

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

## **STANDARD ATV-DVWK-A 139E**

### **Installation and Testing of Drains and Sewers**

June 2001

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

## **STANDARD ATV-DVWK-A 139E**

### **Installation and Testing of Drains and Sewers**

June 2001

ISBN 978-3-935669-81-8



Publisher/Marketing:

Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e. V.

German Association for Water, Wastewater and Waste

Theodor-Heuss-Allee 17 • 53773 Hennef • Germany

Tel.: +49 2242 872-333 • Fax: +49 2242 872-100

E-Mail: [kundenzentrum@dwa.de](mailto:kundenzentrum@dwa.de) • Internet: [www.dwa.de](http://www.dwa.de)

## Notes for Users

This ATV Standard is the result of honorary, technical-scientific/economic collaboration which has been achieved in accordance with the principles applicable therefor (statutes, rules of procedure of the ATV and ATV Standard ATV-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.

Die Deutsche Bibliothek [The German Library]– CIP-Einheitsaufnahme

ATV-DVWK, German Association for Water, Wastewater and Waste:  
ATV-DVWK Set of Rules and Standards [Media combination] / ATV-DVWK, Water,  
Wastewater, Waste. -Hennef : GFA, Publishing Company of ATV-DVWK Water,  
Wastewater, Waste

Previously under the title of: German Association for Water Pollution Control: ATV-Rules  
and Standards

ATV-DVWK Standard  
A 139E. Installation and Testing of Drains and Sewers.

ISBN 3-935669-81-X

All rights, in particular those of translation into other languages, are reserved. No part of this Standard may be reproduced in any form - by photocopy, microfilm or any other process - or transferred into a language usable in machines, in particular data processing machines, without the written approval of the publisher.

Publisher: ATV-DVWK German Association for Water, Wastewater and Waste  
Theodor-Heuss-Allee 17, D-53773 Hennef

Distribution: GFA, Publishing Company of ATV-DVWK, Water, Wastewater, Waste,  
Hennef

Original German edition produced by: DCM, Meckenheim

© Gesellschaft zur Förderung der Abwassertechnik e.V. (GFA), Hennef 2001

# 1 Foreword

The new edition of ATV-DVWK Standard A 139E presented here contains the supplementary information and more extensive comments on DIN EN 1610, which are held to be necessary by the specialist circles involved.

Prerequisite for a long-term functional and watertight sewer network is, in addition to the employment of suitable and resistant materials, above all, the correct production of the sewers and drains.

The solution to be sought is be an overall economically optimised solution. In addition to investment costs the operating costs and the service life are to be taken into account. The recycling of the components and materials used should be considered in the planning.

Based on the Mandate of the Commission of the European Community and, equally, on that of EFTA dated 24 May 1991, CEN (Comité Européen de Normalisation) has taken on the task of aligning all technical rules within the field of wastewater technology and of elaborating European Standard Specifications for the defined areas and products. In the meantime these tasks have very extensively been completed with the inclusion of the technical rules for the laying and testing of drains and sewers outside buildings.

In Germany, in addition to DIN 4033, ATV Standard ATV-A 139 "Standards for the Fabrication of Sewers and Drains" (October 1988 Edition) were available for this and were introduced as a basis for discussion within the framework of the work of the responsible CEN Technical Committee, TC 165 - Wastewater Technology, hereafter WG 10/TG2. The result of the work at CEN level consists of the accepted and, in Germany, as DIN EN Standard Specification converted document DIN EN 1610 "Laying and testing of drains and sewers" (October 1997), whose contents thus describe the generally recognised status of technology in Europe.

As a supplement it is possible to formulate statements which are not or not completely contained in European standards, in order to cover the necessary national contents.

DIN EN 1610 "Laying and testing of sewers and drains" lays down requirements on the correct production and testing of drains and sewers.

The Standard presented here is to aid the planning engineer in recognising the existing leeway present in DIN EN 1610 and to use it creatively. It is to ease the utilisation and interpretation in DIN EN 1610.

The Standard contains supplements and notes for the installation of pipes, their testing, on materials used as well as the acceptance of the structure. The requirements on qualification of the executing firm are equally defined.

In order to ensure uniformity of text, some repeating of the text of statements from DIN EN 1610 is necessary.

Appendices A and B contain requirements on model installation instructions as well as information on economic aspects.

## Publisher

This ATV Standard has been elaborated by the ATV-DVWK Working Group ES-5.1 "General Guidelines for the Construction of Drainage Systems" within the ATV-DVWK Specialist Committee ES-5 "Design of Drainage Systems".

Working Group ES-5.1 has the following members

Dipl.-Ing. Horst Adler, Köln  
 Dipl.-Ing. Ralf Bosse, München  
 Dipl.-Ing. Peter Brune, Gelsenkirchen  
 Dipl.-Ing. Uwe Dickmanns, Coesfeld  
 Dipl.-Ing. Karl-Heinz Flick, Köln  
 Dr.-Ing. Helmuth Friede, Bad Honnef  
 Bau-Techn. Heinz Herz, Kehl  
 Dr.-Ing. Karl Hornung, Stuttgart  
 Dipl.-Ing. Karsten Körkemeyer, Bochum  
 Dipl.-Ing. Ulrich Kusche, Niemetal-Imbsen  
 Dipl.-Ing. Peter Lutz, Kehl  
 Dipl.-Ing. Werner Neubauer, Köln  
 Dipl.-Ing. Gerd Niedrée, Bonn  
 Dipl.-Geol. Andreas Paetz, Berlin  
 Dipl.-Ing. Hans-Joachim Purde, Baldham  
 Dipl.-Ing. Franz Rapp, Regensburg  
 Dipl.-Ing. Wolfgang Rieger, München  
 Dipl.-Ing. Helmut Schgeiner, Berlin  
 Dr.-Ing. Rolf Schlichting, Aurich  
 Dipl.-Ing. Jürgen Schulte, Pulheim  
 Dipl.-Ing. Helmut Stecha, Wiesbaden  
 Ltd. BD Dipl.-Ing. Dieter Sternagel, Kassel (Chairman)  
 Dipl.-Ing. Dieter Wengler, Rheinfelden

<b>Contents</b>	<b>Page</b>
<b>Notes for users</b>	2
<b>1 Foreword</b>	3
<b>Publisher</b>	4
<b>2 Area of Application</b>	7
<b>3 Definitions and symbols</b>	7
3.1 Definitions	7
3.2 Symbols	8
<b>4 General</b>	8
4.1 Technical principles	8
4.2 Ensuring the design load	9
<b>5 Components and materials</b>	10
5.1 General	10
5.2 Components	10
5.3 Materials for the pipeline zone	11
5.4 Materials for the main backfill	11
<b>6 Production of the pipeline trench</b>	11
6.1 Trenches	11
6.2 Trench width	11
6.3 Stability of the trench	13
6.4 Trench sole	13
6.5 Drainage	13
<b>7 Pipeline zone and shuttering</b>	14
7.1 General	14
7.2 Design of bedding	14
7.2.1 Bedding Type 1 (standard design)	15
7.2.2 Bedding Type 2	16
7.2.3 Bedding Type 3	16
7.3 Special design of bedding or carrier construction	16
<b>8 Placement of pipes</b>	18
8.1 Preparatory work	18
8.2 Delivery, loading and unloading on and transport to the construction site	18
8.3 Storage	19
8.4 Lowering into the pipe trench	19
8.5 Laying	19
8.6 Special types of construction	20
8.7 Support and anchoring	20
8.8 Shafts and inspection openings	20

<b>9</b>	<b>Connections to pipes and shafts</b>	20
<b>10</b>	<b>Testing during pipe installation</b>	21
10.1	General	21
10.2	Visual inspections	22
10.3	Testing of sealing	22
10.4	Testing of earthworks	22
<b>11</b>	<b>Backfilling of pipe trench</b>	23
11.1	Compacting	23
11.2	Design of pipeline zone	23
11.3	Implementation of the main backfill	24
11.4	Removal of shuttering	25
11.5	Making good the surface	26
<b>12</b>	<b>Final monitoring and/or testing of pipelines and shafts following backfilling</b>	26
12.1	Visual inspection	26
12.2	Sealing	26
12.3	Pipeline zone and main backfill	26
12.3.1	Compacting	27
12.3.2	Pipe deformation	27
<b>13</b>	<b>Procedures and requirements for the testing of gravity pipelines</b>	27
13.1	General	27
13.1.1	Preparatory measures	28
13.1.2	Requirements on the equipment to be employed and on the execution of the leak testing	29
13.2	Pipeline testing using air	31
13.3	Pipeline testing using water	32
13.4	Testing of individual connections	33
13.4.1	Testing using water	33
13.4.2	Testing using air	33
<b>14</b>	<b>Testing of pressure pipelines</b>	34
<b>15</b>	<b>Qualifications</b>	35
	<b>Literature</b>	35
	<b>Appendix A: Requirements on model installation instructions</b>	39
	<b>Appendix B: Economic aspects</b>	40
	General	40
	Assessment	40
	Technical service life	40
	Influence of the technical design on the active life	40

## 2 Area of Application

This Standard applies for the fabrication and testing of earth covered and surface sewers and drains installed outside buildings.

## 3 Definitions and Symbols

### 3.1 Definitions

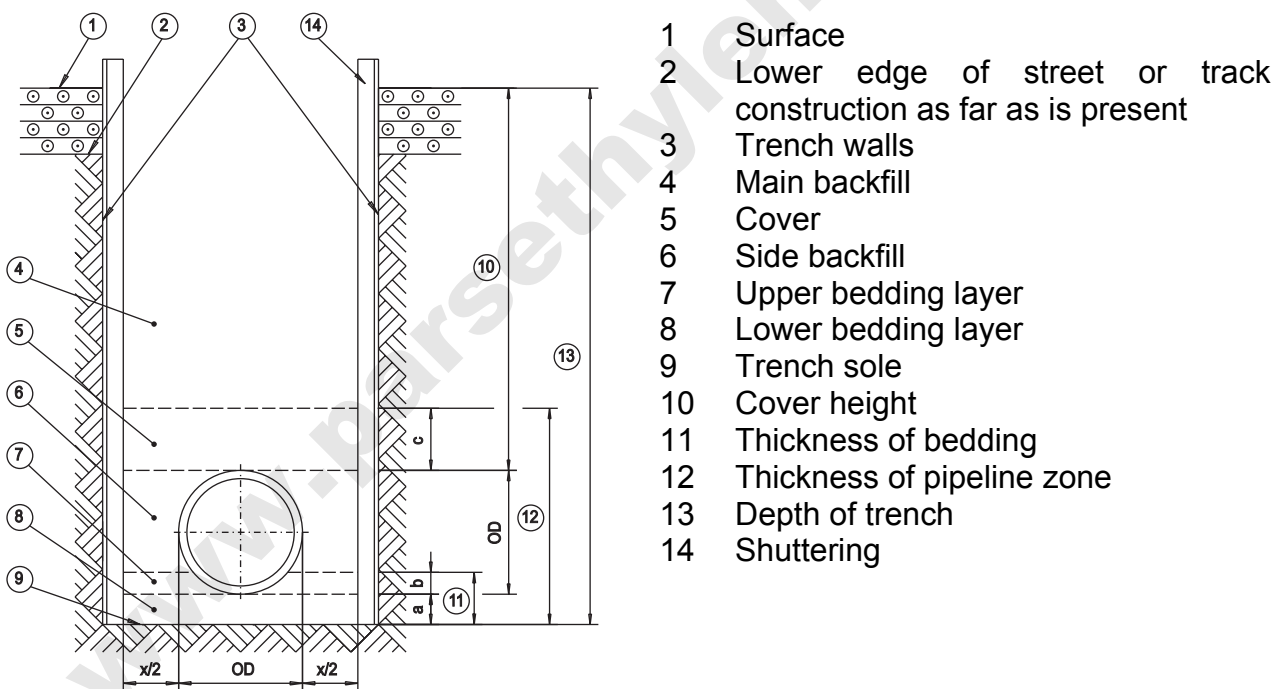
The following term is used in ATV Standard ATV-DVWK-A 139E as supplement to the definitions in DIN EN 1610:

#### Planning

Description of all preparatory services for the production of a structure.

