egeplast

Guidelines for decision-makers

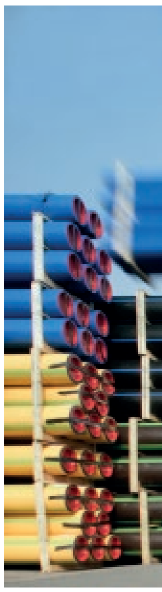
Alternative installation methods with polyethylene pipes

We provide safety.
Experience. Quality. Product variability.

egeplast is an owner-managed family business which has been established as a developer and manufacturer of innovative plastic pipe systems for decades.

Many years of experience have shown that suitable pipe systems made from PE materials can be deployed reliably and economically within the limitations of use for several decades when correctly installed and assembled.

These guidelines provide planners and users with an overview of the significant codes of practice, the most important installation methods and PE pipe materials and pipe constructions suitable for requirements to achieve technical safety of a pipeline during its installation and operation. In order to comprehensively meet the expectations of a decision-making tool, Chapter 6 will subject conventional and trenchless pipe installation methods to an economic comparison.



Permanent
quality controls
during and after production

FACTORY OF THE YEAR
in the category "Outstanding Serial Production" in 2022

> 60 years
of experience in pipe extrusion

50.000
tons of plastic per year in Greven

> 60
patents

Competent support from ideas to delivery

3
Production sites in Europe

High flexibility
in manufacturing and logistics

Power pipe systems made in
Germany

Perfect one-stop service for your construction project

① Planning service

Our customers are able to benefit from customised solutions helping them to safely implement their plans and construction projects. They can rely on a wealth of experience and technical expertise when approaching us for advice. Our staff will be happy to provide personal assistance to you.

② egeplast Training Center

At the training facilities provided by our headquarters in Greven, you can participate in product training and also learn new handling techniques. Feel free to approach our staff for more information.

③ On-site instructions

Do you have any questions about handling and installing our egeplast products? Please feel free to contact us. If you wish, we will provide personal assistance right at the construction site.

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Content



1 Duties and liability risks

The German Advisory Council on Global Change (WBGU, see annual report, 1998) defines risk as the product of occurrence frequency or occurrence probability and the seriousness of the event or extent of damage.

Here the occurrence frequency describes the frequency with which an occurrence takes place within a defined period.

The unit representing the extent of damage depends on the respective subject matter and situation. It may consist of values that can be expressed in amounts of money (e.g. euros), but it may also involve environmental damage or damage to property or even personal injury. In particular, damage to gas pipes with gas explosions repeatedly hit the headlines. Damage to wastewater pipelines, by contrast, means environmental damage.

Currently there are no legally binding standards with respect to requirements on which pipes to select for alternative installation methods. At the same time, the generally formulated requirements contained in higher-ranking laws/ standards and codes of practice must be satisfied, e.g. the stipulations of the „Basic safety considerations" for pipelines in accordance with Annex I of the DGRL Pressure Equipment Directive 97/23/EC and the requirements arising from the German Ordinance on Industrial Health and Safety (BetrSichV).

For this reason egeplast has commissioned the law firm FRESHFIELDS BRUCKHAUS DERINGER to examine the question of the liability of diverse market actors (pipe manufacturer, planner, company processing the pipes and network operator) in the installation of pipes without sand bed and using the trenchless method.

Possible claims are examined in respect of production faults, damage due to insufficient suitability of the pipes for the method selected, planning or specification errors and damage during pipe jacking.

Overview of the liability risks for market actors

	Planner		Processing company		Network operator
	Contractual (vis-à-vis customer)	Tortious (also vis-à-vis third parties)	Contractual (vis-à-vis customer)	Tortious (also vis-à-vis third parties)	Also vis-à-vis third parties
Subject matter	• Faulty planning (this also includes the selection of unsuitable building materials/installation methods) o Inspection obligation o Alert customer to concerns • In accordance with Section 5.4.2 German Association of Gas and Water Engineers (DVGW) Code of Practice GW 321 additional external pipe protection for specific ground conditions	Damage resulting from **culpably** faulty planning or selection of unsuitable materials/installation methods	• Damage during installation • Inspection duty to ascertain whether building materials and subsoil are suitable (load test if doubts exist) • In accordance with Section 5.4.2 DVGW Code of Practice GW 321 additional external pipe protection for specific ground conditions • Modification of warranty rights possible by agreement on VOB/B (German Construction Contract procedures)	Damage resulting from **culpable** damage during installation or violation of the duty to inspect building materials and foundations	• Culpable damage resulting from the selection of the wrong products (-) When making use of external expertise • Liability of the owner of a pipeline system for damage to property or personal injury caused by the system regardless of negligence (-) if the system corresponds to the recognised state of the art
Quality assurance	Evidence of installation free from defects through the use of pipes with integrity test				Invitation to tender to the effect that documentation of installation that is free from defects must be provided during acceptance on the basis of pipes with quality check

Tab. 1: Potential liability risks of planners, processing companies and network operators (source: expert opinion produced by FRESHFIELDS BRUCK HAUS DERINGER)

Currently there are no (legally) binding standards which set out detailed technical regulations for pipe selection for alternative installation methods or which describe the requirements of the installation itself. For this reason high demands are placed on those involved in terms of the selection of materials and methods in order to comply with the generally formulated requirements of applicable laws, guidelines and ordinances. One of the most common sources of error for liability for planners, processing companies and network operators is the choice of unsuitable materials or installation method. Section 5.4.2 of the German Association of Gas and Water Engineers (DVGW) Code of Practice GW 321, for example, is decisive for pipeline construction, according to which an additional external protection for the pipe, e.g. polyolefin outer layer, must be used under certain ground conditions. It is therefore only possible to recommend the use of pipe systems where their suitability and installation free from defects can be unequivocally recognised and documented from a technical perspective. Planners, processing companies and network operators may be liable for up to 30 years insofar as the damage did not occur beforehand.

2 Standards and codes of practice

Harmonised technical principles and rules are necessary for safe and reliable gas and water provision (and also for wastewater disposal). These promote rationalisation and quality assurance, serve the safety of people and property and thereby benefit the public [GW100]. In Germany the technical codes of practice are generally created by the technical scientific associations such as DIN and DVGW, and in Europe by the European standardisation institute CEN. In Germany the DVGW codes of practice are prescribed as the binding benchmark in gas and water technologies. The following chapters are based on German codes of practise, which are taken as an example. In other countries different and/or further regulations may be applied.

DIN

DVGW

PAS

Generally recognised state of the art

The generally recognised state of the art describes the prevalent opinion on technical rules governing the design and execution of works systems that are not exposed to scientific controversy and which have therefore been recognised as being theoretically correct and established; they are also in particular familiar among the technicians who have been trained and who have up-to-date knowledge in the group of rules and who are decisive for the application of the rules concerned and who, on the basis of their ongoing, practical experience, recognise these to be technically suitable, appropriate and necessary (Munich Comment [MüKO], German Civil Code [BGB], 4th Edition, Section 633, Number 17 among others). This benchmark lags behind the aspirations for further technical development:

State of the art

The state of the art consists of rules that can not yet be regarded as generally recognised but which reflect the state of technical findings at a defined period of time and which have gained an entry to operational practice (MüKO, loc cit., Section 633 Number 19).

A Publicly Available Specification (PAS) represents one possibility for defining an established state of the art that has not yet gained entry to classic technical rules. The publication of this industry standard by the German standardisation institute, the Deutsche Institut für Normung e.V., gives it special authority and provides an opportunity for the monitoring of a described minimum quality by an independent certifier.

Codes of practice

Quality requirements on polyethylene pipes for conventional installation in sand beds are described in the European Standards DIN EN 12201 and EN 155. The DVGW has issued procedural descriptions and instructions on alternative installation methods in codes of practices and leaflets in the GW 32x series. The quality requirements placed on pipes with alternative installation have not yet been set out in detail in the rules of technology. Currently the codes of practice of the DVGW merely require pipelines to satisfy installation requirements and produces recommendations. Consequently the same requirements apply to polyethylene pipes used in trenchless installation in the same way as for pipes that are laid in a sand bed. This does not correspond to the state of the art.

