

# GERMAN **ATV-DVWK** RULES AND STANDARDS

## **STANDARD ATV-DVWK-A 157E Sewer System Structures**

November 2000



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The German Association for Water, Wastewater and Waste, DWA (former ATV-DVWK), is the spokesman in Germany for all universal questions on water and is involved intensely with the development of reliable and sustainable water management. As politically and economically independent organisation it operates specifically in the areas of water management, wastewater, waste and soil protection.

In Europe the DWA is the association in this field with the greatest number of members and, due to its specialist competence it holds a special position with regard to standardisation, professional training and information of the public. The ca. 14,000 members represent the experts and executive personnel from municipalities, universities, engineer offices, authorities and businesses.

The emphasis of its activities is on the elaboration and updating of a common set of technical rules and standards and with collaboration with the creation of technical standard specifications at the national and international levels. To this belong not only the technical-scientific subjects but also economical and legal demands of environmental protection and protection of bodies of waters.

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## Foreword

For reasons of environmental protection, as well as from the operational, technical safety and economic aspects, there are principles and minimum requirements on the design and quality of the construction of sewer systems.

Purpose and objective of the Standard is to provide the planner and the examiner with basic elements for the production of structures within the sewer system.

Objective of the revision of the previous Standard dated March 1994 is the increased orientation of the planning towards the economic construction and operation of sewer systems. Compared with the previous Standard the chapters "Inspection Chambers" and "Underrun with Elevator" have been added. In addition, numerous proposals on the optimisation of planning have been incorporated.

A further objective was the matching of the Standard to the current developments of European standardisation. As this standardisation process is not complete successive adjustment is required.

The publisher is grateful for all suggestions which can be used later in further new editions.

## Authors

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## Contents

|   |           |
|---|-----------|
| Foreword.....   | 3         |
| Authors .....   | 3         |
| List of pictures .....  | 6         |
| User Notes .....  | 7         |
| <b>1 Area of Application .....</b>                                  | <b>7</b>  |
| <b>2 Definitions .....</b>  | <b>7</b>  |
| <b>3 Requirements .....</b>   | <b>8</b>  |
| 3.1 General .....   | 8         |
| 3.2 Stability .....   | 8         |
| 3.3 Water Tightness .....   | 8         |
| 3.4 Resistivity.....  | 8         |
| 3.5 Safety Engineering.....   | 8         |
| 3.6 Materials .....   | 8         |
| 3.6.1 General .....   | 8         |
| 3.6.2 Concrete and Reinforced Concrete .....                        | 8         |
| 3.6.3 Brickwork .....   | 9         |
| 3.7 Sealants.....   | 9         |
| <b>4 Climbing Aids .....</b>  | <b>9</b>  |
| <b>5 Structures.....</b>  | <b>10</b> |
| 5.1 General .....   | 10        |
| 5.2 Manholes .....  | 10        |
| 5.2.1 Manholes for Gravity Drains .....                             | 11        |
| 5.2.2 Manholes for Pressure Mains.....                              | 11        |
| 5.2.3 Parts of a Manhole .....                                      | 11        |
| 5.2.3.1 Manhole Bottom Section.....                                 | 11        |
| 5.2.3.2 Manhole Upper Section .....                                 | 14        |
| 5.3 Inspection Chambers .....                                       | 15        |
| 5.4 Structures to Overcome Height Differences .....                 | 15        |
| 5.4.1 Ramp Manholes .....   | 15        |
| 5.4.1.1 Ramp Manhole with Bypass .....                              | 15        |
| 5.4.1.2 Ramp Manhole with Spillway.....                             | 16        |
| 5.4.1.3 Drop Shaft .....  | 16        |
| 5.4.1.4 Ramp Manhole with Cascades.....                             | 16        |
| 5.4.1.5 Vortex Drop Shaft.....                                      | 17        |
| 5.4.2 Steep Stretches in Combination with Reducing Structures ..... | 17        |
| 5.5 Intersection Structures .....                                   | 18        |
| 5.5.1 Intersection without Change to Profile and Gradient .....     | 19        |
| 5.5.2 Bypass Sewer .....  | 19        |
| 5.5.3 Profile Change.....   | 19        |
| 5.5.4 Partial Siphonage .....                                       | 19        |
| 5.5.5 Inverted Siphon .....   | 20        |
| 5.5.5.1 Inverted Siphon Upper Head .....                            | 20        |

|          |   |           |
|----------|---|-----------|
| 5.5.5.2  | Inverted Siphon Drains Pipelines.....   | 21        |
| 5.5.5.3  | Inverted Siphon Lower Head.....   | 21        |
| 5.5.6    | Pipe Bridge .....   | 21        |
| 5.5.7    | Pump Station with Pressure Main.....  | 21        |
| 5.5.8    | Underrun with Lifting Facility .....  | 22        |
| 5.6      | Stormwater Overflows (SO) .....   | 22        |
| 5.6.1    | Upstream Junction Structure.....  | 24        |
| 5.6.2    | Throttle Unit .....   | 24        |
| 5.6.3    | Overflow Sill .....   | 24        |
| 5.6.4    | Siphon Weir .....   | 25        |
| 5.7      | Inlet Structures.....   | 25        |
| 5.7.1    | Inlet Structure with Shingle and Sand Trap in Near-natural Construction.....      | 25        |
| 5.7.2    | Inlet Structure with Rectangular Shingle and Sand Trap .....                      | 25        |
| 5.7.3    | Inlet Structure with Shingle and Sand Trap .....                                  | 26        |
| 5.7.4    | Outlet Tower .....  | 26        |
| 5.8      | Outlet Structures.....  | 26        |
| 5.9      | Gate Valve Structures .....   | 27        |
| <b>6</b> | <b>Additional Information for Sewer Systems in Rurally Structured Areas .....</b> | <b>28</b> |
| <b>7</b> | <b>Stocktaking.....</b>   | <b>28</b> |
|          | <b>Bibliography.....</b>  | <b>29</b> |
|          | DIN Standard Specifications .....   | 29        |
|          | ATV-DVWK Standards .....  | 30        |
|          | Other rules and standards.....  | 30        |
|          | Additional specialist literature.....   | 30        |

## List of pictures

|          |   |    |
|----------|---|----|
| Fig. 1:  | Manhole.....  | 10 |
| Fig. 2:  | Manholes with connections.....  | 10 |
| Fig. 3:  | Smoothing shaft for pressure main outlet .....  | 11 |
| Fig. 4:  | Manhole with large depth.....   | 12 |
| Fig. 5:  | Manhole entry/field of movement .....   | 13 |
| Fig. 6:  | Connection structures .....   | 13 |
| Fig. 7:  | Curved structures .....   | 14 |
| Fig. 8:  | Inspection chamber.....   | 15 |
| Fig. 9:  | Ramp manhole with internal bypass .....   | 15 |
| Fig. 10: | Ramp manhole with external bypass .....   | 15 |
| Fig. 11: | Ramp manhole with spillway .....  | 16 |
| Fig. 12: | Drop shaft with deflector plate .....   | 16 |
| Fig. 13: | Drop shaft with reinforced energy conversion for stormwater sewers and overflow channels .... | 16 |
| Fig. 14: | Ramp manhole with cascades and channel .....  | 17 |
| Fig. 15: | Vortex drop shaft .....   | 17 |
| Fig. 16: | Manhole within the steep stretch, closed pipe passage .....                                   | 18 |
| Fig. 17: | Energy conversion structure with overflow sill .....  | 18 |
| Fig. 18: | Energy conversion structure with deflector body .....   | 18 |
| Fig. 19: | Inverted siphon with drainage facility at the upper head .....                                | 20 |
| Fig. 20: | Inverted siphon with drainage shaft at the low point.....                                     | 20 |
| Fig. 21: | Underrun with pumping station and subsequent pressure main.....                               | 21 |
| Fig. 22: | Underrun with lifting facility .....  | 22 |
| Fig. 23: | Stormwater overflow with one-sided overflow sill .....  | 23 |
| Fig. 24: | Stormwater overflow with double-sided overflow sill .....                                     | 23 |
| Fig. 25: | Stormwater overflow with bottom opening .....   | 24 |
| Fig. 26: | Stormwater overflow structure with air regulated inverted siphon.....                         | 25 |
| Fig. 27: | Inlet structure with shingle and sand trap.....   | 26 |
| Fig. 28: | Outlet tower .....  | 26 |
| Fig. 29: | Outlet structure.....   | 27 |
| Fig. 30: | Gate valve structure (Flooding gate valve) .....  | 27 |

## User Notes

This Standard is the result of honorary, technical-scientific/economic collaboration which has been achieved in accordance with the principles applicable therefore (statutes, rules of procedure of the ATV-DVWK and the Standard ATV-DVWK-A 400). For this, according to precedents, there exists an actual presumption that it is textually and technically correct and also generally recognised.

The application of this Standard is open to everyone. However, an obligation for application can arise from legal or administrative regulations, a contract or other legal reason.

This Standard is an important, however, not the sole source of information for correct solutions. With its application no one avoids responsibility for his own action or for the correct application in specific cases; this applies in particular for the correct handling of the margins described in the Standard.

## 1 Area of Application

This Standard applies for structures in sewer systems outside buildings, which are newly installed or rehabilitated

EN 752 applies for drain systems outside buildings, and EN 12056 together with the residual Standard Specification DIN 1986 (inside and outside buildings) for those underneath buildings.

The basic elements of planning listed apply for planning and implementation. When required in individual cases agreement with the operator and the relevant authority is to be sought.

The basic planning elements are to be supplemented by a collection of exemplary drawings, which are published in a separate Advisory Leaflet.

Peculiarities, which can appear with the planning of sewer systems in rurally structured areas, are presented in their own section.

Structures of centralised stormwater treatment and retention facilities are covered in Standard ATV-A 166 [Currently not available in English].

The hydraulic dimensioning of drains and sewers takes place in accordance with Standards ATV-A 110E, ATV-A 111E and ATV-A 112 [Currently not available in English].

## 2 Definitions

### Sewer [EN 752-1]

Pipeline or other construction, usually underground, designed to carry wastewater and/or surface water from more than one source.

### Pressure main [DIN 4045]

Pipeline for the transport of wastewater under pressure.

### Drain [EN 752-1]

Pipeline, usually underground, designed to carry wastewater and/or surface water from a source to a sewer.

### Structures

Structures within the meaning of this Standard are also manholes within the meaning of EN 752-1.

### Inspection chamber [EN 752-1]

Chamber with a removable cover constructed on a drain or sewer that provides access from surface level only, but does not permit entry of a person.

### Sewer system [EN 752-1]

Network of pipelines and ancillary works which conveys wastewater and/or surface water from drains to a treatment works or other place of disposal.

### Manhole [EN 752-1]

Chamber with removable cover constructed on a drain or a sewer to permit entry by personnel.



## **3 Requirements**

### **3.1 General**

Structures must be fabricated in accordance with the test requirements to be watertight and resistant against internal and external damaging effects, taking into account the relevant [German] Accident Prevention Ordinance and DIN Standard Specifications.

### **3.2 Stability**

Structures are to be so founded and so designed that subsidence is as far as possible excluded and they can safely accept the anticipated loads. This is to be verified.

In the static calculation the loading cases dead-weight, horizontal earth pressure, earth load, traffic, groundwater and similar are to be taken into account.

With the connection of pipes to the structure unacceptable secondary stresses occur, for example through different settlement of manhole and pipeline and direct influence of traffic loads. Therefore, with pipes of nominal widths up to DN 1200, drains and sewers are to be connected double-jointed. In individual cases one can dispense with double-jointing if it is proven that these influences do not occur or can be accepted by manhole and pipe without damage.

With pipes of nominal width  $> \text{DN } 1200$  double-jointing can be dispensed with.