Planning can rest in the area of responsibility of the various persons concerned with the project, therefore those responsible are to be named.

Further definitions are to be taken from Fig. 1



**Fig 1: Pipe, main backfill and pipeline zone (diagram based on DIN EN 1610)**



### 3.2 Symbols

a	Thickness of lower bedding layer
b	Thickness of upper bedding layer
c	Thickness of cover
$d_i$	Measured internal diameter in the test length
DN	Nominal width
$D_{Pr}$	Proctor density
$E_{V2}$	Module of deformation
OD	Outside diameter of pipe shaft
p	Test pressure
$p_o$	Pressure at start of measurement
$\Delta p$	Permitted pressure difference
t	Test time
$t_B$	Settling time
U	Degree of irregularity
V1, V2, V3	Compactability classes
x/2	Minimum working space between pipe and trench wall or trench shuttering (shoring)
$2\alpha$	Support angle
$\beta$	Gradient of slope

## 4 General

### 4.1 Technical Principles

The carrier system pipe/ground is essentially determined from the combination of components as well as from the artificially created and/or naturally existing environment (inter alia bedding, side and main backfills, compacting, types of soils, groundwater, ground bearing capacity). It essentially influences the function and service life of the pipeline.

The carrier system must be able to accept existing and future loadings with sufficient safety. Criterion here, in addition to the load distribution, is the secure function of the sewer or drain.

The accurate conversion of the planning specifications is decisive for the quality of the construction works. The scope and the requirements of the engineering services to be provided are to be agreed between the customer and the planner for the individual case existing (see ATV Advisory Leaflet M 101E).

The static and dynamic loads affecting the sewers and drains are to be laid down during planning. To these also belong loadings due to construction conditions, which can have a determining effect on dimensioning.

## 4.2 Ensuring the Design Load

The carrier system pipe/soil must be verified, decided upon or laid down before implementation. This includes the static verification of components taking into account installation in the pipe trench, the planned bedding, side backfill, covering and main backfill as well as removal of shuttering.

Verification takes place on the basis of a correct implementation in accordance with the status of technology. As far as minima are given, for example, trench widths, design of supports, these must be matched to the requirements of a correct implementation.

The accuracy of the design load is to be monitored and ensured continuously by the construction supervision agency during implementation. With changes to design a new static verification with modified design loads is to be carried out if required. This verification is one task of the planning (see Chap. 3).

Changes to loadings can, for example, occur with:

- changes of ground conditions,
- influence of the groundwater level,
- soil exchange in the pipe trench,
- change of the relative slope (e.g. through exchange of soil),
- increased compaction above the pipe,
- modification of the shuttering,
- modification of the retreat,
- ramming down of the pipeline with the shuttering.

Following procedures are recommended for verification of the carrier system:

- the planner lays down the carrier system,
- design loads are to be announced before implementation. To this belong the type and method of the trench design, shuttering, bedding layer, side backfill, covering, construction conditions etc. These must be entered in an object questionnaire, for example in accordance with ATV Standard ATV-A 127E.
- the static verification in accordance with ATV-A 127E must exist and its contents known on the construction site.
- the minimum trench width is to be determined according to Tables 1 and 2.
- the agreement of the design loads in planning and in implementation is to be checked. With modifications new static verification is to be produced if required.
- design release takes place via the planner.

The procedure is to be documented within the scope of the quality assurance system.

## 5 Components and Materials

### 5.1 General

Selection of materials with regard to suitability and application is a planning task. Criteria for the selection of the material can, inter alia, be:

- wastewater properties
- soil/groundwater properties
- soil mechanical properties.

Supplementary manufacturer's instructions and details for components and materials are to be observed.

Recycled materials are to be assessed with particular care. Their suitability and environmental compatibility are to be verified. For this points for assessment are given, inter alia, in:

- Gemeinsamer Runderlass für das Land Nordrhein-Westfalen [Common Regulation for the German Federal State of Nordrhein-Westfalen] dated 30 April 1991<sup>1</sup> or comparable regulations in other German Federal States.
- Recycling-Baustoffe für den Straßenbau, Gütesicherung [Recycled Materials for Road Construction, Quality Assurance] RAL-RG 501/1<sup>2</sup>.

Attention is to be paid in particular to:

- production/origin,
- processing and storage,
- volume stability,
- resistance against leaching,
- grain strength,
- grain size distribution,
- grain shape,
- compactability,
- purity.

The materials may prejudice neither groundwater nor soil.

### 5.2 Components

Before placing an order, the planner should request verification of regular quality surveillance for the materials and components to be delivered. This can be achieved through:

<sup>1</sup> Ministerialblatt für das Land Nordrhein Westfalen, Vol. 44, No. 45 dated 18 July 1991

<sup>2</sup> RAL Gütegemeinschaft Recycling-Baustoffe e. V., Kronenstraße 55-58, D-10117 Berlin, Tel. +49-30-2 03 14-5 54, Fax +49 -30-2 03 14-5 65

- confirmation of regular surveillance by a surveillance/quality protection association or by a recognised testing institute

and

- presentation of the latest surveillance report, which may not be older than 12 months, by the outside monitoring agency.

### 5.3 Materials for the Pipeline Zone

The planner is to determine the material for the pipeline zone with regard to type of soil, grain size, silt and clay component and, if required, associated grain size distribution curve.

Interactions between existing soil and groundwater are to be taken into account dependent on the material and dimensions of the component.

Recommended bedding types and types of design are presented in Chap. 7.2.

### 5.4 Materials for the Main Backfill

The planner lays down the thickness of the covering. Here, particular attention is to be paid to the largest grain in the main backfill above the pipeline zone.

## 6 Production of the Pipeline Trench

The following points are, inter alia, necessary for the contractual regulation between the customer and the contractor:

- security of the construction site,
- perpetuation of evidence on buildings, structures, roads and other facilities within the area of influence of the construction site as far as is necessary,
- avoidance of impairment of the environment,
- maintenance of traffic safety and the co-ordination of tasks,
- position of and access to supply and disposal facilities within the construction site, manhole covers, gate valves, transformer stations etc.

Working space widths of the construction trench for shafts and special structures are regulated in DIN 4124

### 6.1 Trenches

With the preparation of the trenches it is to be examined whether the excavated material can be reinstalled (see Chap. 11).

### 6.2 Trench Width

The minimum trench widths necessary for the placement of the pipes and for the production of bedding layers, side backfill and covering using layered placement with sufficient compaction, are laid down in DIN EN 1610 depending on pipe diameter and the trench depth. With this, the values given in Tables 1 and 2 apply, whereby the

respectively greatest value is relevant. For the determination of the position at which the respective minimum clear width is to be measured, the appropriate statements of DIN 4124 are to be observed.

If these trench widths are deviated from, the design loads are to be checked (see Chap. 4.2).

The trench width produced must correspond with the structural analysis.

With several pipelines (e.g. supply and disposal pipelines) in one trench, material and system-dependent minimum separations are to be taken into account in the trench width.

Equipment used for excavation is to be matched to the trench width to be produced. This applies also for the production of laterals.

DN	Minimum trench width (OD + x) [m]		
	Supported trenches	Unsupported trenches	
		$\beta > 60^\circ$	$\beta \leq 60^\circ$
$\leq 225$	OD + 0.40	OD + 0.40	
$> 225$ to $\leq 350$	OD + 0.50	OD + 0.50	OD + 0.40
$> 350$ to $\leq 700$	OD + 0.70	OD + 0.70	OD + 0.40
$> 700$ to $\leq 1200$	OD + 0.85	OD + 0.85	OD + 0.40
$> 1200$	OD + 1.00	OD + 1.0	OD + 0.40
With the details OD + x, x/2 represents the minimum working space between the pipe and trench wall or trench shuttering (Pölzung). With this: OD is the outside diameter in m, $\beta$ is the angle of slope of the unsupported trench measured to the horizontal			

**Table 1: Minimum trench width dependent on the nominal width DN <sup>3)</sup>**

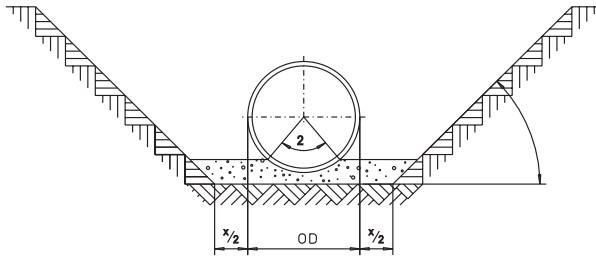
Trench depth [m]	Minimum trench width [m]
$< 1.00$	No minimum trench width laid down
$\geq 1.00$ to $\leq 1.75$	0.80
$> 1.75$ to $\leq 4.00$	0.90
$> 4.00$	1.00

**Table 2: Minimum trench width dependent on trench depth <sup>4)</sup>**

<sup>3)</sup> DIN EN 1610 (1997-10), p.5, Table 1.  
Reproduced by permission of DIN German Institute for Standardisation e.V.  
Relevant for the application of the standard specification is its edition with the latest date of issue, which can be obtained from Beuth Verlag GmbH, Burggrafenstraße 6, D-10787 Berlin.

<sup>4)</sup> DIN EN 1610 (1997-10), p.5, Table 2  
Reproduced by permission of DIN German Institute for Standardisation e.V.

With the details OD + x, x/2 (see Fig. 1 and Fig. 2 respectively) represents the minimum working space between the pipe and trench wall or trench shuttering.



