
PIPE
SEALTEC

Contents

Introduction

Dear user and design engineer,

we are glad to welcome you as a user of our Pipe-Seal product range. Based on your existing know-how in the field of pipe rehabilitation we are convinced that with the aid of these instructions the application and the installation of our Pipe-Seal products will be quite easy.

This manual will be a guideline for you throughout the whole mounting procedure and you herewith dispose of all the experience we have gained so far.

We shall always be ready to respond to individual requests. And we shall just as well help you with words and deeds, if you need us at building sites.

Good luck!

Best regards

The Pipe-Seal-Tec Team

Maxhütte Gewerbering
08056 Zwickau
(Germany)

Contact persons/Locations

Managing directors:
Markus Brechwald
Martin Cygiel

Sales Office work:
Mrs Claudia Werner
Phone: +49(0)375/303 466-11
Fax: +49(0)375/303 466-22
claudia.werner@pipe-seal-tec.de

Sales Field work:
Mrs Andrea Schulz
Cell: +49(0)170/4545749
andrea.schulz@pipe-seal-tec.de

Service technician:
Mr Daniel Schlehahn
Phone: +49(0)375/303 466-20
Fax: +49(0)375/303 466-22
daniel.schlehahn@pipe-seal-tec.de

2 General information and details

For the sake of clarity and to avoid faults, we ask you to carefully read these instructions before you start installing our *Pipe-Seal* products.

On delivery and before the use of our Pipe-Seal products we ask you to check the received goods as to their sound condition. We regret, but later complaints cannot be considered. Please check the completeness and the operational readiness of the necessary tools and the fitting aids before installation. We shall gladly provide you with the appropriate tools and fitting aids as well as a number of useful adaptors and fittings.

When you do not observe these instructions resp. different points thereof, malfunctions and/or defects may occur on our *Pipe-Seal* products and on the mounting system, which may lead to damage on persons and material.

The present instructions do not raise claim to completeness. For tips and suggestions please contact us under:

Internal pipe sealing systems

Pipe-Seal-Tec GmbH & Co. KG
Maxhütte Gewerbering 19
D-08056 Zwickau
Phone +49 (0) 375/303 466-0
Fax +49 (0) 375/303 466 22
pipeseal@pipe-robo-tec.de

www.pipe-seal-tec.de

3 Note: Occupational health and safety and accident prevention

We remind that the currently valid directives concerning the occupational health and safety and the accident prevention must be absolutely followed!

We basically point out that

- When mounting the *Pipe-Seal* products and when starting the mounting pressure, the shaft area must be left.
- Protective glasses and ear muffs must be worn.
- The filling devices (hose; compressor, accessory equipment) must be checked for operational liability before use.
- Wearing the personal protective equipment is a basic requirement for carrying out construction work.

The following general requirements must be observed before installing *Pipe-Seal* products:

- Before mounting *Pipe-Seal* products the areas to be rehabilitated must be kept clear of e.g.:
    - pressure
    - fouling
    - flow media

4 System *Pipe-Seal*

4.1 System

Our Pipe-Seal products Pipe-Seal-Fix und Pipe-Seal-End are suitable for the repair of pipelines with dimensions from DN 150 to DN 800 and Pipe-Seal-Flex for dimensions from DN 200 to DN 400.

It is a mounting system made of stainless steel V4A and a compression seal of EPDM, which is mechanically and continuously adjustable in the corresponding dimensions and areas of application. The damage repair takes place by a permanent contact pressure of the respective stainless steel sleeve in connection with an EPDM rubber seal to the existing pipe wall.

Our Pipe-Seal products -Fix and -End – comprise each on both sides a strip with a single tooth row produced by die-cutting.

Our Pipe-Seal product -Flex – respectively comprises on both sides a strip with a double tooth row produced by die-cutting.

In connection with our patented locking system the tooth row locks when expanding according to the existing local conditions and ensures that the setting and contact pressure durably persists.

In order to be able to mount a stainless steel sleeve in an existing pipe to be rehabilitated, this sleeve is prepared (rolled up) during the production with a smaller nominal diameter, which allows an easy carrying of the stainless steel sleeve to its place of installation.

This transport usually takes place with packer systems, which are expanded by means of compressed air and which simultaneously mount the carried stainless steel sleeve in relation to its system limits (dimensions; areas of application). During this procedure the existing tooth row passes through the patented locking system, which is only moving in one direction.

4.2 Storage and transport

To guarantee the high quality of our products, imperatively watch that storage and transport of the stainless steel sleeves is corrosion-free. That means it must be absolutely avoided that they get into touch with base metals.

Furthermore we point out that our precision products are to be secured during transport.

Securing is necessary to avoid e.g. violent pressures and deformation resulting thereof.

4.3 Rules and standards

Our *Pipe-Seal* products are subject to the following rules and standards:

1. DIN EN 13508-2 „Measures for repairing locally limited damage“
2. Data sheet DWA-M 143-5 „Rehabilitation of drainage systems outside buildings”; Part 5: Repair of sewer pipes and conduits with internal sealing collars
3. DIN EN 681-1 Elastomer seals – Material requirements for pipe seals applied in the water supply and the drainage
4. Stainless steels – Part 1: List of stainless steels; German version EN 10088-1:2014

Our *Pipe-Seal* products were approved for the nominal widths DN 200 to DN 800

1. DIBt-approval No. Z-42.3-521 – Internal pipe seals called *Pipe-Seal* for buried sewage pipes with the nominal width DN 200 to DN 800
2. High-pressure flushing safety according to DIN 19 523 – Requirements and test procedures for detecting the high-pressure jet and flushing resistance of pipe sections for sewer pipes and conduits.
3. Test of the hydrogen identity of the elastomer sealants acc. to ASTM D5576
4. Proof of the stability of the steel quality in relation to wastewater acc. to DIN 1986-3
5. Test of the water tightness acc. to DIN EN 1610 – Installation and testing of sewage pipes and conduits for internal and external pressure of 0.5 Bar

6. Test of the water tightness under heavy load exposure. Deformation and angular offset acc. to DIN 4060 – Pipe connections of wastewater conduits and pipelines with elastomer seals – Requirements and tests on pipe connections with elastomer seals.
7. Elastomer guideline of the Federal Environment Office.

5 Survey - Pipe-Seal products

5.1 Pipe-Seal-Fix

5.1.1 Execution

Figure 5-1 *Pipe-Seal-Fix* without EPDM rubber seal

Supplied product range (see enclosed data sheet)

- Dimensions from DN 150 to DN 800
- Construction length:
  - Dimension DN 150 Construction length 30.0 cm
    - Rubber seal B= 286 mm
  - Dimension DN 188 to DN 530 Construction length 42.0 cm
    - Rubber seal B=500 mm
  - Dimension DN 560 to DN 800 Construction length 50.0 cm
    - Rubber seal B=590 mm
  - Flanging
    - **without**
      - predominantly serial displacement
      - also possible in single displacement according to local requirements
    - **one side**
      - single displacement with flanging opposed to the direction of flow
      - serial displacement as end sleeve with flanging opposed to the direction of flow
    - **two sides**
      - single displacement with flushing safety on both sides

5.2 Pipe-Seal-End

5.2.1 Execution

Supplied product range (see enclosed data sheet)

- Dimensions from DN 150 to DN 800
- Construction length:
  - Dimension DN 150 to DN 500 Construction length 25.0 cm
  - Dimension DN 600 to DN 800 Construction length 30.0 cm
  - Rubber seal B=195 mm for DN 150–DN 500
  - Rubber seal B=225 mm as from DN 600
  - Flanging

Figure 5-2 *Pipe-Seal-End* without EPDM rubber seal

in general on both sides

5.3 Pipe-Seal-Flex

5.3.1 Execution

Supplied product range (see enclosed data sheet)

- Dimensions from DN 200 to DN 400
- Construction length:
  - Dimension DN 200 to DN 400 construction length 42,0 cm
  - Rubber seal B=500 mm
  - Appropriate for the use at angular displacements up to 25 mm and / or angular offsets up to 10°
  - displaceable also in combination with *Pipe-Seal-Fix*
  - Flanging

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- **without**
  - predominantly serial displacement
  - Also possible in single displacement according to the local requirements. In this case corresponding delivery periods must be considered respectively asked for

- **one side**
  - On the customer's request delivered with one-sided flanging. In this case corresponding delivery periods must be considered
- **two sides**
  - single displacement with flushing safety on both sides

5.4 Custom-made products

On your request we also make special designs

5.5 Technical explanations

5.5.1 Technical details

5.5.1.1 Locking mechanism

The locking mechanism is a new concept and consists of the following component parts:

1. Lock
2. Tooth row

The advantage of the *Pipe-Seal products* is that, thanks to the patented locking system, the sleeves can be conically expanded in determined limits.
The lock is made of two toothed wheels which are arranged such that the sleeve can only be expanded in one direction and in the opposite direction the locking mechanism automatically locks.
The locking system is fixed to the sleeve by a very flat holding-down plate (see the following figures).
Because of different technical requirements the *Pipe-Seal-Flex* sleeve has a tooth row on two sides and accordingly also a two-sided locking mechanism.

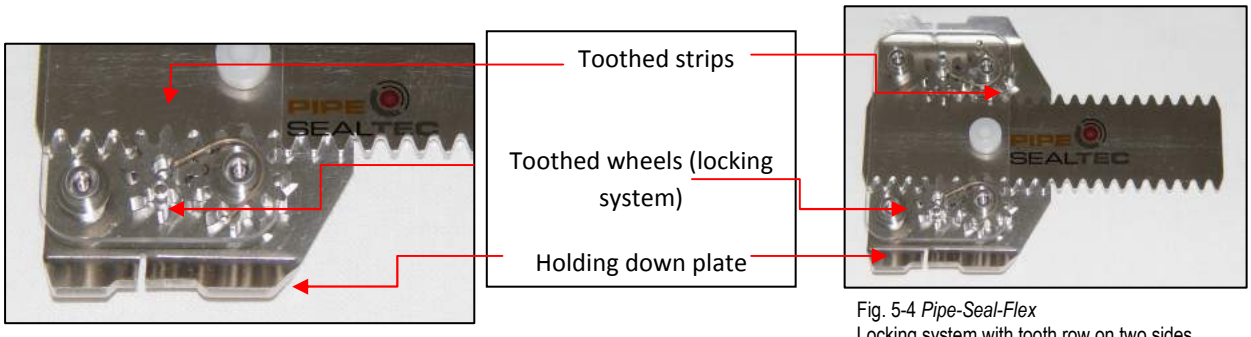


Fig. 5-5 *Pipe-Seal-Fix*/LEM
Locking system with tooth row on one side

Fig. 5-4 *Pipe-Seal-Flex*
Locking system with tooth row on two sides

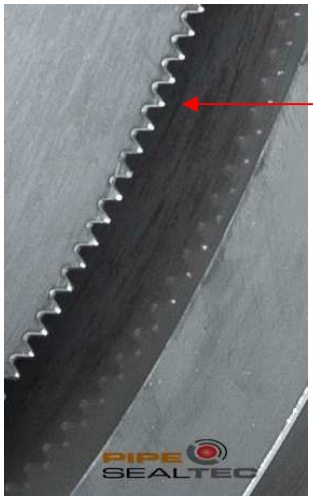


Figure **Fehler! Kein Text mit angegebener Formatvorlage im Dokument.**-4 *Pipe-Seal-Fix/LEM*
tooth row on one side

Toothed strips

Figure **Fehler! Kein Text mit angegebener Formatvorlage im Dokument.**-7 *Pipe-Seal-Flex*
tooth row on two sides

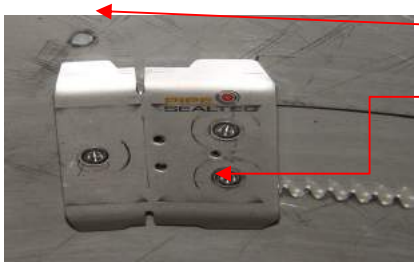


Fig. 5-9 *Pipe-Seal-Fix / LEM*
Holding down plate

Transport locks

Holding down plate

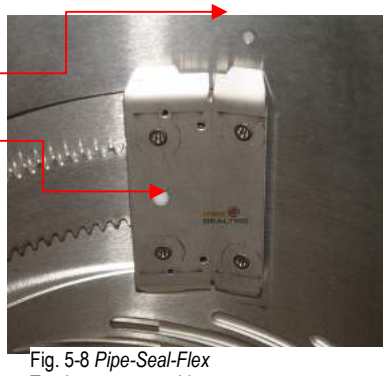


Fig. 5-8 *Pipe-Seal-Flex*
Tooth row on two sides

5.2.1.2 Mode of operation locking mechanism

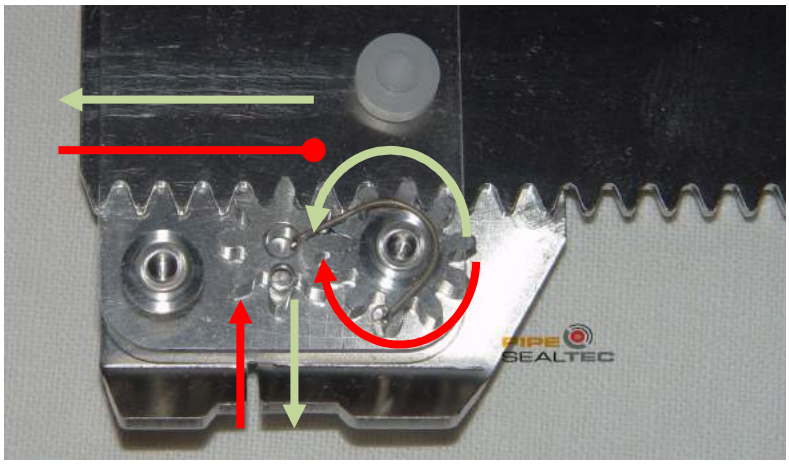


Figure 5-5 *Pipe-Seal*
Lock – direction of travel tooth row

5.5.1.3 Used materials

5.5.1.3.1 Steel

Stainless steel V4A quality 1.4571 / 1.4404 is used for the sleeve. This corrosion-resistant stainless steel is appropriate for the use in municipal wastewaters. Other fields of application must be checked before.

5.5.1.3.2 Rubber seal

A seal of EPDM is most appropriate for municipal wastewaters. The material is resistant to many acids and bases, but not to mineral oils. The temperature resistance lies between -20.0 °C and 140.0°C.