Security against buoyancy is to be verified taking into account the most unfavourable water levels. The horizontal and vertical structural joints must be able to transfer all vertical and horizontal loads without fault.

### **3.3 Water Tightness**

The watertightness of structures is to be tested in accordance with EN 1610. In water protection areas and in water catchment areas still not formerly established for the public supply of drinking water, the respective legal provisions and Standard ATV-A 142E are to be observed.

### **3.4 Resistivity**

All components and materials must possess a sufficient resistivity to the aggressiveness of the groundwater and the neighbouring soil as well as to the composition of the wastewater.

### **3.5 Safety Engineering**

The tasks in a technical wastewater facility and in the sewer system belong in the main to hazardous work. The structural minimum requirements must be observed for the safe operation of technical wastewater facilities.

[In Germany] European Union Directives, regulations of the statutory accident insurance carrier, DIN and EN Standard Specification provide mandatory information on this matter. Measures to be taken are contained in the [German] Accident Prevention Regulations (UVV).

### **3.6 Materials**

#### **3.6.1 General**

Structures can be manufactured as brickwork, concrete or prefabricated components of various materials. For this the appropriate national and/or European Standard Specifications apply (see Bibliography).

#### **3.6.2 Concrete and Reinforced Concrete**

The requirements of DIN 1045 and DIN 4281 apply analogously for the manufacture, processing and post-treatment of the concrete. The minimum content of cement is based on environmental conditions. For Environment Class 5c (heavily chemically corrosive environment), given in EN 206, a minimum cement content of  $300 \text{ kg/m}^3$  is necessary. The concrete must be impermeable to water. With the test for watertightness in accordance with DIN 1048 the greatest depth of penetration of 30 mm may not be exceeded.

To ensure the minimum concrete cover the design and the implementation is to be based on the nominal size (nom c). This nominal size con-

sists of the minimum concrete cover (min c) and the lead amount of 10 mm. With structures, which are concreted on site, a minimum of min c = 40 mm is to be observed; with structures, which are manufactured from prefabricated reinforced concrete components, a minimum concrete cover of min c = 25 mm. The concrete cover must be secured through stable cement based spacers. Plastic spacers are not permitted as they make no bond with the concrete and can cause lateral water infiltration.

To safeguard the durability of structures made from reinforced concrete a crack width of 0.2 mm may not be exceeded.

### **3.6.3 Brickwork**

Brickwork structures must be produced from sewer bricks with low porosity (DIN 4051, DIN 105), at least 24 cm thick (one brick), joints struck flush and fair faced internally (Mortar Group III with additive). The joints are to be smoothed flat both internally and externally. In addition, a 2 cm thick exterior rendering and an at least double coat of protective paint against aggressive soils or groundwater are to be planned. For structural reasons it can be necessary to curve brickwork structures outwards or to reinforce them appropriately.

### **3.7 Sealants**

Joints of structures can be produced using sealants made from elastomers, steel jointing sheet, plastic sealants or mortar. Joints between prefabricated manhole components are to be sealed using elastomer sealants exclusively, in accordance with EN 681 and DIN 4060.

## **4 Climbing Aids**

With manhole entry shafts into the sewer system the restricted space and the limited visibility conditions are to be particularly taken into account. Therefore an as uniform as possible design of climbing aids in all manholes of one system is of great importance due to the security provided by routine.

With the employment of climbing aids suitable holding devices are to be located above entry points.

For new construction and/or rehabilitation of man-accessible structures in the sewer system the following standard specifications apply, until the introduction of EN 1917, with the selection and arrangement of climbing aids:

1. Step irons (staggered); DIN 1212
2. Step irons (single flight); DIN 19555
3. Ladders, locally fixed or movable;  
UVV ladders and stairs
4. Manholes for underground drains and sewers  
EN 476

Other climbing aids can be employed in agreement with the responsible accident insurance carrier.

The riser height for single flight or staggered manhole steps is 250 mm. In special cases, however, a separation of 333 mm can be selected. The separation between benching and lowest step iron should at least match the riser height, but not be greater than 500 mm.

The greatest permitted distance for the separation upper edge of manhole to first step iron, in exceptional cases with height compensation of up to 240 mm, may exceed the standard of 500 mm by a maximum of 150 mm. Height compensation over 240 mm using support rings is not permitted. In these cases suitable safety measures are to be agreed with the responsible statutory accident insurance carriers.

As climbing aid in the area of the channel, the installation of step boxes is recommended to avoid deposits. Minimums given in DIN 1212 are to be observed with the installation of step boxes.

## 5 Structures

### 5.1 General

The examples presented give no inference as to materials used or to the construction to be considered. They should represent their geometric dimensions with regard to hydraulic and technical occupational safety.

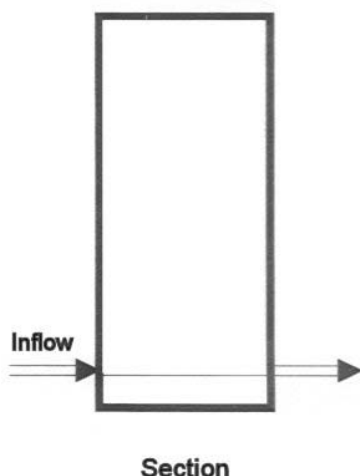


Fig. 1: Manhole

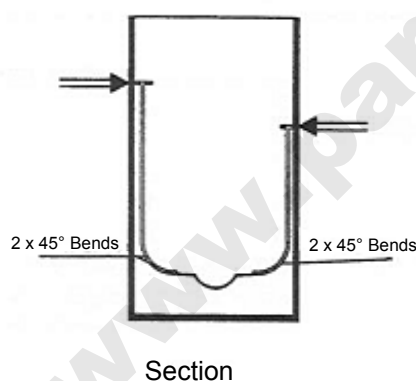


Fig. 2. Manholes with connections

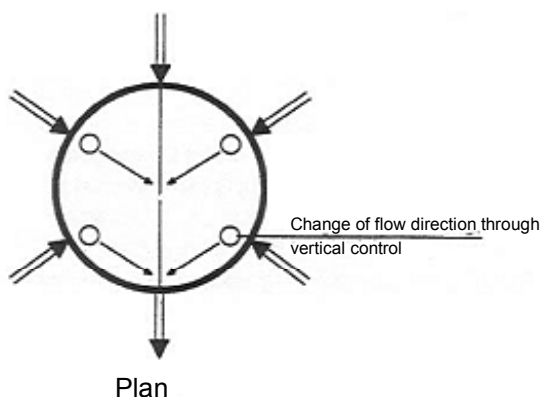
### 5.2 Manholes

Manholes serve for aeration and ventilation, for monitoring and cleaning of sewers and drains. They are arranged with changes of direction (with non man-accessible sewers), of section and of gradient, with the confluence of other sewers, as well as for intermediate manholes in straight stretches of sewer. Drains from private property and road gullies are to be connected correctly to the manhole or, outside the shaft, to the sewers. In defined water protection areas or in non-defined water catchment areas of the public water supply system, the respective water protection area ordinance and/or Standard ATV-A 142E is additionally to be observed.

In order to improve the flushing effect at the start of the first sewer section, initial manholes should have one or more connections at sole level.

If connections into manholes are planned, then the discharge may be undertaken only into the channel and in the direction of flow.

In the separate system the manholes of wastewater and stormwater sewers may have no connection to each other. As both sewers of the separate system should be laid close to each other due to the excavation being as small as possible, displacement of the manholes is to be sought.



### 5.2.1 Manholes for Gravity Drains

The separation of the manholes depends on operational and technical work safety aspects, dependent on whether one is concerned with sanitary, combined or stormwater sewers. Manhole separation, with shafts of all sizes, should satisfy technical work safety and operational aspects. As a rule, however, not exceed 100 m.

With non man-accessible main transport sewers and in particular in rurally structured areas, larger manhole separations can be selected if the operational requirements are fulfilled in another manner (see Section 5.3 Inspection Chambers).

With larger manhole separations the question of ventilation is to be particularly examined. In critical individual cases the involvement of the responsible safety experts or an agreement with the responsible accident insurance carrier is recommended.

With the employment of climbing aids suitable holding devices are to be arranged above the entry points.

It is recommended that a securable, corrosion resistant pipe of  $\frac{1}{2}$ " diameter is installed ca. 100 mm above the highest external diameter of the sewer for the measurement of the groundwater level. If required a transparent hose can be connected in order to determine the groundwater level outside the structure after blowing the pipe free.

### 5.2.2 Manholes for Pressure Mains

Manholes can also be necessary with the laying of wastewater pressure mains. A manhole at the end of the pressure main is required if this discharges into a continuing gravity sewer. The separation of the control shafts and/or cleaning shafts depends on the layout. Shafts are located at low points for emptying and at high points for aeration and ventilation as well as for the installation of appropriate fittings. The bottom of the manhole should have a gradient to a pump well. Anchoring with changes of direction is, as a rule, carried out without forming a shaft.

The manhole is to be so designed that sufficient freedom of movement under the pipe (at least 200 mm) and alongside the pipe (at least 800 mm) is available in order that work on fittings

can be carried out. Structural arrangements for the possible installation of measuring devices are also to be planned.

Support of the pipe and/or fittings is to be provided with larger spans of pipeline lying free in the manhole.

Particular care is to be taken to protect against corrosion at the outlet of the pressure main. With this the outlet is as far as possible to be led under water and to be so designed that turbulence is, as far as possible, avoided. For this see also Advisory Leaflet ATV-M 168E "Corrosion of Wastewater Systems".

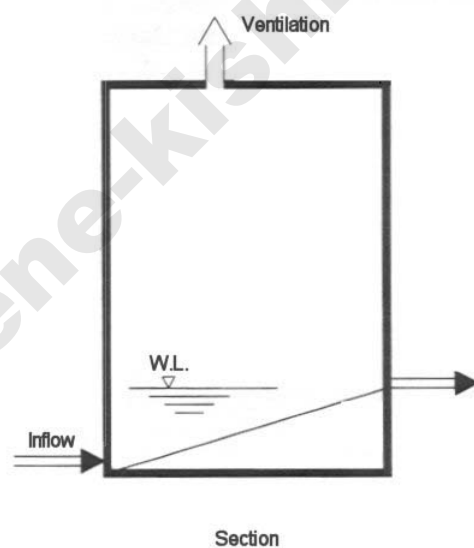


Fig. 3: Smoothing shaft for pressure main outlet

### 5.2.3 Parts of a Manhole

#### 5.2.3.1 Manhole Bottom Section

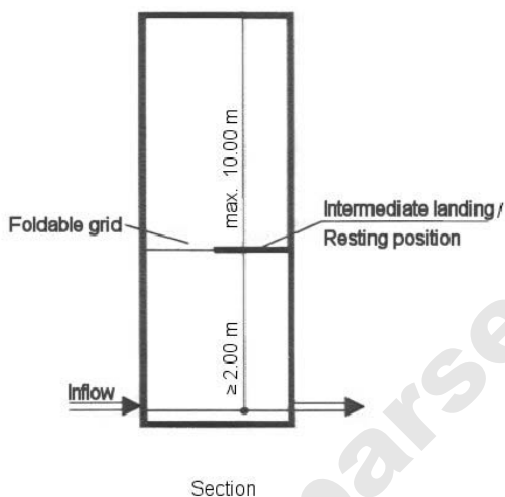
The manhole bottom section consists of  
 the base plate,  
 the channel,  
 the benching,  
 the side walls,  
 the connection pieces,  
 if required, the transition plate,  
 if required, the base ring,  
 the climbing aids.

The clear widths of the manhole bottom section are determined by the number, nominal widths and wall thicknesses of the incoming and outgoing sewers.

With rectangular manholes the minimum clear width is 1.0 m. With circular manhole bottom sections the clear diameter should not be smaller than 1.0 m.