**Fig. 2: Slope angle, width of working space**

DN is the nominal width (DIN 4263). The minimum trench width is determined exclusively from the external diameter (OD = outside diameter) of the pipe shank. With non-circular cross-sections the classification of the DN Group (Table 1) corresponds with the clear height. The minimum trench width is determined from the addition of the largest external width and the value  $x$  from the table.

### 6.3 Stability of the Trench

The trench walls must be sloped or supported with shuttering in accordance with the accident prevention regulation "Construction Works" (BGV C 22) and DIN 4124. In addition to the standard shuttering given in DIN 4124 all types of shuttering can be employed which have been verified in a structural analysis. Shuttering equipment has to be approved by the trade association.

### 6.4 Trench Sole

The trench must be free of water for the placement of pipes, production of pipe connections, bedding and side backfill. If drainage pits are planned there must be permanent measures to prevent fine soil particles entering these, in particular from the area of the bedding and side filling. This can be achieved through suitable measures, for example through wrapping in rot-proof filter fabric (geotextile). If necessary, soil stabilisation is to be undertaken (see Figs. 7 and 8 in Chap. 7.3).

Following the ending of the drainage, the drainage system is to be closed by section. Concrete aprons or puddle clay at the shafts have proved useful for the prevention of a longitudinal drainage effect in the pipe trench.

### 6.5 Drainage

See DIN EN 1610, Chap. 6.5.

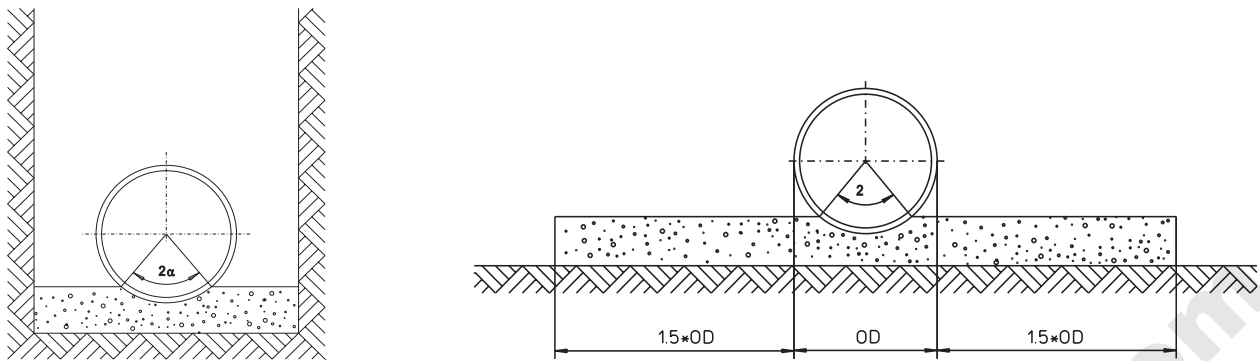
## 7 Pipeline Zone and Shuttering

### 7.1 General

The quality of earthworks in the area of the pipeline zone essentially influences the bearing capacity, the settling behaviour, the serviceability, operational safety and the agreed service life of the sewers and drains.

DIN EN 1610 defines the pipeline zone made up from the bedding, side filling and covering, as the width of the trench with trench laid pipelines, as the width of four times

the outside diameter of the pipe with embankment laid pipelines or very wide trenches (see Fig. 3).



**Fig. 3: a) Pipe in trench**

**b) Pipe in embankment, width of the pipeline zone**

The following materials are particularly suitable for the pipeline zone:

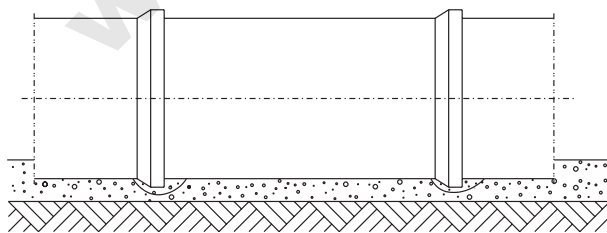
- sand
- very sandy gravel with max. grain size = 22 mm, proportion of sand > 15 % and the coefficient of uniformity  $U \geq 10$ ,
- single-grain gravel,
- screenings-chippings mix with max. grain size 11 mm for pipes < DN 900 and max. grain size = 20 mm for pipes  $\geq$  DN 1000
- hydraulically bonded materials,
- recycled materials (see Chap. 5.1)

Selection is dependent on pipe material, type of pipe and respective nominal width. Details from the pipe manufacturer are to be observed.

## 7.2 Design of Bedding

The bedding must ensure an even pressure distribution under the pipe in the supporting area (see Fig. 4). With this cracks, deformation, point bedding and thus leakages are avoided.

The thickness of the bedding of the upper bedding layer must at least correspond with the lower bedding layer.



**Fig. 4 Pipe shank support and sleeve imbedding before packing down**

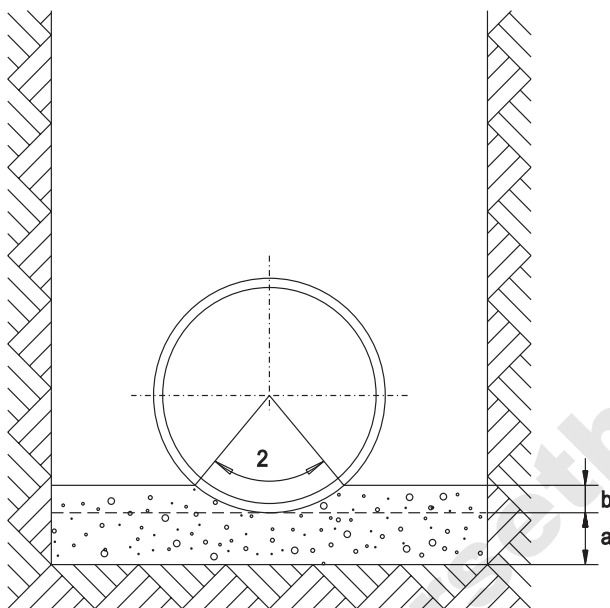
Therefore, following production of the pipe connection, the packing down of the pipe is to be carried out carefully, e.g. using narrow handhammers. Compaction of the lateral pipe curvature, in practice, takes place using light mechanical equipment (see Table 4).

The type of bedding is laid down within the framework of planning. Bedding Type 1 has proved itself as standard design.

### 7.2.1 Bedding Type 1 (Standard Design)

In cases where no suitable soil exists for an immediate bedding, the trench sole is to be excavated deeper and a bedding made up from compactable material.

The thickness of the lower bedding layer given in DIN EN 1610  $a = 100 \text{ mm}$  is a minimum value. In order to reduce the danger of damage and settling the thickness  $a$ , dependent on the diameter of the pipe should be increased to  $100 \text{ mm} + 1/10 \text{ DN in mm}$  (see Fig. 5).



**Fig. 5: Bedding Type 1**

With very firm or closely layered subsoil (e.g. rock, claystone, marl, glacial gravel) the lower bedding layer under the pipe shank should be carried out with a thickness  $a = 100 \text{ mm} + 1/5 \text{ DN}$ ; it must be at least 150 mm thick, in order to avoid load concentrations (see Fig. 5).

The planner is to specify the thickness  $a$ .

The thickness  $b$  of the upper bedding layer must correspond with the structural analysis and/or the planning specifications. It results from the bearing angle.

With

- a bearing angle of  $90^\circ$ :  $b = 0.15 \text{ OD}$
- a bearing angle of  $120^\circ$ :  $b = 0.25 \text{ OD}$



With flexible pipes it is to be ensured, through careful compaction by layers of the backfill material up to the height of the crown, that the bearing angle of  $180^\circ$  ( $b = 1/2$  OD) is achieved.

### 7.2.2 Bedding Type 2

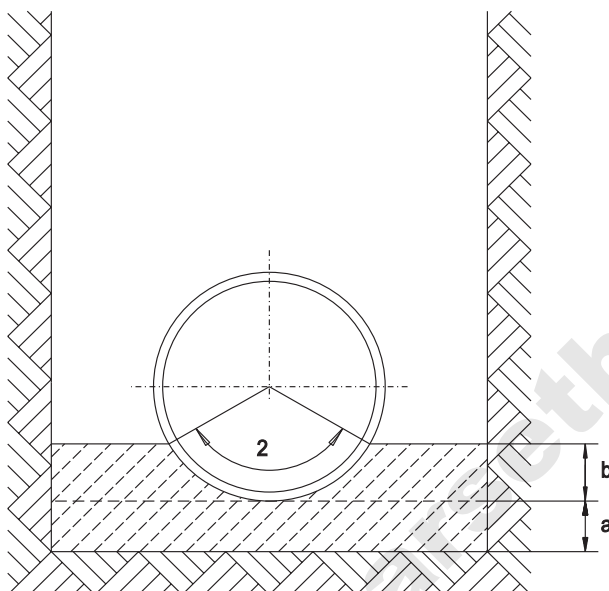
See DIN EN 1610, Chap. 7.2.2. Details from the pipe manufacturer are to be observed.

### 7.2.3 Bedding Type 3

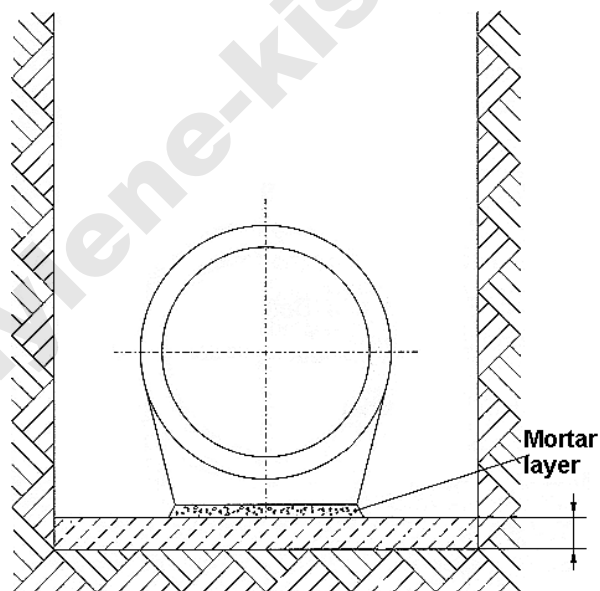
See DIN EN 1610, Chap. 7.2.3. Details from the pipe manufacturer are to be observed.

## 7.3 Special Design of Bedding or Carrier Construction

With construction sites susceptible to subsidence special measures such as, for example, exchange of soil, lean-mix concrete/concrete supports, piles for pipe supports, are to be employed (see also DIN EN 1610 Chaps. 7.3. and 5.4).



