that contain solids. They are also used in rainwater, cooling water, process water and industrial water applications.

The free-flow impeller is optimally suited to fluids with long-fibre particles, as this impeller type does not tend to develop bunches of entangled fibres. Because if its robustness and quiet running, this shape is ideal for applications in building technology. Another outstanding feature of this type is its high wear resistance to abrasive components of the fluid such as sand.

Recommendations

	 Open single-vane impeller	 Open multi-vane impeller	 Free-flow impeller
Clog-free operation	●●	●	●●●
Gaseous fluids	●	●	○
Mud	●	●	●
Efficiency	●●	●●	○
Quiet running	●	●●	●●●
Wear resistance	●●	●●	●●●
Curve steepness	●	●	○

●●● Optimal ●● Very good ● Good ○ Limited

Pipe gradients for gravity drainage

All sewage drain pipes must be able to empty themselves by gravity. Also, flow noises and deposits can be prevented by laying the pipes appropriately. It must also be ensured that all pipes are laid deep enough to prevent them from freezing (recommended minimum depth in Germany > 80 cm).

Minimum gradient in accordance with DIN 1986 Part 1

DN	Wastewater	Rainwater	Combined water
Pipes inside buildings			
≥ 100	1 : 50	1 : 100	1 : 50
150	1 : 66.7	1 : 100	1 : 66.7
200	1 : 100	1 : 100	1 : 100
Pipes outside buildings			
≥ 100	1 : 50	1 : 100	1 : 50
150	1 : 66.7	1 : 100	1 : 66.7
200	1 : 100	1 : 100	1 : 100

Minimum gradient

Range of performance	Minimum gradient	Reference to standard and section
Non-ventilated connection pipes	1.0%	DIN EN 12056-2, Table 5 DIN 1986-100, Section 8.3.2.2
Ventilated connection pipes	0.5%	DIN EN 12056-2, Table 8
Ground and collecting pipes a) For wastewater	0.5%	DIN 1986-100, Section 8.3.4, Section 8.3.5
b) For rainwater (filling level 0.7)	0.5%	DIN 1986-100, Section 9.3.5.2
Ground and collecting pipes DN 90 (toilet bowl with flush water volume of 4.5 l–6 l)	0.5%	DIN 1986-100, Table A.2
Ground pipe for rain-water outside the building (filling level 0.7)	0.5%	DIN 1986-100, Section 9.3.5.2
up to DN 200	0.5%	
from DN 250	1:DN*	

* Flow velocity of at least 0.7 m/s up to max. 2.5 m/s.

Behind a sump with open flow-through, it is possible to work toward complete filling without positive pressure.

Minimum nominal diameter

DIN EN 12050-1
EN 12056-4

Refers to the smallest nominal diameter (connection dimension) in an installation or the smallest required pipe dimension.

Reserve impoundment volume

EN 1671

The reserve impoundment volume indicates the additional protection provided against fluid leaks. It is based on the average daily volume of wastewater generated, and is specified as 25% of that figure. It is equal to the additional volume that must be provided between the cut-in point of the pump system and any fluid leaks. In practice, the inlet-side volume of the pipeline is included in the calculation as a safety factor.

NPSH (see also Cavitation)

One important value for a centrifugal pump is the NPSH (Net Positive Suction Head). This specifies the minimum pressure at the pump inlet that is required by this pump type to work without cavitation, meaning the additional pressure required to prevent evaporation of the fluid and to keep it in a fluid state. Pump factors that affect the NPSH are the impeller type and pump speed. Environmental factors that affect it are the fluid temperature, water coverage and atmospheric pressure. There are two different types of NPSH value:

1. NPSH pump = NPSH required

Specifies the intake pressure necessary to prevent cavitation. The water coverage (height difference between pump inlet and the water level in the sump) is also considered inlet pressure.

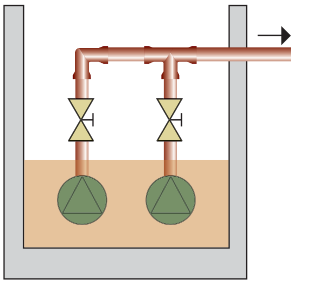
2. NPSH system = NPSH present

Specifies the pressure present at the pump inlet.

$NPSH_{system} > NPSH_{pump}$ or $NPSH_{present} > NPSH_{required}$

For pumps in wet sump installation, the $NPSH_{system}$ is calculated by adding the atmospheric pressure and the fluid coverage of the pump, minus the vaporisation pressure. In dry sump installation, the inlet-side pressure head losses are also subtracted. The $NPSH_{pump}$ is specified by the manufacturer with the definition of a cavitation criterion.

Parallel connection



The objective of parallel operation is to increase the flow rate; the term refers to operation of 2 or more pumps, where all pumps discharge simultaneously into a shared discharge pipeline (with each pump having its own corresponding fittings and its own supply lines). If all pumps are pumping simultaneously, the flow rates can be added at the same delivery head in order to calculate the total delivery head.

As is true for individual operation, the duty point of the pump curve is obtained from the point of intersection of the pump curve with the system curve. Each pump continues to work at its own pump curve. For pumps of the same type, this means that all pumps the have the same flow rate *(also refer to the graphic on page 23)*. Note, however, that the supply line to the collecting discharge pipeline has its own fittings with corresponding losses. These must be subtracted when calculating the duty point.

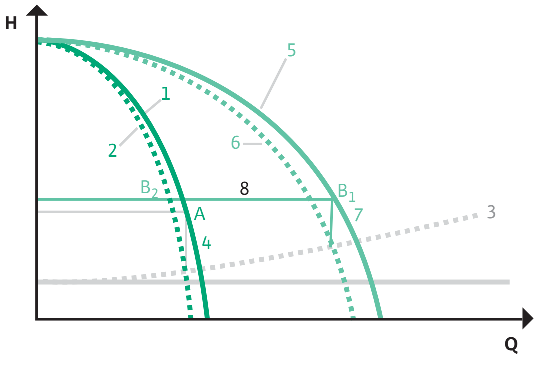
Basically, these rules also apply to the operation of two pumps of unequal size, where both pumps continue to work at their own curve and divide the flow rate between themselves accordingly (at equal pressure, add the flow rates).

There are various reasons for using multiple pumps:

- Parallel operation with base duty pump and corresponding cut-in of peak-load pumps, where the peak-load pumps are switched on only in case of increased demand that cannot be filled by the base duty pump (such as a higher wastewater inflow than the maximum flow rate of the base duty pump).
- Parallel operation to divide the flow rates in order to lower operating costs or in case of greatly varying conditions.
- Operating one pump with a standby pump or pumps that cut(s) in if the operating unit fails.

A temporary changeover between the pumps should always be provided to ensure that the operating hours are distributed as evenly as possible, thus guaranteeing a longer lifetime of the installation. The multiple-pump switching devices offered by WILO offer this function.

Graphic procedure for the calculation:



1. Drawing in the curve of pump 1
2. Reducing pump curve 1 by the losses (for example, due to fittings or clogs) in the discharge pipeline (up to the collecting pipe)
3. Drawing in the system curve
4. Vertically projecting the point of intersection of the system curve with the reduced pump curve upwards up to the original pump curve

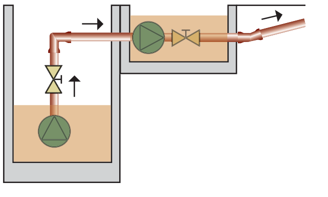
A = Duty point of the pump for individual operation

5. Drawing in the curve of pump 2 (addition of the flow rate with the same delivery head)
6. Reducing pump curve 2 by the losses (for example, due to fittings or clogs) in the discharge pipeline (up to the collecting pipe)
7. Vertically projecting the point of intersection of the system curve with the reduced pump curve upwards up to the original pump curve

B1 = Duty point of the system in parallel operation
B2 = Duty point of pump 1 or 2 considered individually in parallel operation

Series connection

The objective of series connection is to increase the pressure (delivery head); the term refers to operation of two or more pumps, where all pumps discharge simultaneously into a shared discharge pipeline (with each pump having its own corresponding fittings and its own supply lines).



To calculate the corresponding total curve of the pumps, the pressures are added at the same flow rate.

However, series connection should be approached with greater scepticism, as various difficulties can arise.

These can range from cavitations to turbine effects, where the first pump drives the second, thus causing potential damage to both pumps. Exacting design and constant monitoring are absolutely necessary.

Effective volume

Refers to the volume of sewage in a tank (such as a sump) that lies between the cut-in and cut-out point of the system. The cut-in and cut-out points are defined by float switches, level sensors or the like. It specifies the quantity of sewage in a tank that is pumped out during a pumping process.

Sump volume

Refers to the residual volume in the sump after the pump has been switched off by the level sensor.

Basic electrical concepts and their influences

Starting current

This refers to the current required during the process of starting up a machine to overcome friction losses and starting torques. Depending on the type of start, the starting current can be up to seven times the nominal current. If the electrical mains are unstable or larger motors are used, appropriate devices must be provided to reduce the starting current. These devices can be soft starters, frequency converters or the like. A reduction of the starting current can already be achieved by selecting a star-delta motor which, in Germany, is specified by the local energy companies for motor power $P_2 > 4$ kilowatts.

ATEX

See "Explosion protection" on page 24

Operating modes (in accordance with DIN EN 60034-1)

S1 = Continuous duty

The motor temperature increases during operation up to the operating temperature (thermal steady state). During operation, the heat is dissipated by coolant or the surrounding fluid. The machine can be operated in this state without interruption. The installation type (above water/underwater) or installation specified must also be taken into consideration. Continuous duty provides no information about this. S1 does not explicitly mean 24 hours a day, 7 days a week!

Please note the service life specifications and running times per year provided in the relevant documentation.

S2 to S9

The motor cannot be operated continuously, as the power loss that is converted to heat in the motor exceeds the amount that could be dissipated by the cooling. The motor would eventually overheat and possibly switch off via the motor protection.

S3

This operating mode is a common load for sewage pumps. It specifies a ratio of operating time to down time. Both values must be visible on the type plate and/or in the operating instructions. For S3 mode, the calculation always relates to a time period of 10 minutes.

Examples:

S3 – 20% means:	Operating time is 20% of 10 min. = 2 min. Down time is 80% of 10 min. = 8 min.
S3 – 3 min. means:	Operating time is 3 min. Down time is 7 min.

If two values are specified, this means, for example:

S3 – 5 min./20 min.	Operating time is 5 min Down time is 15 min
S3 – 25%/20 min.	Operating time is 5 min. Down time is 15 min.

Bus technology

Bus technology refers to the intelligent networking of electrical components. Here, the bus line is the data highway on which information is exchanged. A great variety of systems are available on the market today. *(Also refer to "LON" on page 26)*

Individual run signal

The individual run signal indicates the operation of the unit (not the operational readiness!).

Individual fault signal

Indicates a fault of the individual pump and provides an accurate evaluation method for building management systems.

Explosion protection

Explosion protection has been modified in the EU. The European Directive 94/9/EC for explosion protection has been in effect since July 1, 2003. The modifications generally lie in the fact that the entire unit (not just the electrical part) must be checked and certified with regard to explosion protection aspects. It is the responsibility of the owner/management to define the zone in which explosion protection must be provided. The units that Wilo certifies as protected from explosion are designed for Zone 1 Group II, Category 2, i.e. for a high standard of safety and where potentially explosive atmospheres are expected to exist.

Explosion protection
For example, EEx de IIB T4

EEx General abbreviation

de Abbreviation for type of protection
- d Pressure-resistant casing
- o Oil immersion
- p Overpressure casing
- q Sand-filled apparatus
- e Increased safety
- i Intrinsically safe

II Abbreviation for the group of the electrical apparatus
- I Mining industries
- II Surface industries

B Subdivision of group II
A – B – C
Different dimensions for border gaps,
Minimum ignition current

T4 Abbreviation for the temperature class
T1 < 450 ºC
T2 < 300 ºC
T3 < 200 ºC
T4 < 135 ºC
T5 < 100 ºC
T6 < 85 ºC

Ex isolating relay

When used along with Ex isolating relays, float switches can also be used in potentially explosive environments (Zone 1 for fluids containing faecal matter). These relays reduce the flow of current to a level at which, even in case of fault, no igniting spark is generated that would cause the fluid or its environment to ignite.

IP protection classes

EN 60034-5

The number used to designate the IP classification is composed of two areas. The first digit identifies the protection against contact and against foreign objects, while the second indicates the degree of protection from water. The table that appears here shows reference values. Information that is more detailed is provided in EN 60034-5 and IEC 34-5.

Example
According to the information provided in the catalogue, the Wilo-Drain TP 80 E 160/14 has protection class IP 68.

This means that this version is completely protected against contact and dust-tight (6..), and can also be immersed in the fluid for long periods (..8).

Digit 1 – Protection from foreign objects	Digit 2 – Protection from water
0 No special protection	0 No special protection
1 Protection against entry by solid objects > 50 mm	1 Protection from vertically dripping water
2 Protection against entry by solid objects > 12 mm	2 Protection from vertically dripping water (titled up to 15°)
3 Protection against entry by solid objects > 2.5 mm	3 Sprayed water, (titled up to 60°)
4 Protection against entry by solid objects > 1 mm	4 Splashed water from any angle
5 Protection against dust (allowed in smaller amounts) – dust-protected, complete protection against contact	5 Jetting water, targeted stream of water from nozzle
6 Dust-tight, complete protection against contact	6 Flood water, water jet without large quantities
	7 Immersed, under certain pressure and time conditions
	8 Continuous immersion, operating condition described by manufacturer

Output

The output of a pump can be divided into electrical output and hydraulic output. The hydraulic output is specified by Q (m^3/h or l/s) and H (m or bar). The electrical output is, in turn, divided into several parameters.
For example, the power consumption is designated as P_1 and specified in kilowatts (kW).
P_2 refers to the shaft power of the motor, i.e. the power that is output by the motor to the hydraulics.
P_3 indicates the hydraulic power output of the pump.

Power consuption P_1

$P_1 = \sqrt{3}\,U \times I \times \cos\varphi$
(three-phase current)

Shaft power P_2 (rated power)

$P_2 = M \times 2n \times \pi$

Hydraulic power output P_3

$P_3 = \rho \times g \times Q \times H$

U = Voltage [V]
I = Current strength [A]
$\cos\varphi$ = Specification of the motor manufacturer
M = Nominal torque [Nm]
n = Nominal speed [rpm]
ρ = Fluid density [g/dm3]
g = 9.81 m/s2
Q = Flow rate [m3/h]
H = Delivery head [m]

LON (Local Operating Network)

Refers to an automation network (such as for building automation) that distributes responsibilities (intelligences) to decentralised components such as the pump, switching device etc. Through the use of a standardised protocol, all functions can be evaluated at corresponding nodes. The modular structure of the network provides continuous flexibility and expandability. A standardised structure is no longer required, as all system components can transmit their information in all directions. *(Also refer to "Bus technology" on page 24)*

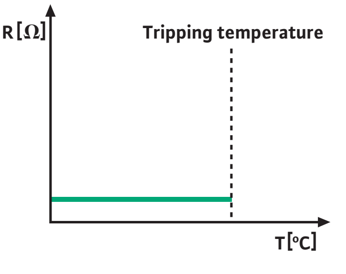
Motor protection

Thermal overcurrent relays (such as PTC thermistors)
These relays are tripped by temperature and interrupt the operation of the unit. They are tripped at certain temperatures (as a result of the temperature increase of the winding) and by increased current consumption. This heating may be caused by blocked hydraulics or by voltage fluctuations.

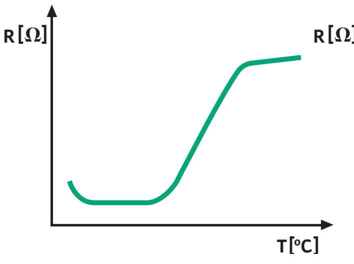
Motor protection switch
Motor protection switches are built into switching devices to protect electrical apparatus. They switch the motor on or off according to its breaking capacity and excessive input voltages. They also serve as protective devices against short-circuit and phase failure. They are tripped by PTOs (bimetallic switches) and PTCs.

Integrated temperature sensors
These temperature sensors are integrated to protect against overheating in the winding of the motor. This guarantees direct temperature monitoring at the winding.

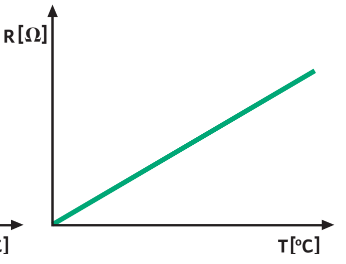
- Bimetallic switch
  These protective functions are tripped by bimetals depending on temperature. The dimensioning of the metal discs causes the bimetallic disc to change shape, which opens the contact when a predefined temperature is exceeded. It returns to its original shape (and clears the unit for operation again) only after it has cooled substantially.
  In alternating current devices, this clearance for operation is also possible without a switching device. New protective relays used by Wilo allow this function for three-phase current, even without a switching device. Please note the specifications of the catalogue documentation.



• Thermistors
For evaluation using PT 100 thermistors, a linear resistance curve that is relative to the temperature development is used as evaluation information. Another type of thermistor is the PTC.



PTC



PT 100

When the PT 100 is used, a continuous and accurate winding temperature in °C or °F can be provided for evaluation.

Level measurement systems

Level control using electrical fluid level signal
Float switch (such as Wilo MS 1)
Each float switch is hung at the respective tripping level. A switch is seated in the float switch that interrupts the sent current when the contact is open, thus giving the corresponding information to the switching device. When used along with Ex isolating relays, float switches can also be used in potentially explosive environments (Zone 1 for fluids containing faecal matter). These relays reduce the flow of current to a level at which, even in case of fault, no igniting spark is generated that would cause the fluid or its environment to ignite. The number of float switches depends on the number of pumps and on the type and quantity of the fuses. Each float switch is suspended into the sump from above and can move freely, resting on the surface of the fluid or suspended in the air. If the fluid exceeds a certain level, they tip on their reference axis and thus trigger the function in the switching device.
This level switching point is defined by the cable length in the sump.

To prevent "knotting" of multiple float switches when there is strong turbulence in the sump, protective pipes should be pulled over the cable to the fixture.

Float switch (Wilo MS 1)

Depending on the number of float switches, a different type of level control (measuring bell or pressure sensor) can be selected for smaller sump diameters.

Level control via hydrostatic trip signal
In this type of signal measurement, the fluid level is measured via the ambient pressure of a diaphragm. This ambient pressure is caused by the surrounding fluid. This information can be relayed electrically (analogue) or via a pressure signal (pneumatically). There is no regulation of the fluid level in the sump until settings are configured on the switching gear (unlike float switches).

Measuring bell (diving bell)
Because of the greater area of its opening, the measuring bell is suitable for highly contaminated fluids. Cast iron is used as the material for the diving bell so that it remains submersed, even in higher-density fluids, due to its heavier weight. When the measuring bell is covered by the fluid, the trapped atmospheric air is compressed by an amount that corresponds to the level. This change in pressure is evaluated by an electronic level transducer located on or in the switching device and calibrated to the values in the switching device. It offers the particular advantage of continuous level measurement with levels that can be evaluated (in centimetres, metres etc.) and can be used in potentially explosive areas (such as sewage containing faecal matter Zone 1) by relaying a pure pressure signal, without additional safety effort, in the bubble aeration method. It is evaluated in the switching device using the device's integrated sensors.

The bubble aeration method (air compressor) guarantees a uniform quantity of air in the system.

Measuring bell

Electronic pressure sensor
Electronic pressure sensors function according to the same principle as diving bells. The primary difference is that the pressure transducer is directly integrated into the pressure sensor, meaning that the pressure signal is converted into an analogue electrical signal (4–20 mA) directly in the sump. Accordingly, the switching device does not require an additional pressure transducer. When the diving bell is used, inaccuracies can be caused by such factors as leakage in the pressure hose or thermal changes with corresponding effects on the quantity of air in the hose. Evaluation using an electronic pressure sensor is more precise. In addition, the material used in pressure sensors is more corrosion-resistant (usually AISI 316 or better). The sensor is installed suspended in the sump; when there is strong turbulence in the fluid, it can be installed in a protective pipe. The sensor used by Wilo can be used in potentially explosive environments. However, as is true for all sensors, a Zener barrier must be used to prevent ignition sparks that can cause explosions in the event of failures/defects.