The manhole must be so spacious and the entry openings so arranged that all requirements of sewer operation can be satisfied.

With manholes of large depth (over 5 m) additional operational (e.g. rope fastenings) or structural (e.g. resting places) measures must be taken in accordance with the applicable regulations. Over 10 m [depth] resting places are absolutely necessary.



**Fig. 4: Manhole with large depth**

With manhole bottom sections produced on-site the minimum thickness of the concrete bottom plate is 20 cm. Reinforcement is to be planned according to structural requirements.

With a diameter of the outgoing sewer up to DN 500 the benching should be on both sides at the height of the crown. With this it can be necessary, in order to ease the insertion of a TV camera, to extend the outer channel side wall only upwards to the crown. However, thought should be given that here one is concerned with hydraulic disadvantages.

With larger cross-sections the extending upwards of the channel side wall up to the crown is also the optimum hydraulic solution. In the normal case the height of the benching with larger crosssections should lie above the water level of twice the dry weather flow ( $2 Q_{DW}$ ), however, at least 500 mm above the bottom. With benching heights above 500 mm, climbing boxes or steps together with supporting grips or bars are to be provided.

The minimum width in the area of the benching should be 200 mm. With nominal widths above DN 600 the benching on the entry side should be at least 300 mm wide. With offset manholes with angular cross-sections this dimension is also to be observed on connection walls.

For circular manholes there is a necessity to define the relevant minimum width as, with circular manholes, the benching always runs against 0 with the pipe mouth.

The outer limits of 60 cm field of movement, whose central axis is identical with the axis of the line of the step irons, are relevant for the minimum width of benching.

With structures with changes of direction and anticipated formation of eddies, the benching in the outer bend should be arranged at the height of the crown so that, with stormwater flow, overflowing of the benching is avoided.

The slope of the benching may not be steeper than 1: 20 (danger of slipping).

With manholes the channel is to be formed continuous without step; with this hydraulic losses through the area of the manhole are taken into account.

With inlets the arrangement of the inverts is to be so determined that no damaging backing-up can occur. Verification is to be carried out through hydraulic calculation (Fig. 6).

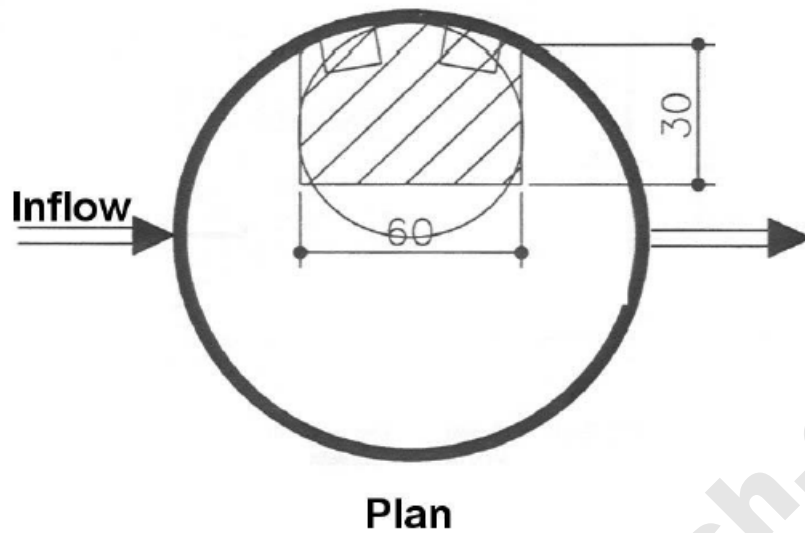


Fig. 5: Manhole entry/field of movement

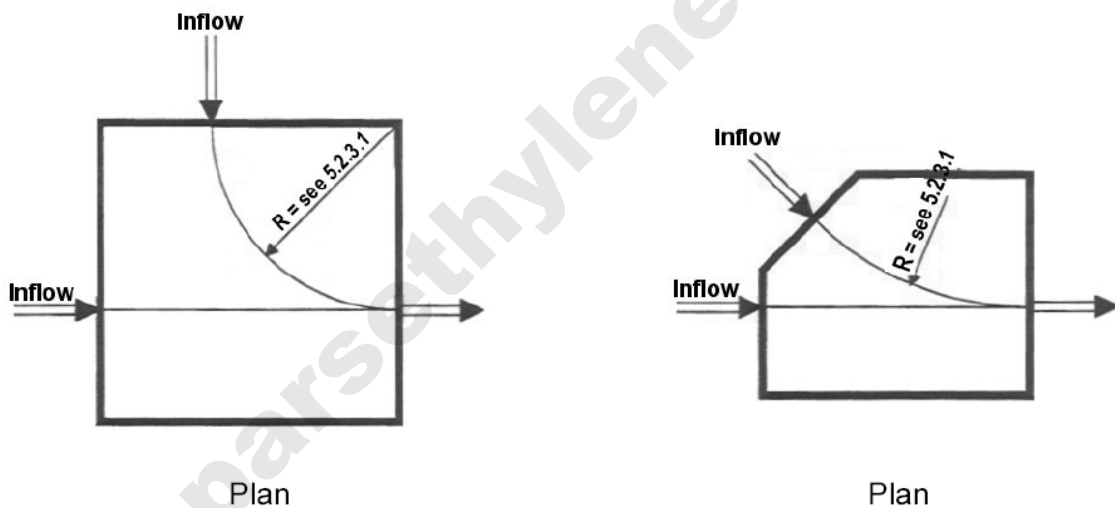


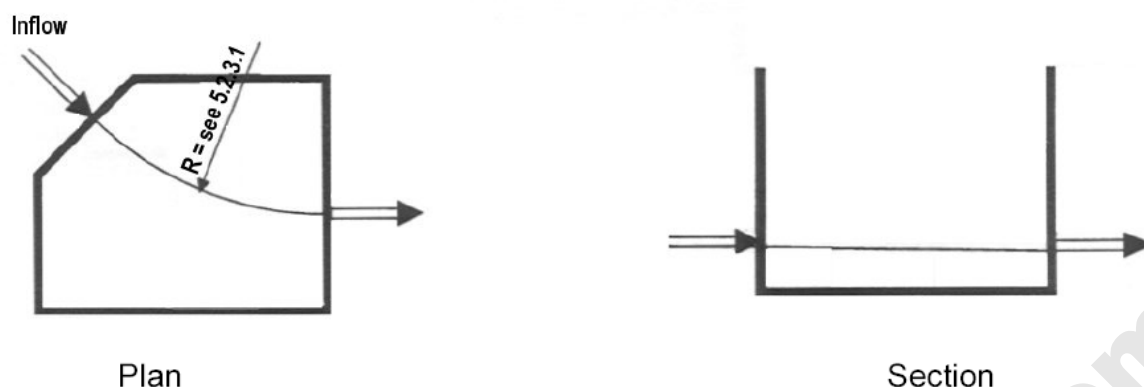
Fig. 6: Connection structures

Changes of direction approaching  $90^\circ$  with high flow rates are not recommended in one shaft.

The radius of the bottom channel, inside the manhole, should be at least 2 to 3 times the clear diameter of the circular cross-section or, with other cross-sections, the clear width of the discharging sewer. If the hydraulic conditions allow, the radius of the bottom channel can be reduced to the simple clear width of the inlet cross-section (Fig. 7).

The hydraulic verification can, for example, be carried out on the basis of Standards ATV-A 110E, ATV-A 111E and ATV-A 112 [Not available in English].

As far as the project-specific conditions allow, a balancing of the energy loss is to be sought within the special structure, so that the pressure line and/or water level with the quantity of water flowing into the structure does not lie above the crown of the pipe.



**Fig. 7: Curved structures**

With man-accessible cross-sections a bend sewer can also be chosen with changes of direction.

For technical cleaning reasons (i.a. shield type operation), with large cross-sections upwards of DN 1200, the radius of curvature axial measurement, should be  $R \geq 15$  m, in exceptional cases  $R \geq 12$ .

For technical and economical reasons the lining of channels and benching with cement is recommended.

Connections of pipes to structures are to be carried out in accordance with the requirements of Chapter 3.2.

The working space above the benching should, if possible, be at least 2.00 m high. Cross-section measurements are to be selected appropriately should a manhole be used for sampling and measuring purposes.

If concrete manhole rings are employed in the rising upper section the brickwork lower section or the local concrete manhole lower section should reach to at least 250 mm above the highest outer diameter of the sewers. With precast concrete components this separation should be at least 200 mm.

### 5.2.3.2 Manhole Upper Section

The manhole upper section consists of the manhole rings and/or manhole pipes, if required, the transition ring, the taper manhole ring (cone), if required, the cover plate, the support rings safe against displacement, the manhole cover incl. dirt pan, the climbing aids.

At least one support ring should be located between taper manhole ring and manhole cover. To balance the height, several support rings can be installed whose overall height of 240 mm may not be exceeded. The support rings must be safe against displacement.

The manhole cover must correspond with the requirements in accordance with DIN 1229. Manhole covers should have ventilation openings. If such manhole covers cannot be used exchange of air is to be ensured in another way (e.g. through ventilation pipes, risers on masts, poster columns etc.). Equally valves or chemical against can be employed.

A dirt pan should be suspended below the manhole covers with ventilation openings in accordance with DIN 1221.

With particular odour nuisances or degassing constraints from the sewer, biofilters to combat odours can be arranged in the manhole itself or in the bypass. The correct aeration and ventilation must in such a case be guaranteed using restricted guidance of air. Attention is to be paid with this, that the inlet air pipe is led down to the bottom of the manhole.

### 5.3 Inspection Chambers

Inspection chambers must in particular correspond with the operational requirements for ventilation, inspection and cleaning. Their cross-section must be matched to the equipment and aids which come into use. Manholes can be replaced by inspection chambers with long transport mains and in rural structure areas with non man-accessible sewers. Separation of inspection chambers is determined by the technical work and safety aspects. Access to inspection chambers must be secured. In places where no accessibility is required inspection chambers can also be employed in place of manholes.

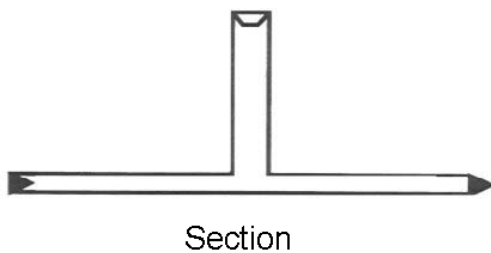


Fig. 8: Inspection chamber

### 5.4 Structures to Overcome Height Differences

Height differences can be overcome through ramp manholes and steep stretches. With man-accessible sewers appropriate safety facilities are to be installed against falling.

#### 5.4.1 Ramp Manholes

Ramp manholes are planned at crossings with other pipelines and structures as well as to overcome height differences over short distances.

They can be designed as:

- Ramp manhole with bypass,
- Ramp manhole with spillway (swan neck),
- Drop shaft with deflector plate,
- Drop shaft with reinforced energy conversion,
- Ramp manhole with cascades,
- Vortex drop shaft.

#### 5.4.1.1 Ramp Manhole with Bypass

Ramp Manholes with bypass, for reasons of accident prevention, should remain limited to sewers  $\leq$  DN 800. Bypasses should have a nominal width of at least DN 200. 90° bend should, if possible, be replaced by 2 x 45° bends. The diameter of the bypass must, however, be so dimensioned that, with sanitary sewers, at least 2  $Q_{DW}$ . Ramp manholes with internal bypass are to be preferred to those with external bypass due to the better possibilities for cleaning. If the drop height of 1.20 m is exceeded suitable benching or floor space is to be planned.

