RSV Rohrleitungssanierungs-verband e.V.

RSV factsheet 2.2

Rehabilitation of sewer pipes with the tight-in-pipe method

Characteristics, requirements, quality assurance

(March 2023)

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Preface

The TIP method (Tight-In-Pipe Lining method) with prefabricated pipes is used for the rehabilitation of gravity pipe systems. Prefabricated discrete pipes or continuous pipes without annulus are inserted into the existing pipeline in a closed construction.

The TIP method can be used to rehabilitate sewers with existing pipe states I to III. Pipes in existing pipe state IIIa (described in DWA A 143-2 and statically calculated according to ATV DVWK 127) can also be renewed using the TIP method. The term replacement is based on the objective of the static design.

This factsheet describes the different variants of the tight-in-pipe method and summarises the requirements and notes that correspond to the generally recognised rules of technology (aaRdT). The aim is to fulfil the quality requirements placed on the rehabilitated pipe and to ensure consistent standards when carrying out the procedure. The factsheet is essentially intended to provide supplements and comments to the existing rules and regulations.

This factsheet refers to the installation of circular profiles. Egg and special profiles are dealt with as lining procedures (discrete pipe lining or continuous pipe relining) in factsheet 3.1, as an annulus to be filled can arise with these profiles due to the dimensional tolerance of the existing sewer. Egg profiles can also be rehabilitated using the tight-in-pipe method. For dimensionally accurate profiles without annular gaps, the specifications in this factsheet are to be applied analogously.

Everyone is free to apply this factsheet. An obligation to apply it may arise from legal or administrative regulations, contract or other legal grounds.

The RSV would be grateful for any experience gained in the application of this factsheet and for any other information.

Hamburg,

March 2023

RSV - Rohrleitungssanierungsverband e.V.

Content

Guide for special labels

In this factsheet, we refer to special contents at various points. These are graphically marked with symbols.

Symbol	Meaning
	information on the internet You can find further information on the Internet at www.rsv-ev.de or on a corresponding website. In the PDF, the symbol is deposited with the link.
	General contents This information is not specific to this factsheet, but also applies to other rehabilitation topics.
	need für regulation The content published here points to regulatory gaps that should be addressed in future rulemaking.
	comment These are comments on existing regulations. These may contain statements that deviate from them.
EXCLUSIVE	**exclusive information** Here you will find exclusive content and information that should be seen as an addition to existing rules and regulations
	recommodation This is an RSV recommendation that deserves special attention from users.
	quote At this point we quote or refer to other factsheets. Consultation is recommended for further questions

1 Basics

This factsheet applies to the rehabilitation of underground pressureless pipes using the tight-in-pipe method (TIP method).

In the TIP method, a factory-made pipe is installed close to the existing pipeline in a trenchless construction. Special pipes with dimensions adapted to the inner diameter of the existing pipeline are used.

The new pipes are inserted tightly into the old pipe by retraction or insertion. Deformations and misalignments in the existing pipeline are reshaped by a leading calibration head (see ***figure 1***).

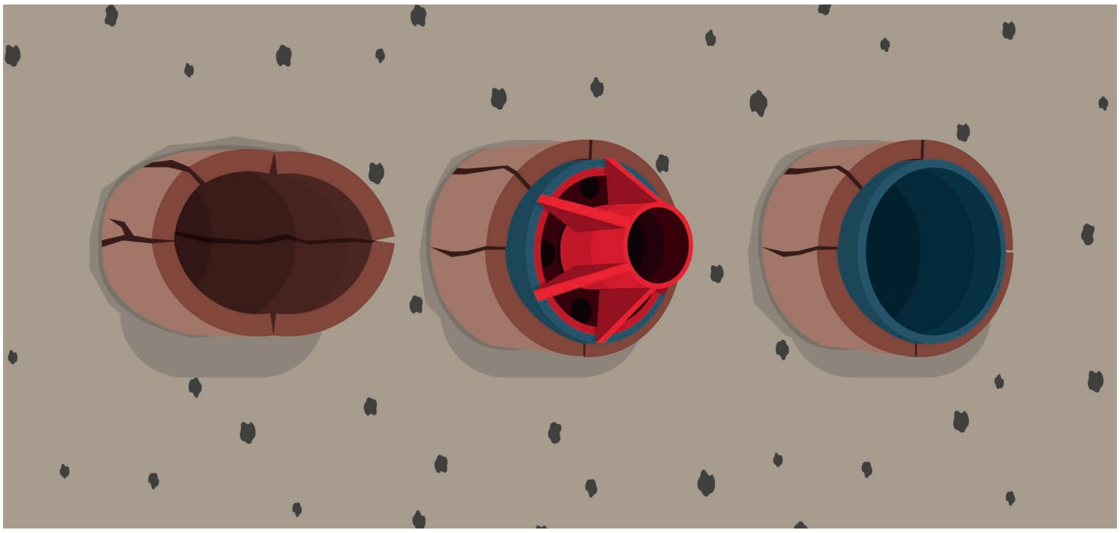


Figure 1: Compensating for deformations with the aid of a calibration head

Depending on the local conditions, the TIP method can be used with discrete pipes or as a continuous pipe. The installation is carried out via manholes or excavations.

The application usually extends to sewers and pipes in public and private areas that are operated as gravity sewers.

After the installation of the new pipe, an annular gap remains between the existing and new pipes. While the classic lining with discrete or continuous pipes create an annulus that has to be backfilled after the pipe has been pulled in, this work step is omitted in the TIP method.

1.1 General classification

According to the classification according to DIN EN 15885, the TIP method is a renovation method that can be classified as a renovation or replacement method depending on the existing pipe state.

The working life of the pipes used corresponds to that of a new installation, provided that the pipes are dimensioned as self-supporting (absorption of all load effects).

In the following overview, based on DIN EN ISO 11296-1:2018-09, the techniques contained in this factsheet should be grouped into the technique families "replacement" and "renovation".

The classification of the tight-in-pipe method in the technique family of "replacement" is carried out according to DWA-A 143-2 for the approach of the existing pipe state IIIa. For the approach of the existing pipe states I to III, the tight-in-pipe method is assigned to the technique family "renovation" (Figure 2). Irrespective of the classification as a renovation or renewal method, the depreciation periods in the tight-in-pipe method can be considered as those of a new pipe (see chapter 1.5).

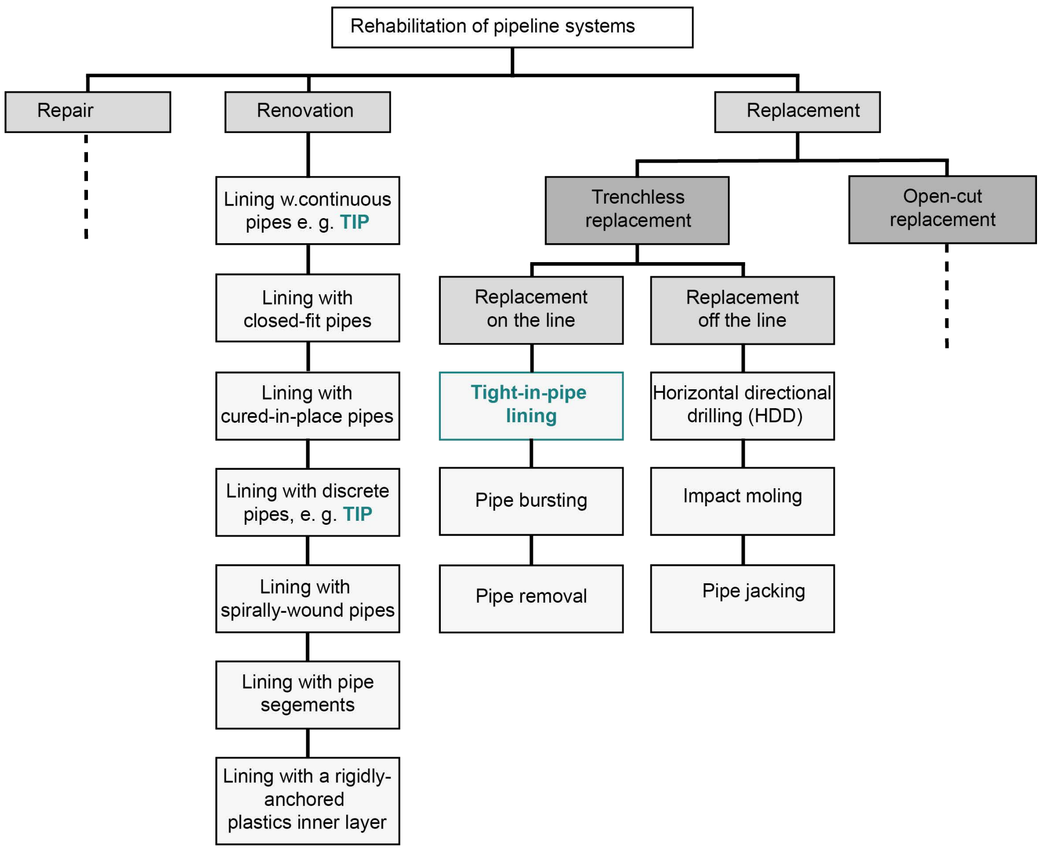


Figure 2: Classification of the TIP method as renovation techniques and renewal techniques based on DIN EN ISO 11296-2:2018-09

1.2 Ecological aspects

Sewer rehabilitation / replacement using the TIP method is an environmentally compatible method. This applies to both the method and the materials used.

Compared to the open-cut replacement, the trenchless installation of the new pipes releases significantly less CO2 emissions due to construction machinery, traffic obstructions and the delivery and removal of construction materials. The amount of construction materials required and any materials that may have to be deposited (soil excavation, existing pipeline) is also reduced. The CO2 emission share of trenchless construction compared to open construction methods is estimated at 20 percent for discrete pipe lining and 25 percent for bursting methods (GSTT e. V. 2015). The tight-in-pipe method corresponds to these two methods because of the comparable construction costs. In terms of CO2 emissions, it can therefore be classified as less than 25 percent compared to excavation (see ***Figure 3***).