Electronic pressure sensor

For increased safety, an additional Wilo MS 1 float switch could be installed as a high water alarm.

Nominal current

Denotes the current consumed by the drive at the best efficiency point at a defined voltage.

Floating normally closed contacts

The floating normally closed contact is an evaluation contact of switching devices. It serves as a signal and control contact for downstream equipment, and requires an external voltage supply. For the contacts, the maximum voltage carrying capacity is to be specified in volts, as well as the maximum current carrying capacity (ampacity) in amperes. For Wilo switching devices used in sewage applications, these values are max. 250 V/1 A. These contacts are strictly outputs; they cannot be used to make adjustments on the switching device. Frequently requested information such as overcurrent, overtemperature, leakage etc. can be output to evaluation systems (such as PCs, signal cards, building management systems etc.) and on relays for separate adjustment of downstream functions.

Collective run signal

The collective run signal indicates the operational readiness of the system (not the operation!).

Collective fault signal

Relays a collective signal for multiple single-head pumps/individual plants to an evaluation mechanism or signal station. Signal points can include: acoustic alarm, visual alarm, counter etc. As soon as one component of the system fails, the collective fault signal is triggered as a fault message of the entire system (not the individual pump!).

Voltage supply

A constant power supply (mains voltage) guarantees a longer service life of the electrical unit. As the current required by the motor increases at lower voltages, an automatic increase of the temperature of the winding follows. This causes more rapid ageing and earlier failure. The voltage increase is due to the reduced efficiency and decreased inductive resistance. In addition, the motor torque and rpm decrease, with the result that the unit does not fulfil the hydraulic output for which it was designed. Protective motor switches, if present, switch off the unit. In AC pumps, defective capacitors are the result.

The following overview lists tendencies for interactions when there are voltage fluctuations:

Voltage increases by 10% of nominal voltage:
- Speed remains unchanged
- Efficiency at full load increases slightly
- Starting current increases up to 10%
- Nominal current at full load decreases by up to 7%
- Winding temperature falls slightly

Voltage decreases by 90% of nominal voltage:
- Speed remains unchanged
- Efficiency decreases slightly at full load
- Starting current decreases up to 10%
- Nominal current at full load increases by up to 10%
- Winding temperature increases

Fault signal

These signals can be either individual or collective fault signals. They are recorded and displayed by the switching device and interrupt the function if programmed to do so. Causes that trigger it can be motor defects, levels that are too high or two low, etc. *(Also refer to "Individual fault signal" on page 24 and "Collective fault signal" on page 29)*

Zener barrier

The Zener barrier is a passive component for reducing the current and voltage that are fed so that level measurement systems can be used in potentially explosive areas. The Zener diode it contains limits the voltage, while the internal resistor limits the current. In case of a fault, a built-in fuse trips and interrupts the connection. The Zener barrier can be used only in conjunction with a level sensor.

Installation and calculation examples

General instructions for calculation

General instructions

- The flow rate to be supplied by the pump must exceed the flow rate of the sewage inflow. Ensure that the pumps run at their optimal duty point wherever possible in order to guarantee a long service life and optimal output.
- Consider that the output of the pump decreases as its age increases. Abrasion and corrosion can have a negative effect on the flow rates and pressures.
- Design the pump so that it is within a range of +/-15% of its best efficiency point.
- Steep pump curves prevent clogging of the discharge pipeline, as when counterpressure is increased, the pump also increases the pressure along its curve, thus flushing away deposits.
- When selecting accessories, consider the properties of the materials with regard to their ability to resist corrosion and abrasion.
- For high geodetic delivery heads, use quick-closing fittings to reduce water hammer.
- For reasons of economy and safety technology, compensate for peak inflows by using twin-head pump units (pump splitting, standby pump is always to be considered separately).
- If the transfer point (sewer) is below the sump level, vents should be provided, as otherwise the generated suction could completely drain the entire sump, including the pump. This would result in ventilation problems; therefore, appropriate precautions should be taken in advance.
- Note the different operating conditions for pipelines that are laid at varying inclines. The situation with regard to partial or complete filling should be considered! *(Also refer to "Delivery head" on page 19/20)*

Pipeline and pump materials

- When designing the system, note that the following influences could mean additional stress for your system:

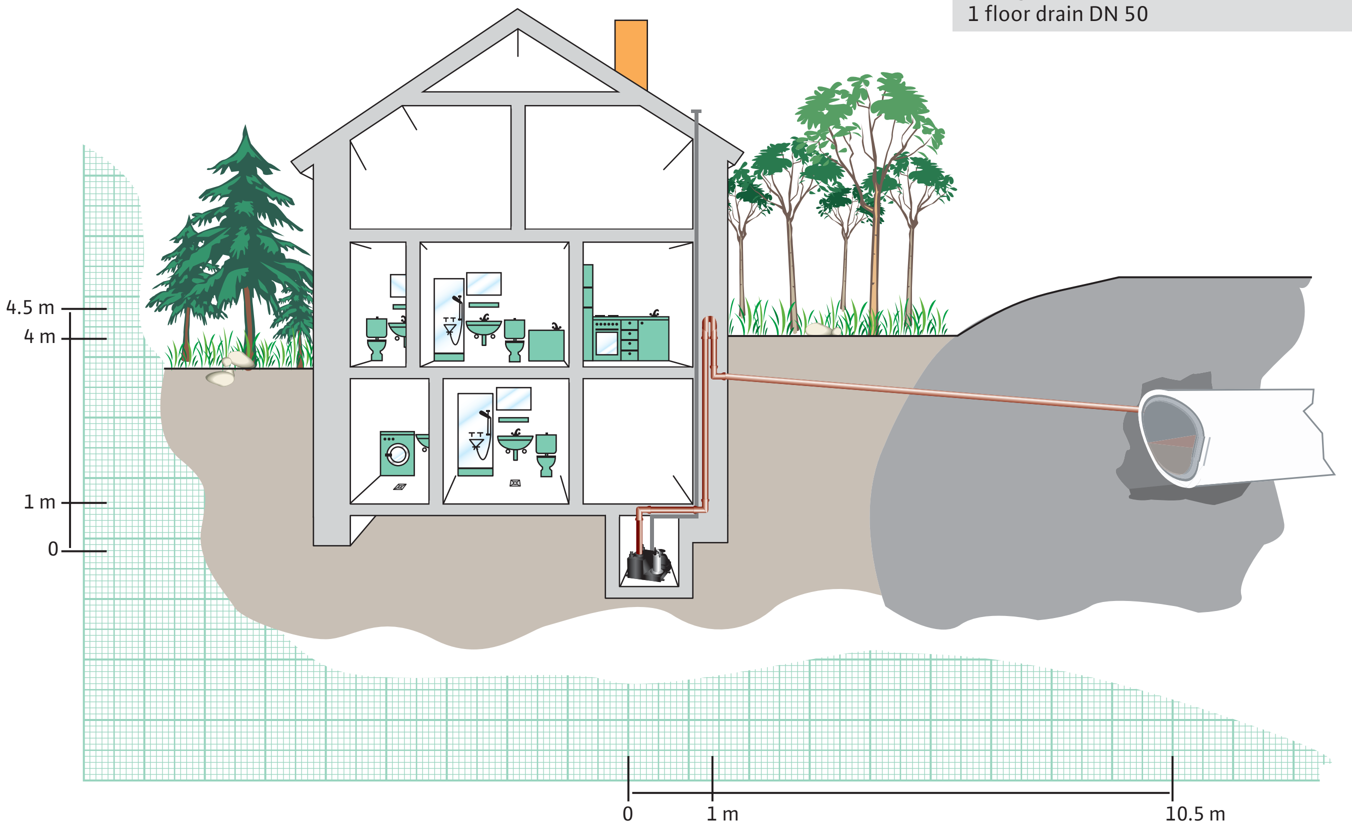
  - Flow velocity of the fluid > Noise, wear
  - pH value of the fluid > Material damage, corrosion
  - Chemical components of the fluid > Corrosion
  - Atmospheric conditions such as humidity, salt content of the air etc. > Corrosion
  - External temperature and fluid temperature > Fluid aggressiveness, corrosion
  - Retention period of the fluid in the pipeline > Odour build-up

- Because of the changes in materials and the resulting changes in pressure rating, PN 10 pipes should always be used for underground pipelines.

Planning instructions for interior installation

Closed lifting plants inside buildings
Fluids containing faecal matter – separate system

Characteristics
1 guest toilet with hand wash basin and toilet
2 bathrooms (2 toilets, 2 showers, 2 hand wash basins and 1 bathtub), of which 1 bathroom has DN 50 floor drain
1 kitchen including dishwasher
1 laundry room with 1 washing machine (10 kg), 1 hand wash basin and 1 floor drain DN 50



1. Determining the preconditions

- Lifting plant for wastewater containing faecal matter located inside the house
- Separate system
- Backflow level is at street level

- DIN EN 12050
- EN 12056
- EN 752
- DIN 1986-100
- EN 1610
- ATV-DVWK

2. Defining the boundary conditions

Determining the current/power supply:
- AC and three-phase current possible
- 50 Hz mains frequency

3. Calculating the wastewater inflow Q_w

Drainage coefficient K for residential buildings: 0.5 l/s

- Also refer to Table 1 of the Annex, "Values for characteristic drainage K"
- DIN EN 12050
- EN 12056

Drainage sources	DU value (Drain connection value)
2 showers	2 x 0.8 l/s
1 bathtub	1 x 0.8 l/s
1 kitchen sink	1 x 0.8 l/s
1 dishwasher	1 x 0.8 l/s
1 washing machine (10 kg)	1 x 1.5 l/s
2 floor drains DN 50	2 x 0.8 l/s
3 toilets with 9 l flushing cisterns	3 x 2.5 l/s
4 hand wash basins	4 x 0.5 l/s
	16.6 l/s

- Also refer to Table 2 of the Annex, "Drain connection values (DU) for sanitary fixtures"
- DIN EN 12050
- EN 12056

Drain connection value [l/s]

Drainage coefficient [l/s]

$$Q_s\,[l/s] = K \times \sqrt{\Sigma DU} + Q_b$$

Drainage value for special load [l/s]

$$Q_S = 0{,}5\ l/s \times \sqrt{16{,}6\ l/s} + 0$$

$$= 2.04\ l/s\ >\ 2.5\ l/s\ (9\ m^3/h)$$

Because the calculated value is less than the drain connection value (DU value) of the largest drainage source, the larger of these two must be used for the rest of the calculation!

4. Calculating the rainwater inflow Q_r

Not necessary, as system is separate system

5. Calculating the combined water outflow Q_c

Not necessary, as system is separate system

6. Piping configuration and determining the minimum flow velocity

Given: 15.5 m pipe
Selected: Cast iron (GG) pipe material
Nominal diameter DN 80

- ATV-DVWK A134
- EN 12056-4

Required flow rate [m³/h]

$$V_{min}\,[m/s] = \frac{Q_{ben}}{\frac{\pi}{4} \times (d_i)^2}$$

Pipe inner diameter [m]

$$\frac{Q_{ben}\,[m^3]}{\frac{\pi}{4} \times (d_i[m])^2 \times 3600\ s}$$

Verifying the flow velocity

$$V_{min} = \frac{9\ m^3/h}{0{,}785\ s \times (0{,}08\ m)^2} = \frac{9\ m^3}{2826\ s \times 0{,}0064\ m^2}$$

$$= 0.5\ m/s$$

The pipeline diameter is not adequately dimensioned with regard to losses and protection against deposits, as 0.7 m/s < V_{min} < 2.5 m/s.
Verification with curve of the pump necessary with regard to actual duty point.

- Also refer to Table 7 of the Annex, "Inner diameters of new pipes"

7. Selecting the required fittings

1 x shut-off valve DN 80 ≙ 0.56 m
1 x check valve DN 80 ≙ 3.3 m
5 x bends 90° DN 80 ≙ 3.95 m

- Also refer to Table 9 of the Annex, "Losses in fittings"
- DIN EN 12050-1
- DIN 1988-T3

---

8. Calculating the required total delivery head

A. Geodetic height difference

$H_{geo-max}\,[m] = NN_1 - NN_0$

Height of transfer or pipe bottom of the backflow loop in the reversal point [m]

Height of water level [m]

$H_{geo-max} = 4.5\ m - 0\ m$

$= 4.5\ m$

B. Losses in pipelines

$H_{DP}\,[m] = H^*_{DP} \times L$

Pipeline losses acc. to diagram

Pipeline length [m]

According to diagram for 15.5 m cast iron pipe, DN 80, new:

$H^*_{DP} = 0.45\ m/100\ m$

corresponds to 0.0045 m/m of pipeline

$H_{DP} = 0.0045 \times 15.5\ m$

$= 0.07\ m$

- Also refer to Table 8 of the Annex, "Pipe friction losses and correction factors"

C. Losses in fittings

$H_{DF}\,[m] = (H_{DF1} + H_{DF2} \ldots + H_{DFn}) \times H^*_{DP}$

Losses in fitting 1 [m]

Losses in fitting 2 [m]

Losses in pipelines acc. to diagram

$H_{DF} = (0.56\ m + 3.3\ m + 3.95\ m) \times 0.0045$

$= 0.035\ m$

- Also refer to Table 9 of the Annex, "Losses in fittings"
- DIN EN 12050-1
- DIN 1988-T3

D. Total losses

$H_{Tot}\,[m] = H_{geo-max} + H_{DF} + H_{DP}$

Geodetic height difference [m]

Losses in fittings [m]

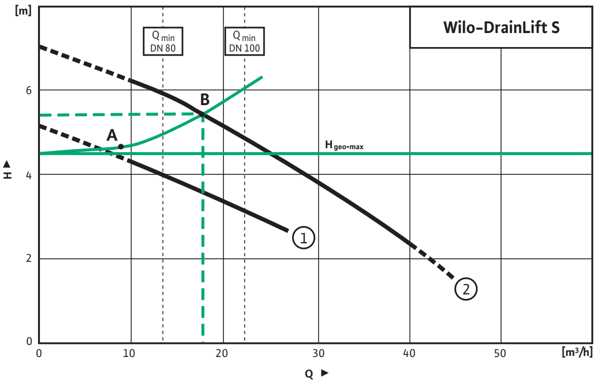
Losses in pipelines [m]

$H_{Tot} = 4.5\ m + 0.07\ m + 0.035\ m$

$= 4.61\ m$

Calculated duty point (minimum value):
$Q_{max} = 9\ m^3/h\ (2.5\ l/s)$
$H_{tot} = 4.61\ m$

9. Selecting the pump/ lifting plant



1 = DrainLift S 1/5 A = Calculated duty point
2 = DrainLift S 1/7 B = Actual duty point

The selected lifting plant is a Wilo-DrainLift S 1/7, as the duty point changes in quantity due to the counterpressure, and thus the criterion of the minimum flow rate is met. The running time of the plant shortens accordingly with no negative effect on the service life.

Actual duty point of the Wilo plant:
Q_{Real} = 16 m³/h (4.44 l/s)
H_{Real} = 5.2 m

• Also refer to Wilo Complete Catalogue

10. Piping configuration and determining the real flow velocity

Corrected flow rate [m³/h]

$$V_{min}\,[\mathrm{m/s}] = \frac{Q_{Real}}{\frac{\pi}{4} \times (d_i)^2}$$

Pipe inner diameter [m]

$$= \frac{Q_{kor}\,[\mathrm{m^3}]}{\frac{\pi}{4} \times (d_i[\mathrm{m}])^2 \times 3600\ \mathrm{s}}$$

$$V_{min} = \frac{16\ \mathrm{m^3/h}}{2826 \times 0{,}0064\ \mathrm{m^2}}$$

= 0.88 m/s

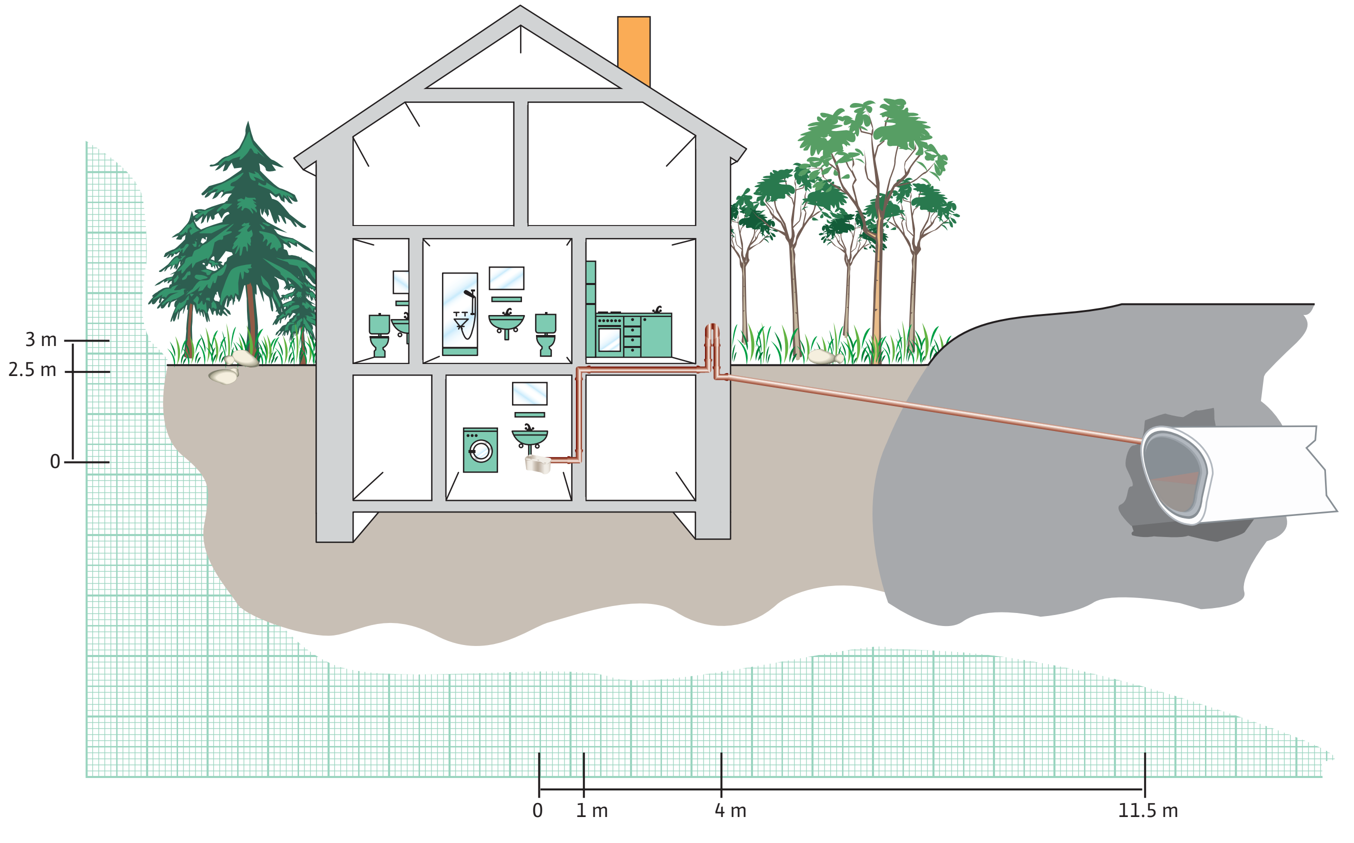
11. Selecting the control system and accessories

Electrical accessories:
All necessary components are already included in the scope of supply
Mechanical accessories:
• 1 x non-return valve (included in scope of supply beginning in 2005)
• 1 x gate valve DN 80
• 5 x bends DN 80

• Also refer to Wilo Complete Catalogue

Closed lifting plants inside buildings
Fluids free of faecal matter – separate system

Characteristics
Laundry room with washing machine (10 kg), 1 hand wash basin
All other drainage sources are drained directly
Pipeline length to sewer system: 15 m
Geodetic height difference between drainage system and sewer system: 2.5 m



1. Determining the preconditions

- Wastewater lifting plant located inside the house
- Separate system
- Backflow level is at street level
- All drainage sources above the backflow level are drained directly

- DIN EN 12050
- EN 12056
- EN 752
- DIN 1986-100
- EN 1610
- ATV-DVWK

2. Defining the boundary conditions

Determining the current/power supply:
- AC and three-phase current possible
- 50 Hz mains frequency

3. Determining the waste-water inflow Q_w

Drainage coefficient K for single-family homes:
0.5 l/s

- Also refer to Table 1 of the Annex, "Values for charac-teristic drainage K"
- DIN EN 12050
- EN 12056

Drainage sources	DU value (Drain connection value)
1 washing machine (10 kg)	1 x 1.5 l/s
1 hand wash basin	1 x 0.5 l/s
	2.0 l/s

- Also refer to Table 2 of the Annex, "Drain connection values (DU) for sanitary fixtures"
- DIN EN 12050
- EN 12056

Drain connection value [l/s]
Drainage coefficient [l/s]

$$Q_s\,[l/s] = K \times \sqrt{\Sigma DU} + Q_b$$

Drainage value for special load [l/s]

$$Q_s = 0{,}5\ l/s \times \sqrt{2{,}0\ l/s} + 0$$

$$= 0.71\ l/s \quad > \quad 1.5\ l/s\ (5.4\ m^3/h)$$

Because the calculated value is less than the drain connection value (DU value) of the largest drainage source, the larger of these two must be used for the rest of the calculation!