**Fig. 6a: Bedding Type 1 - concrete bedding for pipes without foot, upper bedding concreted after pipe installation,  $a = 50 \text{ mm} + 1/10 \text{ DN in mm}$ , min  $a = 100 \text{ mm}$**

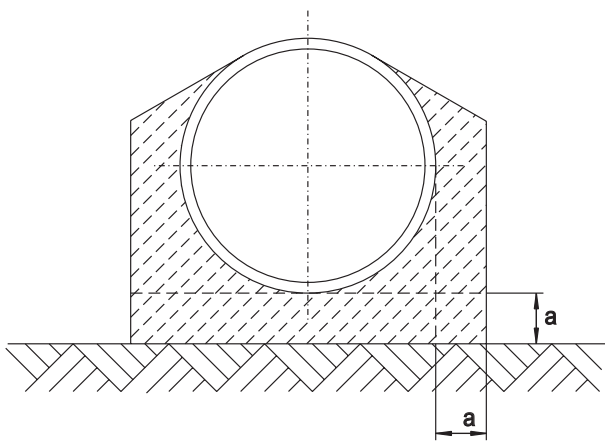


**Fig. 6b: Bedding Type 1 - concrete bedding for pipes with foot, installed on a layer of mortar,  $a = 50 \text{ mm} + 1/10 \text{ DN in mm}$ , min  $a = 100 \text{ mm}$**

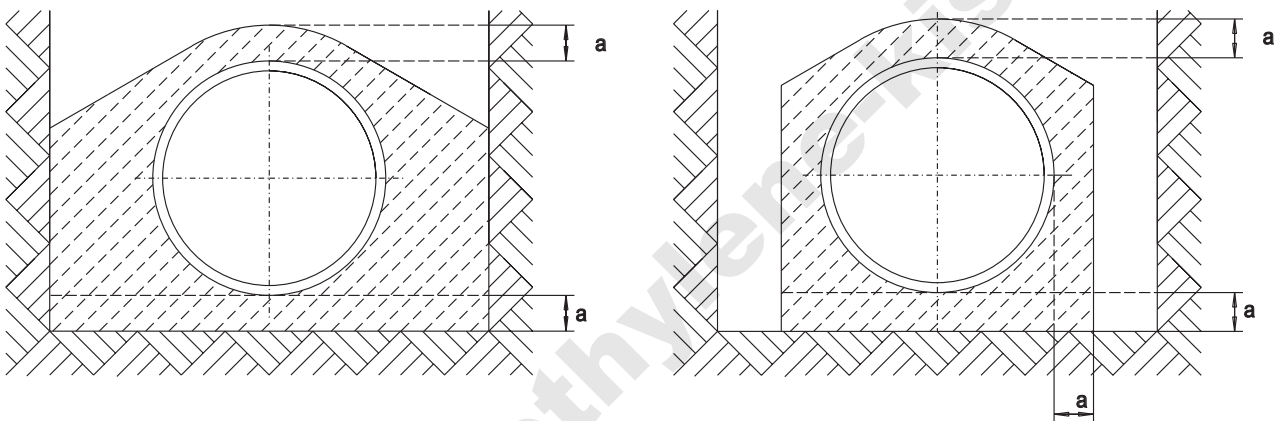
With flexible pipes an intermediate layer between pipe and concrete slab made from compactable sand and fine gravel with minimum thickness of the lower bedding layer in accordance with Sect. 7.2.1 has to be provided. If a concrete jacketing is planned this is to be so designed that the complete static loading can be by it.

With locally varying types of soil and groundwater levels, very sloped trench soles and/or very tightly layered soils or rock, a concrete bedding can be necessary (see Fig. 6a and b).

If, with this, pipes with a foot are employed these are to be installed on a layer of mortar (see Fig. 6b).



**Fig. 6c: Example for partial jacketing using concrete,  $a = 1/4$  DN in mm, min  $a = 100$  mm**



**Fig. 6d: Example of complete jacketing using concrete  $a = 1/4$  DN in mm, min  $a = 100$  mm**

At least a B 15 is to be applied as concrete for the bedding.

The design and the quality of the concrete for a partial or complete jacketing is to be determined by the planner

The trench is to be kept free of water until the concrete has hardened.

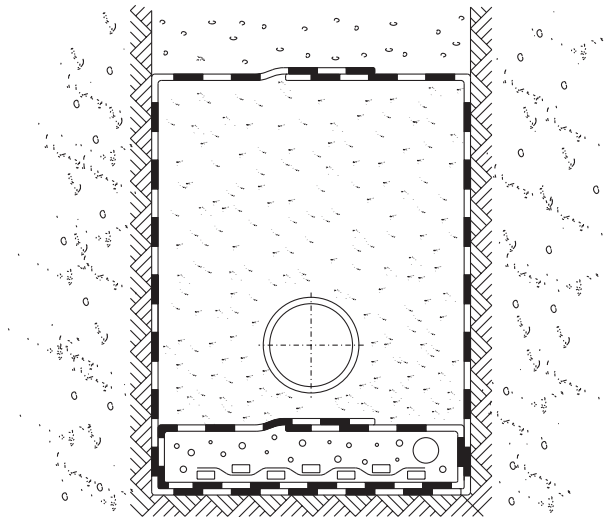
The execution of a concrete bedding has an influence on the relative outreach and is to be taken into account in the structural analysis.

With placement in trenches it is recommended to concrete right up to the trench wall or up against the shuttering. In trenches with shuttering a flexible separation layer (e.g. polystyrene) is to be provided in order to avoid damage to the pipe on removal of the shuttering.

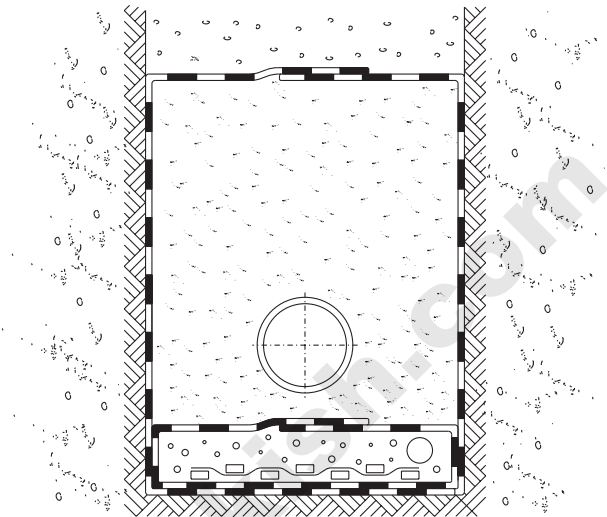
Pipe connections to shafts and structures are to be articulated. The concrete bedding must be interrupted at these points. The same applies for the pipeline insofar as

subsidence is to be expected. Type and scope of the interruptions are to be laid down by the planner.

Examples for the implementation of construction using geotextile can be seen in Figs. 7 and 8.



**Fig. 7: Example for implementation of construction using geotextile** <sup>[1]</sup>



**Fig. 8: Example for implementation of construction using geotextile and soil stabilisation** <sup>[1]</sup>

## 8 Placement of Pipes

Manufacturer's instructions are to be observed as supplementary to the statements in DIN EN 1610 and in this Standard.

### 8.1 Preparatory Work

See DIN EN 1610, Chap. 8.1.

### 8.2 Delivery, Loading and Unloading on and Transport to the Construction Site

On delivery, materials and components are to be examined for faults. In addition it is to be established whether the designation according to the respectively valid standard is present. It is to be checked whether planning specifications agree with the delivery.

[1] Schlichtung, Rolf: Rohrverlegung in weichen Böden, Handbuch Wasserversorgungs und Abwassertechnik [Pipe laying in soft ground, Manual of water supply and wastewater engineering] / 01, 1965, Vulkan-Verlag Essen

Pipe and shaft components with factory installed anchoring systems are to be so produced and so employed that no damage occurs. In particular damage due to corrosion and/or the therefrom resultant leakage is to be avoided. Components with laying slits, that means openings which go right through the walling, are not to be employed.

### 8.3 Storage

See DIN EN 1610, Chap. 8.3.

### 8.4 Lowering into the Pipe Trench

Pipes, pipeline components, sealants and, if required, existing external and internal protection are to be examined for damage before lowering into the pipe trench. Repaired components may only be installed, if they correspond with the planning requirements.

The pipes are to be lowered correctly into the pipe trench, e.g. using lifting equipment applying laying hooks with safety devices, ropes or protected belts. Damage to the pipes, for example through unsuitable holding or gripping devices, through unauthorised suspension devices or through impact is to be avoided.

The accident prevention regulations and operating instructions for the lifting aids as well as the installation instructions of the pipe manufacturer are to be observed.

### 8.5 Laying

With the production of pipe connections an open butt joint of at least 5 mm between the pipes, depending on the pipe technology, is to be maintained. Larger separations between the faces of the pipes can be necessary, for example for movements from expected settling, sinking or similar.

The maximum gap should be laid down by the customer, taking into account the connection technique and pipe geometry. The given or necessary butt joint must be observed in order to avoid damage due to secondary bending at the pipe ends and to allow expansion.

Only that equipment may be employed which allows a controlled connecting of the pipes. A shearing-off of the sealing element or bursting of the pipe sleeve can thus be avoided. Pushing the pipes together using the digger blade is not recommended due to uncontrollable development of forces and due to possible damage unless the pipe manufacturer allows this for his product. The special requirements with regard to work safety are to be maintained.

Following coupling the level is to be monitored and, if required, adjusted. Corrections of position through pressure, pushing or blows using the digger blade or other heavy construction plant are not permitted.

Elastomer seals can also be installed with frost as long as they have the necessary elasticity which, as a rule, is the case down to - 10° C. The temperature ranges given by the manufacturer are to be observed. Loose seals can be tempered before installation.

### 8.6 Special Types of Construction

Concrete, reinforced concrete and brickwork can be considered as materials for sewers, which are produced on site.

Water impermeable concrete in accordance with DIN 1045 with smooth internal surface, which must be at least resistant to the "heavy" degree of attack (see DIN 4030), is to be

used. Arrangement and shape of joints are to be so designed that these are permanent and watertight.

Brickwork is to be carried out using sewer bricks DIN 4051 with cement mortar of mortar Group III DIN 1053, Part 1.

### **8.7 Support and Anchoring**

See DIN EN 1610, Chap. 8.7.

### **8.8 Shafts and Inspection Openings**

In addition to the statements in DIN EN 1610, Chap. 8.8. the requirements in accordance with ATV-DVWK Standard ATV-A 157 [not yet available in English] are to be observed.

## **9 Connections to Pipes and Shafts**

With the construction of the main sewer, the service pipes should be produced in accordance with DIN EN 752. In the case that the service pipe is not constructed at the same time as the main sewer, the planned inlet opening is to be secured permanently, proofed against pressure and against water at the main sewer, using a non-corroding seal.

Connection openings produced at a later date may be produced using suitable core drilling equipment so far as no branch pipe is installed. Tools and processes are to be selected and applied in line with the system.