An NBR seal is characterized by its high resistance to oils, greases, carbon hydrides, favorable aging qualities and good mechanical properties.

5.5.1.3.3 Fields of application Pipe-Seal-Fix / (-Flex)

Our *Pipe-Seal* products are suitable for the following defects:

1. **Pipe outbreaks resp. shard formation**

➔ Please mind that protruding broken fragments, e.g. obstructions must previously be eliminated.

Figure 5-11
Pipe outbreak

2. **Cracks**
   a. Longitudinal cracks
   b. Radial cracks
   c. Crack formation

➔ Please mind that before rehabilitation the defect is carefully examined in order to avoid a widening of the crack during installation

Figure 5-12
Crack formation

3. **Leaks as well as leaky pipe connections**
   a. Groundwater intrusion (infiltration)

➔ Please consider the range of approval of our *Pipe-Seal* products, especially concerning the groundwater level above the bottom.

   b. Escaping flow medium (wastewater exfiltration)

➔ Preparing measures may become necessary.

Fig. 5-13
Leaky pipe connection

4. Deviations in position of pipe connections

a. Change of direction
b. Formation of misalignment

➔ Please mind that this is a classical field of application of our *Pipe-Seal-Flex* (watch the dimensions).

➔ In other cases, preparing measures may be necessary.

Figure 5-14
Axial change of direction

5. Closing of unused laterals

➔ Preparing measures may become necessary.

Figure 5-15
Protruding connection piece

➔ Please watch as well the carrying out of laterals, e.g. as to the number of *Pipe-Seal* products to be used.

Figure 5-16
Branch adaptor

6. Outbreaks, material wear, corrosion

➔ We recommend a previous sound examination of the defect as to the ease of installation resp. application of our *Pipe-Seal* products:

i. Degree of corrosion (sealing effect)

Figure 5-17
Concrete corrosion

ii. intruding obstructions

Figure 6
Penetrating roots

➔ Here preparing measures may become necessary.

7. Intruding obstructions

a. e.g. roots

➔ Here preparing may become necessary.

Figure 5-19
Penetrating roots

In case of a single installation the following damage length can be covered:

- DN 150 max. approx. 200 mm
- DN 200–DN 530 max. approx. 300 mm
- DN 560–DN 800 max. approx. 390 mm

There is no problem to cover misalignments up to max. 2.0 cm and/or angular offsets up to 10.0° with our *Pipe-Seal-Flex* in dimensions between DN 200 and DN 400

In order to cover large damaged areas our *Pipe-Seal* products can be placed in series with an appropriate overlapping.

Here it is also possible to combine both product groups – *Pipe-Seal-Fix* and *Pipe-Seal-Flex* according to the previously mentioned general requirements.

5.5.1.3.4 Fields of application Pipe-Seal-End

Our *Pipe-Seal-End* sleeve is a durable and tight connection of liner systems which are completely cured and free of stress.

Figure 5-20 Liner connections with *Pipe-Seal-End*

The *Pipe-Seal-End* sleeve is on the one hand used as a seal between liner and old pipe and on the other hand as a shaft connection. With this sleeve you obtain a pressure-resistant end sealing between shaft structure, old pipe and liner system.

In fringe areas the *Pipe-Seal-End* sleeve is able to seal eccentrically mounted liners, as it can be conically widened (see also 5.5.1.1 Locking mechanism).

6 Installation "Step by Step" – Pipe-Seal-Fix and –Flex

6.1 Preparing the areas to be worked on

6.1.1 STEP 1 – Cleaning and inspection

The area (reach) intended to be rehabilitated must be cleaned as required and protected against a new fouling before the installation of a *Pipe-Seal* product.
Please take care that with the used cleaning devices the actual damage to be eliminated by the *Pipe-Seal* products will not even be increased.
It may be necessary to take additional preparing measures, such as e.g.:

- milling
- surface levelling in case of serious corrosion
- or similar
  (See also *STEP 2 – Preparation*)

After the cleaning procedure the area intended to be rehabilitated must be visually inspected and the actual state must be documented and it must be verified whether the rehabilitation with *Pipe-Seal* products is possible.

Figure 6-7 Damage documentation

An adaptation of the planned rehabilitation to the actual local conditions may be necessary. Based on the results of the visual examination the appropriate mode of performance must be chosen, as e.g.:

- Single mounting of
  - *Pipe-Seal-Fix* or
  - *Pipe-Seal-Flex*
    - With flanging (1 side/2 sides or without)

- In case of serial displacement
  - *Pipe-Seal-Fix* or
  - *Pipe-Seal-Flex*
    - with flanging (1 side or without)
    - Please consider the technical parameters of our products.

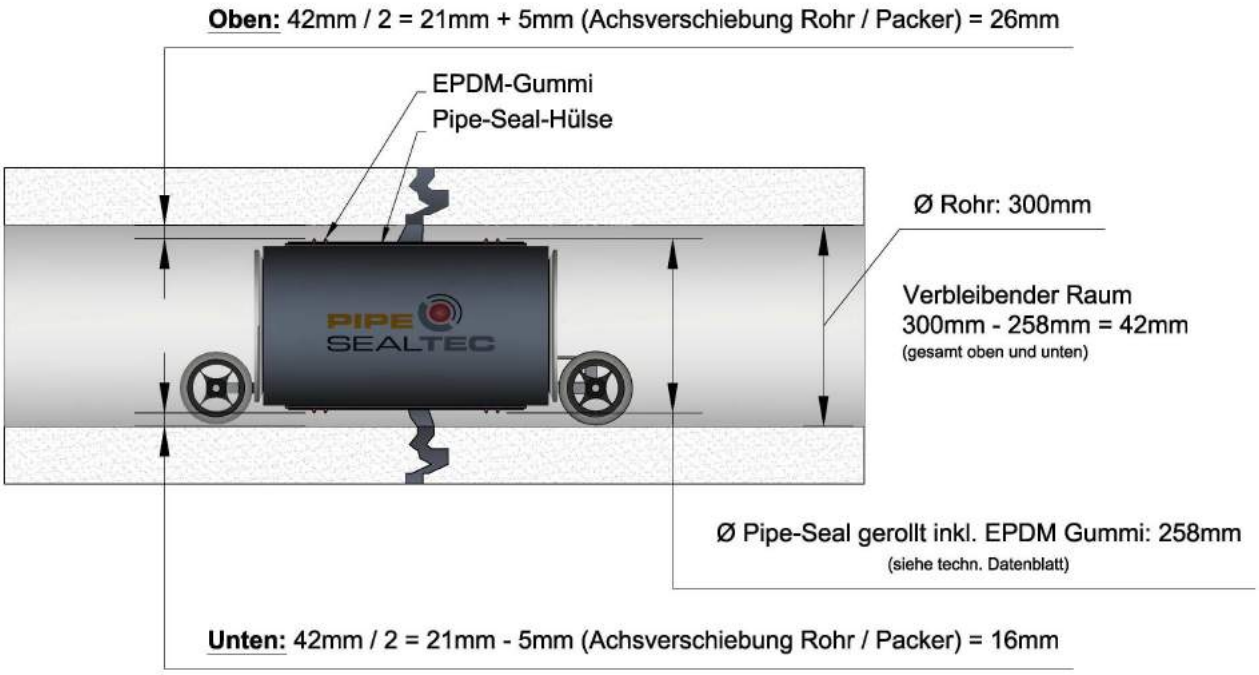
- Combination
  - *Pipe-Seal-Fix* and/or
  - *Pipe-Seal-Flex*
    - with flanging (1 side/2sides or without)
    - Please consider the technical parameters of our products.

Most important when preparing the repair is the knowledge of the local conditions.

NOTE!
Please true and test the rolled-up sizes with the mounting openings resp. the possibilities of access prior to performing the rehabilitation.

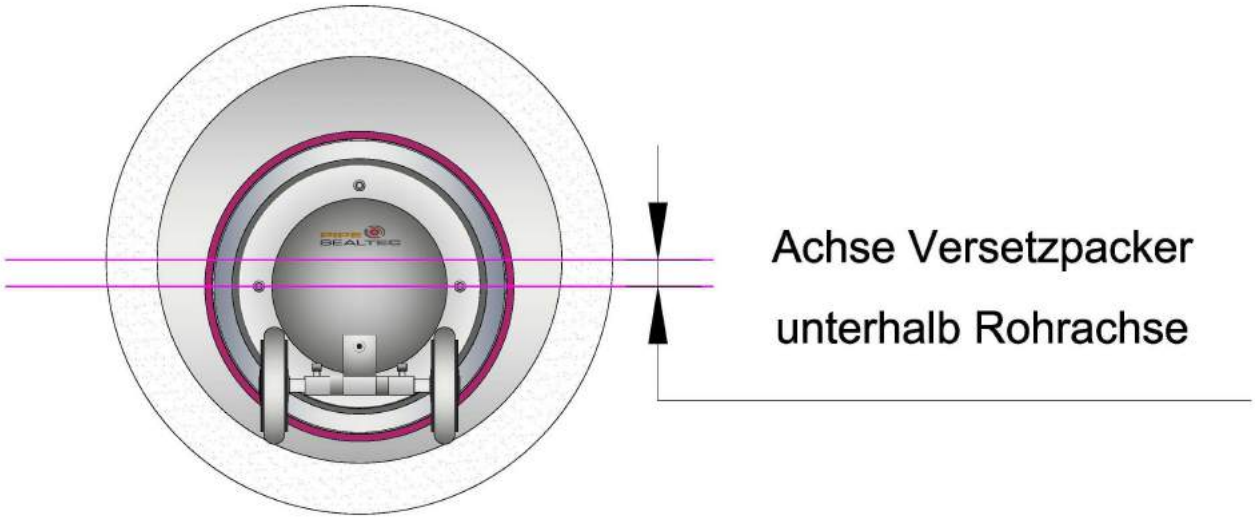
Here we show an example concerning the required mounting space.

Above: 42mm/2=21mm + 5mm (axial displacement pipe/packer) = 26 mm



Pipe ø 300 mm
Remaining space 300mm-258mm=42mm
(in total above and below)

Ø Pipe-Seal rolled-up incl. EPDM rubber: 258mm (see technical data sheet)



Axis packer below pipe axis

6.1.2 STEP 2 - Preparation

The area to be rehabilitated must be prepared so that

- the camera-packer system via connecting rod

Figure 6-8 Mounting system TV-unit / displacement packer and connecting rod

- or the robot-packer system

Figure 6-9 Mounting system Robot unit / displacement packer and robot adaptor

including the respective *Pipe-Seal* product can be positioned without restraints.

At least one access possibility via the revision openings or shaft openings must be guaranteed (previously watch dimensions and/or conditions to be determined) in order to ensure the use of the respective mounting system.

Here particular attention is to be paid to the following factors:

1. Dimension shaft openings (shape and dimensions)

Figure 6-10 Dimension shaft opening

2. Shaft shape (free cross-section)

Figure 6-11 Ensure free work area

3. Channel profile and pipe connection

Note 6--1
Disadvantageous connection
„tangential“

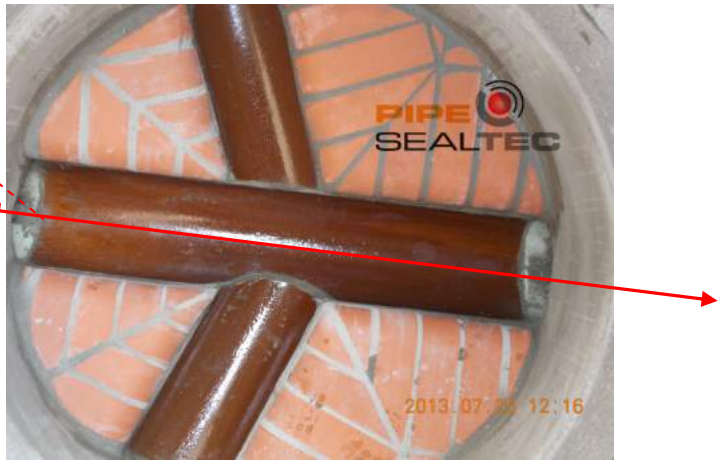


Figure 6-12 Forming of access possibilities such as channel profile and pipe connection

4. Existing situation

Figure 6-13 Misalignment

5. Fouling

Figure 6-14 Shaft fouling

Figure 6-15 Pipe fouling

All the factors impairing the mounting of sleeves must be eliminated beforehand.

See also *Fields of application* and *STEP 1 – Cleaning and inspection*

6.2 Applicable products

6.2.1 STEP 3 – *Pipe-Seal* products and accessories

6.2.1.1.1 Devices, equipment

We recommend the following devices, tools resp. items of equipment:

1. Mounting systems according to the own equipment which are adjusted to the dimensions individually to be worked.
   (See also *STEP 2 – Preparation*

   a. *Pipe-Sea l* products (Fix / Flex / End)

Fig.6-18 *Pipe-Seal-Fix* without EPDM rubber seal

Fig.6-16 *Pipe-Seal-Flex* without EPDM rubber seal

Fig.6-17 *Pipe-Seal-End* without EPDM rubber seal

   b. EPDM rubber

Figure 6-19 *Pipe-Seal* EPDM rubber seal (different models for Fix / Flex / End))

c. Packer

d. Packer coupling system (see also *STEP 2 – Preparation*)
   i. Mounting system Robot unit / displacement packer and robot adaptor
   ii. Mounting system TV unit / displacement packer and connecting rod

e. Adaptor robot system

Fig. 6-20 Adaptor VP to KATE (manuf. *Pipe-Robo-Tec*)

f. Accessories connecting rod

g. Set of wheels for packer for the respective dimension

Figure 6-21 original set of wheels *Pipe-Seal-Tec*

h. Connecting rod

i. Adaptor connecting rod

j. Talcum

Figure 6-22 Talcum (example)

k. Sharp knife

Figure 6-23 Cutter knife

l. Superglue

Figure 6-24 Superglue (example)

m. Manometer with hose connection

Figure6-25 Manometer

n. Compressed air hose with an adequate length

o. Oil (biodegradable and not dissolving rubber)

6.3 Preparing the Pipe-Seal products

6.3.1 STEP 4 – Preparing the *Pipe-Seal-Fix* products

1. Receipt of goods

    a. All the delivered products must be checked as to possible damage before the application!

2. The adhesive strips for securing the position are to be cut out with an appropriate tool (see *Figure 6-23*) (advisable approx. 0.5cm min.)
   as shown in the following figure.