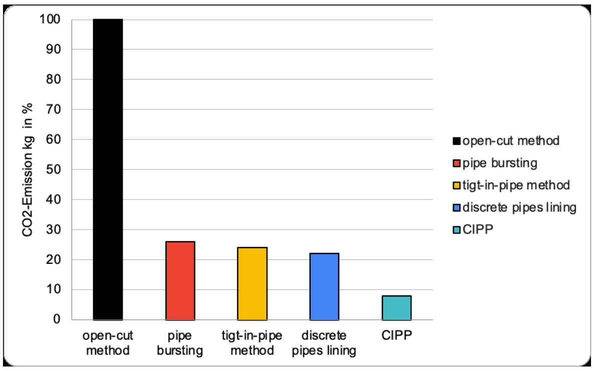


Figure 3: Comparison of CO2 emissions (based on GSTT Information No. 11)

1.2.1 Materials used

Even if plastics themselves are viewed critically in the public discussion, the materials used in the tight-in-pipe method require a differentiated view. The plastic pipes used as new pipes are single-grade materials made of PP or polyethylene. Additives such as plasticisers, which can be released into the environment over time, are not contained in these pipe materials.

The materials PE and PP are based on pure hydrocarbon compounds and are also used in the food sector.

The production of plastics is currently mainly carried out via synthetic methods based on mineral oil. Bio-based, large-scale production using bioethanol is already being used. In view of the progressive development of alternative production processes, significant increases in production volumes are expected in the coming years. Plastics such as polyethylene and PP can already be obtained from CO2 via synthesis processes. In the future, the large-scale implementation of these processes is to be expected.

When plastic pipes made of polyethylene or PP have exceeded their technical working life and their function has become obsolete, they can be easily recycled at any time in accordance with the circular economy principle. PE and PP can be recycled in three different ways without leaving any residues:

- material (use as granulate for new production, e . g. of polyethylene/ PP plastic pipes)
- Raw material (basis for the production of other materials)
- energetic (thermal recovery)

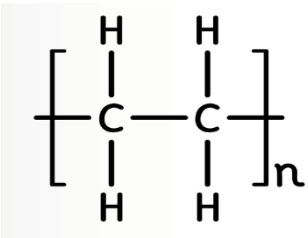
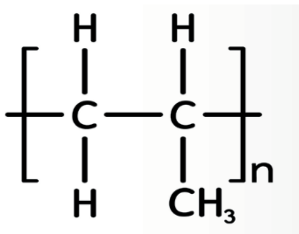
	PE (polyethylene)	*PP (polypropylene)*
Structure		
Initial monomer	*Ethene*	*Propene*
Manufacturing reaction	*radical/ catalytic polymerisation*	*catalytic polymerisation*
Combustion products	*CO2 and H2O*	*CO2 and H2O*
Suitability for food / Drinking water	*given*	*given*
Biodegradable	*no*	*no*
Alternative production method	*Bioethanol, recyclates*	*Bioethanol, recyclates*
Recyclable	*yes*	*yes*

Table 1: *Technical and ecological properties of the pipe materials PE and PP*

1.2.2 Particle emissions in the water cycle

There are numerous studies on how plastic particles (macro-/microplastics) find their way into the water cycle. A very far-reaching consortium study of a total of 30 sources was published by the Fraunhofer Institute Umsicht in 2018. According to the study, abrasion from tyres is responsible for more than half of the primary microplastic input (1228.5 g/(cap a)). The list is followed by releases from waste disposal (302.8 g/(cap a)) and abrasion from bitumen in asphalt (228.0 g/(cap a)). Drifting from sports fields and playgrounds accounts for 131.8 g/(cap a)), abrasion from shoe soles is 109 g/(cap a)). In the lower part of the list, abrasion from sewers is named as 12.0 g/(cap a)), although a more precise differentiation is not made (***Fraunhofer Umsicht 2018***).

A more recent publication by the Fraunhofer Institute on behalf of the Fachvereini-gung Betonrohre und Stahlbetonrohre e.V. (FBS) took a closer look at the abrasion behaviour of the materials in 2021. The institute comes to the conclusion that the abrasion of plastic pipes is significantly lower than initially estimated in the consortium study: 1.45 g/(gap a) instead of 12.0 g/(cap a). This puts plastic pipes at the same level as abrasion from lawn trimmers and power scythes (***Fraunhofer Umsicht 2021***). For more **information on the topic**, see the RSV website.

1.2.3 Transport

Plastic pipes used in the tight-in-pipe method have a low weight, which means advantages in transport and handling.

1.3 Areas of application

The TIP method is used for pipes made of clay, concrete and fibre cement (including asbestos fibre cement). The use of the method for other pipe materials must be examined on a case-by-case basis.
The TIP method is not only used for circular profiles, but also for egg-shaped and special profiles. This factsheet can be applied analogously. The application is to be checked in each individual case.
In addition to the fact that backfilling of the annulus is not required, the TIP process has other characteristic features:

- With regard to the route of the existing pipeline, slight changes in direction can be made in the pipe axis. Bends - for example through fittings - are not possible. The bendability of the systems must be checked in each individual case.
- Vertical position deviations (underbends) of the existing pipeline are passed through but not eliminated. It must therefore be checked in advance whether corresponding position deviations can be accepted in the renewed state.
- Local deformations of up to approx. 25 % and pipe offsets of up to 10 % can be deformed back and the pipeline length renovated / renewed using the tight-in-pipe method.
- The tight-in-pipe method currently enables the rehabilitation of sewers from DN 150 to DN 1200.

1.4 Exemplary pictures from the practice

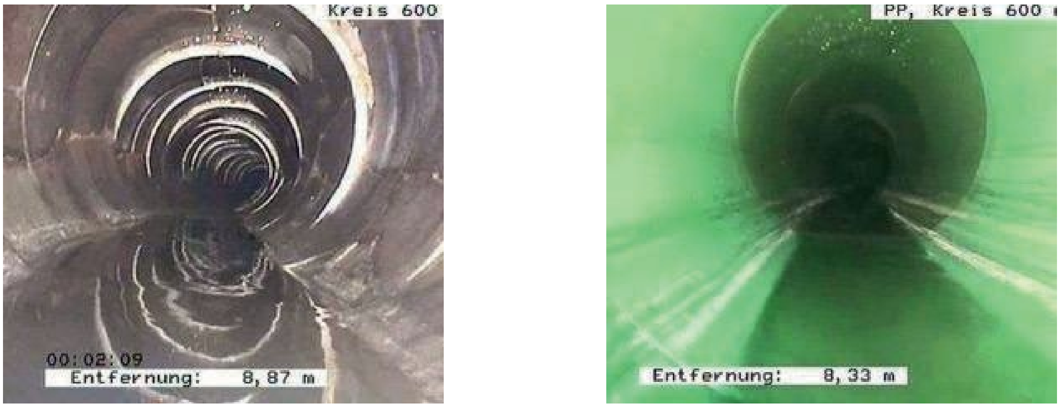


Figure 4: Rehabilitation with the tight-in-pipe method (left: before rehabilitation, right: after rehabilitation)

Figure 5: Application examples for the tight-in-pipe method. Left: Deformation (AZ IIIa), Middle: Breakout at the pipe invert (AZ III), Right: Missing pipe piece (AZ IIIa).

Figure 6: Left: Pipe rehabilitated using the tight-in-pipe method. Right: Manhole connection

1.5 Economic efficiency and working life

For the economic consideration of the tight-in-pipe method, not only purely procedural considerations must be taken into account. In particular, the following aspects must be considered in direct connection with the treatment of sewer construction measures under charging law:

- If the sewer support is expected to have a longer working life than the existing pipeline due to the use of the tight-in-pipe method, this is an investment measure.
- If the sewer support achieves a new "economic life" through the use of the tight-in-pipe method with high-quality materials or with special installation technology, an expected economic working life corresponding to the new construction can be applied.

With regard to the - possibly still existing - residual book values of the processed sewer support, it must be decided to what extent the remaining and further used building fabric is to be taken into account. In this context, regionally different boundary conditions must also be taken into account.

1.6 Notes on occupational health and safety

The PE and PP pipes used in the tight-in-pipe method are free of hazardous substances according to the CMR list of the German Federal Environment Agency (carcinogens, mutagenic, toxic to reproduction (CMR) and other problematic substances in products (*Umweltbundesamt 2011*).

There are also no special requirements for the method in terms of occupational health and safety. The usual requirements for occupational health and safety apply.

2 Requirements

2.1 General

To ensure a consistently high quality of execution, written specifications must exist. These should be available for the type as well as for the scope of all required process steps (procedure manual).

Work processes should be described in work instructions. The personnel employed must be familiarised with the specifications through documented training measures. The work instructions are therefore part of a quality-assured method implementation and must be verified for all quality-relevant activities during the installation of measures in the tight-in-pipe method.

2.2 Qualifications of the company

Only competent companies may be entrusted with the execution of the work. In particular,

this must be proven for:

- Equipment
- Qualification of the personnel for the respective method
- Self-monitoring
- Purchase of supplies and services

The contracting authority can use a "system for the examination of suppliers or companies" in accordance with the EC Directive of 17.09.1990 **(Annex C of DIN EN 1610). Contracting** authorities using this system are obliged to proceed with appropriate care when awarding the contract for the construction work and to request the necessary qualifications or to satisfy themselves of these qualifications. **Guidance on this is given in DIN 1960 (VOB/A §8 No.3).**

The **RAL Quality Assurance GZ 961** contains requirements for renovations. Among other things, it stipulates that any subcontractor used must meet the same requirements as the main contractor.

RAL has recognised the Gütegemeinschaft Herstellung und Instandhaltung von Abwasserleitungen und -kanälen e. V. - **Güteschutz Kanalbau** - as the institution that carries out all tasks in connection with the RAL-GZ 961 Quality Assurance for Sewer Construction.

There is currently no separate system group for the tight-in-pipe method at Güteschutz Kanalbau. Due to the specific requirements of the method, the establishment of such a group is recommended by the RSV. Until this exists, the use of group S 51.1 (pipe bursting) is recommended.