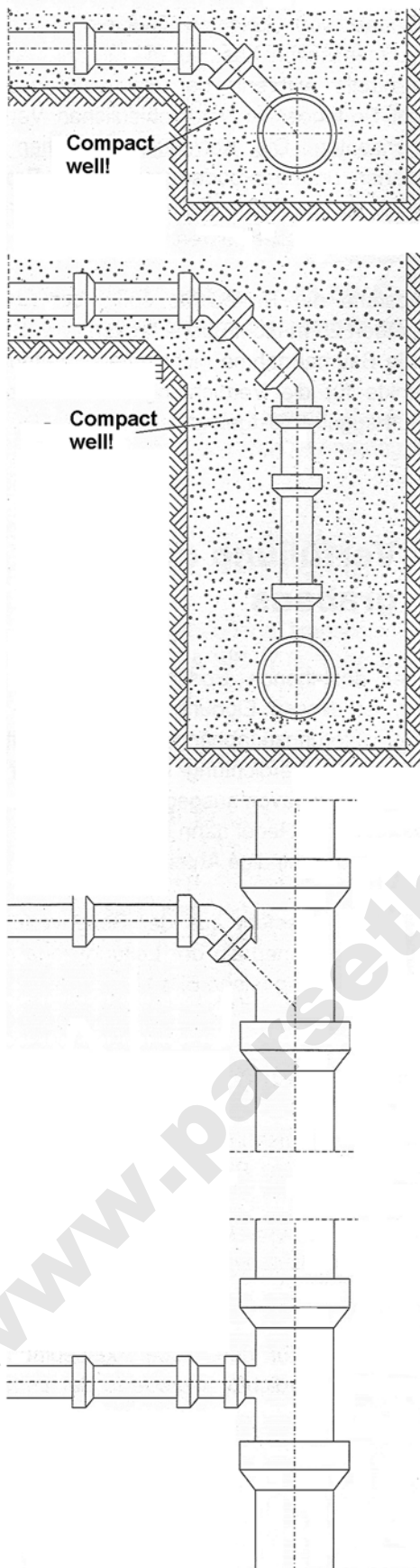
The type and the design of connections are specified by the planner. For examples see Fig. 9.

With non-man-accessible sewers up to DN 800, the connection point should lie between the springer and crown. With man-accessible sewers without berm, the connection point should lie at ca. 35 cm above the sole, however, at least above the dry weather flow. If a berm is present, then the connection point should lie at approximately the berm height and such that a dry weather channel can still be formed.

Service pipes must be so produced and connected that they can accept movements. Possible settling in the area of the connection is to be taken particularly into account.

Connections to shafts must be so produced that the settling movements can be accepted safely without leaks appearing in the area of connections and non-admissible loading on the pipes occurs. Possible secondary stresses due to different settling of pipe and shaft are to be avoided. The regulations in ATV Standard A 157 are to be observed.

Details on the type of connection can be taken from Chaps. 9.2 to 9.6 as well as 8.6.4 in DIN EN 1610.



Connection may be only by using fittings and sealants, which are standard or for which:

- a general construction supervisory authorisation,
- a general construction supervisory certification

or

- approval in the individual case

by the German Institute for Construction Engineering (DIBt) or by the top Federal State authorities exist.

## 10 Testing during Pipe Installation

### 10.1 General

In order to ensure a technically and specifically correct execution of the construction, the tests required under Sect. 12 of DIN EN 1610 as well as the supplementary tests listed below, should already be carried out continuously during the installation of pipes and fittings, e.g. within the scope of own and outside monitoring with quality assured construction work.

Tests carried out are to be documented (daily construction reports).

The daily construction reports are to be presented to and signed off by the customer or his representative. He is to monitor construction work and arrange tests.

Fig. 9: Examples for laterals

## 10.2 Visual Inspections

The visual inspection of components and installation aids includes, inter alia:

- functional monitoring of equipment for the installation of pipes,
- continuous monitoring and, if required, adjustment of the laser setting,
- direction, level and gradient of pipes and fittings,
- examination of pipes and fittings for damage,
- construction of pipe connections,
- construction of connections for private property drainage and street gullies,
- scheduled construction of shafts (design of channels, climbing aids etc.),
- stabilisation of recesses for transport tankers,
- examination of linings, coatings and paintwork

Before carrying out side backfilling the pipeline is to be checked again for correct positioning.

## 10.3 Testing of Sealing

In accordance with DIN EN 1610 tests using water and/or air are equally possible. Insofar as tests take place during the construction phase, these do not replace the acceptance test. Test criteria are identical (see Chap. 13).

## 10.4 Testing of Earthworks

The compaction of the pipeline zone is to be checked. The execution of the tests can take place through the qualified customer himself or through a third party who has the appropriate specialist knowledge.

The compaction test can take place through measurement of the simple Proctor density  $D_{Pr}$  in % in accordance with the specifications in the structural analysis, through the dynamic plate bearing test with the aid of the "light hammer test equipment" or through drop-penetration testing. With pipeline trenches in traffic areas the carrying out of plate bearing tests are additionally recommended.

The employment of "light hammer test equipment" or "dynamic plates" for the monitoring of compaction during construction allows testing in different compaction levels. The correlation between the measured values and the soil specific Proctor density is to be determined.

The separation of test points with pipeline trenches should not exceed 25 m and there should not be less than three checks per construction measure. The test points for compaction monitoring are laid down by the customer.

## 11 Backfilling of the Pipe Trench

Should the existing soil be reinstated its suitability is to be checked (see Chap. 6.1). With reinstatement independent of weather conditions using methodical compaction in the area of the pipeline zone it can be assumed that, as a rule, the soil is suitable if it contains less than a 10 % cohesive component.

Backfilling consists of the side backfill, covering within the pipeline zone and the main backfill (Fig. 1).

### 11.1 Compacting

The most frequent causes of damage to the pipes are pipe bedding and side backfilling, which deviate from the planning. Simultaneous faulty installation of backfill material and insufficient compacting lead inevitably to settling.

The following degrees of compaction in the pipeline zone are characteristic for good bedding conditions:

- Proctor density DPr = 95 % with non-cohesive and slightly cohesive soils,
- Proctor density DPr = 92 % with cohesive soils.

Type of soil	Degree of compaction :D <sub>Pr</sub>	Modulus of deformation: E <sub>V2</sub> <sup>*)</sup>
Cohesive soils	≥ 97 %	≥ 45 N/mm <sup>2</sup>
Gravel, silty (GU)	≥ 100 %	≥ 45 N/mm <sup>2</sup>
Sand (SE), gravel	≥ 100 %	≥ 100 N/mm <sup>2</sup>
Uncombined substrates (GW)	≥ 103 %	≥ 150 N/mm <sup>2</sup>
*) Gravel- and ballast substrates, directly on the subgrade		

**Table 3: Requirements in accordance with Additional Technical Regulations and Standards for Excavation Works in Road Construction (ZTVA - StB 97) on the degree of compaction of trench backfill and on the moduli of deformation above the subgrade and the uncombined substrate**

This does not apply for unworked loosely layered or soft soils, whose natural bedding density is correspondingly smaller.

The structural analysis is relevant from which even higher values can result. If required, the values of the ZTVA-StB 97 (see Table 3) are to be taken into account.

### 11.2 Design of Pipeline Zone

The bedding material is to be filled equally on both sides of the pipeline and carefully compacted. Fill height, material and the compacting equipment used are to be matched to each other. Fill height and number of passes are to be taken from Table 4. Depending on the condition of the soil they may be exceeded or undercut. Exact values can only be established by a sample compacting.



In the area of the side backfill, compacting may only be by hand or using light compacting equipment. Trench widths given in DIN EN 1610 in Tables 1 and 2 are minimum values which must, under certain conditions, be correspondingly increased, depending on the equipment.

With the fabrication of concrete bearing supports and concrete jacketing as well as structures made from concrete or brickwork, a start may be made with the side backfilling only if the concrete or jointing mortar has achieved a satisfactory strength. For flexible pipes attention is drawn to the comments in Chap. 7.3.

In special cases, for example with narrow trench conditions, which allow no satisfactory compacting of the bedding and side filling or if no suitable material for the pipeline zone is available, the pipeline can be embedded partially or completely, using hydraulically bonded material (e.g. earth mortar, damper material, concrete). Horizontal or vertical positional changes are, through suitable measures, to be avoided.

The thickness of the covering over the pipeline should, as a rule, be 300 mm, but at least 150 mm over the pipe shaft or 100 mm over the pipe connection. Compacting in this area may be carried out using hand rammers only.

### 11.3 Implementation of the Main Backfill

The placement of the main backfill is to be carried out according to the details of the plan. To avoid settling the main backfill is so to be carried out in layers, that a sufficient compacting is ensured. Higher values than required in the static calculation can result in accordance with other regulations, e.g. ZTVE-StB 94. Sudden dumping of large masses or earth is not permitted.

The abrupt placement of large masses of earth is not permitted.

A mechanical compacting of the main backfill over the pipes may take place first after incorporation of a layer thickness of at least 300 mm. For this light compacting equipment is suitable. The minimum covering height of the pipeline here results from the greatest fill height for the planned compacting equipment (see Table 4) plus 150 mm.

Medium and heavy compacting equipment may first be used after a minimum covering height of 1.0 m (measured following compacting) has been achieved (see ATV Standard ATV-DVWK A 127E).

The employment of drop weights as well as a compacting of the main backfill by banging or pressing using the excavator bucket are not permitted.

Driving over the covered pipeline with small covering using heavy construction equipment and vehicles as well as the storage of excavated soil above the pipeline are not permitted.

Equipment type		Service weigh [kg]t	Compactability classes								
			V1 <sup>*)</sup>			V2 <sup>*)</sup>			V3 <sup>*)</sup>		
			Suita bility	Fill height [cm]	No. of passes	Suita bility	Fill height [cm]	No. of passes	Suita bility	Fill height [cm]	No. of passes
1. Light compacting equipment (mainly for the pipeline zone)											
Vibro- tampers	light	-25	+	-15	2-4	+	-15	2-4	+	-10	2-4
	medium	25-60	+	20-40	2-4	+	15-30	3-4	+	10-30	2-4
Surface vibrators	light	-100	+	-20	3-5	o	-15	4-6	-	-	-
	medium	100-300	+	20-30	3-5	o	15-25	4-6	-	-	-
Vibratory rollers	light	-600	+	20-30	4-6	o	15-25	5-6	-	-	-
2. Medium and heavy compacting equipment (above the pipeline zone from 1 m cover height)											
Vibro- tampers	medium	25-60	+	20-40	2-4	+	15-30	2-4	+	10-30	2-4
	heavy	60-200	+	40-50	2-4	+	20-40	2-4	+	20-30	2-4
Detonating rammers	medium	100-500	o	20-40	3-4	+	25-35	3-4	+	20-30	3-5
	heavy	> 500	o	30-50	3-4	+	30-50	3-4	+	30-40	3-5
Surface vibrators	medium	300-750	+	30-50	3-5	o	20-40	3-5	-	-	-
Vibratory rollers	medium	600-8000	+	20-50	4-6	+	20-40	5-6	-	-	-
+ = recommended ° = mostly suitable - = unsuitable <sup>*)</sup> V1 = non-cohesive and slightly cohesive soils (GW, GL, GE, SW, SI, SE, GU, GT, SU, ST) V2 = cohesive, mixed grain soils (GU, GT, SU, ST) V3 = cohesive, fine grained soils (UL, UM, TL, TM)											

**Table 4: Soil compacting, fill heights and number of passes**

## 11.4 Removal of Shuttering

Shuttering may only be removed as far as it has become unnecessary due to the backfilling (see UVV [German Accident Prevention Regulations] and DIN 4124).