3. In the lock area and in the metal sheet overlap the respective *Pipe-Seal-Tec* products must be oiled (cf. *Oil (biodegradable and not dissolving rubber)*)

EPDM rubber

a. **Before slipping** the EPDM rubber **over** the respective *Pipe-Seal-Tec* products it must be powdered with talcum.
So slipping over is much easier and the friction between rubber and sleeve is reduced.

Figure 6-26 Powder rubber seal with talcum

Figure 6-27 Talc-powdered rubber

b. **Slipping over** the EPDM rubber

Figure 6-28 adequately slip-over rubber seal

Note: ***Sleeves flanged on one side allow an easier slipping over of the rubber on the non-flanged side***

Figure 6-29 Slipping over of the rubber

c. **Cutting** the existing overlap

For cutting the rubber please use a sharp knife or industrial scissors in order to obtain a clean cut

Figure 6-30
Simple cut of overlapping rubber

Figure 6-31 circumferential cut of overlapping rubber

The rubber seal must be cut in a way that the distance between the rubber and the sleeve border is between 0.5cm und 1.0cm.

Sizing 6-1
Distance rubber – sleeve border
min. 0.5cm -1.0cm

Figure 6-32 exact cutting of rubber overlap

Then the rubber seal must be centered on the sleeve.

d. **Fixing** the EPDM rubber on the respective *Pipe-Seal-Tec* product.
This is to secure the fit of the EPDM rubber up to the place of installation without changing its position on the sleeve.
For this purpose the EPDM rubber is fixed with superglue as shown in the figure,
ideally at both ends of the sleeve,
respectively opposite.

Please take care that no glue comes between the metal sheet overlap and / or the locking mechanism, otherwise the expansion of the sleeve is prevented!

Figure 6-33 Application of glue

Generally the sealing effect in single mountings is in the area between the two-sided sealing knob pairs.

- In case of a single mounting the rubber overlap must always be removed – as mentioned before.
- In case of a serial mounting the existing rubber overlap must absolutely be maintained and not be cut.

4. Positioning and fixing on mounting device

    a. **Positioning** the *Pipe-Seal* sleeve on the displacement packer

Position the *Pipe-Seal* sleeve incl. rubber on the packer such that the locking mechanism is on the crown after the later widening.

In order to ensure this, the lock must be positioned at 11 o'clock resp. 13 0'clock in the direction of flow when loading the mounting system.

Figure 6-34 positioning the prepared stainless steel sleeve on the packer

In case a *Pipe-Seal* sleeve with a flange on one side is used, so the flanging must generally be positioned and mounted opposite the direction of flow.

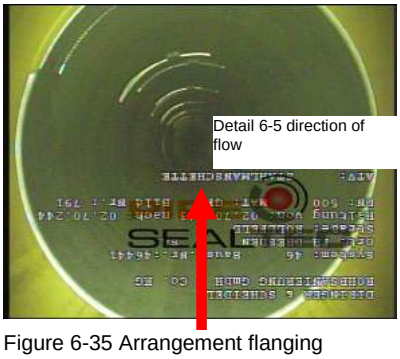


Figure 6-35 Arrangement flanging

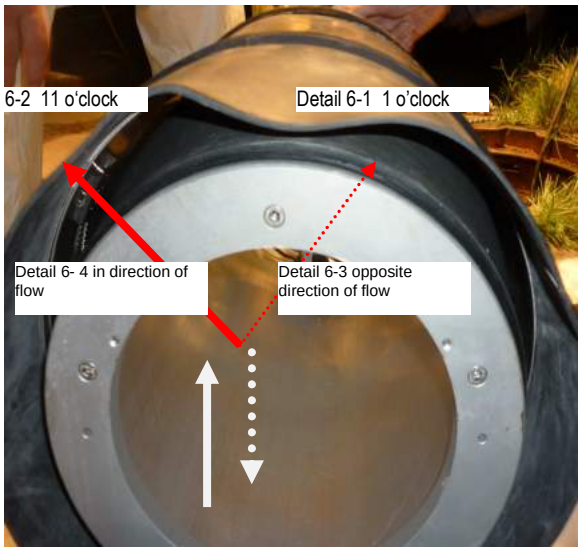


Figure 6-36 Adjustment of locking mechanism

The *Pipe-Seal* sleeve has to be positioned on the mounting device (packer) in a way that a continuous TV supervision of the mounting procedure is guaranteed.

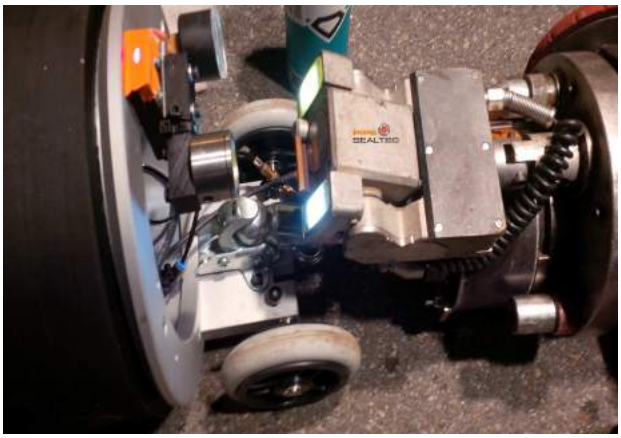


Figure 6-37 Arrangement TV supervision

b. **Fixing** the *Pipe-Seal* sleeve on the mounting device (packer)

f. **Fixing** the *Pipe-Seal* sleeve on the mounting device (packer)

The *Pipe-Seal* sleeve must be fixed with a contact pressure of max. 0.5 Bar on the mounting device (packer) before entering into the area to be worked.

Figure 6-38 Fixing by mounting pressure

The above described positioning of the *Pipe-Seal* sleeve on the mounting device ensures

- The serviceability of the rehabilitation product
- An improvement of the later operability
- The avoidance of flow obstacles.

6.4 Mounting of the Pipe-Seal products

6.4.1 STEP 5 – Mounting of *Pipe-Seal-Fix*

a. **Entering** the *Pipe-Seal* sleeve to the place of installation in the sewer

Drive the mounting system with the *Pipe-Seal* sleeve to the damaged spot.

Please check the damaged area for the suitability of rehabilitation with the *Pipe-Seal* sleeve and document this**.**

Figure 6-39 Access to place of installation in sewer

b. Positioning at the damaged spot

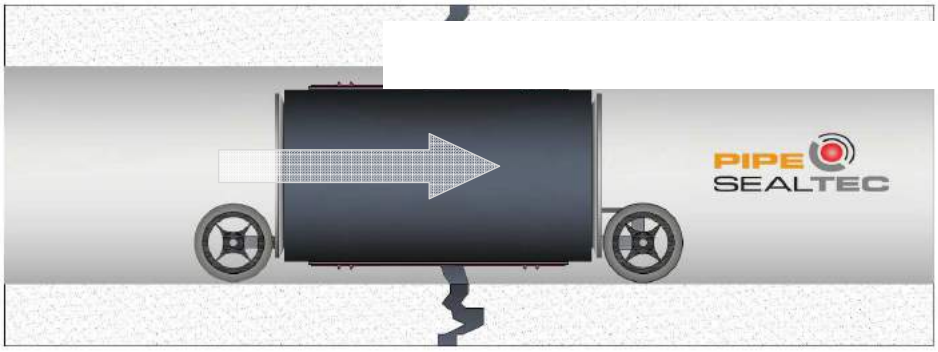


Figure 6-34 Entering to the damaged spot

Position the *Pipe-Seal* sleeve so that the damaged spot is between the sealing knobs.

c. Expansion at the damaged spot

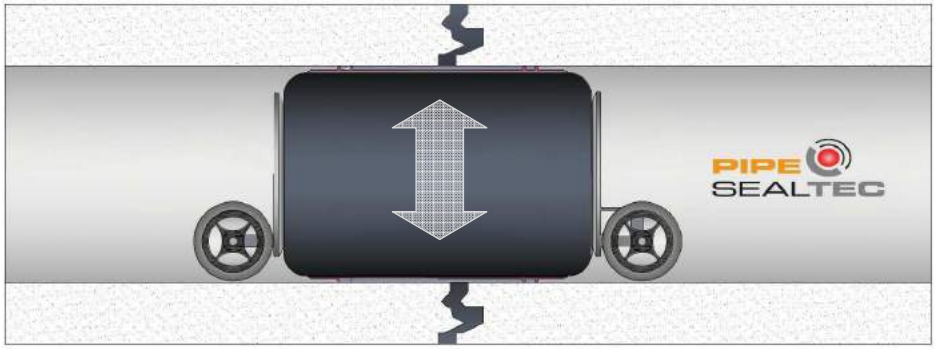


Figure 6-35 Expansion at the damaged spot

Impinge the packer with an air pressure of approx. 2.0 Bar of and expand the sleeve.

Now provide the packer, according to the enclosed table, with the required air pressure, so that the *Pipe-Seal* sleeve entirely fits to the old pipe.
Then relieve the packer (pressure relief). Position the packer in the middle at the respective locks and repeat the above described procedure.

The above described procedure guarantees that the *Pipe-Seal* sleeve ideally fits to the old pipe and the existing rubber seal reaches the required compression and hence the seal effect is achieved.

d. Pressure relief at the packer

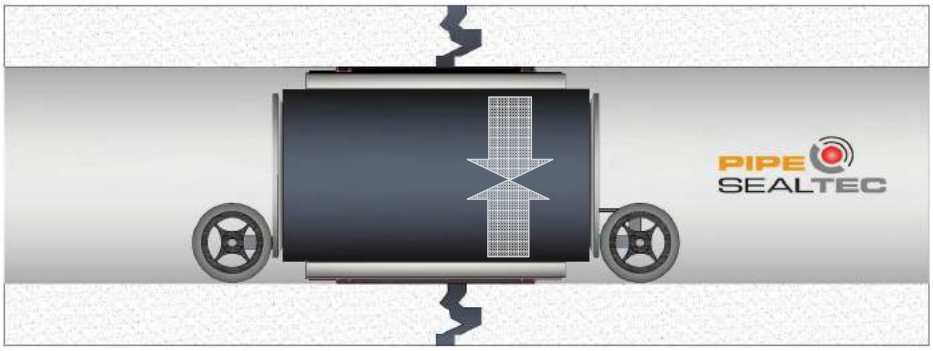


Figure 6-36 Pressure relief completed before removing the packer

Relieve the packer (pressure relief) after the expanding procedure.

e. Remove the packer

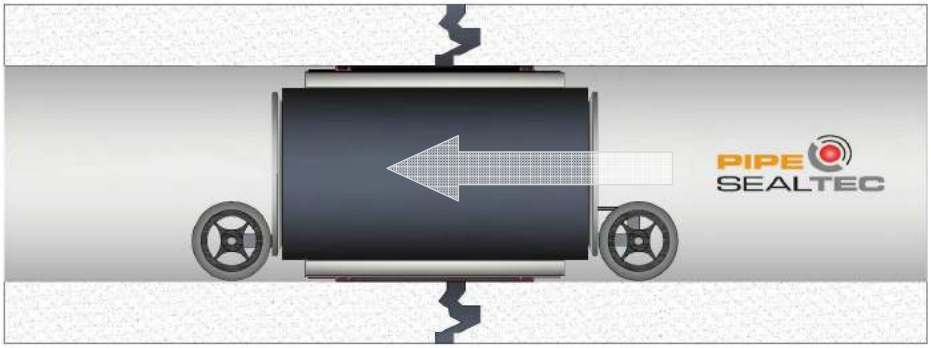


Figure 6-37 remove the packer

Then remove the packer from the rehabilitation area.

f. Document the rehabilitated damaged spot

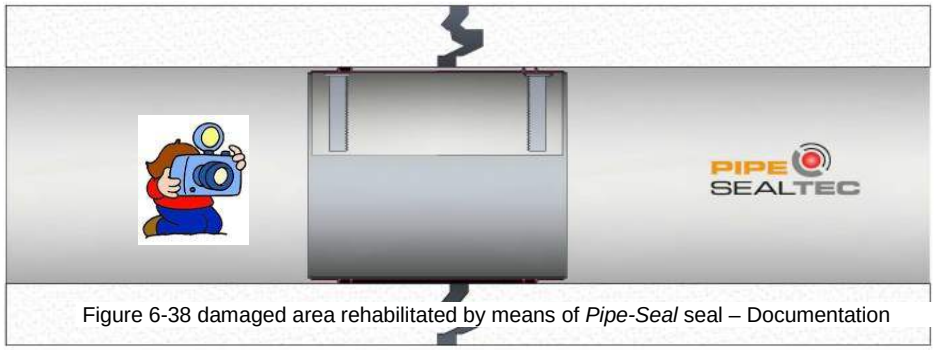


Figure 6-38 damaged area rehabilitated by means of *Pipe-Seal* seal – Documentation

Please document the successful rehabilitation after installation!

6.4.2 STEP 5 – Mounting *Pipe-Seal-Fix with one-sided flanging*

a. **Bringing** the *Pipe-Seal sleeve* to the place of installation in the sewer

See point 6.4.1 STEP 5 – Mounting Pipe-Seal-Fix analogously applies to *Pipe-Seal-Fix* without resp. with flanging on one resp. two sides

When preparing and mounting the *Pipe-Seal*-sleeve with a flanging on one side, please take care that the flanging is positioned against the direction of flow!