Welding Guidelines

The leaflets and guidelines issued by the Welding Societies (DVS, WIS, etc.) apply to connecting plastic pipes by welding the pipe ends. These rules apply irrespective of the type of pipe installation used.

Codes of practice governing installation methods, pipe material and connection technology

Type of installation	Codes of practice on installation methods	Specification and recommendation of codes of practice for installation methods for the pipe material to be deployed	DVS connection technology guidelines DVS 2207-1 Evaluation of the welded joint in accordance with DVS 2202-1
Open trench pipe installation using sand	W 400 – 2 (water) G 472 (gas) DIN EN 805	• GW 335 • max. 10 % scratch depth	max. 0.1 x s Lack of fusion in HM due to scoring in the pipe surface is prohibited in all 3 evaluation groups.
Open trench pipe installation without sand / ploughing/ milling	GW 324 W 400 – 2 (water) G 472 (gas)	• max. 10 % scratch depth • Point load resistance and protection against impermissible groove formation depending on the subsoil	max. 0.1 x s Lack of fusion in HM due to scoring in the pipe surface is prohibited in all 3 evaluation groups.
New installation using pipe jacking Horizontal directional drilling (black box method)	GW 321 W 400 – 2 (water) G 472 (gas)	• max. 10 % scratch depth • Polyolefin layer as external protection for the pipe recommended	max. 0.1 x s Lack of fusion in HM due to scoring in the pipe surface is prohibited in all 3 evaluation groups.
New installation using pipe jacking Impact moles (black box method)	GW 325 W 400 – 2 (water) G 472 (gas)	• max. 10 % scratch depth • Suitable external protection for the pipe may be required depending on the subsoil and embedding conditions	max. 0.1 x s Lack of fusion in HM due to scoring in the pipe surface is prohibited in all 3 evaluation groups.
Renovation using pipe jacking Relining (black box method)	GW 320 -1 (with annular space) W 400 – 2 (water) G 472 (gas)	• max. 10 % scratch depth	max. 0.1 x s Lack of fusion in HM due to scoring in the pipe surface is prohibited in all 3 evaluation groups.
Renovation using pipe jacking Pipe bursting (black box method)	GW 323 W 400 – 2 (water) G 472 (gas)	• max. 10 % scratch depth • Polyolefin layer as external pipe protection recommended	max. 0.1 x s Lack of fusion in HM due to scoring in the pipe surface is prohibited in all 3 evaluation groups.
Renovation using pipe jacking Swagelining (black box method)	GW 320 – 2 (without annular space) W 400 – 2 (water) G 472 (gas)	• max. 10 % scratch depth	max. 0.1 x s Lack of fusion in HM due to scoring in the pipe surface is prohibited in all 3 evaluation groups.

Tab. 2: Codes of practice governing installation methods, pipe material and connection technology

Objectives of PAS 1075

The significant requirements placed on materials and pipes made from polyethylene and which are intended to be installed using alternative installation techniques have been described for the first time in a PAS - an industrial standard published via the DIN - for a minimum service life of 100 years.

The objective was to create a quality standard through this harmonisation of materials and pipe constructions that is guaranteed by accredited test methods and which can be verified by independent certifiers. In such the PAS was an ideal supplement to the tried and tested standards already existing.

The beneficiary of this harmonisation is the user who is provided with a comprehensible quality standard that enables him to select PE pipeline systems for alternative installation methods that offer a guaranteed minimum service life of more than 100 years after installation.

The PAS 1075 guideline for alternative installation methods was withdrawn without replacement in 2020 for formal reasons – however, the use of this guideline remains common practice.

The basic requirements for pipes and materials used in these methods have been implemented in the European standards for gas and water pipes (DIN EN 1555 and DIN EN 12201).

Classification of pipe constructions

Type 1:
Solid wall pipes made from PE 100-RC

Type 2 (two or three-layered):
Pipes with dimensionally integrated layers made of PE 100-RC

Type 3:
Pipes with dimensions in accordance with DIN 8074/ISO 4065 made of PE 100-RC with additional external protective layer

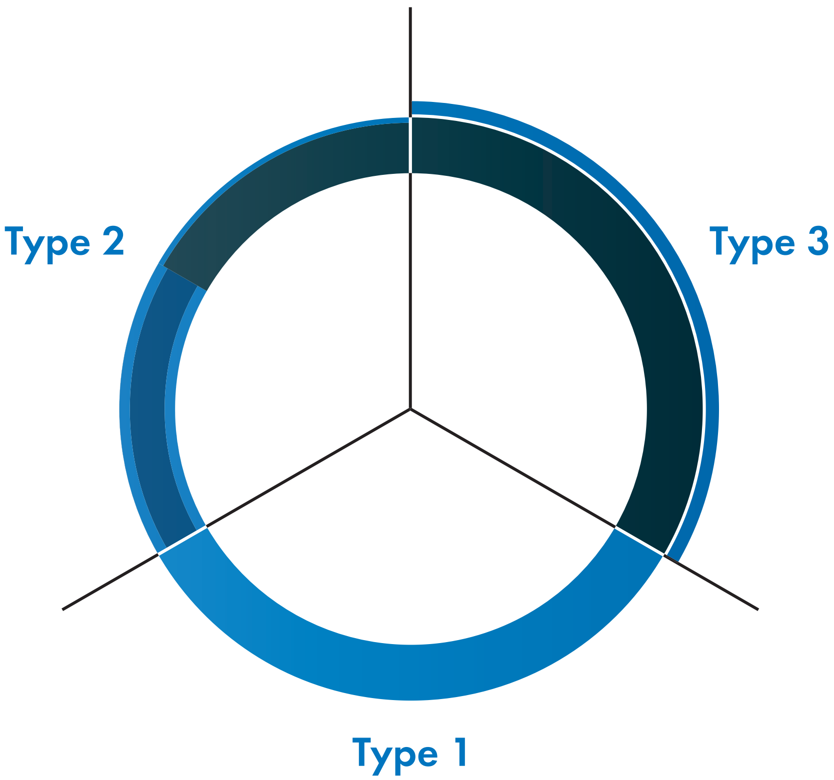

Fig. 1: Pipe system with integrated and added protective layers in accordance with PAS 1075

Inspection and monitoring

Further developments to the tried and tested PE 100 material in terms of resistance to stress induced cracks make it possible to satisfy the special requirements of alternative installation methods.

This special material is characterised by a stress-rupture life of at least 8,760 hours in the FNCT (Full Notch Creep Test) or in the point load test at 80 °C; Sigma 4 N/mm^2; 2 % Arkopal N-100. Materials that meet these requirements are referred to as PE 100-RC.

What is more, PAS 1075 also defines advanced requirements placed on the manufactured pipes that go beyond the minimum requirements of the European product standards DIN EN 12201 and EN 1555.

In order to do justice to the high demands placed on a 100 year service life also with respect to alternative installation methods, the high requirements of the PAS protect against the following risks of failure:

Point loads

PAS 1075 stipulates the minimum requirement placed on PE 100-RC material in terms of resistance to the slow progression of cracks (resistance to stress induced cracking) to avoid damage due to point loads. Since damage caused by point loads is triggered on the inside of the pipe, the PE 100-RC materials must be inserted as a layer that is at least 2.5 mm thick on the inside of the pipe.

Penetration

PAS 1075 has formulated a penetration test to exclude holes being pierced in a polyethylene pipeline installed using alternative installation methods as a result of it coming into direct contact with sharp stones or shards of old pipe lying in the pipe bed.

Protection from wear

In order to ensure safe scratch protection that facilitates 100 % pressure resistance and safe connection technology, PAS 1075 defines a requirement for additional protective outer layer.

Thermal ageing

A 100 year service life has already been defined today for PE 100 in DIN 8074/75, but PAS 1075 also requires PE 100-RC material to provide evidence of ageing resistance for 100 years when subjected to additional point load.