With the removal of the shuttering attention is to be paid that, through a compacting of the backfill soil a contact with the natural soil of the trench wall results. This is achieved if the shuttering is withdrawn before compacting of the respective layer.

If, due to certain situations, a later withdrawal of the shuttering cannot be avoided, suitable methods for the backfilling of the hollow spaces are to be employed (application of damping materials or similar). The later pulling of vertical shuttering (e.g. sheet piling, trench shuttering) is to be taken into account in the structural verification of the supporting framework.

## 11.5 Making Good the Surface

Manner and scope of making good the surfaces are to be laid down in the planning.

## 12 Final Monitoring and/or Testing of Pipelines and Shafts following Backfilling

Following execution of the main backfill and removal of the trench security facilities, the complete sewer construction measure is to be checked and accepted in agreement with DIN EN 1610, Sects. 12.1 to 12.3 and the requirements of this ATV-DVWK Standard.

### 12.1 Visual Inspection

Verification of the agreement with the planning specifications and contractual agreements listed in Sect. 12.1 of DIN EN 1610 and in Sect. 10 of this ATV Standard, are to be furnished and minuted for man-accessible sewers and drains in a visual inspection.

TV techniques are to be employed for acceptance testing of non-man-accessible drains and sewers. If special verification on dimensions (crack widths, gaps at joints, mismatches etc.) are required, a suitable TV system with integrated measuring technology is to be employed for this (see ATV-M 143E, Part 2).

### 12.2 Sealing<sup>5</sup>

The testing of sealing of the pipelines, including connections, shafts and inspection openings takes place in accordance with DIN EN 1610, Sect. 13 and 14 as well as in accordance with the additional definitions of this ATV-DVWK Standard (Chap. 13).

Due to the special structural characteristics, type and scope of testing for pipes > DN 1000 and structures can be laid down in individual cases.

With the examination of individual connections using air overpressure air the definitions of ATV-M143, Part 6 are to be applied (see also Chap. 13.4.2).

Vacuum testing, above all with the testing of sewers with large nominal widths and of shafts, has the advantage of greater working safety.

### 12.3 Pipeline Zone and Main Backfill

Completion of earthwork in the pipeline zone and in the area of the main backfill is to be verified by testing the compacting for agreement with the planning specifications and the static calculation.

<sup>5</sup> Chap. 12.2 is bound to taking into account the existing and introduced regulations in DIN EN 16190. Deviations for the execution of leak testing and assessment of the results cannot be taken into account due to necessary similar type technical regulations. Freed from this are Federal State Regulations. Thus, in Bayern, LfW Advisory Leaflet 4.3/6 "Testing of old and new sewers" apply with the test criteria deviating from DIN EN 1610 and this Standard. The notes on testing individual connections on the basis of ATV-M 143, Part 6 reflect the state of knowledge at that time. Advanced information is to be taken from literature.

#### 12.3.1 Compacting

The degree of compacting in the pipeline zone and main backfill is checked by ram sounding. In the area of the lower edge of the road construction the degree of compacting can also be determined using plate load testing.

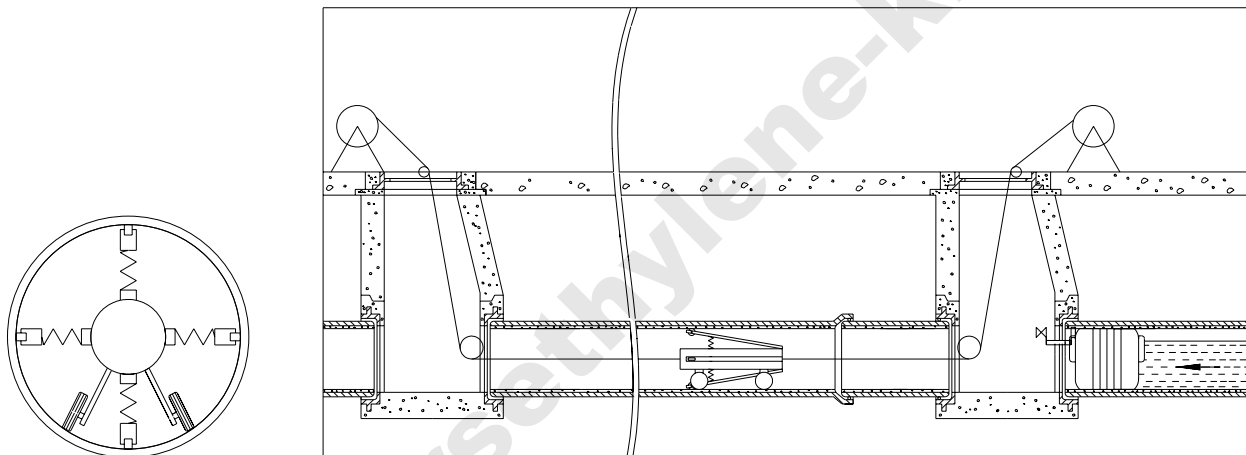
Acceptance criteria are the soil characteristic values based on the static calculation.

### 12.3.2 Pipe Deformation

With flexible pipes deformation is to be checked for agreement with the structural analysis. The change of diameter may not exceed the value given for short as well as long-term deformation given in the static calculation (see ATV-DVWK Standard ATV-A 127E). Permitted short-term as well as the permitted long-term value takes into account the respective installation conditions and the limiting value for the permitted long-term deformation in accordance with ATV-DVWK-A 127E.

Testing of changes to the diameter can take place optically or mechanically (see Fig. 10). Acceptance criterion is the permitted value of the short-term deformation from the structural analysis.

Immediately before testing the reach or section to be examined is to be cleaned. The vertical and horizontal diameters are to be measured. The maximum deviations from the actual condition of the pipe before installation are to be documented graphically in a record.



**Fig. 10: Schematic diagram on the measurement of deformation**

## 13 Procedures and Requirements for the Testing of Freefall Pipelines

### 13.1 General

Test conditions in accordance with DIN EN 1610 apply for all newly constructed sewers and drains up to acceptance.

#### 13.1.1 Preparatory Measures

Planning documents, from which position and defining characteristics of the objects to be tested clearly emerge and which ensure traceability, are to be made available before carrying out the tests.

Leak testing using air, in accordance with § 36 (1) of the Accident Prevention Regulations (UVV) "General Regulations" (BVG A 1), is to be classified as hazardous work. With this the following minimum requirements apply:

- leak testing may not be carried out by one individual person.
- suitable personnel are to be tasked who are familiar the hazards associated with the test
- a supervisor is to be appointed

Tasks must be directed by technically suitable supervisory personnel, who must be permanently present/available in the area of the work place during the work.

Personnel responsible for the leak testing should have constructional and technical material specialist knowledge on drains and sewers and have at least one year's practical experience. A certificate of competence is to be furnished.

With regard to the safety measures which are fundamentally to be carried out, attention is drawn to the relevant safety regulations of the trade associations and of the Federal (German) Labour Association of the Communal Accident Insurers (BAGUV), inter alia to:

- UVV "General Regulations" (BVG A 1),
- UVV "Construction Tasks" (BVG C 22),
- UVV "Wastewater Engineering Systems" (GUV 7.4)
- Safety Rules for Pipeline Construction Work" (ZH 1/559),
- Safety Rules for Work in Enclosed Spaces of Wastewater Engineering Systems (ZH 1/177).

Before starting work in shafts and sewers all hazards of a construction site and of an operational nature are to be determined and, thereafter, the necessary measures for work and safety protection are to be laid down.

Hazards can, for example, arise from:

- hazardous substances,
- electrical plant,
- potentially explosive sewer atmospheres,
- mechanical installations,
- possible rushes of water.

Accessibility of entrances is to be checked and secured, and protected for the duration of testing.

Suitable measures, if required in agreement with the road traffic authorities, are to be taken for the control, security and sealing off of traffic.

The test object must be cleaned in order to allow the secure positioning of the shut-off elements and the disruption-free execution of the leak testing. The sealing function in the contact surfaces between the pipe walls and the shut-off elements must be securely maintained with every test pressure and with every test medium employed.

Before carrying out the leak testing using air pressure the sealing of the test device is to be verified and minuted.

With individual connection testing and leak testing by section (e.g. between two connections) in non-man-accessible drains and sewers, the exact positioning of the shut-off elements must take place under TV surveillance.

Drains and sewers, which are not covered and run above the surface, are to be sufficiently secured taking into account the test pressure. Pipeline components and test elements are to be anchored. Changes of position as well as releases of pressure must be avoided, for example by driving in posts, depositing of bulking cones and by the application of suitable security clamps.

### *13.1.2 Requirements on the Equipment to be Employed and on the Execution of Leak Testing*

With air overpressure and vacuum air pressure testing the following minimum equipment is necessary:

- shut-off elements,
- compressors or vacuum pump,
- filling facilities incl. pressure reduction valve and electronic pressure cut-off,
- pressure measuring device,
- facility for minuting and archiving measured data.

To carry out water pressure testing a gravity container or appropriate equipment for pressureless filling is necessary.

All items of equipment must correspond with the regulations in accordance with VDE (Association of German Engineers) and DIN as well as with the Accident Prevention Regulations (UVV).

Shut-off elements must correspond with the area of application and must be permanently marked by the manufacturer with a type plate with the following details:

- manufacturer, type, year of manufacture,
- lockable pipe diameter or pipe diameter area,
- maximum operating pressure (filling pressure),
- maximum permitted test pressure dependent on the test medium used,
- permitted test medium (water and/or air).

Equipment is to be stored carefully, protected against damage, regularly maintained and checked. Operating instructions for the shut-off elements must be available for inspection on the construction site.

The necessary test pressure can be provided using a normal commercial, sufficiently dimensioned compressor or an appropriate vacuum pump. The filling device must consist of a safety valve, manometer for monitoring the pressure, pressure regulator and a filling hose. Following application of the test pressure the connection of the space under test to the pressure vessel or to the pump is to be interrupted. Pressure reduction

valves and pressure limiters are to be integrated into the filling device in combination with a safety switch (e.g. a dead man's switch), in order prevent the exceeding of the test pressure.

A manometer with a measurement deviation of maximum 10 %  $\Delta p$  is to be used for pressure measurement.

A test counts as passed if the test criteria are met.