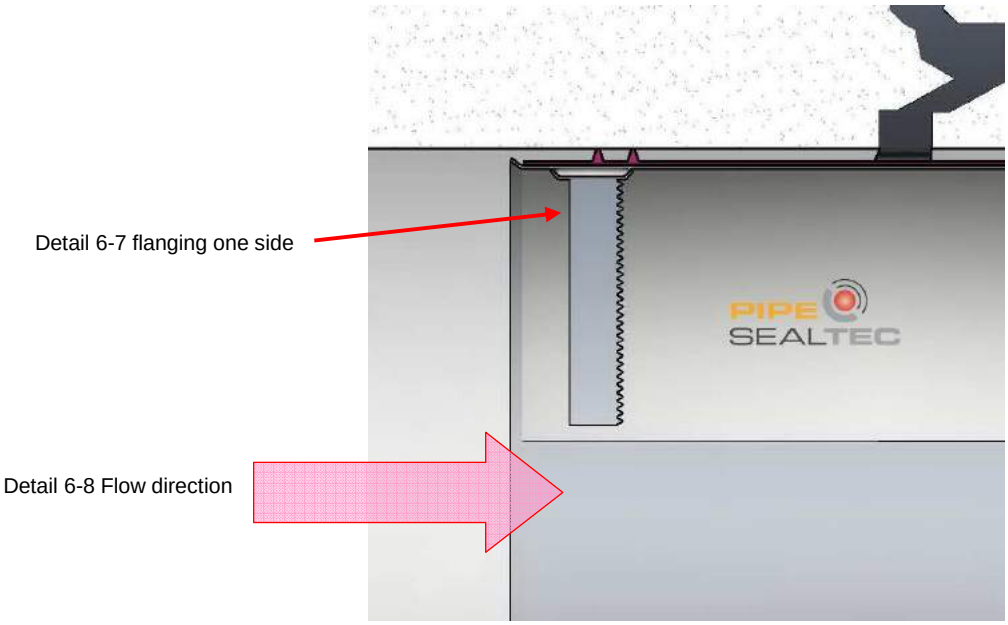


Figure 6-39 Position of flanging to flow direction

b. **Positioning at the damaged spot**

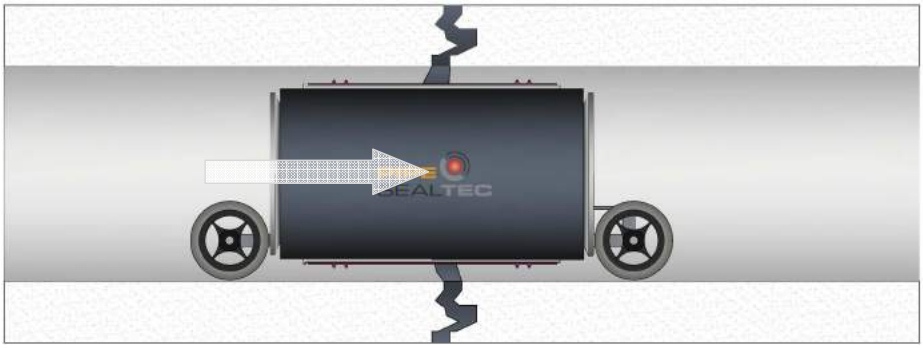


Figure 6-40 driving to the damaged spot

Position the *Pipe-Seal* sleeve in a way that the damaged spot is between the sealing knobs

c. **Expansion at the damaged spot**

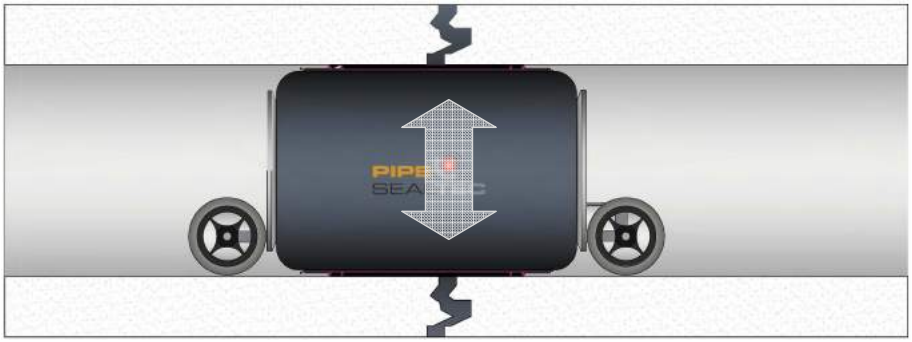


Figure 6-41 Expansion at damaged spot

Impinge the packer with an air pressure of approx. 2.0 Bar of and expand the sleeve.

Now provide the packer, according to the enclosed table, with the required air pressure so that the *Pipe-Seal* sleeve entirely fits to the old pipe.

Then relieve the packer (pressure relief). Position the packer in the middle at the respective locks and repeat the above described procedure.

The above described procedure guarantees that the *Pipe-Seal* sleeve ideally fits to the old pipe and the existing rubber seal reaches the required compression and hence the seal effect is achieved.

d. **Pressure relief at the packer**

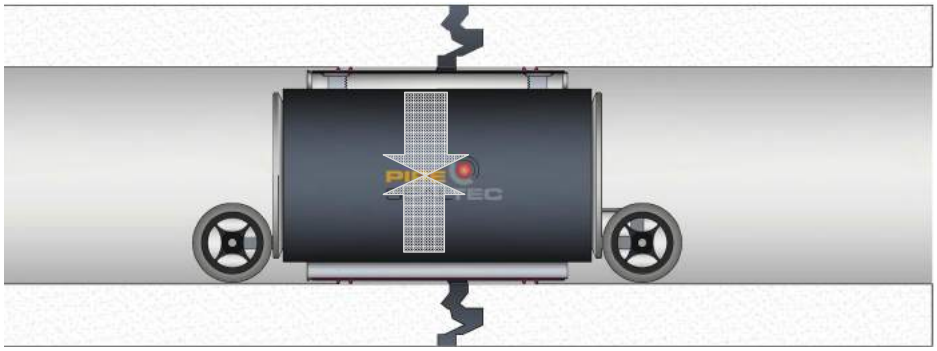


Figure 6-42 Pressure relief completed before removing the packer

Relieve the packer (pressure relief) after the expanding procedure.

e. **Remove the packer**

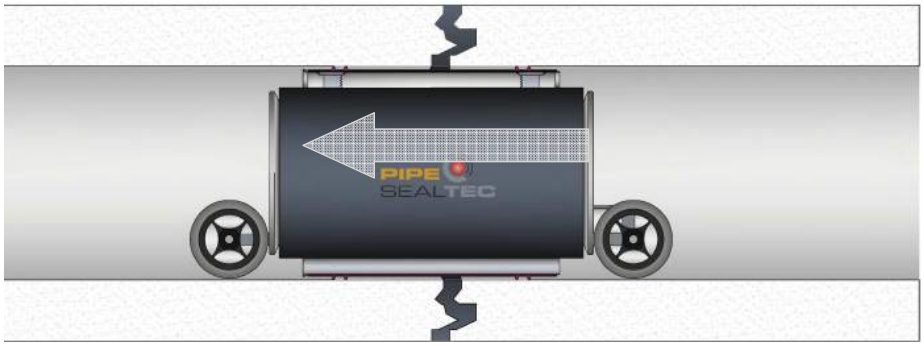


Figure 6-43 Remove packer

Then remove the packer from the rehabilitation area.

f. **Document the damaged spot**

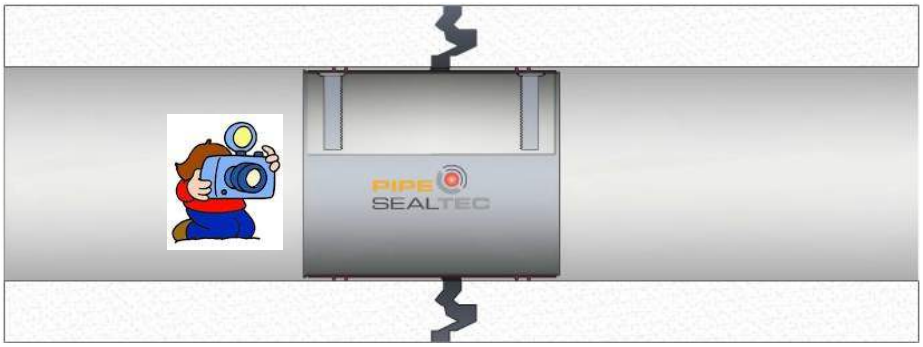


Figure 6-44 damaged area rehabilitated with *Pipe-Seal* sleeve - Documentation

Please document the successful rehabilitation after mounting!

6.4.3 Step 5 – Mounting *Pipe-Seal-Fix in serial displacement*

The mounting in serial displacement is applied in case of extended damage. Here the extent of the damage to be rehabilitated must be determined and assessed prior to mounting. *Pipe-Seal* sleeves with a one-sided flanging or without flanging are used.

When planning the installation/rehabilitation the following basic rules must be observed:

1. The mounting always takes place from the low point against the direction of flow.
2. The sealing area is (area between the pairs of sealing knobs) must be placed in a way that a distance of at least 15 cm of the respective sealing knob will remain at the beginning and at the end of the area to be rehabilitated (complete damage coverage).
3. The rubber overlap serves as an overlapping of the sealing areas in serial displacement .The last rubbers must always be accordingly shortened. That means the last *Pipe-Seal* sleeve is mounted without rubber overlap against the direction of flow (ideally with a one-sided flanging).
4. As in case of serial displacement smaller offsets occur, caused by the thickness of the material of the sleeves, not being however an obstacle to the flow, the mounting takes place against the flow direction.
5. Please consider that in case of longitudinal cracks (see point *5.5.1.3.3 Fields of application PIPE-SEAL-FIX/-FLEX*) it is generally necessary to rehabilitate the complete length of pipe from collar to collar in order to prevent a further crack formation.
6. Please do also check beforehand whether the overlapping areas caused by a serial mounting and the thus produced reduction in cross-section of approx. 2–4 mm still allows a mounting in small dimensions of old pipes.

    a. See point *6.1.1 STEP 1 – CLEANING and INSPECTION*

    b. **Damage documentation -** After cleaning the area intended for rehabilitation must be visually inspected, the actual state must be documented and it must be verified whether the rehabilitation is possible with *Pipe-Seal products*.

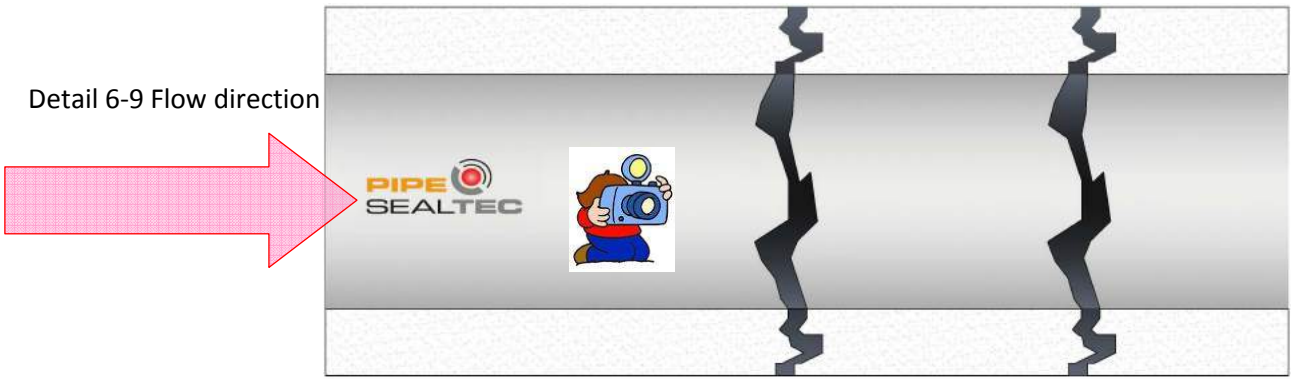


Figure 6-45 Damage documentation

When preparing and mounting please take care that you begin with the damaged spot being at the end in the direction of flow.

Analogous Point 6.4.1 *STEP 5 – MOUNTING PIPE-SEAL-FIX*

c. **Mounting order resp. procedure** of *Pipe-Seal* sleeves

- Begin in the direction of flow with the damage end

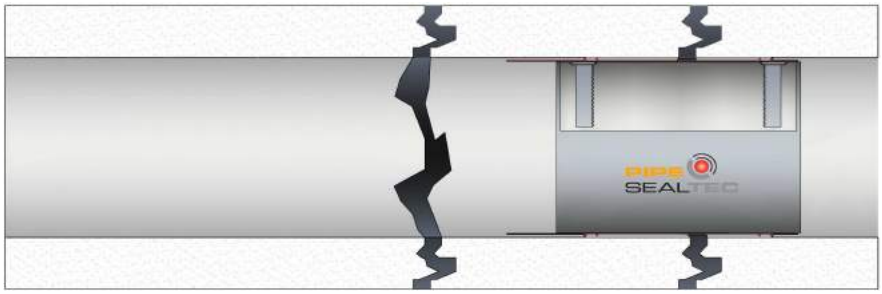


Figure 6-46 Mounting order *Pipe-Seal* sleeve with EPDM rubber and rubber overlap

d. **EPDM rubber overlap** of the *Pipe-Seal* sleeves

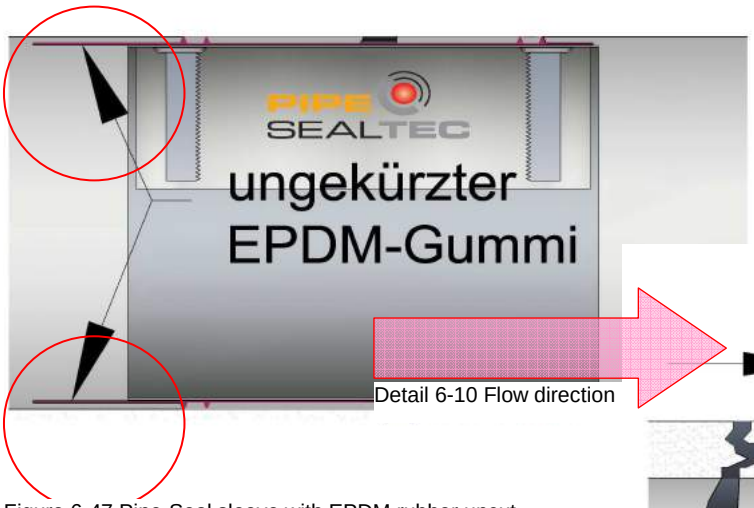


Figure 6-47 Pipe-Seal sleeve with EPDM rubber uncut

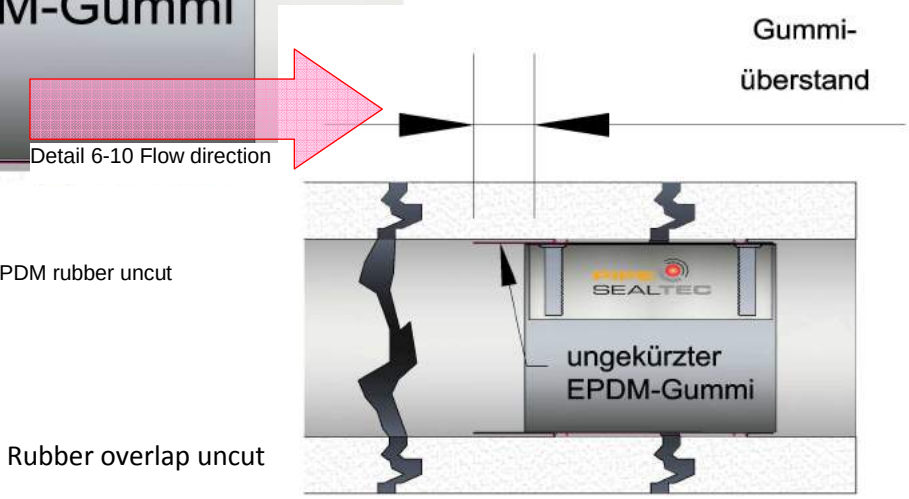


Figure 6-48 EPDM rubber overlap

e. **Positioning and overlapping** of another *Pipe-Seal* sleeve at the damaged spot

Figure 6-49 Mounting direction of another sleeve in a serial mounting

When positioning another *Pipe-Seal* sleeve, this must be mounted against the flow direction (see former figure), i.e. through the already mounted sleeves.