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3 Alternative installation methods

Conventional pipe installation / trenchless installation method

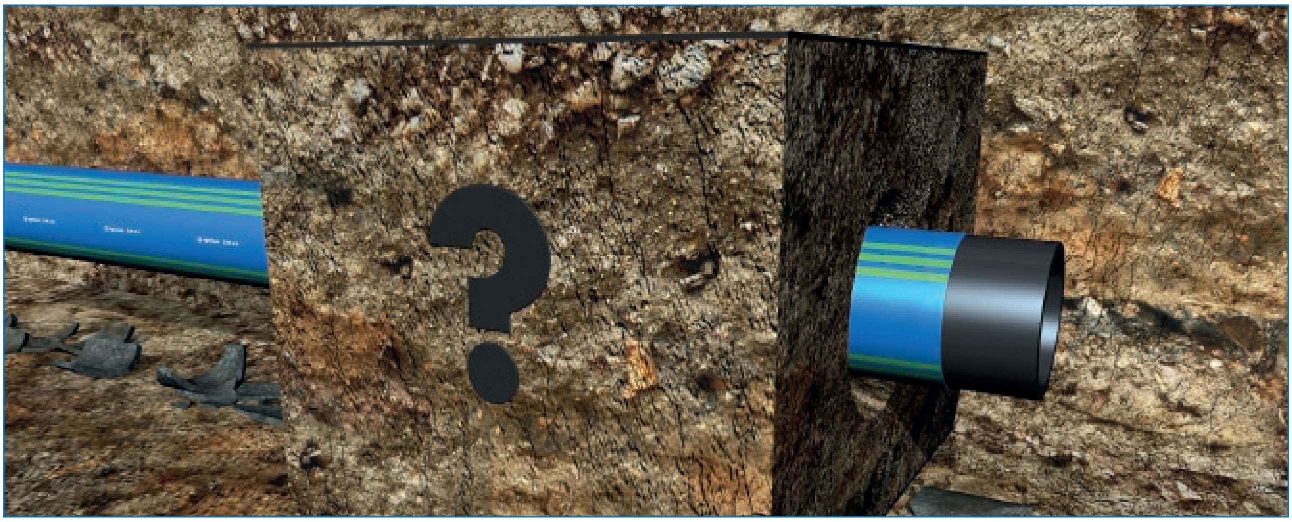


Fig. 2: Black box as characteristic of trenchless / closed construction methods

Supply networks today at least in Germany virtually extend across the entire country. For this reason replacement and renovation, in particular using closed installation methods, are of greater significance than new construction.

In its W 400-1 Directive, the DVGW recommends an examination of the suitability of trenchless techniques: In addition to open-cut installation, [...] the suitability of trenchless installation methods must be examined, taking into account the necessary additional qualifications and the associated additional installation-related stresses [...]. Further information on the regulations for trenchless installation methods can be found, among others, in DVGW GW 320 (A), DVGW GW 321 (A), DVGW GW 322-1 (A) and DVGW GW 323 (M)].

It is not possible using a closed construction method to subject the newly installed pipeline to a quality check because it is pulled through a black box; this increases the risk of future damage caused by damage when pipe jacking takes place. Moreover the new pipeline must manage without a protective pipe bed, something that is associated with added risks such as point loads. Trenchless installations therefore place higher demands on the pipe systems used.

Technical measures must therefore be taken to ensure that the pipe system achieves the same service life when using trenchless or reduced trench installation methods as with the use of open trench installation in a sand bed.

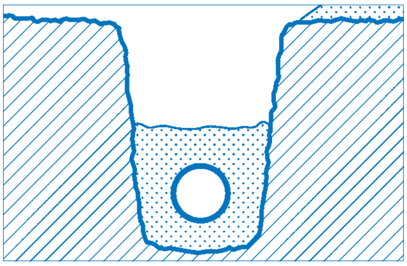
Open trench installation method

Open trench installation in a sand bed

Fig. 3: Standard pipes are installed in a sand bed

When installation takes place using an open trench construction method with sand bed, the pipeline zone is precisely defined and the pipe is laid in a protective sand bed. The surface levels must then be restored.

DIN 4124 „Excavations and trenches" applies among other things with respect to execution of the pipe trench, and precisely stipulates how the working space width and shoring are to be achieved. The pipe must be free from scoring and scratches; the ground surrounding the pipe is then prepared so that the pressure-bearing medium pipe is protected from external influences. DIN EN 805 and the DVGW directive W 400-2 prescribe embedding the pipe in sand or fine gravel.



Open trench installation without sand bed

When installation takes place using an open trench construction method without sand bed the pipe is directly laid in pipe trenches. The surface levels must then be restored.

Growing cost pressures force several suppliers to question whether the time-consuming embedding of the new pipeline in sand is necessary. If the excavated soil can be compressed it may be used as backfill material in place of sand. The prerequisite for these installation conditions is a pipe system that is capable of withstanding the increased strain that arises here.

Dispensing with the sand bed may result in stones causing strain to individual points or to linear areas of the external wall of the pipe over a longer period of time, which is in addition to the operating strains such as internal pressure, soil or traffic strain. If the protection of a sand bed is dispensed with, the selected pipe system must be able to withstand the typical surface damage caused by scratches and in particular point loads so that these do not lead to stress cracks.

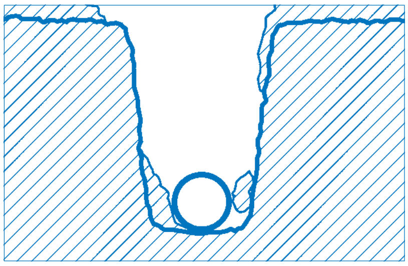


Fig. 4: The use of pipelines with integrated protective layers is recommended when dispensing with a sand bed.

Ploughing method

Fig. 5: When using the ploughing method, the use of pipelines with integrated protective layers is recommended.

With this method the new pipe is continually ploughed in and the channel cut for the pipe is then immediately closed again.

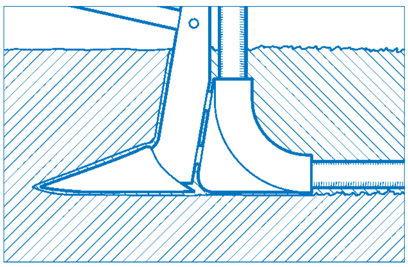
The prerequisite for this type of installation is a pipe system that is capable of withstanding the increased strain that arises here.

Depending on the soil conditions the surface of the newly installed pipeline might become scratched (max. 10 % of the wall thickness is permissible). Moreover, stones may produce strain on individual points or on linear areas of the external wall of the pipe over a longer period of time in addition to the operating strains such as internal pressure, soil or traffic strain.

The plough has a relatively small influence on the soil. It is not necessary to lower the groundwater table when this method of installation is used. For this reason this method is very environmentally friendly, also because of the very limited field damage it causes. The method can be deployed in undeveloped areas up to Category 5. Installation depths of up to 2 metres are possible depending on the soil classification.

Installation using a ploughing method can achieve up to 5,000 metres of laid pipeline per workday, making it probably the most economically efficient method for installing new pipelines. The installation unit consists of the plough with the ploughshare and the installation box, together with a winch mounted on a truck or caterpillar vehicle. The installation unit is pulled towards this vehicle by the winch. Once the plough reaches the vehicle the winch is placed at the next point on the route and the procedure is repeated. The ploughshare is dropped to the desired installation depth at the starting pit. Several pipelines can be ploughed simultaneously depending on the pipe diameter, with installation possible up to OD 225 mm. The pipelines are guided into the ground from above in the installation box that follows behind. The soil closes again behind the ploughshare due to its own weight, although the process can also be accelerated using machines. Point loads triggered by stones in the soil, for example, may cause damage to the pipeline. Pipelines should be used that are made from a material that has been proven to have a high resistance to stress induced cracking in order to actually achieve the intended minimum service life.

The impact mole ploughing method is a variation of the ploughing method, and is in particular deployed for pipe materials whose permissible bending radii are too great for a standard plough. The procedure is identical except for the fact that the pipeline is introduced lengthways. This means that the pipeline is drawn across the entire installation route together with the ploughshare. Pipelines have to demonstrate additional external pipe protection due to the considerably greater mechanical load. It must be ensured here that the permissible tensile forces of the pipeline and the joint are not exceeded. Tensile forces limit the length of the pipeline.