2.2.1 Rehabilitation manual

Contractors who use the tight-in-pipe method must have a corresponding renovation manual. Minimum requirements for this can be found in the proof of suitability according to **RAL-GZ 961.**

2.2.2 Equipment technology

As high forces can occur during the tight-in-pipe method, it is important that the equipment used meets the requirements for functional suitability and occupational safety. They must also comply with the DGUV regulations. All machines used must comply with the Machinery Directive 2006/42/EC CE.

2.2.3 Trainings

The crew responsible for carrying out the tight-in-pipe method must consist of qualified personnel and instructed persons. Qualification certificates, training measures and instructions must be documented and must contain at least the following information:

- Place, date
- Theme and content
- Name and signature of the participants
- Trainer / Training location

At least one procedure-related training shall be conducted and documented per year.

2.2.4 Quality assurance on the construction site

Documentation and traceability

For each construction measure carried out, a complete documentation of all process-relevant steps and preparatory work shall be prepared. These records must be kept for at least 10 years.

The documentation of the work on the construction site must at least include:

- Sample site protocol for tight-in-pipe method (see ***Annex 8.1***)
- Visual inspection before and after refurbishment
- calibration record
- Measuring the connections
- Construction site daily logs The Client shall regulate who is to carry out the documentation within the framework of the award of contract.

2.3 Requirements for new pipes

The requirements for the pipe geometry, the materials used, the joints and the pipe statics are described below.

2.3.1 Diameter and annular gap

The outer diameter of the new pipe is slightly smaller than the inner diameter of the existing pipeline in the tight-in-pipe method, so that the cross-section is only minimally reduced (***Table 2***).

EXCLUSIVE

Nominal diameter of existing pipeline [DN]	*Typical outer diameter of new pipe [mm] **	*Associated annular gap [mm]*
150	144	3
200	192	4
250	242	4
300	292	4
350	340	5
400	392	4
450	440	5
500	485	7,5
600	580	10
700	680	10
800	775	12,5
900	875	12,5
1000	975	12,5

Table 2: *Reference values for dimensioning the new pipe*

** Other dimensions are possible, but the maximum annular gap of 5 % up to DN 450 and 4 % from DN 500 - based on the dimension of the existing pipeline - should not be exceeded.*

The annular gap is half the difference in diameter between the internal diameter of the existing pipeline and the external diameter of the new pipe. **The actual inner diameter of the existing pipeline must be determined, e.g. by means of calibration measurements.** For the new pipe, the outer diameter of the pipe specified by the manufacturer is used. The annular gap determined in this way can be rounded to half a decimal place.

As a general rule, the maximum annular gap of 5 % up to DN 450 and 4 % from DN 500 - based on the dimension of the existing pipeline - must not be exceeded.

2.3.2 Materials

New pipes made of polypropylene (PP) and polyethylene (PE) are usually used for pipe insertion in the tight-in-pipe method. Other materials are also possible after a case-by-case examination (see ***Table 3***: Material of the new pipes).The new pipes for the tight-in-pipe method are usually made of the following materials:

material	*method*	*Dimensional range [DN]*	*Special features*
PP-HM Polypropylene with high E-modulus (material according to DIN EN 1852-1) E-modulus at least 1,700 MPa (short term)	Discrete pipe and continuous pipe lining without forming technology	150 to 1200	Solid wall pipes with inspection-friendly paint or inner layer
PE 100-RC Polyethylene with high stress crack resistance (material requirements according to DIN 8075,DIN EN 12201-1))	Continuous pipe lining with / without forming technology	150 to 1200	Solid wall pipes with inspection-friendly paint or inner layer

Table 3: *Materials of the new pipes*

The following instructions must be observed when selecting the pipe materials:

- Other materials may be used if their suitability is proven.
- Only new pipes with externally smooth joints and dimensions adapted to the existing pipeline can be used for the tight-in-pipe method.
- In the case of the tight-in-pipe method with continuous pipes made of PE, the new pipes must be made of PE 100- RC.
- The new pipes for the tight-in-pipe method must be dimensioned in such a way that the annular gap between the outer diameter of the new pipes and the inner diameter of the existing pipelines corresponds to the notes in ***chapter 2.3.1*** under this ***table.***
- If different internal diameters are found in the existing pipeline, the smallest permissible external diameter of the new pipes must be determined accordingly.

2.3.3 Joints

In the tight-in-pipe method, no pipes with joints that extend beyond the pipe's outer diameter may be used. Plug-in connections with elastomer seals, welded connections or combined plug-in / welded connections are used. The maximum permissible values for the axially acting forces in the joints must be specified by the manufacturer.

Butt fusion welding or wall-integrated electrofusion are used to make welded joints. For PE pipes, the specifications of **DVS guideline 2207 Part 1**. For PP-HM pipes, the specifications based on DVS Guideline 2207 Part 11 and in particular the manufacturer's specifications must be observed. Furthermore, the following applies:

- Welding beads must be removed inside and outside before pipe installation.
- When using plug-in connections with elastomer seals, the seals must comply with the specifications of DIN EN 681-1 or 681-2.
- The joints of pipes made of thermoplastic materials must meet the requirements of DIN EN ISO 13259 test condition A to D. For other materials, the requirements of DIN 4060 must be met as a minimum.

2.3.4 Static requirements

The static calculation of pipes that are installed in existing sewers using the tight-in-pipe method is based on DWA-A 143-2. The new pipes must be able to take on the operational and static loads, taking into account the existing pipe state. The classification of the existing pipe into an existing pipe state is carried out according to DWA-A 143-2.

Verification for existing pipe state I:

If existing pipe state I is present, the static verification of the new pipes is carried out for the effect of external water pressure (minimum groundwater level: 1.5 m above the pipe invert or 0.1 m above the crest). The imperfections to be applied are not yet defined in DWA-A 143-2 for the tight-in-pipe method.

The annular gap wS is the difference between the inner diameter of the old pipe and the outer diameter of the new pipe:

$$w_S = \frac{d_{i,alt} - d_{a,neu}}{2}$$

w_S = annular gap
$d_{i,alt}$ = max. inner nominal diameter existing pipe
$d_{a,neu}$ = outer diameter new pipe

Within the framework of the stability analysis, a local folding wV is assumed. For this, the minimum value according to DWA-A 143-2 of 2 % of the mean new pipe radius is assumed.

Verification for existing pipe state II and III

For the static verification of existing pipe states II and III, no distinction is made in the TIP procedure. In both cases, the new pipes must be verified for the action of earth and traffic loads as well as for external water pressure. Since the new pipes in existing pipe state II do not adapt to the deformed geometry of the existing pipeline, but the latter is deformed back, the effect of earth and traffic loads on the new pipe is to be expected after the pipe has been pulled in. The calculation model defined in DWA-A 143-2 for a new pipe embedded in a four-bar ring must therefore be used.

The new pipes have to be tested against the effects of earth and traffic loads as well as external water pressure. As the new pipes in existing pipe state II do not adapt to the deflected geometry of the existing pipeline, but the latter is deformed, the effect of earth and traffic loads on the new pipe is to be expected after the pipe has been pulled in. Therefore, the calculation model defined in DWA-A 143-2 of a new pipe embedded in a four-bar ring is to be used.

It is recommended that the concentration factor λ R be set at 1.5 and the horizontal earth pressure coefficient K2 at 0.2 in accordance with DWA-A 143-2.

The verification is carried out analogous to DWA-A 143-2 either with the help of a beam work model or an FE model. The gap formation must not be taken into account here (concerns earth and live load). There is no need to apply a local deformation. A joint ring pre-deformation should be applied according to the expected ovality of the pipes used. This should be a maximum of 2 %.

The static verification for the load case external water pressure is carried out analogously to the existing pipe state I for the existing groundwater level or for the minimum water pressure to be applied.

The superposition of the earth and live load cases and the strong water pressure load case according to DWA-A 143-2 must be verified.

Verification for existing pipe state III a

No residual load-bearing capacity is assigned to the existing pipeline. The static verification i s carried out here according to ATV-DVWK A 127 as an underground pipe.

Verification in the installed condition

During pipe installation, the forces acting on the new pipes, resulting from skin friction and other process-specific concerns, must be absorbed by the new pipe and its joints. The corresponding manufacturer's specifications regarding the permissible tensile forces and the jacking forces of the new pipes used must be observed and documented.
In the case of forming technology, the increased stresses on the pipe material and joint must be verified.

2.4 Manhole structures and excavations

Applicable occupational health and safety guidelines must be complied with irrespective of process-specific requirements.
In the tight-in-pipe method, the manhole structures and excavations must meet the machine and process-specific requirements. The corresponding manufacturer's

(pipe and machine) must be observed.

The condition of manhole structures should be checked in advance for the application of the TIP method - especially for the force absorption of the machine technology.

In addition, the following applies to manhole structures:

- A minimum diameter of 1,000 mm is required for manhole structures in which machine technology (hauling carriages, pushing equipment, bracing technology) is installed.
- In the case of manholes from which new pipes are installed, the pipeline length to be rehabilitated should ideally meet the manhole at a right angle in order to ensure sufficient space for handling the technology and the pipe material. If the inlet or outlet of the pipeline length to be rehabilitated meets the manhole structure tangentially, the available space must be checked if necessary.
- In the case of intermediate manholes, the permissible angularity or bending radius (horizontal and vertical) of the new pipes used must be observed.
- For start and reception shafts where a depth of less than or equal to 2.0 m is maintained, the cone must be removed (work safety).
- For pipes larger than DN 500, the cone must also be removed
- The crampons are to be removed to minimise the risk of injury
- Depending on the machine technology, it may be necessary to / or berm to be removed

Additionally for excavations:

- In the case of starting pits for the installation of continuous pipes, the permissible bending radii depending on the pipe temperature must be observed (see ***chapter 3.2***).
- When working in groundwater, suitable measures must be taken to keep the excavations free of water.

Control and storage of materials on the construction site

Before installing the pipes and pipe components, check them for possible damage. Furthermore, the manufacturer's mark, approval or DIN, EN no. etc. of the pipe marking must be checked.