Rubber overlap

Gummiüberlappung

Overlap area

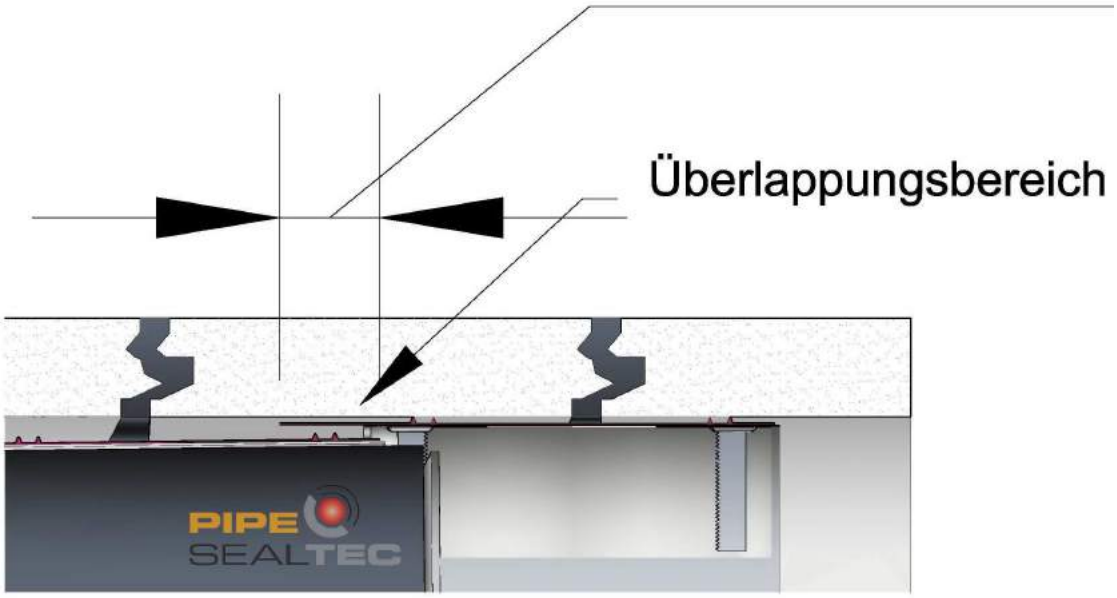
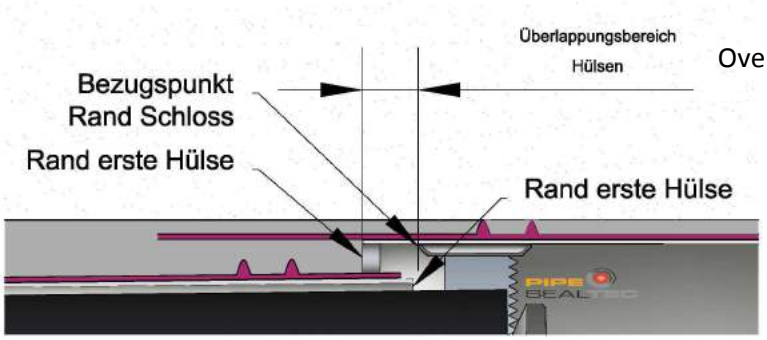


Figure 6-50 positioning another *Pipe-Seal* sleeve

Please take special care that the preparation is correctly executed (see point 6.2.1.1.1 DEVICES, EQUIPMENT, here 1 L SUPERGLUE, as well as point 6.3.1 STEP 4 – PREPARING THE PIPE-SEAL products, here 4.D FIXING), in order to avoid that the *Pipe-Seal* sleeve changes in place on the mounting device when positioned later on at the place of installation, and thus being no longer mountable.

1. Drive the next *Pipe-Seal* sleeve through the already mounted one up to approx. 0.5 cm behind the last lock (sleeve rim to lock position).

Reference point
Lock rim
Rim first sleeve

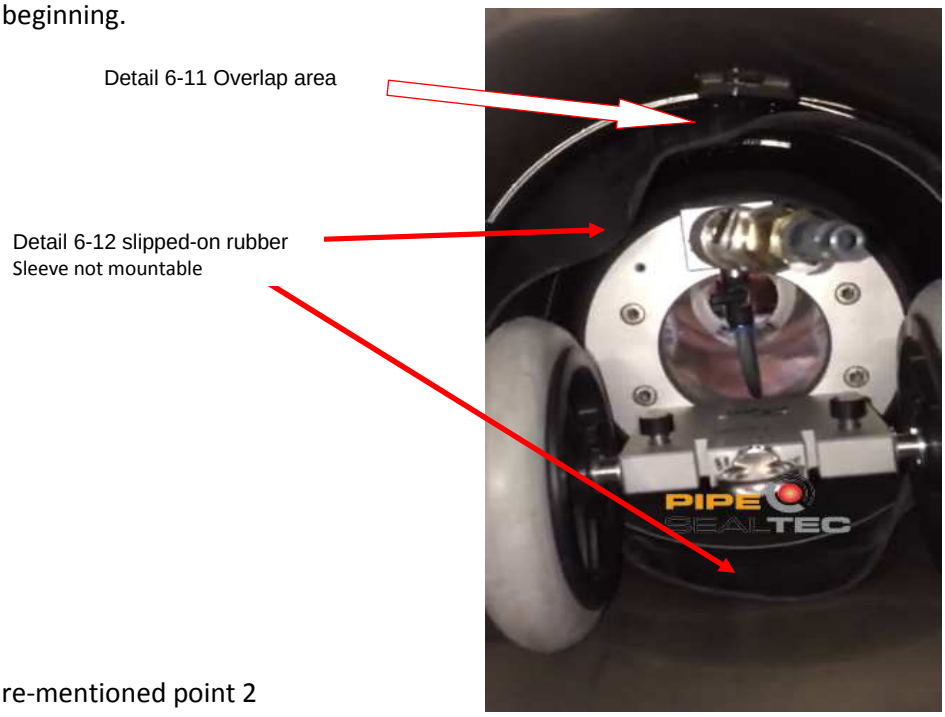


Overlap area sleeves

Figure 6-51 Positioning of *Pipe-Seal* sleeve in overlap area

Please take care that the rubber overlap of the first sleeve does not slide on and that the next sleeve will not be placed on the lock in the overlap area.

2. In case the rubber overlap has slid on, please drive completely back through the existing sleeve, so that the rubber overlap can again raise and start the above described procedure right from the beginning.



Example picture to afore-mentioned point 2

3. The rubber overlap is the basis for a complete connection of the respectively following *Pipe-Seal* sleeves and so a closed, sealing system is produced in serial displacement.

4. The mounting of the end sleeve with a one-sided flanging is carried out as described above. (See point *6.4.2 Step 5 – Mounting PIPE-SEAL-FIX with flanging on one side).*

f. **Expansion at the place of installation**

Figure 6-52 Expansion at the place of installation – Mounting the end sleeve

Impinge the displacement packer with an air pressure of approx. 2.0 Bar of and expand the sleeve.

Now bring, according to the enclosed table, the required air pressure on the packer, so that the *Pipe-Seal* sleeve entirely fits to the old pipe and the already mounted sleeve.

Then relieve the packer (pressure relief). Position the packer in the middle at the respective locks and repeat the previously described procedure.

The previously described procedure guarantees that the *Pipe-Seal* sleeve ideally fits to the existing pipe and the existent rubber seal reaches the required compression and hence the seal effect.

g. **Pressure relief at packer**

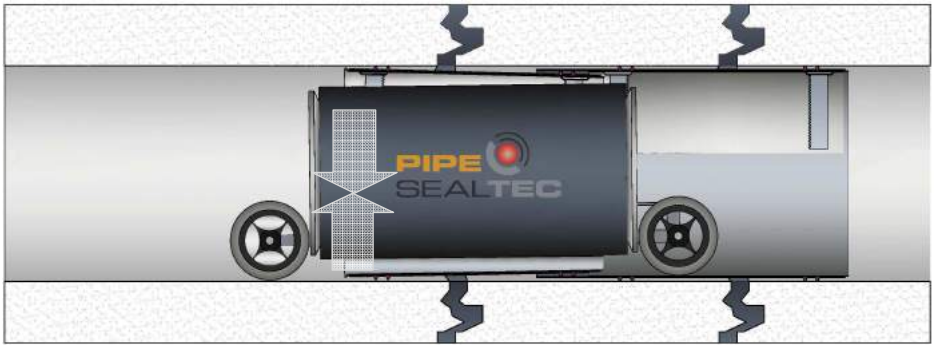


Figure 6-53 Pressure relief competed before removing the packer

Relieve the packer after the expanding procedure (pressure relief).

h. **Remove packer**

Figure 6-54 remove the packer

Then remove the packer from the rehabilitation area.

i. **Document the rehabilitated damaged spot**

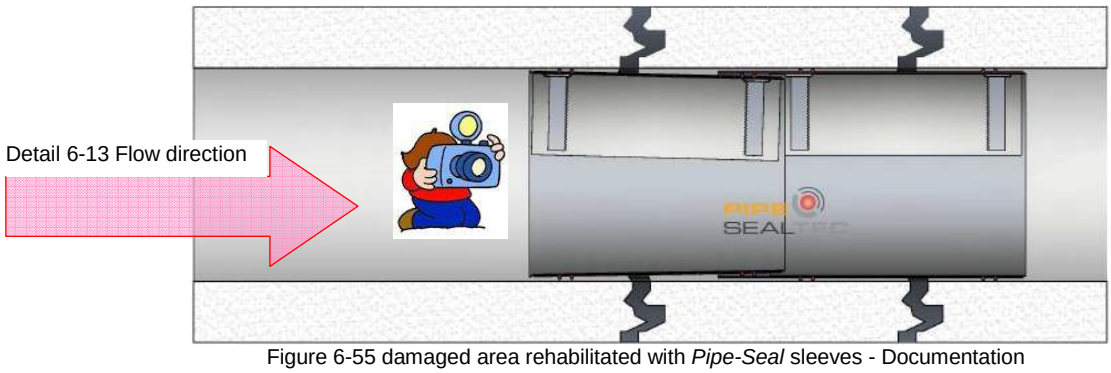


Figure 6-55 damaged area rehabilitated with *Pipe-Seal* sleeves - Documentation

Please document the successful rehabilitation after the installation!

Figure 6-56 documented rehabilitation area *Pipe-Seal* sleeves Serial mounting

6.5 Radial offsets and axial changes of direction – System Pipe-Seal-Flex

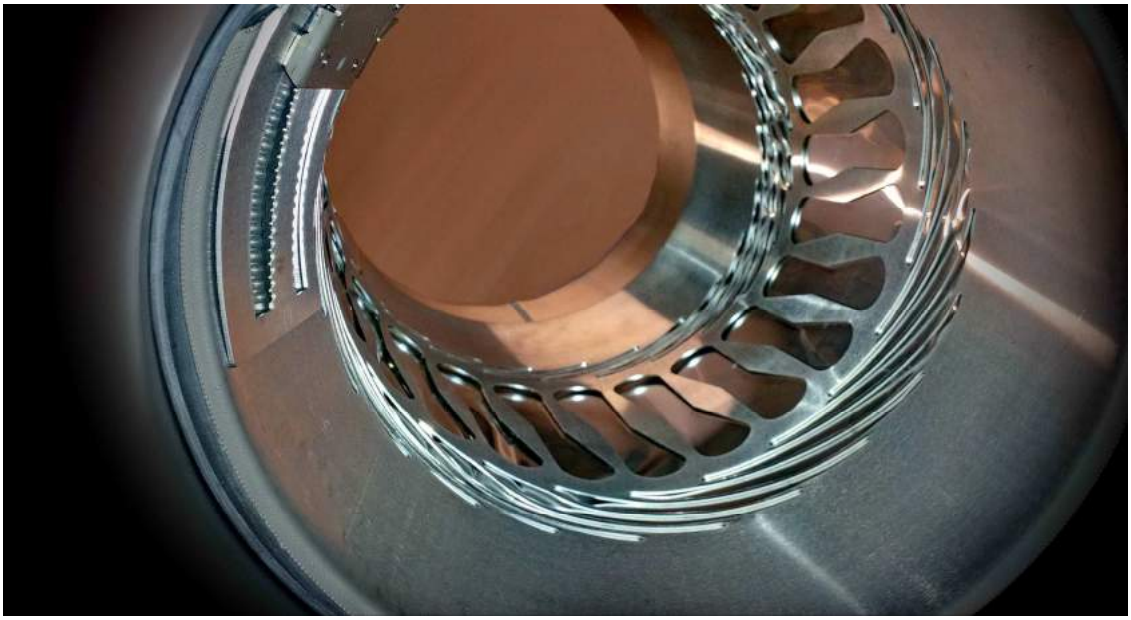


Figure 6-57 *Pipe-Seal-Flex* mounted in case of misalignment and angular offset

6.5.1 Fields of application

During daily work you have certainly had situations where the previously described *Pipe-Seal* products have reached the limits of feasibility.

For this purpose we have developed a sleeve which is able to rehabilitate angular offsets (bends) **and / or** misalignments **without** any further preparation work.

The stainless steel sleeve *Pipe-Seal-Flex*

With this you are able to work resp. rehabilitate e.g. socket misalignments up to approx. 2.0 cm and / or angular offsets (bends) up to approx. 10° of the pipe axis.