Milling method

Special machines cut a narrow pipe trench and at the same time introduce the flexible pipe. The excavated soil is used as backfill material.

Depending on the soil conditions the surface of the newly installed pipeline might become scratched (max. 10 % of the wall thickness is permissible). Moreover, stones may produce strain on individual points or on linear areas of the external wall of the pipe over a longer period of time in addition to the operating strains such as internal pressure, soil or traffic strain.

A motor-operated milling machine opens up a narrow trench with a width of up to 60 cm and depth of up to 2.5 m. The pipe is introduced into this trench, with virtual simultaneous backfilling of the pipe trench, generally using the excavated material. In contrast to the plough method, this method also enables work to take place on difficult soils up to Soil Category 7. The installation performance achieved will be largely influenced by the prevailing soil category, but is lower than installation using the plough method. Since the rules of technology generally do not specify laying the pipeline in a sand bed, pipelines should be used that are made from a material that has been proven to have a high resistance to stress induced cracking.

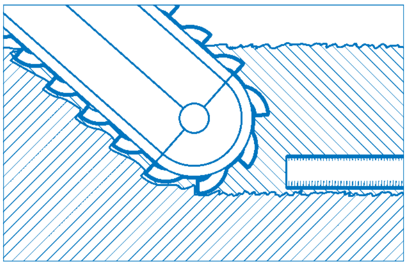


Fig. 6: Since excavated soil is used as backfill material in the milling method it is recommended that pipe systems with integrated protective layers be used.

Trenchless installation (black box)

Soil displacement (impact moles)

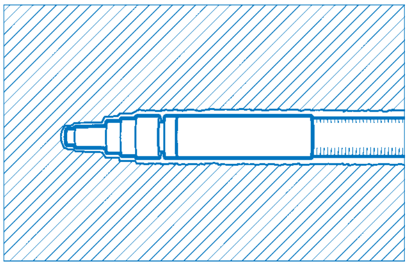
Fig. 7: It is necessary to use pipelines with additional protective layers because installation using impact moles can damage the pipeline that has been injected

An impact mole is „fired" through a few metres of the soil when connecting general building services.

The soil here may lead to unacceptable deep scratches in the new pipe. The maximum permissible depth of the scoring in the pipe wall is 10%. Surrounding stones may also lead to point loads.

The soil displacement installation method using impact moles is generally used to connect building services. A pneumatic hammer creates a hollow space into which the new pipeline is embedded. In order for this to occur the soil must be sufficiently displaceable. Structural support for the impact mole is necessary where soil is loose and soft because insufficient friction is created with the soil to permit independent forward movement. The design of the jacking conduit is therefore more precise in stony ground due to lateral displacement of the stones.

There is limited lateral deflection of the impact moles. The target is identified from the starting pit. Pipelines with an outer diameter of up to OD 200 mm can be laid using this method.



Relining

Relining can be used to renovate defective pipelines. Scratches and notches can occur on the new pipe depending on the state of the old pipe. Steel pipes welded with a V-joint carry a particularly high risk.

Relining is numbered among the trenchless renovation methods. The functional capacity of the existing pipelines is restored with complete or partial incorporation of the original matter and using the existing section of pipeline. Industrially prefabricated and tested plastic pipes are deployed that are jacked or pushed into the old pipe with or without annular gap. In the case of pipeline relining the entire drive length outside the jacking pit is prepared in advance, while in the case of long pipe relining the sections of pipe are joined together when they are jacked in the jacking pit.

Depending on the state of the old pipe the new pipe must take on a structural support function in addition to its sealing function. Relining is accompanied by a reduction in cross-section which is also often desired for reasons of capacity adjustment, e.g. due to the moving away of industry, business and residents. For flow-related reasons the new plastic pipes have comparably low levels of resistance. Despite their reduced cross-section, experience has shown that they often produce an increase in flow rate compared to the old pipes in need of renovation.

The annular gap between the old and the PE pipeline is plugged on completion of the construction work. Channels and spacers fix and secure the pipeline in the desired position. Ballasting with water acts as a support. The resistance to buckling pressure should be heeded when plugging in order to prevent cross-section deformation. Plugging prevents a drainage effect caused by groundwater flowing to the pipeline.

Old pipelines frequently contain fittings, residues of welding materials and rough welded surfaces that may lead to damage to the surface when jacking the new pipe.

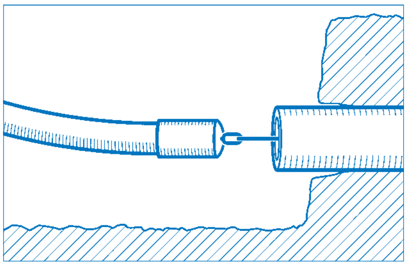


Fig. 8: The use of pipelines with additional protective layers is necessary because the new pipeline may become damaged during the relining process.

Horizontal directional drilling

Fig. 9: The use of pipelines with additional protective layers is necessary because the new pipeline may become damaged during installation using the HDD method.

The horizontal directional drilling method (HDD) is a controllable wet drilling method. Scratches and notches may represent a danger to the newly inserted pipe depending on the properties of the soil and drill radius.

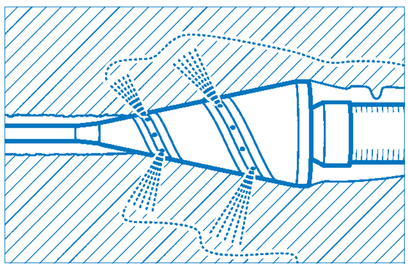
The horizontal directional drilling method is used for lengthwise installation, culverts and in ducts beneath buildings, for drainage and irrigation functions, for cable installation in traffic control systems and for measures to secure slopes and embankments, for example. Drilling is controlled by rotating the angled pilot drill head in the hole.

The drilling suspension flows out of the drill head at high pressure, loosens the soil and stones and drives the cuttings out of the hole. The drilling suspension is adapted to the respective soil conditions and in addition to bentonite, a clay mineral, may contain other additives that can have a further supporting effect on the drill channel, for example.

Several drilling operations to produce expansion may be required after the pilot bore depending on the required pipe diameter in order to prepare the bore channel for insertion of the pipeline that will conduct the media. A hammer mechanism may be deployed in stony ground up to Soil Category 5 and sometimes also for Soil Category 6 which not only makes jacking easier but also eases the control process. A downhole drilling motor with roller chisels is attached to the front when drilling in rock.

Pipelines for the renewal of drinking water systems must at least correspond to 10 bar pressure level in accordance with DVGW Code of Practice GW 321 „Controlled horizontal directional drilling procedure for gas and water pipelines - requirements, quality assurance and inspection". Pipes must not be subjected to strain that goes beyond the permissible tensile forces during the jacking procedure. According to DVGW Code of Practice GW 321 or at the request of the customer the tensile forces that have a direct impact on the media pipe must therefore be measured and recorded. Measurement is conducted using a tensile force measuring device that is mounted in front of the pipe to be jacked. Only pipelines from the SDR 11 series should be deployed especially for small pipe diameters because of the mechanical strain that arises when using this method of installation.

The service life of the newly installed pipeline will depend on how intact it is. Damage of up to 10% of the pipe wall thickness is tolerated by the material, but scratches and scoring that go beyond this will reduce the service life of the supply line. (For this reason DVGW Code of Practice GW 321 also recommends use of pipes with protective layers.)



Pipe bursting

In the case of pipe bursting a bursting and expanding implement is drawn through the old pipe, the broken pieces of pipe are pressed into the soil and at the same time an industrially prefabricated pipe with the same or larger diameter is jacked. The surrounding soil must be displaceable, and there must be knowledge of the position and state of pipes that run parallel. There are dynamic and statically operating systems, which are able to break up almost all pipe material including reinforced concrete pipes. Scratches and notches may occur in the new pipe depending on the material and state of the old pipe. Shards and stones cause point loads during operation.