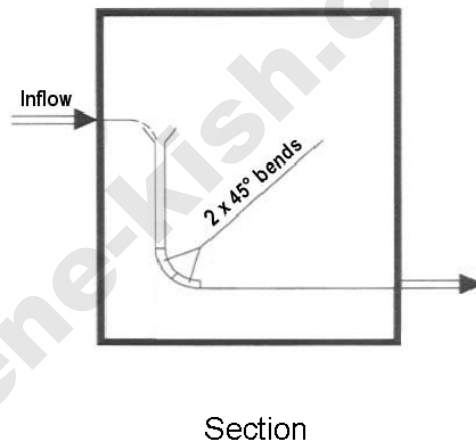


Fig. 9: Ramp manhole with internal bypass

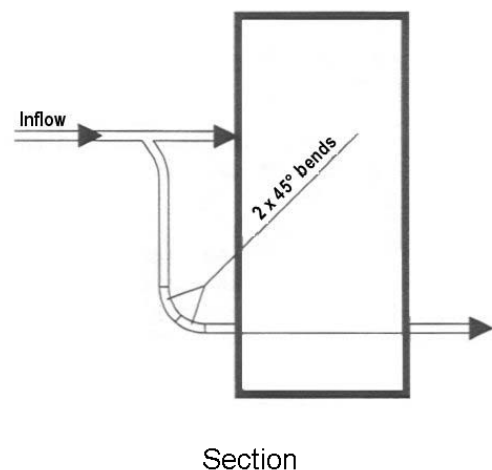


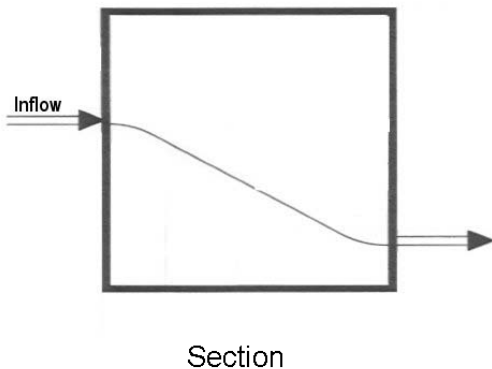
Fig. 10: Ramp manhole with external bypass



**5.4.1.2 Ramp Manhole with Spillway**

Ramp manholes with spillway are used if the employment of a bypass is not possible.

The spillway should be so designed that the water, up to the double dry weather flow ( $2 Q_{DW}$ ), does not separate from it. The geometric shape for this is the trajectory parabola. The wall opposite to the inlet should be formed as a deflector in that area which the trajectory parabola reaches – related to  $Q_{full}$  of the inflow pipeline.



**Fig. 11: Ramp manhole with spillway**

**5.4.1.3 Drop Shaft**

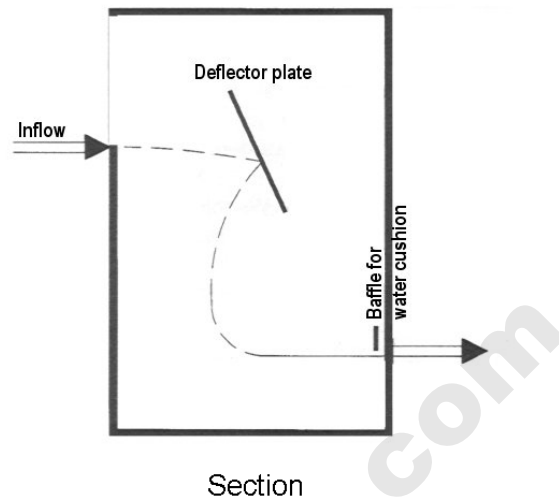
Drop shafts are employed in cases without permanent wastewater flow, e.g. with stormwater sewers in separate systems or with overflow channels with combined systems.

Simple drop shafts can be provided with small height differences and small inflows.

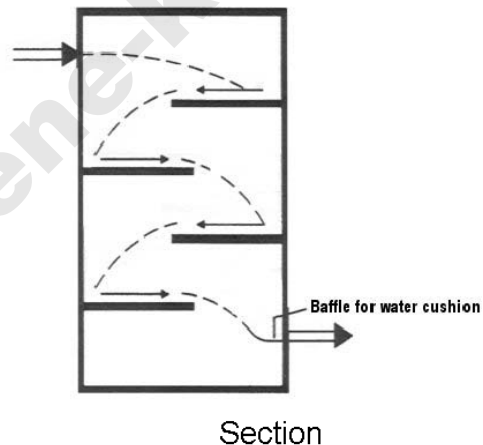
With heavier inflows or larger height differences the arrangement of deflectors is required to convert energy and for the protection of structure walls.

With all ramp manholes provision is to be made for the removal of air at the highest point.

Drop shafts must be safeguarded through suitable structural measures (design of the bottom of the shaft capable of resistance) and provided with a water cushion for the protection of the sole (if necessary installation of a baffle plate in front of the outlet pipe). Care is to be taken that the water cushion empties automatically.



**Fig. 12: Drop shaft with deflector plate**



**Fig. 13: Drop shaft with reinforced energy conversion for stormwater sewers and overflow channels**

**5.4.1.4 Ramp Manhole with Cascades**

Ramp manholes with cascades come into use in larger man-accessible sewers (ca. upwards from 1.80 m clear height). They have either a channel or a bypass for double the amount of the dry weather flow. Handrails are to be provided for reasons of accident prevention.

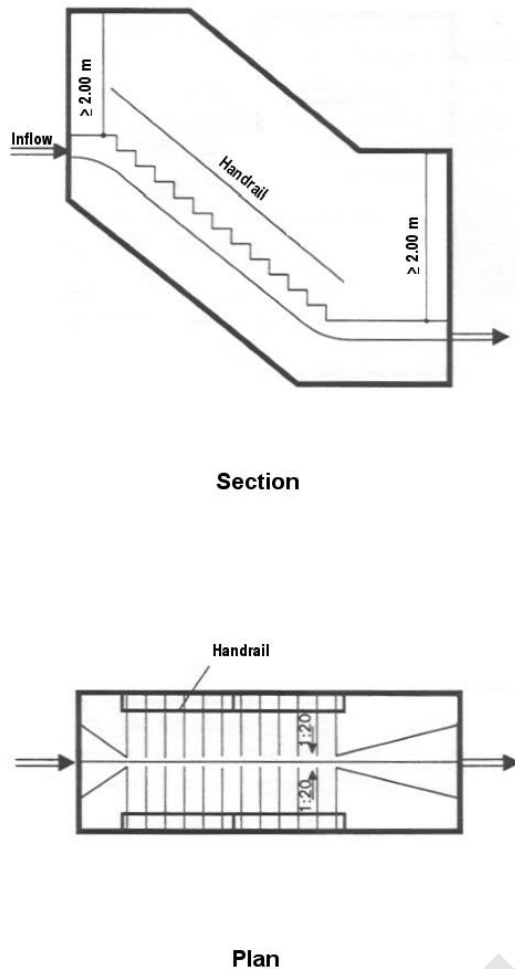


Fig. 14: Ramp manhole with cascades and channel

#### 5.4.1.5 Vortex Drop Shaft

The vortex drop shaft is primarily to be employed if, with restricted space, the incoming water in a channel has to be transported to a lower level without being able to use the energy.

Due to its low noise level the vortex drop shaft is suitable to overcome height differences of more than 10 m.

Through the shaping of the inlet structure a vortex flow is forcibly created over a drop shaft with circular cross-section.

With the inflow it has to be differentiated whether this takes place with open water level, in supercritical or subcritical flow, or under pressure. Basically, the shape of the rotation chamber is to be designed differently for the two types of flow.

Inside the shaft there is a continuous core of air. The vortex drop shaft must be so dimensioned that the core of air is maintained at all times.

As there is no narrowing of the cross-section with the vortex drop shaft, and with suitable design of the bottom of the shaft, there is also no possibility of depositing, both floating solids and sediments can be fed through the ramp manhole with the water.

In order to guarantee the function of the vortex drop shaft a hydraulic calculation in accordance with ATV-A 112 is required.

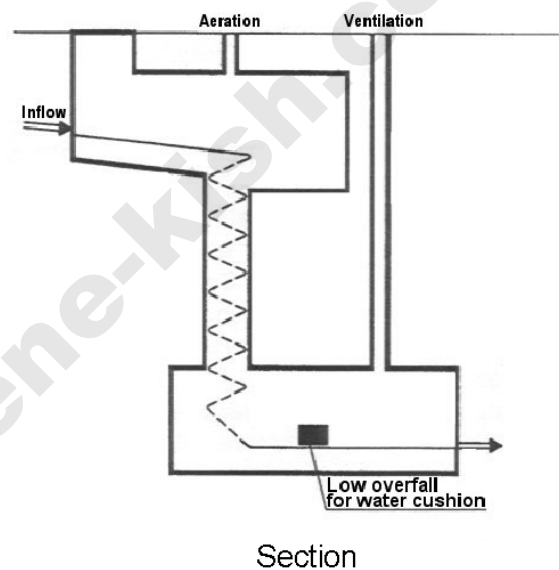


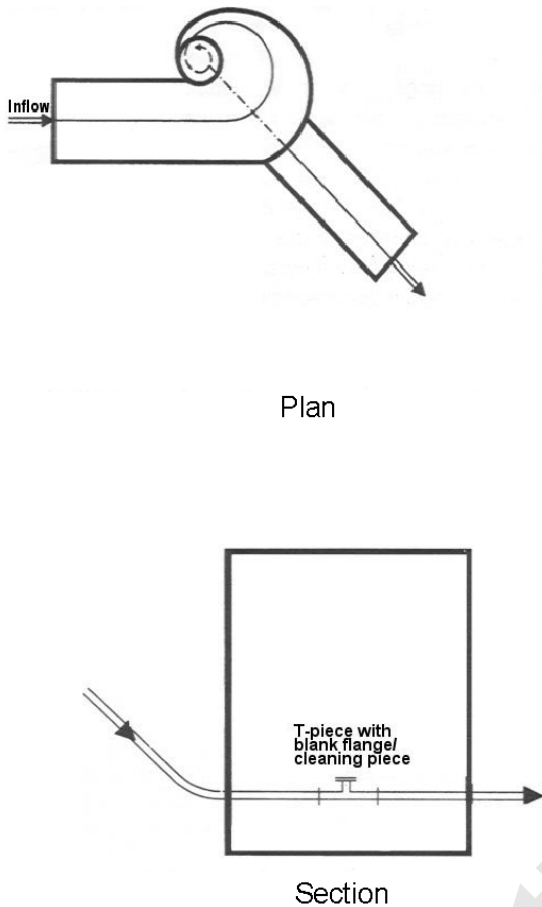
Fig. 15: Vortex drop shaft

#### 5.4.2 Steep Stretches in Combination with Reducing Structures

Steep stretches ( $v > 10$  m/s) require particular consideration with regard to wear and to take into account swell effects and underpressure. Their dimensioning takes place in accordance with ATV-A 110E.

The pipe connections must be designed in accordance with the particular conditions of the steep stretch. The drain itself must be secured against displacement as a result of pressure surges, if necessary using a cross bracket anchoring device.

Within the steep stretch a closed passage of the pipe is to be planned in the entry shaft. For inspection and cleaning purposes a T-piece with blank flange or a threaded cleaning piece is to be installed.