This novel sleeve is flexible, can be conically expanded in certain areas and hence ideally adjusts itself to the existing sewer and damage situation.

Figure 6-58 *Pipe-Seal-Flex* (here without guide plate)

6.5.2 Fields of application

Axial change of direction
Angular offset

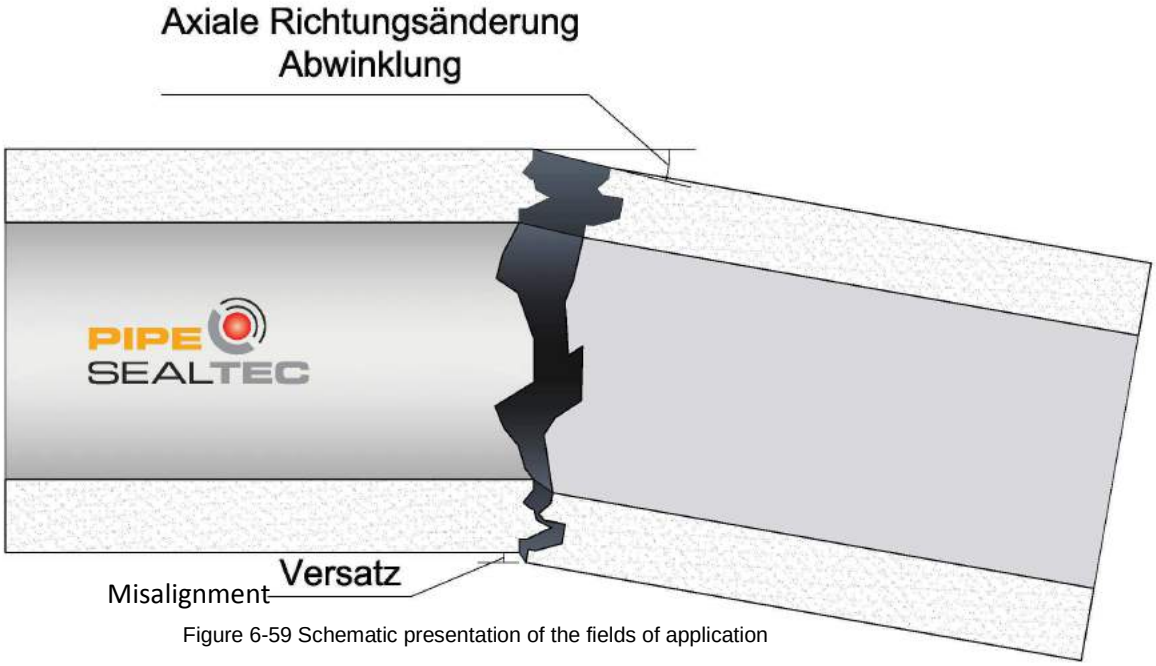


Figure 6-59 Schematic presentation of the fields of application

Figure 6-60 Test set-up axial and radial change of direction (angular offset and misalignment)

- See point *5.5.1.3.3 Fields of application PIPE-SEAL-FIX / - FLEX), here 4* Deviations in position of pipe connections

6.5.2.1.1 STEP 1 – Preparation

- See point *6.1.1 STEP 1 – Cleaning and inspection*

- See point *6.3.1 STEP 4 – Preparing the PIPE-SEAL products*

Please take care of the EPDM rubber: after it has been powdered with talcum according to the previously mentioned points, it must be fixed with superglue on the sleeve at four opposite points.

6.5.2.1.2 STEP 2 –Mounting

- See point *6.4 Mounting the PIPE-SEAL products*

Figure 6-61 Rehabilitation with *Pipe-Seal-Flex* on angular offset

Short description of mounting procedure:

1. Transport the *Pipe-Seal-Flex* with your mounting device to the place of installation resp. the damaged spot.
2. Position the *Pipe-Seal-Flex* so that this is in the middle of the damage.
3. Impinge the packer with an air pressure of approx. 1.0 to1.5 Bar.
4. Then relieve the packer so that this can be positioned again.
5. Now position the packer in the middle of the rear lock and impinge the packer with the appropriate mounting pressure (see list in the appendix).
6. Then relieve the packer so that it can be positioned again.
7. Now position the packer in the middle of the front lock and impinge the packer with the appropriate mounting pressure (see list in appendix).
8. Then relieve the packer completely (ventilate) and remove it.

Please document the successful rehabilitation after installation!

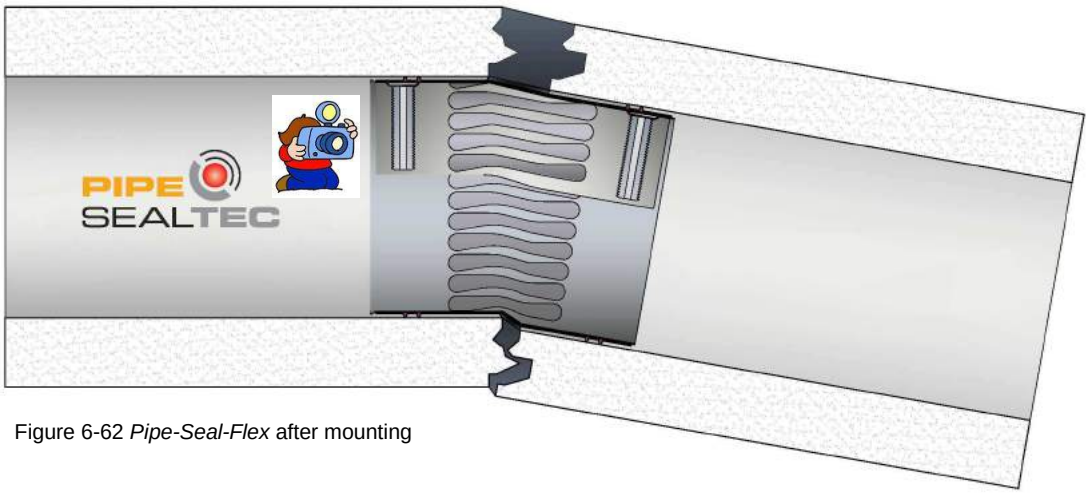


Figure 6-62 *Pipe-Seal-Flex* after mounting

After the mounting please check whether the Pipe-Seal-Flex completely closely fits to both sides of the pipe wall. Should this not be the case, please repeat the previously described points 5 – 8 (see point *6.5.2.1.2 STEP 2 –Mounting; here 5)*

7 Installation „Step by Step"– *Pipe-Seal-End*

7.1 Fields of application

With a *Pipe-Seal-End* sleeve you are able to make durable and impermeable connections of tension-free and completely cured in-Liner systems in the old pipe or in shaft structures.

The *Pipe-Seal-End* sleeve has the same material properties as our products *Pipe-Seal-Fix / -Flex*

Here the sleeve can also be conically expanded to a certain extent due to the special locking mechanism. (See point *5.5.1.1 Locking mechanism)*

Basically the *Pipe-Seal-End* sleeve serves as:

1. sealing of liner systems between liner and old pipe
2. shaft connection – here as a pressure-resistant seal between shaft, structure, old pipe and liner system
3. see also point *5.2 PIPE-SEAL-END; 5.2.1 Execution*

Please measure the wall thickness of the liner system beforehand and check in conformity the suitability of Pipe-Seal-End for this purpose !

Shaft structure

Liner overlap in shaft structure

Shaft entrance

Old pipe

Liner system

Channel flow

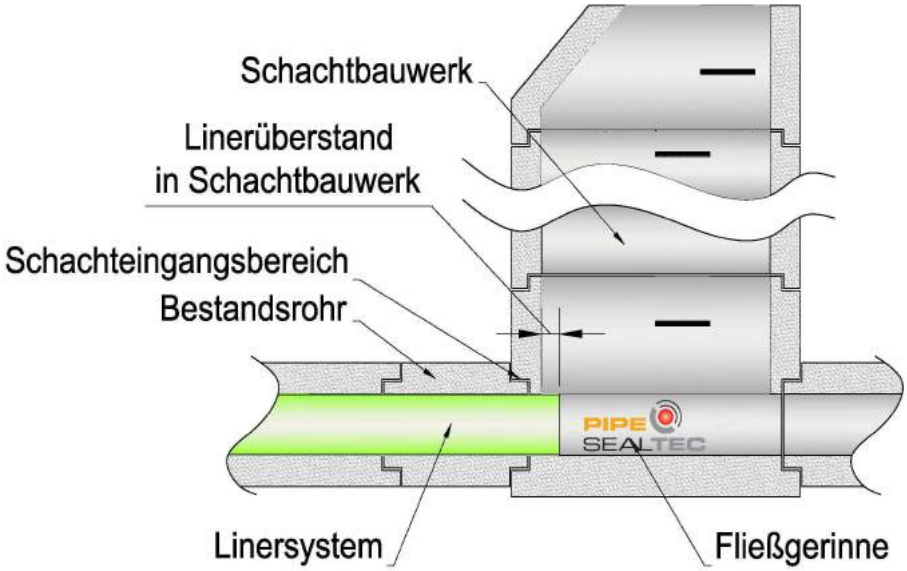


Figure 7-40 Scheme Liner system / Passage to shaft structure

7.2 Mounting Pipe-Seal-End

7.2.1 STEP 1 – Cleaning and inspection

- See point *6.1.1 – STEP 1 - Cleaning and inspection*
- See point *6.3.1 – STEP 4 - Preparing the PIPE-SEAL products*

7.2.2 STEP 2 – Preparation *Pipe-Seal-End*

1. Receipt of goods
    a. All the products must be checked for possible damage before use!
2. The adhesive strips applied for protection during the transport are to be cut with an appropriate tool (see *Figure 6-17)* best cut-in 0.5 cm minimum) as shown in the following figure.

Figure 7-2 Cut adhesive strip

3. The respective *Pipe-Seal* products must be oiled in the lock area and in the metal sheet overlap.
   (comp. oil (*biodegradable and not dissolving rubber*))

Figure 7-3 Apply lubricant

4. EPDM rubber

   a. **Before slipping** the EPDM rubber **over** the respective *Pipe-Seal* products, it must be powdered with talcum. Thus the slipping over is much easier and the friction between rubber and sleeve is reduced.

Figure 7-4 Powder EPDM with talcum

   b. **Slipping over** the EPDM rubber

Figure 7-5 Slip-over the EPDM rubber seal

Fixing the EPDM rubber on the respective *Pipe-Seal* product.
This ensures the seat of the EPDM rubber up to the place of installation without changing its position on the sleeve.

Figure 7-6 Applying superglue

For this purpose the EPDM rubber is fixed with superglue as shown in the figure, ideally on each opposite end of the sleeve.

Please take care that no glue comes between the metal sheet overlap and / or the locking mechanism, otherwise an expansion of the sleeve will be prevented!

4. Equipment

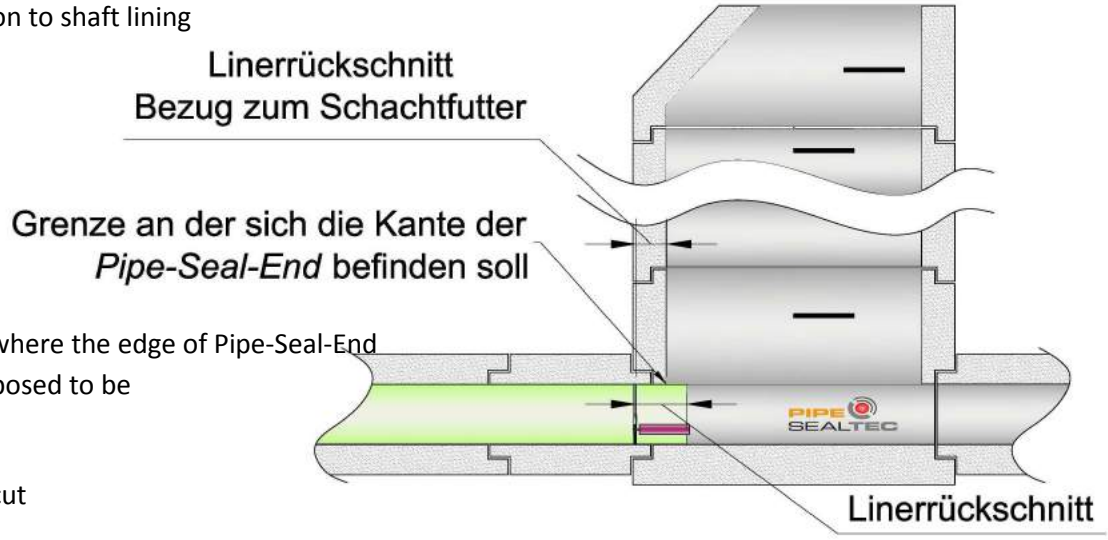
- See also point *6.2.1.1.1 Devices ; Equipment*

Figure 7-7 *Pipe-Seal* Liner end packer

7.2.3 STEP 3 – Mounting *Pipe-Seal-End*

1. Liner cut

Liner cut –
Relation to shaft lining



Limit where the edge of Pipe-Seal-End is supposed to be

Liner cut

Figure 7-8 Making res. positioning the liner cut

Please take care not to damage the old pipe when removing the in-liner.