4. Calculating the rainwater inflow Q_r

Not necessary, as system is separate system

5. Calculating the combined water outflow Q_c

Not necessary, as system is separate system

6. Piping configuration and determining the minimum flow velocity

Given: 15 m pipe
Selected: PE100HD pipe material
Nominal diameter DN 40

Required flow rate [m³/h]

$$V_{min}\,[m/s] = \frac{Q_{ben}}{\frac{\pi}{4} \times (d_i)^2}$$

Pipe inner diameter [m]

$$\frac{Q_{ben}\,[m^3]}{\frac{\pi}{4} \times (d_i[m])^2 \times 3600\ s}$$

Verifying the flow velocity

$$V_{min} = \frac{5{,}4\ m^3/h}{0{,}785\ s \times (0{,}041\ m)^2} = \frac{5{,}4\ m^3}{2826\ s \times 0{,}0017\ m^2}$$

$$= 1.12\ m/s$$

- Also refer to Table 7 of the Annex, "Inner diameters of new pipes"

7. Selecting the required fittings

6 bends 90° DN 40 ≙ 1.62 m

- Also refer to Table 9 of the Annex, "Losses in fittings"
- DIN EN 12050-1
- DIN 1988-T3

8. Calculating the required total delivery head

A. Geodetic height difference

$H_{geo-max}$ [m] = $NN_1 - NN_0$

NN_1: Height of transfer or pipe bottom of the backflow loop in the reversal point [m]

NN_0: Height of water level [m]

$H_{geo-max}$ = 3.0 m – 0 m

= 3.0 m

B. Losses in pipelines

H_{DP} [m] = H^*_{DP} x L

H^*_{DP}: Pipeline losses acc. to diagram

L: Pipeline length [m]

According to table for 15 m HDPE pipe, DN 40, new:

H^*_{DP} = 3.5 m/100 m

corresponds to 0.035 m/m of pipeline

H_{DP} = 0.035 x 15 m

= 0.53 m

- Also refer to Table 6 of the Annex, "Pressure drops relative to flow rates of plastic pipelines"

C. Losses in fittings

H_{DF} [m] = ($H_{DF1} + H_{DF2} ... + H_{DFn}$) x H^*_{DP}

H_{DF1}: Losses in fitting 1 [m]

H_{DF2}: Losses in fitting 2 [m]

H^*_{DP}: Losses in pipelines acc. to diagram

H_{DF} = (1.62 m) x 0.035

= 0.06 m

- Also refer to Table 9 of the Annex, "Losses in fittings"
- DIN EN 12050-1
- DIN 1988-T3

D. Total losses

H_{Tot} [m] = $H_{geo-max} + H_{DF} + H_{DP}$

$H_{geo-max}$: Geodetic height difference [m]

H_{DF}: Losses in fittings [m]

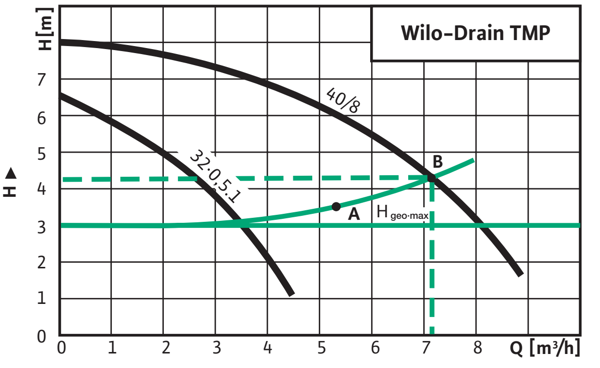
H_{DP}: Losses in pipelines [m]

H_{Tot} = 3.0 m + 0.06 m + 0.053 m

= 3.59 m

Calculated duty point (minimum value):
Q_{max} = 5.4 m³/h (1.5 l/s)
H_{tot} = 3.59 m

9. Selecting the pump/ lifting plant



A = Calculated duty point
B = Actual duty point

The selected lifting plant is a Wilo-DrainLift TMP 40/8

Actual duty point of the Wilo plant:
Q_{Real} = 7.2 m³/h (2.0 l/s)
H_{Real} = 4.2 m

• Also refer to Wilo Complete Catalogue

10. Piping configuration and determining the real flow velocity

Corrected flow rate [m³/h]

$$V_{min}\,[m/s] = \frac{Q_{Real}}{\frac{\pi}{4} \times (d_i)^2}$$

Pipe inner diameter [m]

$$= \frac{Q_{kor}\,[m^3]}{\frac{\pi}{4} \times (d_i[m])^2 \times 3600\ s}$$

$$V_{min} = \frac{7{,}2\ m^3}{2826\ s \times 0{,}0017\ m^2}$$

= 1.5 m/s

11. Selecting the control system and accessories

Electrical accessories:
All necessary components are already included in scope of supply
• Mini alarm switchgear or Wilo-Alarm Control 1 optional

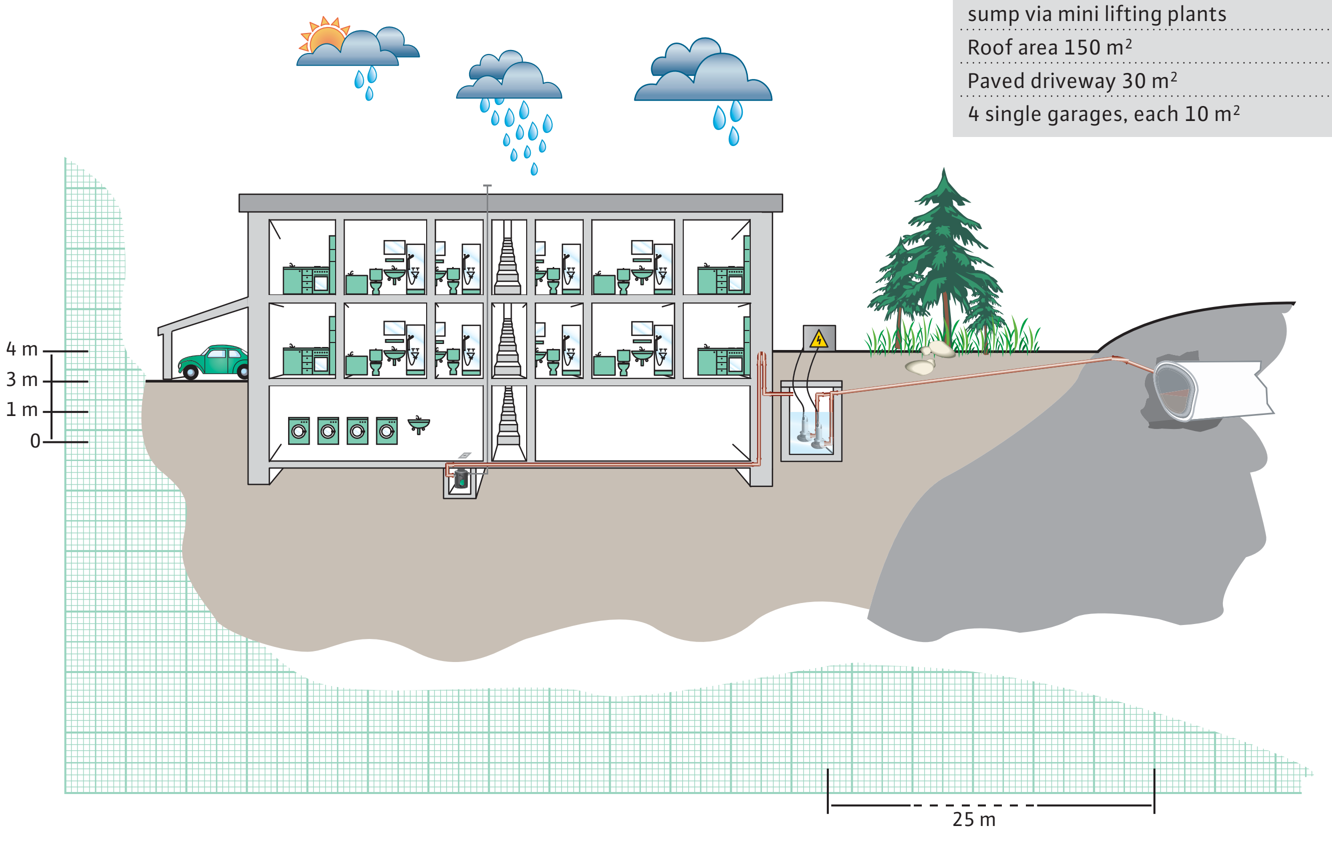
Mechanical accessories:
• 6 x 90° bends

• Also refer to Wilo Complete Catalogue

Planning instructions for exterior installation – sump pump stations

Open system outside the building
Fluids containing faecal matter – combined system

Characteristics
8 bathrooms (4 with shower and bathtub, 4 with shower only)
4 kitchens including dishwashers
Laundry room with 4 washing machines (10 kg) and floor drain DN 50
Pipeline length: 25 m to sewer system Height difference: 4 m
All drainage sources located below the backflow level are drained into the sump via mini lifting plants
Roof area 150 m²
Paved driveway 30 m²
4 single garages, each 10 m²



1. Determining the preconditions

- Sump installation outside the building
- Combined water disposal is permitted
- Backflow level is at street level
- Twin-head pump station, as house is multi-family home
- Effects of wind are to be disregarded
- Rain vertical to roof area (150 m²)

- DIN EN 12050
- EN 12056
- EN 752
- DIN 1986-100
- EN 1610
- ATV-DVWK

2. Defining the boundary conditions

Determining the current/voltage supply:
- AC and three-phase current possible
- 50 Hz mains frequency

3. Calculating the waste-water inflow Q_w

Drainage coefficient K for multi-family homes: 0.5 l/s

- Also refer to Table 1 of the Annex, "Values for characteristic drainage K"
- DIN EN 12050
- EN 12056

Drainage sources	DU value (Drain connection value)
8 showers	8 x 0.8 l/s
4 bathtubs	4 x 0.8 l/s
4 kitchen sinks	4 x 0.8 l/s
4 dishwasher	4 x 0.8 l/s
4 washing machines (10 kg)	4 x 1.5 l/s
1 floor drain DN 50	1 x 0.8 l/s
8 toilets with 6 l flushing cisterns	8 x 2.0 l/s
9 hand wash basins	9 x 0.5 l/s
	43.3 l/s

- Also refer to Table 2 of the Annex, "Drain connection values (DU) for sanitary fixtures"
- DIN EN 12050
- EN 12056

Drain connection value [l/s]

Drainage coefficient [l/s]

$$Q_s\,[l/s] = K \times \sqrt{\Sigma DU} + Q_b$$

Drainage value for special load [l/s]

$$Q_s = 0{,}5\ l/s \times \sqrt{43{,}3\ l/s} + 0$$

$$= 3.29\ l/s\ (11.84\ m^3/h)$$

If the calculated value were less than the drain connection value (DU value) of the largest drainage source, the larger of these two would have to be used for the rest of the calculation!

4. Calculating the rainwater inflow Q_r

If no value is provided by local building authorities, a value of 300 l/(s x ha) can be assumed when flooding must be avoided under all circumstances.

- Also refer to Table 4 of the Annex, "Rainfall intensities in Germany"

Sealed area	Coefficient C
Roof area 150 m²	1.0
Driveway, concrete pavement 30 m²	0.7
Single garages, each 10 m²	1.0

- Also refer to Table 5 of the Annex, "Runoff coefficients C for calculating the rainfall rate Q_r"
- DIN 1986 – 100
- EN 12056 – A
- EN 12056-3:2001-01
- DIN EN 752-2_1996-09

Catchment area [m²]

Rainwater inflow

Runoff coefficient

$$Q_r\,[l/s] = ((C_1 \times A_1) + \ldots + (C_z \times A_z)) \times r\,T_{(n)}$$

Design rainfall intensity $\left[\frac{l}{(s \times ha)}\right]$

1 ha ≙ 10,000 m²

$$Q_r = ((1 \times 150\ m^2) + (0.7 \times 30\ m^2) + (1 \times 40\ m^2)) \times \frac{300\ l/(s \times ha)}{10.000\ m^2}$$

$$= 211 \times 0.03\ l/s$$

$$= 6.33\ l/s$$

5. Calculating the combined water outflow Qc

$$Q_c\,[l/s] = Q_w\,[l/s] + Q_r\,[l/s]$$

$$Q_c = 3.29\ l/s + 6.33\ l/s$$

$$= 9.62\ l/s\ (34.63\ m^3/h)$$

6. Piping configuration and determining the minimum flow velocity

Given: 25 m pipe
Selected: Cast iron (GG) pipe material
Nominal diameter DN 100

Verifying the flow velocity

• Also refer to Table 7 of the Annex, "Inner diameters of new pipes"

Required flow rate [m³/h]

$$V_{min}\,[m/s] = \frac{Q_{ben}}{\frac{\pi}{4} \times (d_i)^2}$$

Pipe inner diameter [m]

$$= \frac{Q_{ben}\,[m^3]}{\frac{\pi}{4} \times (d_i[m])^2 \times 3600\ s}$$

$$V_{min} = \frac{34{,}63\ m^3/h}{0{,}785\ s \times (0{,}1\ m)^2} = \frac{34{,}63\ m^3}{2826\ s \times 0{,}01\ m^2}$$

$$= 1.23\ m/s$$

The pipeline diameter is dimensioned well with regard to losses and protection against deposits, as 0.7 m/s < V_{min} < 2.5 m/s.

7. Selecting the required fittings

1 x Y-piece DN 100 ≙ 8.85 m
1 x shut-off valve DN 100 ≙ 0.7 m
1 x check valve DN 100 ≙ 4.26 m
1 x base support elbow DN 100 ≙ 1.11 m
1 x bend 90° DN 100 ≙ 1.11 m

• Also refer to Table 9 of the Annex, "Losses in fittings"
• DIN EN 12050-1
• DIN 1988-T3

8. Calculating the required total delivery head

A. Geodetic height difference

$$H_{geo-max}\,[m] = NN_1 - NN_0$$

Height of transfer or pipe bottom of the of the backflow loop in the reversal point [m]

Height of water level [m]

$$H_{geo-max} = 4\ m - 1\ m$$
$$= 3\ m$$

B. Losses in pipelines

According to diagram for 25 m cast iron pipe (DN100), new:

H^*_{DP} = 2 m/100 m of pipeline

corresponds to 0.02 m/m

• Also refer to Table 6 of the Annex, "Pressure drops relative to flow rates of plastic pipelines"

$$H_{DP}\,[m] = H^*_{DP} \times L$$

Pipeline losses acc. to diagram

Pipeline length [m]

$$H_{DP} = 0.02 \times 25\ m$$

$$= 0.5\ m$$

C. Losses in fittings

H_{DF} [m] = $(H_{DF1} + H_{DF2} \dots + H_{DFn}) \times H^*_{DP}$

Losses in fitting 1 [m] — Losses in fitting 2 [m] — Losses in pipelines acc. to diagram

H_{DF} = (8.95 m + 4.26 m + 0.7 m + 1.1 m + 1.1 m) x 0.02

= 0.32 m

- Also refer to Table 9 of the Annex, "Losses in fittings"
- DIN EN 12050-1
- DIN 1988-T3

D. Total losses

H_{Tot} [m] = $H_{geo-max} + H_{DF} + H_{DP}$

Geodetic height difference [m] — Losses in fittings [m] — Losses in pipe-lines [m]

H_{Tot} = 3 m + 0.5 m + 0.32 m

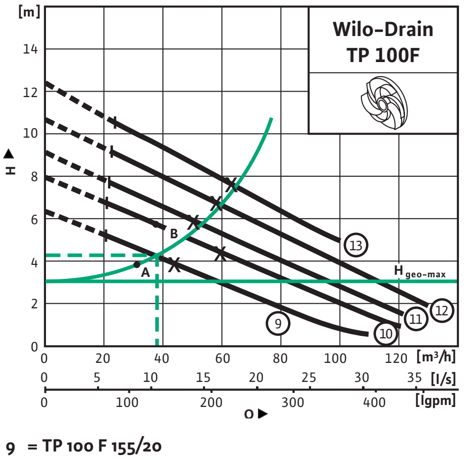
= 3.82 m

Calculated duty point (minimum value):
Q_{max} = 34.63 m³/h (9.62 l/s)
H_{Tot} = 3.82 m

9. Designing the pump/system

- Select an impeller that corresponds to your own priorities.
- Reliable and problem-free: Vortex
- Cost-effective in operation: single or multi-vane
- Here: Vortex is recommended, due to combination of widely varied fluid components

- Also refer to the chapter on "Basic hydraulic concepts and pipelines– Impeller types"



- Also refer to Wilo Complete Catalogue

9 = TP 100 F 155/20
10 = TP 100 F 165/24
11 = TP 100 F 180/27
12 = TP 100 F 190/32
13 = TP 100 F 210/34

A = Calculated duty point
B = Actual duty point

The selected pump is a
Wilo-Drain TP 100 F 155/20 (at 3~400 V: 6.1 A).