The power for pipe bursting is introduced in a pulsating manner using modified impact moles or pile drivers. The bursting and expanding implement is guided in the pipe using rope and winch as stabilising factor. Dynamic methods are particularly suitable for use in compressed or stony ground and for brittle old pipes made from cast iron, earthenware or concrete.

The hydraulically generated bursting force is transmitted via a rod assembly to the bursting and expansion implement. Static pipe bursting is deployed for bursting old pipes made of brittle and ductile materials; the latter are cut in the bottom of the pipe using a special rotating cutter. Subsequent expansion displaces the old pipe and calibrates the burst duct for the jacking procedure.

The new pipe is subjected to considerable stress as a result of the pipe bursting and jacking process. Shards of old pipe lead to scratches and scoring, while stones cause point loads in the end position.

For this reason the DVGW Code of Practice GW 323 recommends the use of pipes with protective layers. Furthermore, the requirements with respect to the minimum thickness of damage or compliance with permissible tension stresses apply here too as they do with respect to other trenchless installation methods.

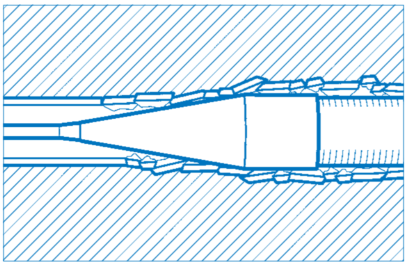


Fig. 10: The use of pipelines with additional protective layers is required because the new pipeline may become damaged during installation using the pipe bursting method.

Fig. 11: Dynamic pipe bursting (pipe cracking)

Fig. 12: Static pipe bursting

4 Types of installation method, their requirements and risks of failure

Considerable underground engineering work is involved when creating underground infrastructures. It is therefore the objective of an operator to be able to operate a new pipeline for as long as possible without damage. When correctly installed, pipes made from polyethylene offer a service life of at least 100 years [8074, Hessel, Schulte]. If, by contrast, they are damaged during installation, this long service life may be substantially curtailed.

Risk of failure No. 1: scratches and scoring weaken the pipe wall

The cause of this may be damage or weakening to the pipe wall during pipe jacking (see Fig. 13). Since the standardised wall thickness is precisely attuned to the operating pressure, albeit supplemented by the safety factor, every weakening means a reduction in the engineered safety factor and therefore an increase in the probability of the risk event (see Page 5) or, in the case of significant damage, even a direct reduction in pressure resistance of the new pipeline and consequently in a curtailment of the service life.

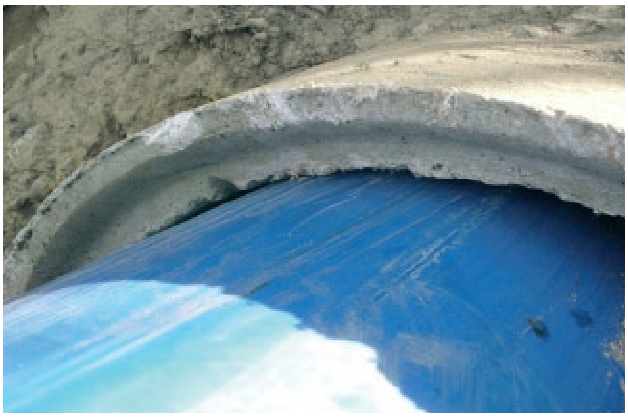


Fig. 13: Scratches and scoring arise during jacking that weaken the pipe wall and which therefore result in a curtailment in service life.

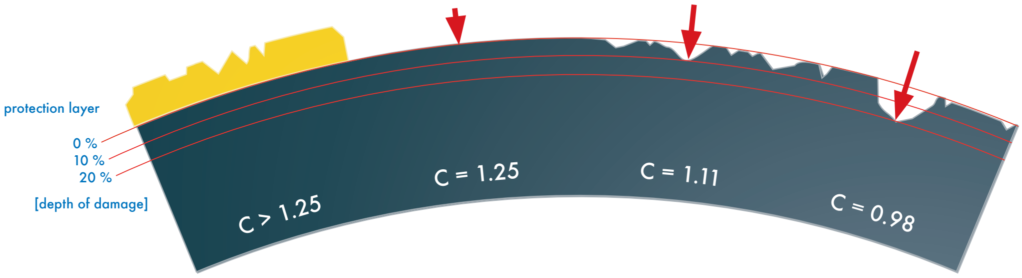


Fig. 14: Consideration of the safety factor C in relation to score depth

A damage depth of 10 % of the pipe wall is permitted by the codes of practice, because despite the reduction in the safety factor, a curtailment of the service life of the pipeline is not to be expected. By contrast, weakening of the pipe wall that penetrates deeper than this is dangerous.

The pressure test on a new pipeline system should serve as building acceptance; weakening of the pipe wall of an SDR 11 polyethylene pipeline only becomes apparent during the pressure test starting from a score depth of around **24 %**. However the safety factor drops to below 1 starting from a damage depth of the pipe wall of 20 % due to the reduction of wall thickness.