**Fig. 16: Manhole within the steep stretch, closed pipe passage**

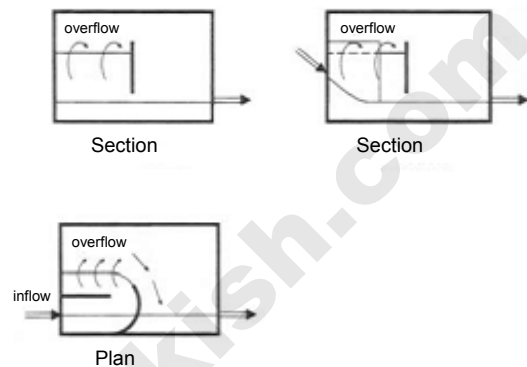
In order that the large flow rate necessary for the steep stretch and the therefrom resultant energy level does not lead to a back-up in the incoming sewer, the manhole in the steep stretch is to be designed in the shape of a ramp manhole, for example with spillway (swan's neck), or it is otherwise to be designed as reducing structure in the first sewer section in the steep stretch.

For the manholes at the start and finish of the steep stretch it is to be checked to what extent the manhole covers have to be designed impermeable to water under pressure.

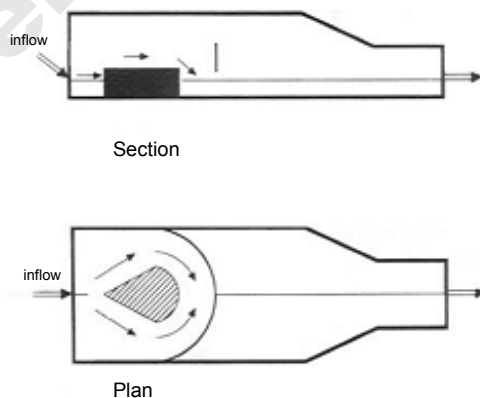
Aeration and ventilation shafts are to be arranged at the end of the transition stretch or at the beginning of the steep stretch, whose covering must be above the pressure head of the incoming sewer. Provision is to be made for sufficient air exhaust.

Covers are to be safeguarded against being lifted. The transition from large to small profile is to be designed as hydraulically rapid.

A transition structure is to be arranged at the end of the steep stretch, which ensures the rapid discharge of  $2 Q_{DW}$  and the energy conversion with the excess channel flow with  $2 Q_{DW}$ .



**Fig. 17: Energy conversion structure with overflow sill**



**Fig. 18: Energy conversion structure with deflector body**

## 5.5 Intersection Structures

The intersection of a sewer with a body of water, traffic facility (underground garage, underground railway), a line for water, wastewater, oil, energy or similar takes place at various levels. The decisive criterion for the type of intersection structure is the difference in height between the levels of the intersecting systems. Here it is already at the study stage of the initial planning that a solution, which takes into account sufficiently the requirements of the drainage system through correction of the height situation, is to be sought with other partners.

Solutions for intersections are:

Intersections without changes of profile and gradient,

Bypass sewer,

Change of profile,

Partial inverted siphoning,

Inverted siphons,

Pipe bridges,

Pumping facilities.

With the selection of the intersection structures the possibility of placing an inverted siphon (5.5.5) is to be avoided as this causes an increased expenditure for operation and maintenance (e.g. danger of blockage).

Basically, with intersections, a manhole or, if required, an inspection chamber is to be arranged before and after the intersection structure.

### **5.5.1 Intersection without Change to Profile and Gradient**

As normal case with intersections it should be sought that the sewer should remain unchanged both in its cross-section and also in its invert gradient.

The number of intersections is to be limited. The sewers are to be secured particularly at the intersections in order to prevent damage. Shafts for monitoring and cleaning should be arranged on both sides of the intersection.

Possibilities for savings with overall height with the sewer and the intersecting structure should be exhausted through the selection of suitable materials and methods of construction (e.g. corrosion resistant steel etc.).

### **5.5.2 Bypass Sewer**

With the later construction of deep roads or underground railways it is often possible to avoid an inverted sewer siphon and in its place provide, for example, a bypass sewer under the traffic ramp.

Due to the longer path the gradient is less. With the danger of increased deposits the sewer can be connected to a point further downstream, and thus lower, in order to achieve a better gradient.

### **5.5.3 Profile Change**

If a sewer is intersected by an obstacle it can often be so designed through slight correction of the planning height with the intersecting construction measure that the height of the invert and the section can remain in the lower range. In the area of the intersection the cross-section, with concurrent reduction of the height of the crown, must be so selected that with  $Q_{\max}$  no damaging backwater results.

The sewer can also be divided into several individual cross-sections with the same hydraulic total performance. Here, with combined systems, the inflow should be so formed, through the arrangement of sills or raising of the invert, that  $Q_{DW}$  is discharge through one cross-section.

If only one flow cross-section is available it should be examined as to whether the combined wastewater flow of  $2 Q_{WW} + Q_{Inf}$  has to be discharged so that a possible case of abnormal occurrence or repair can be covered fully.

### **5.5.4 Partial Siphonage**

If a combined sewer is intersected by the obstacle over part of the height only and a change of profile in accordance with 5.5.3 is not practical for hydraulic or technical grounds then a partial siphonage is recommended.

In these cases the profile should be reduced and in such a manner that at least the dry weather flow is discharged by means of the remaining continuous sewer profile and the sewer invert remains unchanged. The discharge over and above this is reduced via an overflow sill and is fed through an inverted stormwater siphon under the intersecting obstacle and then finally reconnected to the main sewer.

With this the other technical aspects of an inverted siphon are to be applied analogously with the statements according to 5.5.5.

### 5.5.5 Inverted Siphon

Inverted siphons are intersection structures which pass under the obstacle as pressure main.

The cross-section of the inverted siphon is to be matched to the highly variable discharge in the sewer and, if necessary, divided into several profiles. To overcome the hydraulic losses a sufficient gradient is to be planned in the inverted siphon between the inlet and outlet. With subsequent installation of inverted siphons it is to be examined whether a damaging backwater occurs in the inlet sewer. If this is the case, the outgoing sewer should be changed to achieve the necessary siphon gradient over a sufficient stretch with reduced gradient and increased cross-section.

Flushing can take place through backed up wastewater in the sewer or from a special flushing chamber. The usable volume must be at least 2.5 times the volume of the siphon pipe to be flushed.

#### 5.5.5.1 Inverted Siphon Upper Head

The distribution of the inflow to the inverted siphon pipes is most practically achieved through overflow sills or higher placed inlet inverts in the upper head. Through this deposits at the inlet to the siphon are reduced.

For operational reasons shafts for gate valves and/or stop logs are to be placed immediately in front of the inlet.

Structural safety arrangements are to be planned for the protection of personnel.

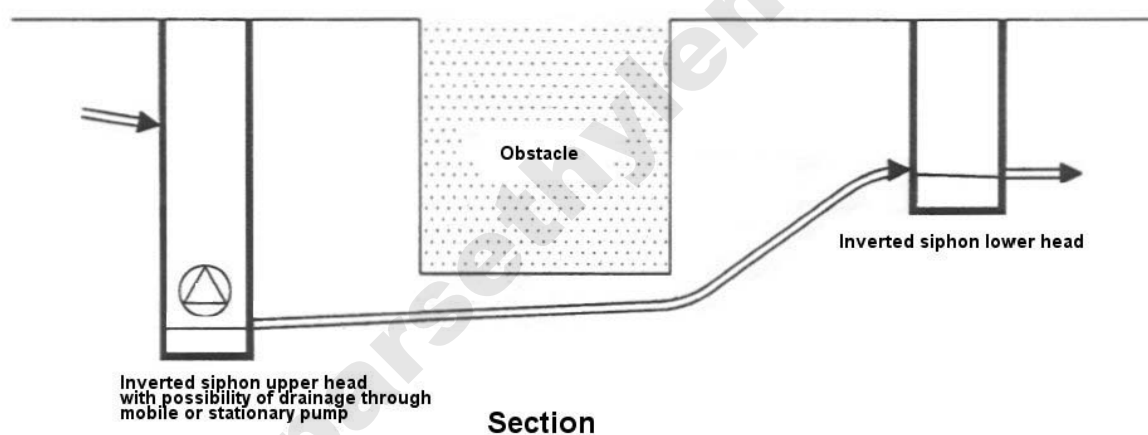


Fig. 19: Inverted siphon with drainage facility at the upper head

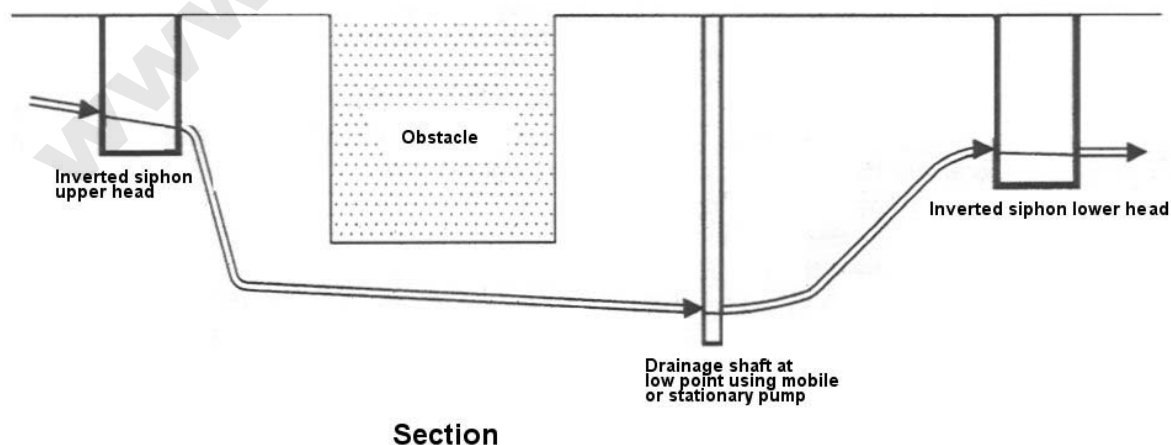


Fig. 20: Inverted siphon with drainage shaft at the low point

### 5.5.5.2 Inverted Siphon Drains Pipelines

It is practical, at the start of the siphon pipelines, to slope the descending branch more severely (1 : 3 and steeper) or almost vertically and the rising branch less severely (1 : 6 and flatter). The angle of slope of the descending branch should not undercut 45° (1 : 1).

At the low point of the siphon pipelines there should be a drainage shaft. The incoming and outgoing siphon branch should each have a gate valve so that each siphon branch can be emptied separately. The drainage structure must have a pump well in order to be able to pump out the quantities drained off. This can take place using a transportable pump; the installation of a fixed pump is, as a rule, not necessary.

### 5.5.5.3 Inverted Siphon Lower Head

At the ends of the rising branch are to be provided with operating gate valves with ventilation devices. Below the gate valve the separate siphon pipelines with higher arranged outlet inverts are again connected together in order to reduce the accumulation of pollutants.

### 5.5.6 Pipe Bridge

If an inverted siphon can be avoided through a pipe bridge then this should be preferred to an inverted siphon. The sewer remains at its level.

It is necessary to carry out a frost protection verification.

### 5.5.7 Pump Station with Pressure Main

Pump facilities are occasionally required in gravity systems in order to avoid a greater depth or to drain low lying areas. With this attention is drawn to Standard ATV-A 134E.