Actual duty point of the Wilo pump:
Q_{Real} = 38 m³/h (10.6 l/s)
H_{Tot} = 4.2 m

10. Configuring the sump

A. Usable volume

• Also refer to Table 10 of the Annex, "Operating cycles per hour of Wilo pumps"

Flow rate of the largest pumps [l/s]

$$V_{Nutz}\,[m^3] = \frac{0{,}9 \times Q}{Z}$$

Operating cycles [per hour]

$$V_{Nutz} = \frac{0{,}9 \times 10{,}6\ l/s}{20\ {}^1/h}$$

$$= 0.48\ m^3$$

B. Sump height (inside)

a. Inlet height depending on the flow rate

• Also refer to Wilo Complete Catalogue

Usable volume of tank [m³]

Minimum level in tank = water coverage of pump

$$H_{Zu\text{-}Q}\,[m] = \frac{V_{N\text{-}Beh}}{(\frac{\pi}{4} \times (D_{Beh})^2)} + H_{Beh\text{-}min}$$

Tank diameter acc. to manufacturer's specifications [m]

Minimum value calculation:

$$H_{Zu\text{-}Q} = \frac{0{,}48\ m^3}{(\frac{}{4} \times (1{,}5\ m)^2)} + 0{,}34\ m$$

$$= \frac{0{,}48\ m^3}{(0{,}785 \times 2{,}25\ m^2)} + 0{,}34\ m$$

$$= 0.79\ m$$

b. Total sump height

Height of the inlet pipeline based on flow rate [m]

Diameter of the discharge pipeline [m]

$$H_{Smp\text{-}Tot} = H_{In\text{-}Q} + H_{In\text{-}DL} + H_{Di\text{-}L} + H_{Fr}$$

Diameter of the inlet pipeline [m]

Safety height for frost-proof installation [m]

Minimum value calculation:

$$H_{Smp\text{-}Tot} = 0.79\ m + 0.15\ m + 0.1\ m + 1\ m$$

$$= 2.04\ m$$

11. Calculating the switching points

Usable volume of tank [m³]

$$H_{Signal}\,[m] = \frac{V_{N\text{-}Beh}}{\frac{\pi}{4} \times (D_{Beh})^2}$$

Inner diameter
of the sump
acc. to manufacturer's specifications [m]

$$H_{Signal} = \frac{0{,}48\ m^3}{(\frac{\pi}{4} \times (1{,}5\ m)^2)}$$

$$H_{Signal} = \frac{0{,}48\ m^3}{(0{,}785 \times 2{,}25\ m^2)}$$

= 0.27 m

- **Minimum cut-in point: 0.61 m**
- **Cut-out point: 0.34 m**

---

12. Selecting the control system and accessories

Electrical accessories:
- Wilo-DrainControl PL 2 (control system)
- Wilo level sensor 4-20 mA (level measurement)

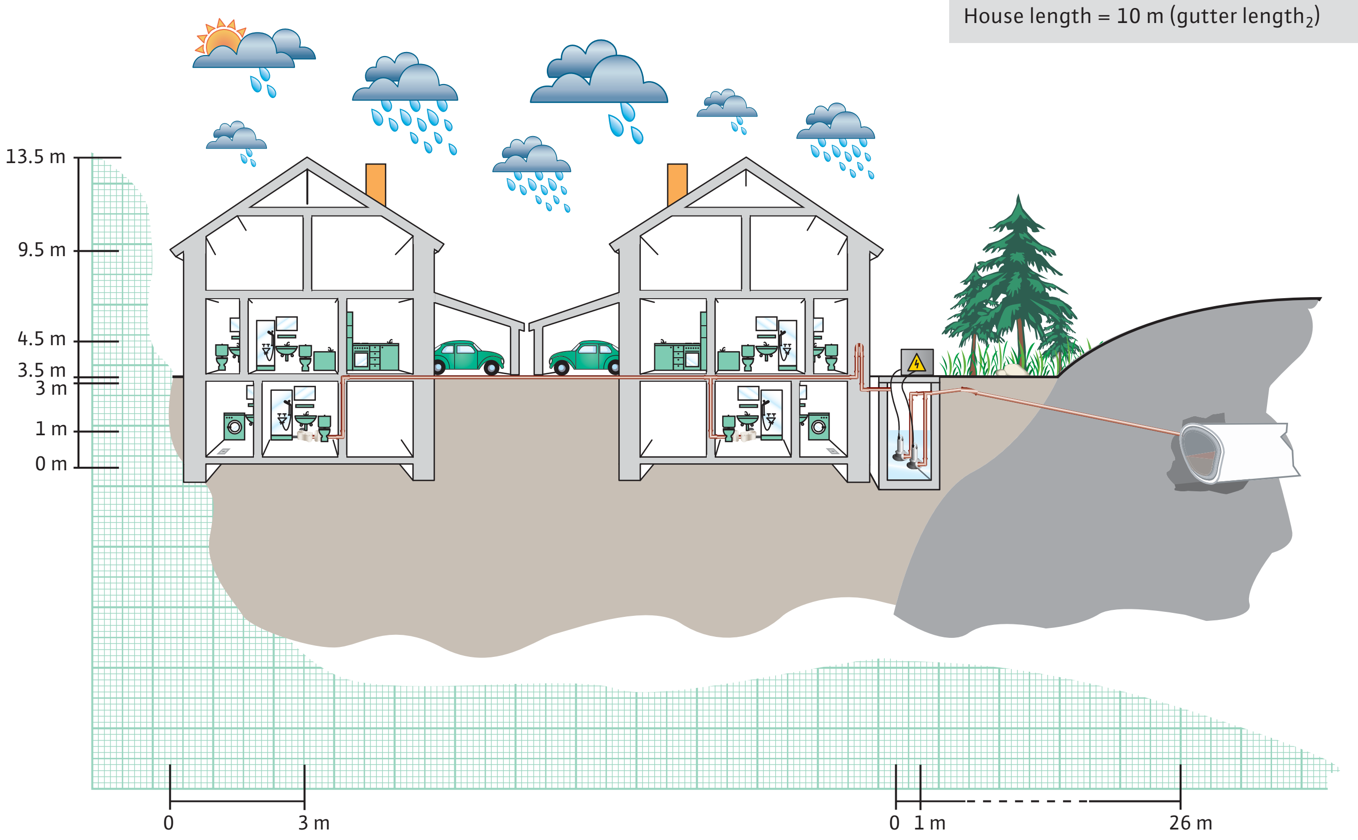
Mechanical accessories for stationary wet sump installation:
- 2 x base support elbows including guide, 2 x check valves
- 1 x gate valve
- 1 x pipe bend 90°
- 1 x Y-piece
- 2 x chains, 5 m

Wilo-Drain WB is supplied already complete from the factory

- Also refer to Wilo Complete Catalogue
- Also refer to the chapter "Additional planning guide– Selecting switch-ing devices for submersible pumps"

Gravity drainage
Fluids containing faecal matter – combined system

Characteristics
1 bathroom with shower and bathtub
1 bathroom with shower
1 guest toilet
1 laundry room with 1 washing machine (10 kg), 1 floor drain, 1 hand wash basin
1 kitchen including dishwasher and hand sink
Paved driveways, total area 40 m²
Single garage with 10 m² floor space
House length = 10 m (gutter length$_2$)



1. Determining the preconditions

- Combined water disposal is permitted
- Both houses have the same floor space
- Location: Dortmund, Germany
- Twin-head pump station
- Note effects of wind for rainwater
- Rain vertical to roof area
- Quantity of rainwater to be drained is identical for each house, as there is also no wind shadow
- All drainage sources are drained into the sump
- Mini lifting plants guarantee drainage of the objects in the basement into the sump

- DIN EN 12050
- EN 12056
- EN 752
- DIN 1986-100
- EN 1610
- ATV-DVWK

2. Defining the boundary conditions

Determining the current/power supply:
- AC and three-phase current possible
- 50 Hz mains frequency

3. Calculating the wastewater inflow Q_w

Drainage coefficient K for residential buildings: 0.5 l/s

- Also refer to Table 1 of the Annex, "Values for charac-teristic drainage K"
- DIN EN 12050
- EN 12056

Drainage sources	DU value
4 showers	4 x 0.8 l/s
2 bathtubs	2 x 0.8 l/s
2 kitchen sinks	2 x 0.8 l/s
2 dishwashers	2 x 0.8 l/s
2 washing machines (10 kg)	2 x 1.5 l/s
2 floor drains DN 50	2 x 0.8 l/s
6 toilets with 6 l flushing cisterns	6 x 2.0 l/s
8 hand wash basins	8 x 0.5 l/s
	28.6 l/s

- Also refer to Table 2 of the Annex, "Drain connection values (DU) for sanitary fixtures"
- DIN EN 12050
- EN 12056

Drain connection value [l/s]

Drainage coefficient [l/s]

$$Q_s\,[l/s] = K \times \sqrt{\Sigma DU} + Q_b$$

Drainage value for special load [l/s]

$$Q_s = 0{,}5\ l/s \times \sqrt{28{,}6\ l/s} + 0$$

$$= 2.67\ l/s\ (9.61\ m^3/h)$$

4. Calculating the rainwater inflow Q_r

- Also refer to the chapter on "Basic concepts–roof area"
- EN 12056-3

A. Calculating the roof area

Roof area — Horizontal roof depth [m]

$$A_{Roof}\,[m^2] = L_{G2}\,(D_{hor} + 0.5 \times D_{vert})$$

Gutter length$_2$ [m] — Vertical roof depth [m]

$$A_{Roof} = 10\ m\ (3\ m + 0.5 \times 4\ m)$$

$$= 50\ m^2 \text{ per roof section}$$

$$= 100\ m^2 \text{ roof area per house}$$

B. Calculating the wall area

Wall area — Gutter length$_2$ [m]

$$A_{Wall}\,[m^2] = 0.5 \times (L_{G2} \times H_{Wall})$$

Wall area [m]

$$A_{Wall} = 0.5 \times (10\ m \times 6\ m)$$

$$= 30\ m^2$$

C. Calculating the total catchment area per roof

Roof area [m²] — Wall area [m²]

$$A_{Total}\,[m^2] = A_{Roof} + A_{Wall}$$

For each house:

$$A_{Total} = 100\ m^2 + 30\ m^2 = 130\ m^2$$

Total quantity

$130\ m^2 \times 2 = 260\ m^2$

D. Calculating the rainwater inflow

Catchment area [m²]

Rainwater inflow

Runoff coefficient

$$Q_r\,[l/s] = ((C_1 \times A_1) + \ldots + (C_z \times A_z)) \times r\,T_{(n)}$$

Design rainfall intensity $\left[\frac{l}{(s \times ha)}\right]$

1 ha ≙ 10,000 m²

Location: Dortmund, Germany

Sealed area	Coefficient C
Roof area 260 m²	1.0
Driveway, concrete pavement 40 m²	0.7
2 garages, each 10 m²	1.0

$$Q_r = ((1 \times 260\ m^2) + (0.6 \times 40\ m^2) + (1 \times 20\ m^2)) \times \frac{277\ l/(s \times ha)}{10.000\ m^2}$$

$$= 8.42\ l/s$$

- Also refer to Table 4 of the Annex, "Rainfall intensities in Germany"
- Also refer to "Determining the preconditions"
- DIN 1986-100
- ATV-DVWK A 118

5. Calculating the combined water outflow Q_c

$$Q_c\,[l/s] = Q_w\,[l/s] + Q_r\,[l/s]$$

$$Q_c = 2.67\ l/s + 8.42\ l/s$$

$$= 11.09\ l/s\ (39.92\ m^3/h)$$

6. Piping configuration and determining the minimum flow velocity

Required flow rate [m³/h]

$$V_{min}\,[m/s] = \frac{Q_{ben}}{\frac{\pi}{4} \times (d_i)^2}$$

Pipe inner diameter [m]

$$= \frac{Q_{ben}\,[m^3]}{\frac{\pi}{4} \times (d_i[m])^2 \times 3600\ s}$$

Given: 29 m pipe
Selected: HDPE pipe material
Nominal diameter DN 80

Verifying the flow velocity

$$V_{min} = \frac{39{,}9\ m^3/h}{0{,}785\ s \times (0{,}08\ m)^2} = \frac{39{,}9\ m^3}{2826\ s \times 0{,}0064\ m^2}$$

$$= 2.21\ m/s$$

The pipeline diameter is dimensioned sufficiently with regard to losses and protection against deposits, as 0.7 m/s < V_{min} < 2.5 m/s. This is also adequate to carry heavier particles of the drainage water.

- Also refer to Table 7 of the Annex, "Inner diameters of new pipes"

7. Selecting the required fittings

1 x Y-piece DN 80 ≙ 6.58 m
2 x shut-off valves DN 80 ≙ 1.12 m
2 x check valves DN 80 ≙ 6.6 m
2 x base support elbows DN 80 ≙ 1.58 m
1 x bend 45° DN 80 ≙ 0.79 m

- Also refer to Table 9 of the Annex, "Losses in fittings"
- DIN EN 12050-1
- DIN 1988-T3

8. Calculating the required total delivery head

A. Geodetic height difference

$H_{geo-max}$ [m] = $NN_1 - NN_0$

Height of transfer or pipe bottom of backflow loop in reversal point [m]

Height of water level [m]

$H_{geo-max}$ = 3 m – 1m

= 2 m

B. Losses in pipelines

H_{DP} [m] = H^*_{DP} x L

Pipeline losses acc. to diagram

Pipeline length [m]

According to diagram for 29 m cast iron pipe, new:

H^*_{DP} = 7.5 m/100 m pipeline

corresponds to 0.075 m/m

H_{DP} = 0.075 x 29 m

= 2.18 m

- Also refer to Table 8 of the Annex, "Pipe friction losses and correction factors"

C. Losses in fittings

H_{DF} [m] = (H_{DF1} + H_{DF2}... + H_{DFn}) x H^*_{DP}

Losses in fitting 1 [m]

Losses in fitting 2 [m]

Losses in pipeline acc. to diagram

H_{DF} = (6.58 m + 1.12 m + 6.6 m + 1.58 m + 0.79 m) x 0.02

= 0.33 m

- Also refer to Table 9 of the Annex, "Losses in fittings"
- DIN EN 12050-1
- DIN 1988-T3

D. Total losses

H_{Tot} [m] = $H_{geo-max}$ + H_{DF} + H_{DP}

Geodetic height difference [m]

Losses in fittings [m]

Losses in pipe-lines [m]

H_{Tot} = 2 m + 2.18 m + 0.33 m

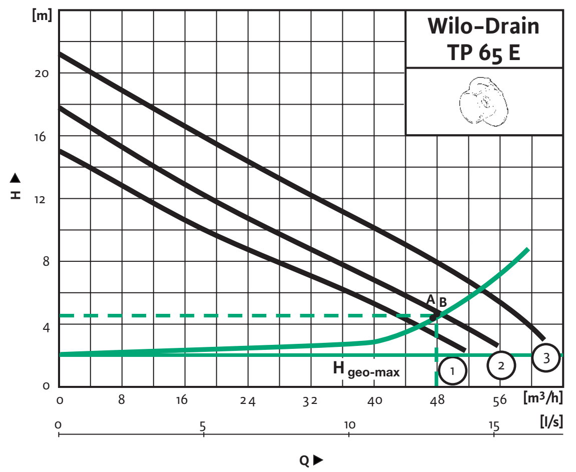
= 4.51 m

Calculated duty point (minimum value):
Q_{max} = 39.92 m³/h (11.09 l/s)
H_{Tot} 4.5 m

9. Selecting the pump

- Select an impeller that corresponds to your own priorities.
- Reliable and problem-free: Vortex
- Cost-effective in operation: single or multi-vane

- Also refer to the chapter on "Basic hydraulic concepts and pipelines – Impeller types – Advantages of use"



1 = TP 65 E 114/11
2 = TP 65 E 122/15
3 = TP 65 E 132/22

A = Calculated duty point
B = Actual duty point

- Also refer to Wilo Complete Catalogue

The selected pump is a Wilo-Drain TP 65 E 114/11 (at 3~400 V: 3.2 A).

Actual duty point of the Wilo pump:
Q_{Real} = 48 m³/h (13.3 l/s)
H_{Real} = 4.6 m

10. Configuring the sump

A. Usable volume

- ATV-DVWK A 134

Flow rate of the largest pumps [l/s]

$$V_{Nutz}\,[m^3] = \frac{0{,}9 \times Q}{Z}$$

Operating cycles [per hour]

$$V_{Nutz} = \frac{0{,}9 \times 13{,}3 \text{ l/s}}{20 \text{ 1/h}}$$

$$= 0.6 \text{ m}^3$$

- Also refer to Table 10 of the Annex, "Operating cycles per hour of Wilo pumps"

B. Sump height (inside)

a. Inlet height depending on the flow rate

• Also refer to Wilo Complete Catalogue

Usable volume of tank [m³]

Minimum level in tank = water coverage of pump [m]

$$H_{Zu\text{-}Q}\,[m] = \frac{V_{N\text{-}Beh}}{\left(\frac{\pi}{4} \times (D_{Beh})^2\right)} + H_{Beh\text{-}min}$$

Tank diameter acc. to manufacturer's specifications [m]

$$H_{Zu\text{-}Q} = \frac{0{,}6\ m^3}{\left(\frac{\pi}{4} \times (1{,}5\ m)^2\right)} + 0{,}3\ m$$

$$= \frac{0{,}6\ m^3}{(0{,}785 \times 2{,}25\ m^2)} + 0{,}3\ m$$

= 0.64 m

b. Total sump height

Height of the inlet pipeline based on flow rate [m]

Diameter of the discharge pipeline [m]

$$H_{Smp\text{-}Tot}\,[m] = H_{In\text{-}Q} + H_{In\text{-}DL} + H_{Di\text{-}L} + H_{Fr}$$

Safety height for frost-proof installation [m]

Diameter of the inlet pipeline [m]

$$H_{Smp\text{-}Tot} = 0.64\ m + 0.1\ m + 0.08\ m + 0.6\ m$$

= 1.42 m

Because the usable and total volumes of the sump are very small, a Wilo-DrainLift WS 1100 standard sump is recommended.

11. Calculating the switching points

Usable volume of tank [m³]

$$H_{Signal}\,[m] = \frac{V_{N\text{-}Beh}}{\frac{\pi}{4} \times (D_{Beh})^2}$$

Inner diameter of the sump acc. to manufacturer's specifications [m]

$$H_{Signal} = \frac{0{,}6\ m^3}{\left(\frac{\pi}{4} \times (1{,}5\ m)^2\right)}$$

$$H_{Signal} = \frac{0{,}6\ m^3}{0{,}785 \times 2{,}25\ m^2}$$

= 0.34 m

- **Minimum cut-in point: 0.64 m**
- **Cut-out point: 0.3 m**

12. Selecting the control system and accessories

Electrical accessories:

- Wilo-DrainControl PL 2 (control system)
- Wilo level sensor 4-20 mA (level measurement)

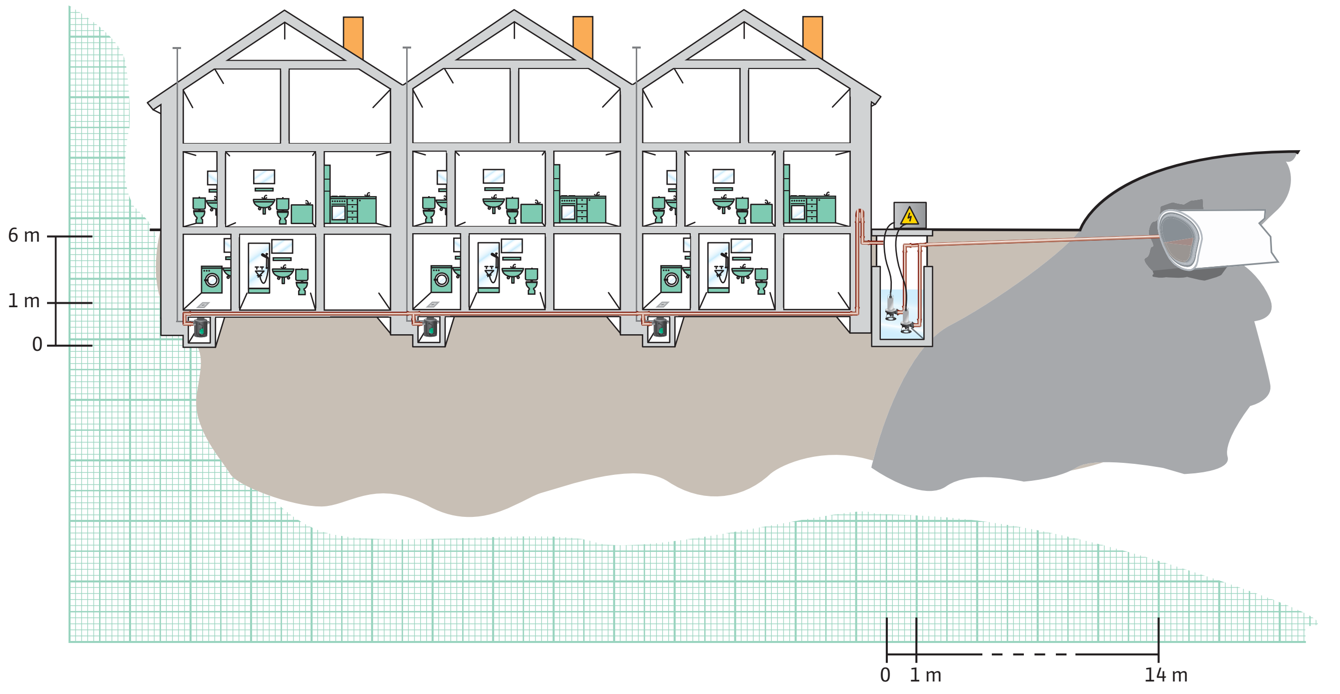
Mechanical accessories for stationary wet sump installation: 2 x base support elbows incl. guide, 2 x check valves, 2 x gate valves, 2 x pipe bends, 1 x Y-piece, 2 x chain 5 m

Wilo-Drain WS is supplied from the factory with all pipework installed (no additional fittings required in the sump).