The pipes and pipe components must be stored in accordance with the manufacturer's instructions. The material must be protected especially against high temperatures and intensive UV radiation.

3 Process variants

3.1 TIP method with discrete pipes

In the tight-in-pipe method with discrete pipes, factory-made new pipe modules are installed in the sewer to be renewed. This can be done either from manholes or construction trenches. When installing the pipes, the permissible jacking forces must be observed. These are specified by the respective manufacturer. The actual jacking forces must be monitored and recorded (see ***Appendix 8.2*** for a sample).
Depending on the local conditions, the tight-in-pipe method can be used with individual pipes from manhole to manhole, manhole to excavation and from excavation to excavation.

3.1.1 Manhole - manhole

The installation is carried out without any further civil engineering work. The requirements for the start and reception shafts are described in chapter 2.4.

Different variants are available for the installation (see ***Appendix 8.3***)

- Insertion procedure
- Insertion method with traction support
- Pull-in method under pretension

The variant shown in Figure 8 is the pre-stressed pull-in method.

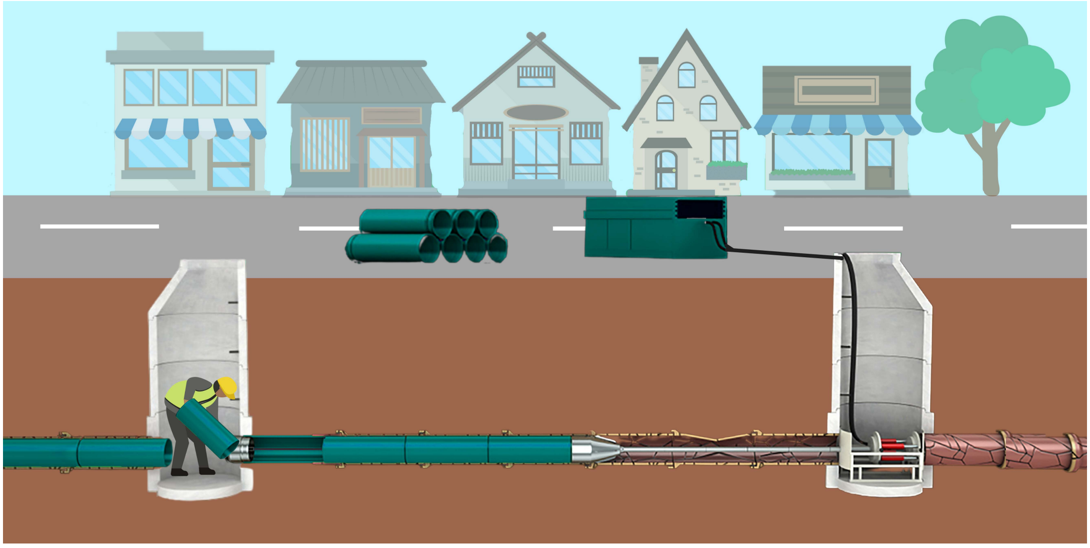


Figure 8: Installation of discrete pipes entry shaft (l.) - reception shaft (r.) (winched-in-place insertion)

3.1.2 Excavation - manhole

With this variant, the pipe installation can be carried out from an excavation or an appropriately designed manhole.

Different variants are available here (see ***Appendix 8.3***: Installation methods):

- Insertion procedure
- Insertion method with traction support
- Pull-in method under pretension

In the variants shown in ***Figure 9*** and ***Figure 10***, the pipe installation is carried out from a starting pit. Figure 9 shows the insertion method. Figure 10 shows the insertion method.

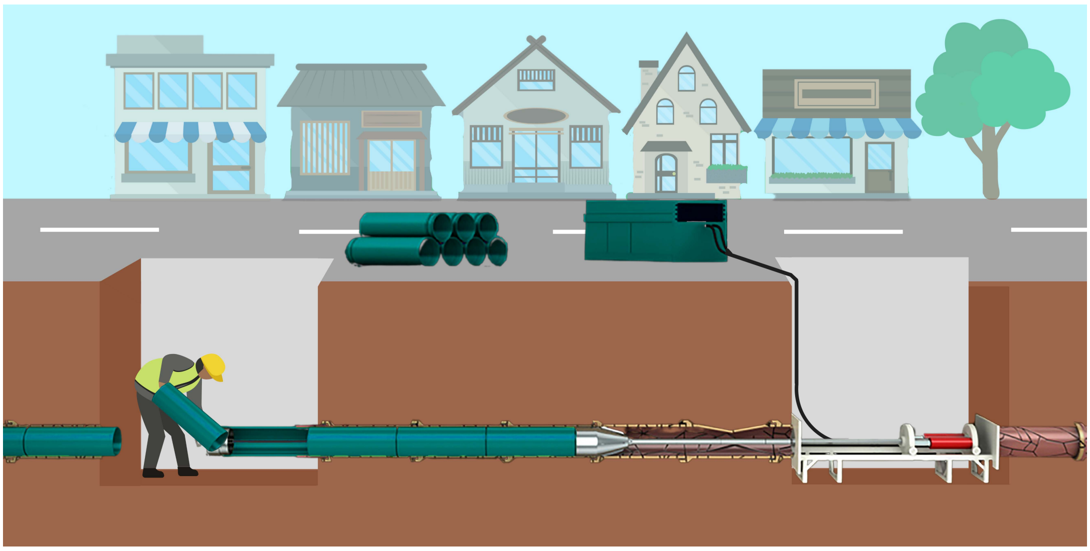


Figure 9: Installation of discrete pipes starting pit - reception shaft (winched-in-place insertion)

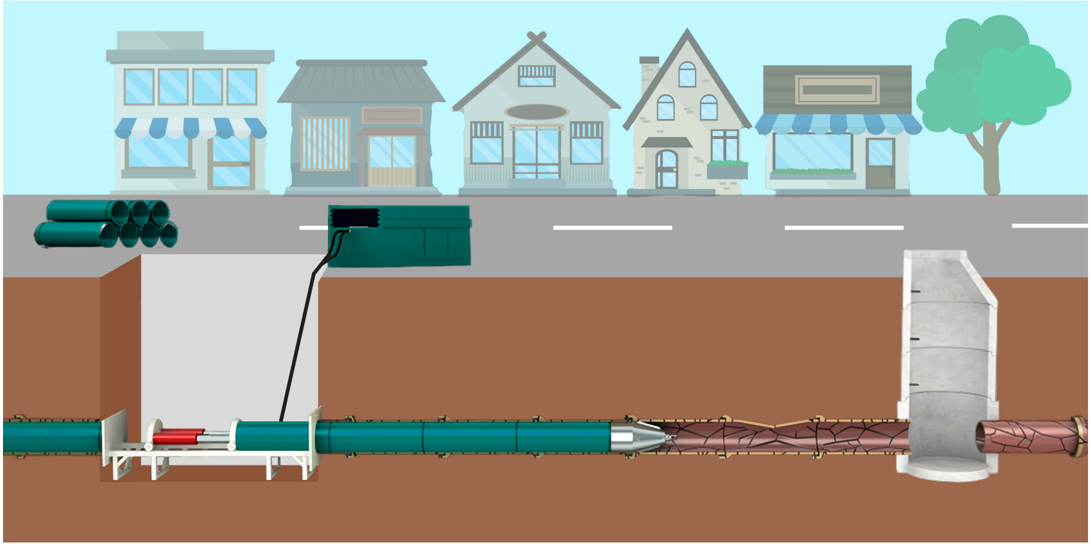


Figure 10: Installation of discrete pipes starting pit - reception shaft (insertion method)

3.1.3 Baugrube - Excavations

In this variant, the raw paving is carried out from excavations. Different variants are available here (see ***Annex 8.3***):

- Insertion procedure
- Insertion method with traction support
- Pull-in method under pretension

In the variant shown in ***Figure 11***, the pipe installation is carried out using the pull-in method from a starting pit.

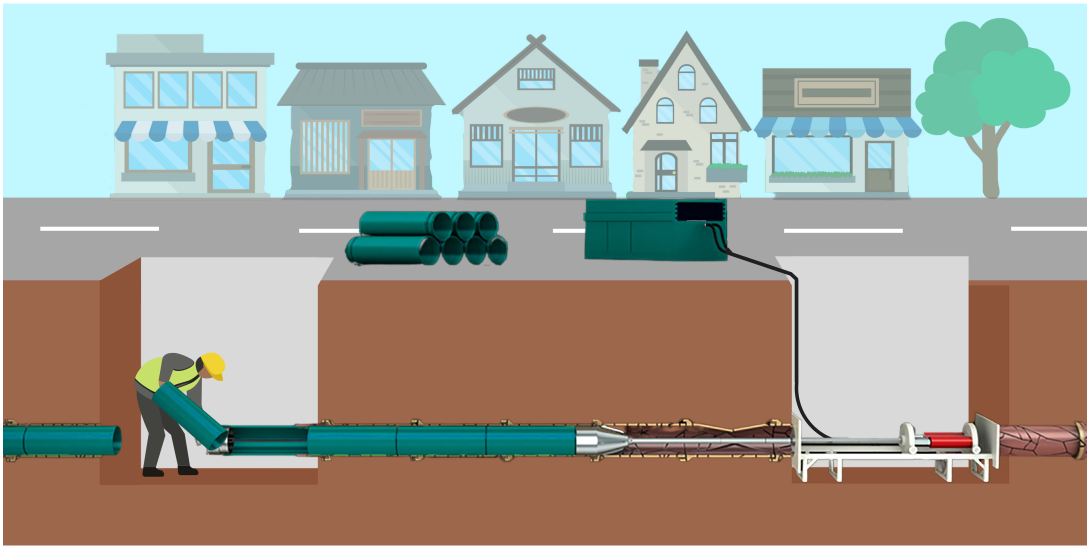


Figure 11: Installation of discrete pipes starting pit to target pit (winched-in-place insertion)

3.2 TIP method with continuous pipe

In this method, a previously welded continuous pipe is installed in the section to be rehabilitated. The new pipes can be installed from excavations - as described in ***Annex 8.3*** Installation methods - and, in the case of special methods, also from manholes.