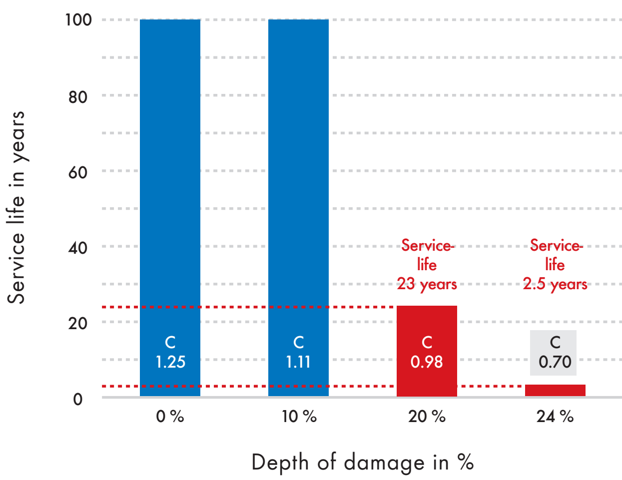


Fig. 15: Diagram of service life in relation to damage depth

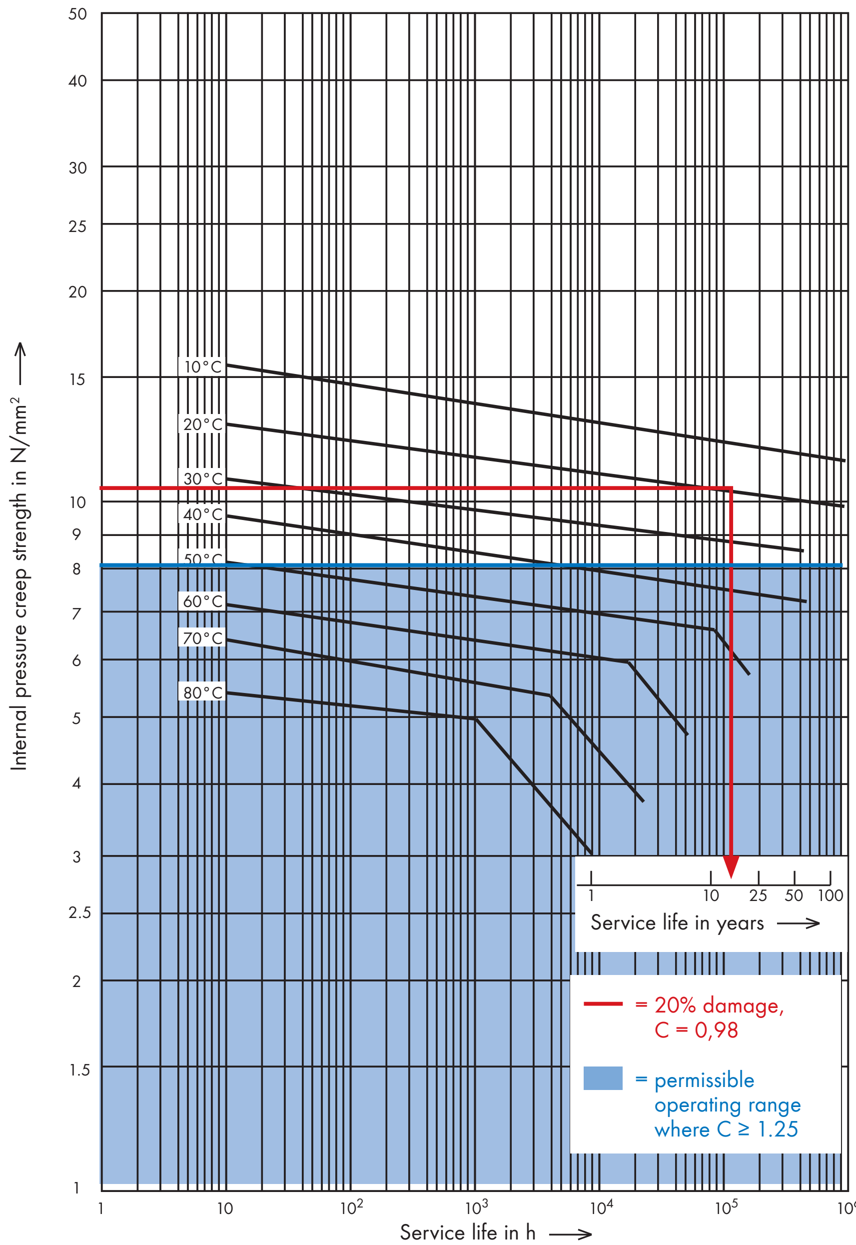


Fig. 16: Service life in hours of an undamaged pipeline made of PE 100-RC and one weakened by 20 %

Comparative calculation of undamaged and damaged pipe wall: Dimension: 110 x 10.0 mm, SDR 11 drinking water pipeline PE 100-RC admissible operating pressure 16 bar:

With damage depth of 20 % the wall thickness in this area is reduced to 8.0 mm which increases the test tension locally to 10.20 N/mm². To simplify the calculation the notch geometry and the impact on the component is not taken into consideration here. The impact on service life can be read off from the reference characteristic curves of the internal pressure creep rupture resistance (minimum curves in accordance with DIN 8075) of pipes made from PE 100. A residual service life remains of **just 23 years**. This consideration using the flat, i.e. ductile branch of the creep curve, only applies to the PE 100-RC materials which are resistant to stress induced cracking in accordance with PAS 1075. Earlier failure due to brittle breakages must be feared with standard PE 100 qualities that are more sensitive to notching.

Risk of failure No. 2: point loads

The occurrence of point loads represents a further risk factor for operation of a PE pipeline that is not embedded in sand. These are caused, for example, by stones lying on top which press onto the pipe wall. In the case of poor material quality this can also result in premature damage caused by stress cracks in the pipe wall (see Fig. 19).

Decisive for the service life expectation of the pipe when used under extreme operating conditions is the resistance of the pipe material to stress cracks caused by point loads if the normative service lfie of 100 years is to be achieved despite greater demands.

Fig. 17: PE pipes without protective sand bed

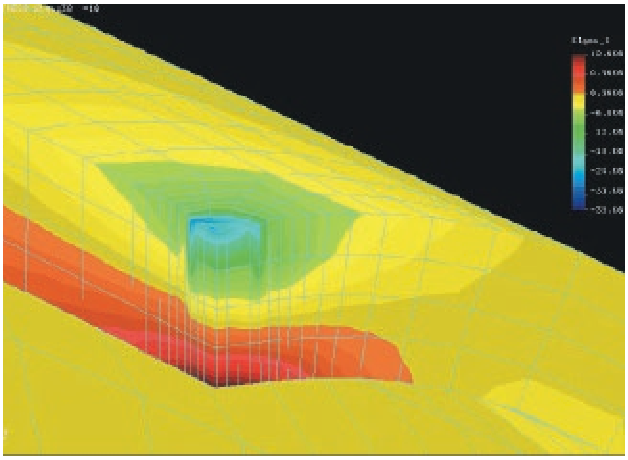


Fig. 18: Impact of point load on unprotected PE pipe: extremely high concentration of tension on the inside (Source: FEM calculation, University of Applied Sciences, Münster)

Fig. 19: Stress crack on the inside of the pipe caused by point load and incorrect choice of material (source: HESSEL technical engineering)

Overview of the different methods of installation and their risks of failure

Installation method	Description of method	Risk of a reduction in the service life in if unsuitable materi-als are used (s.p. 7)	Impact when unsuitable pipe materials/ pipe constructions are selected
Open trench pipe installation in a sand bed			–
Open trench pipe installation without a sand bed			Premature failure of the pipeline due to point loads
Open trench pipe installation without a sand bed Ploughing and milling method	 		Premature failure of the pipeline due to point loads
New installation using pipe jacking Horizontal directional drilling/impact moles (black box)	 		- Premature failure of the pipeline due to point loads, risk of notching - Reduced safety factor and/or curtail-ment of service life - unsafe welds
Replacement using pipe jacking Relining (black box)			- Premature failure of the pipeline due to point loads, risk of notching (V-joints on steel pipes) - Reduced safety factor and/or curtail-ment of service life - unsafe welds
Replacement using pipe jacking Pipe bursting (black box)			- Sharp edged geometry of pieces of the old pipe impact on the new pipe - Reduced safety factor and/or curtail-ment of service life - unsafe welds

Tab. 3: Installation methods and their risks of failure

5 Selection of pipe material

The installation method selected is decisive for the choice of material and consequently the risk of damage to the pipe systems deployed.

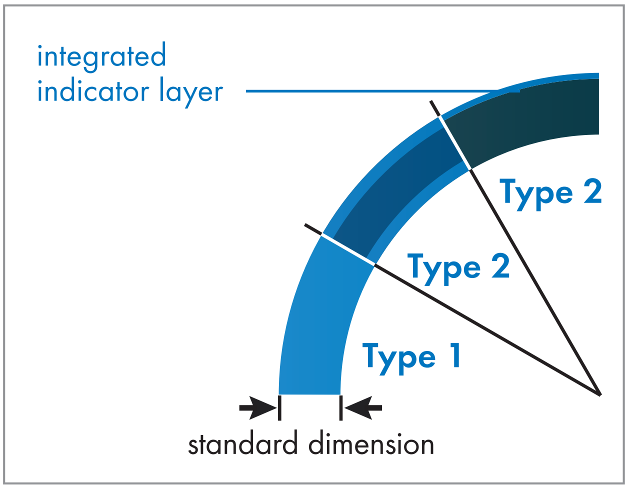


Fig. 20: Pipes with dimensionally integrated protective layers in accordance with DIN 8074/ISO 4065 made of PE 100-RC to PAS 1075 Types 1 and 2

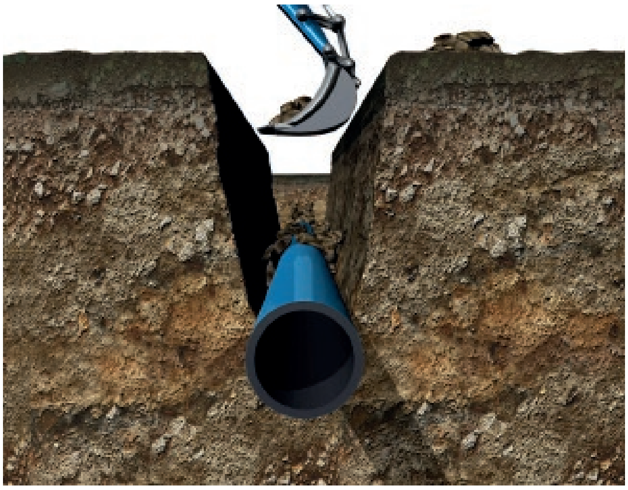


Fig. 21: Open trench installation method without sand bed

The occurrence of point loads caused by stones or shards can be expected using the **open trench installation technique** without a sand bed which then press against the pipe wall. The use of polyethylene pipes made of RC materials with integrated protective layers and the greatest resistance to slow crack progression is essential for this type of installation. The pipes should correspond to PAS 1075 Type 1 or 2 standard. This pipe construction does not have a notch protection.