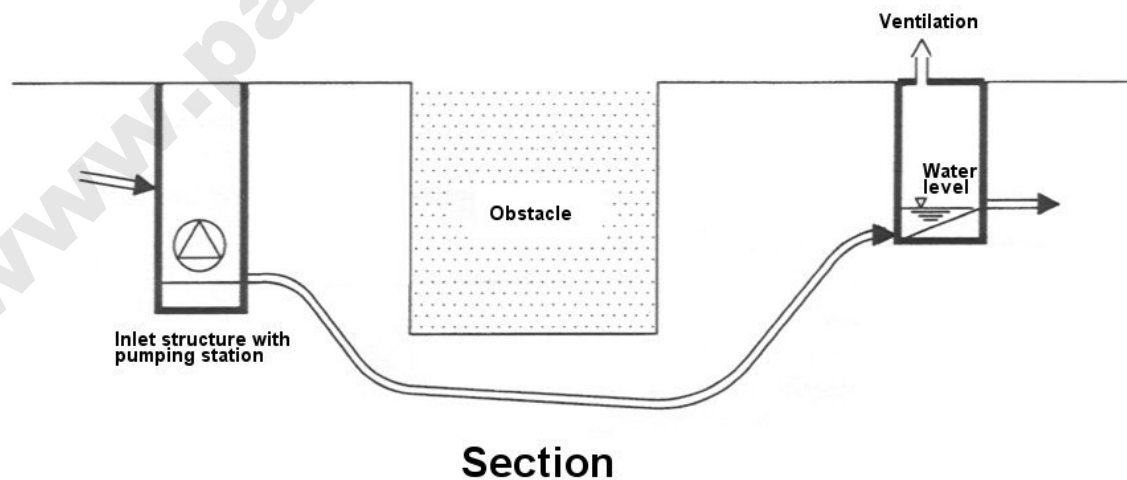
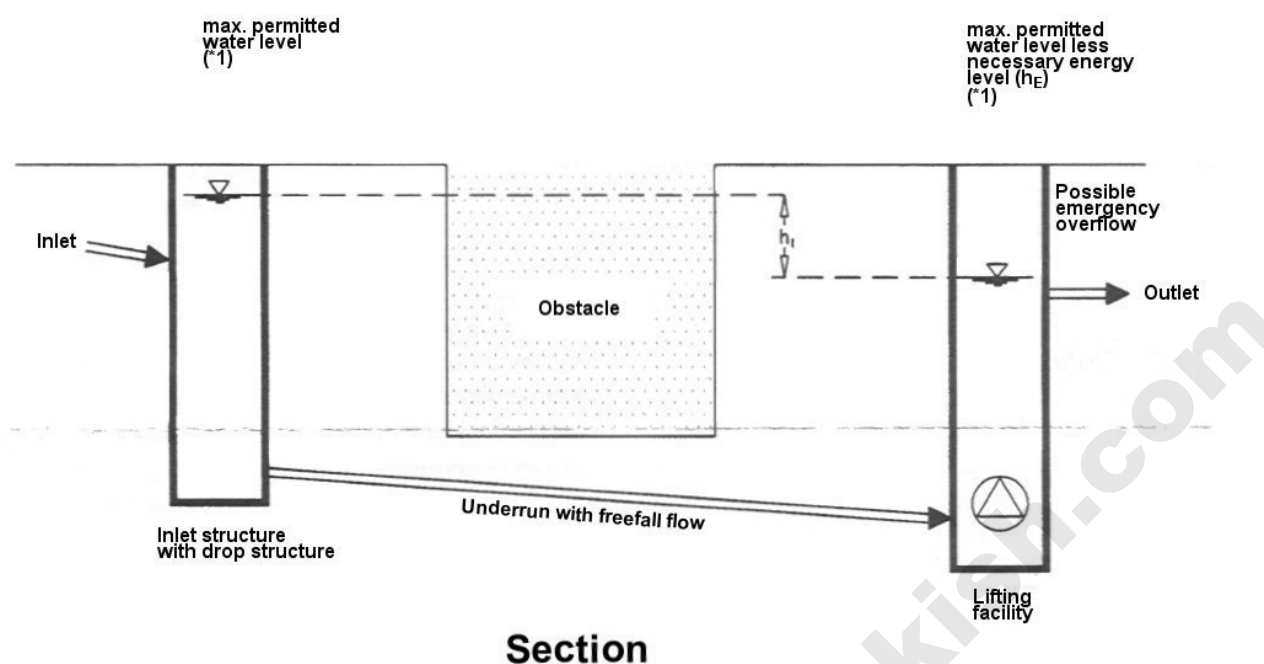


Fig. 21: Underrun with pumping station and subsequent pressure main



\*1 (Emergency operation with failure of lifting facility)

**Fig. 22: Underrun with lifting facility**

## 5.5.8 Underrun with Lifting Facility

The arrangement of the pumping station (lifting facility) following the crossing of the obstacle offers considerable advantages in comparison with the pumping station with pump pressure mains. Although this version is, as a rule, connected with higher investment costs with regard to the construction works there are, however, lower costs for the mechanical and electrical engineering equipment.

While very often there is no possibility of an emergency overflow in the onward sewer with the pumping station with subsequent pump pressure mains, as a rule this emergency overflow can be located in the onward sewer following the lifting facility located after the underrun. Through this, faults with the pump operation can be temporarily overcome. A hydraulic calculation also for the emergency overflow and the possible associated backwater in the incoming sewer is essential in the individual assessment case.

## 5.6 Stormwater Overflows (SO)

Stormwater overflows (SO) in the combined wastewater system, whose dimensioning is described

in Standard ATV-A 128E, are provided if technical drainage and water management aspects demand this.

They can be designed, inter alia, as one- or double-sided SO with raised sill and throttle or with bottom openings.

The flow channel to the onward sewer is to be tapered evenly. The reduction of the cross-section requires a greater invert gradient in the SO than in the inflow sewer in order that no backwater occurs.

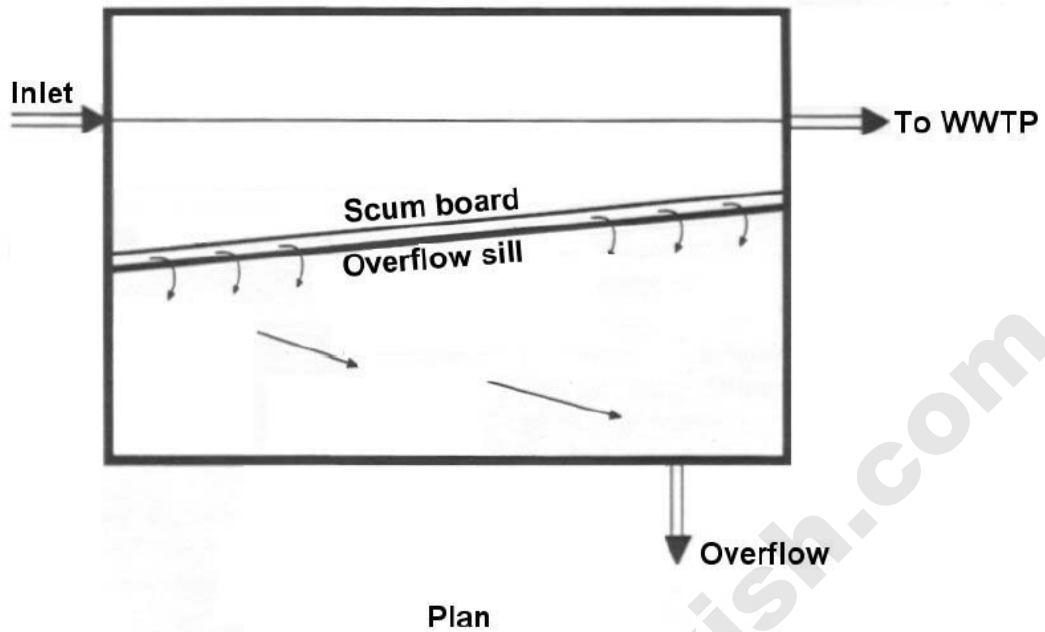


Fig. 23: Stormwater overflow with one-sided overflow sill

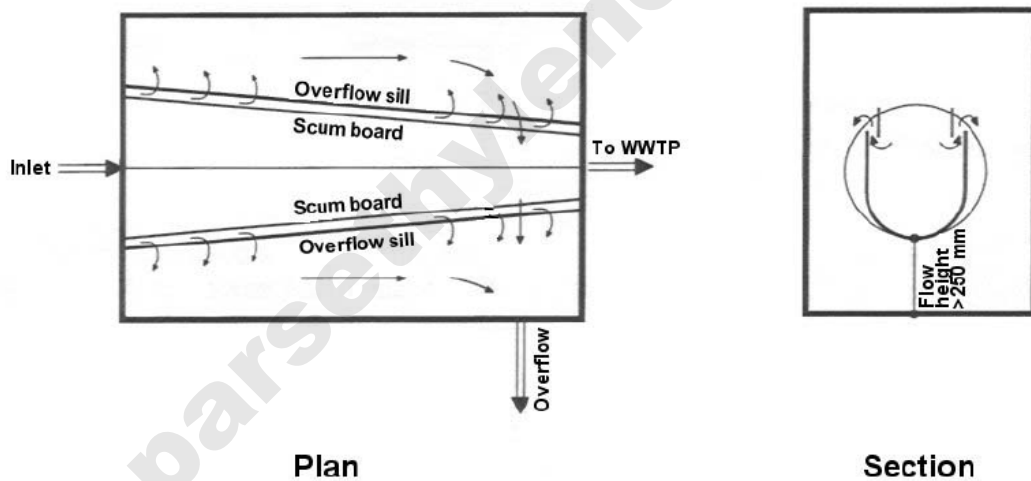
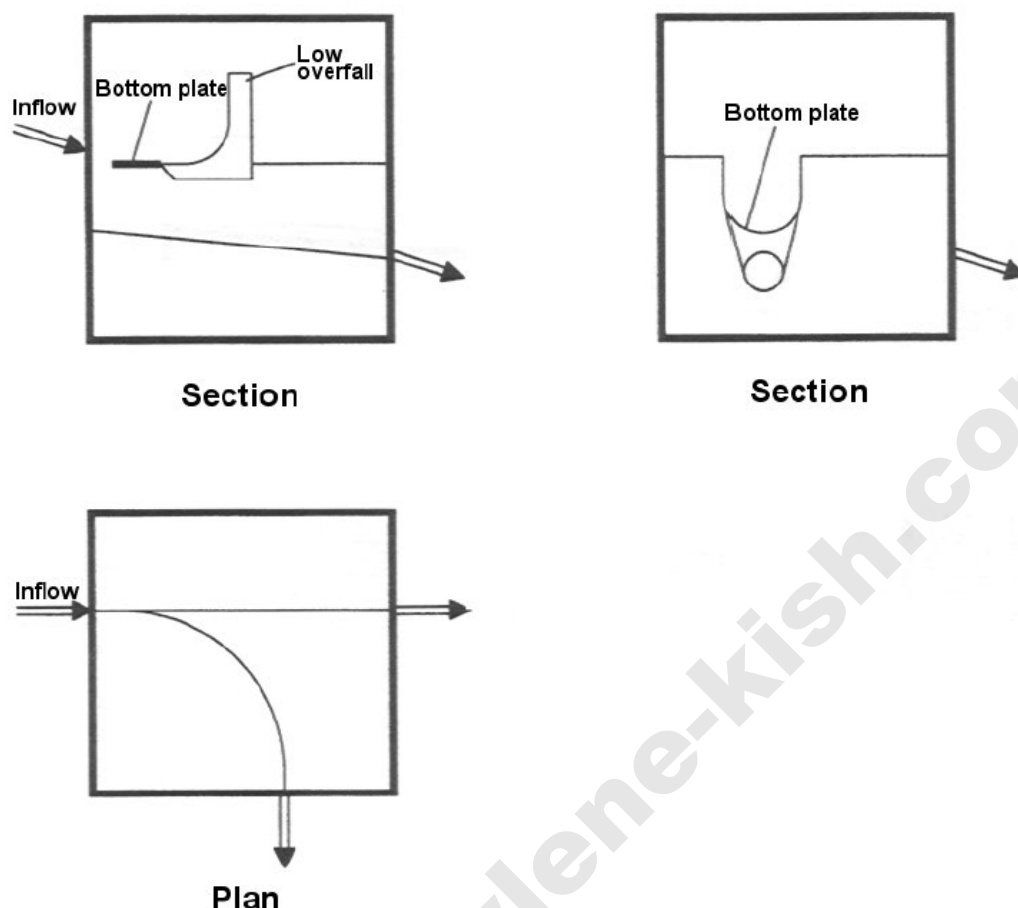


Fig. 24: Stormwater overflow with double-sided overflow sill

Entry openings are to be provided in sufficient numbers so that all sewer reaches are wellventilated and can, in addition, be well-monitored and cleaned.