The following should be noted:

- The permissible tensile forces of the new pipes used must not be exceeded when pulling in the continuous pipe.
- The occurring tensile forces are to be measured and recorded. Alternatively, overload protection can be ensured by suitable measures. This must also be recorded. (see sample protocol ***appendix 8.2***)
- The temperature-dependent minimum permissible bending radius of the continuous pipe must not be undercut during installation.
- Depending on the depth and the permissible bending radius, the required excavation length or length of the pipe intake slot is determined. The permissible bending radius results from the material, the temperature and the dimension of the pipe.

Figure 12 below shows how the excavation length can be calculated as a function of the bending radius of the continuous pipe.

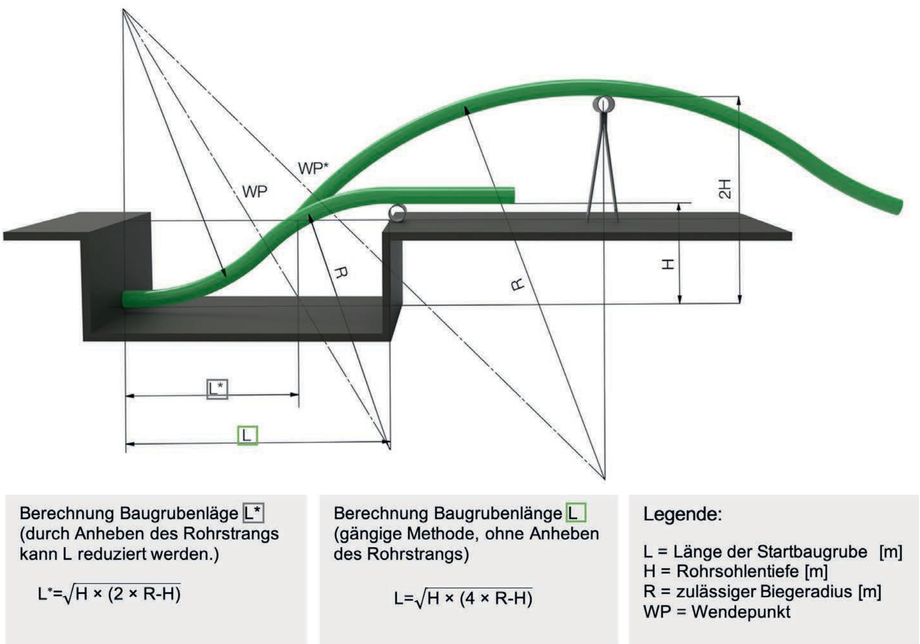


Figure 12: Calculation of the excavation lengths with/without lifting the continuous pipe

Depending on the local conditions, the tight-in-pipe method with continuous pipe from excavation to excavation (see example in ***Figure 13***) as well as from excavation to manhole (see example in ***Figure 14***) can be used.

3.2.1 Baugrube - Excavations

The installation of the pre-welded continuous pipe is carried out from a starting pit to a target pit. The continuous pipe is retracted via the starting pit. The target pit contains the machine technology / deflection for the pipe pull-in.

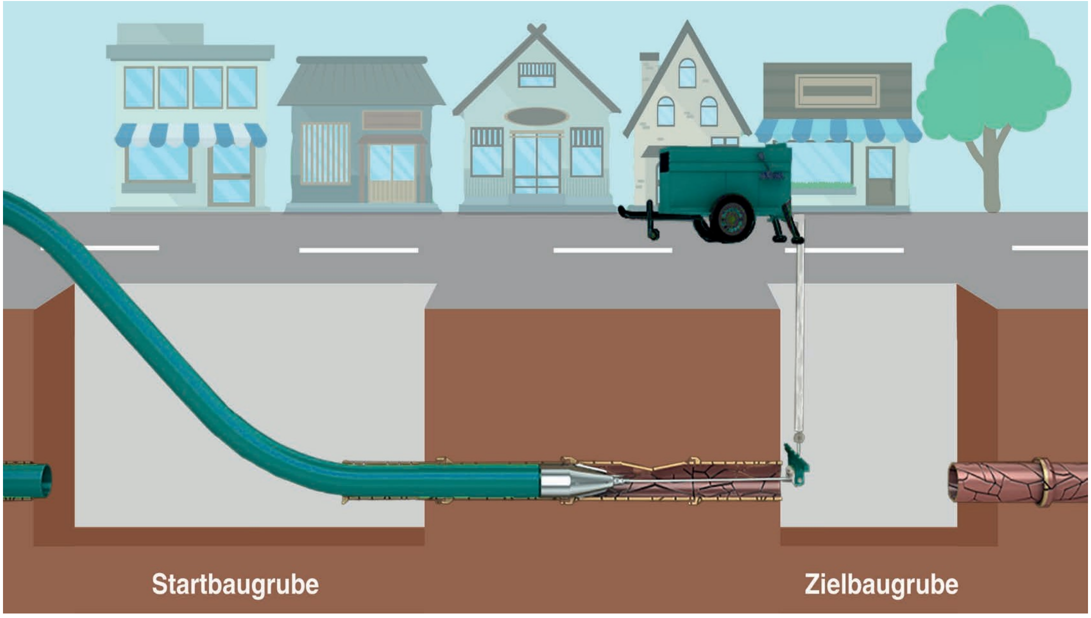


Figure 13: Installation of continuous pipe from starting pit to target pit

3.2.2 Excavation - manhole

The installation of the pre-welded continuous pipe is carried out from a starting pit to a target manhole. The continuous pipe is retracted via the starting pit. The reception shaft contains the machine technology / deflection for the pipe intake.

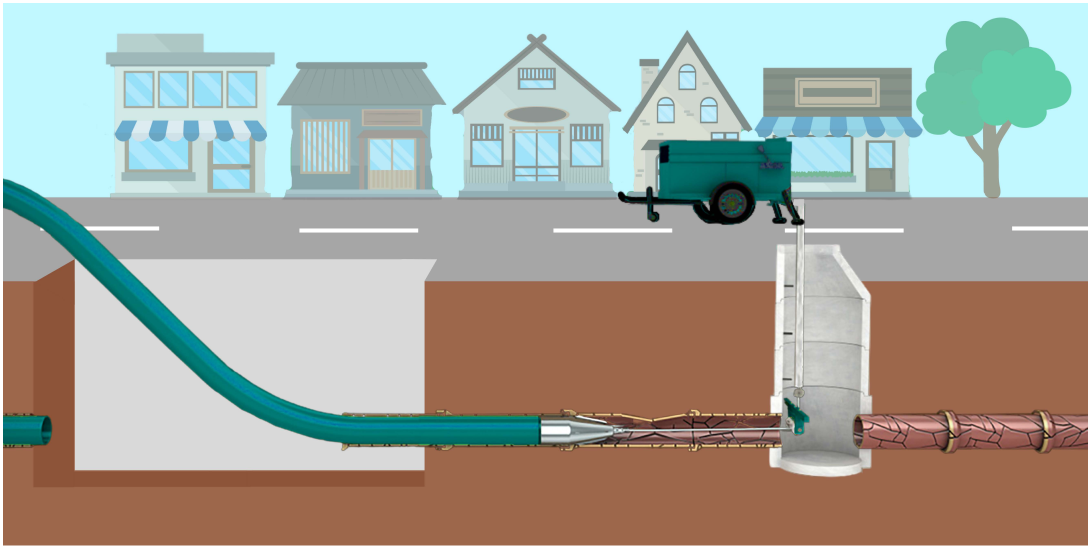


Figure 14: Installation of a continuous pipe from the starting pit to the reception shaft

3.2.3 Forming technology (special processes)

In this process variant, a continuous pipe that has previously been welded together is ovalised, deflected and re-formed using a special forming technique. This shortens the bending radius (see ***Figure 15***). This variant has the advantage that the pipe can be pulled in via an existing manhole or a shortened excavation. This method is suitable for the old pipe dimensions DN 200, DN 250 and DN 300. New pipes made of the material PE 100 RC must be used for the forming technique.

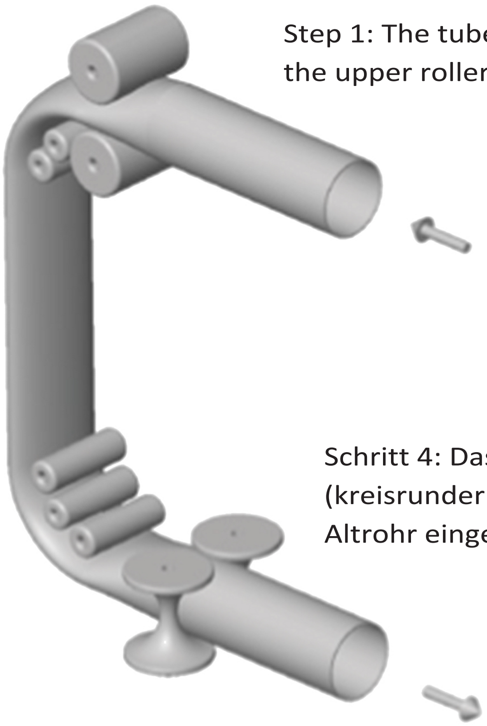


Figure 15: Forming technique for deflection of the pipe when moving into the excavation/ manhole

To be noted:

- The forming must be carried out with a suitable machine technology.
- As for other technologies in which deflections of the pipe material occur during installation, the following applies: The pipes used must be explicitly marked as suitable for the forming technique by the manufacturer. In particular, the maximum ovalisation and the minimum bending radius of the ovalised pipes as well as the maximum permissible tensile force of the deformed pipes must be specified.
- Any necessary joints and the shaft connections must be installed with end load bearing.

The installation of the pre-welded continuous pipe is carried out via an existing manhole (see ***Figure 16***) or a starting pit. The machine technology for pulling in is located in a target pit.