• Also refer to Wilo Complete Catalogue
• Also refer to the chapter "Additional planning guide– Selecting switch-ing devices for submersible pumps"

Exterior installation outside the building
Fluids containing faecal matter – separate system

Characteristics
6 bathrooms (3 with shower and 3 with bathtub)
3 kitchens including dishwashers
3 laundry rooms with 3 washing machines (10 kg) and 3 floor drains DN 50



1. Determining the preconditions

- 3 single-family terraced houses
- Separate system
- Backflow level is at street level
- Sump installation outside the building
- Twin-head pump system
- All drainage sources located below the backflow level are drained into the sump using mini lifting plants

- DIN EN 12050
- EN 12056
- EN 752
- DIN 1986-100
- EN 1610
- ATV-DVWK

2. Defining the boundary conditions

Determining the current/power supply:
- AC and three-phase current possible
- 50 Hz mains frequency

3. Calculating the wastewater inflow Q_w

Drainage coefficient K for single-family homes: 0.5 l/s

- Also refer to Table 1 of the Annex, "Values for characteristic drainage K"
- DIN EN 12050
- EN 12056

Drainage sources	DU value
3 showers	3 x 0.8 l/s
3 bathtubs	3 x 0.8 l/s
3 kitchen sinks	3 x 0.8 l/s
3 dishwashers	3 x 0.8 l/s
3 washing machines (10 kg)	3 x 1.5 l/s
3 floor drains DN 50	3 x 0.8 l/s
9 toilets with 6 l flushing cisterns	9 x 2.0 l/s
9 hand wash basins	9 x 0.5 l/s
	39 l/s

- Also refer to Table 2 of the Annex, "Drain connection values (DU) for sanitary fixtures"
- DIN EN 12050
- EN 12056

Drain connection value [l/s]

Drainage coefficient [l/s]

$$Q_s\,[l/s] = K \times \sqrt{\Sigma DU} + Q_b$$

Drainage value for special load [l/s]

$$Q_s = 0{,}5\ l/s \times \sqrt{39\ l/s} + 0$$

$$= 3.12\ l/s\ (11.23\ m3/h)$$

If the calculated value were less than the drain connection value (DU value) of the largest drainage source, the larger of these two would have to be used for the rest of the calculation!

4. Calculating the rainwater inflow Q_r

Not necessary, as system is separate system

5. Calculating the combined water outflow Q_c

Not necessary, as system is separate system

6. Piping configuration and determining the minimum flow velocity

Given: 20 m pipe
Selected: PE100HD pipe material
Nominal diameter DN 50

Required flow rate [m³/h]

$$V_{min}\,[m/s] = \frac{Q_{ben}}{\frac{\pi}{4} \times (d_i)^2}$$

Pipe inner diameter [m]

$$= \frac{Q_{ben}\,[m^3]}{\frac{\pi}{4} \times (d_i[m])^2 \times 3600\ s}$$

Verifying the flow velocity

$$V_{min} = \frac{11{,}23\ m^3/h}{0{,}785\ s \times (0{,}051\ m)^2} = \frac{11{,}23\ m^3}{2826\ s \times 0{,}0026\ m^2}$$

$$= 1.53\ m/s$$

- Also refer to Table 7 of the Annex, "Inner diameters of new pipes"

The requirement of 0.7 m/s < V_{min} < 2.5 m/s is thus fulfilled. Larger pipe diameters should not be used, as more deposits would build up in that case.

7. Selecting the required fittings

1 x Y-piece DN 50 ≙ 3.87 m
1 x shut-off valves DN 50 ≙ 0.38 m
1 x check valve DN 50 ≙ 1.84 m
1 x base support elbow DN 50 ≙ 0.38 m
1 x bend 90° DN 50 ≙ 0.38 m

- Also refer to Table 9 of the Annex, "Losses in fittings"
- DIN EN 12050-1
- DIN 1988-T3

8. Calculating the required total delivery head

A. Geodetic height difference

$H_{geo-max}$ [m] = $NN_1 - NN_0$

NN_1: Height of transfer or pipe bottom of backflow level in reversal point [m]

NN_0: Height of water level [m]

$H_{geo-max}$ = 6 m – 1 m

= 5 m

B. Losses in pipelines

According to table for 20 m PE 100 (DN 50) pipe:

H^*_{DP} = 0.05 m/100 m pipeline

corresponds to 0.0005 m/m

- Also refer to Table 8 of the Annex, "Pipe friction losses and correction factors"

H_{DP} [m] = H^*_{DP} x L

H^*_{DP}: Pipeline losses acc. to diagram

L: Pipeline length [m]

H_{DP} = 0.06 x 20 m

= 0.1 m

C. Losses in fittings

H_{DF} [m] = (H_{DF1} + HD_{F2}... + H_{DFn}) x H^*_{DP}

H_{DF1}: Losses in fitting 1 [m]

HD_{F2}: Losses in fitting 2 [m]

H^*_{DP}: Pipeline losses according to diagram

H_{DF} = (3.87 m + 0.38 m + 1.84 m + 0.38 m + 0.38 m) x 0.1

= 0.69 m

- Also refer to Table 9 of the Annex, "Losses in fittings"
- DIN EN 12050-1
- DIN 1988-T3

D. Total losses

H_{Tot} [m] = $H_{geo-max}$ + H_{DF} + H_{DP}

$H_{geo-max}$: Geodetic height difference [m]

H_{DF}: Losses in fittings [m]

H_{DP}: Losses in pipelines [m]

H_{Tot} = 5 m + 0.69 m + 1.2 m

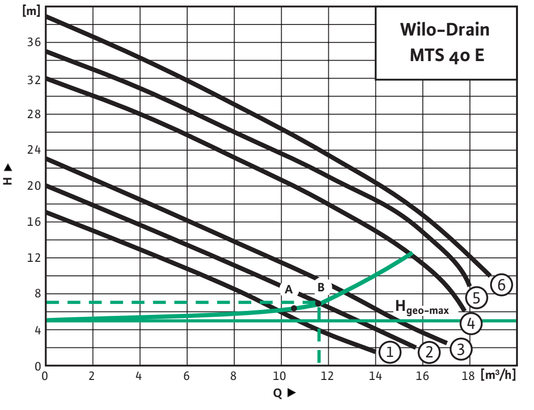
= 6.9 m

Calculated duty point (minimum value):
Q_{max} = 11.24 m³/h (3.12 l/s)
H_{Tot} = 6.9 m

9. Selecting the pump/lifting plant

- Select an impeller that corresponds to your own priorities.
- Reliable and problem-free: Vortex
- Cost-effective in operation: single or multi-vane
- Alternative: pump with macerator

- Here: pump with macerator recommended



1 = MTS 40 E 17.13/11
2 = MTS 40 E 20.14/13
3 = MTS 40 E 23.15/15
4 = MTS 40 E 32.14/21
5 = MTS 40 E 35.15/23
6 = MTS 40 E 35.15/23

A = Calculated duty point
B = Actual duty point

The selected pump is a Wilo-Drain MTS 40 E 20.14/13 (at 3~400 V: 2.8 A).

Actual duty point of the Wilo pump:
Q_{Real} = 11.4 m³/h (3.2 l/s)
H_{Real} = 7.8 m

- Also refer to the chapter on "Basic hydraulic concepts and pipelines– Impeller types"

- Also refer to Wilo Complete Catalogue

10. Configuring the sump

A. Usable volume

Flow rate of the largest pumps [l/s]

$$V_{Nutz}\,[m^3] = \frac{0{,}9 \times Q}{Z}$$

Operating cycles [per hour]

$$V_{Nutz} = \frac{0{,}9 \times 3{,}2\ l/s}{20\ ^1/h}$$

$= 0.14\ m^3$

- ATV-DVWK A 134

- Also refer to Table 10 of the Annex, "Operating cycles per hour of Wilo pumps"

B. Sump height (inside)

a. Inlet height depending on the flow rate

Usable volume of tank [m3]

Minimum water level in tank = water coverage of pump [m]

$$H_{Zu\text{-}Q}\,[m] = \frac{V_{N\text{-}Beh}}{\left(\frac{\pi}{4} \times (D_{Beh})^2\right)} + H_{Beh\text{-}min}$$

Tank diameter acc. to manufacturer's specifications [m]

$$H_{Zu\text{-}Q} = \frac{0{,}14\ m^3}{\left(\frac{\pi}{4} \times (0{,}84\ m)^2\right)} + 0{,}245\ m$$

$$= 0.5\ m$$

• Also refer to Wilo Complete Catalogue

b. Total sump height

Height of the inlet pipeline based on flow rate [m]

Diameter of the discharge pipeline [m]

$$H_{Smp\text{-}Tot}\,[m] = H_{In\text{-}Q} + H_{In\text{-}DL} + H_{Di\text{-}L} + H_{Fr}$$

Safety height for frost-proof installation [m]

Diameter of the inlet pipeline [m]

$$H_{Smp\text{-}Tot} = 0.5\ m + 0.05\ m + 0.05\ m + 1\ m$$

$$= 1.6\ m$$

Because the usable and total volumes of the sump are very small, a Wilo-DrainLift WS 1100 standard sump is recommended.

---

12. Selecting the control system and accessories

Electrical accessories:
• Wilo-DrainControl PL 2 (control system)
• Wilo level sensor 4-20 mA (level measurement)

Mechanical accessories for stationary wet sump installation:
• 2 x base support elbows incl. guide
• 2 x check valves
• 1 x gate valve
• 1 x pipe bend 90°
• 1 x Y-piece
• 2 x chains, 5 m

Wilo-Drain WS is supplied from the factory with all pipework installed (no additional fittings required in the sump).

• Also refer to Wilo Complete Catalogue
• Also refer to the chapter "Additional planning guide– Selecting switching devices for submersible pumps"

For exterior installation – pressure drainage
Fluids containing faecal matter – separate system – rough calculation

1. Determining the preconditions

- The geodetic height differences are known (red digits)
- The number of occupants is 126
- It is a separate system

- EN 1671
- ATV-DVWK A 116

2. Defining the boundary conditions

Determining the current and power supply:
- AC and three-phase current possible
- 50 Hz mains frequency

3. Calculating the wastewater inflow Q_w

Formula in accordance with DIN EN 1671

Consumer value [l/s]

$$Q_{max}\ [l/h] = Pers. \times 0.005\ l/s \times 1.5$$

Number of persons **Safety factor**

$$Q_{max}\ [l/h] = \frac{Pers. \times 120\ l}{10\ h}$$

Average hours of pump running time per day (experience value)

126 persons in 6 residential buildings
(21 persons per building)

$$Q_{max} = \frac{126\ Pers \times 120\ l}{10\ h}$$

= 1512 l/h (~1.5 m³/h = 0.42 l/s)

In the following, the calculation example is calculated in accordance with the experience values. Thus, the calculation is realistic based on the experience values, but it does not conform to DIN EN 1671.

- DIN EN 1671
- Wilo note: Measurements have yielded average values of 80–90 l. Experience has shown that a value of 120 l per occupant and day, including safety factors, is realistic when calculating the pump system.

---

4. Calculating the rainwater inflow Q_r

Not necessary, as system is separate system

---

5. Calculating the combined water outflow Q_c

Not necessary, as system is separate system

---

6. Piping configuration and determining the minimum flow velocity

Required flow rate [m³/h]

$$V_{min}\ [m/s] = \frac{Q_{ben}}{\frac{\pi}{4} \times (d_i)^2}$$

Pipe inner diameter [m]

$$= \frac{Q_{ben}\ [m^3]}{\frac{\pi}{4} \times (d_i[m])^2 \times 3600\ s}$$

Given: 769 m max. pipeline lengths
Selected: HDPE, nominal diameter DN 50

Verifying the flow velocity

$$V_{min}\ [m/s] = \frac{1{,}5\ m^3/h}{0{,}785\ s \times (0{,}051\ m)^2}$$

$$= \frac{1{,}5\ m^3}{2826\ s \times 0{,}003\ m^2}$$

= 0.18 m/s

The flow velocity is not sufficient to avoid deposits.
This must be verified again after selecting the pump.

- Also refer to Table 7 of the Annex, "Inner diameters of new pipes"

7. Selecting the required fittings

2 bends 90° DN 50 ≙ 0.76 m
1 x check valve DN 50 ≙ 1.84 m
1 gate valve DN 50 ≙ 0.38 m

- Also refer to Table 9 of the Annex, "Losses in fittings"
- DIN EN 12050-1
- DIN 1988-T3

8. Calculating the required total delivery head

A. Geodetic height difference

$H_{geo-max}$ [m] = $NN_1 - NN_0$

Height of transfer or pipe bottom of backflow level in reversal point [m]

Height of water level [m]

$H_{geo-max}$ = 55 m – 50 m

= 5 m

B. Losses in pipelines

According to diagram for 769 m cast iron pipe (DN 50), new:

H^*_{DP} = 4 m/100 m pipeline

corresponds to 0.04 m/m

- Also refer to Table 8 of the Annex, "Pipe friction losses and correction factors"

Pipeline correction value

H_{DP} [m] = H^*_{DP} x L x C

Pipeline losses acc. to diagram

Pipeline length [m]

H_{DP} = 0.04 x 769 m x 0.007

= 0.22 m

C. Losses in fittings

- Also refer to Table 9 of the Annex, "Losses in fittings"
- DIN EN 12050-1
- DIN 1988-T3

Correction factor (see stainless steel components)

H_{DF} [m] = (H_{DF1} + H_{DF2}... + H_{DFn}) x H^*_{DP} x H_C

Losses in fitting 1 [m]

Losses in fitting 2 [m]

Losses in pipelines acc. to diagram

H_{DF} = (0.76 m + 1.84 m + 0.38 m) x 0.02 x 0.8

= 2.98 m x 0.02 x 0.8

= 0.05 m

D. Total losses

H_{Tot} [m] = $H_{geo-max} + H_{DF} + H_{DP}$

Geodetic height difference [m]

Losses in fittings [m]

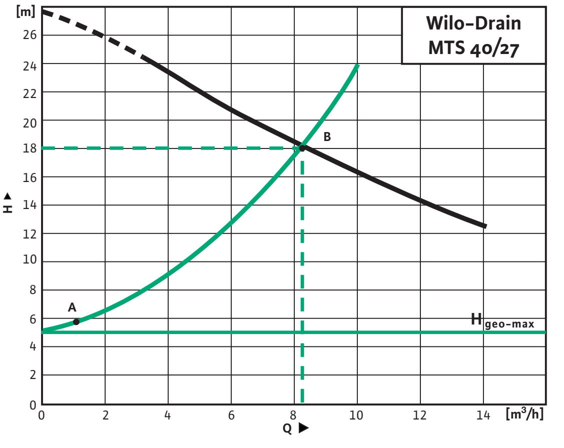
Losses in pipelines [m]

H_{Tot} = 5 m + 0.05 m + 0.22 m

= 5.27 m

Calculated duty point (minimum value):
Q_{max} = 1.5 m3/h (0.42 l/s)
H_{Tot} = 5.27 m

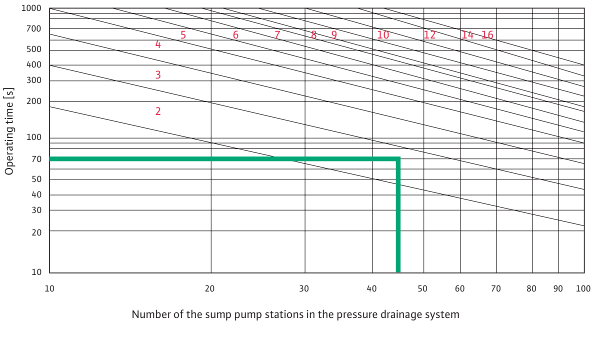
9. Selecting the pump/lifting plant



A = Calculated duty point
B = Actual duty point

- Also refer to the chapter on "Basic hydraulic concepts–Impeller types"

Parallel operation of pumps is to be excluded in this system.



- Also refer to Table 11 of the Annex, "Sump pump stations in parallel operation"

Should parallel operation of pumps occur, refer to the chapter on "Basic hydraulic concepts–Parallel connection"

The selected pump is a
Wilo-Drain MTS 40/27 F (at 3~400 V: 3.0 A).

Actual duty point of the Wilo pump:
Q_{Real} = 8.1 m³/h (2.25 l/s)
H_{Real} = 18.2 m

Due to changed pump capacity with regard to the required duty point, only the required operating time of the pump is reduced, which has a positive effect on the lifetime of the pump.

10. Piping configuration and determining the real flow velocity

Corrected flow rate [m³/h]

$$V_{min}\ [m/s] = \frac{Q_{Real}}{\frac{\pi}{4} \times (d_i)^2}$$

Pipe inner diameter [m]

$$= \frac{Q_{kor}\ [m^3]}{\frac{\pi}{4} \times (d_i[m])^2 \times 3600\ s}$$

$$V_{min}\ [m/s] = \frac{8{,}1\ m^3/h}{0{,}785\ s \times 0{,}0017\ m^2}$$

$$= \frac{8{,}1\ m^3}{2826\ s \times 0{,}0017\ m^2}$$

= 1.69 m/s

11. Selecting the sump

Selected: Usable volume 120 l

Given: Wilo-Drain MTS 40/27
$Q = 8.1\ m^3/h$
$H = 15.9\ m$
Daily quantity 120 l/pers

• Wilo note: experience value

Usable volume [l]

$$Q_{Res}\ [l] = Q_{usbl} \times Pers. \times Q_{day}$$

Number of persons in the household

Daily quantity [%]

Reserve impoundment volume: 25% of daily quantity

$$Q_{Res} = 120\ l \times 21 \times 25\%$$

= 630 l

Selected Wilo sump: Wilo-Drain WS 1100

• Also refer to Wilo Complete Catalogue

12. Selecting the control system and accessories

Electrical accessories:
Three-phase current recommended due to better starting behaviour
• Wilo-DrainControl PL 1 (control system)
• Wilo level sensor 4-20 mA (level measurement)

Mechanical accessories for stationary wet sump installation:
• 1 x base support elbow
• 1 x check valve
• 1 x gate valve
• 2 x pipe bends, possibly flush connection
• 1 x chain, 5 m

Pipework already installed in Wilo-Drain WS 1100 when supplied from the factory (no additional fittings required in the sump).

• Also refer to Wilo Complete Catalogue


STRATE
AWASTOP

Peripherals

Discharge pipeline ventilation

Long holding times of sewage in discharge pipelines frequently result in unwanted odours caused by hydrogen sulphide. Adding air prevents fouling of the sewage and keeps it "fresh." Literature shows that in every two-hour period, a supply of air equal to 10% of the content of the pipeline is required to keep the sewage "fresh." The air supply to the discharge pipeline is provided by a suitable compressor without a boiler.

Discharge pipe flushing or purging the discharge pipeline

If the flow velocity in a discharge pipeline does not reach the required minimum, or if a discharge pipeline is laid with high and low points (in this case, ventilation is only to the next high point), pressure flushing helps. The delivery rate of the compressed air system should be selected such that the flow velocity of the water column or the individual water plugs in the discharge pipeline is at least 1 m/s. In general, the calculations of the required air pressure and the air quantity when flushing or purging a discharge pipeline are to be equated with the calculation for the pump system. The velocity of the water column increases as the discharge pipeline becomes increasingly empty, corresponding to the compressed air system's properties. The system calculation is thus based on the theoretically least favourable case, the beginning of the flushing or purging process.

Grease separators

EN 1825-1
DIN 4040

Grease separators are used to hold back organic oils and greases. Sewage with faecal matter cannot be introduced, nor can rainwater and sewage with mineral oils or greases. A grease separator consists of a sludge trap, the grease separator itself and a sampling point. Suspended matter is separated in the sludge trap. The separation of oils and greases in the grease separator takes place using gravity alone. Emulsions and dispersions of oil and grease can be held back only minimally or not at all.

Sewage or rainwater containing faecal matter may not be introduced. Operation is limited to wastewater.

EN 12056

If the separator is located below the backflow level, a lifting plant must be installed. The design of the grease separator will be determined by the wastewater inflow, the connected grease inlets of the installations (hotel, canteen kitchen, etc.) and the density/concentration of the fluid.

Oil/petrol separator

Oil/petrol separators are used for environmental protection of natural bodies of water and sewer systems. Their functional principle is based on the differences in specific density of water-insoluble materials. The materials on the surface of the water are separated from the water by corresponding inlet systems and drained separately.