a. Circumferential liner cut

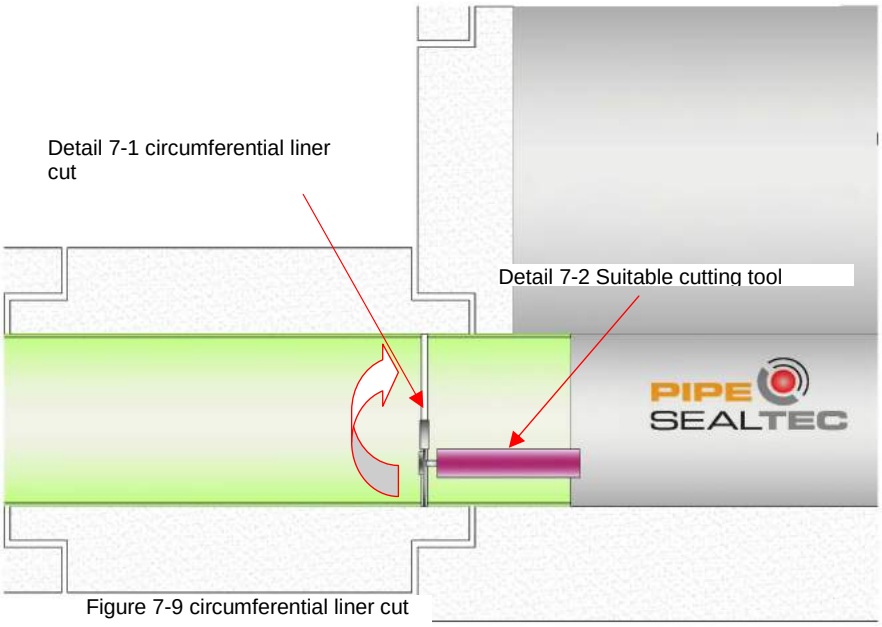


Figure 7-9 circumferential liner cut

b. Longitudinal cut liner

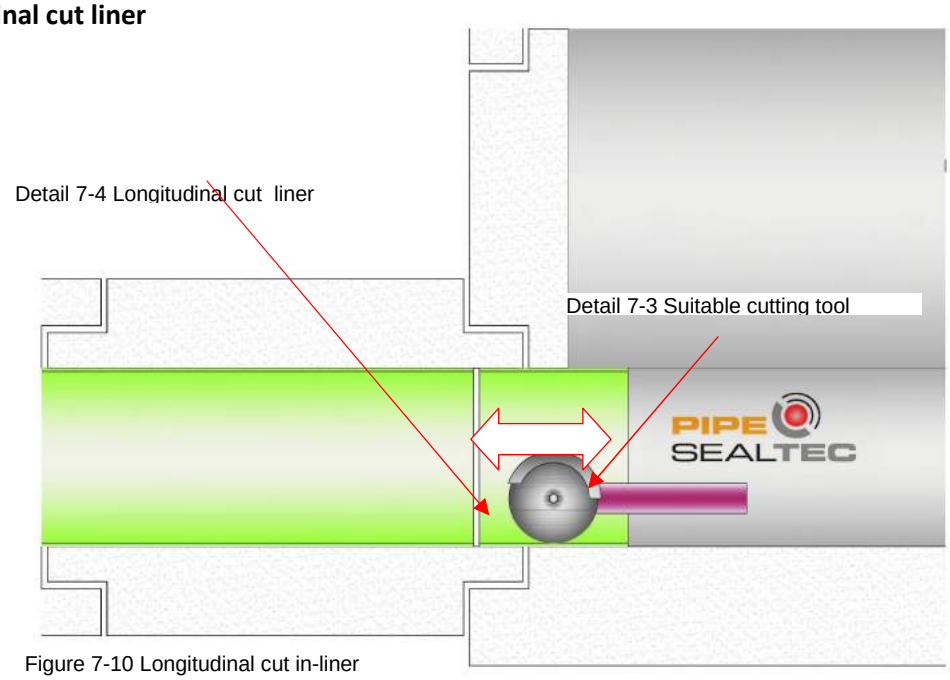


Figure 7-10 Longitudinal cut in-liner

After having removed the liner overlap, check whether the pipe connection does not exceed an angular offset (bend) of 1° and whether its surface is suitable for the mounting procedure!

c. Position packer and *Pipe-Seal-End*

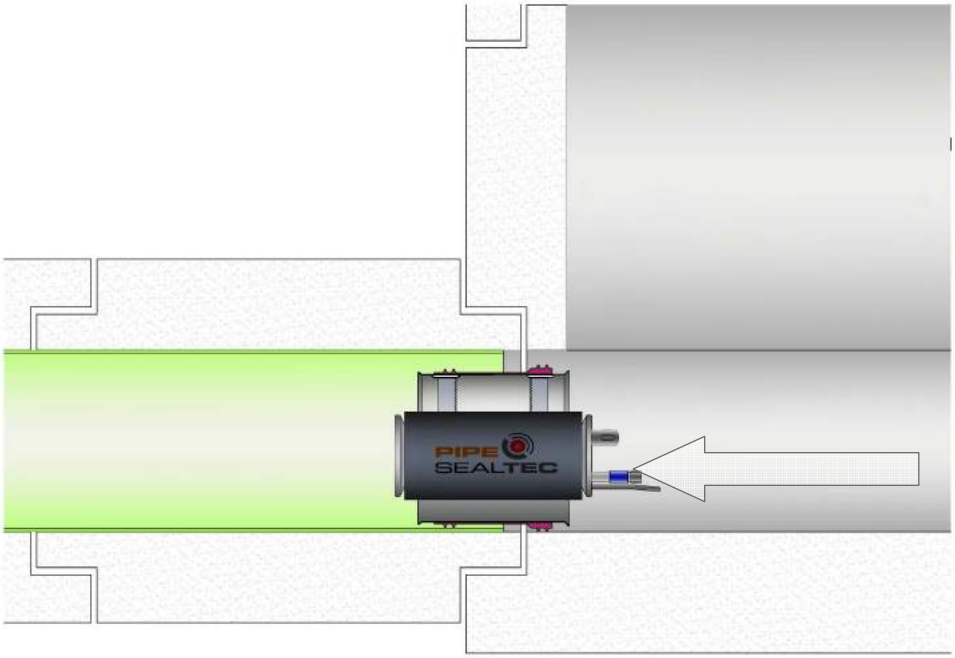
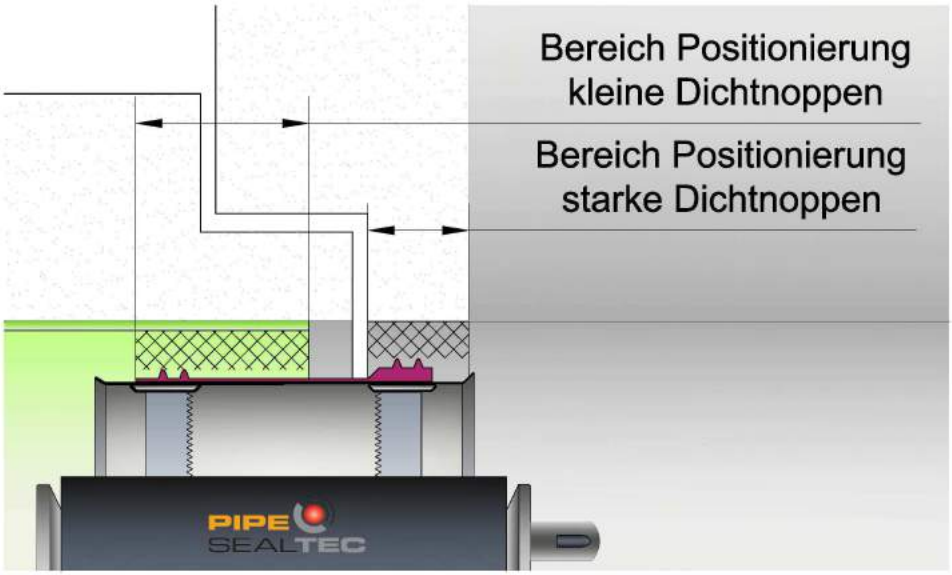


Figure 7-11 Positioning packer / *Pipe-Seal-End*

Area positioning of small sealing knobs

Area positioning of big sealing knobs



1. Position the rubber seal in a way that the heightened sealing knob area (in front), as previously described in the figure, is located just like the small sealing knob area in the area of the liner system.

2. The edge of *Pipe-Seal-End* shall align with the edge of the structure. (See *Figure 7-8 Making res. positioning the liner* cut cut*).*

3. Position the lock in the position between 1 – 2 o'clock (viewing direction from shaft into pipeline – mounting area).

4. Now locate the sleeve in the pipe and apply a pressure of approx. 1.8 Bar on the liner-end packer, so that the *Pipe-Seal-End* sleeve can fit to the existing pipe.

5. Then you firmly apply the necessary pressure onto the liner-end packer, according to the enclosed table.

6. Relieve the liner-end packer and position it in a way that maximum 1/3 of the balloon length is protruding into the shaft and impinge it with the necessary fixing pressure (see table in appendix).

7. Relieve the liner-end packer and position it in the middle of the rear lock and repeat the procedure as previously described in point 5.

For reasons of technical safety, NO person should be in the shaft structure during the impingement of the liner-end packer with the fixing pressure!

d. Expanding the packer

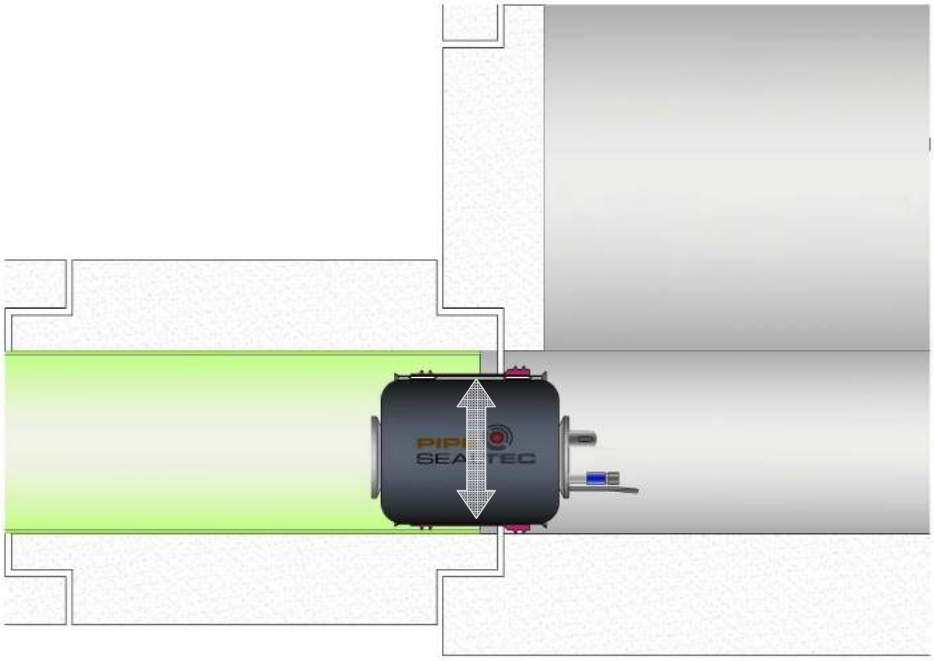


Figure 7-13 expanding the packer

e. Applying the installation pressure

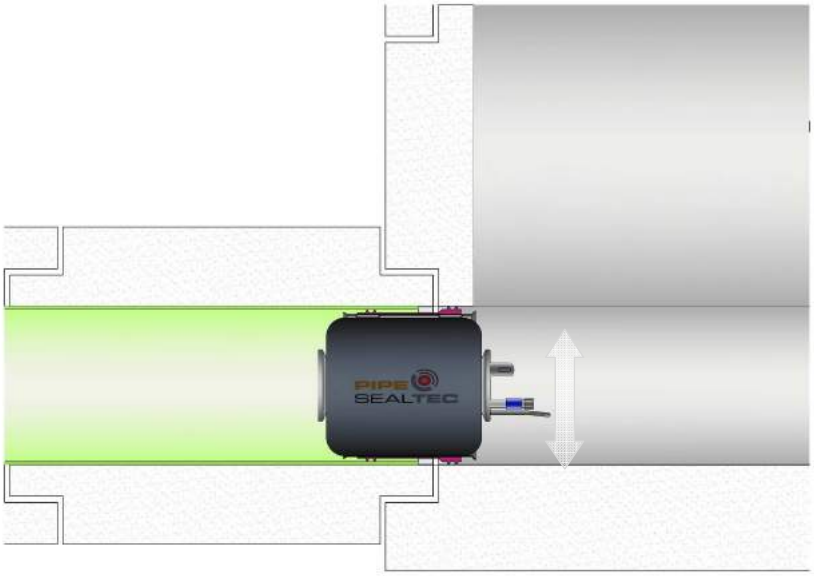


Figure 7-14 apply the installation pressure

f. **Pressure relief on packer and removal**

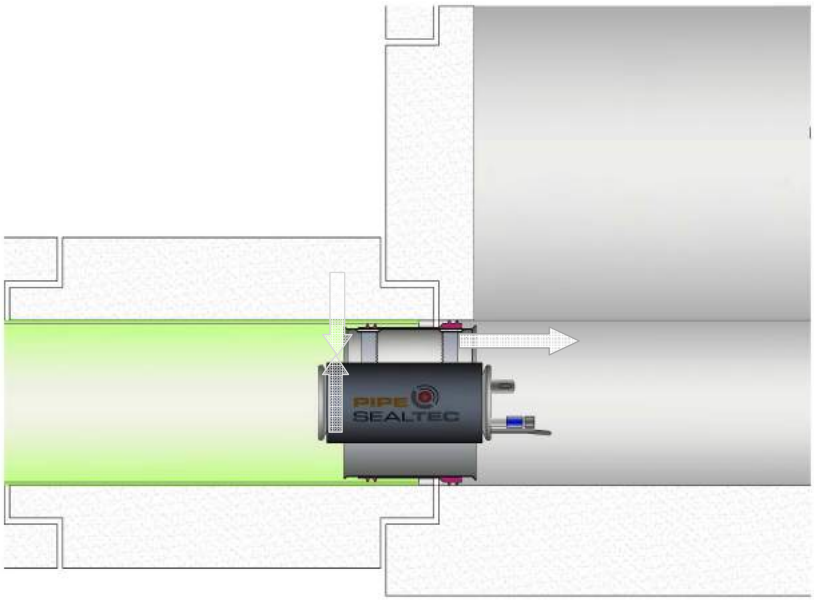


Figure 7-15 Pressure relief on liner-end packer

g. **Successful liner connection**

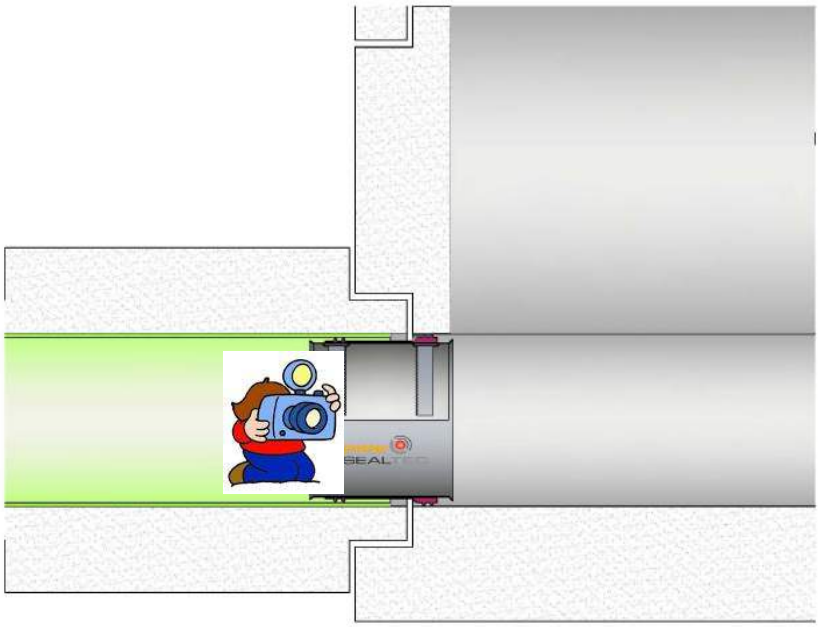


Figure 7-16 Liner connection with *Pipe-Seal-End*

Please document the successful rehabilitation after mounting?