Leak testing can be carried out alternatively using water or air. The test using air is significantly quicker to carry out than the test using water.

Acceptance criterion for leak testing, with testing using air, is the permitted pressure drop or rise and, with testing using water, the permitted water addition value referred to the test time.

The preferred leak testing of shafts is by carrying out water pressure testing.

Shut-off elements are to be positively secured against unintended displacement in the pipeline to be tested. For the selection of suitable safety devices against expulsion manufacturer's details can be used or a calculation using a safety factor of 1.5 can be carried out. With the calculation the frictional forces between sealing body and the pipe inner wall may not be included.

With leak testing, following completion of the safety device, the point of installation is to be evacuated and the filling of the shut-off elements with the laid-down filling pressure is to be undertaken outside the shaft or pipeline.

With the removal of the shut-off elements work may first be started after the over or under pressure in the test space has been completely returned to atmospheric pressure or the test water is completely runoff.

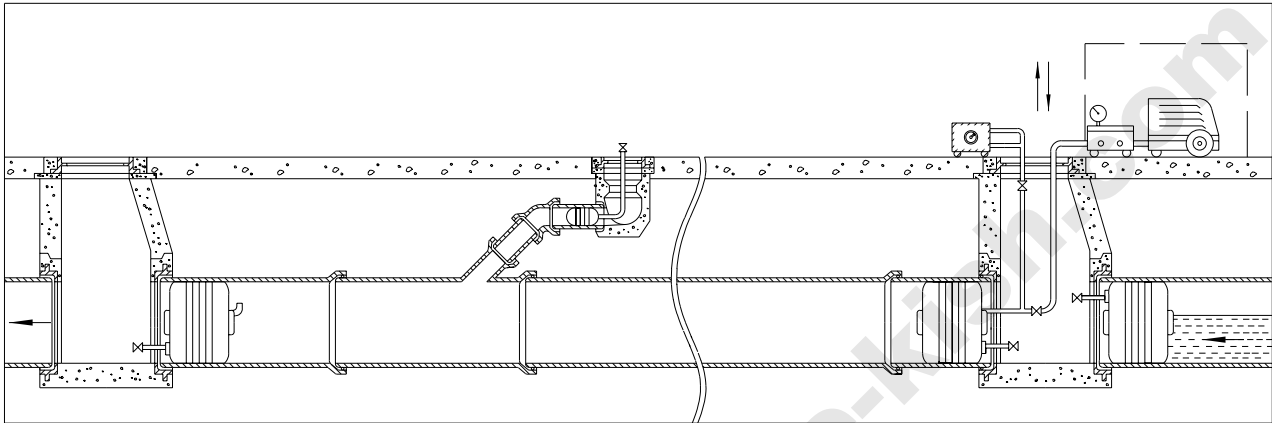
The test record is to be produced separately for each test. In detail it must contain:

- customer, contractor, if required project manager, equipment operator, test site, date and time, road name, reach number and/or the designation of the shafts limiting the reach;
- inventory data of the object to be tested such as, for example, type of object (leak testing by reach/section or sleeve test), nominal width, cross-sectional dimensions, test length, material, type of sewer, year of construction, origin of length measurement, groundwater level;
- details on test specifications, test pressure, test period, response time, permitted pressure difference or permitted water addition;
- details on measurement results: measured pressure difference or addition of water;
- measurement graphic with an air overpressure or partial vacuum test: graphic representation of the pressure progression over the test period with details of the required test pressure, the permitted pressure difference, the beginning and end of the required response time as well as the start and finish of the test period;
- details on correction measures during testing;
- test certificate on the result of the leak test with the signature of all parties involved;

- the test records are to be allocated a serial number and are to be archived systematically.

### 13.2 Pipeline Testing Using Air

In the course of processing of DIN EN 12889, Table 3 on testing using air from DIN EN 1610 was revised. Test periods and test pressures in Table 5 are therefore taken from DIN EN 12889. Testing is recommended by reach or by section (ca. 100 m) (see Fig. 11).



**Fig. 11: Example of air overpressure and vacuum air pressure testing of sewers and laterals (without representation of thrust protection facilities)**

For air overpressure testing, procedures LC and LD are recommended for technical measurement reasons. With pipes of larger diameter (ca. > DN 1000), procedure LC is to be preferred for reasons of work safety. A response time of  $10 \cdot \text{DN [m]}$  in minutes, however, at least 5 minutes, is recommended.

With groundwater present the test pressure per metre groundwater above the pipe sole is to be increased by 10 kPa per metre groundwater. Test periods are to be interpolated linearly. For safety reasons the test pressure in every case remains limited to 20 kPa air overpressure.

If, during the testing, the groundwater level is above the crown of the pipe, an infiltration flushing may be carried out with case-related specifications..

The test periods in Table 6 for vacuum testing result on the basis of the  $K_p$  values from Table 5.

Test procedure	P <sub>O</sub> <sup>*)</sup>	Δp	Test period (min)						
			kPa	DN 100	DN 200	DN 300	DN 400	DN 600	DN 800
LA	1	0.25	5	5	7	10	14	19	24
LB	5	1	4	4	6	7	11	15	19
LC	10	1.5	3	3	4	5	8	11	14



LD	20	1.5	1.5	1.5	2	2.5	4	5	7
K <sub>p</sub> value **)		0.058	0.058	0.040	0.030	0.020	0.015	0.012	
<p>*) Pressure above atmospheric pressure</p> <p>**) <math>t = \frac{1}{K_p} \cdot \ln \frac{p_o}{p_o - \Delta p}</math></p> <p>K<sub>p</sub> = 12/DN with a max. value of 0.058, whereby  t with t ≤ 5 minutes is rounded up to the next 0.5 minutes, and with t &gt; 5 minutes rounded up to the next whole minute.</p> <p>ln = log<sub>e</sub>  1 kPa = 10 mbar and represents 0.1 m water column</p>									

**Table 5: Test conditions with pressure air testing<sup>6</sup>**

Test procedure	P <sub>o</sub>	Δp	Test period t [min]						
	[kPa]	[kPa]	DN 100	DN 200	DN 300	DN 400	DN 600	DN 800	DN 1000
LCU	-10	1.1	2.5	2.5	3	4	6	8	10
LDU	-20	1.1	1	1	1.5	2	3	4	5

**Table 6: Test conditions for vacuum testing**

### 13.3 Pipeline Testing Using Water

The test object may, with a water pressure test, have no direct connection to a pipeline under pressure or to a pump. The pipeline to be tested is to be so filled with water that the trapped air can escape at the shut-off device installed at the high point of the reach and, through this, an endangering or false reading through compromised air pockets can be avoided. With the start of filling of the test space, work in neighbouring reaches or shafts is not permitted.

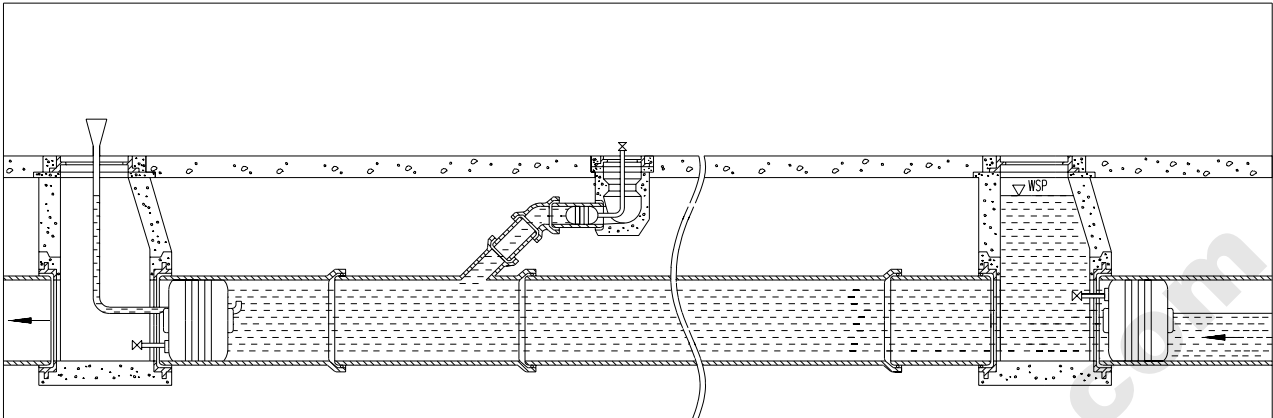
<sup>6</sup> DIN EN 12889  
Reproduced with permission of DIN German Institute for Standardisation e.V.

Permitted quantities of added water for the water pressure test:

- 0.15 l/m<sup>2</sup> in 30 min for pipelines,
- 0.20 l/m<sup>2</sup> in 30 min for pipelines including shafts,
- 0.40 l/m<sup>2</sup> in 30 min for shafts and inspection openings.

Preparation time should not exceed one hour. During this time the test section is to be kept completely filled with water.

The test pressure is related to the gradient level. It is a maximum of 50 kPa and at least 10 kPa above the pipe crown at the highest point of the test object. It is recommended that testing takes place by reach including shafts (see Fig. 12).



**Fig. 12: Principle for the watertightness testing of sewers, connections and shafts (without representation of thrust protection facilities)**

## 13.4 Testing of Individual Connections

### 13.4.1 Testing Using Water

With the testing of individual connections using water, the test period can, in agreement between customer and contractor, be reduced to 10 minutes with pipes > DN 1000; the quantity of water added is then 0.05 l/m<sup>2</sup>.

In cases of disagreement the test time of 30 minutes, laid down in DIN EN 1610, is relevant.

### 13.4.2 Testing Using Air

With the testing of individual connections for sealing, the regulations in accordance with ATV-M 143, Part 6 are used. The following procedure is recommended:

- flush and clean the pipeline immediately before the test and keep it free of discharges during testing,
- monitor test equipment for operability (check sealing of packer as well as all connections and couplings),
- carry out surface zero measurement of the pressure drop at the packer in an accompanying short pipe,
- carry out reference measurement of pressure drop on three pipes, in each case in the centre of the pipe shaft in the sewer to be tested,
- measurement of pressure loss at pipe joints which may not be greater than the average value of the reference measurements,
- with negative results of the individual joint test using air carry out a joint test using water under constant pressure of 50 kPa (0.5 bar) and measurement of the water input.

For the determination of the necessary test periods the test volume of the sleeve test equipment used, including the volume of the inlet hoses in the case these indicate a connection to the test space during the test, as well as the volumetric pipe connection <sup>7</sup> must be determined. In addition the surface of the pipe walls between the shut-off elements must be known.

Sleeve test equipment, whose air feed hoses have no connection to the test space during the test, should be used in preference.