Selecting switching devices for submersible pumps

Selecting switching devices

A wide variety of factors must be considered when selecting switching devices. Thus, the selection of functions is not the only important factor; even more important is how well the electrical part of the pump is tuned to the switching device. The most important fundamental is the tuning between the rated motor power (setting + 10% over type plate information) at the corresponding nominal voltage and the specified current of the switching device, as the safety functions (tripping functions) such as motor protection are based on these values. Furthermore, the switching device must be tuned to the installation. Thus, the installation location has to be considered here. This means making sure that the switching device has the correct protection class (IP) to prevent ingress of moisture. It is likewise of fundamental importance to observe the explosion protection directives. The switching devices Wilo offers are designed for

	ER1_A	SK530 incl. float switch
No. of pumps that can be connected	1	2 /1 possible
Electrical connection		
3~400 V	●	●
3~230 V	●	–
1~230 V	●	●
Neutral conductor	Not required	Not required
Direct start	●	●
Max. power for direct start	$P_2 \leq 4$ kW	$P_2 \leq 3$ kW
Current for direct start	0.5-10 A	1-10 A
Star-delta	–	–
Max. power for star-delta	–	–
Max. current for star-delta	–	–
50 Hz frequency	●	●
Frequency 60 Hz	●	–
Protection class	IP 41	IP 41
Level systems		
Pneumatic pressure sensor (diving bell)	–	–
Electronic pressure sensor (4-20 mA) (level sensor)	–	–
Float switch(es)	Yes (max. 2)	Yes (max. 3)
Motor monitor		
Evaluation–thermal winding contact (WSK)	●	●
Evaluation–PTC	●	–
Evaluation–leakage (Di)	–	–
Electronic motor protection	●	●
Motor protection switch	–	–
Fault signals/run signals		
Collective run signal	●	●
Collective fault signal	●	●
Individual run signal	–	○
Individual fault signal	–	○
Separate signal contact for high water	–	–
Integrated alarm (buzzer)	–	–
Battery-powered alarm (integrated battery)	–	–
Operation/display		
LCD display	–	–
Parameter adjustment	Potentiometer	Potentiometer
Microprocessor-controlled	–	–
Version with plug and cable	–	–
Main switch (3-pole)	●	–
Software		
Pump starts	–	–
Elapsed time indicator	–	–
Automatic pump duty cycling	–	●
General		
Ambient temperature	0 to +40°C	0 to +40°C
Adjustable delay time	0-120 sec.	–
Test run	●	–
Logic reversal of inputs	●	–
Primary application		
	TC 40, TS 40, TS 50, TS 65, TP 50, TP 65, TM/TMW 32, MTS 40, STS 80, STC 80, CP	TC 40, TS 40, TS 50, TS 65, TP 50, TP 65, TM/TMW 32, MTS 40, STS 80, STC 80, CP

● Standard ○ Optional – Function not available installation in "non-potentially explosive environments." This means that these devices may not be installed in explosion-protected rooms. However, the switching device can be used in potentially explosive areas by using Ex isolating relays and Zener barriers *(also refer to "Ex isolating relay" on page 25 and "Zener barrier" on page 29)*. These additional switch boxes are placed between the switching device and pump/level control outside of the potentially explosive area. The selection of the functions of the switching device should be viewed in the context of the installation (information that can be evaluated, signal functions, alarm etc.) and the pump. The motor protection function (motor monitor) can be tripped in pumps in different ways, and thus is dependent on the capabilities of the switching device.

DrainControl 1	DrainControl 2	DrainControl PL1	DrainControl PL2	SK 545
1	2	1	2 / 1 possible	1 or 2
●	●	●	●	●
●	●	–	–	–
●	●	●	●	–
With/without	With/without	Required	Required	Not required
●	●	●	●	–
$P_2 \leq 4$ kW	$P_2 \leq 4$ kW	$P_2 \leq 4$ kW	$P_2 \leq 4$ kW	–
0.5–10 A	0.5–10 A	0.3–12 A	0.3–12 A	–
●	●	–	○	–
$P_2 \leq 5.5$ kW	$P_2 \leq 5.5$ kW	–	○	–
55.1–71A	55.1–71 A	–	○	–
●	●	●	●	●
–	–	●	●	–
IP 54	IP 54	IP 65	IP 65	IP 20
–	–	●	●	–
●	●	●	●	–
Yes (max. 5)	Yes (max. 5)	Yes (max. 3)	Yes (max. 4)	–
●	●	Yes (2x thermal winding contacts)	Yes (2x thermal winding contacts)	●
●	●	–	–	–
●	●	–	–	●
●	●	●	●	–
–	–	○	○	–
–	–	–	–	–
●	●	●	●	–
●	●	–	–	●
–	–	–	●	–
–	–	●	●	–
–	–	●	●	–
–	–	–	–	–
●	●	●	●	–
Menu-controlled/keys	Menu-controlled/keys	Menu-controlled/rotary knob	Menu-controlled/rotary knob	–
●	●	●	●	–
–	–	–	–	–
●	●			
–	–	●	●	–
●	●	●	●	–
–	●	–	●	–
0 to +40°C	0 to +40°C	-20 to +60°C	-20 to +60°C	0 to +40°C
0-60 sec. for base duty pump	0-60 sec. for base duty pump	0-180 sec.	0-180 sec. for base duty pump	–
–	–	●	●	–
–	–	–	–	–
TC 40, TS 40, TS 50, TS 65, TP 50, TP 65, TP 80-150, STS 80-100, STC 80-100, MTS 40, CP	TC 40, TS 40, TS 50, TS 65, TP 50, TP 65, TP 80-150, STS 80-100, STC 80-100, MTS 40, CP	TC 40, TS 40, TS 50, TS 65, TP 50, TP 65, MTS 40, STS 80, STC 80, CP	TC 40, TS 40, TS 50, TS 65, TP 50, TP 65 MTS 40, STS 80, STC 80, CP	TP 80-150, MTS 40, CP

Sump design

Sump design/planning

- Sump size and pump selection are not the only critical factors when sizing a pump station. Rather, pipelines, fittings and installed parts of the sump such as pipework are of decisive importance.
- Always provide shut-off valves for service and repair work. In some cases, these are already prescribed by standards.
- End discharge pipelines must be sized in accordance with the parameters (such as flow velocity) specified by the standards.
- Always place backflow valves at the top of the sump in the discharge pipeline, as this can prevent deposits.
- Sump bottoms should be designed at an angle of up to 40° to facilitate the inflow of solids to the hydraulics of the pump.
- Provide baffles at the inlet of the sump to prevent damage to the pump from inflowing water and to stabilise the fluid (prevents air from entering the pump).
- During the construction phase, provide a foundation earth electrode or earth strip for potential equalisation.
- The non-return valve and the gate in the fitting shaft should be installed towards the very top of the pipe, so that they are easily accessible for maintenance, cleaning and inspection.
- To minimise water hammer, provide a water hammer dampening system a short distance above the check valve (preferably with floating ball). Similar results can also be obtained using a check valve with floating ball.
- If the transfer point (sewer) is below the sump level, vents must be provided, as otherwise the generated suction would completely drain the entire sump, including the pump. This results in ventilation problems.

Fault diagnostics

Fault diagnostics (also refer to "Maintenance checklist" on page 70)

When does cavitation occur, and how can cavitation problems be solved?

- Combination of vent line that is too small or clogged with high fluid temperature.
  > Install/redimension or clean the vent line.
- Long suction line for pumps in dry sump installation. > Select a suitable new pump.
- There is air and/or gas in the fluid. > Ensure that the water coverage of the pump is correct and/or install a baffle at the inlet so that the water jet does not impact close to the pump; change the position of the signal transmitter.
- $NPSH_{system} > NPSH_{pump}$ or $NPSH_{present} > NPSH_{required}$ has not been followed when selecting the pump. > Reduce the impeller size; reduce the delivery rate; reduce the fluid temperature; reconfigure a suitable pump.
- Pump inlet is clogged. > Clean the inlet pipeline or sump; clean the pump hydraulics.
- Fluid temperature is too high by a significant amount (> 75°C). > Select a suitable new pump.
- There is air in the pump/discharge pipeline and the pump cannot be ventilated. > Install a vent line or clean the existing one.
- Pump has no counterpressure and runs out of its curve towards the right. > Select a suitable pump; increase the resistances in the end discharge pipeline by installing artificial resistance such as additional bends, pipeline with higher pipe friction loss values etc.

Why does the pump not supply the desired pump capacity (H, Q)?

- Direction of rotation of the pump wrong (possible with three-phase current only).
  > Reverse two phases (wires at the bus bar of the pump) to correct the direction of rotation.
- Impeller is damaged due to abrasion or corrosion. > Replace damaged parts (such as corroded impeller).
- Pump inlet or impeller is clogged.
  > Clean hydraulics.
- Non-return valve is clogged or blocked.
  > Clean fitting.
- Gate valve in the discharge pipeline is not open all the way. > Open gate valve all the way.
- There is air and/or gas in the fluid. > Ensure that the water coverage of the pump is correct and/or install a baffle at the inlet so that the water jet does not impact close to the pump.
- Motor bearings of the pump are defective.
  > Replace motor bearings–contact Wilo after-sales service.
- Pump vent line is clogged (in case of delivery head problems). > Check and clean if necessary.

Why does the switching device trip the overcurrent/overload signal?

- Mains voltage has dropped. > Check voltage fluctuations.
- Viscosity of the fluid is too high, resulting in a higher load on the motor. > Reduce impeller size or configure a new pump.
- Pump does not run on the specified curve.
  > If necessary, restrict pump output using shut-off valve to increase counterpressure.
- Temperature rise of the motor too high
  > Check number of starts and stops and, if necessary, limit them using the switching device via a delay time.
- Direction of rotation of the pump wrong (possible with three-phase current only).
  > Reverse two phases (wires at the bus bar of the pump) to correct the direction of rotation.
- One phase of the power supply of the pump has failed. > Check power supply connections and replace fuse if defective.
- Winding of the pump is defective.
  > Contact Wilo after-sales service.
- Motor bearings of the pump are defective.
  > Replace motor bearings–contact Wilo after-sales service.

Why do the pump housing and discharge pipeline become clogged with deposits?

- As a result of a lower flow rate, deposits settle due to the decreased flow velocity > Check the duty point of the pump and pipeline sizing with regard to flow velocity.
- Too frequent operation with quantities that are too small. > Redefine switching levels of the system (larger volume per pumping process), increase delay time using the switching device if necessary.

What causes water hammer and how can it be prevented/reduced?

- When the pump starts, a large volume is pushed through a small pipe diameter. > Check the duty point of the pump and pipeline sizing with regard to the flow velocity.
- Air cushion(s) in the discharge pipeline. > Install vent valves directly above the non-return valve or in high points of the pipeline.
- Pump pumps the entire volume into the discharge pipeline too quickly. > Switch from two-pole pump to four-pole pump or use soft starter/frequency converter with start-up ramp for slower pump start.
- Pump starts very frequently, causing irregular pressure waves to build up in the discharge pipeline. > Adjust delay time using the switching device.
- Quick-closing fitting at the end of the discharge pipeline. > Replace fitting and use slow-closing fitting.

What causes noises of the non-return valve and how can they be reduced/prevented?

- The valve does not close quickly enough and, after the pump cuts out, is slammed onto the valve seat by the water column that covers it. > Replace the valve with a quick-closing valve, use a non-return valve with rubber seat, adjust the delay time using the switching device.

Why is the pump/system too loud? How can noise problems be solved?

- Direction of rotation of the pump wrong (possible with three-phase current only). > Reverse two phases (wires at the bus bar of the pump) to correct the direction of rotation.
- Impeller is damaged due to abrasion or corrosion. > Replace damaged parts (such as corroded impeller).
- Pump inlet or impeller is clogged. > Clean hydraulics.
- Motor bearings of the pump are defective. > Replace motor bearings—contact Wilo after-sales service.
- Pump vent line is clogged. > Check and clean if necessary.
- Fluid level in tank is too low. > Check level switch and readjust if necessary.
- Pipelines are causing vibration noises. > Check elastic connections and ensure that pipelines are securely anchored in place, check wall ducts.
- Pump in sump can also be heard inside the building. > Proper soundproofing is not in place between sump and building; disconnect direct, rigid connection between building and sump.
- System can be heard throughout the building. > System is not insulated from the floor/wall; use insulating strips to insulate it.

You can reach Wilo after-sales service at:

Phone (+49) 1805 W•I•L•O•K•D*
9•4•5•6•5•3
or
(+49) 231 41027900

*12 cents per minute

Representatives are available anytime between 7 a.m. and 5 p.m.!

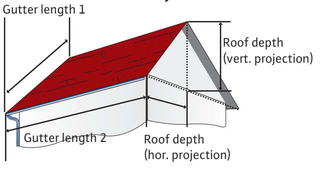
At the weekend and after hours, you can reach us using our interactive voice response system with call-back guarantee!

Checklists for installation, operation and maintenance

Checklist – Design

1. Determining the preconditions

Determining the discharge criteria	☐ Separate system	☐ Combined system
Rainwater disposal	Location of the building ______________________	
(if in combined system)	Consider effect of wind for rainwater ☐ Yes	☐ No
	Rainfall to roof area	________ °
	Gutter length 1	________ m
	Gutter length 2	________ m
	Roof depth (vertical)	________ m
	Roof depth (horizontal)	________ m
Type of building	☐ Single-family home	☐ Multi-family home
	☐ Office building	☐ Industrial building
	☐ Public building	
Installation criterion	☐ Inside the building	☐ Outside the building
Backflow level	Backflow level or sump cover is located above the pump(s)	________ m
Installation	**Desired number of pumps**	________ **pcs.**
	of which	________ **pcs. are standby pump(s)**



2. Defining the boundary conditions

Current/voltage supply	☐ 1~220 V	☐ 3~400 V	☐ 50 Hz	
	☐ 1~230 V	☐ 3~340 V	☐ 60 Hz	
Types of wastewater and sewage	☐ Domestic sewage		☐ Rainwater	
	☐ Industrial wastewater		☐ Sea water	
	☐ Brackish water			
	Fluid contains faecal matter		☐ Yes	☐ No
	Contains solids		☐ Yes	☐ No
	Max. size of the solids: ø		________ mm	
	Long-fibre particles in the fluid		☐ Yes	☐ No
	pH value: ________			
	Fluid temperature: ______°C ______°F			
	Zone 1 explosion protection required		☐ Yes	☐ No
	Additional information about the fluid:			
	______________________________			
	______________________________			

This list makes no claim to completeness, but is intended solely as an aid to orientation.
We disclaim any liability based on this information.

3. Determining the wastewater inflow Q_w

Wastewater calculation	Shower	pcs. x 0.8 l/s =	________	l/s
	Bathtub	pcs. x 0.8 l/s =	________	l/s
	Bidet	pcs. x 0.8 l/s =	________	l/s
	Sink	pcs. x 0.8 l/s =	________	l/s
	Dishwasher	pcs. x 2.0 l/s =	________	l/s
	Washing machine (10 kg)	pcs. x 1.5 l/s =	________	l/s
	Toilet	pcs. x 1.0 l/s =	________	l/s
	Wash basin	pcs. x 1.0 l/s =	________	l/s
	Floor drain DN 50	pcs. x 0.8 l/s =	________	l/s
	Floor drain DN 70	pcs. x 1.5 l/s =	________	l/s
	Floor drain DN 100	pcs. x 2.0 l/s =	________	l/s
	Urinal	pcs. x 0.5 l/s =	________	l/s
		Total	________	l/s

4. Determining the rainwater inflow Q_r

Sealed areas	Patio ________	m^2	Garage	________	m^2
	Parking space ________	m^2	Path	________	m^2
	Carport ________	m^2	Other area	________	m^2
	Driveway ________	m^2			

5. Determining the combined water outflow Q_c

$Q_c = Q_r + Q_w =$ ________ l/s = ________ m^3/h

6. Piping configuration

a) Existing pipelines

Length of the discharge pipeline

Discharge pipeline* DN ________ Material ____________________

Inlet pipeline DN ________ Material ____________________

b) Pipelines for new installation

Length of the discharge pipeline = distance to sewer system ____________

Nominal width* of the pump DN ________

Discharge pipeline* DN ________ Material ____________________

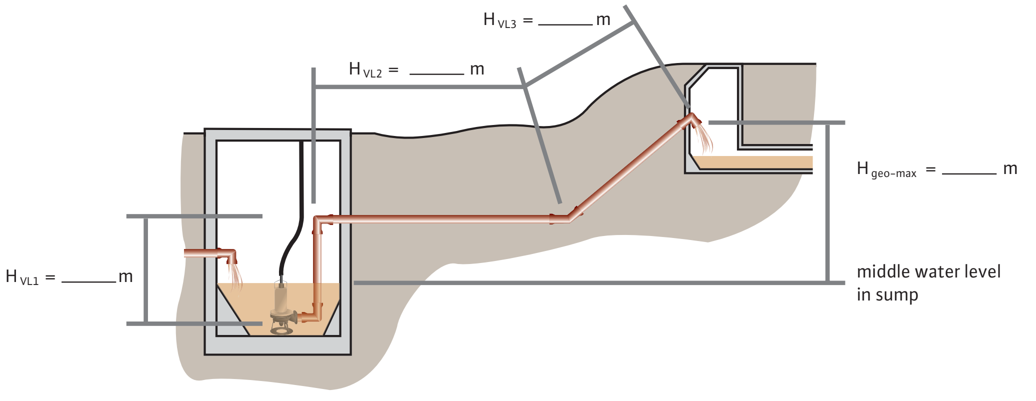
Inlet pipeline DN ________ Material ____________________

*For sewage containing faecal matter:

Nominal diameter of the pipeline ≥ nominal diameter of the pump

This list makes no claim to completeness, but is intended solely as an aid to orientation.
We disclaim any liability based on this information.

6. Piping configuration



a) Existing fittings	Existing bends 90°	________	pcs.		DN ________
	Existing bends 60°	________	pcs.		DN ________
	Existing bends 45°	________	pcs.		DN ________
	Expanders	________	pcs.	from DN ________	to DN ________
	Reducers*	________	pcs.	from DN ________	to DN ________
	T-pieces	________	pcs.		DN ________
a) New installation	Existing bends 90°	________	pcs.		DN ________
	Existing bends 60°	________	pcs.		DN ________
	Existing bends 45°	________	pcs.		DN ________
	Expanders	________	pcs.	from DN ________	to DN ________
	Reducers*	________	pcs.	from DN ________	to DN ________
	T-pieces	________	pcs.		DN ________

*For sewage containing faecal matter:
Nominal diameter of the pipeline ≥ nominal diameter of the pump

This list makes no claim to completeness, but is intended solely as an aid to orientation.
We disclaim any liability based on this information.

Checklist for selecting switching devices	Yes / No
Ambient temperature	________ ºC
Delay time	________ sec.
Test run	☐ / ☐
Evaluation information	
Pump starts	☐ / ☐
Elapsed time indicator	☐ / ☐
Automatic pump duty cycling	☐ / ☐
Number of pumps that can be connected	________ pcs.
Control functions	
Pneumatic pressure sensor (diving bell)	☐ / ☐
Electronic pressure sensor (level sensor = pressure sensor)	☐ / ☐
Float switch	☐ / ☐
Electrical connection	
1~230 V	☐ / ☐
3~230 V	☐ / ☐
3~400 V	☐ / ☐
Neutral conductor	☐ / ☐
Direct start	☐ / ☐
Star/delta start	☐ / ☐
Max. current strength (see pump type plate)	________ A
Frequency	________ Hz
Protection class	IP ________
Motor monitor	
Evaluation via thermal winding contacts	☐ / ☐
Evaluation via PTC	☐ / ☐
Leak monitoring	☐ / ☐
Electronic motor protection	☐ / ☐
Motor protection switch	
Fault/run signals	
Collective run signal	☐ / ☐
Collective fault signal	☐ / ☐
Individual run signal	☐ / ☐
Individual fault signal	☐ / ☐
Separate high water signal contact	☐ / ☐
Integrated alarm (buzzer)	☐ / ☐
Battery-powered alarm	☐ / ☐
Display/operation	
LCD display	☐ / ☐
LEDs	☐ / ☐
Red button	☐ / ☐
Type of function	
Microprocessor-controlled	☐ / ☐
Electronic	☐ / ☐
Electro-mechanical	☐ / ☐
Version	
Main switch	☐ / ☐
Switching device with plug and cable	☐ / ☐

This list makes no claim to completeness, but is intended solely as an aid to orientation.
We disclaim any liability based on this information..