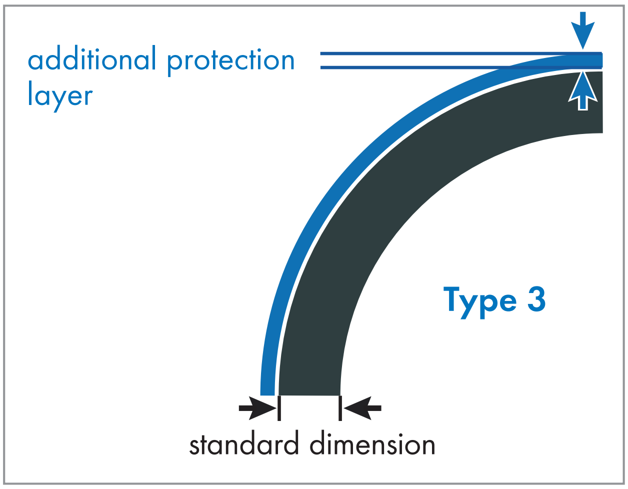


Fig. 22: Pipes with dimensions in accordance with DIN 8074/ISO 4065 made of PE 100-RC to PAS 1075 Type 3 (with additional protective layer)

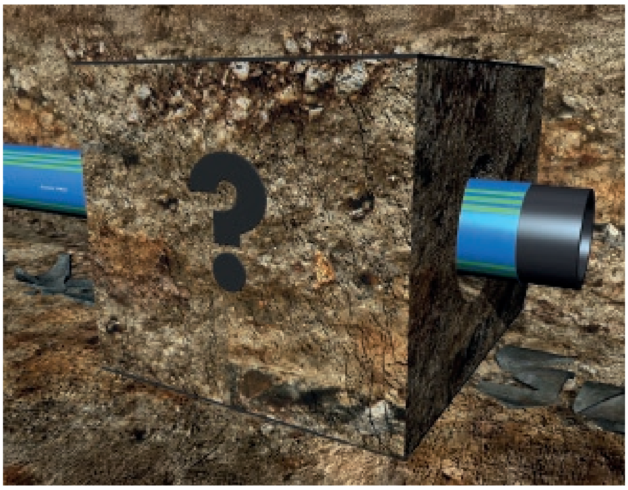


Fig. 23: Black box installation method / closed construction

Trenchless installation techniques place special stress on the pipes to be installed. Scoring and notches in the pipe cannot be avoided during new installation or renovation of old pipes. Pipes with an additional protective layer are therefore required for black box methods in order to guarantee a damage-free operation of the pipeline. Pipes with protective layers correspond to PAS 1075 Type 3.

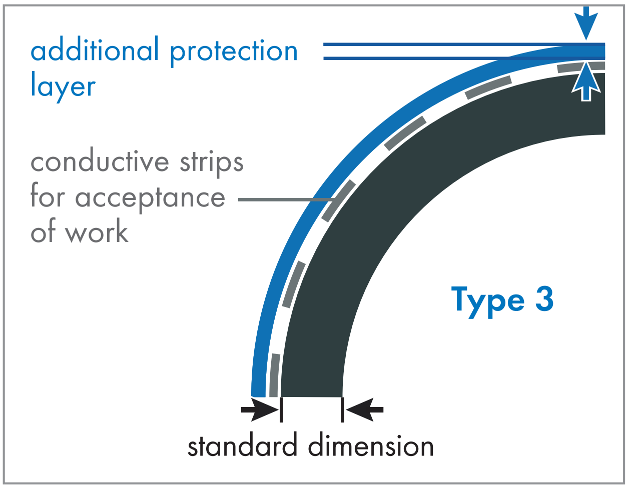


Fig. 24: Pipes with dimensions in accordance with DIN 8074/ISO 4065 made of PE 100-RC to PAS 1075 Type 3 (with additional protective layer and quality certificate)

Fig. 25: Continuity check as evidence of lack of damage to the new pipeline

The codes of practice for trenchless installation methods require complete documentation of all relevant processes in the building project. In this connection valid DVGW rules recommend an intensive incoming goods inspection of the pipeline and pipeline parts before open trench and trenchless installation. Particularly in the case of trenchless installation it is recommended that the exposed sections of newly installed pipelines undergo a visual inspection for impermissible damage before the pressure test. This means that the sections of pipeline that cannot be seen (black box) remain untested.

It is therefore not possible to prove lack of damage in this way. Pipes with integrated conductive strips for building acceptance therefore provide a possible way to demonstrate quality and close the inspection gap.

When using pipe systems with quality certificate the recording of the continuity check serves as evidence of lack of damage to the newly introduced pipeline.

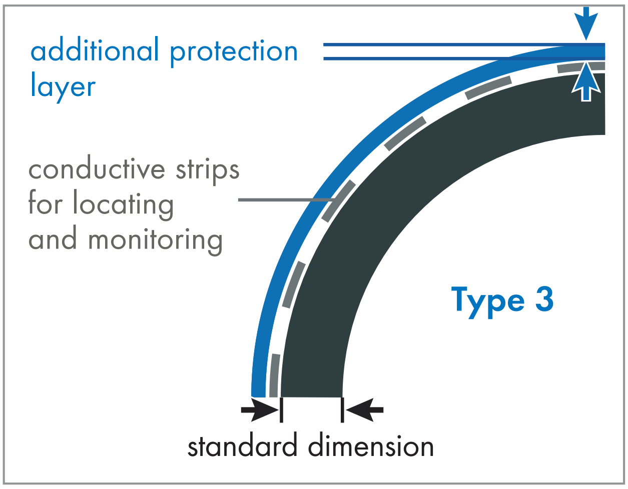


Fig. 26: Pipes with dimensions in accordance with DIN 8074/ISO 4065 made of PE 100-RC to PAS 1075 Type 3 (with additional protective layer and functional monitoring)

Fig. 27: Discontinuous or continuous monitoring during operation

Monitoring the damage-free condition of a pipeline during ongoing operation increases safety and reduces operating costs – eliminating the need for manual inspections. Subsequent costs for pipeline rehabilitation and damage to people, equipment, and the environment are avoided. Early detection of pipeline damage minimises operator risk.

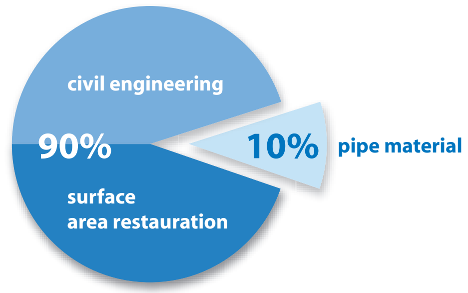
Pipes with leakage monitoring offer the possibility of reliably verifying damage-free installation and reliably eliminating losses due to leaks during operation over their entire service life. The use of such systems ensures compliance with legal regulations when a leakage monitoring system is required.

6 Economic perspectives

The selection of pipe materials and systems in civil engineering has extremely long-term and especially economic implications. Once they have been installed and designed for several generations, subsequent access to pipelines is scarcely possible:

- Valuable and sealed surface areas are created
- Enormous costs are incurred in the event of subsequent damage
- It is almost impossible to divert traffic or close off streets in the light of current traffic density

Economic efficiency means a favourable price-performance relationship taking into consideration the service life, operating and maintenance costs. External costs such as traffic disturbance, noise and CO_2 emissions are as a rule currently still lacking in the decision-makers' cost comparison or economic efficiency calculations. These costs must then be picked up by society.



Source: A. Hügging in 3R international (2000)

Fig. 28: Civil engineering costs up to 90 %, of which up to 50 % are for surface area restoration. Pipe material: 10 %

Fig. 29: Cost comparison program to calculate construction projects

The cost relations in civil engineering also make alternative, trenchless installation techniques economically interesting. The difference in pipe price is rarely more than 15%, while 85% or more of the overall costs are determined by civil and underground engineering or restoring the surface areas. The use of trenchless installation techniques opens up considerable potential for cost reduction.

egeplast has developed a cost comparison program to compare pipe materials (PE, cast iron, steel) and installation methods. The egeplast web calculator enables installation comparisons to be made simply. The performance items are arranged as for technical specifications, stored with guide values in line with actual practice and support planners and customers when planning the construction project.