Stormwater overflows with bottom openings are employed in supercritical stretches. Through this the calming stretches and long overflow sills are avoided. The bottom opening should be adjustable through the installation of a longitudinally movable plate made from corrosion-resistant material. Attention is to be paid to a sufficient, automatic ventilation of the area below the bottom plate.





**Fig. 25: Stormwater overflow with bottom opening**

### 5.6.1 Upstream Junction Structure

If several sewers meet at one SO these should be combined in a junction structure upstream of the SO. Lateral junctions in the SO are to be avoided.

The sewer continuing from the junction structure should be designed as a calming stretch of sufficient length so as to achieve a subcritical flow.

Equally, with supercritical flow, a calming stretch is to be provided in the incoming sewer.

### 5.6.2 Throttle Unit

The outgoing sewer should be designed as a throttle unit in exceptional cases only, as suitable throttle facilities are available. Additionally attention is drawn to Standard ATV-A 128E, Section 10.2.4 and ATV-A 166 [Not available in English].

### 5.6.3 Overflow Sill

The overflow sill can be made, for example, from concrete, reinforced concrete or brickwork. It is to be dimensioned for single side acting, full water pressure on each side. Concrete and reinforced concrete are to be produced without dressing or cement coating. The sill crown is to be constructed horizontally and smooth over its complete length; the use of prefabricated half sections has proved itself.

Under certain preconditions it is recommended that the sill crown is designed adjustable for height.

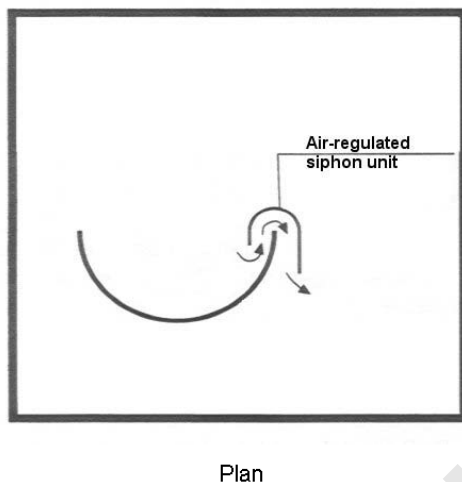
To avoid pollution of surface waters the overflow weirs can be equipped with suitable devices to retain floating matter (e.g. scum boards, screen and sieve systems).

#### 5.6.4 Siphon Weir

To rehabilitate existing stormwater overflow structures air regulated lifting facilities can be installed and thus considerably improve the function.

The air regulated siphon consists of individual segments which are produced in a workshop and can be rapidly assembled on site.

In comparison with conventional structures with fixed overflow sills here there are considerably shorter overfill lengths with the same objectives. Plan



**Fig. 26: Stormwater overflow structure with air regulated inverted siphon**

### 5.7 Inlet Structures

Inlet structures are provided in order, as far as permitted under water management aspects, to accept surface water in sewer systems.

They are to be so arranged that the surface water can be accepted and discharged without flooding the ground. If required, in order to keep deposits as small as possible, sand or shingle traps and/or coarse screens are to be provided.

Solutions for inlet structures are:

- inlet structure with shingle and sand trap in near-natural construction,
- inlet structure with rectangular shingle and sand trap
- inlet structure with circular shingle and sand trap in near-natural construction,
- outlet tower (special case).

#### 5.7.1 Inlet Structure with Shingle and Sand Trap in Near-natural Construction

They can be employed both with small inflows with slight sand conduction and also with larger inflows with larger bed loads.

The structural form of the sand traps should be in line with the existing mechanical clearance equipment. Here a low-lying sand trap space can be positioned, in place of a drainage facility.

For the arrangement of the screen and other covers see Point 5.7.2. With subordinate structures the inlet can be so arranged that it is at the top.

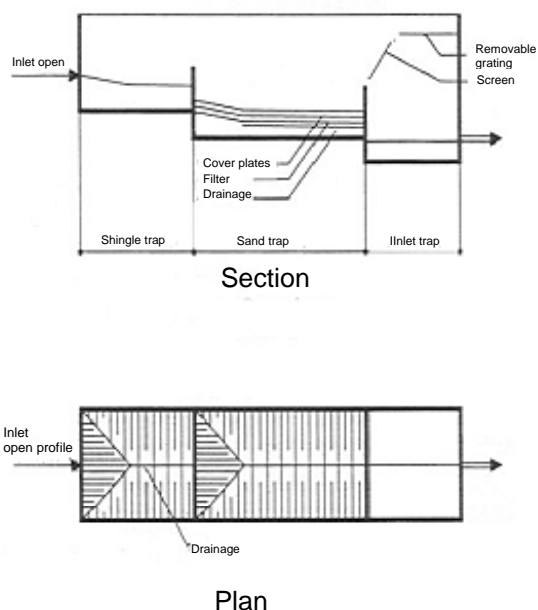
#### 5.7.2 Inlet Structure with Rectangular Shingle and Sand Trap

These inlet structures are to be employed with larger inflows and heavier shingle and sand conduction. With particularly heavy shingle conduction sufficiently dimensioned shingle traps are to be provided. For the sand trap the minimum length should be 3.0 m, the minimum width 1.0 m and the minimum depth 0.5 m.

A screen, preferably inclined, whose bar separation for reasons of safety is not to exceed 120 mm, is to be located in the outlet cross-section. In order that, with a blocked screen, an even more rapid flow is ensured there a free cross-section of 120 mm height should be available above this screen. It is recommended that there is a free flow crosssection of max. 120 mm provided above the invert.

The inlet shaft is to be covered by a removable grid with clear bar separation of max. 40 mm.

In order to avoid accidents the complete inlet structure is to be enclosed by a fence if necessary.



**Fig. 27: Inlet structure with shingle and sand trap**

## 5.7.3 Inlet Structure with Shingle and Sand Trap

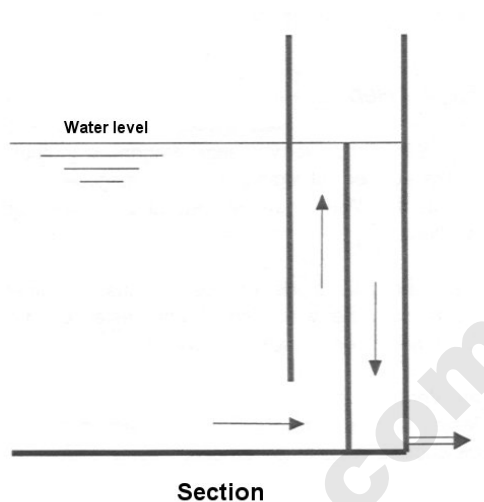
They can be planned if:

- an extensive de-sanding is to be achieved and
- there is a large water conduction.

In order not to disturb the sand trap effect the outlet must be located radially. Attention is to be paid to the avoidance of short circuit flow. Stop logs can be provided for staged evacuation of the water when clearing the sand trap. Incidentally the statements of Section 5.7.2 apply analogously.

## 5.7.4 Outlet Tower

Outlet towers can be employed if an impounded water level has to be regulated.



**Fig. 28: Outlet tower**

## 5.8 Outlet Structures

Outlet structures are installations at the point of outlet of sewers into surface waters.

With outflow into a near natural body of water attention is to be paid with the design of the outlet structure to an appropriate connection.

The design possibilities here are strongly dependent on local conditions. Ecological interests are to be taken into account. Natural construction materials (e.g. quarry stones, stone fillings, native woods) are to be preferred.

Discharge conditions are to be coordinated in agreement with the authority responsible for the body of water.

A cut-off wall or sheet piling, a row of piles or a safety embankment made from a pile of hydraulic bricks is to be arranged at the exit into the surface water.

The bottom and the embankments of the surface water above and below [the exit] as well as, if required, the opposite side to the sewer outlet are to be reinforced and secured against underwashing.

If required, a manhole is to be installed before the sewer exits into the surface water. The exit velocity of the water should be kept as low as possible, if necessary by widening the exit profile. Sewer exits are, for example, to be secured against any form of access by using a grating with a clear bar width of max. 120 mm.

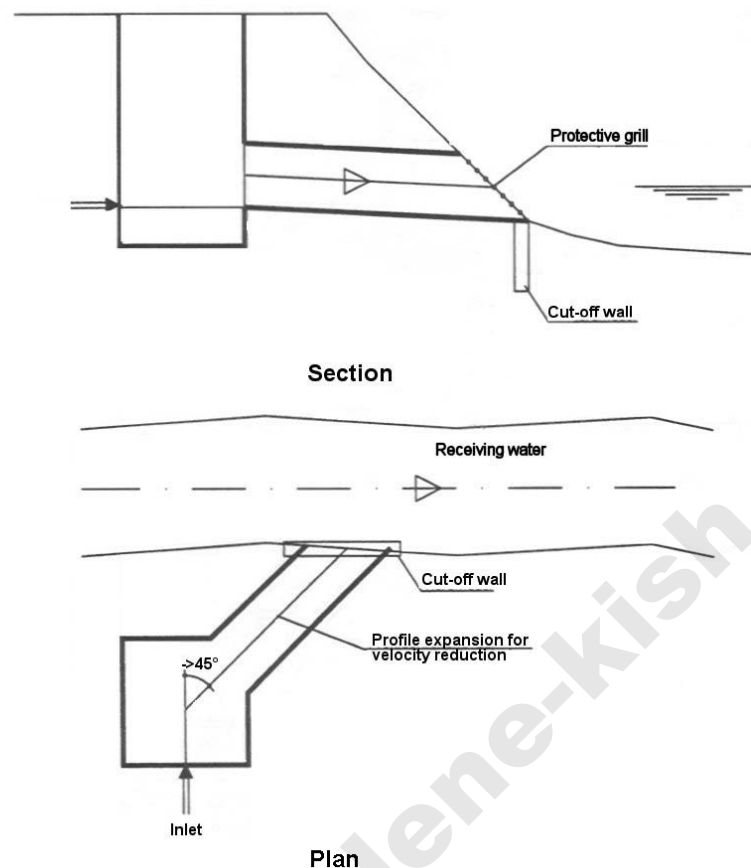


Fig. 29: Outlet structure

## 5.9 Gate Valve Structures

Gate valve structures are required in order to cut off temporarily a flow completely or partially, and/or prevent the ingress of flood water into the sewer.

The seal consists of a hand or motor operated gate valve. The drive units are as far as possible to be accommodated in a watertight chamber. Attention is to be paid to an explosion-protected construction. It is recommended that stop log slits are provided in front of and behind the gate valve for its maintenance. The threaded spindle and the articulated parts of the gate valve must be designed corrosion resistant. Lubrication points must be easily accessible and maintained regularly. For this a maintenance stage with foldable grating (safety grid) should be provided in manholes with larger profiles – as far as the construction height allows.

With sewer profiles which are to be closed against flood water it is recommended that double

gate valves are provided. Anti-flooding flaps are not suitable as secure protection against ingress of flood water. The operation of the flood seals should also be possible with flooding.