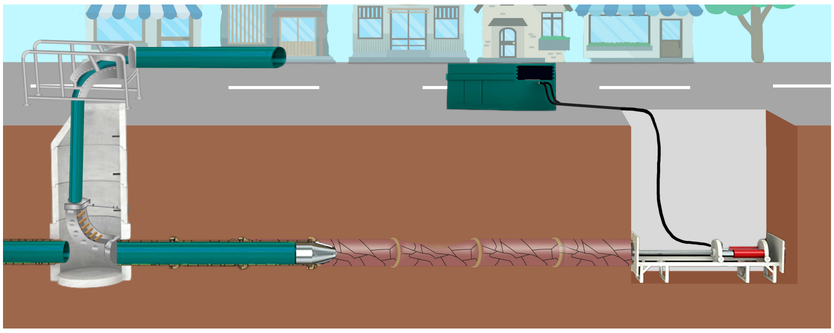


Figure 16: Pipe installation with the forming technology from the entry shaft to the target pit

If auxiliary shafts are available, it is possible to work from manhole to manhole without excavations (see Figure 17). The auxiliary shaft is used to accommodate the haulage system for the rehabilitation between the entry shaft and reception shaft.

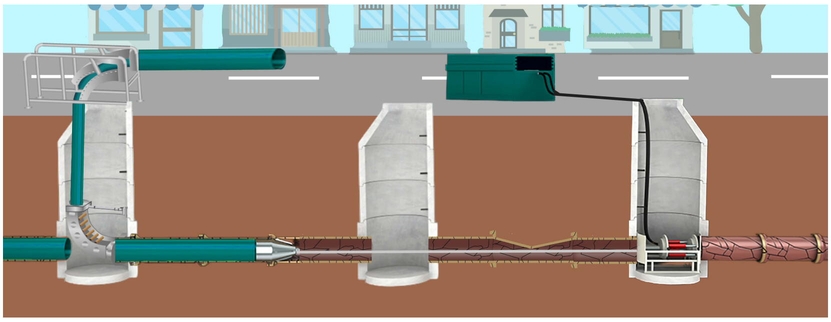


Figure 17: Pipe installation with the forming technique from the entry shaft to the reception shaft

4 Planning

For the planning of the work, a careful actual recording (visual inspection and calibration measurement) of the existing old pipes must be carried out in order to determine whether the TIP method can be used, taking into account the following points.

4.1 Hydraulic performance

As with other methods, a hydraulic analysis of the section to be rehabilitated must also be carried out in advance for the TIP method. The hydraulic capacity must be checked according to the expected requirements of the new sewers (DWA-A 118). In the tight-in-pipe method, the hydraulic cross-section is reduced by the wall thickness of the new pipe. The operational roughness of the materials used ensures favourable hydraulic conductivity of the rehabilitated sewer.

4.2 Condition survey

For the use of the tight-in-pipe method, the following boundary conditions of the old sewer in particular must be taken into account with regard to preparatory and finishing work.

- Differences in inner diameter
- Changes of direction
- Pipe offsets
- Branches or connections
- root growth
- Groundwater ingress with / without soil ingress
- Drainage obstacles
- Deformation
- position deviation

For the use of the tight-in-pipe method, the following boundary conditions of the manholes in particular must be taken into account with regard to the insertion of the pipes or integration of the old sewer (see also ***chapter 2.4***):

- Inner diameter
- Course of the channel
- Location / Condition Inlet and outlet
- Suitability of the manhole as a pipe installation or machine shaft
- Shaft depth
- Material / Geometry

4.3 Choice of procedure variant

Based on the existing discrete pipes and the local conditions, it must be decided whether a single pipe or pipe string method is to be selected and whether work is to be carried out from excavations or manholes. Working from manholes offers the advantage that no or only minor civil engineering work is required for the installation of the pipes.

Excavations can be used to create the required space and prefabricated continuous pipes can be used. In addition, longer installation distances can be realised.

When selecting the process variant, boundary conditions such as traffic conditions, surface conditions and other pipes must also be taken into account.

4.4 Building plot

Since no soil displacement takes place in the tight-in-pipe method, this point is not relevant in the planning of the pipe installation. If excavations are necessary, a corresponding ground survey is required for the verification of the absorption of the load forces, soil disposal etc.

4.5 Details of the redevelopment section

The planned measures are to be presented by the client with a site plan and longitudinal section.

To be indicated are, among others:

- Inner diameter of the existing pipeline, deviations (calibre measurement)
- Material of the existing pipeline, deviations
- If applicable, location and size of the excavations
- Detailed drawings, e.g. of the connection of the new pipe to manholes and special constructions
- Outer diameter of the new pipe
- Bed heights, as well as bed slopes
- Connections, marking of connections no longer required
- planned discharge diversion

4.6 Calibration

Due to the small annular gap in the TIP method, a calibre measurement with simultaneous visual inspection must be carried out. The inside diameter of the undamaged existing pipeline must be determined.

Calibre measurement systems are divided into mechanical and optical systems. When choosing the respective method, the specific boundary conditions must be considered.

The following minimum requirements must be met when measuring the calibre:

- Accompanying visual inspection during calibration measurement
- Continuous indication of the internal diameter of the existing pipeline including stationing
- Documentation of the minimum and maximum inner diameter

The technical boundary conditions of the respective measuring methods must be observed when preparing the calibration measurement.

4.7 Planning the preparatory work

4.7.1 Cleaning / obstacle removal

Cleaning of the rehabilitation section and the manholes is necessary before work begins. It may be necessary to remove obstacles in advance as mentioned in ***chapter 5.2.1.***

The cleaning methods should be chosen in such a way that any damage to the sewers is avoided. In practice, high-pressure water and hydromechanical cleaning methods have proven effective for removing loose encrustations and incrustations.

If there are cross-cutting encrustations, these must be removed by other, suitable methods.

4.7.2 Discharge diversion (receiving water)

During rehabilitation, the receiving water of the sewer and all inlets must be maintained by suitable measures such as diversion via temporary drainage pipes, pumping around or by controlled backwater.

5 rehabilitation procedure

Information on the rehabilitation procedure is described in the following points.

5.1 Construction site procedure

The essential points for the preparation of the remediation measure with the tight-in-pipe method are:

- Start-up meeting with the client
- Visual inspection in the run-up to refurbishment
- Calibrate the entire pipeline lengths to be rehabilitated (see ***chapter 4.6***).
- Checking the layout and size of the planned excavations / checking the suitability of manholes as start/target shafts (see ***chapter 2.4***)
- Ordering of the new pipes as well as other required materials (auxiliaries, moulded parts, cuffs, etc.) based on the values determined
- Preparation of a construction schedule and coordination with the client
- Creation of a discharge diversion concept
- Obtaining the necessary permits
- Distribute citizen information
- Verification of sufficient building clearance

Note: If data deviating from the planning is found, the client must be informed immediately and, if necessary, the remediation concept must be adjusted.

5.2 Preparatory work

Before commencing the work, the following preliminary work must be carried out on the basis of this information:

5.2.1 Establishing accessibility

In the tight-in-pipe method, the new pipes are installed both via standard manhole structures and via excavations. Any excavations required must be constructed in accordance with the applicable rules and regulations.

The space required for installation of the new pipes depends on the diameter and length of the pipe elements.

For larger dimensions, it is necessary to create a construction pit at the installation or entry shaft or to remove the manhole cone. (see ***chapter 2.4***)

In the manholes located in the rehabilitation section, the channels and integration areas must be prepared and, if necessary, removed in such a way that new pipes, calibration head and the machine equipment can be installed and removed.

Obstacle removal

Protruding obstacles that hinder the professional installation of the new pipes are to be removed by a sewer robot. The type and location of the obstacles are to be taken from the preliminary visual inspection.

Obstacles are, for example:

- encrustations
- protruding lateral sewer lines, seals
- root growth

5.2.2 Discharge diversion (receiving water)

Main sewer: Before starting work, the receiving water must be ensured. Suitable measures must be taken to prevent wastewater from the sewer network above the rehabilitation line from entering. In addition, backflow from the network below into the pipe section to be rehabilitated must be avoided. Receiving water can be ensured by diversion or overpumping.

Sewer laterals: A discharge diversion is not mandatory for every lateral sewer line, but should be provided for higher wastewater volumes and longer rehabilitation times.

5.2.3 cleaning

Cleaning of the rehabilitation section and the manholes is required before work begins. The cleaning procedures are to be chosen in such a way that impairment of the damaged pipeline length is avoided.

5.2.4 Visual inspection

The contractor shall verify the data supplied from the planning by visual inspection of the pipeline lengths to be rehabilitated. All necessary data such as length, geometry, changes in direction, damage pattern and obstacles, type and number of connected lateral sewer lines shall be recorded.

5.2.5 Pre-sealing

As a rule, pre-sealing against groundwater ingress is not necessary. It is necessary if sand or alluvial sand has been found to have flushed in.

5.2.6 Calibration of connection attachments

For the trenchless connection, lateral sewer connections are to be measured and documented according to station and position. The same device should be used here that is also used for subsequent opening. If possible, the connections should be measured and opened by the same personnel.

When measuring, it must be taken into account that the reference point (measuring point 0) is maintained until the reconnection of the lateral sewers

5.3 Installation of the new pipes

The procedure for installing the new pipes depends on the choice of the respective process variant (see chapter 3). The installation must be carried out in accordance with the procedure manual.

5.4 Connection of lateral sewer pipes

The connection of lateral sewer lines in the TIP method can be made in the tight-in-pipe method or in the open excavation method. The choice of method is part of the planning, but may require adjustment in the course of the rehabilitation.

When selecting the variant of the inlet connection, various factors must be taken into account such as:

- Accessibility
- Condition of the pipe
- Position and angle
- Dimension of rehabilitated pipe and connected pipe.

For all variants of the inlet connection, both the joint to the side inlet and the joint to the side inlet (A) and the joint to the rehabilitated pipe (B) must be installed professionally. The connections A and B are made from the inside in trenchless construction and normally on the outside diameter of the pipes in open construction (Figures 18 and 19).