Installation checklist (1)

Lifting plant for wastewater containing faecal matter in the building

Plant		
• Lifting plant for wastewater containing faecal matter, without comminution, with minimum nominal diameter DN 80	DIN EN 12050-1	☐
• Lifting plant for wastewater containing faecal matter, with comminution, with minimum nominal diameter DN 32	DIN EN 12050-1	☐
• For buildings that depend on the operation of the plant, a twin-head pump unit must be provided.	DIN EN 12050-1	☐
• Lifting plant for wastewater containing faecal matter is closed off from the surrounding room	EN 12056-4	☐
• The plant is installed so that it is twist-proof and frost-free	EN 12056-4	☐
• The plant is installed so that it is protected from buoyancy and pressing water	EN 12056-4	☐
• The collector tank is not structurally connected to the building (e.g. sump); rather, the tank is freestanding.	EN 12056-4	☐
• The area surrounding the plant is at least 60 cm on every side	EN 12056-4	☐
• Rainwater is not fed to the lifting plant for wastewater containing faecal matter located inside the building (combined drainage permitted outside the building only)	EN 12056-4	☐
• An inspection opening is provided for freestanding-type installation		
• Backflow protection is installed as	EN 12056-4	☐
backflow loop ________ cm above backflow level	EN 12056-"4	☐
Backflow seal only if	EN 12056-4	☐
• There is a gradient to the sewer		☐
• The room is of secondary use		☐
• Another toilet is provided above the backflow level.		☐
• It is possible to do without this drain in case of backflow		☐
• Diaphragm hand pump for emergency drainage for single pump stations is installed	DIN EN 12050-1	☐
• Pump sump for room drainage is installed	DIN EN 12050-1	☐
• Check valve is installed on the discharge side (Exception: volume of the discharge pipeline is less than the usable volume of the plant)	DIN EN 12050-1	☐
• A shut-off valve is installed on the inlet side	DIN EN 12050-1	☐
• A shut-off valve is installed on the pressure side behind the check valve	DIN EN 12050-1	☐
• Ventilation of the lifting plant (if present) above roof level only At least DN 70 for lifting plants without comminution/DN 50 with comminution	DIN EN 12050-1	☐
• All connections are designed to be sound-absorbing	DIN 4109	☐
• Harmful materials (see operating instructions) have already been removed from the		
• fluid before reaching the unit		
• A fault signal device (acoustic, visual or Building Management System) is installed where it can be easily seen		

Pipes		
• Pipes can empty by themselves	EN 12056-4	☐
• All pipes are laid without tension	EN 12056-4	☐
• The weight of fittings and pipelines is borne by supports/fasteners	EN 12056-4	☐
• There is no other connection to the discharge pipeline after the lifting plant (e.g. downpipe)	EN 12056-4	☐
• The pipe cross section is not tapered at any point	EN 12056-4	☐
• Individual pipes are connected in the top area or above the collecting pipe to prevent deposits		

This list makes no claim to completeness, but is intended solely as an aid to orientation.
We disclaim any liability based on this information.

Installation checklist (2)

Operational reliability

• The selected duty point lies in the middle one-third of the hydraulic curve provided by the manufacturer in order to achieve optimum capacity utilisation and service life		☐
• The free passage of the pump is sized according to the requirements		☐
• $NPSH_{system} > NPSH_{pump}$ or $NPSH_{present} > NPSH_{required}$		☐
• Sufficient access for service and maintenance is guaranteed		☐
• The units are adequately protected from external influences		☐
• The power supply has been checked with regard to voltage fluctuations		☐
• Corresponding settings have been made on the switching device		☐
• The position of the switching device is flood-proof		☐
• There are no reducers in the discharge line	EN 12056-2	☐

Limited-use plant

• The plant is installed below the backflow level (for renovation, also permitted above the plant)	EN 12056-1	☐
• The plant is installed immediately behind the toilet	EN 12056-1	☐
• All connected drainage sources are in the same room	EN 12056-1	☐
• The plant is on the same level as the toilet	EN 12056-1	☐
• No bathtubs, washing machines or dishwashers are connected	EN 12056-1	☐
• No separate ventilation is connected	DIN EN 12050-3	☐
• Ventilation takes place free of odour via the built-in ventilation of the plant	DIN EN 12050-3	☐
• The minimum inner diameter of the discharge pipeline and the following fittings is at least 20 mm for units with comminution (for those without comminution, 25 mm)	DIN EN 12050-3	☐
• There is a toilet above the backflow level with free gravity flow to the sewer	DIN EN 12050-3	☐
• The end user has been informed of the danger of clogs caused by sanitary napkins, condoms etc.	DIN EN 12050-3	☐

Pumping stations (outside the building)

• Pipes have been laid on a steady uphill/downhill incline without high and low points		☐
• Vent valves are installed in high points		☐
• The minimum flow velocity is assured at all times		☐
• For pressure drainage, the contents of the pipeline are flushed at least ≤ 8 hers. (EN 1671); Recommendation: flush ≤ 4 hers.!		☐
• All fittings have the same free passage as the pipeline		☐
• The pump sump has a funnel shape with _____° incline for better inflow of the fluid to the pump		☐
• The surfaces of the pump sump are smooth		☐
• All construction debris has been removed and the pump sump is clean		☐
• The sump can hold the pipeline volume		☐
• The exit losses have been taken into consideration in the design		☐
• The compaction of the sump is in accordance with ATV-A 139 and/or DIN EN 1610	DIN EN 1610	☐
• A pressure test has been conducted in accordance with the applicable directives for a pressure drainage station (high points must first be bled)	DIN 4279 T1–T9	☐

This list makes no claim to completeness, but is intended solely as an aid to orientation.
We disclaim any liability based on this information.

Commissioning

• The parameters of the switching device match the specifications on the type plate of the pump	☐
• For a potentially explosive area, the pump has been checked for explosion protection (type plate, installation and operating manual); Ex zone must be specified by the owner/management!	☐
• The sump has been cleaned before commissioning (particularly of construction debris)	☐
• The sump has been filled for test purposes; repeated, manual filling with clear water is provided	☐
• All installation-related parts are connected to each other so that they are firm and pressure-tight (pipeline, pump flow etc.)	☐
• The pump has been ventilated at the discharge line (by gently lifting the pump by the chain)	☐
• The direction of rotation of the unit (3~) has been checked	☐
• The current consumption of the pump has been checked	☐

Maintenance

Sewage lifting plants must always be maintained by qualified specialists in accordance with EN 12056-4. Protective gloves must be worn during maintenance work to prevent injuries and infections. A repeated filling of the plant with clear water must be provided for test purposes. Regular maintenance intervals in accordance with EN 12056-4,5.1 should be maintained.

Maintenance work to be carried out on regularly used mini lifting plants for limited use (e.g. Wilo-DrainLift KH 32):
- Flush the plant several times.
- Pull the power plug and remove the cover.
- Wear protective gloves because of the risk of injury posed by the macerator!
- Clean the sieve basket, remove solids from tank and clean the vent.
- Replace the active carbon filter.
- Reassemble the unit.
- Insert the power plug.

Maintenance work to be carried out on lifting plants for wastewater containing faecal matter (e.g. Wilo-DrainLift S1/7):
- Test the connecting parts of pipelines and fittings for leaks.
- Check the function and ease of movement of the gates; clean the non-return valve if necessary.
- Check the pumping equipment (tank/pump/impeller)
  - Disconnect the power supply.
  - Close the gate valve.
  - Drain the collector tank (for example, using a diaphragm hand pump).
  - Remove impurities from the walls of the tank and flush the tank several times with clear water.
  - Reassemble the unit.
  - Open the gate valve and reconnect the power supply.
- Visually inspect the switching device and tank.
- Check the function of the switching device.
- Check the current consumption.

Maintenance work to be carried out on sump pump stations (e.g. Wilo-Drain WS):
- Ensure that all electrical equipment is de-energised.
- Remove deposits from pump parts and the walls of the sump.
- Check the discharge pipelines and flush or clean them.
- Check the switching device memory/Building Management System/counters for fault messages.
- Check the function of electrical equipment and fittings.
- Check the switching levels (e.g. check measuring bell with pressure hose for leaks).
- Visually inspect the level sensor.
- Switch on the current and check the current consumption.
- Check pump seat for leaks (visual inspection).

This list makes no claim to completeness, but is intended solely as an aid to orientation.
We disclaim any liability based on this information.

Tables and diagrams for calculation examples

Table 1: Values for characteristic drainage K

Building types	K value
Irregularly used buildings such as residential buildings, restaurants, guest-houses, hotels, office buildings etc.	0.5
Hospitals, large food service facilities, hotel facilities etc.	0.7
Regularly used buildings such as schools, frequently used installations such as in laundries, public toilets, public shower facilities etc.	1.0*
Installations for special use such as laboratories in industrial operations	1.2

* If no other defined drainage values are known.

Table 2: Drain connection values (DU) for sanitary fixtures (in accordance with EN 12056-2:2000)

For single downpipe systems with partially-filled connection pipes:

Sanitary fixture		DU [l/s]	DU [m³/h]
Wash basin, bidet		0.5	1.8
Sink, household dishwasher, kitchen drain		0.8	2.88
Shower without stopper		0.6	2.16
Shower with stopper		0.8	2.88
Washing machine, up to 6 kg of laundry		0.8	2.88
Washing machine, up to 10 kg of laundry		1.5	5.4
Commercial or industrial dishwasher		2.0**	7.2
Urinal with flush valve (single)		0.5	1.8
Up to 2 urinals		0.5	1.8
Up to 4 urinals		1	3.6
Up to 6 urinals		1.5	5.4
Per 2 additional urinals		0.5	1.8
Floor drain:	DN 50	0.8	2.88
	DN 70	1.5	5.4
	DN 100	2.0	7.2
Toilet with 6 l flushing cistern		2.0	7.2
Toilet with 7.5 l flushing cistern		2.0	7.2
Toilet with 9 l flushing cistern		2.5	9
Wash basin for foot care		0.5	1.8
Bathtub		0.8	2.88

** Please refer to manufacturer's specifications.

Table 3: Water consumption figures (in accordance with DIN 1986-100, Table 4)

Use case	From ...litres	to...litres
Single/multi-family home		
Drinking, cooking, cleaning, per person/day	20	30
Doing laundry, per kg	25	75
Toilet flushing, once	6	10
Bath	150	250
Shower	40	140
Watering the lawn, per m^2/day	1.5	3
Watering vegetables, per m^2/day	5	10
Hotel/institution		
School, per person/day	5	6
Barracks, per person/day	100	150
Hospital, per person/day	100	650
Hotel, per person/day	100	130
Public swimming pool, per m^3/day	450	500
Fire hydrant, per second	5	10
Commerce/industry		
Slaughterhouse, per head of large cattle	300	500
Slaughterhouse, per head of small cattle	150	300
Laundry, per washing station	1000	1200
Brewery, per hectolitre of beer	250	500
Dairy, per litre of milk	0.5	4
Weaving mill, per kg of cloth	900	1000
Sugar factory, per kg of sugar	90	100
Meat factory, per kg of meat/sausage	1	3
Paper factory, per kg of fine paper	1500	3000
Concrete factory, per m^3 concrete	125	150
Building trades, per 1000 bricks with mortar	650	750
Food processing industry, per kg of starch	1	6
Food processing industry, per kg of margarine	1	3
Weaving mill, per kg of lamb's wool	90	110
Mining, per kg of coal	20	30
Agriculture		
Large cattle, per head/day	50	60
Sheep, calf, pig, goat, per head/day	10	20
Transport		
Cleaning a car	100	200
Cleaning a lorry	200	300
Cleaning a goods wagon	2000	2500
Cleaning a poultry wagon	7000	30000

Table 4: Rainfall intensities in Germany (excerpt from DIN 1986-100:2002-03 Table A1)

$r_{X(Y)}$ means a rainfall intensity that lasts for X minutes (duration) and statistically occurs every 1/Y years.
Example: $r_{5(0.5)}$ Five-minute rain that statistically occurs every 1/0.5 (=2) every 2 years.

Location	$r_{5.2}$ [l/(s x ha)]	$r_{15.2}$ [l/(s x ha)]	$r_{5.30}$ [l/(s x ha)]	$r_{15.30}$ [l/(s x ha)]	$r_{5.100}$ [l/(s x ha)]
Aachen	240	121	431	214	516
Aschaffenburg	293	143	539	267	649
Augsburg	285	138	499	243	595
Aurich	240	121	416	214	494
Bad Salzuflen	282	133	455	233	532
Bad Tölz	416	205	655	355	762
Bayreuth	285	144	524	276	630
Berlin	341	169	605	321	723
Bielefeld	260	132	475	248	570
Bonn	266	132	505	248	611
Braunschweig	289	143	498	267	591
Bremen	238	118	403	202	477
Chemnitz	340	162	552	288	646
Cottbus	260	129	477	232	574
Dessau	292	137	530	250	635
Dortmund	277	134	441	226	513
Dresden	297	145	540	268	648
Düsseldorf	227	135	518	245	626
Eisenach	269	135	478	249	570
Emden	246	124	444	230	532
Erfurt	243	121	404	214	476
Frankfurt/Main	314	145	577	268	695
Halle/Saale	285	137	503	250	601
Hamburg	258	129	423	232	497
Hannover	275	124	538	230	655
Heidelberg	338	158	579	287	686
Ingolstadt	283	138	456	243	534
Kassel	273	140	505	266	608
Kiel	230	112	404	192	481
Köln	281	138	535	266	648
Leipzig	324	147	545	276	690
Lingen	316	148	588	284	709
Magdeburg	277	129	517	232	624
Mainz	333	164	603	304	723
Munich	335	166	577	305	685
Münster	283	137	510	250	611
Neubrandenburg	330	148	607	284	731
Nuremberg	296	145	533	272	638
Rosenheim	402	191	733	350	880
Rostock	232	118	375	202	438
Saarbrücken	255	131	448	240	534
Stuttgart	349	169	663	325	802
Würzburg	293	140	511	266	608

Table 5: Runoff coefficients C for calculating the rainfall rate Q_r

(DIN 1986-100:2002-03, Table 6)

No.	Type of surfaces	Runoff coefficient C
1	Impermeable surfaces, such as	
	• Sloping roofs > 3° incline	1.0
	• Concrete surfaces	1.0
	• Ramps	1.0
	• Hardened surfaces with joint packing	1.0
	• Bituminous pavement	1.0
	• Pavement with joint sealing	1.0
	• Sloping roofs ≤3° incline	1.0
	• Gravel roofs	0.8
	• Green roofs*	
	• For intensive greening	0.5
	• For extensive greening with system thickness of 10 cm or more	0.3
	• For extensive greening with system thickness less than 10 cm	0.5
2	Semi-permeable and low-runoff surfaces, such as:	
	• Unpaved streets, courtyards, promenades	0.5
	• Surfaces with slabs	
	• Paved surfaces with joints > 15% of total area e.g. 10 cm x 10 cm and smaller	0.6
	• Waterbound surfaces	0.5
	• Playgrounds with partial revetment	0.3
	• Sports fields with drainage	
	• Synthetic surfaces, artificial turf	0.6
	• Tennis courts and similar sports surfaces	0.4
	• Grass surfaces	0.3
3	Permeable surfaces with little or no runoff, such as:	
	• Parks and planting areas, gravel and slag surfaces, pebbles, also with partially hardened surfaces such as:	0.0
	• Garden paths with waterbound covering	0.0
	• Driveways and single parking spaces with turfstone	0.0

* According to "Guidelines for the planning, execution and upkeep of green-roof sites – Guidelines for green-roof sites"

Table 6: Pressure drops relative to flow rates of HDPE plastic pipes

(DIN 1986-100:2002-03, Table 6)

Nominal diameter	DN 25		DN 32		DN 40		DN 50		DN 65	
dxs	32 x 2.9		40 x 3.7		50 x 4.6		63 x 5.8		75 x 6.9	
dl	26.2		32.6		40.8		51.4		61.2	
Q	v	Pressure drop ΔP	v	Pressure drop ΔP	v	Pressure drop ΔP	v	Pressure drop ΔP	v	Pressure drop ΔP
[l/s]	[m/s]	[bar/100 m]	[m/s]	[bar/100 m]	[m/s]	[bar/100 m]	[m/s]	[bar/100 m]	[m/s]	[bar/100 m]
0.0315	0.06	0.041								
0.04	0.08	0.0061								
0.05	0.09	0.0088	0.06	0.0031						
0.063	0.12	0.013	0.08	0.0045						
0.08	0.15	0.0195	0.1	0.0067	0.06	0.0024				
0.1	0.19	0.0285	0.12	0.0098	0.08	0.0034				
0.125	0.24	0.0417	0.15	0.0144	0.1	0.005	0.06	0.0017		
0.16	0.3	0.0638	0.19	0.0219	0.12	0.0076	0.08	0.0027	0.05	0.0011
0.2	0.38	0.0939	0.24	0.0321	0.15	0.0111	0.1	0.0037	0.07	0.0016
0.25	0.47	0.1384	0.3	0.0473	0.19	0.0163	0.12	0.0055	0.09	0.0024
0.315	0.59	0.2072	0.38	0.0796	0.24	0.0244	0.15	0.0082	0.111	0.0036
0.4	0.75	0.3152	0.48	0.1071	0.31	0.0369	0.19	0.0123	0.14	0.0054
0.5	0.94	0.4672	0.6	0.1585	0.38	0.0544	0.24	0.0182	0.17	0.0079
0.63	1.19	0.7039	0.76	0.2381	0.48	0.0816	0.30	0.0272	0.21	0.0119
0.8	1.51	1.0776	0.96	0.3634	0.61	0.1242	0.39	0.0413	0.27	0.018
1.0	1.88	1.6072	1.2	0.5405	0.77	0.1842	0.48	0.0611	0.34	0.0266
1.25	2.35	2.4022	1.5	0.8053	0.96	0.2738	0.6	0.0906	0.43	0.0394
1.6	3.01	3.7567	1.92	1.2547	1.22	0.4253	0.77	0.1403	0.54	0.0609
2.0			2.4	1.8774	1.53	0.6345	0.96	0.2088	0.68	0.0904
2.5			3	2.8148	1.91	0.9483	1.21	0.3112	0.85	0.1345
3.15					2.41	1.4406	1.518	0.4714	1.07	0.2033
4.0					3.06	2.2247	1.928	0.7254	0.36	0.3123
5.0							2.41	1.0873	1.7	0.467
6.3							3.036	1.6567	2.14	0.7098
8.0									2.72	1.0965
10.0									3.4	1.6493

Table 6: Pressure drops relative to flow rates of HDPE plastic pipes

(continued)