8 Removal of *Pipe-Seal* products

Should there be misplacement, our Pipe-Seal sleeves can be dismounted leaving no residue.

This is realised by removing the locking mechanism.

1. *Pipe-Seal-Fix* / *-Flex*
    a. Use of milling robots
2. *Pipe-Seal-End*
    a. Mechanical destruction of the locking mechanism (opened by force with suitable tools).

The tension of the sleeve material and the residual tension of the EPDM rubber allow the *Pipe-Seal* sleeve to roll up again (to a certain extent).

Once these will have been dismounted and removed from the rehabilitation area, our *Pipe-Seal* sleeves can no longer be used.

9 Special applications

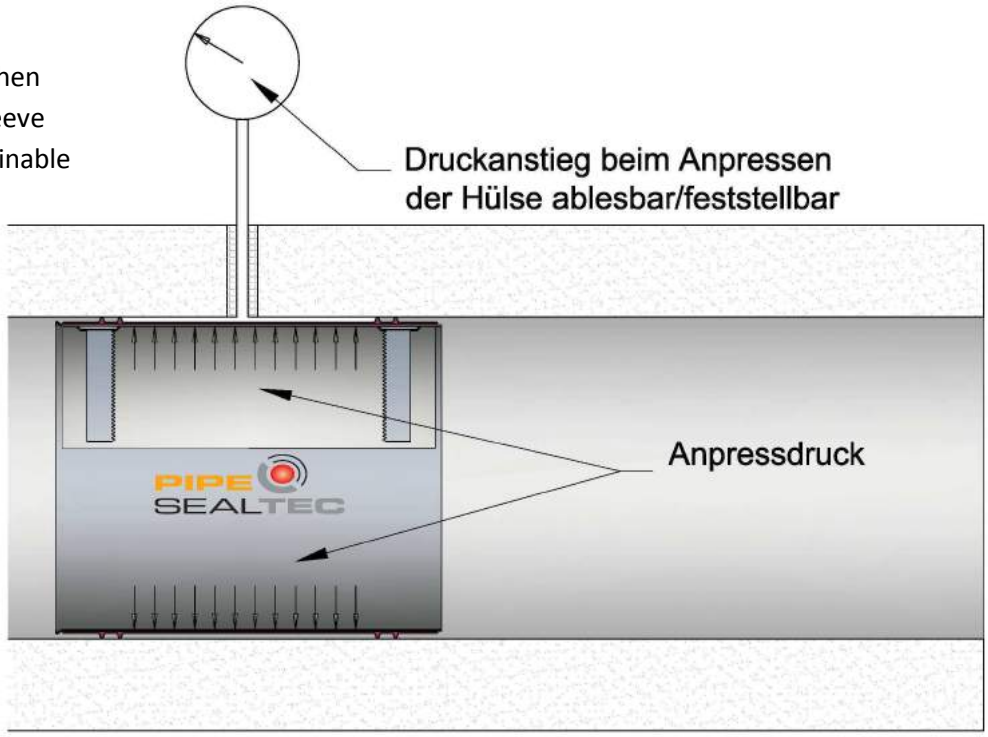
9.1 Pipe-Seal sleeves in tight pipe systems

Due to the excellent sealing properties of our *Pipe-Seal* sleeves, a pressure build-up may be caused in tight pipe systems in the area between the sealing knobs when installing the *Pipe-Seal* sleeve. The effect usually takes place in pipe systems with very smooth surfaces and absolutely tight pipe connections.

You avoid the possible pressure build-up by cutting the EPDM rubber before its installation in the area between the sealing knobs.

The arising pressure can thus be reduced resp. escape.

Rise in pressure when pressing on the sleeve readable / determinable



Contact pressure

Figure 9-1 possible pressure build-up between sealing knobs

9.2 Pipe-Seal sleeves in case of root penetration

In the following procedure we show you possibilities with which you can rehabilitate demanding damage situations.

Here a successful rehabilitation depends on the existing limiting factors and cannot be generally guaranteed.

9.2.1 STEP 1 – Preparation

1. Proceed as described under point:
    a. See the following points
        i. *6.1.1 STEP 1 – Cleaning and inspection*
        ii. *6.1.2 STEP 2 - Preparation*
        iii. *6.3.1 STEP4 - Preparing the PIPE-SEAL products*

2. Owing to circumstances it may become necessary to previously remove existing roots with another suitable rehabilitation system (e.g. milling robot).

3. Before the subsequent mounting apply in the area between the sealing knobs (on the EPDM rubber) highly alkaline and mineral Flex glue up to the maximum height of the sealing knobs. In doing so, at least 5 cm on both sides between the sealing knobs and the Flex glue should not be coated. It is guaranteed that the sealing properties will not be impaired.

    We recommend a product with good adhesive properties so that the material does not tear and / or get lost upon expansion.

Figure 9-2 applying the Flex glue

The *Pipe-Seal* sleeves are prepared as previously described.

9.2.2 STEP 2 – Mounting

1. Proceed as described under point:

    a. See the following points
    /. *6.4.1 STEP 5 – Mounting PIPE-SEAL-FIX*

9.3 Pipe-Seal sleeves *in corroded reinforcements of reinforced-concrete pipes*

Generally prepare the ground of the old pipe and the damage to be worked in a way that a smooth sealing surface is produced in order to ensure resp. produce the excellent sealing properties of the *Pipe-Seal* sleeves.

9.3.1 STEP 1 – Preparation

1. Proceed as described under point:
    a. See the following points
        i. *6.1.1 STEP 1 – Cleaning and inspection*
        ii. *6.1.2 STEP 2 - Preparation*
        iii. *6.3.1 STEP 4 – Preparing the PIPE-SEAL-FIX products*
2. Owing to circumstances it may become necessary to work existing roots beforehand with a suitable rehabilitation system (e.g. milling robot).

9.3.2 STEP 2 – Mounting

2. Proceed as described under point:
    a. See the following point
        I. *6.4.1 STEP 5 – Mounting PIPE-SEAL-FIX*

9.4 Pipe-Seal sleeves *in case of heavy water ingress*

In case of heavy water ingress it is possible to work with water blocking tape or a one-component sealing compound on a polyurethane base.

9.5 Pipe-Seal sleeves in plastic pipes

Please check beforehand the dimensions of the plastic pipes you have to work on. (See point *6.1Preparing the areas to be worked on).*
Please use our technical data sheet which we enclose in the appendix (See point *10.2 Technical data sheet PIPE-SEAL-FIX / - FLEX).*).
Please check the dimensions of the plastic pipes to work on with the available roll-up and maximum stretching size.

Eventually existing deformation in the rehabilitation area can be levelled with our *Pipe-Seal* sleeves.

10 Appendices

10.1. Survey compression pressure

Pipe material	Damage	Nominal width DN In (mm)	Contact pressure in (Bar)	Installation pressure in (Bar) (Compression pressure)
PVC, concrete pipes, asbestos-cement and vitrified clay pipes	Longitudinal cracks	188	Max. 0.5	4.0 – 4.5
		200		3.30 -3.5
		250-800		2.7 – 3.0
	Transverse cracks, Leaky sockets	188		4.0 – 4.5
		200		3.5 – 4.0
		250-800		3.0 – 3.5
GRP (PE,PP) reinforced concrete and cast iron pipes	All kinds of damage	188		4.5 – 4.5
		200		3.0 – 3.5
		250-800		3.0 – 3.5

Pipe-Seal-Fix/Flex

		Nominal width DN in (mm)	Contact pressure in (Bar)	Application pressure in (Bar) (Compression pressure)
		188	Max 0.5	4.0 – 4.5
		200		4.0 – 4.5
		225 – 400		3.0 – 4.5
		450 - 600		3.0 – 4.0

Pipe-Seal-End

10.2 Technical data sheet Pipe-Seal-Fix/-Flex

Technisches Datenblatt: Pipe-Seal-Fix und Pipe-Seal-Flex

Pipe-Seal-Hülse Nennweite DN	Gummi-Dichtung Nennweite DN	Hülsen-länge	Edelstahlhülse		geeignet für Rohre		Edelstahlhülse		EPDM Gummidichtung			Verstellpacker	Radsatz SV Spurverbreiterung	Gesamt-länge	Blasen-länge	Blasen Ø	Radsatz Ø
			Rollmaß	max. Auf-spannung	Rohr-innen-durch-messer mind.	Rohr-innen-durch-messer max.	max. Abdichtungs-bereich bei Einzelversetzung	Blechs tärke	Gummi fläche stärke	Dichtno ppenhö he	Gummist ärke inkl. Dichtno ppen						
mm	mm	mm	mm		mm	mm	mm	mm	mm	mm	mm						
150	150	300	120,0	153	132,0	161,0		1	2	4	6	150-200	150 / 150				
188	188	420	151	188	166,0	199,0	300	1,25	2,5	5	7,5	200-300	188 / 188	782	460	138	75
200	200	420	160,5	201	175,5	212,0	300	1,25	2,5	5	7,5	200-301	200 / 200	782	460	138	75
210	200	420	170	212	185,0	223,0	300	1,25	2,5	5	7,5	200-302	210 / 210				
225	225	420	183	227	198,0	238,0	300	1,25	2,5	5	7,5	200-300 / 250-300	225+SV300 / 225	782	460	138/157	68/67
240	225	420	195	242	210,0	253,0	300	1,25	2,5	5	7,5	200-300 / 250-300	236+SV300 / 236	782	460	138/157	79/75
250	250	420	203	252	218,0	263,0	300	1,25	2,5	5	7,5	200-300 / 250-300	250 / 250	782	460	138/157	125/75
276	276	420	222	276	237,0	287,0	300	1,25	2,5	5	7,5	200-300 / 250-300	275+SV300 / 275	782	460	138/157	100/100
286	276	420	229	286	244,0	297,0	300	1,25	2,5	5	7,5	200-300 / 250-300	280+SV300 / 280	782	460	138/157	100/100
300	300	420	243	305	258,0	316,0	300	1,25	2,5	5	7,5	200-300 / 250-300	250+SV300 / 300	782	460	138/157	125/125
315	300	420	252	315	267,0	326,0	300	1,25	2,5	5	7,5	200-300 / 250-300	250+SV300 / 300				
330	300	420	266	335	281,0	346,0	300	1,25	2,5	5	7,5	200-300	330	782	460	138	125
350	350	420	290	355	305,0	366,0	300	1,25	2,5	5	7,5	350-500	350	800	490	269	75
380	350	420	300	377	321,0	390,0	300	1,5	2,5	8	10,5	350-500	380	800	490	269	100
400	400	420	327	408	348,0	421,0	300	1,5	2,5	8	10,5	350-500	400	800	490	269	125
450	450	420	374	455	395,0	468,0	300	1,5	2,5	8	10,5	350-500	400+SV450	800	490	269	125
480	450	420	388	480	409,0	493,0	300	1,5	2,5	8	10,5	350-500	480+SV500	800	490	269	125
500	500	420	424	505	445,0	518,0	300	1,5	2,5	8	10,5	350-500 / 500-600	400+SV500 / 500	800/863	490/540	269/397	125
530	530	420	448	530	469,0	543,0	300	1,5	2,5	8	10,5	500-600	530	863	540	397	125
560	500	500	455	560	476,0	573,0	390	2	2,5	8	10,5	500-600	550	863	540	397	125
600	600	500	515	609	536,0	622,0	390	2	2,5	8	10,5	500-600 / 600-700	500+SV600 / 600	863/888	540	397/462	125/150
650	600	500	565	658	586,0	671,0	390	2	2,5	8	10,5	600-700	650	888	540	462	125
700	700	500	570	713	591,0	726,0	390	2	2,5	8	10,5	600-700 / 700-800	600+SV700 / 700	888	540	462/542	150/150
750	700	500	595	750	616,0	763,0	390	2	2,5	8	10,5	700-800	SV750	888	540	542	125
800	800	500	695	815	716,0	828,0	390	2	2,5	8	10,5	700-800	700+SV800	888	540	542	150

- Verfügbarkeit Pipe Seal Fix + Pipe Seal Flex

- Verfügbarkeit Pipe Seal Fix

10.3 Technical data sheet Pipe-Seal-End

Pipe-Seal-End Hülse	Hülsenlänge	max. Linerstärke		ca. Rückschnitt Liner	Edelstahlhülse			EPDM Gummi		
		von	bis		Blechstärke	Rollmaß Stahlhülse	max. Aufspannmaß	Gummistärke	gesamt Dichtnoppenhöhe im Altrohr	gesamt Dichtnoppenhöhe im Liner
mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
150	250	3	8	100-140	1	120,0	153,0	2	12	6
188	250	3	8	100-140	1,25	151,0	188,0	2	12	6
200	250	3	8	100-140	1,25	160,5	201,0	2	12	6
225	250	3	8	100-140	1,25	183,0	227,0	2	12	6
250	250	3	8	100-140	1,25	203,0	252,0	2	12	6
276	250	3	8	100-140	1,25	222,0	276,0	2	12	6
300	250	3	8	100-140	1,25	243,0	305,0	2	12	6
350	250	3	8	100-140	1,25	290,0	355,0	2	12	6
400	250	3	10	100-140	1,5	327,0	408,0	2	12	6
450	250	3	10	100-140	1,5	374,0	455,0	2	12	6
500	250	3	12	100-140	1,5	424,0	505,0	2	12	6
600	300	3	12	100-140	2	515,0	609,0	2	12	6
700	300	3	12	100-140	2	570,0	713,0	2	12	6
800	300	3	12	100-140	2	695,0	815,0	2	12	6

Figure 5-1 *10*