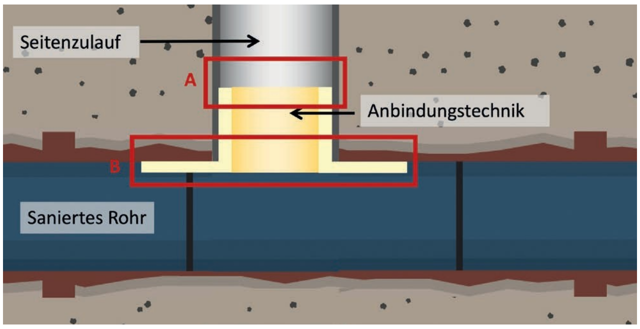


Figure 18: Connection of lateral sewers in trenchless construction from the inside.

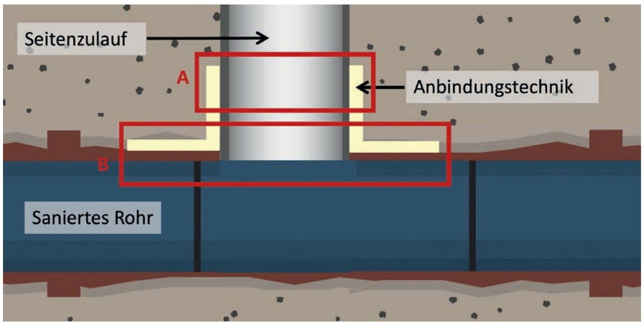


Figure 19: Connection of lateral sewers in open excavation on the outer diameter of the pipes.

*5.4.1 Connection of lateral sweers by **trenchless** technology*

After the installation of the new pipe, existing connecting pipes - depending on the diameter of the main sewer and the geometry of the connection - can be connected from the inside in trenchless construction. For this purpose, the connections are precisely measured and documented with the milling robot before the installation of the new pipes.
Connections can be trenchless from an existing pipe cross-section of DN 250. Smaller nominal diameters are possible, but cross-section reductions must be taken into account.
The lateral sewers are to be connected depending on the boundary conditions and material of the new pipes. The following methods are common:

- a - Weld-in saddle with a fabric hose (lateral connection collar) or in joint with a hat profile
- b - Weld-in saddle in joint with injection method / grouting technique
- c - Injection method / injection technology

  For these methods, special features regarding the suitability of the systems must be checked and the manufacturers' specifications must be observed.

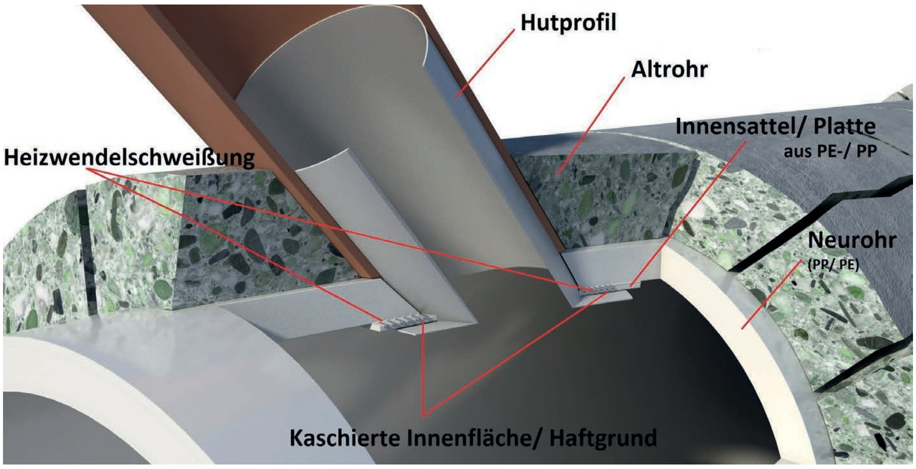


Figure 20: Example inner saddle with lateral connection collar

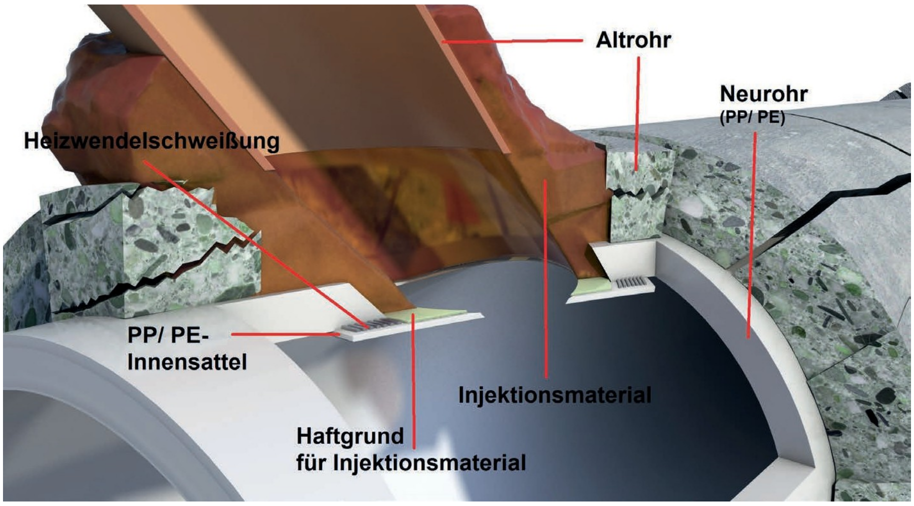


Figure 21: Example inner saddle with grouting (c)

To a and b: When making the connection with a weld-in saddle, a dry working environment must be ensured.

To c: In the case of connections using the injection method / grouting technique, there is no bonding, but rather a form-locking seal free of dead space.

5.4.2 Connection of swer laterals by open-cut methods

For the connection of lateral sewers, weld-in, weld-on or mountable fittings are used. Here, the manufacturer's instructions must be observed and the suitability for the pipe to be connected must be checked. The surface condition of the new pipe must allow the installation of weldable fittings.

5.5 Manhole connections

The connection of the new pipes to manholes must be waterproof. This is usually done by means of manhole inlets or manhole tendons matched to the new pipe.

When installing manhole entries in existing manholes, the existing pipe connections must be chiselled out by hand and the new manhole entries professionally installed. If groundwater is present, appropriate precautions must be taken.

When using shaft end pipes, the existing pipe connections do not have to be chiselled out. However, a functional, existing shaft entry of the existing pipeline into the respective existing shaft is a prerequisite here. The annular gap between the old and new pipes is sealed by the shaft end pipes. This can be done using elastomer seals, swellable seals, compression technology or a combination of these variants.

In the case of new manholes, manhole inlets are incorporated at the factory.

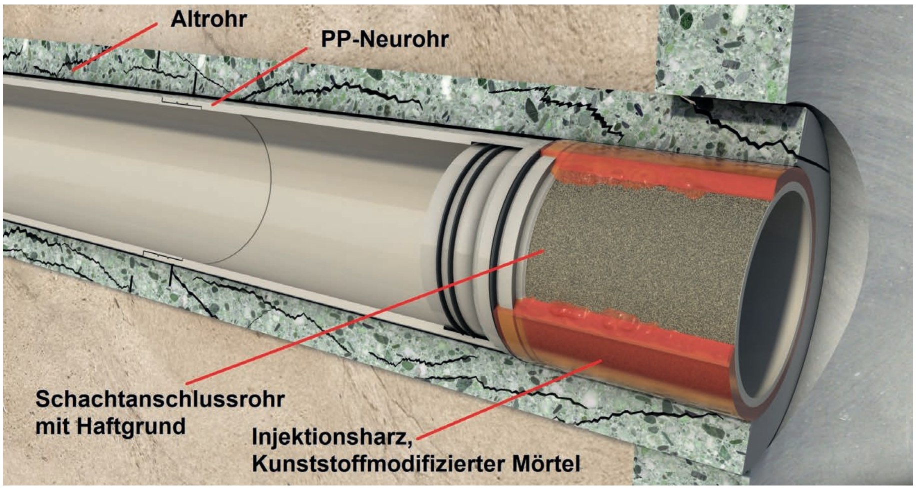


Figure 22: Manhole connection pipe with adhesive primer.

5.6 Pipe joints in excavations

The following systems are available for joints between pipes in excavations:

- Slip-on sleeves
- Pipe couplings / cuffs
- Electric welding sockets

These must be matched to the respective pipe.

5.7 Manhole flumes and berms

Manhole flumes and berms must be professionally rebuilt after pipe installation. The flume must be made level with the bottom, e.g. using prefabricated manhole base parts or sewer clinkers. It is important that the systems are matched to the materials of the installed pipes. Care must be taken to ensure that there is no counter-slope during installation. If this cannot be avoided, it must be taken into account during operation.

6 Quality inspection

For acceptance in accordance with VOB/B §12, the following documents must be submitted for fulfilment of the construction contract.

6.1 Site documentation

All installation records and evidence (e.g. delivery notes, works certificates, records in accordance with the procedure manual or construction contract) must be submitted.

6.2 Optical Inspection

After rehabilitation, a final visual inspection must be carried out in accordance with DWA-M 149-2.

6.3 leak tightness testing

The leak tightness testing is carried out in accordance with the specifications of DIN EN 1610 or DWA-A 139. It must be carried out and documented before the inlets are opened.

7 Laws, standards and rules and regulations

The RSV has compiled a list of basic information on remediation methods on its website under the menu item "Verfahren" (only available in German yet). After selecting the procedure, all relevant current rules and regulations are listed under "Rules and regulations".