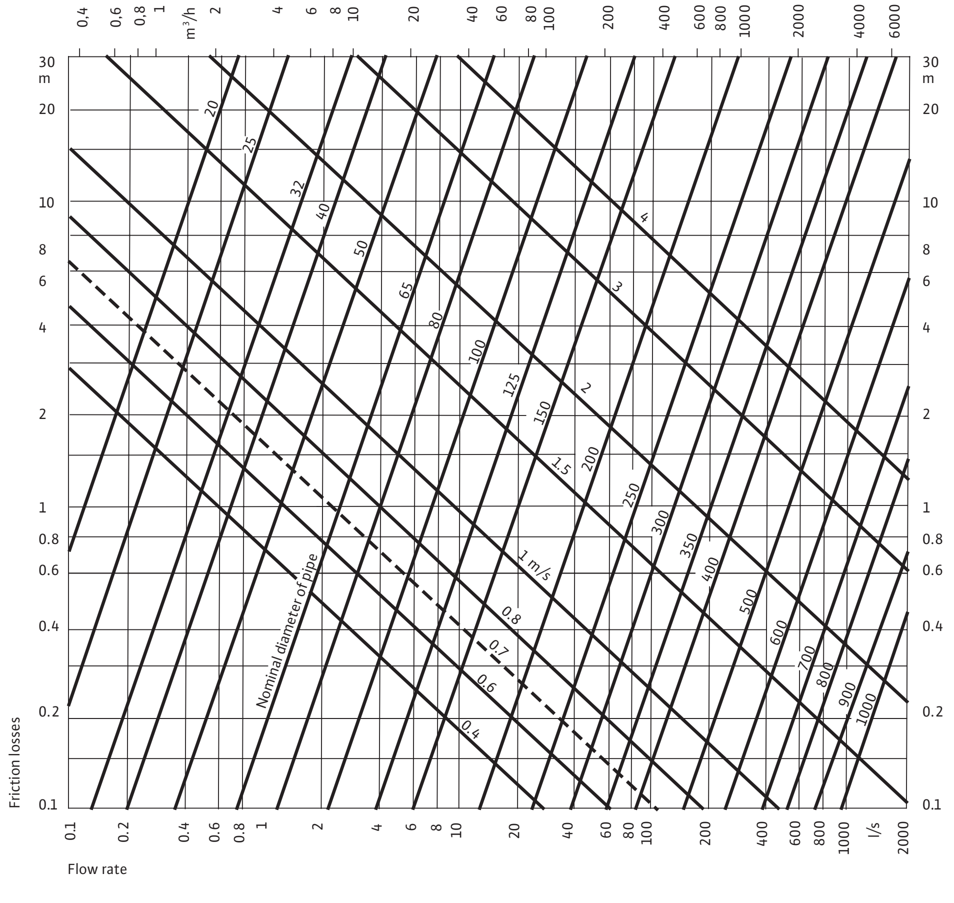
Nominal diameter	DN 80		DN 100		DN 100		DN 125		DN 150	
dxs	90 x 8.2		110 x 10.0		125 x 11.4		140 x 12.8		160 x 14.6	
dl	73.6		90		102.2		114.4		130.8	
Q	v	Pressure drop ∆P	v	Pressure drop ∆P	v	Pressure drop ∆P	v	Pressure drop ∆P	v	Pressure drop ∆P
[l/s]	[m/s]	[bar/100 m]	[m/s]	[bar/100 m]	[m/s]	[bar/100 m]	[m/s]	[bar/100 m]	[m/s]	[bar/100 m]
0.3	0.06	0.01								
0.3	0.07	0.0015								
0.4	0.09	0.0023	0.06	0.0009						
0.5	0.12	0.0033	0.08	0.0013	0.06	0.0007				
0.6	0.15	0.0049	0.1	0.0019	0.08	0.001	0.06	0.0006		
0.8	0.19	0.0075	0.13	0.0029	0.1	0.0016	0.08	0.0009	0.06	0.0005
1.0	0.24	0.0111	0.16	0.0043	0.12	0.0023	0.1	0.0014	0.07	0.0007
1.3	0.29	0.0163	0.2	0.0063	0.15	0.0034	0.12	0.0002	0.09	0.0011
1.6	0.38	0.0252	0.25	0.0097	0.2	0.0054	0.16	0.0031	0.12	0.0016
2.0	0.47	0.0374	0.31	0.0143	0.24	0.0078	0.2	0.0046	0.015	0.0024
2.5	0.59	0.0555	0.39	0.0212	0.31	0.0116	0.24	0.0068	0.19	0.0036
3.2	0.74	0.0838	0.5	0.032	0.38	0.0174	0.31	0.0102	0.23	0.0054
4.0	0.94	0.1285	0.63	0.489	0.49	0.0266	0.39	0.0155	0.3	0.0082
5.0	1.18	0.1917	0.79	0.0729	0.61	0.0396	0.49	0.0231	0.37	0.0121
6.3	1.48	0.2908	0.99	0.1103	0.77	0.0598	0.61	0.0348	0.47	0.0183
8.0	1.88	0.448	1.26	0.1695	0.98	0.0919	0.78	0.0534	0.6	0.0281
10.0	2.35	0.6722	1.57	0.2537	1.22	0.1373	0.97	0.0797	0.74	0.0419
13.0	2.94	1.0104	1.97	0.3804	1.52	0.2056	1.22	0.1193	0.93	0.0625
16.0			2.52	0.5966	1.95	0.3219	1.56	0.1865	1.19	0.0976
20.0			3.14	0.8977	2.44	0.4836	1.95	0.2798	1.49	0.1463
25.0					3.05	0.7279	2.43	0.4205	1.86	0.2195
32.0							3.0650	0.6424	2.34	0.3347
40.0									2.98	0.5188

Table 7: Inner diameters of new pipes (in accordance with corresponding DIN)

In each case, smallest diameters of the nominal diameters

DN	Cast iron pipe PN16 [mm]	PVC pipe PN10 [mm]	PE80HD pipe SDR11 PN12.5 [mm]	PE100HD pipe SDR11 [mm]	Minimum value acc. to DIN EN 12056-2 (for cast iron) [mm]
32	not specified	36	32.6	32.6	n. s.
40	n. s.	45.2	40.8	40.8	34
50	n. s.	57.0	51.4	51.4	44
65	n. s.	67.8	61.2	61.2	n. s.
80	80	81.4	73.6	73.6	75
100	100	99.4	90.0	90.0	96
150	151	144.6	130.8	130.8	146
200	202	203.4	184	184	184

Table 8: Pipe friction losses and correction factors



c = 0.1 mm
(e.g. new cast iron pipes, bitumen-coated cast iron pipes, straight welded steel pipes)

Friction losses in "m" per 100 m
New cast iron pipeline

For factors for adjustment to other materials or older pipes, see page 83

Table 8: Pipe friction losses and correction factors

Continued

Factors for adjustment to other materials or older pipes	
0.1	New galvanised steel pipes
0.8	New rolled steel pipes, new plastic pipes
1.0	New cast iron pipe, bitumen-coated cast iron pipe
1.25	Older, rusted cast iron pipes
1.5	New galvanised steel pipes, clean cast iron pipes
1.7	Encrusted pipes
2	New concrete pipes, medium-smooth
2.5	Stoneware pipes <Tab/>
3	New concrete pipes, smooth finish
15–30	Cast iron pipes with light to heavy encrustations

Table 9: Losses in fittings

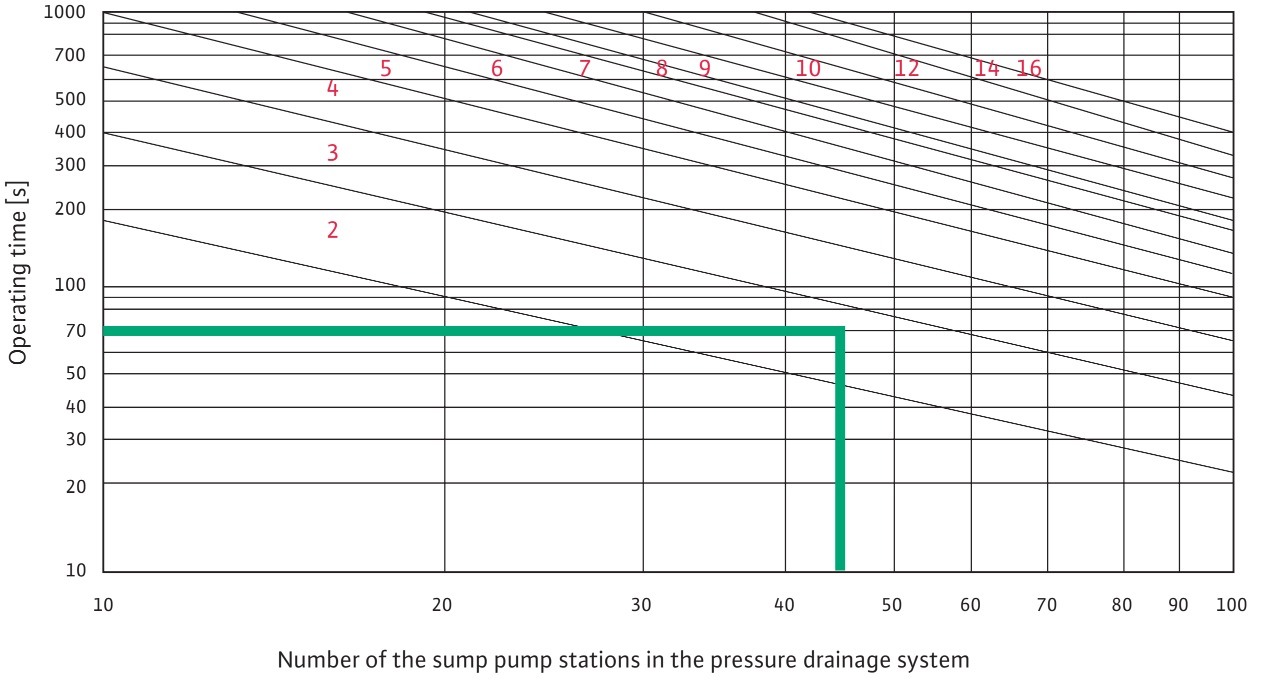
Guide values for rough calculation of losses, specified in m of pipeline length (for reducers or expanders, always refers to the larger diameter).

Type of resistance	DN 32	DN 40	DN 50	DN 65	DN 80	DN 100	DN 150	DN 200
Branch or T-piece	2.02	2.74	3.87	5.61	6.58	8.85	15.45	23.36
Expander	-0.85	-1.13	-1.5	-2.29	-2.4	-3.72	-5.02	-13.22
Reducer	1.08	1.45	1.94	2.46	3.19	4.85	8.04	19.25
Abrupt expander	-0.24	-0.34	-0.48	-0.56	-0.76	-1.05	-1.96	-2.6
Abrupt reducer	0.29	0.42	0.6	0.7	0.95	1.31	2.45	3.25
Bends with R = d and smooth surface 45°	0.11	0.15	0.2	0.3	0.4	0.55	0.95	1.4
60°	0.15	0.2	0.28	0.43	0.59	0.93	1.5	2.28
90°	0.19	0.27	0.38	0.58	0.79	1.11	2.06	3.18
Check valve	1.7	1.48	1.84	2.6	3.3	4.26	7.26	10.58
Gate valves, ball valves	0.27	0.3	0.38	0.49	0.56	0.7	1.08	1.45

Table 10: Operating cycles per hour of Wilo pumps (recommended)

Wilo-Drain TMW	30
Wilo-Drain CP	15
Wilo-Drain TC 40	30
Wilo-Drain VC	20
Wilo-Drain TS 40–65	20
Wilo-Drain MTS 40	20
Wilo-Drain TP 50–65	20
Wilo-Drain TP 80–150	20
Wilo-Drain STS 80–100	20
Wilo-Drain STC 80–100	15
Wilo-Drain FA 15.xx–20.xx	10

Table 11: Sump pump stations in parallel operation (guide values)



According to T. Szabo, Debrecan, Hungary (KA 8/1988)
Probability of approx. 95%

Conversion tables of dimensions

Table 12: Conversion table – lengths, volumes and weights

0.03937 inch	=	1 mm	25.4 mm	=	1 inch
0.3937 inch	=	1 cm	2.54 cm	=	1 inch
39.37 inches	=	1 m	0.0254 m	=	1 inch
3.281 ft	=	1 m	0.03048 m	=	1 ft
1.0936 yd	=	1 m	0.9144 m	=	1 yd
0.6214 miles	=	1 km	1.609 km	=	1 mile

1 kW	=	1.341 hp	0.7455 hp	=	1 kW
1 inch	=	0.0833 ft	1 ft	=	12 inches
1 ft	=	0.3333 yd	1 yd	=	3 ft
1 yd	=	0.000568 miles	1 mile	=	1.76 yd

1 l/sec	=	0.016 l/min	1 l/min	=	60 l/sec
1 l/min	=	0.016 l/hr	1 l/hr	=	60 l/min
1 l/sec	=	60 l/hr	1 l/hr	=	3600 l/sec

	cm	m	in	ft	yd
1 cm	1	0.01	0.3937	0.0328	0.0109336
1 m	100	1	39.37	3.2808	1.0936
1 in	2.54	0.00254	1	0.0833	0.028
1 ft	10.48	0.3048	12	1	0.333
1 yd	91.44	0.9144	36	3	1

	cm^2	m^2	in^2	ft^2	yd^2
1 cm^2	1	10^{-4}	0.15499969	1.0763867×10^{-3}	1.1959853×10^{-3}
1 m^2	104	1	1549.9969	10.763867	1.1959853
1 in^2	6.4516	6.4516258×10^{-4}	1	6.9444444×10^{-3}	7.7160494×10^{-3}
1 ft^2	929.034	0.092903412	144	1	2
1 yd^2	8361.307	0.8361307	1296	9	$0.111111\bar{1}$

	cm^3	in^3	ft^3
1 cm^3	1	0.061023378	3.5314455×10^{-4}
1 in^3	16.387162	6.4516258×10^{-4}	1
1 ft^3	2.8317017×10^{-4}	0.092903412	144
1 ml	1.000028	0.8361307	1296
1 l	1.000028×10^{-3}	836.1307	1296000
1 gal	3.7854345×10^{-3}	4.3290043×10^{-3}	7.4805195

	ml	litres	gal
1 cm^3	0.999972	0.9999720×10^{-3}	2.6417047×10^{-4}
1 in^3	16.3867	1.63870×10^{-2}	4.3290043×10^{-3}
1 ft^3	2.831622 x 104	28.31622	7.4805195
1 ml	1	0.001	2.641779×10^{-4}
1 l	10^{-3}	1	0.2641779
1 gal	3.8785329×10^{-3}	0.3785329	1

	g	kg	lb	metric ton	ton
1 g	1	10^{-3}	2.2046223×10^{-3}	10^{-6}	1.1023112×10^{-6}
1 kg	10^3	1	2.2046223	10^{-3}	1.1023112×10^{-3}
1 lb	4.5359243×10^2	0.45359243	1	4.5359243×10^{-4}	0.0005
1 mt ton	10^6	10^{-3}	2204.6223	1	1.1023112
1 ton	907184.86	907.18486	2000	0.90718486	1

Table 13: Conversion table – temperatures

Conversion from	to	Conversion formula
°C	°F	t [°F] = 1.8 x t [°C] + 32
	K	T [K] = t [°C] + 273.15
°F	°C	t [°C] = (t [°F] – 32) : 1.8
	K	T [K] = (t [°F] + 459.67) : 1.8
K	°C	t [°C] = T [K] – 273.15
	°F	t [°F] = 1.8 x T [K] – 459.67

Abbreviations

Acronym	Description
AISI	American Iron and Steel Institute
ASTM	American Society for Testing and Materials
ATV-DVWK	German Wastewater Association
DWA	German Association for Water, Wastewater and Waste; new name for the ATV-DVWK beginning in 2005
IEC	International Electrotechnical Commission
ISO	International Standards Organisation
DIN	German Institution for Standardisation
EN	European Standards published by the CEN (European Committee for Standardisation).
UL	Underwriters Laboratories
CSA	Canadian Standards Association
VDE	German Association of Electrical, Electronic & Information Technologies
VDMA	German Mechanical and Plant Engineering Association

Standards

ASTM 182 = EN 10088-3

Stainless steels

ATV-DVWK A 116 (DWA A 116)

Special Sewer Systems – Vacuum Drainage Service – Pressure Drainage Service

ATV-DVWK A 134 (DWA A 134)

Planning and Construction of Wastewater Pump Stations with Small Inflows

ATV-DVWK A 157 (DWA A 157)

Construction of Sewer Systems

ATV-DVWK M 168 (DWA M 168)

Corrosion of Wastewater Systems – Wastewater Discharge

DIN EN 476

General requirements for components used in discharge pipes, drains and sewers for gravity systems

DIN 1986 Part 1

Wastewater lifting plants for buildings and sites, technical requirements for construction

DIN 1986-100: 2002-03 Annex A

Rainfall events in Germany

DIN 4109

Sound insulation in buildings

DIN EN 12050-1

Wastewater lifting plants for buildings and sites – Principles of construction and testing – Part 1: Lifting plants for wastewater containing faecal matter

DIN EN 12050-2

Wastewater lifting plants for buildings and sites – Principles of construction and testing – Part 2: Lifting plants for faecal-free wastewater

DIN EN 12050-3

Wastewater lifting plants for buildings and sites – Principles of construction and testing – Part 3: Lifting plants for wastewater containing faecal matter for limited applications

DIN EN 12050-4

Wastewater lifting plants for buildings and sites – Principles of construction and testing – Part 4: Non-return valves for faecal-free wastewater and wastewater containing faecal matter

EN 752 Part 1

Drain and sewer systems outside buildings – Generalities and definitions

EN 1671

Pressure sewerage systems outside buildings

EN 12056-1

Gravity drainage systems inside buildings – Part 1: General and performance requirements

EN 12056-2

Gravity drainage systems inside buildings – Part 2: Sanitary pipework, layout and calculation

EN 12056-3

Gravity drainage systems inside buildings – Part 3: Roof drainage, layout and calculation

EN 12056-4

Gravity drainage systems inside buildings – Part 4: Waste water lifting plants; Layout and calculation

EN 12056-5

Gravity drainage systems inside buildings – Part 5: Installation and testing, instructions for operation, maintenance and use

EN 10088-3 = ASTM 182

Stainless steels

Index

WILO AG has invested the greatest care into preparing all of the texts in this Planning Guide. Still, the possibility of errors cannot be excluded. The publisher expressly disclaims any and all liability regardless of legal basis.

First edition 2005

Pumpen Intelligenz.

WILO AG
Nortkirchenstrasse 100
44263 Dortmund, Germany
Phone (+49) 231 4102-0
Fax (+49) 0231 4102-363
wilo@wilo.de
www.wilo.de

Wilo sales agencies

G1 North
WILO AG
Hamburg sales agency
Sinstorfer Kirchweg 74–92
21077 Hamburg, Germany
Phone (+49) 40 5559490
Fax (+49) 40 55594949

G2 East
WILO AG
Berlin sales agency
Juliusstrasse 52–53
12051 Berlin-Neukölln, Germany
Phone (+49) 30 6289370
Fax (+49) 30 62893770

G3 Saxony/Thuringia
WILO AG
Dresden sales agency
Frankenring 8
01723 Kesselsdorf, Germany
Phone (+49) 35204 7050
Fax (+49) 35204 70570

G4 Southeast
WILO AG
Munich sales agency
Landshuter Strasse 20
85716 Unterschleissheim, Germany
Phone (+49) 89 4200090
Fax (+49) 89 42000944

G5 Southwest
WILO AG
Stuttgart sales agency
Hertichstrasse 10
71229 Leonberg, Germany
Phone (+49) 7152 94710
Fax (+49) 7152 947141

G6 Rhine-Main:
WILO AG
Frankfurt sales agency
An den drei Hasen 31
61440 Oberursel/Ts., Germany
Phone (+49) 6171 70460
Fax (+49) 6171 704665

G7 West
WILO AG
Düsseldorf sales agency
Hans-Sachs-Strasse 4
40721 Hilden, Germany
Phone (+49) 2103 90920
Fax (+49) 2103 909215

G8 Northwest:
WILO AG
Hannover sales agency
Ahrensburger Strasse 1
30659 Hannover-Lahe, Germany
Phone (+49) 511 438840
Fax (+49) 511 4388444

Central order processing for specialist wholesalers

WILO AG
Order Processing
Nortkirchenstrasse 100
44263 Dortmund, Germany
Phone (+49) 231 4102-0
Fax (+49) 231 4102-7555

The Wilo Team of Experts

- Answers to all of your questions regarding our products, delivery times, shipment, sales prices
- Processing of your orders
- Spare parts orders– with 24-hour delivery for all in-stock spare parts
- Mailing informational materials

Phone (+49) 1805
R•U•F•W•I•L•O*
7•8•3•9•4•5•6
Fax (+49) 231 4102-7666

Available weekdays between 7 a.m. and 6 p.m.

Wilo after-sales service

WILO AG
Wilo Service Centre
Nortkirchenstrasse 100
44263 Dortmund, Germany

- Your primary contact for after-sales service
- Maintenance and commissioning
- Factory repairs
- Spare parts advice

Phone (+49) 1805 W•I•L•O•K•D*
9•4•5•6•5•3
(+49) 231 4102-7900
Fax (+49) 231 4102-7126

Available weekdays between 7 a.m. and 5 p.m., at all other times interactive voice response system with call-back guarantee!

Wilo International

Austria
Vienna head office:
WILO Handelsgesellschaft mbH
Eitnergasse 13
1230 Vienna
Phone (+43) 1 25062-0
Fax (+43) 1 25062-15

Salzburg sales agency:
Gnigler Strasse 56
5020 Salzburg
Phone (+43) 662 8716410
Fax (+43) 662 878470

Upper Austria sales agency:
Trattnachtalstrasse 7
4710 Grieskirchen
Phone (+43) 7248 65051
Fax (+43) 7248 65054

Switzerland
EMB Pumpen AG
Gerstenweg 7
4310 Rheinfelden
Phone (+41) 61 8368020
Fax (+41) 61 8368021

Additional subsidiaries located in:

Belarus, Belgium, Bulgaria, China, Denmark, Finland, France, Greece, Great Britain, Ireland, Italy, Canada, Kazakhstan, Korea, Lebanon, Lithuania, Latvia, The Netherlands, Norway, Poland, Romania, Russia, Sweden, Serbia & Montenegro, Slovakia, Slovenia, Spain, Czech Republic, Turkey, Ukraine, Hungary

You can find their addresses online at **www.wilo.de** or **www.wilo.com**.

Status: March 2005
*12 cents per minute

W 2197/2T/0503/D/PRS