This takes full consideration of the material-related advantages of PE pipes (flexibility, low weight, long lengths, small building pits etc.).

Conclusion

Fig. 30: Pipe with additional protective layer after the insertion process

PE pipes have been valued for decades for their material properties and are gaining market share throughout the world with respect to other pipe materials.

Modern RC pipes make it possible to dispense with the otherwise prescribed backfilling with sand, thereby generating time and cost advantages. Specification of material requirements in the european standards and PAS 1075 serve to reassure the user.

An additional protective layer is essential in order to attain an effective and reliable protection of the media pipe when using trenchless installation methods if one follows logical and empirical criteria. Full pressure resistance and the possibility of safe connection technology can only be maintained in this way.

RC pipes with additional outer layer and the possibility to check the pipeline for lack of damage constitute the current state of the art for trenchless building methods. Use of these pipes offers processing companies, planners and customers the only possibility for quality assurance when deploying trenchless installation methods. An increased level of danger must even be assumed for pipes that do not have a protective outer layer.

With pipeline systems that have integrated conductive strips

- ✓ the planner can document that he has selected the correct pipes for the installation method and has delivered contractual performance without defects. He can point to this in the event of subsequent damage;
- ✓ the processing company can by way of precaution have the fact that pipes have been installed without damage demonstrated and documented during acceptance. He can point to this in the event of any subsequent damage;
- ✓ the network operator can be way of precaution document that the pipeline systems were undamaged at the time they were completed. For this reason it is important that a network operator stipulates in the invitation to tender that there must be proof of undamaged installation during acceptance through the use of pipes with conductive strips.

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Innovative pipe systems for increased security requirements

Open-trench installation

in a sand bed | without a sand bed

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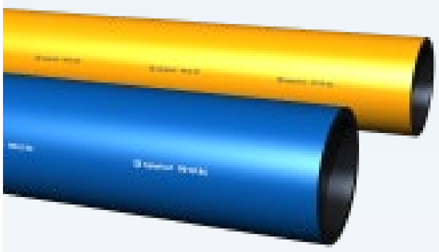
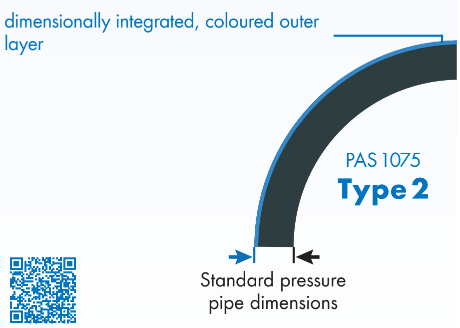


Pointload-resistant

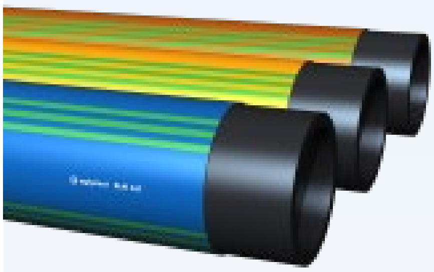
The egeplast **90 10® RC** is a pressure pipe system to transport gas, water and sewage. 100 years of service life even without a sand bed.



Trenchless installation methods

Additional protection

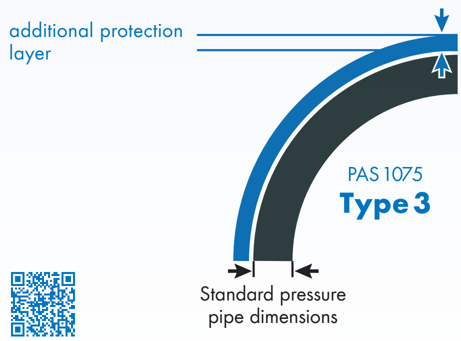
egeplast SLM® 3.0



Pointload-resistant

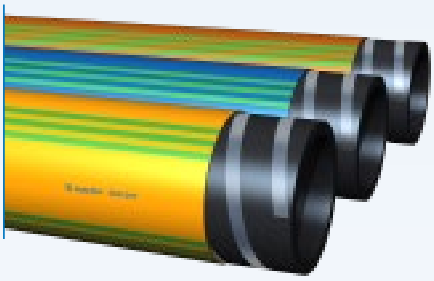
Scratch- and score-mark-resistant

The egeplast **SLM® 3.0** is a protective layer pipe system to ensure damage-free installation. Suitable for butt-welding thanks to a design based on homogeneous materials.



Quality check
of damage-free installation

egeplast SLM® DCT

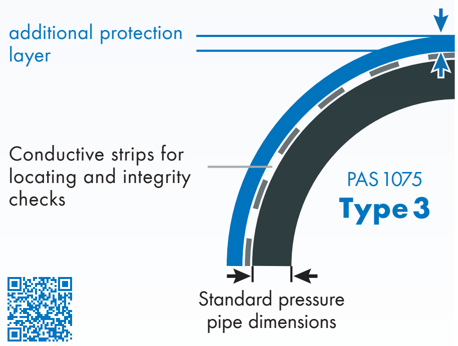


Pointload-resistant

Scratch- and score-mark-resistant

Quality control

The egeplast **SLM® DCT** is a protective layer pipe system to enable quality control for trenchless installation.



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to ensure special protection of drinking water

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Pointload-resistant | Scratch- and score-mark-resistant | Diffusion-tight

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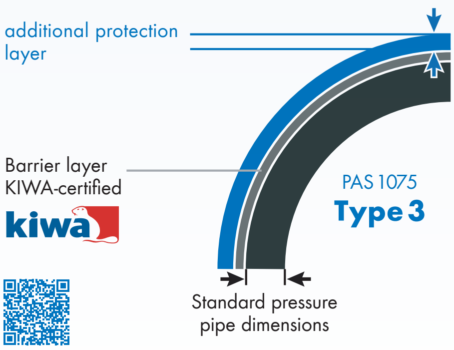
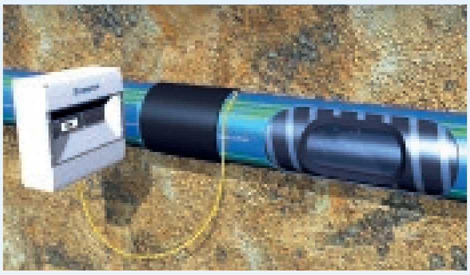


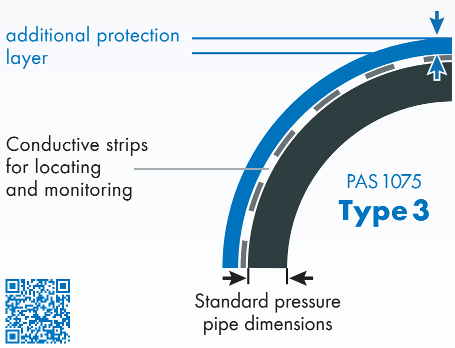
Early warning system
for monitoring critical infrastructure



egeplast
SLM® DCS

Pointload-resistant | Scratch- and score-mark-resistant | Leakage-monitoring

The egeplast **SLM® DCS** is a protective layer pipe system to enable early detection of pipe damage and precise locating of leaks. Locatable.



Permanent monitoring
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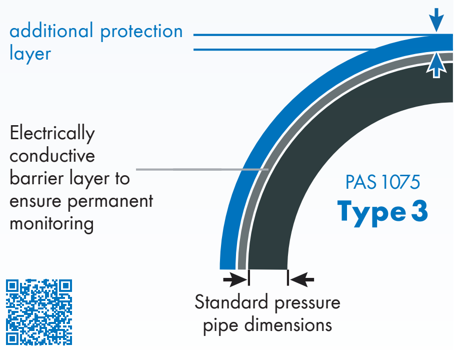

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