Test criteria:

Test pressure:  $p = 10 \text{ kPa}$

Permitted pressure difference:  $\Delta p = 1.5 \text{ kPa}$

Response time:  $t_B \geq 15 \text{ s.}$

Necessary test periods:  $t = 1800 \cdot \sqrt{d_i + 0.5} \cdot \frac{V_{\text{Testvolume}}}{V_{\text{Pipewalling}}} \quad [\text{s}]$

with

$d_i$  the measured inner diameter in the test section [m].

## 14 Testing of Pressure Pipelines

Testing of wastewater pressure drains takes place in accordance with DIN EN 805. In summary the following applies:

- the test is to be carried out as water pressure test.
- as far as no nominal pressure stage is given for the test in the project planning, 1.5 times the operating pressure of the pipeline applies as test pressure.
- a preliminary test and a main test are to be carried out on the basis of DIN 4279. Short tests are excluded for the assessment of drains and are not permitted.
- pressure tests are to be carried out specific to materials. Test period and tolerance values are to be calculated for the pipeline material. Details on this are contained in Parts 2 to 8 as well as Part 10 of DIN 4279.
- the test records should be in line with DIN 4279, Part 9. Alternative records or documents must be equivalent (e.g. records of recording manometers).
- the requirements of this Standard on the execution of pressure tests (Chap. 13) apply analogously and are to be observed.

<sup>7</sup> With non-man-accessible drains and sewers, one can, in general, dispense with the determination of the volume of the pipe connection.

## 15 Qualifications

Prerequisites for quality and function of sewers and drains are correct installation and correct testing.

Customers are obliged to use appropriate care with the award and execution of contracts and to make inquiries into the necessary qualifications and to convince themselves about the contractor for these qualifications. DIN 1960 (VOB/A § 8 (3)) is to be applied for this.

Specialist knowledge and suitability is to be verified in accordance with DIN EN 1610. The following requirements are listed in the RAL Quality and Test Conditions GZ 961:

- personnel,
- equipment,
- advanced and further training,
- own monitoring of construction work,
- outside monitoring,
- employment of subcontractors,
- procurement of deliveries and outside services.

The customer can make use of a “System for the inspection of suppliers or businesses” in accordance with the EC Directive dated 17.09.90 (Appendix C of DIN EN 1610). The German “Güterschutz Kanalbau e. V. [Quality control sewer construction] is such a system

**Literature** [Translator's note: known translations are given in English, otherwise a courtesy translation is provided in square brackets]

ATV-M 101E	Planning of Drain and Sewer Systems: New Construction, Rehabilitation and Replacement
ATV-DVWK-A 127E	Standards for the Structural Calculation of Drains and Sewers
ATV-A 142	Abwasserkanäle und -leitungen in Wassergewinnungsgebieten [Sewers and Drains in Water Catchment Areas]
ATV-M 143E - 2	Inspection, Repair, Rehabilitation and Replacement of Sewers and Drains; Part 2: Optical Inspection
ATV-M 143E - 6	Inspection, Repair, Rehabilitation and Replacement of Sewers and Drains; Part 6: Leak Testing of Existing, Earth Covered Sewers and Drains and Shafts Using Water, Air Overpressure and Vacuum
ATV-DVWK-A 157	Bauwerke der Kanalisation [Sewer System Structures]
ATV-H 162	Baumstandorte und unterirdische Ver- und Entsorgungsanlagen [Locations of Trees and Underground Supply and Drainage Facilities]
ATV-DVWK-A 400E	Principles for the Preparation of German ATV Standards
DIN 1045	Concrete and reinforced concrete, design and construction

DIN 1053-1	Mauerwerk Teil 1: Berechnung und Ausführung [Brickwork, Part 1: Calculation and design]
DIN 1960	Construction contract procedures (VOB) - Part A: General provisions relating to the award of construction contracts
DIN 1986	Entwässerungsanlagen für Gebäude und Grundstücke, Teil 30: Instandhaltung [Site drainage systems, Part 30: Maintenance]
DIN 4022-1	Subsoil and groundwater; classification and description of soil and rock; borehole logging of soil and rock not involving continuous core sample recovery
DIN 4030	Assessment of water, soil and gases for their aggressiveness to concrete
DIN 4033	Entwässerungskanäle und -leitungen [Sewers and Drains] (Replaced by DIN EN 1610, Oct 1997)
DIN 4051	Sewer clinkers; requirements, testing, control
DIN 4124	Building pits and trenches; slopes, working space widths, shuttering
DIN 4279	Testing of pressure pipelines for water by internal pressure Part 2: Pressure pipes made of ductile cast iron Part 3: Ductile cast iron pressure pipes and steel pipes with cement mortar lining Part 4: Steel pipes with and without bitumen lining Part 5: Reinforced concrete pressure pipes and prestressed concrete pressure pipes Part 6: Asbestos- cement pressure pipes Part 9: Specimen pages for test reports Part 10: Synopsis
DIN 18196	Soil classification for civil engineering purposes
DIN EN 752-3	Drain and sewer systems outside buildings Part 3: Planning
DIN EN 805	Wasserversorgung - Anforderungen an Wasserversorgungssysteme außerhalb von Gebäuden und Bauteilen [Water supply - requirements on water supply systems outside buildings and components]
DIN EN 1295-1	Statische Berechnung von erdverlegten Rohrleitungen unter verschiedenen Belastungsbedingungen Teil 1: Allgemeine Anforderungen [Static calculation of underground pipelines under various

	loading conditions Part 1: General requirements]
DIN EN 1610	Verlegung und Prüfung von Abwasserleitungen- und -kanälen [Laying and testing of drains and sewers]
Supplement 1 to DIN EN 1610	Verlegung und Prüfung von Abwasserleitungen und -kanälen Verzeichnis einschlägiger Normen und Richtlinien [Laying and testing of drains and sewers List of relevant standard specifications and directives]
DIN EN 12889	Grabenlose Verlegung und Prüfung von Abwasserleitungen und -kanälen [Trenchless laying and testing of drains and sewers]
DVWK	Merkblatt 221 Anwendung von Geotextilien im Wasserbau [Advisory Leaflet 221 Application of geotextiles in hydraulic engineering]
FGSV	Checklisten für den Einsatz von Geotextilien und Geogittern im Erdbau für den Straßenbau [Checklists for the employment of geotextiles and geo-screens for road construction]
LAWA	Leitlinie zur Durchführung von Kostenvergleichsrechnungen [Guideline for the execution of cost comparison calculations]
LfW-Merkblatt 4.3/6	Prüfung alter und neuer Abwasserkanäle [LfW Advisory Leaflet - Testing of old and new sewers]
RAL GZ 961	Herstellung und Instandhaltung von Entwässerungskanälen und -leitungen. Gütersicherung [Production and maintenance of sewers and drains. Quality assurance]
RAL-RG 501/1	Recycling-Baustoffe für den Straßenbau. Gütersicherung [Recycled materials for road construction. Quality assurance]
UVV	"Allgemeine Vorschriften" (BVG A 1) [Accident Prevention Regulations - "General requirements"]
UVV	"Bauarbeiten" (BVG C 22) ["Construction works"]
UVV	"Abwassertechnischen Anlagen" (GUV 7.4) ["Wastewater engineering facilities"]
UVV	Sicherheitsregeln für Rohrleitungsbauarbeiten (ZH 1/559) [Safety rules for pipeline construction]
UVV	Sicherheitsregeln für Arbeiten in umschlossenen Räumen von abwassertechnischen Anlagen (ZH 1/177)(GUV 17.6)

	[Safety regulations for work in enclosed spaces of wastewater engineering systems]
ZTVE-StB 94	Zusätzliche Technische Vertragsbedingungen und Richtlinien für Erdarbeiten in Straßenbau [Additional Technical Contract Conditions and Standards for Earthwork in Road Construction]
ZTVE-StB 97	Zusätzliche Technische Vertragsbedingungen und Richtlinien für Aufgrabungen in Verkehrsflächen [Additional Technical Contract Conditions and Standards for Excavations in Traffic Areas]
Kaufmann, O.	Dichtheitsprüfungen an Abwasserkanälen und -leitungen [Leak testing on sewers and drains] Oldenburg IRO, Vol. 18. Vulkan-Verlag Essen, 1999
Kaufmann, O Stevens, T	Dichtheitsprüfung an einzelnen Rohrverbindungen; [Leak testing on individual pipe connections] Korrespondenz Abwasser (2000), Vol. 2, p. 213 ff.
Schlichting, Rolf	Rohrverlegung in weichen Böden, Handbuch Wasserversorgungs- und Abwassertechnik/01, 1955, Vulkan-Verlag, Essen [Pipe laying in soft soils Handbook of water supply and wastewater engineering]
Zeller, Alexander	Methoden der Bodenverdichtung und Messung, aus Rohre, Rohrleitungsbau, Rohrleitungstransport; [Methods of soil compaction and measurement, from pipes, pipeline construction, pipeline transport] 3R international, 2/99, p. 110 ff.

## Appendix A:

### Requirements on model installation pipelines

If special characteristics of the respective pipe material have to be taken into account, the manufacturer is to provide a supplementary, binding, detailed installation instruction. In particular it should contain details on:

- delivery,
- loading and unloading,
- transport to the construction site,
- storage,
- lowering into the pipe trench,
- emplacement,
- connection to structures,
- connection to an existing sewer or to a water pipeline,
- support and anchoring,
- covering,
- embedment (material, compacting),
- surcharging (minimum cover, materials, compacting),
- site stabilisation,
- production of pipe connections,
- details on permitted separation of faces,
- details on welding capability,
- notes on the maintenance of permitted (pipe)-sole shifts,
- securing and release of end covers,
- shortening of pipes and post-treatment of cut surfaces,
- production of subsequent connections,
- tests,
- monitoring.



## **Appendix B: Economic aspects**

### **General**

Total costs of a sewer system are mainly determined by:

- investment costs,
- depreciation,
- interest,
- maintenance,
- operating costs,
- social costs,
- disposal costs.

Assuming the planned function, the totality of all costs within a period of consideration should show the optimum lowest value.

The period of consideration is dependent on the interest of the cost carrier (depreciation/service life).

As a rule, very long service lives are sought for sewers. The selection of the service life leads, dependent on investment costs and the associated other costs, to different results in the economic statement.

### **Assessment**

With the economic assessment the selected or expected service life is of particular significance. Planning alternatives are to be assessed correspondingly.

A very good method of assessment is a consideration of the annual costs. The manner of such calculations is, inter alia, to be found in the LAWA [Federal (German) State Working Group Water] Guideline "Cost comparison calculations".

### **Technical service life**

Important for the economic assessment is the most accurate estimate as possible of the service life, during which the sewer pipeline meets its function with normal maintenance resources. This service life is, as a rule, not to be compared with the depreciation time of the commercial depreciation.

### **Influence of technical design on service life**

With regard to their technical service life, sewers are, to a great extent, dependent on the quality of the transfer of project requirements into planning and design.

A correct planning must meet these expectations. Important are the conversion within design and the ensuring of quality. These are prerequisites for the estimate to be made of the data in an economic calculation.