8 Attachments

8.1 Enclosure: Installation protocol for pipe installation

Baustellen Nr.: ____________		☐ Berstlining-Verfahren ☐ Kaliberberst-Verfahren
Baustelle: ____________		☐ TIP-Verfahren ☐ Berst-Press-Verfahren

Auftraggeber: ____________	Wetter	Trocken ☐	Regen ☐	
Straße: ____________				
Ort: ____________	Temperatur	______ C°		

Daten des Altkanals		Werkstoff	____________	
von Schacht: ______	Tiefe ______	Haltungslänge	____________	m
bis Schacht: ______	Tiefe ______	Durchmesser i. L.	____________	mm
		Anzahl der Anschlüsse	____________	Stck

Daten des Neurohres		Mängelfrei		
Rohrmaterial	____________	ja ☐	nein ☐	
Außendurchmesser	____________ mm	ja ☐	nein ☐	
Durchmesser i. L.	____________ mm	ja ☐	nein ☐	
Wanddicke	____________ mm	ja ☐	nein ☐	
Einzelrohrlänge	____________ m	ja ☐	nein ☐	
Modul-Anzahl	____________ Stck	ja ☐	nein ☐	
Verbindungsart	gesteckt ☐ geschweißt ☐	ja ☐	nein ☐	
Profiltyp	____________			

Aufrechterhaltung Vorflut			
a) Abwasserart	MW ☐	RW ☐	SW ☐
b) des Kanals	nicht erforderlich ☐	Rückstau ☐	Überpumpen ☐
c) der seitlichen Zuläufe	nicht erforderlich ☐	Rückstau ☐	Überpumpen ☐

Baugrube für Einzelrohr	Modullänge + 0,30 m	ja ☐	nein ☐
Baugrube für Rohrstrang	Biegeradius DA x 30 eingehalten	ja ☐	nein ☐

Grundwasser vorhanden	mit Bodeneintrag	ja ☐	→ Abbruch
	ohne Bodeneintrag	ja ☐	
		nein ☐	

Sample site protocol Page 1/2

Mindestüberdeckung vorhanden mind. 10 x Aufweitungsmaß		ja ☐	nein ☐	
Mindestabstand zu parallel liegenden Leitungen vorhanden		ja ☐	nein ☐	
bindige Böden -	mind. das dreifache des Aufweitungsmaßes, jedoch mind. 40 cm			
nichtbindige und oder steinige Böden -	mind. das fünfache des Aufweitungsmaßes, jedoch mind. 1,00 m			
Einbringvorgang				
a) einziehen ☐		zulässige Zugkraft	________	(siehe Anlage)
b) einschieben ☐		zulässiger Druck	________	(siehe Anlage)
Vorbereitende Leistungen				
Reinigung am:	________	Ausführende Firma:	________	
Hindernissbeseitigung:	________	Ausführende Firma:	________	
TV-Inspektion:	________	Ausführende Firma:	________	
Kalibrierung am:	________	Ausführende Firma:	________	
Art der Kalibrierung:	________	Min. ø	________	
Abschließende Leistungen				
Anbindung Zuläufe am:	________	Ausführende Firma:	________	
Dichtheitsprüfung DIN EN 1610 bestanden:	ja ☐ nein ☐	Ausführende Firma:	________	
Dichtheitsprüfung EN 805 bestanden:	ja ☐ nein ☐	Ausführende Firma:	________	
Sichtprüfung / TV-Abnahme durchgeführt:	ja ☐ nein ☐	Datum:	________	
Besonderheiten:				
Verantwortliche Fachkraft:	________ Datum, Unterschrift	**Unterschrift:**	________ Datum, Unterschrift	

Sample construction site protocol Page 2/2

8.2 Attachment: Logging of the retraction/insertion force (sample)

Baustellen Nr.:		von Schacht	
Baustelle:		nach Schacht	
		Streckenlänge	
Auftraggeber:		Modullänge	
Straße:		Einziehkraft (Soll)	

Rohrmodule	tatschächliche Einziehkraft/	Rohrmodule	tatschächliche Einziehkraft/	Rohrmodule	tatschächliche Einziehkraft/
1		22		43	
2		23		44	
3		24		45	
4		25		46	
5		26		47	
6		27		48	
7		28		49	
8		29		50	
9		30		51	
10		31		52	
11		32		53	
12		33		54	
13		34		55	
14		35		56	
15		36		57	
16		37		58	
17		38		59	
18		39		60	
19		40		61	
20		41		62	
21		42		63	

Besonderheiten:

Verantwortliche Fachkraft: Datum, Unterschrift

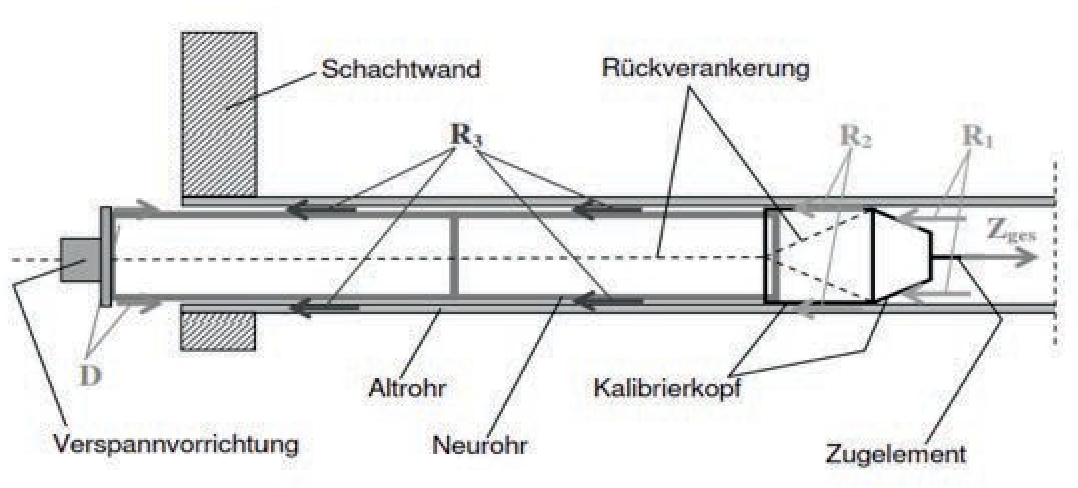
Unterschrift: Datum, Unterschrift

8.3 Appendix: Installation method

Force application with bracing of the discrete pipes (pull-in method)

In this method, the forces for installing the pipes are divided into two main components. On the one hand, this is the force for compensating the deformations and misalignments (R1) and for overcoming the casing friction (R2) at the calibration head and, on the other hand, the tensioning force (D) at the tensioning device, which counteracts the casing friction at the neurotubes (R3).

The required tensile force (Zges.), which is transmitted via the tension element, must be at least large enough to overcome the forces R1, R2 and R3.

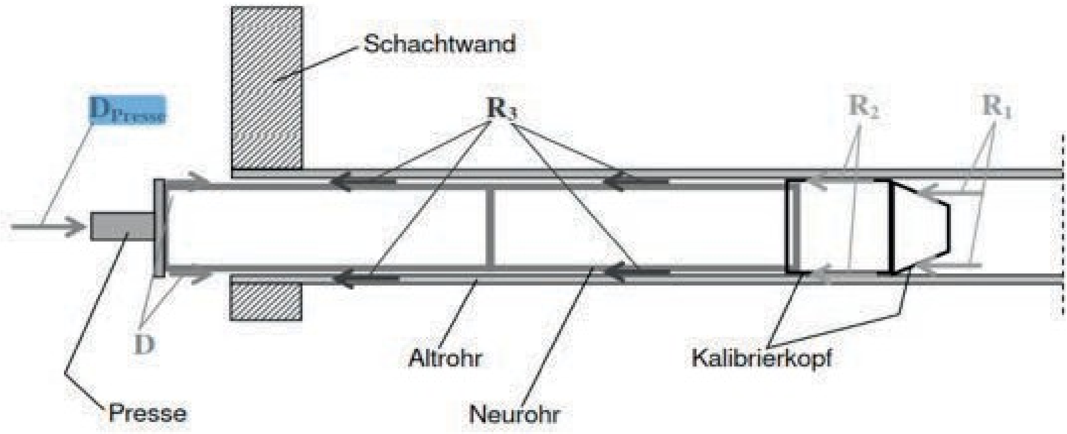


The tensioning force D must at least correspond to the casing friction at the new pipes (R3) and must not exceed the permissible jacking force of the new pipes.

Force application during insertion of the discrete pipes (insertion method)

In this variant, the force for compensating the deformations and misalignments (R1) at the calibration head, the force for overcoming the jacket friction (R2) at the calibration head and the force for overcoming the jacket friction at the neurotubes (R3) are completely introduced via the neurotubes as pressing force (D) via a press. The pressing force D must not exceed the permissible jacking force of the pipes.

Force application during insertion of the discrete pipes (insertion method)



9 definitions

Sewer	Mostly underground sewer or other device for the Discharge of wastewater and/or rainwater from several sources
Drain	Mostly underground pipe for the discharge of waste water. and/or rainwater from the point of origin to the sewage canal
Discharge diversion	Measures to ensure proper drainage of wastewater water drainage (main sewer and connections) during decommissioning of the affected sewer section
Discrete pipe	Single pipe module that can be connected to other discrete pipes by means of a factory-fitted joint and is suitable for trenchless installation.
Replacement	Construction of new drains and sewers in the same or a different line, whereby the new installations incorporate the function of the original drains and sewers.
Pipeline length	Section of a sewer between two manholes and/or special constructions.
Auxiliary shaft	Manhole that is used additionally if the start or reception shaft cannot accommodate the machine technology required for the intake or insertion.
Working life	The working life is the period of time during which the the rehabilitated sewers can be used for operational purposes
Renovation	Measures to improve the current functional The existing pipeline, with full or partial incorporation of its original substance.
Remaining working life	Operational suitability, which exceeds the technical useful life of the asset. The duration of the
Annular gap, annulus	Half of the difference between the existing pipeline's inner diameter and the New pipe outer diameter results in a gap dimension. If this gap dimension is smaller than 5 % in relation to the existing pipeline up to and including DN 450, and smaller than 4 % from DN 500, the pipe is considered to be close-fitting and backfilling is not necessary. In this case, the difference is referred to as an annular gap (for further guide values, see Table 2). A larger gap dimension results in an annulus that must be backfilled.
Continuous pipe	Pipe which is manufactured from bar stock or connected individual pipes in a tension-locking manner.
Rehabilitation	Measures to restore or improve existing piping systems by means of repair, renovation or replacement.
Manhole	A structure with a removable cover placed in a drain or sewer to allow people to enter.
entry shaft / -excavations	Starting point for pipe installation
Reception shaft / excavations	End point for pipe installation

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For more information on the working groups, please visit www.rsv-ev.de/arbeitskreise.

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If you have any questions, please do not hesitate to contact us! We look forward to hearing from you

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