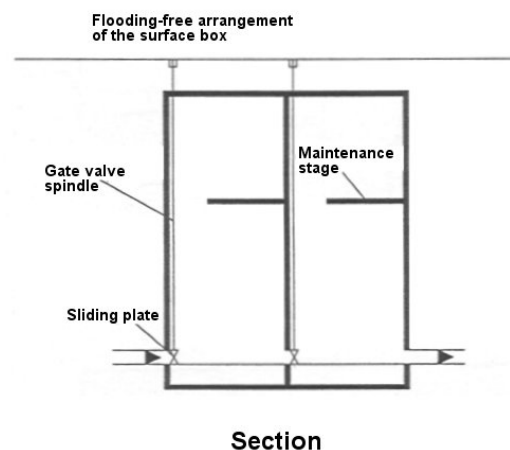


Fig. 30: Gate valve structure (Flooding gate valve)

## **6 Additional Information for Sewer Systems in Rurally Structured Areas**

The sewer network, with ca. 70 % of the total expenditure for municipal wastewater disposal, represents the largest cost factor. For the disposal of the in part uncontrolled widely spread urbanisation of rurally structured areas the planning of wastewater disposal must be therefore particularly matched to local conditions.

In accordance with Standard ATV-A 200E the planner should check for possible potential for savings within the scope of the draft planning.

To this belong, for example:

- Manholes at junctions and exit points only.
- Otherwise employment of inspection chamber (DN 400 to DN 600), which guarantees the correct operation and maintenance taking into account the available technical equipment.
- The separation of watertight manholes and inspection chambers is based on the technical working and safety aspects and should not exceed 200 m dependent on the pipe dimension.
- With transport pipelines, if necessary dispensing with shafts at every change of direction in position and height.

## **7 Stocktaking**

All structures in the sewer system are to be recorded for position and height, documented and archived following their construction. With this, the measurement should in general take place on the geodetic position and height network. As manholes and special structures are, as a rule, positioned at all changes of height and direction, the complete positional and height-related line of the sewer is also fixed by the position of the structure as this, as a rule, runs in a straight line between the manholes. It is therefore recommended that, additionally, all manholes and structures should be surveyed in for position to immovable reference points for their location during or following the completion of the construction measure. Where these reference points are lacking – for example in open terrain outside built-up areas – it can be sensible to carry out a progression parallel to the line of the sewer and to measure the facilities of the sewer system based on this. In special cases the structures are to be identified by indicating labels in accordance with DIN 4068.

The recording for height is to take place using a control levelling and is to be linked with an official datum point of altitude.

Inventory plans should, along with general plans if required also contain the longitudinal section and, with regard to their elaboration, correspond with DIN 2425. With special structures it can be necessary also to document the structure for the inventory. These structurally related inventory plans, in particular for special structures (e.g. inverted siphons, stormwater overflow structures, gate valve structures), are an indispensable requirement for sewer operation, maintenance and practice-oriented accident prevention.

## Bibliography

[Translator's note: Where there is a known official translation the title is given in English only. Otherwise a courtesy translation is given in square brackets after the German title]

### DIN Standard Specifications

|          |  |
|----------|--|
| DIN 105  | Clay bricks, Parts 1-4   |
| EN 752   | Drainage systems outside buildings<br>Part 1 General and definitions<br>Part 2 Requirements<br>Part 3 Planning<br>Part 4 Hydraulic calculation and environmental aspects<br>Part 5 Rehabilitation<br>Part 6 Pumping stations<br>Part 7 Operation and maintenance |
| DIN 1045 | Concrete and reinforced concrete; design and construction  |
| DIN 1212 | Step irons for staggered manhole steps,<br>Parts 1-3   |
| DIN 1221 | Schmutzfänger für Schacht-abdeckungen<br>[Dirt pans for manhole covers]  |
| DIN 1229 | Aufsätze und Abdeckungen für Verkehrsflächen<br>[Gully gratings and covers for traffic areas]  |
| EN 1610  | Construction and testing for drains and sewers   |
| DIN 1986 | Site drainage systems for buildings and private property   |
| DIN 2425 | Plans for public utilities, water resources and long-distance-lines;<br>Part 4 Sewer network drawings for of public sewerage systems   |
| DIN 4045 | Wastewater engineering - Vocabulary  |

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| DIN 4051     | Sewer clinkers; Requirements, testing, control  |
| DIN 4051     | Kanalklinker, Anwendungsbeispiele   |
| Bbl [Suppl.] | [Sewer clinkers, examples of application]   |
| DIN 4060     | Dichtmittel aus Elastomeren für Rohrverbindungen von Abwasserkanälen und -leitungen; Anforderungen und Prüfungen<br>[Polymer sealants for pipe connections of sewer and drains; requirements and tests]   |
| DIN 4068     | Wastewater; Indicating labels   |
| EN 476       | General requirements for components used in discharge pipes, sewers and drains  |
| prEN 12056   | Gravity drainage systems within buildings<br>Part 1: General and performance requirements<br>Part 2: Sanitary pipework, layout and calculation<br>Part 3: Roof drainage, layout and calculation<br>Part 4: Wastewater lifting plants, layout and calculation<br>Part 5: Installation and testing, instructions for operation, maintenance and use<br>Part 6: Acceptance and testing |
| DIN 19226    | Control Technology<br>Teil 1: Allgemeine Grundbegriffe<br>[Part 1: General basic terms]<br>Teil 2: Begriffe zum Verhalten dynamischer Systeme<br>[Part 2: Terms for the behaviour of dynamic systems]<br>Teil 3: Begriffe zum Verhalten von Schaltsystemen<br>[Part 3: Terms on the behaviour of control systems]   |

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|           | <p>Teil 4: Begriffe für Steuerungs- und Regelsysteme<br/>[Part 4: Terms for control systems]</p> <p>Teil 5: Funktionelle Begriffe<br/>[Part 5: Functional terms]</p> <p>Part 6: Terms and definitions of functional and constructional units</p> |
| DIN 19555 | <p>Steigeisen für einläufige Steigeisengänge -Steigeisen zum Einbau in Beton<br/>[Step irons for straight manhole steps – Step irons for installation in concrete]</p>   |

## ATV-DVWK Standards

ATV-A 110E: Hydraulic Dimensioning and Performance Verification of Sewers and Drains

ATV-A 111E: Standards for the Hydraulic Dimensioning and the Performance Verification of Stormwater Overflow Installations in sewers and drains

ATV-A 112: Richtlinien für die hydraulische Dimensionierung und den Leistungsnachweis von Sonderbauwerken in Abwasserkanälen und -leitungen [Standards for the Hydraulic Dimensioning and Performance Verification of Special Structures in Sewers and Drains]

ATV-A 128E: Standards for the Dimensioning of Stormwater Structures in Combined Sewers

ATV-A 134E: Planning and Construction of Wastewater Pumping Stations

ATV-A 142E: Sewers and Drains in Water Catchment Areas

ATV-A 166: Bauwerke der zentralen Regenwasserbehandlung und -rückhaltung – Konstruktive Gestaltung und Ausrüstung [Structures of Central Stormwater Treatment and Detention – Design and Equipment]

ATV-M 143E, Part 6: Inspection, Maintenance, Rehabilitation and Replacement of Sewers and drains Leak testing of existing, earth covered sewers and drains and shafts using water, air overpressure and vacuum

ATV-M 168E: Corrosion of Wastewater Facilities

ATV-M 157E: Sewer System Structure – Examples (in preparation)

## Other rules and standards

Forschungsgesellschaft für das Verkehrs- und Straßenwesen

Richtlinien für den Bau von Straßen, RAS-EW, Entwässerung, Ausgabe 1987

## Additional specialist literature

ATV: ATV-Handbuch Bau und Betrieb der Kanalisation [ATV Manual - Construction and operation of the sewer system] Verlag v. Wilhelm Ernst u. Sohn

Lautrich: Der Abwasserkanal – Handbuch für Planung, Ausführung und Betrieb [The sewer – Handbook for planning, implementation and operation], Verlag Paul Parey, Hamburg und Berlin

Hosang/Bischof: Abwassertechnik [Wastewater engineering] B.G. Teubner, Stuttgart

A. Kleinschroth: Strömungsvorgänge im Wirbelfallschacht [Flow processes in vortex drop shafts] Mitteilung Heft Nr. 8 des Institutes für Hydraulik und Gewässerkunde, TU München, Hydraulische Entwurfskriterien für Wirbelfallschächte

A. Kleinschroth, H. Wirth: Dimensionierung von Wirbelfallschächten unter Berücksichtigung verschiedener Zuflussbedingungen [Dimensioning of vortex drop shafts taking into account various inflow conditions]

A. Kleinschroth: Hydraulische Entwurfskriterien für Wirbelfallschächte [Hydraulic design criteria for vortex drop shafts], Steinzeug-Information, Ausgabe 30

Markus H. Kellenberger: Wirbelfallschächte in der Kanalisationstechnik [Vortex drop shafts in sewer system technology] Mitteilungen Heft Nr. 98 der Versuchsanstalt für Wasserbau, Hydrologie und Glaziologie, ETH Zürich

Schweizerischer Ingenieur- und Architektenverein, Zürich: Sonderbauwerke der Kanalisationstechnik 1, Dokumentation Nr. 40 [Special structures of sewer system technology 1, Documentation No. 40]

- Sonderbauwerke der Kanalisationstechnik 11, Dokumentation Nr. 53 [Special structures of sewer system technology 11, Documentation No. 53] (Absturzbauwerke, Regenüberläufe, Vereinigungsbauwerke, Düker), [Ramp manholes, stormwater overflows, junctions, inverted siphons]
- Würgler, Bern, Fehr (Zürich): Bau und Betrieb von Fallschächten [Construction and operation of drop shafts], Verbandsbericht Nr. 227 des Verbandes Schweizerischer Abwasserfachleute
- P. Volkart: Hydraulische Bemessung steiler Kanalisationsleitungen unter Berücksichtigung der Luftaufnahme [Hydraulic dimensioning of steep drains taking into account aerial photographs]
- P. Volkart: Steilleitungen bei Teilfüllung [Steep drains with partial filling] Wasserwirtschaft 81, 1991
- Dipl.-Ing. R. Rössert: Hydraulik im Wasserbau [Hydraulics in hydraulic engineering]
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- E. Naudascher: Hydraulik der Gerinne und Gerinnebauwerke [Hydraulics of channels and channel structures] Springer Verlag, Wien
- Schweizerischer Ingenieur- und Architektenverein, (Zürich): Kanalisation, Norm SJA 190, Kanalisationen, Referate; Dokumentation Nr. 38, Kanalisationen II, Referate; Dokumentation Nr. 88 [Sewer systems, Papers; Documentation No. 38, Sewer systems II, Papers, Documentation No. 88]
- K. Möhring: Möglichkeiten der Heranführung von Anschlusskanälen an Einsteigeschächten, [Possibilities of leading lateral sewers on to manholes], Korrespondenz Abwasser 5/87
- R. Kampen: Beton in der Abwassertechnik [Concrete in wastewater engineering], Korrespondenz Abwasser 7/87
- E. Bayer: Hinweise auf die Herstellung dauerhafter Betonbauwerke [Notes on the production of permanent concrete structures], Bauverlag Wiesbaden/Berlin
- E. Bayer, R. Kampen, N. Klose, H. Moritz: Betonbauwerke in Abwasseranlagen [Concrete structures], Bundesverband der Deutschen Zementindustrie, Köln
- L. Franke: Dipl.-Ing. D. R. Dreeßen, (TU Hamburg-Harburg): Dichtigkeit von Mauerwerk für Abwasseranlagen im Grundwasserbereich [Sealing of brickwork for wastewater facilities in areas of groundwater]
- Bielecki, Macke, Hoppe, Stahn: Reduzierung von Überlaufwassermengen in Mischkanälen mit einem luftgesteuerten Heberwehr [Reduction of overflow quantities using an aircontrolled siphon weir]
- I. Bonzel: Beurteilungsgrundsätze und technologische Maßnahmen für Beton in angreifenden Wässern, Böden und Gasen [Principles for assessment and technical measures for concrete in aggressive waters, soils and gases]
- N. Klose: Beton in Abwasseranlagen [Concrete in wastewater facilities], Beton 6/78
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